AIR TRANSPORT MANAGEMENT

AN INTERNATIONAL PERSPECTIVE

EDITED BY **LUCY BUDD** AND **STEPHEN ISON**

Air Transport Management

Commercial air transport is a global multimillion dollar industry that underpins the world economy and facilitates the movement of over 3 billion passengers and 50 million tonnes of air freight worldwide each year.

With a clearly structured topic-based approach, this textbook presents readers with the key issues in air transport management, including: aviation law and regulation, economics, finance, airport and airline management, environmental considerations, human resource management and marketing. The book comprises carefully selected contributions from leading aviation scholars and industry professionals worldwide. To help students in their studies the book includes case studies, examples, learning objectives, keyword definitions and 'stop and think' boxes to prompt reflection and to aid understanding.

Air Transport Management provides in-depth instruction for undergraduate and postgraduate students studying aviation and business management-related degrees. It also offers support to industry practitioners seeking to expand their knowledge base.

Lucy Budd is Senior Lecturer in Air Transport and Programme Director of the MSc in Air Transport Management in the School of Civil and Building Engineering at Loughborough University, UK. Dr Budd has extensive experience of teaching air transport at both undergraduate and postgraduate level and she has published widely in the area of air transport operations and aviation management.

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An international perspective

Edited by
Lucy Budd and Stephen Ison

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Acronyms

AAIB	Air Accidents Investigation Branch (UK)
A-CDM	Airport Collaborative Decision Making
ACI	Airports Council International
ACMI	aircraft crew maintenance and insurance (lease)
AIS	aeronautical information service
AMSL	above mean sea level
ANSP	Air Navigation Service Provider
APD	Air Passenger Duty
API	Advanced Passenger Information
APU	auxiliary power unit
AR	aircraft routing
ASA	air service agreement
ASK	available seat kilometre
ASM	airspace management
ASQ	airport service quality
ATC	air traffic control
ATFM	air traffic flow management
ATM	air traffic movement *or* air traffic management (depending on context)
ATS	air traffic services
AWB	air waybill
BA	British Airways
CAA	Civil Aviation Authority (UK)
CASK	cost per available seat kilometre
CCO	continuous climb operation
CDO	continuous descent operation
CFIT	controlled flight into terrain
CNS	communication, navigation and surveillance
CO_2	carbon dioxide
CPI	consumer price index
CRM	customer relationship marketing (or management)
CRS	computer reservation system

CUSS	common-use self-service (check-in kiosk)
CUTE	common-use terminal equipment
CWC	carrier-within-a-carrier
EAS	Essential Air Service
EASA	European Aviation Safety Agency
EBIT	earnings before interest and tax
EBITDA	earnings before interest, tax, depreciation and amortisation
EC	European Commission
ECAA	European Common Aviation Area
EEA	European Economic Area
EFB	electronic flight bag
EIA	environmental impact assessment
EMS	environmental management system
ETS	Emissions Trading System
EU	European Union
FAA	Federal Aviation Administration (US)
FAL	final assembly line
FAM	fleet assignment model
FDI	foreign direct investment
FEGP	fixed electrical ground power
FFP	frequent flyer programme
FIFO	fly-in fly-out
FIR	flight information region
FL	flight level
FOD	foreign object debris
FSNC	full service network carrier
FTK	freight tonne kilometre
GDP	gross domestic product
GDS	Global Distribution System
GSIE	Global Safety Information Exchange
IAG	International Airlines Group
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
ICT	information communication technology
IFR	Instrument Flight Rules
ILS	instrument landing system
IMC	instrument meteorological conditions
IPCC	Intergovernmental Panel on Climate Change
KPI	key performance indicator
LCC	low-cost carrier
LOC-I	loss of control in-flight
LOS	level of service
MARS	Multi Aircraft Ramp System
MCT	minimum connection time

MNJV	metal neutral joint venture
MRO	maintenance, repair and overhaul
NNI	Noise and Number Index
NO_x	nitrous oxides
NPR	noise preferential route
NTSB	National Transportation Safety Board (US)
OD	origin and destination
OEM	original equipment manufacturer
OTA	online travel agent
PSO	Public Service Obligation
PSR	primary surveillance radar
RASK	revenue per available seat kilometre
RDF	Route Development Fund
RET	rapid exit taxiway
RF	radiative forcing
ROCE	return on capital employed
RPI	retail price index
RPK	revenue passenger kilometre
RTK	revenue tonne kilometre
RVSM	reduced vertical separation minima
SARPs	Standards and Recommended Practices
SDR	Special Drawing Rights
SEL	sound exposure level
SEM	security management system
SES	Single European Sky
SIDS	small island developing states
SMS	safety management system
SSR	secondary surveillance radar
STOL	Short Take-Off and Landing
TA	tail assignment
TAWS	terrain awareness and warning system
UHF	ultra-high frequency
UIR	upper flight information region
ULCC	ultra-low-cost carrier
ULD	unit load device
UN	United Nations
VFR	Visual Flight Rules *or* visiting friends and relatives (depending on context)
VHF	very high frequency
VMC	visual meteorological conditions
VOR	VHF omnidirectional range (beacon)
WLU	work load unit
WTO	World Trade Organization

An introduction to air transport management

Lucy Budd and Stephen Ison

The provision of a safe, efficient and reliable commercial air transport industry has become one of the most important factors in delivering global economic growth. In a little over 100 years after the world's first scheduled flight in 1914, the commercial air transport industry has developed into the world's most significant high-speed mode of long-distance travel. Every year, over 3.3 billion passengers and 50 million tonnes of air freight (worth over US$6.4 trillion) are flown on 37.4 million scheduled flights on all seven continents. Air transport both drives and is driven by processes of globalisation, the intensification of international trade, and growing cultural and social exchange, and it has been responsible for changing patterns of international migration, commerce and tourism.

Since the end of the Second World War, commercial airlines have brought the world's major cities and commercial centres closer together in time and space. They have enabled the mass movement and temporary or permanent migration of hundreds of thousands of people and afforded access to educational, cultural, commercial and professional opportunities that were unavailable to previous generations. Evolving patterns of air service provision not only reflect technological advances in aircraft design and performance and changes in geopolitical relationships and forms of market regulation but also reveal and reinforce the uneven distribution of global wealth and economic activity. The purpose of this textbook is to detail the scale and scope of air transport management and explain the legal, regulatory, economic, technological, commercial and environmental factors that underpin its structure and operation.

Commercial air transport

Commercial air transport describes the scheduled or non-scheduled aerial conveyance of passengers, cargo or mail in exchange for revenue. Commercial air transport, which is available to members of the public, is distinct from military aviation, which concerns the use of specialised aircraft by nation states for reasons of defence and national security, and from general aviation, which refers to the recreational, agricultural and instructional use of civil aircraft which are not available for public use and which are not flown in exchange for remuneration. Despite this apparently straightforward classification and definition, the commercial air transport industry includes a wide range of business approaches and operational practices, incorporating everything from 500-seat A380s flown by leading airlines between major airports to seasonable charter flights and small single-engine aircraft that serve some of the most remote regions on earth.

Characteristics of the commercial air transport industry

Commercial air transport is characterised by a number of factors which have major implications for the management of the industry. Some of these operate at the macro or inter/national level, whereas others occur at the organisational level (see Figure I.1).

Macro-level factors include:

- The air transport industry was historically subject to strict regulation and control, which has shaped how the global industry has developed (➤Chapter 1). Although policies of deregulation and liberalisation, which started in 1978 in the US, have

Figure I.1 Organisational and external factors influencing the air transport industry progressively subjected the market to increased competition and stimulated the development of innovative new business models, restrictions on air service rights and foreign ownership restrictions remain in many markets. Deregulation of the industry manifests itself in a number of ways, not least the growing privatisation and commercialisation of airlines, airports and, increasingly, Air Navigation Service Providers (ANSPs). This change of emphasis has resulted in the introduction of new initiatives and business approaches that focus on efficiency, cost reduction, ancillary revenue generation and, ultimately, profit maximisation.

- The air transport product is derived demand in nature. This means that by far the majority of demand arises from a need for passengers, freight or mail to be somewhere else, not because the actual journey between origin and destination is desired for its own sake. This results in cyclical and seasonal variations in demand between and within years and between individual airports that create peaks in traffic, which makes the management of both material assets and human resources inherently challenging (➤Chapter 2). Owing to the derived demand nature of the industry, it is vulnerable to external shocks such as fuel price volatility, civil conflict, outbreaks of disease, terrorist threats (which have led to the introduction of new security interventions), volcanic eruptions and media coverage of aircraft accidents, all of which act to suppress demand.
- The airline product is a single-use consumer good. As such, once an aircraft is airborne, empty seats cannot be sold, so airlines have to manage demand and their yields carefully to efficiently utilise their inventory (➤Chapter 8).
- Deregulation and liberalisation has changed patterns of airline and airport ownership. Many airlines are no longer state-owned but, as Chapter 5 details, the situation with respect to airport ownership is altogether more complex, as some countries have taken steps to fully or part privatise their airport operators, while others have chosen to retain public sector ownership. In addition, some airports change owners relatively frequently. In contrast, the majority of ANSPs, for reasons of national security and defence, remain wholly or majority-owned by the state.
- Despite several decades of market deregulation and liberalisation, air transport essentially remains an oligopolistic market that is dominated by a small number of (often historically dominant) airlines and airline alliances (➤Chapters 7 and 9). In August 2015, the three leading global airline alliances – oneworld, SkyTeam and Star Alliance – accounted for 54 per cent of all airline seats worldwide (Capstats 2015). The commercial air freight sector is similarly oligopolistic (➤Chapter 15), although in both the passenger and freight sector there is room for specialist operators, not least those which specialise in serving bespoke markets in remote regions (➤Chapter 20).
- Air transport operations have a social and environmental impact in terms of noise, vibration, odour, air pollution and ground access congestion (➤Chapter 17). The management of these externalities is becoming increasingly important given growing scientific evidence of aviation's impact on the global climate and its local impact in terms of human health and wellbeing.

All these macro-level factors create a complex pattern of international regulation, ownership and operation which, when set against growing global demand for flight, increased competition and market saturation, requires informed organisational micro-level decision-making and management in the following areas:

- Selecting the most appropriate airline business model for the market, taking into account the competitive environment and prevailing market conditions (➤Chapter 7).
- Aircraft procurement, fleet selection and finance are all prerequisites of efficient operations, and different business models lend themselves to particular approaches (➤Chapters 11 and 14).
- The provision and utilisation of runway, terminal and ground access infrastructure are vital to safe and efficient operations, and the relationship between airlines and airports is integral to the effective management of these scarce resources and mitigating their adverse environmental effects (➤Chapters 3, 4 and 6).
- Pricing and revenue managing of airline and airport products so as to maximise profits and manage yields (➤Chapter 8).
- Scheduling aircraft and crew to maximise resource utilisation and minimise costs (➤Chapter 10).
- Ensuring safety and security through the adoption of company-wide safety and security management systems that comply with international protocols and regulations (➤Chapter 12).
- Tactical decision-making with respect to the use of airspace and selection of optimal flight paths so as to ensure safety, minimise costs, maximise efficiency and reduce externality effects (➤Chapter 13).
- ICT underpins air transport operations and is vital to the effective management of revenues, marketing, human resource control and flight operations (➤Chapter 16).
- Managing human resources to ensure the consistency and reliability of service delivery (➤Chapter 18).
- Marketing the product using a variety of online and offline channels to attract and retain customers and engender brand loyalty through the use of initiatives such as frequent flyer programmes (➤Chapter 19).

Air transport management

Managing an industry that includes over 25,000 commercial aircraft and over 100,000 daily departures on almost 50,000 routes between 3,850 airports worldwide (ATAG 2014) in accordance with strict international regulations concerning safety, security, consumer affairs, finance, auditing, environmental performance and professional competence is inherently complex. It requires the combined and coordinated actions of hundreds of thousands of employees and billions of dollars' worth of assets and infrastructure to ensure that people, goods and information are safely, efficiently, cost-effectively and profitably transported around the world by air at agreed standards of service.

Air transport management describes the business processes and functions that are deployed by companies involved at all stages of the air service delivery chain to achieve corporate objectives with the optimum use of available resources. It requires detailed consideration of forecasting, planning, procurement, staffing, supervision and operational coordination from the initial conception, design and manufacture of new aircraft and cabin service products to the collation of post-flight customer feedback and evaluations of financial performance.

To meet the industry's growing requirements for highly skilled labour, dedicated degree programmes in air transport management have been established to equip students with the theoretical, practical and technical skills they need to successfully manage air transport operations and services worldwide. Students studying such specialised aviation curricula require both subject-specific knowledge of aircraft and airport operations and a broader understanding of economics, law, regulation, finance, geography and international relations. Being cognisant of the diverse social, economic, political, physical and regulatory environments in which air transport operates not only enriches the learning experience and the value of the qualification(s) students obtain but also enhances employment prospects and provides a valuable mechanism through which theoretical constructs can be applied to real-world challenges.

Structure and organisation of this book

This book has been designed to be accessible and informative and is clearly structured for ease of use. Each of the 20 chapters addresses a different but intrinsically interrelated aspect of commercial air transport management. Every chapter includes:

- a series of detailed **learning outcomes** which convey the chapter's key contents and objectives;
- definitions of important terms, provided in **keyword boxes**;
- carefully selected **case studies** and **worked examples** to aid understanding and demonstrate the practical application of key concepts;
- **cross-references** to other chapters to remind readers of topic areas that have already been covered in previous chapters or to refer to topic areas that will be covered in more detail later in the book; and
- strategically placed **'Stop and think'** boxes to invite readers to pause and reflect on key topics and test their understanding of important issues.

Each chapter concludes with:

- a series of **key points**; and
- **references** and **suggestions for further reading** for those who wish to read more widely around a particular subject.

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CHAPTER 1

Aviation law and regulation

Ronald Bartsch and Samantha Lucy Williams

LEARNING OUTCOMES

- To identify the difference between air law and aviation law.
- To appreciate the importance of national sovereignty over airspace.
- To understand the reasons for, and implications arising from, the Chicago Convention 1944.
- To recognise the freedoms of the air.
- To describe the scope and purpose of the Warsaw and Montreal conventions.
- To determine the extent to which aviation law and regulation shape contemporary air transport operations and management.

1.0 Introduction

It is the freedom and agility by which air transport operations can readily transcend previously restrictive geographic and political boundaries that differentiates flying from other modes of transport. To harness this freedom, aviation regulation provides the requisite authority, responsibility and sanctions. The regulation of aviation is as fundamental and important to the industry as civil order is to modern society.

Almost since its inception, commercial aviation has been subject to stringent legal and regulatory control. This was required for reasons of national security, defence, consumer protection, national economic interest and for the protection of life and property. There are early recorded instances involving ballooning accidents in which damage to personal property occurred and the courts were required to pass judgment. One such accident occurred in New York in 1822 (Case Study 1.1).

CASE STUDY 1.1

GUILLE V *SWAN*, 19 JOHNS 381 (NY SUP CT, 1822), SUPREME COURT OF NEW YORK

Mr Guille, the defendant balloonist, landed his balloon in the vicinity of the plaintiff Mr Swan's garden. When the defendant descended, he was in a dangerous situation and asked for assistance from a person who was working in Swan's field. The event attracted the attention of hundreds of local residents who, in all the excitement, broke through Swan's fences and spoiled the plaintiff's vegetables and flowers. The damage caused to the balloon was minimal, totalling approximately US$15, whereas the damage resulting from the stampede was in the order of US$90. The court held that the defendant was liable for all damages that occurred to the premises as the defendant should have anticipated that his descent and landing would most likely have attracted such a large crowd.

Only six weeks after the commencement of the first regular international passenger air service, 27 states signed the *Convention Relating to the Regulation of Aerial Navigation* in Paris on 13 October 1919. The Paris Convention 1919 (as it became known) saw the beginning of international air law in confirming, virtually at the beginning of airline operations, the desire of governments throughout the world to systematically control aviation.

Today, the *Convention on International Civil Aviation* (Chicago Convention 1944), which updated and replaced the Paris Convention 1919, has been ratified by more than 190 sovereign states. These countries have agreed, under international air law, to be bound by the technical and operational standards developed by the International Civil Aviation Organization (ICAO) and which are detailed in the 19 Annexes.

The essence of aviation is travel. With rapid advancements in aircraft design and technology, largely attributable to the two World Wars, aircraft are now able to fly faster, higher and further than ever before. In very few fields of human endeavour or scientific achievement have advances been accomplished so swiftly and with such global application.

1.1 Air law

Throughout the world there has been considerable debate in relation to the formation of a universally agreed definition for the terms 'air law', 'aeronautical law' and 'aviation law'. Sometimes the terms are even used interchangeably. With respect to the terms 'air law' or the 'law of the air', if they were to apply to the literal or common meaning of the word 'air' as the medium or the atmosphere, then this would include all the law associated with the use of the air, including radio and satellite transmissions. In the main, **air law**, as it applies to aviation, has a far narrower interpretation and is generally considered to be 'the law governing the aeronautical uses of the air space' (Milde 2008, p2).

> **Air law:** that branch of law governing the aeronautical uses of airspace.

Air law is predominantly the concern of specialist lawyers. Consistent with the above definition, air law has received widespread acceptance and usage even though the actual term is somewhat of a misnomer. As Milde (2008, p2) states:

> It is safe to conclude that the term 'air law' from its inception was confined only to the legal regulation of social relations generated by the aeronautical uses of the airspace. The

term 'aeronautical law' would be more precise but a century of common use of the term 'air law' should be respected and any terminological doubts, disputes or preferences are of no practical relevance.

An alternative definition of air law, and one which has received considerable support, is 'that body of rules governing the use of airspace and its benefits for aviation, the general public and the nations of the world' (Diederiks-Verschoor 2006, p1). The second definition significantly expands the scope of activities to which air law applies.

Not that there is anything fundamentally irreconcilable with the second definition; however, to deviate so substantially from the subject matter of the first potentially creates confusion and ambiguity as to its meaning and usage. Throughout this chapter, air law will be considered as originally defined as 'that branch of law governing the aeronautical uses of airspace'.

1.2 Aviation law

Aviation law is a broader term than air (aeronautical) law and has been defined as 'that branch of law that comprises rules and practices which have been created, modified or developed to apply to aviation activities'. Aviation law is to air law what maritime law is to the law of the sea. To assist with the clarity of expression and reduce the potential for problems to arise in the application of these terms, the above definitions will respectively apply to the terms 'air law' and 'aviation law'.

Aviation law: that branch of law that comprises rules and practices which have been created, modified or developed to apply to aviation activities.

Aviation law therefore encompasses the regulation of the business aspects of airlines and general aviation activities. Consequently, aspects of insurance law, commercial law and competition law all form part of aviation law. Security and environmental regulations applicable to aviation activities are also within the scope of aviation law. Also included within the domain of aviation law is the regulatory oversight of aviation activities by regulators and government agencies.

Aviation law is not separate from other divisions of law like the law of contract and the law of negligence. The fact that there are relatively few reported cases on aviation has tended to obscure and mask the identification of this branch of law.

Stop and think

What are the main differences between air law and aviation law?

1.3 International air law

International law is that body of legal rules that apply between sovereign states and such entities that have been granted international personality. Within the aviation community, the concept of international personality extends to organisations including ICAO, which is a division of the United Nations, both of which are key players in international law.

Bilateral air service agreement: an agreement which two nations sign to allow international commercial air transport services to occur between their territories.

Conflict of laws: the laws of different countries, on the subject matter to be decided, are in opposition to each other or that laws of the same country are contradictory.

International conventions (e.g. the Chicago Convention 1944 in regard to ICAO) detail and confer international personality upon these respective organisations.

As there is no sovereign international authority with the power to enforce decisions or even compel individual states to follow rules, international law has often been considered as not being a 'true law'. In aviation, however, because of the extensive and important role of international institutions such as ICAO and IATA (International Air Transport Association) and the proliferation of honoured **bilateral air service agreements** between nations, including the almost universal ratification of international conventions concerning international civil aviation, the existence of an international law would be difficult to deny.

The branch of international air law that determines the rules between contracting states and other international personalities is known as 'public international air law'. The Paris Convention 1919 and the Chicago Convention 1944 are true charters of public international air law. This term contrasts with the law relating to private disputes in which one of the parties may be of another state. This is the realm of 'private international air law' or **conflict of laws**.

International air law is essentially a combination of both public and private international air law. It has been suggested that its principle purpose is to provide a system of regulation for international civil aviation and to eliminate conflicts or inconsistencies in domestic air law.

Stop and think

Consider why international air law is required.

1.4 International convention law

Convention law is the major source of international air law and is constituted by multilateral and bilateral agreements between sovereign states. To provide a further insight into the application and importance of both public and private international air law to the aviation industry, three major international conventions will be examined; but first it is important to highlight the importance of the concept of sovereignty as it applies to airspace.

1.5 Sovereignty of territorial airspace

Sovereignty: the authority of a state to govern itself.

In international aviation, the concept of **sovereignty** is the cornerstone upon which virtually all air law is founded. At the Paris Convention 1919, 26 Allied and Associated nations had to decide whether this new mode of transport was to follow the predominantly unregulated nature of international maritime operations or whether governments would choose to regulate this new technology. It was the First World War that had brought about the realisation of both the importance of aviation and its potential danger to states and their citizens in threatening their sovereignty.

It was, therefore, not surprising that the first Article of the Paris Convention 1919 stated:

> The High Contracting Parties recognise that every Power has complete and exclusive sovereignty over the air space above its territory.

This proclamation addressed the debate of whether airspace was 'free', as it is with the high seas, or whether it was part of the subjacent state or territory. The decision to follow the latter path was almost unanimous. While the Paris Convention 1919 clearly asserted that exclusive or absolute sovereignty extends to the airspace above the territory of the state, issues were raised as to what constitutes the vertical and horizontal territorial limits of each state.

In respect to vertical limits, customary law, based on an ancient Roman principle, had long recognised that absolute sovereignty of the state over its territorial airspace extended to an unlimited height. The Roman principle was based on an old maxim, *cujus est solum ejus usque ad coelum*, translated to mean 'whose is the soil, his is also that which is up to the sky'. Although international treaties have since modified this position in asserting that '[no] national appropriation by claim of sovereignty' can prevent overflight rights of satellites in outer space (space beyond the navigable airspace), no precise definition of outer space is provided (➤Chapter 13). The *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies* (Outer Space Treaty) (1967) does not provide a precise definition of outer space either.

Once again, in respect to horizontal or lateral limits of sovereignty, international treaties have clarified the situation. Article 2 of the Chicago Convention 1944 states:

> For the purposes of this Convention the territory of a State shall be deemed to be the land areas and the territorial waters adjacent thereto under the sovereignty, **suzerainty**, protection or mandate of such State.

Suzerainty: the situation in which a dominant state controls the foreign relations of another state but allows it sovereign authority in internal affairs.

The *United Nations Convention on the Law of the Sea* (UNCLOS) (1982) defines the limits to which sovereignty of the coastal state may apply to the airspace above the territorial waters or sea.

It is important to realise that the Paris Convention 1919 did not create the principle of exclusive air sovereignty but rather *recognised* it. Article 1 was drafted such that it was 'declaratory of pre-existing customary international law' (Haanappel 1998). Furthermore, the principle extends to all nations, irrespective of whether a particular state has signed or ratified the convention.

Subsequent conventions in Madrid in 1926 and Havana in 1928 achieved little by way of advancement in international air law. Significantly, however, the Havana (Pan-American) Convention 1928 was the first multilateral convention which challenged the principle of absolute sovereignty and was signed by the United States, Mexico and 14 South American states.

The principle of absolute sovereignty was again challenged with the Chicago Convention 1944, but ultimately the status quo prevailed. The Chicago Convention 1944 recognised and confirmed the principle that every state has complete and exclusive sovereignty over the airspace above its territory. The territory of a state for the purposes of the Chicago Convention 1944 was deemed the land areas and the territorial waters adjacent to them under the sovereignty, suzerainty, protection or mandate of the state. The question of the vertical extent of the airspace above a state's territory remains undetermined. However, the view that rights in airspace extend to a height without any limit has been firmly rejected (➤Chapter 13). Apart from the right of overflight by satellites in outer space, the concept of sovereignty remains the basis upon which both the structure and proliferation of bilateral air service agreements continue. This chapter now examines what is the most important international treaty in aviation.

1.6 Chicago Convention 1944

As in the aftermath of the First World War, the positive contributions of aviation during times of peace were realised following the improved performance and capabilities of aircraft during the Second World War. By the end of the Second World War, advances in aircraft design and technology had culminated in the development of the first jet engine. Following preliminary discussions initiated by the British Government in early 1944, the US called for an international conference in Chicago in November 1944. It was the intention of the US and Allied nations to establish post-war civil aviation arrangements and institutions and, in particular, the US sought to promote the freedom of international exchange by removing the restrictions to international air travel imposed by absolute air sovereignty. The conference was attended by most of the established nations of the world, including Britain, the US and Australia.

The general aims of the conference, in terms of promoting international air transportation, were:

- *Economic.* These included the promotion of freedom of airspace to nations and airlines; procedures for determining airfares, frequencies, schedules and capacities; and arrangements for simplifying customs procedures and standardising visas and other documentation.
- *Technical.* These were concerned with establishing international standards with respect to a variety of technical standards, including the licensing of pilots and mechanics, registering and certifying the airworthiness of aircraft, and the planning and development of navigational aids.

The resulting Chicago Convention, which was signed on 7 December 1944, only applies to civil aircraft and does not apply to state aircraft. However, Annex 13 of the Convention implies that states are expected to apply its provisions domestically, while Annex 17 of the Convention was amended following the events of 11 September 2001 to 'require' states to implement certain security standards domestically, except where it is impracticable to do so.

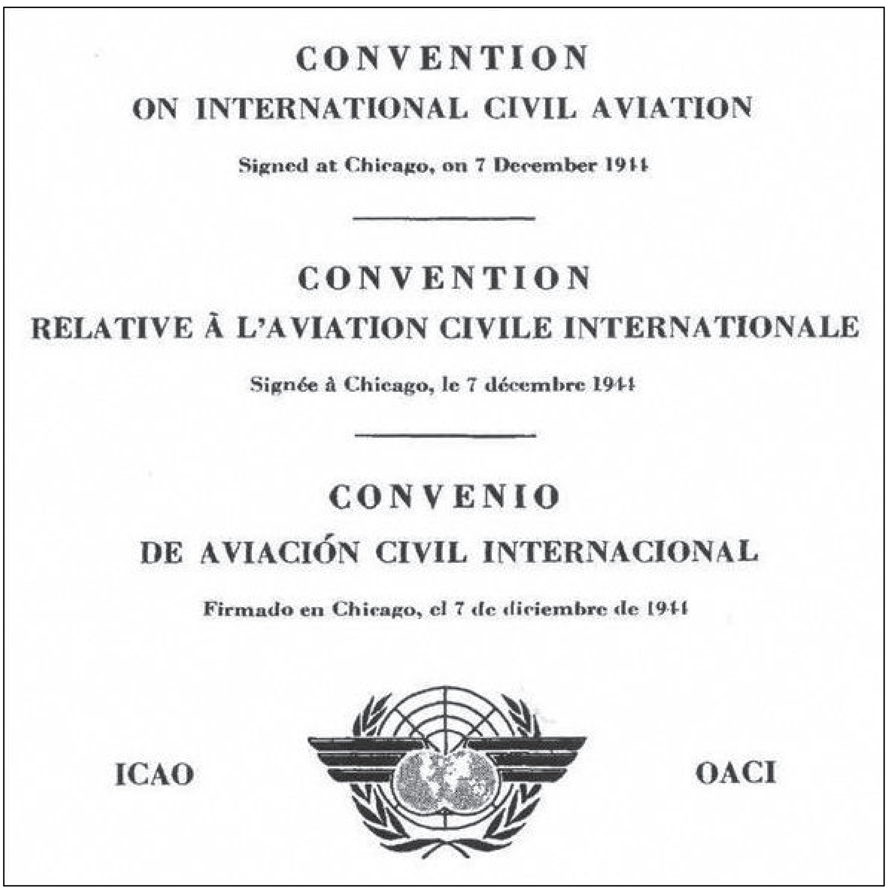
1.7 Freedoms of the air

As with the Paris Convention 1919, the Chicago Convention 1944 restated and reinforced the principle of absolute air sovereignty. Consequently, air transit and traffic rights between contracting states required specific agreement. The US advocated complete freedom of the air for commercial air transportation, while Britain, supported by Australia and New Zealand, proposed varying degrees of international regulation. A Canadian proposal for

freedoms of the air was documented as the *International Air Transport Agreement* (see Figure 1.1). Only 20 states signed the agreement at Chicago, including the US, but not all subsequently ratified it. Only five freedoms were discussed at Chicago. There are three other freedoms which, although not officially recognised by the Chicago Convention 1944 or granted in bilateral air service agreements, are referred to and taken into account in bilateral air service agreements.

Freedoms of the air: freedom to cross the territory of another country and conduct commercial services to other countries.

Although nearly all the delegates at Chicago agreed that some degree of regulatory control was desirable, and indeed necessary for a cooperative development of international civil aviation, there was no general consensus apart from agreement of the first two freedoms. It was hoped that the other freedoms might be settled on a multilateral basis, but that was not practicable as the more powerful nations stood more to gain through negotiating bilateral arrangements. As the free market approach was not acceptable and multilateral approaches were not practicable, the only other way to secure international air travel consensus was by way of individual bilateral air service agreements that were reciprocally negotiated between two national governments.


CONVENTION
ON INTERNATIONAL CIVIL AVIATION
Signed at Chicago, on 7 December 1944

CONVENTION
RELATIVE À L'AVIATION CIVILE INTERNATIONALE
Signée à Chicago, le 7 décembre 1944

CONVENIO
DE AVIACIÓN CIVIL INTERNACIONAL
Firmado en Chicago, el 7 de diciembre de 1944

ICAO OACI

Figure 1.1 Chicago Convention 1944

1st Freedom—Freedom to overfly the territory of a Foreign State without landing

2nd Freedom—Freedom to land for technical reasons in a Foreign State without picking up or setting down commercial traffic

3rd Freedom—Freedom to transport commercial traffic from the Home to a Foreign State

4th Freedom—Freedom to transport commercial traffic from a Foreign to the Home State

5th Freedom—Freedom to transport commercial traffic between two Foreign States on a route to or from the Home State

6th Freedom—Freedom to transport commercial traffic between two Foreign States via the Home State

7th Freedom—Freedom to transport commercial traffic directly between two Foreign States

8th Freedom—Freedom to operate commercial services between two points within a Foreign State

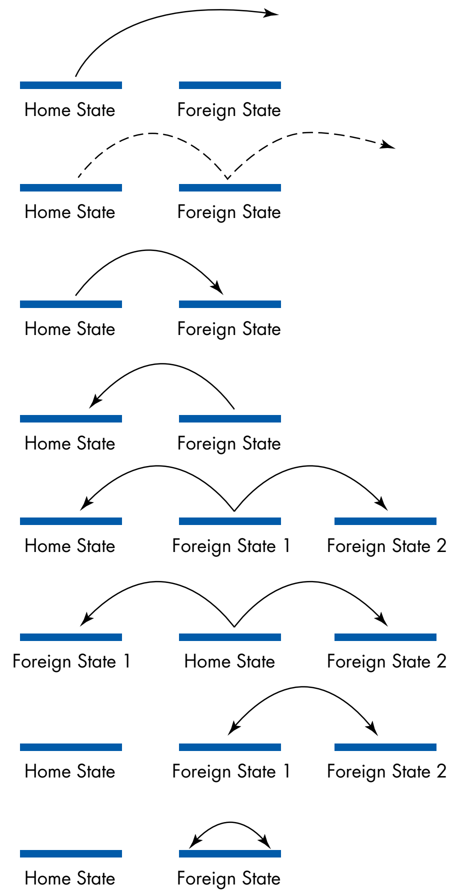


Figure 1.2 Freedoms of the air

Under the Chicago Convention 1944, all scheduled international air services (that either pass through the airspace of more than one state, carry passengers, mail or cargo or service two or more destinations in accordance with a published timetable) must acquire prior permission before flying into or over foreign territories. To fill the gap with regard to scheduled international air services, most states, including Australia, Britain and the US, signed the *International Air Services Transit (Two Freedoms) Agreement* (Transit Agreement). This agreement has proved to be extremely effective in terms of simplifying overflight rights and practical when diplomatic tensions arise between contracting states. In practice, although ICAO is authorised to resolve disputes arising from the Transit Agreement, this power is rarely invoked.

It is at the contracting state's discretion whether to adhere to the Transit Agreement. Bilateral agreements can, and usually do, include terms exchanging these two freedoms. This is an alternative arrangement for overflight rights where one or both states are not party to the multilateral agreement. The Transit Agreement does not specifically require contracting states to obtain a permit prior to exercising transit or non-traffic stopovers. In practice, irrespective of how overflight rights have been established, the filing of flight plans for operational purposes is usually all that is required to provide the requisite safety, technical and security information.

Stop and think

Consider the extent to which airspace sovereignty influences the pattern of air transport provision worldwide.

1.8 The International Civil Aviation Organization (ICAO)

The most important contribution of the Chicago Convention 1944 was the agreement over technical matters and the groundwork which led to the establishment of ICAO. ICAO is without doubt the most important international organisation in the area of public international air law.

Article 44 of the Chicago Convention 1944 describes the purpose of ICAO:

> To develop the principles and techniques of international air navigation and foster the planning and development of international air transport so as to insure the safe and orderly growth of international civil aviation throughout the world.

On 6 June 1945, the required 26th state, including each of the 20 states elected to the ICAO Council, had accepted the *Interim Agreement on International Civil Aviation*. The 'Provisional' ICAO or PICAO came into effect as planned within six months of the signing of the Chicago Convention 1944. It was agreed by member states that PICAO would remain in operation until the permanent forum, ICAO, came into force within the three-year limit prescribed in the convention.

ICAO provides the structure for the achievement of international cooperation and coordination in civil aviation. Through a variety of mechanisms, ICAO works to uphold the principles underlying the Chicago Convention 1944. It develops and adopts internationally agreed standards and procedures for the regulation of civil aviation, coordinates the provision of air navigation facilities on a regional and worldwide basis, collates and publishes information on international civil aviation, and acts as the medium by which aviation law develops at an international level.

Apart from technical matters, ICAO has also been instrumental in providing the organisational structure for the determination of less contentious economic arrangements. ICAO has addressed matters such as customs procedures and visa requirements and also assumed responsibility for collecting statistical data for international civil aviation, including information on safety-related issues, most notably incident and accident statistics (➤Chapter 12).

The international specifications for civil aviation appear in 19 Annexes to the Chicago Convention 1944. Each Annex addresses a particular subject. The specifications are divided into two categories, namely, Standards and Recommended Practices, although they are collectively, and most commonly, referred to as 'SARPs'. Today, the 190 signatories to the Chicago Convention 1944 are obliged to comply with the extensive and comprehensive technical, safety, operational, security and environmental provisions as set out in the SARPs. In the next section, we move into the area of private international air law.

Stop and think

Outline the principal functions of ICAO.

1.9 Warsaw Convention 1929

International carriage by air is predominantly governed by international conventions. These international conventions were established as a result of the development in the air transport industry and were aimed at addressing conflict of law problems commonly associated with international carriage.

The first true instrument of private international air law was the *Convention for the Unification of Certain Rules relating to International Carriage by Air* (Warsaw Convention 1929). It adopted a uniform set of rules governing international carriage by air and deals with the rights of passengers and owners or consignors of cargo and provides for internationally accepted limits on a carrier's liability for death, injury or damage.

Prior to the establishment of the Warsaw system, there were no uniform rules of law concerning international carriage by air. The problems inherent in international air travel often relate to matters concerning conflicts of law. The rights of passengers and owners of cargo, most of which had been previously stated in the contract of carriage, would vary from country to country and in accordance with each country's domestic law. Similarly, the liabilities of the carriers would vary enormously. The Warsaw Convention 1929 represented the first uniform international effort to implement universal laws relating to international air carriage, especially in respect of carriers' liability.

The implementation of internationally accepted limits on a carrier's liability for death, injury or damage was also a driving force which ultimately led to the Warsaw Convention of 1929. At that time airlines were predominantly state-owned and particularly supportive of the introduction of known limits on liability. Arguments advanced in favour of liability limits included:

- protection of a developing and financially vulnerable aviation industry;
- distribution of potentially large risks;
- practicality of carriers being able to fully insure against liabilities;
- standardised and readily quantifiable damages awards;
- allowing passengers to take out their own insurance policies; and
- reducing litigation against airlines and facilitating settlement of disputes.

The objectives of the Warsaw Convention 1929 were achieved for approximately two decades after implementation, but its effectiveness and support have been gradually eroded. In an attempt to retain its effectiveness, the Warsaw Convention 1929 was updated several times by way of amendments. As a consequence of the US (and others countries) not having adopted all of the subsequent amendments to the Warsaw Convention 1929, a non-uniform international system of liability of carriers governing international air carriage emerged, thereby frustrating the most fundamental objective as to why it was originally created. Moreover, the terminology and language used in the Warsaw Convention 1929 (and amending protocols) had become outdated and was the source of much ambiguity and dispute.

It is important to realise that the Warsaw Convention 1929 only applies to international carriage. Case Study 1.2 illustrates the importance of determining whether or not a particular flight is deemed to be international carriage and thereby limiting the liability of the carrier.

CASE STUDY 1.2

STRATIS V EASTERN AIR LINES LIMITED 682 F 2D 406 (1982)

Mr Stratis was a crewman on a Greek tanker. He was booked to fly on Delta Air Lines from Baton Rouge to New Orleans, then on Eastern Air Lines from New Orleans to New York and finally on Olympic Airways from New York to Athens. He had paid for all travel prior to departure but was only issued with tickets for the domestic **sectors**, having arranged to collect his international ticket in New York. The Eastern Air Lines flight crashed on approach to New York, and Mr Stratis became a quadriplegic. The Court awarded him US$6.5 million in damages, which was apportioned as follows: 60 per cent for the negligence of the hospital who had treated him and 40 per cent against Eastern Air Lines and the US government for the negligence of their pilots and air traffic controllers respectively. On appeal to the US Circuit Court of Appeals, the Court accepted Eastern Air Lines' defence that their liability was limited under the Warsaw Convention 1929 because it was international carriage. It was held that the contemplation of the parties was for international carriage, and the fact that the domestic tickets were annotated to that effect was a significant factor.

On 4 November 2003, the *Convention for the Unification of Certain Rules for International Carriage by Air* (Montreal Convention 1999) came into force and replaced, for those states which have ratified it, the Warsaw Convention 1929. This convention has fundamentally changed this area. The new liability rules were developed during an International Air Law Conference called by ICAO to modernise the Warsaw Convention. Since it took effect, the importance of the Warsaw Convention 1929 and subsequent amendments to the development of international air law cannot be overstated.

Sector: (also known as a 'route') a single flight that connects an origin and destination airport (an OD pair).

1.10 Montreal Convention 1999

The development of various international conventions relevant to international air carriage, in the context of a maturing commercial aviation industry, gave rise to a complex system of international treaties, many of which have now become unwieldy and outdated. Although the Montreal Convention 1999 consolidates the many amendments to the Warsaw

Codeshare: a reciprocal agreement between two or more airlines that enables a flight that is operated by one carrier (e.g. ABC123) to be marketed by another using its own code and flight number (ZYX987). The carrier operating the flight (ABC) is the operating carrier, while the airline marketing the flight (ZYX) is the marketing carrier. The resulting flight is identified by the shared codes (in this case ABC123/ZYX987).

Air waybill (AWB): a type of bill that serves as a receipt of goods by an airline (carrier) and as a contract of carriage between the shipper and the carrier. It includes conditions of carriage that define (among other terms and conditions) the carrier's limits of liability and claims procedures. Further, it provides a description of the goods and the applicable charges.

Convention 1929, it is an entirely new treaty that unifies and replaces the system of liability established by the Warsaw Convention 1929 and its subsequent amendments.

Prior to the introduction of the Montreal Convention 1999, compensation limits remained generally low, in line with the early philosophies aimed at supporting a fledgling air transport industry. The industry, despite present-day challenges, has developed significantly in respect of its commercial stability and relative safety standards. Commercial arrangements such as intercarrier, **codeshares** and airline alliance agreements and the complex nature of international trade have led to practices never envisaged by the drafters of earlier conventions, such as electronic documentation in place of traditional paper tickets and **air waybills (AWBs)**.

The Montreal Convention 1999 establishes an alternative carriage by air regime for determining the liability of air carriers for injury or death of a passenger, loss or damage to luggage or cargo and damage caused by or delay in the transport of passengers, luggage or cargo which occurs during the course of international carriage. Overall, the Montreal Convention 1999 has sought to address the problems that developed in the Warsaw system by substantially raising carriers' liability limits, presenting the liability framework in a single consistent convention and updating the language and terminology used.

The Montreal Convention 1999 distinguishes between international and domestic carriage. The convention applies to international carriage only. Domestic travel is treated as 'other carriage', to which the *Civil Aviation (Carriers' Liability) Act 1959* (Cth) applies.

The convention lists five guiding principles agreed by its contracting parties as a preamble to its substantive provisions; namely, the Montreal Convention 1999:

- Recognises the significant contribution of the Warsaw Convention 1929 (as amended) to the harmonisation of private international air law.
- Recognises the need to modernise and consolidate the Warsaw Convention 1929 (as amended).
- Recognises the importance of ensuring protection of consumer interests in international air transport and the need for equitable compensation based upon the principle of restitution.
- Reaffirms the desirability of the orderly development of international air operations and the smooth flow of passengers, baggage and cargo in accordance with the Chicago Convention 1944.
- Promotes collective state action for further harmonisation and codification of certain rules governing international air carriage through a new convention as the most adequate means of balancing interests.

Interesting issues have arisen throughout the ratification and implementation process of the Montreal Convention 1999. Legislation in operation in the European Union (EU) has taken a broad interpretation of the provisions of the convention. EC Regulation 261/2004 in particular has attracted much attention. Argued to be overly focused on 'passenger protection', the regulation imposes obligations on carriers to assist passengers in the event of delay, including those situations where the events giving rise to a delay are beyond the control of the carrier, such as when the delay is caused by adverse weather conditions or air traffic disruptions.

This regulation proved to be particularly controversial because it has the potential to affect foreign, non-European carriers and also since it appears to contravene those provisions of the Montreal Convention 1999 which provide carriers with a defence in circumstances where delay is beyond their control. Further, such issues will likely continue to arise as additional implementing legislation is introduced by various state parties, who are likely to look to the example set by the EU as a point of guidance and comparison – most notably the 'Passenger Bill of Rights' enacted by the State of New York in the US and later overturned by the US courts.

1.11 Differences between the Warsaw and Montreal conventions

It is important to note that carriage under the Warsaw system does not cease to be legally binding because of the entry into force of the Montreal Convention 1999. The Warsaw Convention 1929 still applies to round trips departing from a state which is not a member of the Montreal Convention 1999 and to one-way flights between two states where either has adhered to the Montreal Convention 1999. The convention applies to all international air carriage in which the country of departure and the country of destination have both adopted it.

Through its Chapter III, the Montreal Convention 1999 establishes a new two-tiered scheme to govern passenger compensation. The first tier, which operates up to 100,000 **Special Drawing Rights (SDR)**, imposes strict liability upon the carrier. The carrier's liability under the first tier can only be reduced by the demonstrated contributory negligence of the passenger. Liability under the second tier is unlimited if damages are proven in excess of 100,000 SDR, but can be avoided by the carrier proving that the damage was not caused by its negligence or was caused solely by the negligence or other wrongful act or omission of a third party.

Special Drawing Rights (SDRs): an international monetary reserve currency created by the International Monetary Fund.

The Montreal Convention 1999 only applies if the parties agree to its application to transportation between two locations (the destination may be changed during the flight or the flight may be a round trip). This rule excludes pilot training and test flights. Although carriage occurs in these examples, it does not occur pursuant to a contract of carriage. Therefore, the Montreal Convention 1999 is excluded by the absence of a contract and not by the absence of carriage. It follows that carriage does not need to be defined according to the parties' subjective intentions. Over 100 states have adopted the Montreal Convention 1999, and accordingly the importance and application of the Warsaw Convention 1929 has, and will continue to be, significantly reduced.

Stop and think

How do the Warsaw and Montreal conventions differ?

1.12 International carriage by air

As the Montreal Convention 1999 applies to international carriage only, it is imperative, in the first instance, to determine whether or not a particular flight is domestic or international. The leading authority on this issue is *Stratis v Eastern Air Lines Limited* (see Case Study 1.2). International carriage under the Montreal Convention 1999 includes baggage (luggage) and cargo. In the case of cargo, Article 4 of the Montreal Convention 1999 requires that every carrier of cargo has the right to require the consignor to generate an air consignment note, called an 'air waybill'. Every consignor has the right to require the carrier to accept this document.

The question arises as to whether the Montreal Convention 1999 provides an exclusive right of action in respect of claims arising from international air transportation. This question was discussed in the context of the Warsaw Convention 1929 in *Sidhu v British Airways plc (Scotland)* (see Case Study 1.3).

CASE STUDY 1.3

SIDHU V BRITISH AIRWAYS PLC (SCOTLAND) [1997] AC 430

The claimants in this case had been travelling from London on BA Flight 149 to Kuala Lumpur via Kuwait in August 1990. The flight had the misfortune of landing in Kuwait in the hours immediately after Iraq had invaded. While the aircraft refuelled, the airport was seized by Iraqi troops. The passengers and crew were taken by force to Baghdad and detained for approximately one month. The claimants alleged the airline knew of, or ought to have known of, the dangerous situation between Iraq and Kuwait and the possibility of imminent invasion. Damages were claimed in respect of both physical and psychological injuries. The passengers brought their claim at common law, arguing that the Warsaw Convention 1929 did not prevent or extinguish their rights at common law. The House of Lords dismissed the claimant's arguments and held that the objects and structure of the Warsaw Convention 1929 supported its interpretation as a uniform international code that could be applied by all the high contracting parties without reference to their own domestic law.

In delivering the judgment of the UK House of Lords, Lord Hope stated that the structure of Article 17 and Article 24 of the Warsaw Convention 1929 required the carrier to surrender its freedom to exclude or limit its liability on one hand, while restricting the passenger in the claims which can be brought in any action for damages on the other. He stated:

> The idea that an action of damages may be brought by a passenger against the carrier outside the Convention in the cases covered by art 17 … seems to be entirely contrary to the system in which these two articles were designed to create (*Sidhu v British Airways plc (Scotland)* [1997] AC 430 at 447).

Lord Hope concluded that while the Warsaw Convention 1929 did not purport to deal with all matters relating to contracts of international carriage by air, it was intended to be uniform and exclusive of any resort to the rules of domestic law in the areas dealt with by its terms.

1.13 Globalisation of aviation

The extent to which there has been an adoption of international treaties such as the Chicago Convention 1944 is unique to aviation. This particular treaty not only *influences* all aviation activities – that is, international, domestic and, to an increasing degree, military – but to a large and increasing extent *dictates* all operational, technical, safety and security standards within the industry. The study of international air law is important, not just to attain a more complete picture of aviation, but also to provide a clear understanding of the legal basis upon which *all* aviation law is founded.

As an industry, what makes aviation unique can be explained in terms of both its development and how it is regulated. These two aspects of aviation, although quite distinct, are in fact highly interrelated and, to a large extent, account for why there is a greater degree of international harmonisation of aviation legislation than with any other industry.

From the outset, aviation activities have been subject to strict regulatory control. Soon after the first hot-air balloon assents by the Montgolfier brothers in 1783, the Paris police required flight permits to protect the safety of persons and property on the ground. The trend of international harmonisation towards universal conformity of aviation activities is not only increasing but is doing so at an ever increasing rate. The catalyst for this was the First World War, and the trend has continued to be fuelled by major worldwide events which include: the Second World War; international terrorism; government economic rationalisation; airline strategic alliances; pandemics and epidemics; customer loyalty (frequent flyer) programmes; codesharing; global reservation systems; highly dynamic oil prices; proliferation of low-cost carriers; internet ticketing; the global financial crisis; and increased government liberalisation towards more 'open skies' policies. Unlike any other mode of transportation, air transport is not restricted by political and geographical boundaries. The internationalisation of aviation activities, and the legal processes that have supported and assisted this development, commenced with the invention of aircraft.

Key points

- Air travel is an inherently international mode of transport but this gives rise to potential conflict of laws.
- Air transport is regulated at an international and national level for reasons of national security, defence, safety, consumer protection and competition.
- Air law is a branch of international law that governs use of and access to airspace.
- Airspace is sovereign territory and airlines have to seek permission to enter and overfly foreign territory.
- The Chicago Convention 1944 led to the formation of ICAO and resulted in international accord on Standards and Recommended Practices (SARPs).
- The Warsaw Convention 1929 established private air law and define carrier liability.
- The Montreal Convention 1999 replaced and updated the Warsaw Convention.

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CHAPTER 2

Aviation economics and forecasting

David Gillen

LEARNING OUTCOMES

- To identify the factors that affect the demand for air travel.
- To understand the concept of price elasticity as it relates to air transport demand.
- To recognise three key features of airline supply: joint production, perishability and overcapacity.
- To appreciate the key characteristics of different airline business models.
- To understand the term 'deregulation' and its impact on airlines.
- To examine the factors that affect aggregate air travel demand and understand how to forecast aggregate and origin and destination (OD) demand.

2.0 Introduction

This chapter will provide an explanation of the fundamental features of aviation economics. This includes a description of the aviation supply chain and its characteristics, such as the importance of network design, and the fact that airline seats cannot be stored, and that aviation services are offered by a variety of companies with different business models. The chapter also explains the factors that affect the demand for aviation services and how aggregate air travel has grown considerably as a result of deregulation. It also examines demand forecasting in aggregate and between origins and destinations.

2.1 The aviation value chain

Airlines deliver a service to customers, passengers and shippers by moving people and goods between places. Airlines are one component of the aviation value chain, which begins with airframe, engine and aircraft component manufacturers, infrastructure and service providers, and ends with the distribution of passengers and freight (see Figure 2.1).

This chapter will focus principally on passenger airlines in the value chain. Both organisations that are input providers as well as organisations that distribute an airline's product will affect how the airlines produce and deliver their service and structure their business models. For example, the high costs of distribution through travel agents and computer reservation systems (CRSs) have resulted in airlines moving to internet distribution (➤Chapter 16). The internet has resulted in lower distribution costs but has also allowed fare transparency and comparison-shopping, which have changed the way airlines compete and set fares. The subsequent development of Global Distribution Systems (GDSs) was shaped by the initial foray into the new technology of internet distribution.

Airline service prior to deregulation in the US in 1978 was an **experience good** with an emphasis on quality as price was not a strategic focus. With regulated high fares, only a small proportion of the population flew. This meant that the market structure had little, if any, effect on airfares. The emphasis of regulators was on supply availability. However, deregulation changed every aspect of the industry as new competition through market entry led to lower prices owing to significant improvements in efficiency and new business models

Experience good: a good or service where its characteristics (price, quality) can be difficult to observe without consuming it.

ANSP (Air Navigation Service Provider): a body that provides air traffic services within a country.

MRO (maintenance, repair and overhaul): a company that provides third-party maintenance for airlines.

OTA (online travel agent): travel companies that sell airline tickets over the internet.

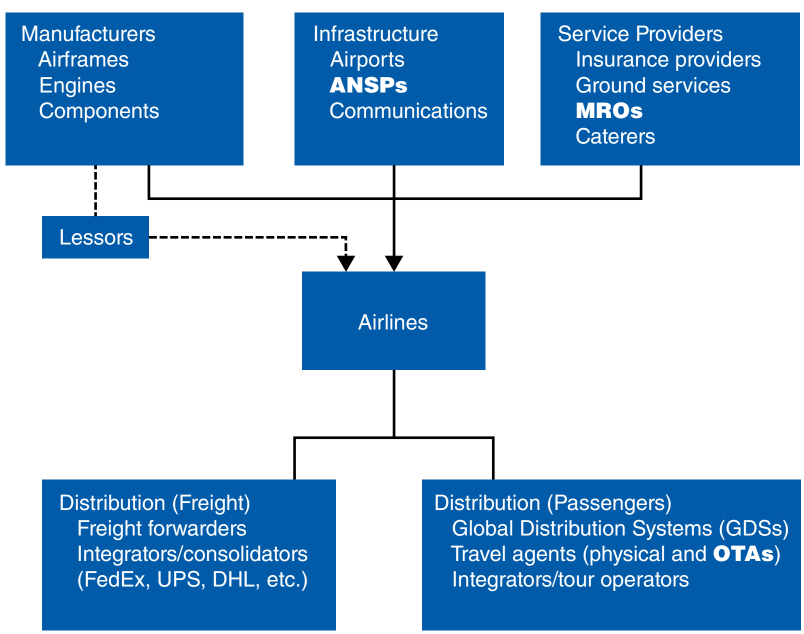

Figure 2.1 The aviation value chain

Source: Tretheway and Markhvida (2014)

led to a focus on costs. Airline service was commoditised and the key demand parameter was price.

The delivery of the airline product also affected network design as the business model of traditional **full service network carriers (FSNCs)** moved to **hub-and-spoke** networks, while **low-cost carriers (LCCs)** developed a **point-to-point** system (➤Chapters 7 and 8).

The evolution of the airline industry has been shaped by the growth in international aviation. Unlike domestic markets that had been deregulated, international aviation markets were regulated by bilateral air service agreements. These agreements controlled prices, market entry, flight frequency and seat capacity (➤Chapter 1). The development of international airline alliances was affected significantly by constraints imposed by bilateral agreements as airlines sought access to **beyond and before traffic**. SkyTeam, oneworld and Star Alliance have developed into major transnational alliances (➤Chapter 9) and most FSNCs have become a member of an alliance. Even non-aligned carriers, including Virgin Atlantic, Emirates and Etihad, have entered into strategic partnerships with overseas airlines to extend their geographic presence and market reach.

Over time, these alliances have developed into **metal neutral joint ventures (MNJVs)** which enjoy significant market power. At the same time as alliances were gathering more members and decreasing the number of independent competitors, there was increasing consolidation in North America and Europe, and there were constraints on the number of carriers in China, the fastest-growing aviation market.

Another segment of the industry that was dynamic was the low-cost carrier (LCC) market; and this was true in every market: the US, Canada, Australia, Asia, Europe, Latin America and the Middle East. The traditional LCC business model has undergone three main developments. First, LCCs morphed into carriers that moved away from a strict focus on costs and low price. For example, UK-based easyJet focused on passengers who valued access to major airports and higher flight frequency; and, in Canada, WestJet started a regional airline (Encore) and entered codeshare agreements with other carriers. A second shift was the emergence of a class of LCCs known as ultra-low-cost carriers (ULCCs), which concentrated on minimising costs, no-frills service, revenue from add-ons and relied on market stimulation; Wizz Air and Ryanair are examples in Europe, while Allegiant, Frontier and Spirit are examples in the US. The most recent shift has been LCCs flying longer-haul services and flying internationally; AirAsia, for example, started flying long-haul routes with **wide-body aircraft**.

Full service network carrier (FSNC): also known as a 'legacy carrier', an airline that offers high levels of in-flight service and connectivity, attracts a range of passenger segments to its network of short- and long-haul routes, and flies a variety of aircraft types.

Hub-and-spoke: a network in which passengers are transported between two locations via an intermediate (hub) airport.

Low-cost carrier (LCC): an airline that adopts a rigorous cost-minimisation strategy to keep its costs and fares low.

Point-to-point: a network in which each airport is directly connected to other airports.

Beyond and before traffic: passengers who travel from an origin that is not a departure gateway, through the gateway, to a destination that is beyond the gateway.

Stop and think

Outline what is meant by the aviation value chain, and detail its importance to airline operators.

Metal neutral joint venture (MNJV): an alliance in which members are indifferent to who operates the 'metal' (aircraft) when they jointly market services.

Wide-body aircraft: an aircraft with two aisles.

Derived demand: a demand which is a consequence of the demand for something else, e.g. for [air] transportation, the demand arises from a desire for passengers or cargo to be somewhere else, not because the trip between origin and destination is desired.

Income elasticity: a measure of how the demand for a good or service will change when the income of the individual changes.

2.2 Airline markets: demand

Air travel demand is driven by aggregate economic activity: trade, gross domestic product (GDP) growth, urbanisation and growth in emerging economies. Demand is also affected by the growth in connectivity provided by more seats, more frequency and more destinations. The substantial increase in global trade as a result of the reduction in trade barriers and tariffs under the World Trade Organization (WTO) has resulted in a significant increase in global air travel.

The key characteristics of demand for airline services are that it is a **derived demand** and there are a range of market segments with differing degrees of price and service quality sensitivity. As a derived demand, it is also affected by the prices of complementary products or services. The movement of people and cargo between two points is based on the desire to be at a destination. If this involves a leisure destination, the price of hotels and leisure activities will affect the demand for airline services.

Demand is affected by a number of factors, including price and income, service quality (reliability), passenger demographics, the frequency and timing of flights, and the price and availability of alternative modes of transport. Demographic factors are also important, such as population, age distribution and cultural ties between cities. The demand for a specific airline will be affected by relative prices and service quality but also by amenities such as food, entertainment options and loyalty programmes; people may choose one particular airline in order to accumulate credits that will offer 'free' flights in the future (➤Chapter 9).

Figure 2.2 illustrates the different market segments. Each segment will have its price and service quality sensitivity depending on a number of factors. For example, in the leisure market, whether long- or short-haul, there will be differences between true leisure (holiday) and VFR (visiting friends and relatives) traffic and whether these travellers are retired or not.

The degree to which demand is responsive to price and service quality will vary across these segments. Studies of air travel demand provide a range of estimates for these elasticities. There is a distinction between short- and long-haul passengers, domestic and international, and business and leisure. Generally business travellers have a low-price, high-service quality and a low **income elasticity** of demand. Leisure travellers, on the other hand, have a broader range of sensitivity (elasticity) estimates. The range depends on whether travellers are holidaymakers, VFR, and retired or still working.

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Stop and think

Detail what is meant by derived demand, and outline the factors that impact on demand for air services.

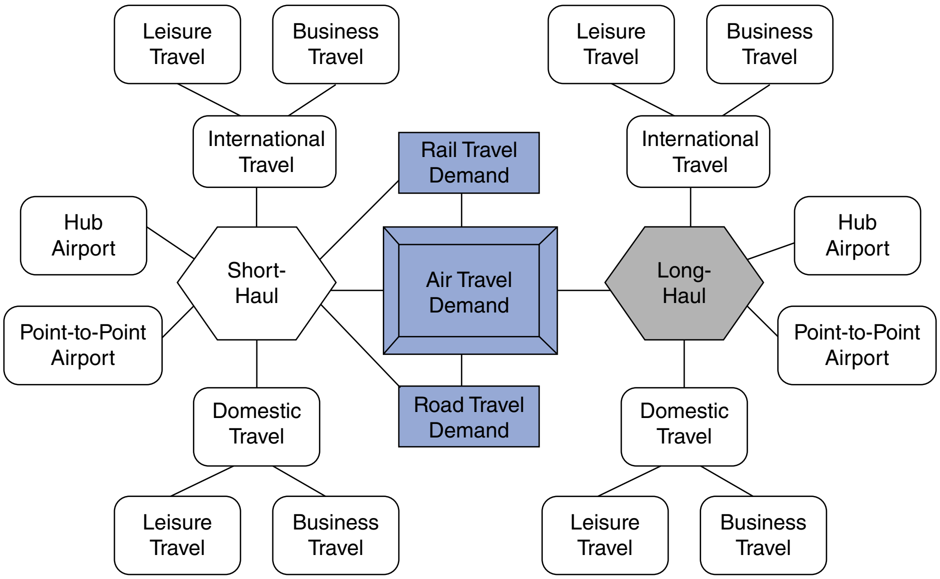

Figure 2.2 Market segments for air travel demand

Source: Gillen, Morrison and Stewart (2002)

Table 2.1 reports a summary of elasticity estimates for different trip types (purposes), sector lengths and markets (domestic and international). The median values, rather than means, are used because in all cases there were some elasticity estimates that were significant outliers. There has been little formal work undertaken on measures of other key factors that affect demand such as frequency, destinations and service quality. Fu *et al.* (2014) have produced a model that provides estimates of the own-frequency elasticity of demand for air trips with respect to an increase in flight frequency. For short-haul trips (< 500km) the frequency elasticity is 0.39, and for long-haul trips (> 500km) it is 0.42. These are relatively high values, indicating markets are responsive to increased frequency, but there are two issues. If airline x increases frequency relative to airline y, x will 'steal' high-time-value passengers from y; however, if all carriers increase frequency, the market will grow. These additional passenger trips must come from somewhere. They would come from other modes, and some would be induced trips (see Example 2.1 for examples of demand and pricing).

Stop and think

Explain what is meant by income elasticity of demand and why it is important to the air transport industry.

Table 2.1 Summary of median elasticity values

Category	*Elasticity values*
	All studies
Own-price: long-haul international business	−0.265
Own-price: long-haul international leisure	−0.993
Own-price: long-haul domestic business	−1.15
Own-price: long-haul domestic leisure	−1.12
Own-price: short-/medium-haul leisure	−1.52
Own-price: short-/medium-haul business	−0.73
Income elasticity	+1.39

Source: Gillen, Morrison and Stewart (2002)

Differential pricing: charging different customers different prices for the same service.

Origin and destination (OD): the start and end points of a passenger's itinerary, regardless of their actual routing.

Arbitrage: the buying of an asset at a high or low price and reselling it at a low or high price respectively.

Example 2.1

Air travel demand, market segmentation and differential pricing

In the era of regulation, airlines were allowed to have two fares, first class and unrestricted economy (also called coach), and these fares were typically set on a mileage-based formula. Deregulation resulted in a revolution in pricing where airlines based their prices not on costs but on the value of the service to customers; cost was the level below which prices should not fall. **Differential pricing** was first introduced into different **origin and destination (OD)** markets based on their demand characteristics. So, unlike mileage-based fares, short-haul fares could exceed long-haul fares and fares on one segment of a two-segment flight could exceed the fare for both segments.

Following this, airlines introduced differential prices based on passengers' willingness to pay; airlines charge different prices based on demand sensitivity. The different prices could apply to different demand segments in the same OD market as well as across markets. The airline's ability to engage in price discrimination was based on three factors: the existence of different willingness to pay across customers, a way of identifying the different customer segments and a means of preventing customers **arbitraging** between low and high fares.

Airlines also introduced service-based pricing through product differentiation, whereby different fares were based on the quality of the product. Higher-quality products, a larger sleeper seat in business class versus a narrower seat in economy, for example, are more costly for the airline, and higher prices reflect in part these higher costs.

Airlines are able to identify different willingness to pay by experimenting with different fare structures and levels. They collect large amounts of data daily across the markets they serve. Airlines are therefore able to estimate demand and identify own and **cross-price elasticities of demand**. They have been able to maintain the range of fares and minimise any fare arbitrage (diversion) by placing restrictions on different fares, such as Saturday night stay overs, minimum length of return trips, and purchase date restrictions prior to a flight departure date (e.g. by purchasing a ticket three weeks in advance of travel).

The natural evolution of differential pricing and demand segmentation has been the unbundling of the airline product so separate charges are levied for on-board food, checked luggage, early boarding and more legroom – so-called à la carte pricing.

Cross-price elasticity of demand: the change in the quantity demand of one good or service when the price of another good or service changes. If the cross-price elasticity is positive, the two goods or services are substitutes, and if it is negative the two are complements.

2.3 Airline markets: supply

Airlines supply products which are produced jointly are perishable and generally in excess supply. On any given flight between A and B, FSNCs may have multiple classes (first, business and economy) on the same aircraft. This results in common costs that must be allocated across classes in an efficient way to ensure maximum profits. Another form of **joint production** is that many markets can be served by a single flight. For example, on a flight from Boston (BOS) to Chicago (ORD), there can be passengers who arrived in Boston from overseas, others may be flying through Chicago to another destination and still others may be flying BOS–ORD. FSNCs provide air transportation over a network, so any one flight will have a combination of origin and destination (OD) and connecting traffic. These airlines generally deliver services through a hub-and-spoke network with the hub serving to redistribute connecting passengers among flights. In many cases, 70 per cent or more of passengers on a given flight through a hub will be connecting. Demand is an OD trip, which can be accomplished using non-stop or connecting routings or paths, but supply is via a network where a flight segment can be supplying seats to many OD markets.

LCCs offer services through a point-to-point network with ODs connected directly. However, as LCCs have developed, there have been concentrations of traffic, such as Southwest Airlines at Phoenix (US), WestJet at Calgary (Canada) and Jetstar at Sydney (Australia). These are not hubs in the way FSNCs use hubs, although some LCCs will sell a through ticket with a connection; a FSNC hub strategy coordinates incoming and outgoing flights, and LCCs do not do this.

The product is also perishable since a flight leaving with an empty seat means the seat is wasted as it cannot be placed in inventory. The perishability of seats has led to an emphasis on yield management, whereby airlines carefully manage their seat inventory to ensure seats are reserved for late-booking high-yield passengers and lower-priced seats are sold to more price-elastic passengers.

A third important feature of airline supply is that capacity tends to be oversupplied, meaning utilisation is rarely 100 per cent (the **load factor** of passengers to seats is < 100 per cent). Load factors vary regionally and in domestic versus international markets. The International Air Transport Association (IATA) reported in 2013 that the average load factors on international flights were 79.3 per cent and 79.9 per cent on US domestic flights. The variation across international markets for 2013 appears in Table 2.2.

Joint production: a situation in which two products or services are created at the same time in the production process.

Load factor: the ratio of the number of passengers to the number of seats on a flight, also sometimes measured by ratio of revenue passenger kilometres (RPK) to available seat kilometres.

Spilled: when a passenger wants to book a particular flight but cannot get a ticket, this passenger is 'spilled'. This represents a potential loss of revenue for the airline and dissatisfaction and inconvenience for the passenger.

S-curve effect: an observation from airline markets whereby airlines that offer more flights (frequencies) obtain proportionately more market share.

Capacity discipline: the practice of airlines restricting the capacity they bring to a market.

Supply commonly exceeds demand in the airline industry. If flights operated at 100 per cent load factor, many customers willing to pay for a flight would not be able to purchase a ticket on a desired flight. As a result, a passenger may be '**spilled**'. An airline may have the passenger spilled onto another of its flights, but the passenger may move to another airline.

There are a number of reasons carriers would seek to increase seats in a market. First, traditionally, scheduling frequency disproportionately increased revenues. This was due to a claimed **S-curve effect**. Airlines use frequency as a strategic competitive variable. The airline with the higher frequency is more likely to offer passengers a flight close to their preferred departure time. This is considered to be a higher quality of service, which translates into a greater proportion of travellers and a greater market share. The widespread belief in the S-curve effect has led to excess flight scheduling.

Recently what has been observed in both North America as well as the EU is what has been termed '**capacity discipline**' (Wittman 2013). The increase in average load factor in both jurisdictions reflects a change in airline strategy from one of pursuing market share to one of pursuing profits. Traditionally, seat growth increases more than proportionately than GDP growth, but over the last four or five years it has been less than proportionate. This change in behaviour is a result of airline consolidation in the US market and the increase in the number of metal neutral joint ventures. Both factors have resulted in a decrease in competition in many markets.

Table 2.2 Variation in load factors, international markets, 2013

Airline	*Load factor (Int'l)*
Asia-Pacific airlines	77.7%
European airlines	81.0%
North American airlines	82.8%
Middle Eastern airlines	77.3%
Latin American airlines	79.2%
African airlines	69.0%

Stop and think

Define joint production, and provide examples of where it might occur in the air transport industry.

A second reason for supplying more seats is that the addition of a new network point geometrically increases the product lines (city-pairs) of an airline. For example, if the number of network points connected to a hub increases from 9 to 14 points (5 added points), the potential additional city-pairs rise from 45 to 105. An approximate 50 per cent increase in points served increases the number of markets served by 122 per cent. Airlines recognise that network reach affects whether passengers choose their airline.

A third reason for increasing supply is that aircraft represent a significant fixed cost, and the carrier incurs these fixed ownership costs regardless of how much the aircraft is used. It may be more sensible to operate the aircraft even if it covers the incremental flying costs and makes some contribution to fixed costs. Another reason is that a route may be of strategic value to the airline. There are many network industries, besides airlines, that have high fixed costs and produce excess capacity: hotels, telecommunications firms, TV and radio broadcasters, energy firms, railways and logistics companies are examples. These industries, including airlines, can produce differentiated products, and there is ample room for competition to exist and fixed costs to be spread over increasing output(s). The high fixed-cost nature of airline services is not a sufficient condition to regulate the industry.

Stop and think

Outline why the airline product might be oversupplied, and identify the factors that influence the oversupply.

2.4 Airline business models

Prior to deregulation, there were essentially two airline business models: FSNCs and **charter airlines**. FSNCs operated a mix of a hub-and-spoke and point-to-point networks; these carriers had major airports that represented concentrations of traffic but they did not yet operate as true hub-and-spoke systems. The regulatory regime did not have fare flexibility, so charter carriers emerged to serve the more elastic parts of the air travel demand market. Another interesting feature characterising the regulated era is that every country except the US had a national flag carrier. This in part reflected the geographic and population size of the US market relative to other countries and the predominance of domestic relative to international travel for US air travellers. A more detailed analysis of different airline business models is presented in Chapter 7.

Charter airline: airline that offers non-scheduled flights to holiday destinations, sets fares to operate at or close to a 100 per cent load factor and/or bundles the flight with a holiday package of flight, hotel and tours.

The introduction of deregulation in US domestic markets had three major outcomes. First, FSNCs adapted their hybrid hub and point-to-point models into a true hub-and-spoke system. Second, a different business model emerged; LCCs generally followed the model pioneered by Southwest Airlines in the US. Third, as a result of deregulation and the rise of LCCs, the charter airline sector disappeared in most markets, with some exceptions for speciality services and the survival of a number of firms in the European market. Deregulation of international aviation markets took place at a slower rate.

In every market in which deregulation took place, a similar pattern of air service emerged. There was a proliferation of LCCs (➤Chapter 7). The economic impact of LCCs has been considerable. Research has shown that when LCCs enter a market the network carriers reduced average airfares by 35–40 per cent (Hofer *et al.* 2009). There has also been a very large stimulus to demand. Lower fares led to a significant expansion of traffic in every market an LCC entered. Over the period 1995 through to the late 2000s, the cost of air travel

Revenue tonne kilometre (RTK): a measure of freight volume. Moving one tonne of revenue cargo one kilometre is one RTK.

decreased by 17 per cent in real terms and air travel (measured in **revenue tonne kilometres (RTKs)**) has increased 42 per cent. In Europe, similar outcomes have occurred as airlines like Ryanair have stimulated demand and opened up a substantial number of new markets. Traffic growth was 60 per cent from 1995 to 2000. From 2000 to 2008, growth was near 9 per cent annually, and since the financial crisis it has been about 2 per cent. Asia and Australia have experienced similar growth.

Fares at hubs tended to be higher due to the market power of the hub carrier but also the higher service quality of more flights to more destinations. This premium decreases considerably when an LCC enters the market. LCCs brought not just low fares but also one-way fares. Their entry, coupled with the rise of the internet, meant fares could be easily compared and booking could be done on airline websites and with virtual travel agents such as Expedia, Opodo and Travelocity (➤Chapter 16).

International markets have been liberalised at a much slower pace than domestic airline markets. The international air transport sector has grown under a complex regime of regulations since the conclusion of the Chicago Convention 1944 (➤Chapter 1). Lack of agreement at that time on how the market for air services should be regulated led to the growth of bilateral agreements between countries. The US wanted open skies with no control on tariffs or capacity and a maximum exchange of rights, including fifth freedoms (➤Chapter 1). The UK and other European countries were more protectionist. The two divergent views could not be reconciled and no multilateral agreement on traffic rights, tariff control and capacity was reached. The most important outcome of the Chicago Convention 1944 was that it provided a framework for the orderly development of international air transport. It also agreed on the first and second freedoms. The key institutions that emerged from the Chicago Convention were: first, air service agreements (ASAs) for the exchange of traffic rights (the ASAs were matters for negotiation between states not carriers); second, the tariff fixing machinery of IATA; and third, the control of capacity and frequencies by inter-airline agreement. All agreements that emerged were highly protectionist or 'predetermined'. The ASAs are trade agreements between governments not airlines and contain administrative (soft) and economic (hard) provisions. The soft provisions cover taxation, exemption from duties on imported aircraft parts, airport charges and transfers of funds from ticket sales from abroad. The hard provisions cover pricing and capacity limits.

In 1946, the UK and US negotiated an ASA for travel between the two countries. It became known as the Bermuda Agreement and was more liberal than agreements emerging from the Chicago Convention. The two 'liberal' features of these agreements were that fifth freedoms (➤Chapter 1) were more widely available and there were no controls on capacity or frequency.

The Bermuda II Agreement was signed in 1977, also between the UK and US. This was a renegotiation of the 1946 Bermuda Agreement and it allowed four airlines to operate direct flights from London Heathrow to the US and barred any other carriers from operating such flights. The designated airlines were: British Airways, Virgin Atlantic (added in 1991), American Airlines (replaced Pan American World Airways in 1991) and United Airlines (replaced Trans World Airlines in 1991). Other airports in Britain, including London Gatwick Airport, were restricted to other carriers. The airlines that were excluded did not like this arrangement.

The ASAs came under pressure in the early 1970s as nearly 30 per cent of trans-Atlantic traffic was flying on charter carriers, a segment that had developed as a result of the high fares and capacity restrictions inherent in the bilateral ASA arrangements. The rapid deregulation of the US air transport market from 1978 and the domestic market deregulation in numerous other countries soon thereafter gave an impetus for international reform of both cargo and passenger air services. Considerable progress has been made since that time in liberalising international air transport. Some of the changes have come through renegotiation of bilateral agreements to remove many barriers to competition. The open skies policy of the US reflected a new approach to international markets. They were successful in negotiating with one country, which led to adjacent countries also seeking a similar arrangement. This was successful in Europe, where individual countries still negotiated ASAs. From the early 1990s, it allowed the US and many trading partners to sign a liberal template bilateral accord, which has led to a common framework of agreements. The US open skies policy is a clear example of bilateral liberalisation, with 114 agreements having been signed to date. The EU created the European Common Aviation Area (ECAA) in 2006, which included 26 member countries. This agreement essentially removed the need for bilateral agreements between EU member states.

There have been a number of liberal regional air trade agreements which have open skies features. Canada signed its first open skies agreement with the US in 1995, and this agreement was re-negotiated and made even more open in 2005. Australia and New Zealand also have a liberal accord, particularly across the Tasman Sea, with a single aviation market accord signed in 1996 and further liberalised in 2000. The EU has taken additional steps, which focus on liberalisation within the European Economic Area (EEA), although individual member states and the EU have also concluded aviation agreements with countries outside the EU.

In 2008, the EU and US signed an open skies (first stage) agreement that provided significant liberalisation for air services and included the entire EEA. In this first stage, both the commercial agreement, as well as the legal framework for cooperation, had to be negotiated. In the second stage, the legal issues become more contentious: night flight bans in the EU, symmetric traffic rights, foreign ownership and control, US homeland security and EU-style slot coordination. Rising marginal costs and declining incremental benefits are likely to be the outcome.

Stop and think

To what extent have airline business models been affected by deregulation, and how has the liberalisation of international air services changed the pattern of service provision?

2.5 Airline profit, yield and unit costs

Available seat kilometre (ASK): the product of the number of seats and route distance and a measure of available capacity.

Airlines' units of sale differ from their units of output. Unlike an automobile manufacturer which produces and sells cars and trucks, airlines produce seat kilometres but sell passenger kilometres. Passenger traffic is measured as a passenger travelling a unit distance, which takes account of the spatial nature of demand. Passenger traffic is measured as revenue passenger kilometres (RPK); however, care must be taken in distinguishing one passenger travelling 1,000km and ten passengers travelling 100km: both would be measured as 1,000 RPK.

Airlines produce a product termed '**available seat kilometres (ASKs)**', which again reflects the spatial nature of their output; the caution of the relative proportions of seats and distance mentioned with respect to RPK is also true for ASKs. The utilisation of capacity is termed 'load factor' and is measured as RPK/ASK; for a given OD this would be passengers/seats.

Two measures of airline revenue performance are yield, which is revenue divided by RPK, or the average fare paid per kilometre and revenue per available seat kilometre (RASK), which is total operating revenue divided by ASK; RASK is also equal to yield times load factor. Cost per available seat kilometre (CASK) is a measure of cost performance and is measured as total operating costs per ASK; CASK is also referred to as unit cost. Airline costs are composed of salaries and benefits, purchased materials (which includes fuel), purchased services and landing fees, rentals, depreciation and other (➤Chapter 11). Airline operating profit is a simple calculation of revenues (including ancillary revenues) less costs, or RPK × Yield – ASK × unit cost. The objective is not to maximise revenues or to minimise costs but to maximise the difference between them.

Stop and think

What are the issues associated with using ASKs and RPKs as measures of airline output?

2.6 Alliances

Cabotage: the right of a foreign airline to operate domestically between two points in another country.

Alliances are a common feature of the airline industry. After US domestic deregulation, FSNCs formed alliances with regional air carriers to feed passengers into the FSNC domestic hubs (Gillen *et al.* 2015). The formation of international airline alliances was a direct outcome of the failure to have significant and broad liberalisation of international air travel markets. There were three factors at work. First, many countries prohibit or limit foreign ownership of domestic airlines (➤Chapter 11). Therefore, mergers were not possible and alliances were a means of achieving many of the benefits a merger would bring. Second, there were (and are) restrictions on **cabotage** rights, which are the rights of a foreign airline to operate between two or more airports in a domestic market. Third, increasingly passengers are originating in before hub markets and going to beyond hub markets, and alliances provide a means of accessing these points. By forming alliances, two (or more) carriers can increase service frequency and the number of accessible destinations. This increased connectivity improves load factors.

The motivation to join alliances arises from marketing cooperation, cost synergies and increases in market power. Marketing benefits include broader **frequent flyer programmes (FFPs)**, codeshare agreements and lounge access. Cost synergies stem from shared airport facilities, joint scheduling, reciprocal sales agreements and increased purchasing power. Alliances do have anticompetitive effects; these include higher fares, reduced capacity and a lack of access to alternative alliances.

Frequent flyer programme (FFP): a membership scheme with different status levels that enables passengers to collect mileage points for flights and related purchases which can be redeemed for free flights, upgrades or discounts on selected retail and travel products.

The range of types and degrees of cooperation is illustrated in Figure 2.3. It extends from simple interlining to codesharing to co-investments and metal neutral joint ventures. The forms of limited cooperation are essentially marketing agreements and tend to have a high pay-off in the short to medium term. As expanded cooperation occurs, airlines co-invest in coordinating schedules, sharing facilities and cooperative pricing. Because this latter activity involves agreeing prices, an activity that is generally not allowed under national competition law, it requires the approval of antitrust authorities. The alliances have convinced authorities that, despite a reduction in competition, the synergies and cost savings as well as joint fare determination result in net consumer benefits.

As Table 2.3 indicates, the alliances have evolved into joint ventures where there is a high degree of coordination and some co-investment. In many cases, these joint ventures have become metal neutral joint ventures, which means the alliance acts as one airline in setting prices, capacity and scheduling, and alliance members involved in the joint venture share revenues and profits (➤Chapters 7 and 9).

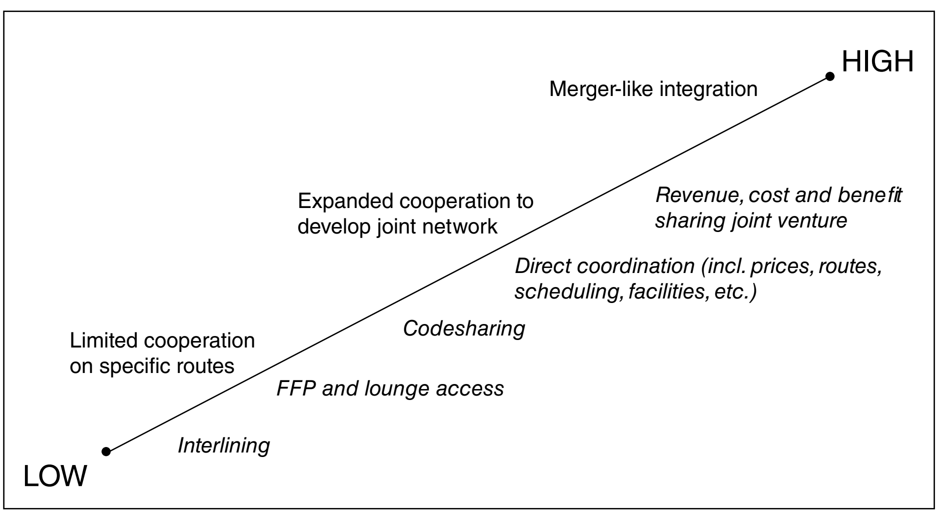

Figure 2.3 Range of alliance cooperation

Source: EU/USDOT Joint Report (2010)

Table 2.3 North Atlantic alliance structure market shares (frequency) percentages, July 2013

Markets	*Joint venture*	*Other alliance*	*Non-aligned*	*Hub*
US – Europe	78.5	14.3	7.2	
US – UK	94.5	3.5	2.0	
US – London Heathrow	96.4	3.1	0.4	oneworld
US – Paris Charles de Gaulle	90.3	4.2	5.5	SkyTeam
US – Amsterdam	94.4	3.0	2.6	SkyTeam
US – Frankfurt	81.8	12.1	6.1	Star Alliance

Source: Based on OAG schedule data, July monthly flights (author's calculation)

2.7 Demand and demand forecasting

In Section 2.2, demand segments were defined according to two key parameters: price and time sensitivity. These two variables are key in forecasting the demand in OD markets and for measuring the respective elasticities in these markets. However, the aggregate demand for air travel is established by linking air travel to macroeconomic variables.

The demand for air travel is a derived demand. It should therefore be influenced by general economic conditions. Aggregate travel demand models will relate total or interregional demand to measures of GDP, fuel prices and include dummy variables for negative traffic events, such as SARS, the 11 September attacks in New York City, wars and traffic-generating events such as the Olympic Games. These models will generally yield a parameter estimate on the GDP variable which is greater than 1. This means that air passenger travel grows faster than the growth in GDP; Oum *et al.* (2009) estimate this parameter to be 1.58, which implies for each 1 per cent growth in GDP, global air traffic will grow by 1.58 per cent. Gillen (2009) estimates a forecast model that disaggregates GDP into trade (imports and exports) and investment and finds trade and connectivity have the largest impacts on aggregate air travel demand.

The problem with many macro air travel demand-forecasting models is that they exclude key market variables that will influence aggregate air travel. However, over time, as markets have liberalised fares have decreased, new routes have developed and connectivity has grown. The liberalisation of air service agreements has led to expansion in markets, but it also leads to more efficient continental and international networks that further stimulate traffic growth. The indirect efficiency effect would reinforce the direct effect of liberalisation on opening markets. The degree to which this would occur depends on the extent of liberalisation and the way it is done. Another key factor is the growth in global trade, which has led to increased globalisation of manufacturing and assembly. This growth in world trade has subsequently led to a growth in air travel.

Another consideration is the way industries and services that make up the economy have changed. High technology industries and the financial services sector are aviation intensive. Rapid growth in these sectors leads to even more rapid growth in air travel than would be expected with growth in GDP.

To sum up, the five fundamental drivers of long-term international air passenger growth are: GDP growth, political disruption, cost changes (such as fuel costs), service quality changes and trade growth. Political disruption would include terrorism, geopolitical tension and protectionism. While protectionism reduces trade growth, it also appears in the form of reductions in foreign direct investment. Foreign ownership of 'strategic assets' such as ports, energy and airlines are either up for review or prohibited. Such constraints increase capital costs and reduce trade in the long term. Political disruption and friction also increase costs in the form of security and regulation. These costs make shippers and service providers worse off and lessen trade and air travel. Cost changes, particularly fuel costs, are a long-term threat. In the past, growth in real fuel costs was zero or negative. In the future, this will not be the case as the real cost of energy will go up and environmental taxes will become a permanent feature. In the past, cost reductions provided a 0.7 per cent stimulus to passenger growth (Swan 2008). It is unlikely this will continue, and even advances in engine and fuel technology will not fully offset the costs of raw materials inputs and taxes.

Quality changes occurred in the network over the last two to three decades. International networks reorganised with gateway hubs and airline alliances. This increased accessibility and stimulated traffic growth. A significant quality change was the growth in new markets; old markets did not simply get bigger but there were more routes opened and frequencies grew. Both of these outcomes stimulated traffic growth by 1 per cent or more. In the future, the network will not improve due to higher costs, hence bigger aircraft and less frequency; frequencies were a significant stimulus to traffic growth in the past. As trade growth slows, frequencies decline, fewer routes are added, some abandonments may occur and underserved cities continue to be underserved. All of this adds up to a negative net effect on past forecast traffic growth.

The slowing of trade growth over the longer term will also reduce the previous growth forecasts. As important will be the restructuring of trade as merchandise trade (trade in goods) falls and trade in services grows. In the past, trade growth was double that of GDP growth and added 1–2 per cent to forecast air traffic growth. In the short term, with recession and trade reductions, traffic growth will also be negative. In the longer term, increased protectionism, a failure to reduce tariffs and increased costs from security and regulatory barriers will mean zero stimuli from the trend in the future.

Market OD demand forecasts rely much more on route-specific values such as airfares, the prices of alternative modes, the total trip time, and the income and population of the origins and destinations. A conventional demand-forecasting model for economy air travel would be represented as:

$$D_E = M \cdot q_E^{\delta} \cdot q_B^{\tau} \cdot p_E^{\alpha} \cdot p_B^{\beta} \cdot t^{\gamma} \cdot \epsilon$$

where D_E is demand for economy travel (the OD subscripts are excluded for ease of presentation); M is a market size variable such as population; q_E and q_B are measures of service quality in economy and business class respectively; p_E and p_B are fares in economy and business; t is a trip time variable; and ϵ stands for economy. The parameters α, β, γ, δ and τ can be interpreted as elasticities with this functional specification. Thus, δ is the own-service quality elasticity of demand, α is the **own-price elasticity of demand** and β would be the

Own-price elasticity of demand: a measure of how demand for a good or service responds to a change in the price of that good or service.

Revenue management: the process of maximising revenue from every flight.

cross-price elasticity of demand for economy travel with respect to the price of business. These types of demand models are used for forecasting in **revenue management** systems. Airlines and aircraft manufacturers are constantly getting new data that they will use to re-estimate their models to update the parameters. Example 2.2 provides details of this.

Example 2.2

Forecasting market growth versus growth in the number of markets

The A380 seats up to 850 people (most are configured to seat approximately 525) and was developed by Airbus in the belief that large city-pair markets were going to get larger and airport capacity was going to become scarcer. Airbus believes in the hub-and-spoke network model and predicts airlines will continue to fly small aircraft into big hubs to fill large aircraft. The A380 has a range of 15,200km.

The Boeing 787-9, which seats up to 280 passengers, was developed by Boeing because it saw more growth in the number of markets and routes rather than in the size of markets. Boeing does not believe the hub-and-spoke model will dominate. Boeing's research showed that since 1990 the number of city pairs greater than 4,800km apart has doubled, frequencies have doubled and ASK has doubled. Average aircraft size has been declining. The 787 has a range of 14,000km.

Airbus forecast sales of 1,200 A380s when it launched the aircraft in 2000. As of April 2016, Airbus had delivered 187 A380s and had another 132 on order, with half of the orders from Gulf carriers (Emirates, Qatar, Etihad).

Boeing forecast sales of 1,300 787 aircraft in early 2000. As of April 2016, Boeing had 1,154 orders for the B787 family and had delivered 40 aircraft. Boeing has three models of 787; 787-8, 787-9 and 787-10. The 787 has two unique features, an all-composite fuselage and a completely new supply chain. Boeing's forecast was based on five key factors: deregulation drives airlines to offer more routes and more frequencies using smaller aircraft; there are diminishing cost savings with aircraft size; there are cost savings to airlines by avoiding intermediate stops; route networks evolve into highly connected networks; and, as average income increases, people's value of time increases.

Stop and think

What are the challenges of forecasting demand, and why are forecasts used despite their limitations?

Key points

- Airlines are just one (albeit it very important) component of the aviation value chain which starts with aircraft and aircraft engine manufacturers and ends in the delivery of an air service to passengers.
- Airlines deliver services to passengers, goods and shippers by enabling people and freight to move from A to B.
- Air travel is a derived demand, which means it is affected by the health of the global economy, GDP growth and levels of disposable income among consumers.
- Multiple air travel market segments exist, and each one exhibits different price elasticities of demand.
- Airlines practise price discrimination and differential pricing to maximise their flight revenue and overall profits.
- Airlines supply products that have three distinguishing features: they are produced jointly, they are perishable and they are generally oversupplied because demand is variable and airlines provide capacity to serve expected demand.
- Deregulation and liberalisation have changed the nature of airline service provision. The emergence and rapid expansion of LCCs has put increased emphasis on cost and price.
- Demand forecasting is complex and has to consider a range of variables. OD demand forecasts, which provide estimates of own- and cross-price and service quality elasticities, are used in airline revenue management.

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CHAPTER 3

Airfield design, configuration and management

Lucy Budd and Stephen Ison

LEARNING OUTCOMES

- To identify the principal components of the airfield and understand the interrelationships between them.
- To understand the main factors that affect runway design and orientation.
- To describe the four basic types of runway configuration and their effect on capacity.
- To appreciate the role of the ICAO and national regulators in the formation and enforcement of airfield and runway design standards.
- To demonstrate the management issues which arise from different airfield configurations.
- To recognise the environmental and social implications of developing, operating and managing an airfield.

3.0 Introduction

The design and configuration of an airfield directly affect safety, usability, efficiency and environmental and social impacts. Given the fundamental importance of airfield design and configuration to safe and efficient air transport operations, this chapter will: identify the role of the principal components of the airfield and discuss the interrelationships that exist between them; examine the factors that affect the location,

Apron: a defined area of land on an aerodrome that accommodates the parking, loading/unloading, refuelling and maintenance of aircraft.

orientation and physical dimensions of runways, taxiways and **apron** areas and how these affect capacity; detail the role of the International Civil Aviation Organization (ICAO), the Civil Aviation Authority (CAA) in the UK, the Federal Aviation Administration (FAA) in the US and other national regulatory agencies in the formation and enforcement of airfield design standards; demonstrate the principal management issues which arise from different airfield layouts; and consider the environmental and social implications associated with developing, operating and managing an airfield.

3.1 The airfield and its components

Aerodrome: a defined area of land or water which is used for the arrival, departure and surface movement of aircraft.

Airfield configuration: the siting, number and orientation of runways, taxiways and apron areas.

An airfield includes all of an airport's airside aircraft manoeuvring areas (including the runway(s), taxiways and aprons) and the open grass or hard-surfaced spaces that are adjacent to them. The airfield can cover up to 80–90 per cent of an **aerodrome**'s total land area and is protected by a secure perimeter fence to prevent unauthorised access.

Although every airport is unique in terms of its geographic location, physical layout, demand characteristics, built environment and mix of air traffic, the design and configuration of every airfield must fulfil three basic requirements:

1. It must facilitate routine safe and efficient air transport operations while complying with (inter)national safety and design standards.
2. It must be designed to enable future expansion, should it be required.
3. It must minimise and mitigate local environmental and social impacts as far as possible.

The design of airfield infrastructure and **airfield configuration** requires considerations of:

- The number, length, spacing and orientation of the runway(s).
- The number, location and design of exit taxiways and rapid exit taxiways (RETs, or high-speed turn-offs).
- The design and layout of taxiways.
- The design and layout of apron areas.
- The relative siting and interaction between these elements.
- Aerodrome safeguarding.

The number, orientation, physical dimensions and configuration of the individual components of an airfield are affected by the space that is available for development, the capital cost of providing the infrastructure and likely return on investment, the type of air traffic that will use the airport both now and in the future, the nature of consumer demand, surrounding land use and airspace constraints, and local environmental and social considerations. Airfield design is so important to the safety and efficiency of airport operations that international design standards have been established to ensure that safety-critical infrastructure and associated assets including runway markings, airfield signs and aerodrome lighting are consistent around the world.

The regulations governing airfield planning, design and management are strict. At the international level, ICAO's *Aerodrome Standards: Aerodrome Design and Operations* manual provides best practice design standards for airports worldwide. These standards are used as a basis for national regulations in individual countries. The CAA's *CAP 168: Licensing of Aerodromes* document details the standards that are required at UK airports, while the FAA's *150/5300-13A-Airport Design* document contains detailed guidance on the design standards required of US airports. Collectively, these airfield design standards stipulate the minimum length, strength, width, orientation, configuration, slope, sight lines, approved construction materials and pavement thickness of runways, taxiways and aircraft manoeuvring areas and aprons, as well as the provision of navigation aids, lighting, signs, maintenance regimes and upgrades.

Although (inter)national design standards provide best practice guidance, many airports are constrained by their existing layout which, in some cases, may have evolved in an ad hoc way over many decades or been originally designed for military use, which may render (parts of) them incompatible with current regulations.

Five basic airfield design elements need to be considered when planning or expanding an airport:

1. The runway(s) have to be long enough and strong enough to accommodate the largest and heaviest aircraft that are likely to use the airport, both now and in the future.
2. The primary runway(s) should be aligned in the direction of the prevailing wind for maximum operational usability.
3. Taxiways and adjoining apron areas have to be wide enough and big enough to facilitate simultaneous aircraft movements, be positioned in such a way so as to minimise runway occupancy and taxiing times and ensure the safe and efficient surface movement of aircraft.
4. The configuration of the aprons and the landside interface must maximise efficiency and minimise the potential for ground collision between aircraft, fixed infrastructure and mobile vehicles.
5. The runway(s), taxiways and aprons should be designed and operated in a way that minimises and mitigates any adverse local environmental and social impacts.

3.2 Runways

A **runway** is an airport's most important resource. Many factors determine runway design and configuration. The most important is the airport's geographic site and situation. The site refers to the physical surface area within the perimeter fence as well as the airfield's dimensions, elevation (above mean sea level), relief (whether the land is flat or undulating), sight lines and prevailing local weather conditions (particularly relating to wind direction

Runway: a defined rectangular area of land on an aerodrome that is prepared for the take-off and landing of aircraft.

and visibility). The situation describes an airport's location relative to local topography (whether the surrounding relief is flat or mountainous), urban areas and key markets, as well as the configuration of surrounding airspace, the availability of land for future expansion, the existence of noise abatement or other environmental and social operating restrictions, the volume and type of air traffic that is handled and the performance characteristics of the aircraft that use the airport.

During the early years of powered flight, runways were not demarcated and pilots could take off and land in any direction. The relatively low mass of the early aircraft meant that there was no need to prepare a dedicated landing surface, and take-offs and landings could occur from any direction. While this arrangement suited the operation of small single engine aircraft, the introduction of larger airframes necessitated the preparation of dedicated runways that could accommodate the additional weight of the aircraft and prevent them from getting stuck in wet ground. From the early 1920s onwards, cinders (crushed coal or embers), pulverised rock, gravel and ashes began to be added to the landing area to stop the runway flooding and to create a hardened surface and greater surface friction for braking. As this process was expensive, prepared runways were normally only laid along the line of the prevailing wind (see Case Study 3.1).

CASE STUDY 3.1

THE SIGNIFICANCE OF LIFT AND PREVAILING WIND DIRECTION

In order to maximise airflow over an aircraft's wings and generate the maximum amount of lift, aircraft need to land and take off into the wind. In most locations, the wind blows from one or two directions year round. The most frequent wind direction is called the prevailing wind, and runways are aligned into it to take advantage of this natural aid to flight. Some airports, due to local circumstances, have had to be developed with one or more crosswind runways which are not aligned with the prevailing wind. The domestic airport serving Reykjavik in Iceland, for example, has three operational runways which are aligned in different directions. This ensures that the airport can remain operational in most weather conditions, irrespective of where the wind is coming from. Other airports that are subject to variable wind conditions and so have crosswind runways include Halifax in Canada, Sydney Kingsford Smith, and New York Newark.

The introduction of progressively larger and heavier aircraft from the mid-1920s onwards required the preparation of stronger and more resilient runways. The world's first hard-surfaced runway was reportedly constructed at Leipzig-Halle airport in Germany in 1926. A hard runway at New York Newark followed in 1928 and, from that date onwards, hard runways became an increasingly common sight at major airports. Although hard-surfaced runways offered a number of significant operational benefits, they were expensive to construct and maintain, and their orientation required careful planning to ensure maximum operational usability.

As well as determining the prevailing wind direction and thus the optimum runway orientation (see Example 3.1), other important design considerations include the number and physical dimensions of runways. The number of runways should be sufficient to meet current demand during peak operations. Careful analysis needs to be conducted to ascertain what constitutes the peak period and whether it is cost-effective to build runway infrastructure that may be underutilised at other times. Runway length is determined in part by physical attributes of the site, including local topography, average surface temperatures and elevation, but also by the performance characteristics and weight of the aircraft that use the airport now and in the future. Runways also need to be sufficiently long, wide and strong enough to accommodate the largest aircraft that are likely to use the airport.

Example 3.1

Runway orientation and identification

Every runway is identified by a two-digit number which is derived from its bearing relative to magnetic north. These identifying numbers are painted in highly visible white paint at the start of the runway threshold (the point on the runway which denotes the start of the area designated for take-off and landing). This identification is vital as it ensures that pilots are operating from the correct runway. To determine a runway designator, the runway's compass heading is divided by ten and rounded to the nearest whole integer to give a two-digit number. A runway on a bearing of 092°, for example, would be identified as runway 09 (092° ÷ 10 = 9.2, which is rounded to the nearest whole number and prefixed by a zero to render it a two digit number). A runway on a bearing of 147° would be runway 15. As runways are straight, the designation at the other end always differs by 18 (180°). In these examples, the runways are identified 09/27 and 15/33.

When an airport has two runways on the same alignment, the letters L (left) and R (right) are used to distinguish them. When viewing a pair of parallel runways on a heading of 272°, the runway on the left is designated 27L and the runway on the right 27R. Where there are three parallel runways, an additional classification of C (centre) is used (making 27L, 27C and 27R when viewed down their length). At airports with four or more parallel runways, such as Los Angeles International and Dallas Fort Worth, some runway designators have to be changed to avoid confusion. Los Angeles' four parallel runways are designated 06L, 06R and 07L and 07R even though they are all on a bearing of 069°. Similarly, the five parallel runways at Dallas Fort Worth, which are all on a bearing of 175.4°, are designed 17L, 17C, 17R and 18L and 18R.

3.3 Runway configuration and capacity

The number and configuration of runways are usually determined by the volume and type of air traffic that an airport handles and the prevailing wind direction. Aircraft size and weight are also important as aircraft generate powerful **wake vortices** when they fly, and distance- and time-based separation minima are used to sequence arriving and departing aircraft to allow the wake vortices to dissipate (see Section 3.4). These physical factors and aircraft performance characteristics directly affect runway capacity. Runway capacity can be defined as the maximum number of aircraft movements that can be safely accommodated in a

Wake vortices: powerful spinning columns of air that spiral off from an aircraft's wingtips as it passes through the air. Wake vortices have the potential to damage roof tiles, injure people and damage vehicles.

Runway configuration: the siting, number, orientation and layout of runways at an airport.

Theoretical runway capacity: the maximum number of aircraft movements that can be safely accommodated in a defined time period under specified operating conditions. It varies according to the number and orientation of serviceable runways, as well as local weather conditions, ATC facilities, aircraft mix and type of operations.

Aircraft movement: a single take-off or landing; 50 air traffic movements (ATMs) per hour means 50 aircraft land or take-off in 60 minutes.

Visual Flight Rules (VFR): under VFR, pilots navigate visually with reference to the ground. VFR is only permitted during daylight hours, and weather conditions (particularly visibility) have to be good.

Instrument Flight Rules (IFR): under IFR, pilots fly using flightdeck instruments. IFR permits operations during the hours of darkness and low visibility, as navigation functions are automatically performed by computers.

defined time period under specified operating conditions. It varies according to the number and orientation of serviceable runways, as well as local weather conditions, the availability and sophistication of air traffic control (ATC) facilities, aircraft mix and type of operations.

While many different **runway configurations** exist, four basic types can be identified. These are:

- single runway;
- parallel runways;
- intersecting runways; and
- open-V runways (see Figure 3.1).

Single runway

A single runway is the simplest configuration as it consists of a single strip of land that is demarcated for the landing and take-off of aircraft. The **theoretical runway capacity** of a single runway airport varies from 50–100 **aircraft movements** per hour under **Visual Flight Rules (VFR)** to 50–70 aircraft movements per hour under **Instrument Flight Rules (IFR)**

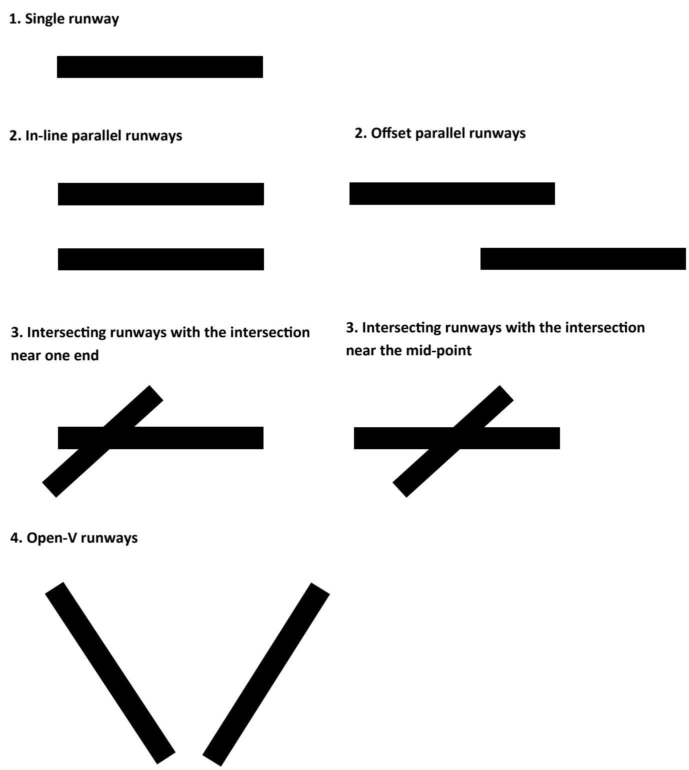

Figure 3.1 The four basic types of runway configuration

depending on traffic mix and traffic demand (see Case Study 3.3), although the **practical capacity** is often lower. Owing to prevailing winds, one direction is usually used for the majority of movements. At East Midlands Airport in the UK, for example, which has one runway (09/27), the prevailing westerly wind means the majority of aircraft take off and land from runway 27 (into the wind). Aircraft only use 09 when the wind is coming from the east.

Practical capacity: describes the number of aircraft movements that can be handled at a certain level or standard of service.

Although single runway airports are common and generally easy to operate, there are a couple of notable exceptions. At Gibraltar Airport, for example, the four-lane Winston Churchill Avenue runs right across the single runway, and road traffic has to be halted to allow aircraft to operate, while the runway at Gisborne Airport in New Zealand is bisected by a railway line and train drivers have to ask permission from air traffic control to cross the runway.

CASE STUDY 3.2

SINGLE RUNWAY, LONDON GATWICK AIRPORT

London Gatwick is the UK's second busiest airport and the busiest single runway airport in the world. In 2015, it handled over 40.26 million passengers and 267,760 aircraft movements. During peak times, the airport processes over 50 aircraft movements per hour. Although Gatwick technically has two runways (08L/26R and 08R/26L), the centrelines are too close to one another to permit simultaneous operations. Consequently, the longer of the two (08R/26L) effectively operates as a single runway.

Parallel runways

A parallel runway system consists of two or more operational runways on the same alignment. These runways may be located next to one another or be staggered to decrease taxi distance from the terminal(s). Airports may also possess two pairs of parallel runways (on different alignments). The capacity of a parallel runway system depends on the number and relative siting of the runways (ideally, they need to be positioned to minimise or eliminate runway crossings) and the centreline spacing between them.

- *Close parallels*: less than 2,500ft (750m) between centrelines. If the centreline spacing is too close, the runways cannot be operated independently and the airport effectively becomes a single runway system (see Case Study 3.2).
- *Intermediate parallels*: 2,500ft (750m) – 4,300ft (1,300m) between centrelines.
- *Far parallels*: over 4,300ft (1,300m) between centrelines.

Whether parallel runways can support simultaneous arrivals and departures depends on their position, centreline spacing and local operating restrictions. In segregated mode, one of the parallel runways is used for arrivals while the other handles departures. In mixed mode operations, both runways can be used by arriving and departing aircraft. The capacity of parallel runway airports varies from 50 to 125 aircraft movements per hour under IFR, depending on local weather conditions, traffic mix, airspace constraints and local operating procedures. London Heathrow (see Case Study 3.3) is an example of a far parallel runway system, while Manchester Airport in North West England has two staggered parallel runways. In both cases, aircraft may be required to cross an active runway which, as this increases the risk of collision, reduces capacity.

CASE STUDY 3.3

PARALLEL RUNWAYS, LONDON HEATHROW AIRPORT

London Heathrow is one of the world's busiest and most capacity-constrained airports, handling over 74.95 million passengers and 474,087 scheduled aircraft movements in 2015. Heathrow currently has two east–west far parallel runways. The northern runway (27R/09L) is separated from the southern runway (27L/09R) by the central terminal complex. For many years, local operating restrictions dictated that the runways were operated in segregated mode. Under this regime, one runway would be used solely for arrivals and the other one solely for departures from the time the airport opened in the morning until 3pm local time every day, when operations would be switched to give local residents some respite from the noise. As Heathrow has become busier and more capacity constrained (the runways operate at over 98 per cent capacity during its operating hours), pressure to operate both runways in a more efficient mixed mode regime in which aircraft can take off and land using the same runway, subject to appropriate safety considerations, increased, and the airport is now permitted to operate in mixed mode at certain times of the day.

Crosswind: a wind which blows at an angle across the runway rather than along its length. Crosswinds can be dangerous, and aircraft are not allowed to operate if crosswinds exceed defined safety parameters.

Primary runway: the runway that is used in preference to others.

Intersecting runways

An airfield with intersecting runways has two, or more, runways on different alignments that cross one another somewhere along their length. Intersecting runways are required where relatively strong winds frequently blow from more than one direction and would result in excessive **crosswinds** and a low usability factor if only one runway were provided.

Normally, the **primary runway** is longer than any secondary or crosswind runway(s), and it is used in preference to other runways when local weather conditions permit. If the wind strength and wind direction allow, intersecting runways can be used simultaneously. While this offers a high degree of usability irrespective of wind direction, the interdependent nature of such operations requires careful control and coordination by ATC and acute situational awareness from flightcrew.

The capacity of an intersecting runway system depends on the location of the intersection and whether it is midway along the runway length or near one end. The highest capacity is realised when the intersection is close to the take-off and landing threshold of the two runways. The further the intersection is from the threshold, the lower the capacity because the risk of collision is increased. Depending on the location of the intersection, the capacity of an intersecting runway system can be as high as 90 aircraft movements per hour under VFR (see Case Study 3.4).

CASE STUDY 3.4

INTERSECTING RUNWAYS, NEW YORK LAGUARDIA AIRPORT

LaGuardia Airport handled 28.4 million passengers on 366,274 flights in 2015, making it the 21st busiest passenger airport in the US. The airport has two intersecting runways. Runway 04/22 runs southwest/northeast and intersects at 90° with runway 13/31, which runs northwest/southeast. High demand means the two runways are operated simultaneously. The location of the intersection near the threshold of runways 13 and 22 requires careful control and coordination from ATC to maximise the available capacity. LaGuardia can handle 80–86 aircraft movements per hour under VFR but only 68 movements per hour under IFR, which can lead to delays.

Open-V runways

The fourth type of runway configuration is an open-V system. Open-V systems consist of two runways which are aligned in different directions but which do not intersect. When winds are light, both runways can be used simultaneously. The highest capacity (50–80 aircraft movements per hour) is realised when air traffic operations are divergent (aircraft operate away from the apex of the V). When operations are convergent (they come towards the apex of the V), capacity is reduced to 50–60 aircraft movements per hour for safety reasons owing to the increased risk of collision (see Figure 3.2). Open-V runways occupy a large land area and they are typically only found where a lot of land has been made available for airport development (see Case Study 3.5).

CASE STUDY 3.5

OPEN-V RUNWAYS, EDMONTON INTERNATIONAL AIRPORT

Edmonton International is the fifth busiest passenger airport in Canada, handling 8 million passengers in 2015. It has two operational runways (02/20 and 12/30) which are aligned northeast/southwest and southeast/northwest in an open-V configuration. They are 11,000ft (3,350m) and 10,200ft (3,100m) long respectively and can accommodate aircraft up to and including the Antonov 225, the world's largest commercial aircraft. The airport has a footprint of 7,000 acres (28km^2) of land, making it the biggest airport in Canada in terms of land area (www.flyeia.com, 2015). In contrast, London Heathrow, which handled 74.95 million passengers in 2015, occupies a site that is only around 3,000 acres (12km^2) in extent.

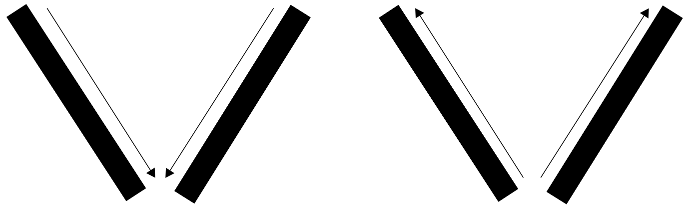

Figure 3.2 Convergent and divergent operations on open-V runways

Although there are four types of runway configuration, many airports exhibit a combination of these designs, and the configuration and operation of runways at individual sites are often a compromise between local topography, the availability of land for development, local obstructions, airspace constraints, environmental and social considerations, and optimal usability.

Usability factor: the percentage of time that normal runway operations are not restricted by excessive crosswinds. A figure of 95 per cent or more is usually required.

Runway configuration and usability

While many physical, geographic and financial factors influence the provision, orientation, siting and configuration of runways, one of the most important considerations from a management perspective is the **usability factor** of the system. An airport must ideally be capable of handling the aircraft it is intended to serve at least 95 per cent of the time, irrespective of local weather conditions. In the case of a single runway airport, if the usability factor falls below 95 per cent, it may be necessary to construct a crosswind runway to raise the usability factor above it.

Stop and think

With the aid of diagrams, identify the four basic types of runway configuration, and discuss their effects on capacity.

3.4 Other factors that affect runway capacity

In addition to runway orientation and configuration, other factors that affect runway capacity include:

- the provision of ATC services and navigation aids ('navaids') such as instrument landing systems (ILSs) and high-intensity runway lights;
- aircraft performance characteristics;
- local meteorological (weather) conditions;
- environmental and social considerations and operating restrictions;
- runway/taxiway/landside interface design factors.

The availability of trained ATC personnel and the provision, range and sophistication of navaids and ILSs all affect runway capacity. High-intensity runway lights and automated ILSs enable aircraft to continue to operate during hours of darkness and poor visibility and so enhance the usability of an airport. Such systems are, however, expensive to install, operate and maintain, and airport managers must assess the relative benefits of providing them against the cost of their installation and operation.

The performance characteristics of the aircraft that use an airport also affect runway capacity. The size, weight, speed, manoeuvrability, acoustic footprint, climb performance and braking capability of the aircraft, combined with the aeronautical skill and experience of the flightcrew and their familiarity with the airfield, all have the potential to affect or degrade runway capacity. Individual aircraft types exhibit different approach and landing speeds and, on take-off, have different climb characteristics. Typically, larger and heavier aircraft require longer (both in terms of time and distance) **take-off rolls** and longer **landing rollouts** than smaller and lighter aircraft and, as a consequence, **runway occupancy times** for larger aircraft tend to be greater, leading to lower hourly capacities as fewer aircraft movements can be accommodated.

Larger and heavier aircraft also generate dangerous wake vortices that have to dissipate before the next aircraft can land or take off. All commercial aircraft are classified into one of four wake turbulence categories, according to their weight and the wake vortices they generate. Strict regulations specify the length of time and/or distance that must be left between movements by different categories of aircraft. 'Heavy' aircraft include wide-body jets, such as the B747 (the A380 often has its own classification); the 'medium' category (which is subdivided into 'upper medium' and 'lower medium') includes A320s and B737s; 'small' aircraft include Dash 8 turboprops and commuter aircraft; while the 'light' category describes general aviation aircraft. The temporal and longitudinal (distance) separation that must be observed in the UK between arriving and departing aircraft operating from the same runway is provided in Tables 3.1 and 3.2. The implications of aircraft mix for runway separation minima and runway capacity are significant.

Take-off roll: the period of time or the runway distance used between the aircraft's brakes being released and it becoming airborne.

Landing rollout: the period of time or the runway distance used between the aircraft's wheels touching the ground and it exiting the runway.

Runway occupancy time: the amount of time (in minutes or seconds) individual aircraft spend on the runway. Airports try to decrease runway occupancy times to maximise the use of this facility.

Table 3.1 Wake turbulence separation minima distances (in nautical miles) – aircraft arriving

		Following aircraft					
		A380	*Heavy*	*Upper medium*	*Lower medium*	*Small*	*Light*
Leading aircraft	*A380*	#	6	7	7	7	8
	Heavy	#	4	5	5	6	7
	Upper medium	#	#	3	4	4	6
	Lower medium	#	#	#	#	3	5
	Small	#	#	#	#	3	4
	Light	#	#	#	#	#	#

Source: Derived from CAA (2014) p16/17

Note: # = no wake turbulence separation minima required

Table 3.2 Wake turbulence separation minima (in minutes) – aircraft departing from the same runway or from a parallel runway that is less than 2,500ft (760m) away

		Following aircraft					
		A380	*Heavy*	*Upper medium*	*Lower medium*	*Small*	*Light*
Leading aircraft	*A380*	#	2	3	3	3	3
	Heavy	#	4nm or time equivalent	2	2	2	2
	Upper medium	#	#	#	#	#	2
	Lower medium	#	#	#	#	#	2

Source: Derived from CAA (2014) p18

Note: # = no wake turbulence separation minima required

An airport handling a mix of heavy, medium and light aircraft on a single runway may not be as efficient as one handling all the same category of aircraft. Runway occupancy time (and hence runway capacity) is also affected by the mix of departing and arriving traffic that is operating from the same runway and the proportion of fixed-wing and rotary traffic the airport handles.

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Stop and think

Why are wake vortices potentially dangerous, and why does aircraft size affect runway capacity?

Local meteorological conditions also have the potential to degrade runway capacity. Strong or gusting (cross)winds, poor visibility and low cloud can all reduce runway capacity by necessitating the implementation of low-visibility procedures and increased separation between aircraft. Rain, sleet and snow can affect the runway surface and its performance, leading to loss of friction and reduced braking action, which may increase landing rollouts and runway occupancy times. High surface temperatures lower the ability of an aircraft's wings to generate lift and require aircraft to have longer take-off rolls and/or use higher thrust settings (or reduce payloads, with less freight or passengers, which impacts on an airline's revenues). Strong headwinds can also reduce the landing rate and, in 2015, London Heathrow introduced a time-based separation system in order to improve runway capacity and reduce flight delays.

Stop and think

Can you think of any other weather conditions that affect runway capacity?

A range of environmental and social considerations may also affect an airport's runway capacity (➤Chapter 17). Environmental impacts concerning air quality, surface water drainage and its treatment and, in particular, noise, together with the measures introduced to minimise or mitigate their impacts on local residents, are very important. Noise abatement procedures and noise preferential routes (NPRs) that route aircraft away from densely populated urban areas (to reduce the acoustic impacts of aircraft operations), night noise quotas that restrict the use of certain noisy aircraft types (or reduce the number of aircraft movements) during the night-time period, and other local operating restrictions may limit the use of one or more runways during particular hours of the day or night or during certain days of the week. Air quality is increasingly becoming an issue (for an airport and its operations and its impact on local residents' health), which may become relevant in terms of future mitigation measures restricting the use of certain aircraft types (in terms of their emissions) or restricting the use of one or more runways during particular periods. The need to drain surface water from an airfield or treat it (in terms of airfield-related activities, such as de-icing fluids during cold weather) is increasingly requiring airports to invest in on-site surface drainage and water treatment facilities, which require land that could, otherwise, be used for improvements to the runway and taxiway systems. Bird activity can also affect runway capacity, with airports having to invest in a variety of measures to deter or scare birds so that they do not present a hazard to aircraft.

3.5 Runway demand management

Many airports are operating close to their design capacity and have little flexibility to accommodate non-routine events or recover normal operations following disruption (➤Chapter 10). Where the demand for flights exceeds the available supply (capacity) a system of **slot allocation** can be used (➤Chapter 5).

Individual slots are valuable as many FSNCs hold '**grandfather rights**' at their main operating base(s), which means few new slots can be traded on the open market (see Case Study 3.6).

Although slot allocation can be used to manage demand at severely capacity constrained airports, the system may prevent other airlines from entering the market and restrict competition and route choice. Many airports are, consequently, seeking to develop and expand their airside infrastructure in order to cope with forecast increases in demand and maintain their market share in the face of growing competition.

Slot allocation: a technique used to manage demand at capacity constrained airports. A slot is essentially permission to land or take off at a particular time.

Grandfather rights: airlines can retain use of a slot that has been previously allocated to them providing they use it regularly.

CASE STUDY 3.6

SLOT TRADING AT LONDON HEATHROW

The number of aircraft movements permitted at London Heathrow is capped at 480,000 a year. As demand for slots exceeds the available supply, slot allocation is used to manage demand and slot trading has become the principal mechanism through which airlines can enter the market and expand. The scarcity of slots makes them valuable assets and they can be traded for millions of dollars. In February 2015, SAS, the Scandinavian airline, reportedly sold a pair of slots at London Heathrow for US$60 million.

Stop and think

What are the advantages and disadvantages of slot allocation for airports and airlines?

3.6 Runway development

Growing consumer demand for air travel and the introduction of larger aircraft are driving the development of new and extended runways and airport infrastructure. Airports may seek to grow their business by increasing the length of their primary runway(s) to accommodate larger aircraft with heavier payloads. Airports may also desire a new runway to increase capacity and accommodate more aircraft. Either option may require the acquisition of additional land beyond the existing boundary and/or involve substantial civil engineering works to overcome site limitations (see Case Study 3.7), necessitate significant environmental and societal mitigation measures and involve substantial investment by the airport operator. Any runway development is expensive and the relative risk and rewards for the airport, its customers, surrounding communities, the local environment and the regional economy must be carefully considered.

Stop and think

Why do many airports want to extend or build new runways, and what are the risks associated with doing so?

CASE STUDY 3.7

RUNWAY EXTENSION AT FUNCHAL AIRPORT, MADEIRA

The airport serving the Portuguese Atlantic island of Madeira used to be famous for its short runway, mountainous terrain, non-standard curved final approach over the ocean and dangerous crosswinds. In 2000, the airport's single runway was extended to 2,781m (9,124ft), almost doubling its length, at a cost of over €500 million. The eastern extension was built on a platform over the ocean, supported by 180 70m-high concrete columns. The extension, opened in October 2002, enables the airport to accommodate wide-body aircraft, such as the A330, and has boosted the island's tourist industry.

3.7 Taxiway design

Irrespective of the siting, orientation and number of available runways, if adequate connecting **taxiways** are not provided, an airport cannot operate safely and/or efficiently, and it is imperative that runway design includes considerations of taxiways. The principal function of a taxiway is to facilitate the safe and efficient surface movement of aircraft to or from the runway(s) and between terminals, maintenance areas and other parts of the airfield.

Taxiway: a defined path linking different parts of the airfield which is used by taxiing aircraft or aircraft under tow.

Taxiways need to connect all parts of the airfield that are used by aircraft, and they need to be arranged so as to:

- provide adequate separation between aircraft;
- not endanger, interfere with or delay arrivals, departures or other taxiway operations;
- provide the shortest practicable route between the terminal and the active runway(s) to minimise taxi distances;
- offer a sufficient number of runway entry/exit points, including RETs (or high-speed turn-offs) to enable landing aircraft to vacate the runway as quickly as possible;
- minimise or mitigate any local environmental or social impacts.

Runways and taxiways should be located so as to provide safe separation between flying and taxiing aircraft and to minimise delays to landing, taxiing and take-offs. Taxiways need to be sufficiently wide and strong enough to accommodate the largest aircraft that are likely to use the airport, and their centrelines have to be sufficiently far apart to allow for simultaneous operation and ensure adequate wing-tip clearances. In addition, the radius for a taxiway, where its alignment changes or turns (to access other parts of the airfield or a terminal), needs to be such that it can accommodate the largest aircraft likely to use the airport and facilitate aircraft manoeuvring, otherwise aircraft may not be able to make a turn safely, with the potential for conflict with other aircraft, airfield facilities or airfield equipment or the potential for aircraft to become stuck in the soft ground immediately adjacent to taxiways. As with wake vortex categories, commercial aircraft are assigned a classification code for taxiways and apron stands ranging from Code A (the smallest) to Code F aircraft (the largest) according to the physical span of the aircraft's wing and outer main gear wheels. Taxiways need to be designed to accommodate the largest aircraft that are likely to use the airport and, at some airports (including London Heathrow), Code F aircraft can only use a limited number of taxiways.

Wherever possible, it is desirable to build a taxiway that is parallel to the runway, but the danger of lateral (sideways) runway excursion needs to be considered. Where the airfield layout is severely constrained, it may be necessary to build a turning circle at one or both ends of the runway to allow aircraft to turn through 180° in preparation for take off or to backtrack down the runway after landing. This practice, however, increases runway occupancy times and lowers runway capacity. Examples of airports with turning circles at both ends of the runway include London Luton and Kos and Skiathos in Greece.

Stop and think

Why are turning circles required at some airports, and what are their operational impacts?

The provision of appropriately positioned exit taxiways and RETs (or high-speed turn-offs) allows for higher runway utilisation and increased capacity. Right-angled 90° exit turn-offs require aircraft to decelerate to a very low speed before vacating the runway, whereas shallower angles of 30° allow aircraft to exit at higher speeds, thereby decreasing runway occupancy time and improving runway capacity. The provision and location of exit taxiways depend on the mix of aircraft that use the airport and their relative approach and braking speeds, the point of touchdown, their deceleration rate and the normal condition of the runway surface (i.e. whether it is usually wet or dry). Even when accounting for these factors, it is important to recognise that individual airlines have different standard operating procedures and flightcrew will operate their aircraft according to local conditions. Consequently, the provision of a rapid exit taxiway does not oblige flightcrew to use it, and the configuration of some airfields may prevent their retrospective installation.

Environmental and social impact issues also need to be considered in terms of a taxiway's operations, particularly where it may be close to the airport boundary and local housing. There could be impacts concerning ground noise from aircraft using the taxiway and a noise bund may be necessary to provide a barrier between the taxiway and local housing. A taxiway's operations could be restricted during parts of the day or night, or reduced aircraft engine operations (or single engine taxiway operations) could be used on taxiways to reduce ground noise levels. Single engine taxiing may also improve air quality and odour levels for any local housing immediately adjacent to a taxiway.

3.8 Aprons and the landside interface

So far, this chapter has concentrated on the design, orientation and configuration of runways and taxiways, but it is also important that these airfield components are not considered in isolation, as their interface with passenger and freight terminals and landside areas affect an airport's total capacity. Wherever possible, apron areas and terminal buildings should be located adjacent to the principal traffic runway and positioned in such a way that landing and departing aircraft do not pass directly overhead.

The apron is sometimes referred to as a 'ramp', and it is here that individual aircraft stands interface with terminal buildings and where aircraft are turned around between flights. Ramp areas should be designed so as to allow for the safe and efficient entry and exit of aircraft, and they should be free from obstacles or other restrictions but should also allow for access by service vehicles (including baggage handling equipment, fuel bowsers and in-flight catering vehicles). Some stands are configured to accommodate particular aircraft types (based on the aircraft codes referenced earlier in terms of taxiways), while others may be flexible and able to accommodate different sized aircraft (and aircraft codes) according to demand. Multi Aircraft Ramp Systems (MARS) allow airports to make their gates – and, by association, aircraft turnarounds – more flexible and efficient. MARS stands can be configured according to the type of aircraft that needs to use them, and this configuration can be changed throughout the day as the nature of the traffic demand changes. This system means that a MARS stand recently vacated by a single A380 could be subsequently filled by two smaller aircraft, such as A320s. The ability to adapt apron infrastructure in this way permits airports to maximise the efficiency of their stands while providing the flexibility to serve different types of aircraft.

Stop and think

What are the advantages and disadvantages of MARS stands?

Again, there are environmental and societal impact issues to consider with an apron area and its aircraft stands, particularly in terms of aircraft ground noise and air quality. The use of some aircraft stands may be restricted during parts of the day or night, while fixed electrical ground power (FEGP) can be provided by the airport, as an alternative to using an aircraft's on-board power systems, to reduce aircraft ground noise and emissions.

3.9 Airfield management

Given the safety-critical nature of airfield operations, it is imperative that airfield operations teams are employed to patrol the airfield and safeguard infrastructure, aircraft, passengers, freight and airport personnel and employees from risk of accident and harm. The airfield environment is dangerous, and health and safety is a critical issue. People can be injured or killed by jet blast and prop wash (the exhaust from aircraft engines), be crushed or injured while using machinery and servicing aircraft, and slip and fall in snow, ice and rain. Airfields also need to be regularly patrolled to ensure the perimeter is secure and to scare birds and wildlife away from the active runways and aircraft manoeuvring areas. Airfield operations are also responsible for ensuring the structural and operational integrity of the airfield and must be equipped to respond to any eventuality, from removing foreign object debris (FOD) on the airfield to escorting maintenance teams out onto the airfield to repair cracked taxiways and broken light bulbs. Airfield operations teams are also responsible for keeping detailed reports, monitoring defects and analysing data to identify hazards and impediments to efficient operations.

It is vital that the runway, taxiway and apron areas are well maintained and that essential maintenance is performed if there is any serious deterioration that requires local resurfacing or replacement. Over time, as a result of the volume, number and type of aircraft landing or taking off, a runway's surface will wear and need to be resurfaced along its complete length with a full runway closure (typically at night and during off-peak periods). Maintenance of taxiways, aprons and individual stands may require temporary closure. All routine maintenance work should be planned well in advance and communicated to the airlines who will be affected. Specialised contractors will need to be employed to undertake the work and any adverse impacts on airport operations or revenues need to be carefully managed. One way in which airports can protect the airfield is through a set of processes and procedures called 'aerodrome safeguarding'.

3.10 Aerodrome safeguarding

Aerodrome safeguarding: active control of land use to protect surrounding land and airspace from developments which could affect the safe operation of an airport.

Aerodrome safeguarding seeks to protect the safety of aircraft and their occupants during take-off and landing and when manoeuvring within, and immediately around, an airport. It involves the active control of local land use to protect the land and airspace around an airport from any development which could adversely affect the safety of aircraft operations.

In the UK, aerodrome safeguarding requires protection of:

- The airspace surrounding the airport, which is achieved through a series of 'obstacle limitation surfaces' or blocks of airspace that cannot be penetrated by tall buildings, trees or construction equipment such as cranes.
- The integrity of radar installations and navigation aids, through preventing the construction of buildings, wind turbines or new developments which could cause reflections, diffractions and distortions to radio signals. In the UK, any wind farm which is proposed within a 30km radius of an airport has to be evaluated for its potential to cause radar and radio signal interference.
- The airport's visual aids and lighting, by ensure that neighbouring street lights, advertising hoardings or floodlights do not risk obscuring visual aids or dazzling or confusing flightcrew.
- The airfield from the risk of bird strikes. All land uses that are known bird attractants, such as wildlife sanctuaries, reservoirs and landfill sites, within a 13km radius of an airport have to be actively monitored and managed to reduce the risk of bird strikes (CAA, 2006).

Stop and think

What is aerodrome safeguarding, and why is it required?

Key points

- An airfield comprises all the secure airside aircraft manoeuvring areas and the land adjacent to them.
- Runways are an airport's most important asset. Their siting, orientation and physical characteristics affect the capacity and operational efficiency and safety of an airport.
- There are four basic types of runway configuration: single, parallel, intersecting and open-V; although some airports have a combination of these basic types.
- Runways have to be designed for maximum operational usability and be capable of handling both the volume and type of air traffic that is using the facility now and in the future.
- Runway capacity is affected by the physical characteristics of the runway and the surrounding land and airspace as well as the nature of demand, the mix of air traffic, weather conditions and local operating restrictions.
- Taxiways and aprons must be designed to allow for the safe and efficient surface movement of aircraft around the airfield.
- Runway development or expansion is expensive and often contentious (➤Chapter 17). Airport operators must ensure that local environmental and social impacts are minimised and mitigated as far as possible.
- Aerodrome safeguarding processes protect the air and land space around an airport from developments which could affect safe operations.

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CHAPTER 4

Airport systems planning and design

Richard de Neufville

LEARNING OUTCOMES

- To understand that airport forecasts are 'always' wrong in that the continuing volatility in the aviation industry means that what actually occurs differs, often substantially, from original predictions.
- To appreciate the need for flexibility in design, as a way of enabling easy adaptation to future situations.
- To recognise the need for a comprehensive systems view of airports and the competition between them.
- To acknowledge that measures of capacity at airports are not absolute but depend on the nature of operations and on differing judgements concerning acceptable levels of service.
- To realise that the inherent instability of queues under peak loads drastically reduces the acceptable maximum capacity of operations.

4.0 Introduction

Airport management: the range of activities needed to run airports effectively. These range from planning future facilities to implementing projects and supervising ongoing operations.

Airport management requires attention to some particular features that characterise airports' behaviour. The purpose of this chapter is to present and explain the essential elements and consequences of these features.

All those concerned with planning, developing, and managing airports should consider the following five points:

1. **Forecasts are 'always' wrong.** Experience shows that it is not possible to anticipate future levels or types of traffic accurately. Air transport is highly volatile in the short run and continually in the midst of major changes in trends over the long run.
2. **Flexibility in airport planning and design is essential.** Changes in the types of traffic and modes of operation constantly modify the requirements and performance of airport facilities. To be effective, airport managers need to be able to easily adjust the capacity and capability of their facilities to new conditions.
3. **Any airport is part of a competitive air transport system.** It faces other airports and airlines that compete vigorously. This means that airport managers need to be attentive to this competition and how it can affect the performance of their own facility.
4. **Measures of airport 'capacity' can be very misleading.** Measures of airport 'capacity' are conceptually challenging as they depend on specific assumptions about the concept and mode of operations. This means that the same physical facility can lead to different estimates of 'capacity'. This can confuse managers and others trying to provide adequate capacity for airport facilities.
5. **Queues are at the heart of airport operations.** People wait to check in, to pass security, to board aircraft; aircraft queue up to land, to move to a gate, to take off. Queues inherently reduce capacity. Managers need to carefully understand the ways queues behave to do their job effectively.

Experience worldwide indicates that these points are frequently overlooked and generally not understood. Failure to deal adequately with them has been a continuing source of difficulty in the field of airport systems planning and design.

Forecast: a prediction, based upon past data and current best guesses as to future trends, of what might happen over the planning period. However calculated, they are still guesses of future trends – often disrupted by 'trend-breakers'.

4.1 Forecasts are 'always' wrong

The central fact is that **forecasts** of airport activities are almost certainly wrong. Again and again, the reality of what actually happens at an airport at some future time differs significantly from what forecasters anticipated. Study after study demonstrates the phenomenon by comparing forecasts with eventual results. ACRP (2012) and de Neufville and Odoni (2013) cite many such examples, such as those provided below. Readers can verify this observation by looking up previous airport forecasts and comparing these predictions with what actually happened in the forecast year.

Eventual actual outcomes deviate, often over a large range, from original predictions. The reality can be higher or lower than the forecast. It can even sometimes – rarely given the possibilities – coincide closely with the forecast! In general, however, we must anticipate that future reality will differ greatly from original, inherently speculative, forecasts.

The extent that actual future situations deviate from forecasts depends principally on three elements: the length of the forecast period, the level of detail and the degree of stability of the issue. Thus:

- **The longer the forecast, the greater we can expect the possible deviations to be.** Patterns of activity are normally tied most closely to current habits; the farther we are from the present, the greater the chance that new patterns will have formed. This feature is particularly crucial since the most important airport investments – in runways and terminals – are long-term, capital-intensive projects designed to service traffic well into the future. Over-reliance on long-term forecasts has led to many poor investments when actual levels of traffic failed to meet expectations.
- **The greater the level of detail, the greater the variability of the forecast.** As a general rule, overall forecasts of activity, for example, of the total air travel from a city, are normally less variable than their components. This is because gains in one component tend to balance out losses in other components. For example, overall leisure air travel from Europe is less likely to deviate substantially from a trend than travel to particular destinations. The demand for travel to specific destinations such as the Canary Islands, Egypt, Greece, Spain or Tunisia depends upon the vagaries of fashion, political unrest, currency exchange rates, and so on. Holidaymakers can and do easily shift from one destination to another.
- **Some patterns have limited volatility.** For example, airlines do not change their aircraft fleets easily; they invest not only in expensive physical assets but also in the training of their pilots and associated personnel. Likewise, the travel pattern of summer holidays in Europe is firmly fixed in labour contracts. But note, however, that airlines often ground aircraft or reduce route frequencies when customer demand drops. Providers and customers of air transport can and do adjust their level of activity extensively according to circumstances.

Overall, many factors influence the degree of uncertainty in airport forecasts. Importantly, the 10- to 20-year forecasts that guide major investments are likely to be most unreliable.

A conservative estimate of the discrepancies between actual results and forecasts is that actual traffic at an airport deviates on average about ±10 per cent from forecast after only five years. This figure compounds over time, so that the average deviation might be ±20 per cent after ten years, for example. This is the experience in the US, a well-established market that has little room for the rapid changes and greater uncertainties possible in developing markets. This figure derives from comparisons of the annual Federal Aviation Administration (FAA) five-year forecasts of overall traffic at major airports with the subsequent actual results.

Such deviations have enormous implications for planning airport investments. This is because airports typically plan investments to cover prospective gaps between what they have and what they expect to need. The uncertainties in the forecasts of total traffic thus translate into much greater uncertainties in the estimates of the gaps (see Example 4.1).

Example 4.1
Forecast errors lead to greater planning errors

Consider the example of an airport whose traffic might double over the planning period, for example, from 10 to 20 million passengers. If the passenger forecast is wrong by ±20 per cent, the total traffic might range from 16 to 24 million passengers, and the planning gap – the difference between available and needed capacity – would range from 6 to 14 million passengers! The point is that normal uncertainties in traffic forecasts can readily lead airport managers to face situations in which the range of their prospective needs differs by a factor of two.

The above estimates of forecast uncertainties represent average conditions. Original forecasts for airports can also be spectacularly wrong. Some examples include:

- Traffic forecasts for Dubai International Airport in 1984, when it had only one runway and Emirates airline did not exist, did not anticipate that 30 years later the airport was poised to be among the top three worldwide in terms of passenger traffic and the busiest international airport.
- Conversely, around that time, forecasts anticipated that Boston Logan International Airport would double its traffic to over 50 million passengers, but 30 years later, its total traffic had barely changed.
- St Louis (US) and Zürich airports are among several that saw their traffic collapse when their home airlines (TWA and Swissair, respectively) ceased operations. At St Louis, the total passenger traffic dropped 60 per cent from over 30 million to around 12.6 million passengers – shortly after the airport had invested in a new runway designed to cope with traffic growth to over 40 million passengers.

Cause of bad forecasts

'Trend-breakers' cause most failures in airport forecasting. The term refers to a continuing series of events that are game changers in that they disrupt established patterns of service, of demand, and of modes of operation. This phenomenon most immediately impacts airlines; changes in the airline industry then affect airport operations and management.

Most of the trend-breakers concerning the airline/airport industry are a consequence of the economic deregulation of airlines (➤Chapter 2). This began in 1978 in the US. It has since spread worldwide. Deregulation resulted in far-reaching changes, which stimulated more changes, and this cascade continues to spread internationally and disrupt and transform patterns of use, of demand, and of requirements in the airline and airport industry.

Liberalisation is thoroughly changing air transport and airport systems planning and design. Before deregulation, government ownership and regulation encased the industry in rigid rules set by national legislation and international conventions. Change required layers of political and regulatory approval and occurred slowly, if at all. The airlines were monopolistic and enjoyed high fares. Although aircraft technology advanced, real innovations in services, routes, pricing and marketing were rare. Liberalisation changed all that. It lets airlines decide on fares and routes, and this generates new services. The resulting competition drives smaller or inefficient airlines into bankruptcy or consolidation with larger airlines, while more efficient airlines demand different airport services and different facilities. These waves of change resonate and reinforce each other as they spread across the world.

Consequences of bad forecasts

Here are some of the highlights of the trend-breakers that have been occurring and their impacts:

- **Rise of low-cost carriers (LCCs)**. These new airlines have set the standard of operations and are coming to dominate their markets. Southwest Airlines has become the leading carrier, by far, of domestic passengers in the US. Ryanair and easyJet, which started in Europe about 20 years after Southwest, have been building up similar dominance in Europe. AirAsia provides an example of how this may occur in Asia. These new airlines have spurred sudden growth in traffic (➤Chapter 7).
- **New airports, modes of operation.** LCCs push for low airport costs (➤Chapters 5 and 6). They turn their aircraft around quickly at gates, and thus require fewer gates. They favour simpler terminals and cheaper secondary airports, such as Miami Fort Lauderdale, London Stansted and Bangkok Don Mueang. These pressures have disrupted traditional concepts of airport planning.
- **Consolidation of airlines.** Competition from efficient LCCs has driven some traditional airlines into bankruptcy and/or consolidation with others. Within 30 years, the traditional US airlines consolidated into three major operators: American, Delta and United. Continental, Northwest and US Airways have disappeared, along with Eastern, Pan American and TWA. In Europe, independent national airlines are disappearing: Air France took over KLM; IAG consolidated British Airways and Iberia; and Lufthansa took control of Austrian, SWISS and the remains of Sabena. These changes relocate flight patterns and airport needs; for example, after BA took over Iberia, it rerouted much of its traffic from Madrid to London Heathrow.
- **Hub-and-spoke operations.** The development of transfer hubs is a result of the freedom of airlines to establish new routes easily. Such operations provide more connections to passengers and facilitate the management of aircraft and crews. This development also reallocates traffic from some airports and airlines to others. Thus Emirates is taking transfer traffic to and from India, Southeast Asia, and Australia away from Singapore in Asia, and away from London Heathrow and Frankfurt in Europe.

Table 4.1 Market value of selected airlines, February 2015

Innovative	*US$ billion*	*Low-cost*	*US$ billion*	*Traditional*	*US$ billion*
UPS	90	Southwest	31	Singapore	11
FedEx	48	Ryanair	16	IAG (BA + Iberia)	10
Emirates	14	easyJet	7	Lufthansa	6

Source: obtained via New York Stock Exchange

- **New competitors**. The liberalisation of air transport has resulted in the development of integrated carriers that collect and deliver parcels door-to-door. These have become the workhorses of online shopping and delivery. UPS and FedEx are among the largest airlines in the world and have the highest market value (see Table 4.1). These emerging giants are transforming the air transport industry, as they require new types of airports and airport facilities. See Chapter 15 for a more detailed discussion of air cargo.

Further trend-breakers supplement the continuing current of changes resulting from deregulation of the airline industry. These have to do with the expansion of free-trade areas, such as the North American Free Trade Association (NAFTA), the European Union (EU), the Association of Southeast Asian Nations (ASEAN) and globalisation generally. The airline/airport industry is in the midst of continued market and operational volatility, and this is likely to continue for some time.

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Stop and think

Why are demand forecasts invariably wrong, and what are the consequences of incorrect forecasts?

4.2 Flexibility is essential

The overall consequence of the forecasts 'always' being wrong is that it is impossible to know exactly what to plan for. This is really awkward: What do you do if you don't know what to expect? This is most inconvenient from the management perspective.

The reality that it is impossible to know future conditions accurately also runs against standard practice. Indeed, Step One of standard guidance is: 'predict future conditions'. How do you proceed once you understand that the results from this task are unlikely to be accurate?

Standard practice thus does not develop consistently good plans. Indeed, its Step Two is: 'find the best plan to meet the forecast'. As reality differs, often substantially, from the forecast, the standard approach to airport planning often results in a 'wonderful plan for a fairy-tale future'. The actual results of conventional planning frequently range between having excess or inappropriate capacity to needing to expand facilities under difficult conditions. Such situations are wasteful and expensive.

The solution to dealing with the problem of planning for an uncertain future is adaptive planning. Managers need to deal with uncertainty strategically. This means that they need to provide for future requirements incrementally, in line with demonstrated experience. To do this, they need to choose the earlier steps so that these enable developments that might be desirable in the future. Given the impossibility of predicting future issues, they need to think of airport systems planning and design rather like a game of chess: they need to think ahead over many periods, to recognise possible opportunities and vulnerabilities, and then to act in each period in a way that makes it possible to develop good situations while keeping themselves protected against undesirable developments.

Flexibility in design is the main way managers can implement **adaptive planning**. Flexible designs enable airports to adjust their capabilities or capacities to deal with unexpected levels of traffic, new clients, innovative operating procedures and changing regulatory requirements (see Example 4.2). Case after case demonstrates that flexible designs can deliver greater expected value over time.

Flexibility in design: the capability of a design to add capacity or capability easily. Designers typically implement flexibility by providing unencumbered space for growth, or strength to deal with greater loads, or open spaces amenable to low-cost rearrangement.

Adaptive planning: a planning process that recognises that plans need to adapt to circumstances as they evolve. It consequently anticipates possible changes and creates plans and designs that enable and facilitate the future evolution of the facilities.

Example 4.2
Flexibility in airport planning and design

Land banking is an example of long-term, generation-ahead flexible planning. The idea is to set aside land for future airport expansion, acquiring it before metropolitan growth drives up prices and engulfs airport sites. Singapore, for example, filled in a big area next to its Changi Airport so that it could add two runways, as it began to do in 2014. Sydney Airport (Australia) likewise reserved the Badgery's Creek site for an eventual Western Sydney Airport. Such set-asides provide insurance that it would be easy to develop new airport capacity if needed, while in any case being a valuable long-term investment in land for other purposes as desirable.

Swing gates at airports provide short-term flexibility for dealing with variations in daily or seasonal traffic. Typically, these gates can serve either domestic or international passengers subject to border controls. Designers implement them using a series of doors and corridors that can be opened or closed so as to 'swing' a gate between domestic and international traffic as needed. Canadian airports have been noticeable users of swing gates. Vancouver International Airport, for example, makes double use of gates between domestic flights, transborder traffic to the US and other international passengers.

In practice, managers can develop flexibility in design, and thus practise adaptive planning by following a three-step procedure, namely:

1 Recognise that they and their successors need to deal with a range of possible futures, varying not only in levels of traffic but also in the operational requirements of their clients and regulators;

2 Consider what would be needed, in terms of capacity and capabilities, to meet the range of different possible conditions; and then

3 Develop plans that meet immediate needs which could be developed to deal with future requirements and which do not preclude or foreclose other developments that might eventually be desirable.

A flexible design will generally feature the following characteristics:

- It will be more modest and smaller than the design that would develop the full capabilities that forecasts project as needed. This approach reduces the losses that would occur if some of that projected capacity might be unnecessary.
- It will thus be less expensive than a design tailored to the most likely forecast. This is for two reasons. It will be smaller at the start and thus reduce initial capital expenditures ('capex'). It will also defer the cost of added capabilities for many years, and thereby save interest and lower the present cost of these expenses.
- It will allow room to expand each of the important facilities (runways, terminal buildings, passenger lounge, and baggage areas), being careful to locate supporting facilities (such as roads, air conditioning plants and office buildings) so that these will not impede future expansions or capabilities that might be needed (such as larger buildings or automated passenger vehicles).
- The design of interior spaces will allow for easy reconfiguration so as to enable managers to adapt them for changing requirements due to new aircraft types, changes in government regulations and emerging economic opportunities.

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Stop and think

Why might it not be possible to adopt flexible design in all airports?

Airport system: the set of airports that affect each other in providing air transport. They may compete. They may also complement each other by providing connections in a network, much as Guangzhou Airport (China) is a hub on the FedEx network based in its main hub at Memphis (US).

4.3 Airports are part of a competitive air transport system

Airport managers need to recognise that they operate in a highly competitive system. The performance of any airport depends considerably on competition elsewhere, which may be located a long way away. Managers of airport facilities need to be alert to the way changes elsewhere in the **airport system** – both physical and organisational – may impact their performance and thus require them to react effectively. Moreover, changes may occur rapidly and require prompt attention.

To illustrate how competitive decisions can have wide repercussions through the system, consider the following generic cases and examples:

- **Airline mergers.** Corporate decisions to acquire or merge with other airlines generally lead to significant changes in routes and operations. Thus when IAG, the parent company of British Airways, acquired Iberia and effectively merged their operations, this led to a 30 per cent drop in traffic at Madrid (from over 50 million down to about 35 million annual passengers). IAG decided that their operations would be more efficient if they routed transfer passengers through the UK instead of Spain. In general, hub airports compete with each other not only for passengers but also as potential long-term bases for airlines.

- **Airline route planning.** As deregulation spreads, airlines are increasingly free to plan their destinations according to their economic interests. They can add or drop destination airports at short notice – and often do. The main assets of an airline are the aircraft and the staff, and these are highly mobile. So they may switch their routes to more profitable areas. Thus Qantas shifted its base in Singapore to Dubai. Similarly, Ryanair focused its routes to Catalonia on Barcelona (and away from Girona and Reus) when appropriate terminal facilities became available.

- **Passenger routing.** Passengers have considerable choice as to where they go and how they get there. Most obviously, the competition between leisure destinations affects airport traffic. The European holidaymaker might choose between the Red Sea, the Canary Islands and the Caribbean, for example. Longer-distance travellers, who are likely to connect through transfer hubs, generally have many choices and make them not only on the basis of airline fares but on the airport itself. A passenger travelling from Vienna (Austria) to Boston (US) can, for example, connect through London, Frankfurt, Munich, Paris or Zürich. Which route is chosen may depend on the perceived performance of these facilities as well as price.

- **Airport shopping.** The most profitable duty free items – such as alcohol and perfumes – can be purchased from almost any duty free outlet. So the passenger has a choice: buy it at the departure airport, at some connection point or at the destination? Airport retail areas thus compete actively with each other. More attractive facilities and prices elsewhere affect local revenues and net income to the airport.

Airport managers need to take a comprehensive, systems view of airports and the competition between them. It is not enough to focus on one's own local facility (see Case Study 4.1). They need to recognise that they are actively competing with other airports for traffic and revenue. They thus should routinely monitor their competition and benchmark their performance against that of other facilities.

CASE STUDY 4.1

AIRPORT COMPETITION

In the 1990s, planners for Miami International Airport, a major international gateway between the US and Latin America, ignored Fort Lauderdale–Hollywood International Airport (FLL), then a small regional facility 40km (25 miles) away with little traffic. By 2015, however, FLL catered to some 25 million passengers and was among the 100 busiest airports worldwide. It had become the favourite airport for North American travellers to Miami and the cruise ship market, and a base for the major US LCCs. Miami International had not recognised the competition in time.

London Heathrow most obviously competes with Frankfurt Airport for passengers between North America and Asia. Increasingly, it also competes for this traffic with Dubai – over 4,800km (3,000 miles) away – as Emirates offers easy and convenient connections between many US and Asian destinations. To emphasise the competition between airports far from each other, in 2013 Qantas shifted its transfer base for European traffic from Singapore to Dubai.

4.4 Measures of airport 'capacity' can be very misleading

Airports constantly have to deal with the problem of providing sufficient capacity. Almost inevitably they face complaints that some facility or another (e.g. the runway or security inspection) is not providing enough capacity to their clients (aircraft or passengers, as the case may be). Moreover, as air traffic continues to increase, this problem may seem endless. Dealing with a bottleneck in one part of the airport soon reveals some new constraint further along in the system.

Airport managers have to consider capacity issues carefully. There is a lot of confusion in this regard. This is because the concept of capacity for airports is problematic – as it is for transportation in general and a range of other industries. The central idea planners, designers and managers need to focus on is that the capacity of a given airport facility is not a single number that anyone can determine absolutely. In general, with few exceptions, the capacity of an airport facility depends on the way managers operate that facility.

Airport capacity: the capacity of airport facilities to fulfil their intended function to an acceptable level of service.

Lack of **airport capacity** does not mean that the clients do not obtain a service or that the system turns them away. If the capacity of the security inspection system is insufficient, this does not imply that the passengers cannot get through security. What complaints about capacity signal is that the facility does not provide an acceptable level of service (LOS), that it causes excessive delays or that it is too crowded.

Airport capacity is not an absolute quantity that can be unambiguously measured. In this respect it is not comparable to the capacity of a physical container whose volume is definite and constant. Airports provide services, so airport capacity is contingent rather than absolute. Airport capacity depends both on customer expectations and on management practices which can improve – or degrade – capacity at short notice.

Airport capacity depends on customer expectations

In practice, a prevalent definition of airport capacity corresponds to definitions of levels of service (LOS) that reflect qualitative characterisations of the service provided to passengers. A common scale for LOS runs from A (best) to F (unacceptable failure). This scale applies to both people in buildings and to highways. The LOS scale is three-dimensional. It considers crowding, ease of movement and delays. For example, the rating for people moving along a corridor indicates how close people are to each other on average, the ease of flow (steady or stop-and-go) and the delays they may incur relative to unimpeded movement. The definition of any specific LOS is inherently subjective (how else does one balance personal space and waiting time?). It also changes over time as airport experts discuss the issue and revise previous norms. Every recent new edition of the IATA *Airport Development Reference Manual* has reflected these adjustments. The one constant is that a higher LOS provides more space and better service.

The logic of the connection between airport capacity and LOS means that any facility may simultaneously be considered to be at capacity or not, depending on the point of view. A waiting lounge may be over capacity from the perspective of providing a 'good' level of service (LOS = C) but may provide enough adequate capacity (LOS = D).

The capacity rating for runways also reflects subjective judgements about LOS. Historically, the definition of the 'practical annual capacity' ('pancap') for runways was a capacity such that aircraft would not have to wait more than four minutes for take-off. This corresponded to a very high LOS. Airlines and airports now agree that they can accept a lower LOS (average wait times at busy airports indeed greatly exceed four minutes), and thus rate the capacity of runways much higher than was previously the case.

Noticeably, as regards runways, the rated capacities of any given runway system differs between the US and most of the rest of the world. This is because the usual practice in the US is to schedule aircraft to Visual Flight Rules (VFR) appropriate for good weather rather than Instrument Flight Rules (IFR) suited for low visibility, as airports do in Europe and many other countries (➤Chapter 13). VFR allows for more landings and take-offs but results in much greater delays when weather is bad. Thus, when a European airport declares its runway capacity, the figure is lower than would be acceptable in the US for an equivalent runway configuration.

Airport capacity depends on management practices

The capacity of airport facilities often depends on management practices (see Example 4.3). Specifically, capacity depends on the speed of the service, which managers can affect in many ways. This is obvious when we consider replicable units for providing service, such as the number of available passport control booths or security check lanes. If more lanes are operating, the rate of service and capacity of the system increases correspondingly (but not necessarily, for a number of reasons that require detailed analysis). Management can thus influence the capacity of the service both by providing the possibility of more service (installing appropriate booths or scanners) and – most importantly – by appropriately scheduling staff to perform the service.

Example 4.3

How operational changes alter capacity

The capacity of many facilities depends on the way they operate:

- The capacity of a car park would seem simple to estimate: count the number of spaces! But this number does not give a good indication of the motorists it can serve. This number depends on how long the cars stay in the parking area and thus the speed of the turnover. A car park with 30 spaces might serve 500 cars a day if cars only spend 15 to 30 minutes in a space.
- The capacity of runways generally decreases when larger aircraft start to use them. This is because larger aircraft create bigger wake vortices and greater separation is required between landing aircraft. Consequently, fewer aircraft can land per hour (➤Chapter 3).
- When jetBlue took over aircraft gates at Boston Logan International Airport that were formerly used by United Airlines, their capacity almost doubled. The reason was simple: jetBlue turned around aircraft in 30 minutes instead of an hour and thus served twice as many passengers per gate. The gate areas were correspondingly more crowded, but that was acceptable to passengers accustomed to and expecting low-fare airline service.

The capacity of facilities also depends on what the clients consider an acceptable LOS. This fact is a standard part of airport references. For example:

- A 'good' level of service (LOS = C) for passengers in a gate waiting area has been $1m^2$ per person. On that basis, a room of $200m^2$ would have a rated capacity of 200 persons. However, LCCs might accept an 'adequate' level of service (LOS = D) that calls for only $0.8m^2$ per person, and thus consider that the room has a capacity of 250 persons. Viewed as a VIP lounge (LOS = A or 'excellent'), the capacity of the room would be half or less.

Management can also alter capacity by changing the way staff perform operations. For example, some airlines choose not to weigh each checked-in bag. This speeds up the check-in operation and increases the capacity of a given set of check-in counters. Note in this regard that since managers can also increase capacity by scheduling more staff, they can generally choose between efficiency in operations, the number of staff assigned and, by extension, the LOS they offer to customers in terms of the time they wait and the length of the queues.

Management can alter the effective capacity of space by how they schedule customers into and out of them. For example, many airports, such as London Heathrow and Singapore, only open gate areas to passengers a short time before the flight. The practical effect is that some passengers are already boarding the aircraft while others are entering the gate lounge. The result is that passengers move through the area quickly, reducing their **dwell time**, and lowering the number of travellers in the gate area at any time. This is equivalent to increasing the capacity of the gate area in terms of the LOS that it provides.

In this connection, management practices in one part of the airport system typically have knock-on consequences for other parts of the airport. This is because airports provide their services through a sequence of processes. Thus changes to one process are likely to affect how passengers access and perceive the capacity and LOS of other processes. As a case in point, the practice of limiting passenger access to gate areas forces those who arrive early – from connecting flights or for other reasons – to wait elsewhere, often in areas with inadequate facilities.

Airlines have a most important role in defining the capacity of airport facilities. Indeed, one of the important recent innovations as regards the capacity of airport terminals has been the practice, pioneered by LCCs, of reducing the turnaround time of aircraft at their gates. Airlines typically all used to plan on taking an hour between the arrival of an aircraft at a gate and its departure for the next flight. Southwest and other LCCs reduced this turnaround time to around 25 minutes or less. They did this to increase the productivity of their aircraft – less time on the ground means more time in the air carrying passengers and earning money. They achieved this by introducing a range of practices such as having flight attendants collect garbage during the flight and at the gate. This innovation has had a significant knock-on impact on the capacity of airport terminals. Lower dwell time of aircraft at a gate increases the capacity of each gate, and thus of the terminal building as a whole, regarding the number of aircraft it can serve.

Dwell time: the typical length of time customers stay in an area waiting for service. When they leave the space, other customers can use it. The dwell time thus translates into the number of customers that can use a space per unit of time, that is, per hour or per day for example. Thus: [Customers for a space/unit time] = [1/ Dwell time].

Planning, designing and managing airport capacity

Managers need to recognise that a proper estimation of the amount of capacity to provide for the range of airport facilities and processes requires more than a technical analysis of the built environment. Importantly, a well-done, complete analysis of capacity involves an understanding of the LOS that the range of airport customers will want and need. These clients are not all the same. Some airlines and airports will want special lounges and facilities to promote their image and strengthen brand loyalty. Others may specialise in providing good 'value for money' and will prefer more economical facilities that will serve users adequately at a lower LOS. Additionally, planning, designing and managing capacity needs to recognise the importance of organisation and staffing in determining effective capacity.

Providing appropriate airport capacity is much more than a matter of creating physical facilities. Construction and equipment can provide the potential for capacity, but it can only be realised through effective management, organisation and service delivery. Airport managers should avoid the mistake of seeing construction as a solution to operational problems.

Stop and think

Why should airport managers avoid seeing construction as a solution to operational problems?

4.5 Queues are at the heart of airport operations

Queue: a number of clients waiting for service from some process. Often the persons or things in the queue actually line up in a conventional queue. More generally, they may simply have a ticket or an appointment for service, and thus may be waiting over some area, ready to present when the service is available to them.

It is useful to visualise airports as a sequence of **queues** for service. Indeed, airports provide their services through a sequence of processes. Clients present sequentially at each process, almost always wait until that process is ready to serve them, and then go through the process. For example, aircraft proceed through a series of steps: they land, taxi in and access a gate. Travellers likewise check in, pass through security and go to their gate for boarding. Queues are central to airport operations. Good management of these queues is central to providing good airport service.

Good queue management is challenging. Queues can quickly escalate and become almost unmanageable in demanding situations. Whenever requests for service near the nominal capacity of the process, queues lengthen, waiting times greatly increase and the process becomes unpredictable. The following subsections explain how queues form, describe when and why they become chaotic, and provide advice as to how to deal with them and prevent such situations from occurring, where possible.

How queues form

Queues arise because of mismatch between the arrival of customers and the capability of the process to serve them. An obvious situation occurs when customers arrive continuously while the process provides service in batches – customers filter into the boarding lounge, but the bus to take them to the remotely parked aircraft does not proceed until ready. The more general situation at airports is that both customers and the serving process are operating continuously – aircraft move into position for take-off at the end of the runway one by one, likewise passengers at the security check proceed one at a time. Continuous processes are subtler and require special attention.

Queues form in continuous situations because both the arrival of customers and the delivery of service are irregular. If each process were totally regular, like gears on a machine, then there would be no delays (so long as the process had enough capacity). Everything would run smoothly – literally like clockwork. However, what happens is that irregularities in the process mean that queues and wait times build up. Customers do not present at a constant rate: families and friends arrive together and may congregate in the check-in hall. Similarly, the service may likewise be irregular: a passport control officer may wave some travellers through, yet take a long time with another passenger. In short, queues and delays occur even when the facility has sufficient nominal capacity (see Example 4.4).

How queues escalate

Queues routinely escalate when stressed. The lines in the queue build up rapidly, leading to delays. Moreover, the overall performance becomes highly variable. Under apparently the same conditions, the system might perform reasonably well – or incur gridlock. Small, seemingly insignificant differences in the patterns of arrivals and service magnify into major changes in the length of queues and delays. This is a universal experience. You may have seen it yourself when driving: some days the traffic moves along steadily, other days incur gridlock – all it takes is a small traffic incident somewhere on the network. Managers need to

Example 4.4

How queues form

Consider a process that can serve exactly 1 customer per minute. Imagine that the actual customers arrive irregularly, on average at the rate of 1 per minute. This might lead us to think that there is enough capacity to serve the traffic and that all should proceed without delay. Actually, queues build up as this example demonstrates.

Suppose 5 customers arrive over a 5-minute period: 3 arrive at Minute 2, 2 more arrive at Minute 3. Now consider what happens:

Minute 1: no customers, no queue
Minute 2: 3 customers, 1 gets served, 2 are in queue
Minute 3: 2 more arrive, 1 gets served, 3 are in queue
Minute 4: 1 gets served, 2 are in queue
Minute 5: 1 gets served, 1 is in queue

Overall, although the system could process the customers without delay if they arrived like clockwork, 1 each minute, in this case the queue builds up to a maximum of 3 customers and the average wait time is 1.8 minutes.

understand the conditions that drive these phenomena so that they can minimise the difficulties.

A few simple terms are all that are needed to describe and understand the situation.

- The average arrival rate of customers (traditionally, λ).
- The average rate at which the process can serve customers (traditionally, μ).
- The ratio between them, the utilisation ratio ($\lambda/\mu = \rho$).

The basic phenomenon is that the average length of queue and wait time increases exponentially with the average rate of arrivals, specifically in general proportion to the multiplier $1/(1-\rho)$. What this means is that congestion and delays increase very rapidly as the utilisation ratio ρ gets close to full capacity. For example, a 5 per cent increase in utilisation from 75 per cent to 80 per cent increases the multiplier for delays from 4 to 5 [$= 1/(1-0.8)$], which means a 25 per cent increase in average delays. Small changes in the utilisation ratio lead to large increases in delays. Moreover, the effect gets far worse for higher utilisation ratios. If the utilisation rate moves 5 per cent, from 90 to 95 per cent, the multiplier goes from 10 to 20, which implies that waits increase about 100 per cent compared to the 25 per cent increase for the same change at the lower utilisation. Figure 4.1 shows the phenomenon graphically. Delays first increase gradually as the utilisation increases, and then very sharply as the utilisation ratio approaches full nominal capacity (at $\rho = 1$). This is sometimes known as the 'hockey stick' curve on account of its shape.

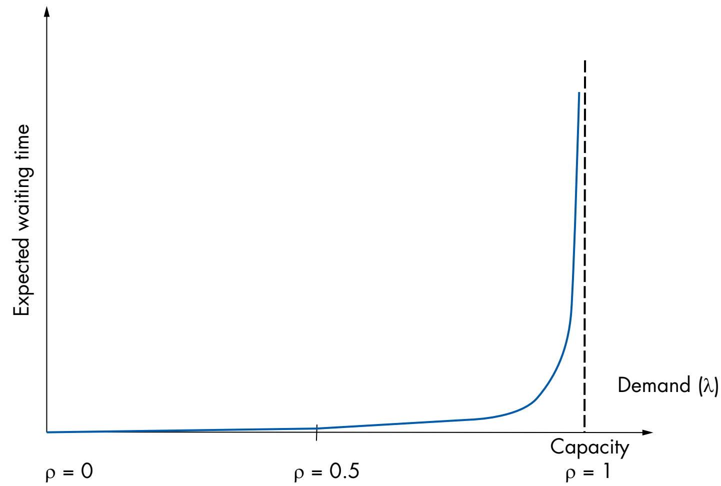

Figure 4.1 Relationship between utilisation ratio and expected waiting time

Additionally, when utilisation is close to capacity, the queuing process becomes unstable and unreliable. This is because the variability of the process also increases in proportion to the $1/(1-\rho)$ multiplier (technically, it is the variance of the delays that follow this pattern, which is the square of the standard deviation). As a practical matter, what this means is that neither customers nor managers can count on the system performance. An average delay of 20 minutes at a security check might some days be 10 minutes, but 40 minutes on others. This variability makes it very difficult to schedule activities. In simple terms, the inevitable unreliability of queues under stress can cause chaos (see Case Study 4.2).

Queues manifest themselves too late

Queuing processes exhibit another feature that can confuse managers. The long lines and delays build up over time, so that the problem becomes most evident long after it really started. In this sense, the problem is rather like a disease that incubates. The factor that triggers the problem, such as an increase in arrivals that increases the utilisation ratio to a disruptive level, occurs quite some time before the peak length of queues.

The practical implication of this reality is that managers should deal with the problem before it peaks. If they wait until the problem is self-evident, they will have acted too late to make the most difference. For example, they should call in extra staff for security checkpoints well before the queues are excessive. To do this effectively, managers need to monitor their processes for signals that will alert them early on to take countermeasures against conditions that can create long lines and excessive waiting times, severely degrade the LOS and thereby lower the effective capacity of the airport process and of the entire airport through knock-on effects.

CASE STUDY 4.2

AUTOMATED BAG SYSTEM AT DENVER INTERNATIONAL AIRPORT

The design of the automated bag system at Denver was a management disaster. Technically, it did not deliver the capacity and reliability as intended, largely due to a failure to understand queuing systems. It cost US$500 million due to monthly carrying charges on the original investment at about US$30 million over 17 months of delay.

The nominal capacity of the system was originally estimated at 4,000 bags per hour. It consisted of carts running on tracks through a network of tracks with multiple access and exit points to serve many loading and unloading stations. Each of these processes offered opportunities for queues and consequent delays.

According to informal advice from the station manager for the operations, the system could never deliver more than about 40 per cent of the nominal capacity. Beyond that amount, the overall average delays grew rapidly and the system became excessively unreliable – what was fine one day would lead to gridlock on another. Because Denver operates as a transfer hub at which it is essential that bags make the connecting flights with their owners, high reliability is essential. Managers could only achieve this by operating the system at a fraction of its nominal capacity.

The operators abandoned the automated system ten years after its 1995 opening.

The unreliable performance and the inability to operate near the rated capacity were quite predictable. All it took was an understanding of how queues behave, especially under stress.

Guidelines for managing queues

Simple guidelines for dealing with queuing processes for airport managers, planners and designers are:

- Recognise that the rated capacity of a facility, as estimated by multiplying its average rate of service (such as bags per minute), is not a good indication of actual performance. The system will only be capable of delivering acceptable, reliable service at a fraction of its rated service (see Case Study 4.2).
- Queuing processes are highly sensitive to the utilisation ratio. Managers face a trade-off between capacity utilisation and acceptable levels of service in terms of queue length, wait times and reliability. Greater utilisation degrades LOS.
- Early action on staff levels is an important way to prevent, or at least to minimise, the worst operational conditions.

Stop and think

Are queues an inevitable consequence of airport systems planning?

!

Key points

- Aviation and airport forecasts are 'always' wrong in that the continuing turbulence in the airline/airport industry means that what actually occurs differs, often substantially, from original predictions..
- Due to the uncertainty of forecasts, there is a need for flexibility in design, as a way of enabling easy adaptation to actual future situations.
- There is a need for a comprehensive systems view of airports and the competition between them.
- Measures of capacity at airports are not absolute but depend both on the details of operations (especially for runways) and on differing judgements concerning acceptable levels of service.
- The inherent instability of queues under peak loads drastically reduces the acceptable maximum capacity of operations.

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CHAPTER 5

Airport management and performance

Anne Graham

LEARNING OUTCOMES

- To identify the principles of airport management.
- To understand the importance and challenges associated with measuring airport performance.
- To appreciate the changing airport operating environment as it relates to privatisation, regulation and competition.
- To define performance metrics that can be used to measure key areas of airport operations and management.
- To evaluate mechanisms for managing scarce runway capacity.
- To assess future airport management and performance challenges.

5.0 Introduction

Airport operators provide the infrastructure, facilities and services that allow aircraft to take off and land safely and efficiently and which enable passengers and cargo to transfer between surface and air modes of transport. They increasingly also offer a broad variety of commercial facilities to satisfy the needs of passengers, employees and visitors and to generate additional revenue by, for example, selling products and services to other airports overseas. Airports bring together a wide range of different organisations and companies, including airlines, air traffic control (ATC) providers, ground handling companies, government agencies and commercial concessionaires in order to perform their role as an essential component of the air transport system.

The aim of this chapter is to identify the principles of airport management and understand the different metrics or standards of measurement that can be used to assess airport performance. The chapter begins by considering the contemporary operating environment for airports. This is followed by an examination of the key performance areas of airfield operations, financial management and service quality. A major issue for many airport operators is the management of scarce runway capacity, and this is discussed in Section 5.3. The chapter concludes by assessing future challenges for airport management and performance.

5.1 Airport ownership and the changing operating environment

An airport operator has overall control and responsibility for the airport, even though the number of services and facilities that it provides directly can vary significantly. In the US, for example, the airport operator has more of a landlord role, with airlines, government agencies and others supplying most of the essential activities. In extreme cases, individual airlines actually operate their own terminals, as at New York's John F. Kennedy Airport. By contrast, in Europe, the airport operator is often more actively involved in the provision of services and may directly provide security, ground handling or ATC.

Historically, nearly all airports were government-owned, either at a national or local level. However, in the last couple of decades, there has been a trend towards shifting airport ownership and/or management into the private sector or to a private–public partnership. The reasons for this vary, although most often it is to improve efficiency and financial performance and/or to provide new funds for investment or access to capital markets. Table 5.1 provides a list of the most common reasons for airport privatisation.

There are different types of privatisation models, ranging from the sale of part or all of the airport to investors on the stock exchange, as is the case with a number of European airports, including Frankfurt and Paris Charles de Gaulle, to handing over ownership (or long-term leases) of the airport to a **consortium** of investors, as with the major airports in Australia, Rome and Brussels, or allowing a consortium to operate the airport as a concession for a limited period, typically 20–30 years. This latter option is especially popular when the

Consortium: a group consisting of several different companies.

Table 5.1 Reasons for airport privatisation

- To improve efficiency and/or financial performance.
- To provide new airport investment funds and/or access to capital markets.
- To bring financial gains to the government and/or remove the financial burden of operating the airport.
- To lessen government influence in airport operations.
- To improve airport service quality.
- To enhance airport management effectiveness.
- To allow diversification into new non-aeronautical areas.
- To encourage more competition.

government wants to maintain ownership of the airport for strategic reasons but recognises the need to bring in the private sector to provide investment and management expertise. Examples here include some of the major airports in India, Brazil (see Case Study 5.1) and other South American countries. North America is unusual in this respect as virtually all US airports remain in local public ownership, and in Canada the major airports are operated by local state-owned not-for-profit organisations.

CASE STUDY 5.1

PRIVATISATION OF BRAZILIAN AIRPORTS

Brazil has over 2,000 airfields and, until recently, all the main airports were managed by the state-owned Infraero organisation. However, the rapid expansion of the Brazilian economy, together with the selection to host the football World Cup in 2014 and the summer Olympic Games in 2016, necessitated urgent modernisation and expansion of airport infrastructure to cope with anticipated traffic growth and these special events. The three major international airports, São Paulo–Guarulhos (the main international gateway to Brazil and the largest airport in Latin America), São Paulo Viracopos/Campinas International Airport (São Paulo's third airport and a major cargo hub) and Brasília (serving the capital), were partially privatised in 2012 as concessions, with Infraero maintaining a 49 per cent share in each. The time periods for the concessions range from 20 to 30 years. These three airports together handle around a third of all the passenger traffic in Brazil. A different consortium was chosen to run each airport, with one including the airport company Airports Company South Africa (ACSA), which had previous experience of handling Olympic traffic. Subsequently, Rio de Janeiro's Galeão International Airport and Belo Horizonte's Confins Airport were privatised in a similar manner in 2013 with concessions of 25 and 30 years respectively. Changi (Singapore) Airport has involvement with the Rio consortium, while Munich and Zürich airports belong to the winning consortium for the Belo Horizonte airport concession.

By nature of their complex role in meeting the needs of airlines, passengers and other stakeholders, airports are subject to regulation globally (with regulation set by the International Civil Aviation Organization (ICAO)), regionally (e.g. the EU) and nationally (e.g. the US Federal Aviation Authority (FAA). Many of these regulations relate to the operational, safety and security aspects of managing an airport. There are other areas such as the protection of employees and passengers (e.g. regulations relating to passengers with reduced mobility (PRMs)), and airports are also increasingly subject to stringent environmental regulations, primarily due to the noise and air quality impacts that they produce (➤Chapter 17). This includes restrictions on noisy aircraft or night-time flying. Within the EU, examples include directives relating to the introduction of noise-related operating restrictions (Directive 2002/30/EC) and the assessment and management of environmental noise (Directive 2002/49/EC).

One major aspect of airport regulation is economic regulation, which is used to modify or control the behaviour of stakeholders involved in the delivery of the airport product. This primarily covers prices, the supply of services, and market entry and/or exit. The regulation of airport prices (through charges or fees) and slots are two key areas which will be discussed below. However, there are others that can be considered. In the EU, for example, ground

Monopoly supplier: a single company that supplies a particular product.

Price cap: a form of airport economic regulation that sets a cap or limit on the price that airport operators can charge.

RPI +/– X: the price cap typically used with airport regulation, where RPI is the retail price index and X is the efficiency factor (sometimes the consumer price index (CPI) rather than RPI is used).

Regulatory till: the airport facilities and services, and the cost and revenue allocation processes, which are considered in the airport economic regulation process.

Airport use agreement: a legally binding contract which detail the fees and rental rates an airline has to pay, the method by which they are calculated and the conditions of use of airport facilities.

handling services have been regulated since 1996 in order to encourage a more competitive environment by preventing **monopoly suppliers** at all but the smallest airports.

With regards to airport charges there are again different levels of regulation. At the global level there are ICAO principles that state that the charges should be non-discriminatory, cost-related and transparent (ICAO 2012). These must be incorporated into any national regulation. Within Europe there is an extra level of regulation with respect to charges which was introduced in 2011 and covers all airports serving more than 5 million passengers (EC 2009). This builds on ICAO principles and includes additional features, such as the mandatory consultation and swapping of information between airports and airlines, and the requirement to have an independent supervisory or regulatory body.

At a national level, the amount of regulation concerning airport charges varies considerably. For some airports, typically those under public sector ownership, it may be a national government's responsibility to set charges or approve those set by the airport operator. In different cases, usually with smaller and often privately owned airports, there may be no specific state control. At the other extreme, there may be formal economic regulation, which typically occurs at relatively large airports, especially when they have been privatised. In this case, the types of regulation vary from so-called 'heavy-handed' approaches either when the regulator permits an airport operator to earn enough revenue to cover its costs and make a profit (rate of return or cost-based methods), which is comparatively rare but occurs, for example, at Amsterdam Airport Schiphol; or alternatively when there is incentive regulation, which is more focused on encouraging efficiency, with a **price cap** on the charges. The price cap is typically defined as **RPI +/– X**. This is a more popular practice and is used, for instance, at London Heathrow, Paris Orly and Dublin as well as the major airports of India, Mexico and South Africa.

In setting the economic regulatory control, the **regulatory till** has to be established. Usually this involves deciding whether a 'single till' approach is used, when all airport revenues are considered in setting the charges, or whether a 'dual till' is adopted, in which the aeronautical and commercial aspects of airport operations are treated separately. There are also 'hybrid tills' which fall in between these two arrangements. In the US, there are 'residual' and 'compensatory' approaches which have some similarities to these two tills. The actual US regulatory system is significantly different to elsewhere, with charges predominantly depending on detailed conditions relating to revenues and funding, which are laid out in federal law and in **airport use agreements** with airlines, rather than having the involvement of a specific regulatory body.

Some countries adopt a 'lighter touch' approach to the regulation of airport charges with price monitoring. Here, it is the threat of regulation rather than actual regulation that is used. In this case, if airports and airlines cannot reach an agreement over charges, or if the airport operator is considered to be acting anti-competitively, the regulator will intervene, but otherwise no control will be exercised. Successful examples of this type of regulatory regime can be seen at the major Australian airports (see Case Study 5.2) and Copenhagen Airport. Most recently at London Gatwick, the airport operator introduced its so-called 'contracts and commitments' initiative which involved agreeing a series of commitments with its airlines on price, service conditions and investment. With a few airlines (including Emirates, Norwegian and Thomson), the operator integrated these commitments into bespoke formal contracts. This had an influence on the regulator's decision in 2014 to shift the regulatory system from heavy-handed to a more light-handed, price-monitoring approach.

CASE STUDY 5.2

REGULATION OF AUSTRALIAN AIRPORTS

When the major Australian airports were privatised in the late 1990s, a regulatory framework with a price cap and a dual till was established, with a regulatory review every five years. However, after a few years of volatile airport profits, this form of price regulation was identified as causing a number of problems – not least the requirement of detailed and cumbersome regulatory intervention if investment was planned. As a result, in 2001, price regulation was temporarily suspended, and then this was subsequently made permanent with a shift to a light-handed regulation system. This situation has periodically been reviewed by the Australian Productivity Commission, but it remains largely unchanged. As a consequence, a number of airlines have formed longer-term agreements with the airports concerning airport charges.

Economic regulation needs to be considered alongside airport competition because economic regulation is primarily introduced when it is considered that there are insufficient competitive forces to ensure that airports do not abuse their market power (such as an ability to raise prices above what would prevail under competition). The amount and nature of competition vary from airport to airport. Table 5.2 identifies the different ways in which an airport can commonly compete.

The weakest competition tends to exist when airports possess a unique catchment area, particularly if they are located on an island or in a remote location (➤Chapter 20). Regulatory or operational constraints may also limit the effective competition, for example if an airport cannot offer long-haul services because of a lack of traffic rights or insufficient runway length. However, air service liberalisation combined with the development of commercially oriented and increasingly privately run airlines and airports means it has been argued that light-touch regulation, or even just normal competition law, is now the most effective way forward for airport economic regulation. This approach would eliminate the direct administrative and indirect market distortion costs associated with more heavy-handed approaches.

Table 5.2 Types of airport competition

Nature of competition	*Example*
Shared local market in an urban situation	New York, Washington, London
Shared local market in a regional situation	Regional airports
Transfer traffic	Amsterdam, Singapore
Destination traffic	Tourism resorts, cruise embarkation points
Cargo traffic	Hong Kong, Dubai
Other transport modes	High-speed rail
Commercial facilities	Shopping malls, airline on-board sales

Stop and think

What are the advantages and disadvantages of airport privatisation for airports, airlines and passengers?

5.2 Airport performance

Faced with this increasingly competitive environment, and combined with growing pressures on both physical and financial resources, it has become more important than ever for airports to effectively measure their performance. This task is challenging owing to the complex nature of airports with many different facilities and processes and because of the existence of many different organisations which collectively enable an airport to function. Traditionally these issues have meant that airports have monitored their own performance and have been cautious about benchmarking themselves against others since each airport tends to be unique in the way it organises its operations. However, there does seem to be greater acceptance now that the benefits gained through the careful measuring of peer performance outweigh the shortcomings associated with less-than-perfect comparable data.

Performance can be measured against many aspects of airport management. Three key areas – airfield operations, financial management and the provision of service quality – are considered here. This is not an exhaustive list, and other areas of performance such as human resources, information technology, maintenance and planning/construction can be considered (Hazel *et al.* 2011). One area which has received increasing attention is environmental performance, where airports have been measuring performance in areas such as their carbon footprint, energy use, waste recycling and the use of public transport (➤Chapter 17).

As an airport's primary function is to support airlines and their passengers and cargo in departing to, and arriving at, their chosen destination, the broadest indication of an airport's performance can be assessed by looking at the number of aircraft movements, the passenger throughput, and the cargo which is loaded and unloaded. Table 5.3 presents the top ten airports in the world according to these three measures in 2013. While Atlanta has maintained its position as the world's largest airport in terms of passenger numbers for many years, it has begun to be challenged by a growing number of airports outside of Europe and North America. These airports include Beijing, Dubai and Jakarta (Soekarno–Hatta) – the latter two being in the top ten for the first time only in 2012. In terms of cargo, Memphis (the hub of FedEx) has lost its top position to Hong Kong, and other airports including Shanghai, Seoul Incheon and Dubai have seen their cargo volumes grow considerably in recent years. However, with regards to movements, the US still dominates, since the average aircraft size is smaller due to competitive pressures, shorter sectors and the dependence on domestic traffic.

Table 5.3 Traffic at the top ten airports, 2013

Passengers	*(Millions)*	*Cargo*	*('000s tonnes)*	*Movements*	*('000s)*
Atlanta	94,431	Hong Kong	4,166	Atlanta	911
Beijing	83,712	Memphis	4,138	Chicago ORD	883
London LHR	72,368	Shanghai	2,929	Los Angeles	696
Tokyo HND	68,907	Incheon	2,464	Dallas/FW	678
Chicago	66,777	Dubai	2,436	Denver	583
Los Angeles	66,668	Anchorage	2,421	Beijing	587
Dubai	66,432	Louisville	2,216	Charlotte	558
Paris CDG	62,053	Frankfurt	2,094	Las Vegas	521
Dallas/FW	60,471	Paris CDG	2,069	Houston	497
Jakarta	60,137	Tokyo NRT	2,020	Paris CDG	478

Source: ACI (2014)

Airfield operations

When looking at airfield operational performance, there are a wide range of different features that need to be considered. These include the number, length and configuration of runways; ATC services; instrument landing systems (ILSs); lighting and weather monitoring systems; ramp and apron space allocation; stand and gate provision; and fire, rescue and policing/security services. Taking these into account, there are many factors that will have an influence on the airport operator's ability to effectively handle inbound and outbound aircraft movements. Many of these are related to the critical functions of safety and security. These include the ability to cope with runway accidents and incursions (e.g. an occurrence on the ground that involves an aircraft, vehicle, person or foreign object) and to implement successful wildlife (usually airborne animals such as birds and bats) hazard management, emergency responses and bad weather operations (typically for snow and ice but also for hurricanes and thunderstorms).

Airport finance and productivity

Measuring the financial performance of an airport is also important, especially given the increased commercial focus of many airport operators. While there are standard generic financial measures – including profit measures such as earnings before interest and tax (EBIT) and earnings before interest, tax, depreciation and amortisation (EBITDA) – some of the unique characteristics of the airport industry necessitate specially defined measures. Typically this involves considering financial ratios that relate certain costs or revenues to aircraft movements, passenger or cargo volume – or a combination of these as with the **work load unit (WLU)**. With regards to cost, it is also essential to know the comparative importance of labour, capital and other inputs, especially given the relative capital intensity of the airport sector.

Work load unit (WLU): an airport traffic output measure which is equivalent to one passenger or 100kg of cargo.

Aeronautical revenue: revenue derived from aviation-related activity in the form of landing fees, aircraft parking fees, passenger handling charges and freight handling.

Non-aeronautical revenue: revenue derived from retail space, car parking, rents and leases. Non-aeronautical revenue is also sometimes termed 'commercial revenue'.

For revenues, the most useful distinction is made by dividing them into **aeronautical revenue** and **non-aeronautical revenue** (commercial) sources. Aeronautical sources include all the revenues generated from airline activities such as the landing charge (usually based on the weight of the aircraft), the passenger charge (based on passenger throughput) and the aircraft parking charge (usually based on aircraft weight or wingspan). Ground handling revenues will also be included if the airport operator directly provides this service. The commercial or non-aeronautical revenues are from commercial facilities such as retail, food and beverage outlets (which are usually outsourced, with a percentage of income being paid to the airport operator), car parking, car hire, advertising and rents (➤Chapter 6). Further disaggregation of these revenues, particularly in the commercial area (e.g. different types of retail revenues as well as different sales per square metre) is common practice when assessing performance.

Airport service quality

The quality of service that an airport provides is another key performance aspect that needs to be evaluated. The actual service delivery can be measured objectively and some operational performance metrics for the airfield area, including taxi time and gate delays, could arguably be included here. Typically, within the terminal, the service delivery measures will relate to queue lengths and waiting time at check-in, security, border control and baggage delivery times, and check-in to gate time. However, some of the more intangible aspects of service quality cannot be measured in this way, and moreover these objective measures are unable to assess passenger expectations and perceptions. Hence many airports use performance measures gathered through passenger surveys related to passenger satisfaction as well. Such feedback can be divided into different areas, including the essential processes where passengers will be asked to comment on issues commonly relating to queuing, staff helpfulness, waiting and crowding. Commercial and other terminal facilities are also usually considered when questions may be asked about seat availability, comfort, temperature and value for money. Other popular areas include wayfinding, cleanliness and availability of flight information. Many airport operators undertake their own passenger surveys to gather this feedback and/or they participate in cross-airport studies, such as those undertaken by the Airports Council International (ACI) (see Example 5.1).

Performance measures

Table 5.4 presents ten key performance measures for each of these three performance areas. These are illustrative of core indicators which can be included in an overall system of airport performance measurement. These will typically cover specific services and facilities and contain more detailed and disaggregated information.

Example 5.1

ACI's airport service quality (ASQ) survey

ACI undertakes the largest global study of airport service quality. This covers nearly 300 airports in over 80 countries and involves over 550,000 interviews. In 2015, 41 airports in North America, 34 in Latin America and the Caribbean, 17 in Africa, 10 in the Middle East, 75 in Asia-Pacific and 113 in Europe participated. The survey covers 34 service quality areas including access, check-in, security, airport facilities, food and beverage, and retail. It involves a passenger self-completion questionnaire which is distributed at the departure gates, and a minimum of 1,400 passengers per year are selected to participate at each airport. In 2015, Seoul Incheon and Singapore achieved the highest scores for airports with over 40 million passengers, Mumbai and New Delhi for airports with 25–40 million passengers, Seoul Gimpo for 15–25 million passengers, Sanya Phoenix in China for 5–15 million passengers and Jaipur for 2–5 million passengers (ACI 2016).

Table 5.4 Examples of performance measures

Airport operations

- Runway accidents per thousand movements.
- Runway incursions per thousand movements.
- Public injuries per thousand passengers.
- Employee injuries per thousand hours worked.
- Average emergency response time.
- Wildlife/bird strikes per thousand movements.
- Average gate departure delay per flight in minutes.
- Average time to taxi from gate to runway.
- Average time to clear runway of snow and ice.
- Number of airport closures due to adverse weather.

Airport finance

- Labour cost per passenger (or WLU).
- Capital cost per passenger (or WLU).
- Total cost per passenger (or WLU).
- Passengers per employee.
- Aeronautical revenue per passenger (or movement).
- Non-aeronautical revenue per passenger.
- Non-aeronautical revenue as percentage of total revenue.
- Profit per passenger (or WLU).
- Profit margin (profit as percentage of total revenue).
- Return on net assets (profit as percentage of net assets).

Table 5.4 continued

Airport service quality

- Queue lengths at check-in, security, border control.
- Waiting time at check-in, security, border control.
- Baggage delivery time (first and last bag).
- Average time from check-in to gate.
- Overall passenger satisfaction with the airport.
- Passenger satisfaction with processes.
- Passenger satisfaction with commercial and other facilities.
- Passenger satisfaction with wayfinding.
- Passenger satisfaction with flight information.
- Passenger satisfaction with cleanliness.

Stop and think

How can airport performance be measured, and what are the relative merits of each approach?

5.3 Managing runway capacity

One of the most critical areas of performance concerns the airport operator's ability to effectively match demand for airport services with the available capacity. This role has become more and more difficult in recent years as air traffic has continued to grow faster than the available supply at many major airports, primarily due to environmental, physical or financial constraints involved with providing new or expanded capacity. While capacity constraints can occur at many places in the airport, including terminals and gates, arguably the most challenging area to manage concerns is the runway.

A pricing mechanism is often used to ration demand when there is a shortage of supply. However, even though a few airports have adopted some form of peak pricing, the differential between the peak and off-peak prices, as well as the actual level of peak charges, is insufficient to significantly influence airline demand and 'clear the market' at peak times. This is particularly due to the fact that airline scheduling is complex, and that airport charges often only make a small contribution to total costs, which results in airlines being fairly inelastic to changes in the charges.

So, in the absence of the use of an effective pricing mechanism to balance supply and demand, an administrative system for allocating slots has evolved. These slots are scheduling slots, which are different from the actual operational take-off and landing time slots that are assigned to the airline by the air traffic controllers. There are three types of airports that have to be considered. First there are level 1 airports, where there is plenty of runway capacity and gaining an airport slot at a certain time is not a problem. Then there are level 2 or schedule facilitated airports, where demand is approaching capacity but where slot allocation can be resolved through voluntary cooperation. Lastly, there are fully coordinated level 3 airports, where demand exceeds capacity and formal administrative procedures have to be used to allocate slots.

The allocation of slots at level 2 and 3 airports is dealt with by the International Air Transport Association (IATA) scheduling committees and slot conferences. Within this slot allocation process, the most important feature is the principle of grandfather rights, which means that if an airline operated a slot in the previous season it has the right to operate it again. This is as long as it meets the slot retention requirements or so-called 'use it or lose it' rule, which states that the airline must operate at least 80 per cent of the flights associated with the slot. There are also lower-priority rules that apply which relate to giving preference to services for a longer time period, and to those which balance different types of services or markets at airports (IATA 2014).

Within the EU, slot allocation comes under the 1993 regulation EU/95/93 (EC 1993). These EU rules are a legal requirement, while the IATA coordination system is voluntary. The EU regulation retains the principle of grandfather rights but has introduced new concepts such as encouraging new entrants and financially independent coordinators. Over the last decade, the regulation has been revised with the aim of making it more effective, but doubts still remain as to whether the processes it requires are the best to manage the scarcity in slots or to encourage competition. It certainly provides a stable environment for airlines and other stakeholders, but it is administratively burdensome and has encouraged inefficiencies, such as airlines flying uneconomic operations in order to preserve slots (so-called 'babysitting' slots) and not making full use of them. Hence, there has been considerable debate as to whether there are any alternative systems which would be more suitable. The options discussed broadly fit into two categories: first, maintaining an administrative system but changing the rules; and second, introducing some sort of market mechanism.

Within a reformed administrative system, priority could be given to different types of airlines rather than retaining the grandfather rights principle. For example, priority could be given to long-haul flights that normally have less flexibility in scheduling, or to those where there is no surface access option. Alternatively, flights that have a smaller noise or emissions impact could be favoured, or airlines using larger aircraft could be chosen. Priority could be given to scheduled flights over charter flights, passenger flights over cargo flights, or new entrants could be given greater opportunities to gain slots. Another option could be to cap frequencies to a certain destination once a set threshold has been reached.

However, it has been argued that, even with a new set of administrative rules, the mechanism will still share the shortcomings of the traditional system in not ensuring that the slots will be used by the airlines who value them the most. This can only be achieved by using a pricing mechanism. Here consideration needs to be given to both primary allocation, when the slots are initially allocated, and secondary allocation, when the use of slots may be subsequently changed. For primary allocation, prices could be set for slots with very high 'market-clearing' values in the peak – much higher than any of the current peak charges at airports. Another option could be to use auctions to allocate the slots. Both these systems should theoretically provide for better use of the runway but may be detrimental to airline competition as they will tend to favour the airlines with the greatest market power. In practice, they could also be disruptive to airline schedules, and a major issue of concern would be who should benefit from the money paid through the high charges or auctions.

With regards to secondary trading, in the 1993 regulation slot exchanges were permitted, but slot trading was not specifically allowed or banned. There are provisions in proposed new legislation for the clear acceptance of secondary trading, and the new EU aviation strategy (published December 2015) called for this revised regulation to be adopted swiftly. However, at some airports, notably London Heathrow where capacity has become more and more scarce in recent years, slot trading has become accepted practice already. Indeed it was estimated that in 2010 the value of a slot pair was £30–40 million for pre-0900 arrivals and £10 million for 0900–1300 arrivals, with over 400 weekly slots being traded (Steer Davies Gleave 2011). The only other area outside of Europe which has experienced slot trading is the US, which has a different slot allocation process (see Case Study 5.3).

CASE STUDY 5.3

SLOT ALLOCATION IN THE US

In the US, there is generally no formal slot allocation process as this would be in conflict with US antitrust laws, which prevent predatory acts and anticompetitive behaviour. Instead, in most cases there is open access to the airports, with a first come, first served system. Airlines design their schedules independently by taking into account any expected delays, but when many flights are scheduled around the same time there can be considerable congestion. The exception has been at the so-called 'high-density' airports of New York, Chicago O'Hare and Washington Reagan National.

Since 1969, the airlines at these airports have been given antitrust immunity to discuss their schedule coordination. In 1985, due to increasing traffic, slot trading was allowed at these airports. However, criticism of this system led to the allocation rules for high-density airports being withdrawn in 2002 at Chicago O'Hare (also due to the additional of new capacity) and in 2007 for the New York airports. In the latter case, both as a result of anticipating congestion (LaGuardia) and actual experience of severe delays (JFK and Newark), temporary slot control had to be introduced, which involved a cap on the number of slots, a minimum 80 per cent use requirement and permission for secondary trading through leases but not on a permanent basis. To replace these temporary controls, auctioning of 10 per cent of slots was planned in 2009 but abandoned after fierce opposition, particularly from the airlines. Therefore, these temporary rules have been extended, although there are plans to introduce a more permanent 'slot management and transparency rule' which would continue to control slots but also establish a secondary market for US and foreign airlines.

Stop and think

Why has it proved difficult to implement a pricing mechanism for allocating runway slots?

5.4 Future challenges

The changing airport operating environment has undoubtedly brought major challenges for airports as they strive to optimise their performance in all aspects of airport operations. One of the major reasons for these challenges has been the enhanced competitive pressures from airline deregulation (➤Chapter 2) and airport privatisation, together with increased demands for a more sustainable, secure and quality-conscious industry. A key issue for airports is how to effectively serve increasingly diverse airlines and passengers. This has meant that, at many airports, the concept of 'one-size-fits-all' has been replaced with greater flexibility and adaptability, and a growing focus on providing facilities and services to suit the different needs of customers.

For instance, this may well involve focusing on being a hub and ensuring that the minimum connection time (MCT) is as short as possible and that reliable transfer facilities are always on offer. At large international airports, operators may be required to group alliance members together so that the airlines can achieve cost economies, coupled with brand and operational benefits (e.g. at London Heathrow, BA/oneworld members are handled in Terminals 3 and 5; SkyTeam in Terminal 4; Star Alliance in Terminal 2). This can be operationally demanding, especially if the airport was designed with terminals for different types of domestic, international and intercontinental traffic. At the other extreme, the airport may make available specialist facilities for low-cost carriers (LCCs) to meet their demand for a cheaper and simpler product. For instance, there are LCC terminals at the airports of Kuala Lumpur, Kansai, Bordeaux and Marseilles, and LCC terminal/gate facilities at Amsterdam and Copenhagen airports. Such developments have major impacts on airport physical performance and have important consequences for other key performance metrics, for example those related to the level and mix of aeronautical and commercial revenues.

Example 5.2
Airport Collaborative Decision Making (A-CDM)

A-CDM is a European initiative that aims to improve the overall efficiency of operations at an airport, with a particular focus on the aircraft turnaround and pre-departure sequencing process. This is achieved by the real-time sharing of operational data and information between the key stakeholders, such as airport operators, airlines, ATC and handling agents. Its goal is to optimise the interactions between these organisations and to lead to better punctuality, for example by reducing taxiing time. Munich, Brussels and Paris Charles de Gaulle airports were the first to become A-CDM compliant in 2011. In 2014, a further 14 European airports were using A-CDM, and many more have plans to implement it in the future.

Technological developments offer many opportunities for enhancing performance in the future. A good example for airfield operations is Airport Collaborative Decision Making (A-CDM) (see Example 5.2). In addition, within the terminal area there is considerable scope for technological improvements to be made to essential processes such as check-in, security and border control. These can potentially reduce airport costs and allow for the terminal space to be used more effectively, while at the same time providing a better quality, simpler and quicker passenger experience. Particularly in the security area, there has been considerable discussion concerning the use of biometrics and more effective data sharing technology for risk-based security processes. A relevant example in the US is called TSA Pre✓®, where modern technology is used to allow certain members of airline frequent flyer programmes and US Customs and Border Protection (CBP) Trusted Traveler Programs, and any US citizen who applies to the programme and is evaluated to represent a low risk, to receive a known traveller number and expedited security screening benefits at over 130 US airports. Globally IATA and ACI are collaborating in a so-called 'Smart Security' project (see Case Study 5.4).

CASE STUDY 5.4

THE SMART SECURITY (SMARTS) PROJECT

In 2013, IATA and ACI agreed on a joint project called Smart Security, which is supported by ICAO. This recognises that the current security model is no longer sustainable in the light of traffic growth, evolving security threats, and passengers' increasing dissatisfaction with queues and intrusive screening measures. Smart Security aims to strengthen security by focusing resources where the risk is greatest and making full use of existing and future technologies. It plans to increase operational efficiency by maximising space, staff and other resource utilisation and reducing the cost per passenger. At the same time, it has the goal of improving the passenger experience by reducing queues and waiting times, and using technology for less intrusive and time-consuming security screening. Areas under consideration include behaviour analysis of passengers, passenger security scanners, cabin baggage screening, centralised image processing, explosive trace detection, lane design and automation, and checkpoint real-time monitoring. Tests have already been conducted of the individual components of this project at airports such as Geneva, Amsterdam, London Heathrow and London Gatwick.

New technology also offers opportunities to improve service quality and the passenger experience in other areas, with product features such as remote and self-service check-in, electronic bag tags, electronic boarding gates and self-service transfers set to become the norm. Social media and smartphone developments have the potential to improve flight status and wayfinding information and to increase the attractiveness of the commercial offer for passengers, while at the same time providing opportunities for enhancing the airport's financial performance in non-aeronautical areas.

Stop and think

What are the future challenges facing airport operators in terms of airport management and performance?

Key points

- Airports are arguably the most complex element of the air transport system because they bring together many different facilities and processes, many of which are provided by different organisations.
- Measuring airport performance is crucial in ensuring airports function efficiently, yet this can be a very challenging task.
- Increased privatisation, economic regulation and competition have placed increased emphasis on airport performance and management.
- A key area of performance relates to managing scarce runway capacity, but major uncertainties still exist regarding the optimal slot allocation mechanism.
- Airports may be able to enhance their future performance by focusing more clearly on the specific needs of their customers and harnessing the potential provided by new technology.

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CHAPTER 6

The airport–airline relationship

Ian Humphreys and Graham Francis

LEARNING OUTCOMES

- To describe what is meant by the airport–airline relationship.
- To discuss the factors that affect the airport–airline relationship and the complexities that are involved.
- To understand how and why the airport–airline relationship has evolved.
- To appreciate airport and airline perspectives of the airport–airline relationship.

6.0 Introduction

The airport–airline relationship describes the formal agreements, business arrangements and daily interactions that exist between airports and the airlines that operate from them. These relationships are necessary from an operational perspective. Airports are dependent on airlines deciding to operate services from their facility, as without them they have no passengers or freight and no means through which to realise their market potential. Airlines, in turn, depend on airports to provide safe and secure facilities that can serve the needs of their passengers and aircraft, at a convenient location, at the required time and at the right price. Yet, despite the mutual dependency that exists between them, and airports' and airlines' shared aim to enhance customer satisfaction and the passenger experience, the airport–airline relationship is highly competitive. The different commercial objectives and priorities of airports and airlines may not always align. Airports need to optimise the use of their assets and maximise the revenues they can derive from airlines and their passengers, while highly mobile airline operators, particularly low-cost carriers

Airport charges: the fees levied on airline operators by the airport. These include landing fees and passenger handling charges.

(LCCs), can and do relocate to other airports to take advantage of more favourable financial terms and lower **airport charges**.

Given the operational and financial importance of the relationships to both airports and airlines, this chapter examines the scope and changing nature of the interaction between airports and airlines. In particular, the growth of LCCs (➤Chapter 7) and the development of global airline alliances (➤Chapter 9) have changed the nature of the airport–airline relationship and necessitated new approaches to airport charges and airport terminal design and configuration. This chapter examines the complexities of the airport–airline relationship, discusses how and why it has evolved, and details how it might be managed for the benefit of both airports and airlines.

6.1 The airport–airline relationship

The nature of the relationship between individual airports and their airline partners differs according to geographic, political and commercial contexts. A major hub airport, for example, may have over 80 full service network carriers (FSNCs) operating into it year round, while a secondary regional airport may only be served by a limited number of low-cost, charter or regional airlines (➤Chapter 7) at certain times of the year. Worldwide, airports and airlines are subject to different national regulatory regimes and degrees of government intervention, with some countries pursuing a more liberalised aviation policy while others are more protectionist. Different airport and airline ownership patterns and levels of local competition also affect the nature of the relationship. The main factors which influence the nature of the airport–airline relationship can be identified as:

Privatisation: the full or part change of ownership from the public to private sector.

Commercialisation: the imposition of commercial objectives on an organisation. Commercialisation can occur under public or private ownership.

- the extent of the **privatisation** and **commercialisation** of individual airports and airlines;
- the relative strengths, scale and market power of individual airports and airlines;
- the deregulation of airline routes, growing passenger demand and forecasts for future growth;
- the emergence of new airline business models which increasingly focus on cost and service.

Historically, the common state ownership and operation of major airports and airlines meant that the airport–airline relationship was very close and developed in the joint interest. In the UK, for example, the British government owned both British Airways (BA) and the British Airports Authority (who operated a number of major UK airports, including BA's main base at London Heathrow until they were privatised in 1987). This meant that UK airport policy developed, at least in part, to meet the needs of the country's national airline. Moves towards deregulation and privatisation, particularly in Europe, from the late 1980s and 1990s onwards, rapidly dissolved the close relationship that had existed between airports and airlines and introduced new elements of competition and commercialisation (➤Chapter 5). This meant that both airports and airlines were suddenly competing for custom and seeking to develop new business opportunities. Even airports and airlines that still remain fully or partly state-owned have had to adapt to the changing commercial environment by investing in new infrastructure and new products to attract and retain airlines.

6.2 The changing nature of the airport–airline relationship

Under traditional regimes of state ownership, the commercial interaction between airports and airlines was a simple supplier/customer relationship. The airports supplied the infrastructure, in the form of runways, passenger terminals and departure gates, and entered into legally binding agreements with airlines concerning their access to, use of and charges for using airport facilities (see Example 6.1). Airports were primarily concerned with providing for airlines as opposed to passengers, since aeronautical charges, in the form of landing fees and passenger handling charges, represented their main source of revenue. The introduction of a more commercialised and competitive environment resulted in airports placing more emphasis on non-aeronautical revenue streams that are derived from retail, car parking, property development and consultancy services. This has had the effect of complicating the traditional airport–airline relationship (see Figures 6.1 and 6.2).

Example 6.1
Airport use and lease agreements in the US

Although not compulsory, a number of US airports enter into formal and legally binding use and lease agreements with their airlines. These use and lease agreements describe the nature of the operational and financial relationship between the airport and the airlines. They define the rights and responsibilities of each party, set charges, stipulate how the airport can be used, and define how the financial risks will be shared (➤Chapter 5). These agreements typically consist of two elements:

- *Lease agreements*: which concern an airline's occupation of airport buildings.
- *Use agreements*: which detail an airline's use of airport facilities.

Owing to the capital intensive nature of airport infrastructure and operations, these agreements also define how the financial risk of current and future operations will be shared between the airport operator and the airlines, and in what proportion. Three basic models can be identified:

- *Residual agreements*: airlines assume the financial risks of airport operations.
- *Compensatory agreements*: the airport assumes the financial risk of operations.
- *Hybrid agreements*: combine elements of both models to share financial risk.

Figure 6.1 The traditional airport–airline relationship

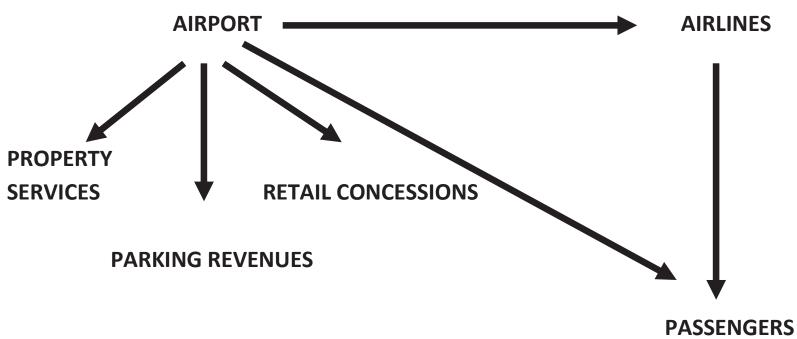

Figure 6.2 The contemporary airport–airline relationship

Many airport operators have developed their facilities and the land that they own in an attempt to diversify their business and develop new revenue streams. Airport-owned land has increasingly been developed for commercial mixed use, often in partnership with local government agencies or businesses such as hotel chains, logistics providers and freight forwarders who value proximity to an airport and connectivity to national road and rail networks. Some airports are now marketing themselves as an 'Airport City' or Aerotropolis to emphasise the range of products and services they offer.

This has meant that airports are increasingly trying to meet the needs of multiple customer segments, including passengers, tenants, retail, car parking providers and airlines. The challenge for airport management is to carefully consider and manage these diverse revenue streams.

These multifaceted roles can lead to a conflict of interest when, for example, aircraft are delayed by passengers being distracted by the retail opportunities in the departure lounge and not hearing gate announcements because of a lack of loud speakers in shops, something certain retailers deem disruptive to the retail environment. Given the interdependent nature of the relationship, it might be expected that vertical integration would occur. However, relatively little vertical integration has occurred. In the US, some airlines own, manage and/

or operate the terminals they fly from. These **airline unit terminals** enable the airline to develop the terminal to suit the needs of its business and its passengers over a longer time period. Although relatively rare both within and outside the US, examples of airline unit terminals can be found at New York's JFK Airport (where jetBlue subleases Terminal 5 from the airport operator) and Newark in New Jersey. One example of full vertical integration between an airport and an airline has occurred at Humberside Airport in the UK (see Case Study 6.1).

Airline unit terminals: terminals that are built, financed, leased and/or operated by an airline.

CASE STUDY 6.1

VERTICAL AIRPORT–AIRLINE INTEGRATION: HUMBERSIDE AIRPORT, UK

In August 2012, Manchester Airports Group sold its 82.7 per cent stake in Humberside Airport, a regional facility in North East England, to Eastern Group, the owner of Humberside-based regional airline Eastern Airways. Despite only being the UK's 31st busiest passenger airport with 221,000 passengers in 2015, Humberside is one of the UK's busiest commercial heliports with over 46,000 passengers a year using it to access the oil rigs in the North Sea. Eastern Group's acquisition of the airport represents one of only a few examples of vertical integration between airlines and airports. Eastern Airways hopes to grow its business out of Humberside and believes that taking a controlling stake in the airport will be the best way to ensure the facility's long-term future.

Stop and think

How has privatisation and commercialisation affected the relationship between airports and airline operators?

6.3 Airport perspectives on the airport–airline relationship

Commercialisation has been a key driver in changing the airport–airline relationship. Worldwide, a mixed pattern of airport ownership has emerged as a consequence of privatisation. The reasons for privatisation are explained in Chapter 5. Irrespective of whether they are in public or private ownership, airports are seeking to improve their commercial performance by raising additional revenue through varying the charges levied on operators and encouraging additional airlines and their passengers to use the facility in preference to a competitor. However, there is an inherent difficulty in doing this. Raise fees too quickly and too much and airlines will choose to serve alternative airports. Set fees too low and the facility may become congested or operate at a loss and/or might ultimately cease to operate.

In terms of managing the relationship with its airline operators, an airport must assess whether it views the airline primarily as a resource (in terms of passengers and revenue), an opportunity (to grow the business), a consumer (of the airport product), a service provider (to passengers) or a problem or liability (not least in terms of its social and environmental impact but also its relative bargaining power and market dominance) that must be effectively managed. In reality, an airline may be all of these things simultaneously.

In order to effectively manage the relationship with its airline partners, an airport needs to:

- understand its market and passenger catchment and promote the facility to passengers;
- be flexible in its approach and understand and meet the needs of its different airline users (which may vary by airline business model, airline nationality, route or time of the year);
- work with airlines to develop new routes and support the introduction of new services by, for example, joint marketing;
- define the financial terms of aeronautical fees and charges and establish a transparent business arrangement for airlines' use of airport facilities;
- ensure that benefits are available to all operators and treat all airlines (both domestic and foreign and full service and low cost) the same;
- keep airlines informed of any changes or developments that may affect their operation and provide them with an opportunity to engage with the airport management team through dedicated consultative committees, liaison groups and user fora;
- invest in passenger facilities and airside infrastructure in accordance with its traffic mix and growth forecasts;
- respond to changing market conditions and evolving passenger expectations;
- maintain relationships with existing airline operators while exploring the growth opportunities provided by new entrant carriers;
- work with regulators, government agencies, business partners and local communities to promote inward investment, job creation and the economic benefits of airport operations.

However, airports face a number of key challenges when managing the airport–airline relationship. These include:

- high levels of sunk costs in infrastructure which, unlike aircraft, cannot be transferred to another location. This makes airports vulnerable to airline operators suddenly withdrawing services;
- tension between existing operators and new entrant airlines if the former perceive (or can prove) the latter are receiving preferential terms;

- meeting the needs of new airline operators and supporting the development and diversification of routes;
- competition from neighbouring airports who may attempt to attract airline operators away from their current airport by offering financial incentives such as free aircraft parking, free office space, free use of airbridges or reduced landing fees for a certain period of time;
- vulnerability to external economic conditions impacting on consumer demand for flight;
- changing government policy with respect to airport ownership and operations, route competition and new security directives (➤Chapter 12).

At many major hub airports, such as London Heathrow, where demand is strong and there is a high propensity to fly, the level of congestion can determine whether or not an airline is able to gain access to the market. Severe slot constraints can prevent market entry unless an airline withdraws a service and sells its slot (➤Chapter 5). This can protect incumbent carriers from the effects of new competition by acting as a barrier to entry. The impact of this on the airport operator is that the airline will invariably use the slots on the most lucrative routes rather than on those routes the airport operator would prefer they served.

Given the expense and inability to serve the major hubs, LCCs have typically established services at secondary regional airports (➤Chapter 7). Although this has led to significant growth at some formerly underutilised airports, it has also resulted in these airports being more vulnerable to the withdrawal of airline services. In particular, LCCs may swiftly withdraw from airports if the services prove to be unprofitable or new competition emerges. The stability and longevity of the airport–airline relationship will depend on the carrier, the competition and the context. Different types of airline may offer contrasting economic benefits to an airport. While LCCs may offer growth in the short run, full service network carriers (FSNCs) may be more attractive in the long run as they offer network connections and potentially more stable operations. They are, however, also vulnerable to market forces. This is illustrated by the demise of the Cypriot national airline Cyprus Airways (2015), the Belgian national carrier Sabena (2001) and the Swiss national carrier Swissair (2002). Freight carriers might prove attractive to some airports by offering relative stability and capacity utilisation during off-peak periods, although these operators require different facilities and the nature of their operation may lead to community complaints about aircraft noise at night. Smaller and/or less congested airports may look to other types of traffic, such as charter airlines and executive jets, as potentially useful sources of aeronautical revenue.

Stop and think

What issues do LCC operations present to airport operators?

Home base: an airline's headquarters and centre of operations. The airline will usually be a major (possibly majority) user of the airport's capacity and will be reluctant to move its operations elsewhere.

Not all airport–airline relationships are short term. For example, when an airport is an airline's **home base** or a main hub, there is a different dynamic to the airport–airline relationship. A major airline and its home airport can find themselves in a position of mutual dependency. Examples include American Airlines at Dallas/Fort Worth, KLM at Amsterdam Schiphol, Emirates at Dubai, Lufthansa at Frankfurt and British Airways at London Heathrow.

So important is the relationship between hub airports and their leading airlines that joint investment decisions may be undertaken for the mutual benefit of both parties. Examples of airport–airline cooperation include the construction of Terminal 2 at London Heathrow (which was jointly developed by the airport operator, Heathrow Airport Limited, and members of the Star Alliance) and the regional terminal at Christchurch (which was jointly developed by Air New Zealand and Christchurch International Airport). Dedicated low-cost terminals, which have been designed to fulfil the needs of low-cost operators, have also been developed (see Example 6.2).

Example 6.2

Low-cost terminals

Airports including Amsterdam Schiphol, Copenhagen, Singapore Changi, Lyon, Kuala Lumpur, Marseilles and New York JFK have tried to accommodate the needs of low-cost operators through the development of dedicated low-cost terminals. Typically these facilities reflect the need for fast turnarounds. They lack airbridges, have a simple layout for point-to-point traffic and are designed to facilitate rapid passenger throughput. The level of retail provision often reflects the short-haul flight duration, destinations served and the LOS offered. Airport managers have the challenge of tailoring the retail opportunities to the needs of passengers. Providing dedicated piers or separate terminals for LCCs can result in efficient terminal and gate utilisation at certain times of the day or year. However, peaks in low-cost traffic may coincide with those of other traffic, and managing the traffic mix and the impact of low-cost operations on an airport's available capacity and how the facility is perceived by airlines and passengers alike is a further challenge.

Externalities: effects created by airport and aircraft operations, including noise pollution, wake vortices, jet fuel odour and surface access congestion.

Social and political factors may also affect the airport–airline relationship. The political and regulatory regime will shape market access and volatility. In remote locations, for example, the national government may decide to subsidise airline services as part of a Public Service Obligation (➤Chapter 20). In the Highlands and Islands of Scotland, these are known as 'lifeline' services on account of their importance to the remote communities they serve.

An undesirable consequence of the growth in air traffic has been increased **externalities**. Airport communities are increasingly sensitive to airport growth and the associated noise and pollution it may bring. In many parts of the world, airport opposition has restricted development, and long planning enquiries have been held to determine whether the development should go ahead. For example, it took 15 years from the formal planning application being submitted in 1993 for Terminal 5 at London Heathrow to open. Many airports receive complaints from the local community relating to aircraft noise, and many airport operators have embarked on public relations programmes to respond to their concerns.

6.4 Airline perspectives on the airport–airline relationship

Airlines have a range of objectives when entering into a commercial relationship with an airport. Different airline business models (➤Chapter 7) influence the nature of the relationship. Traditional FSNCs seek network connectivity for their passengers and often operate a hub-and-spoke network that places pressure on airport capacity. They also require a high level of passenger facilities and are prepared to pay for them. LCCs, in contrast, do not wish to pay for services and infrastructure (such as airbridges) that they generally do not use.

Many FSNCs have joined alliances (➤Chapter 9). As a consequence, member airlines have moved between terminals to co-locate with their partners. This has meant that a terminal designed for one airline or airline alliance may ultimately end up servicing a different model and mode of operation altogether. For example, Terminal 4 at London Heathrow, although originally designed for use by British Airways, is now used by members of the SkyTeam alliance. The expansion of global airline alliances has also raised capacity management issues for airports who had planned on the assumption of particular airlines operating from particular terminals. Airlines moving to be next to alliance partners may make demands for premium service features within the terminal to match the service offered, and this can present airport management with capacity challenges. Airports have to plan for flexible facilities owing to the degree of uncertainty in forecasting and the notoriously dynamic nature of the market (➤Chapter 4). The need for flexibility in terminal design in order to accommodate the changing needs of airlines is illustrated by Case Study 6.2.

CASE STUDY 6.2

DALLAS/FORT WORTH INTERNATIONAL AIRPORT

Dallas/Fort Worth was designed for point-to-point traffic but, shortly after opening, American Airlines selected it as one of their main hub airports. Hub operations required increased airport capacity to cope with large peaks in traffic as waves of aircraft are scheduled to arrive in quick succession and to depart together to enable maximum connectivity between flights for passengers. Instead of the short airport roadside to check-in distances required for point-to-point operations, new infrastructure was required to facilitate the transfer of passengers and baggage to meet the airline's connections.

LCCs seeking low fees, quick turnarounds, short taxi times and basic facilities present further challenges. If an airport offers incentives (such as a reduction in landing fees or marketing support) to attract a new operator, then this can lead to pressure from established operators for equivalent terms. A low-cost operator that fills vacant capacity at a low marginal cost to the airport can be an asset, providing the airport is assessing the costs and covering them. The moment new investment is needed to accommodate a low-cost operator, an important decision is required by the airport management. Some airports have modified facilities, added extensions, refurbished old buildings and developed low-cost terminals or piers to accommodate this new type of airline user (see Example 6.2). Given the long-term nature and high cost of airport infrastructure investment and the relative volatility in the low-cost airline market, airport managers should carefully evaluate the costs and benefits of providing dedicated capacity for LCCs. The financial evaluation should consider both the long- and short-term implications of any commercial arrangement.

There is an increasing trend towards airports marketing themselves and actively seeking the operation of new services from airlines (➤Chapter 19). The development of new routes or the increase in frequency of existing services ultimately depends on the decisions of the airlines, but increasingly airports and airlines are seeking new ways to establish relationships. Airports and airlines can approach each other in several ways. These include organised events, independent consultants and the use of online services (see Example 6.3). Commercial benefits such as a reduction in airport charges to help establish routes or support to help market new services may be offered as an incentive to new operators.

Example 6.3
Route development events

Every year, a number of 'speed dating' events are held to bring airlines, airports and local tourism authorities together to develop new routes and business opportunities. One such event is World Routes. The 2015 World Routes event involved 650 airports, 300 airlines and 9,000 prearranged meetings.

The extent to which an airport might negotiate with an airline will depend upon whether it is an existing or new operator, a major airline adding a new service, a low-cost operator promising a network of services or an independent airline offering a route for the first time. All these services pose a different level of risk and potential reward and will require different forms of support. When negotiating, airport managers need to assess the risks and benefits on a case-by-case basis. They should consider not only the aeronautical revenues but also any associated additional non-aeronautical revenues that would arise. Care also needs to be taken to consider the impact on existing airline relationships. The infrastructure cost implications of accommodating new services must also be assessed.

One way in which airlines and airports can lower their costs is through the use of common-use terminal equipment (CUTE) and common-use self-service (CUSS) check-in kiosks. Sharing equipment in this way not only allows for greater flexibility in airport operations but also maximises the use of terminal floor space, lowers costs and simplifies the installation and operation of the equipment as usually one service provider (or vendor) is responsible for setting up and maintaining it.

When the airport–airline relationship breaks down

There will be situations in which the airport–airline relationship breaks down. This may be due to a change in airport or airline strategy, a change in airport or airline ownership or an external factor beyond either partner's immediate sphere of influence, such as the denial of planning permission for a new terminal or runway extension. While a withdrawal of an airline's custom may be challenging for airports in the short term owing to a sudden loss of passengers and revenue, it may prove beneficial in the long run if it forces an airport to reconsider its market position, re-evaluate its commercial offer and reduce its reliance on a small number of operators.

Stop and think

How will the airport–airline relationship change in the future and what factors will affect it?

Key points

- The airport–airline relationship is complex, dynamic, competitive and co-dependent.
- Traditionally, airlines were an airport's primary customer, but now airports must meet the needs of a diverse group of users including airlines, tenant companies and passengers.
- Deregulation has transformed the relationship into a highly competitive and dynamic business partnership.
- Commercialisation has led airports to seek to take advantage of non-aeronautical as well as aeronautical revenues.
- The nature of each airport–airline relationship is unique and varies according to local context.
- Factors which affect the airport–airline relationship include: the relative strength and market power of the airport and airline; the regulatory environment and freedom of market entry and exit; the rise of LCCs and their focus on costs; the emergence of airline alliances and their demands on airport capacity and terminal infrastructure; and the changing ownership of airports and airlines.
- Airports are fixed geographically so do not have the flexibility of airlines. They need to consider the long-term implications of arrangements they enter into and capital investment decisions that they make.
- It is important for managers to be able to deal with uncertainty and understand the complex nature of the airport–airline relationship and their implications for the air transport industry.
- Not all airport–airline relationships will endure in the long run.

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CHAPTER 7

Airline business models

Randall Whyte and Gui Lohmann

LEARNING OUTCOMES

- To identify the process of business modelling and its importance to airlines.
- To compare and contrast the business models of FSNCs, LCCs, regional airlines, charter operators, hybrid carriers and specialist operators.
- To appreciate the competitive threat LCCs pose and understand how FSNCs have responded.
- To explore the internationalisation strategies pursued by some FSNCs and new entrant airlines.
- To consider the motivations for, and impacts of, global airline alliances.

7.0 Introduction

This chapter identifies the importance of business modelling to airlines and explores the operational and managerial aspects that characterise the six different types of airline business model. The chapter explores why low-cost carriers (LCCs) pose a competitive threat to established operators and the strategies full service network carriers (FSNCs) have adopted in response. This is followed by a discussion of the main characteristics of new entrant network airlines such as Emirates and Etihad. The final section examines the motivations for, and impacts of, global airline alliances.

7.1 Airline business models

Airlines operate in a dynamic and highly competitive business environment. This demands flexible approaches to conducting business that can rapidly adapt to sudden periods of economic downturn as well as exploit new market opportunities during times of economic prosperity. Airline operations are not only very capital and labour intensive (➤Chapters 11 and 18) but also vulnerable to external factors such as fuel price rises, increased competition, weakening of consumer demand and political unrest. Consequently, airline profitability is a major challenge and has been since the inauguration of regular commercial flights in the early 1920s. All airlines develop, operate and continually refine (and, in some cases, redefine) their **business model** in response to changing market conditions in order to remain operational.

Business model: a conceptual structure or plan that defines how a company conducts its business.

Brand proposition: what a business stands for and what it aims to deliver.

Product differentiation: the process of distinguishing a product from its competitors by highlighting its unique attributes or qualities.

Airlines are not unique in having business models. Indeed, business models are used by virtually all companies, from small start-ups to major multinational corporations and from retail chains to financial service providers. In essence, a business model describes a company's purpose, its approach to doing business, its **brand proposition** and its strategic corporate objectives. The purpose of business modelling in the airline industry is to enable managers to identify target customers, identify different revenue streams, establish a robust cost structure, specify margins and build flexibility into their organisation. Establishing a business model is an exercise which Mason and Morrison (2008) describe as developing an 'airline's architecture'.

Although all passenger airlines provide the same basic service of transporting people between places, few airlines can be 'all things to all people' and airlines have become adept at segmenting their markets and using **product differentiation** to cater for the needs of different types of passengers. As a consequence, the nature, distribution and cost of services individual airlines provide differ substantially. Some airlines, for example, create a product and sell it directly to their consumers over the internet, whereas others use commissionable intermediaries and travel agents. Certain carriers may franchise (license) their brand to other companies, while other airlines engage in strategic partnerships or global alliances. Individual carriers may decide to offer a high-value proposition and multiple different travel classes or adopt a more streamlined no-frills approach to customer service. Some carriers fly a mix of aircraft types on long- and short-haul services to major airports, while others have found a niche operating particular types of aircraft into smaller regional airports or tourist destinations. This enables different types of business model to be identified.

Types of airline business model

Airlines can be categorised as one of six basic types of business model. These are: full service network (or legacy) carriers, LCCs, regional, charter, hybrid or specialist, depending on the characteristics of the products and services they offer (see Figure 7.1). While this is a useful guide, these categories are not absolute and some overlap exists between them; for example, when FSNCs operate in regional short-haul markets or where charter carriers have adopted attributes more commonly associated with LCCs. Irrespective of which business model is followed, every airline must be sufficiently flexible to meet changing market conditions and exploit new opportunities as they arise.

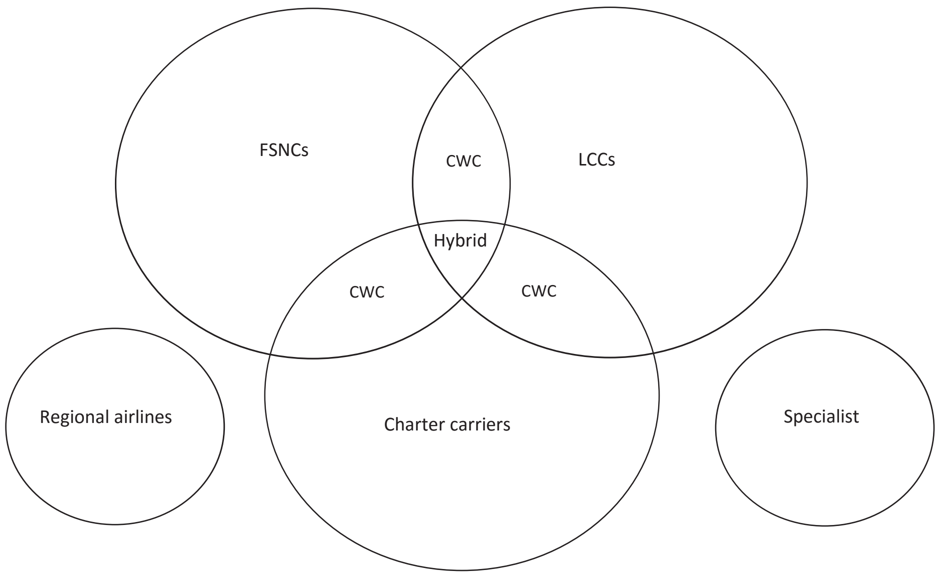

Figure 7.1 Airline business models

One of the most significant developments has been the emergence and rapid expansion of a new type of airline business model that occurred as a consequence of deregulation and liberalisation (➤Chapter 2). Freed from the capacity and fare restrictions that had characterised airline operations prior to 1978 in the US and the 1990s and 2000s in Europe and other world markets, a number of airlines and new entrant operators developed a model that was based on minimising costs and offering low fares. The cost-conscious business model that resulted meant that the new low-cost operators have been able to undercut the airfares charged by incumbent operators and erode their market share. Indeed, LCCs pose a significant competitive threat to the short-haul networks of established FSNCs in all the markets in which LCCs operate. As later sections will show, LCCs have been adept at growing market share by exploiting point-to-point routes that have either been vacated by FSNCs or never operated by them and offering low fares. However, LCCs have yet to penetrate long-haul markets to any significant extent as the different operating characteristics of long-haul markets mean that it will be difficult to achieve the same cost savings that are available in short-haul markets.

The need for airlines to focus on their business models has been driven by:

- the rapid growth of LCCs in many world markets since the late 1990s and the resulting erosion of FSNC market share;
- the need to address and reduce costs across the business;
- the reticence or inability of national governments to provide bailouts and subsidies to national airlines, even when the government is a direct or indirect shareholder;

- a reassessment of route network, capacity and flight frequency, including building partnerships and codeshares with alliance partners;
- the need to fulfil fleet requirements through financing and leveraging debt (➤Chapter 11);
- competition in traditional markets from new carriers, exemplified by the presence of new Gulf State airlines in long-haul markets between Australasia, Asia and Europe via hubs in Dubai, Abu Dhabi and Doha;
- static or declining yields;
- the need to adopt a product differentiation strategy suited to the destination, length of haul and market served;
- the cost of marketing and advertising in an increasingly competitive market;
- greater use of new technology (including the internet and social media) to: lower distribution costs, manage reservations, and communicate with passengers (➤Chapter 16).

Every airline has to assess both its current position in the market and where it would like to be. Certain markets are nearing maturity; others are emerging; while some (particularly in Africa) are restricted by regulations that effectively prevent the adoption of more innovative and financially sustainable business models. A complete business analysis should include actual and predicted route performance, such as number of passengers, classes of travel, load factor; yield (per seat kilometre); seasonal fluctuations; route profitability; product and service offering; competitors' strengths and weaknesses; and the different operating characteristics of short-, medium- and long-haul, where applicable. In addition, labour costs, the second highest expenditure after fuel, is an important area to review, as well as how and where maintenance is conducted.

Full service network carriers (FSNCs)

Many of the world's oldest surviving FSNCs were originally established as state-owned 'flag carriers'. These airlines often enjoyed protection from competition and were authorised to fly the most lucrative air routes courtesy of bilateral agreements (➤Chapter 1). However, financial pressures on governments combined with growing moves towards deregulation, commercialisation and privatisation led many governments to sell their stakes from the late 1980s onwards. The mid-1990s saw the emergence of a new competitive threat in the form of LCCs, while the 2000s saw FSNCs operating in an environment with record high fuel prices, increasingly stringent security measures, and overcapacity and intense competition in almost every market.

Some elements of the FSNC model include: using major airports; developing a hub; seeking route expansion beyond short-haul operations; rewarding frequent travellers; and using travel agents and other commissionable sources as a distribution channel but adhering to cost containment to price the product attractively.

FSNCs, out of necessity, have progressively remodelled and restructured their operations to focus on accelerating cost reduction and promoting yield and revenue management. Today, many FSNCs operating short-haul regional routes are not that dissimilar to LCCs. Increased use of technology for bookings and check-in, self-generating boarding passes and minimising in-flight services are just some of the LCC-type strategies that FSNCs have implemented.

The hub-and-spoke principle is fundamental to FSNCs who rely heavily on concentrating their operations on a major hub which is fed by radiating spoke services (➤Chapter 9). Mergers and joining strategic alliances have helped to consolidate the sector further (see Section 7.3), with many airlines building substantial global networks of destinations and **interline agreements**.

Interline agreement: a voluntary commercial agreement between airlines to transport passengers on itineraries that require the services of two or more airlines.

Relationship marketing has become a significant marketing strategy for FSNCs (➤Chapter 19). Unlike LCCs, who continuously seek new customers and whose relationship with their customers may merely be a single transaction bought on price and perhaps schedule, FSNCs use customer relationship marketing to retain customers and obtain repeat business. This group includes mainly the corporate and government sector, as well as private individuals who are frequent flyers. The notion is to develop loyalty and reward repeat purchase with incentives such as frequent flyer programmes (FFPs), tickets to sports events, stage shows and exclusive retail offers (➤Chapter 9). FFPs can be profit-generating businesses in their own right, and some airlines partly sell on their loyalty schemes to include other businesses like banks, rental car companies, supermarket chains and petrol stations to attract additional customers.

Low-cost carriers (LCCs)

LCCs, or no-frills budget airlines, proliferated during the 2000s. They have become established in domestic and regional markets worldwide as a result of deregulation and liberalisation; increased ease-of-market entry on routes and at airports either ignored or abandoned by FSNCs; and a simple, streamlined business model where cost is rigidly controlled. While there are many common features of an LCC, the sector is not homogeneous, and differences occur between carriers according to location.

LCCs generally opt for a one-class service with a narrow seat pitch and limited galley space. They tend not to use expensive terminal facilities such as airbridges. Some LCCs predominately use secondary airports to reduce costs and to ensure fast turnaround times in order to increase the utilisation of their aircraft. Other cost-reduction strategies include outsourcing and contracting out services to reduce fixed overhead costs; keeping advertising and promotional messages short and simple; and bypassing travel agents and other commissionable sources in favour of incentivising customers to book directly with the airline. Technology has had a major impact, increasing the availability of information available to consumers and shifting leverage into consumers' hands, resulting in less homogeneous customer segments. A significant point of difference between LCCs and FSNCs is LCCs' ability to innovate and adapt. This makes them more agile and able to respond quickly to changing circumstances and new opportunities. Some LCCs have unbundled the air service product to its bare basics and make passengers pay for any extra product or service they require such as pre-assigned seats, in-flight meals and movies, and checked hold baggage. These carriers can be termed 'ultra-low-cost' carriers. The principal differences between FSNC and LCC business models are detailed in Table 7.1.

Table 7.1 FSNC and LCC business models compared

Business model element	*FSNCs*	*LCCs*
Aircraft fleet	Operate different types of both narrow (single aisle) and wide-body (two aisles) aircraft according to the route flown and required capacity.	Generally operate one type of narrow-body aircraft, such as the Boeing 737 or Airbus A319/320.
Aircraft utilisation	Lower than LCCs, due to delays, connecting flights, consolidating passengers at hub airports, time zones on long-haul operations leading to dwell time, including crew rest periods.	Aim for 11+ hours utilisation per aircraft per day through short-haul operations (1–2 hours flight time) and fast and efficient 25–30 minute turnarounds.
Route network	Operate a hub-and-spoke network to and from (more expensive and often congested) major airports. Transfers and interlining are common.	Operate point-to-point services between cheaper and less congested secondary regional airports. No transfers or interlining.
Product offering and in-flight service	Offer two, three or four-class cabin configurations according to route and demand. Seat pitch in economy is generally 32–34 inches (81–86cm). Meals and in-flight refreshments are usually included in the ticket price (especially in premium cabins), as are headsets for in-flight entertainment.	One-class all-economy configuration, narrow seat pitch (28–30 inches; 71–76cm); some LCCs apply no pre-allocated seating. Meals/ refreshments and in-flight entertainment are offered as pay-for extras.
Target market	Corporate accounts, business and government travel. Medium- and long-haul markets (all classes of travel). Leisure travellers prepared to pay a fare above LCCs for perceived service enhancements.	Predominantly leisure travellers and less time-sensitive travellers. Some business travel.
Pricing strategy (➤Chapter 9)	Flexible fares set high, catering for corporate accounts and business and government travel. Other fares set according to day of week/time of day/ holiday periods. Have evolved from round-trip fares to offering one-way fares in response to LCCs.	Simple fare structures. Offer one-way fares and use promotional offers to stimulate demand.
Strategic alliances (➤Chapter 9)	Most major airlines – with some exceptions – belong to an alliance to enhance operational and marketing position and to gain traffic.	Usually remain independent, although some subsidiaries of larger airlines do belong to an alliance.
Checked baggage allowance	Up to 23kg free in economy. More for business and first class.	Hold baggage typically incurs an added charge.
Advertising and promotion (➤Chapter 19)	Brand image and reputation is very important. FSNCs may use desirable aspects of national stereotyping (such as punctuality, reliability, good food and hospitality) in their advertisements.	Message is simple – a destination, a price and a brand.
Distribution (➤Chapter 16)	Online bookings are encouraged, but travel agencies and corporate bookings (which charge commission) remain important.	Use new technologies to handle online reservations and avoid commissionable sources.

Frequent flyer programmes (➤Chapter 9)	Most offer a loyalty programme to reward frequent travel and incentivise repeat purchases	Not usually offered.
Labour and industrial relations (➤Chapter 18)	Often have legacy agreements that specify job functions and govern the rate of pay and overtime. Often highly unionised.	Pay lower wages and try to avoid collective union bargaining. Greater use of outsourcing and contracting to lower costs. Workforce typically less unionised.

Charter airlines

Charter airlines originated in Europe and offer a distinctive type of service. Charter airlines operate on a demand-driven basis. They often operate from cheaper and less-congested secondary or regional airports that are not otherwise served by scheduled airlines. The service may include complementary checked baggage, in-flight meals and entertainment as standard. Seats on charter flights may only be available as part of an inclusive tour, and the charterer may purchase an entire flight's seat inventory and undertake to fill it for an agreed price. This business model appeals to tour operators and special interest groups, but charter airlines' business is very seasonal and dependent on 'summer sun' tourists and 'winter ski and sun' traffic. Charter airlines may lease their aircraft to foreign operators during leaner months of the year when demand is low.

Charter airline: an airline that provides point-to-point services to popular holiday and leisure destinations, often as part of an inclusive tour (also known as a package tour).

Regional airlines

A **regional airline** operates medium-density routes between a main hub (or hubs) and regional destinations using regional jets or turboprop aircraft. Regional airlines may be independent (such as Flybe in the UK), government owned (such as Aurigny of Guernsey in the Channel Islands), wholly owned subsidiaries of FSNCs (Dragonair is a wholly owned subsidiary of Cathay Pacific) or **franchises** (such as Air Nostrum, which operates as a franchisee of Iberia and Binter Canarias).

Regional airlines form an important link to remote destinations which are difficult, expensive and/or time-consuming to access by surface transport modes (➤Chapter 20). In many respects, they are niche specialists, operating on secondary routes and providing the 'spokes' to/from a key hub. Regional carriers may have higher costs than FSNCs because they do not have the same economies of scale and usually operate smaller aircraft on routes with less demand. In Europe, regional airlines collectively serve over 1,200 short-haul point-to-point routes. They have 16 per cent of the market and transport 45 million passengers a year on over 960,000 flights. Each flight lasts for an average of 71 minutes and has an average capacity of 67 seats (ERA 2015). In order to access larger computer reservation systems (CRSs), broaden their distribution, raise their profile in foreign markets and grow their traffic, a number of regional carriers have become affiliates members of major alliances and/or entered into codeshare agreements (see Case Study 7.1).

Regional airline: an airline that operates frequent short-haul routes within particular geographic regions, usually with a fleet of small regional jets or turboprops.

Franchise: an independent airline that uses another airline's branding and operates services on its behalf.

CASE STUDY 7.1

FLYBE

Flybe is a British regional airline based in Exeter. It operates over 210 routes between ten countries and 75 airports in Europe, carrying 7.7 million passengers in 2014/15. Flybe is involved in franchises with Loganair (on Scottish and Irish services), Stobart Air (on flights from London Southend Airport) and Blue Islands (on Channel Islands flights). The airline also has codeshare agreements with Aer Lingus, Air France, British Airways (primarily to/from London Gatwick), Cathay Pacific, Emirates, Etihad, Finnair and KLM.

Hybrid airlines

Hybrid airline: an airline that does not adhere to one single strategy but which adopts attributes from different airline business models.

The term **hybrid airline** evolved from the recognition that the 'one-size-fits-all' business model descriptors do not adequately explain airlines that exhibit characteristics from several different business models. A number of LCCs, for example, in addition to offering lower fares, are also offering connecting flights and joining alliances, blending low-cost traits with those of traditional FSNCs. UK LCC easyJet, for example, now offers paid-for optional extras such as 'Speedy Boarding' and the use of airport lounges, while New York-based jetBlue has broadened its route portfolio and introduced new products to attract higher-yielding passengers. Its premium intercontinental product, 'Mint', for example, offers lie-flat beds and arguably has more in common with a traditional FSNC than an LCC.

Specialist operators

Specialist operators undertake low density but vital services, such as flights flown as part of Public Service Obligation (PSO) routes to/from remote airfields. Specialist operators often use particular aircraft (including helicopters) that can operate from short and/or unprepared runways (➤Chapter 20).

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Stop and think

Detail the operational characteristics of the different airline business models and assess the relative merits of each.

7.2 The FSNC response

FSNCs have responded to the changing operating environment by rationalising their route networks and introducing cost-cutting measures across all areas of the business. In order to retain market share in the face of growing LCC competition and to consolidate their position at key airports, many FSNCs have merged with former competitors or entered global alliances.

A number of mergers during the 2000s were driven by poor financial performance, large debt and the desire to remain operational. In the US, high-profile mergers included FSNCs Delta and Northwest Airlines (2008), United and Continental Airlines (2010), and American Airlines and US Airways (announced in 2013). In Europe, Air France and KLM completed a transborder merger in 2004 but have kept their separate brand names and their own networks. Elsewhere, the International Airlines Group (IAG) was formed in 2011 and includes British Airways, Iberia and Vueling. Lufthansa has also pursued a strategy of acquiring smaller regional and international airlines as well as developing its capacity in operational, managerial, safety and maintenance, and information technology services (see Case Study 7.2).

CASE STUDY 7.2

LUFTHANSA

The German national carrier Lufthansa is one of the EU's most dynamic airlines. The company has a global route network of 274 destinations in more than 106 countries and access to the skills of almost 500 subsidiaries and associated companies. It has five business segments – the passenger airline group (consisting of Lufthansa, SWISS and Austrian Airlines, plus equity investments in Brussels Airlines and SunExpress), logistics, MRO, catering and IT.

Lufthansa offers management services to airlines seeking improvement in areas such as safety management, engineering and pilot training as well as customer service, catering and information technology. It has also been involved with Philippine Airlines and Garuda Indonesia, establishing joint ventures to provide aviation services with a focus on aircraft maintenance, cabin reconfiguration and painting.

In short-haul markets, FSNCs have responded to the no-frills challenge by abandoning their old pricing convention that low fares must come with onerous conditions that are often unattractive to business travellers, and by matching no-frills fares, especially for late bookings. Websites such as BA.com and Airfrance.com now show a range of one-way fares, allowing travellers to combine the best fare out with the best fare back (➤Chapter 8).

The carrier-within-a-carrier (CWC) model

A further response has seen some FSNC and charter airlines pursue a 'carrier-within-a-carrier' (CWC) or an 'airline-within-an-airline' (AWA) model in which they establish an in-house low-cost subsidiary or low-cost brand (see Table 7.2). This model, which was initially attempted in North America and Europe, is now predominantly found in Asia and Australasia (Whyte and Lohmann 2015). Over 20 FSNCs and charter airlines have established wholly owned LCC subsidaries. These CWCs usually have their own corporate identity, staff and aircraft.

CWCs have two main aims. One can be seen as a defensive strategy to protect market share that had been threatened by new entrant LCCs. At East Midlands Airport in the UK,

Table 7.2 Examples of low-cost CWCs

Parent airline	*Business model of parent airline*	*Name of low-cost subsidiary/brand*	*Origin*
Air Canada	FSNC	Tango	Canada
Air India	FSNC	Air India Express	India
bmi	FSNC	bmibaby	UK
British Airways	FSNC	Go	UK
Channel Express	Cargo	Jet2	UK
Comair	FSNC	Kulula	South Africa
Delta Air Lines	FSNC	Song	US
Jet Airways	FSNC	Jet Konnect	India
KLM UK	FSNC	Buzz	UK/Netherlands
Lufthansa	FSNC	Germanwings	Germany
MyTravel	Charter	MyTravelLite	UK
Qantas	FSNC	Jetstar	Australia
SAS	FSNC	Snowflake	Scandinavia
South African Airlines	FSNC	Mango	South Africa
Thomson Airways	Charter	Thomsonfly	UK
Transavia	Charter	Basiq Air	Netherlands
United Airlines	FSNC	Ted	US
Virgin Atlantic	FSNC	Virgin Express (Belgium), Virgin Blue (Australia), Virgin America (US)	UK

for example, incumbent FSNC bmi established an in-house LCC, bmibaby, to counter the competitive threat posed by the introduction of LCC services by BA-backed Go. The second aim is to promote market development and exploit new strategic opportunities of deregulation and liberalisation such as entering new markets, launching new routes and segmenting markets between leisure traffic and business/corporate travel. However, a number of FSNCs found it difficult to build an integrated business platform owing to trying to operate two different business models simultaneously, cultural differences between the mainline and subsidiary workforce, and the danger that the LCC subsidiary undermined the parent airline's brand. As a consequence, a number of CWCs were ultimately reincorporated into the parent carrier (as SAS did with Snowflake and United Airlines did with Ted) and no longer operate as separate entities. Some may now differentiate their standard economy class product with an 'economy lite' product whereby passengers can pay for optional extras like food and refreshments and in-flight entertainment. Despite claims the CWC strategy is unsustainable in the long term, it is a model that that has been successfully pursued by some European, North American and Asian carriers.

Qantas's Jetstar arguably exemplifies a successful CWC strategy. Jetstar began operations in May 2004 and established a two-brand CWC segmentation strategy on a route-by-route basis. Qantas was unable to reduce its costs quickly enough to contend with the rapid rise of the then LCC Virgin Blue (now Virgin Australia and restructured into an FSNC). Low yields on routes where leisure travellers predominated forced Qantas to combat Virgin. Qantas was committed to industrial relations agreements that restricted labour market adjustment, flexibility and work conditions, enabling a more flexible and agile Virgin to hold a 20–25 per cent cost advantage. Finally, international expansion was to follow, and in a mature Australian market, Qantas sought growth to expand into Asia, which was relatively late in opening its markets to increased competition and start-up airlines. The Jetstar brand now operates outside Australia in Southeast Asia, Japan and New Zealand.

Stop and think

What are the challenges faced by FSNCs when launching a low-cost CWC, and why have few CWCs succeeded?

7.3 Strategic alliances

Strategic alliance: a business agreement in which airlines combine resources and efforts to jointly achieve common objectives while remaining separate entities.

Strategic alliance partners have become an integral marketing strategy and part of most major international airlines. One only has to look at an airline's airport departures or arrivals board to see a range of codeshare flight numbers related to the actual airline operating the service to highlight the extent of alliance agreements. Codesharing, as it is known, has given airlines the ability to purport to have a very extensive network and offer airline consumers a 'seamless' service.

Strategic alliances are considered a form of competitive strategy offering more destinations and frequencies, with each group seeking a competitive advantage. Most importantly, membership of an alliance allows access to markets that would otherwise be difficult and costly to access. Smaller airlines have the most to gain because they can receive feed traffic at a hub point which both airlines serve for transfer into their spoke network. For larger airlines, feeder traffic coming into a major hub enables the carrier to build its capacity. Alliance agreements overcome, in part, the lack of access or traffic rights to a particular country or where demand is such that the carrier's own service is not justified.

The creation of a 'seamless service' for the travelling passenger from origin to destination has been a key driver of global alliances. A key customer benefit of travelling with a major alliance airline is that it will include check-in at the origin of the journey to the end destination via any en route transfer point. For example, a passenger originating in northern or central Europe flying to Australia has many choices with at least one transfer point. A oneworld carrier such as Finnair can promote its Helsinki to Southeast Asia services at a broader geographic market using Helsinki as a transfer point and then a transfer to either a Qantas service at Singapore or Hong Kong or to Cathay Pacific at Hong Kong for onward travel to Australia. A continuous journey includes baggage transfer and a seat pre-allocated for the onward connection at the first check-in point including a boarding pass. A further benefit applies to those frequent flyers or club members who are eligible to use airline lounge facilities. For example, on this journey, lounge facilities could be enjoyed at both Helsinki and at the Southeast Asia transfer point. Alliances are aimed primarily at business travellers. Different frequent flyer programme tier levels apply according to the amount of travel undertaken. This accords passengers a certain status, such as priority boarding, priority at airport check-in, priority baggage handling and additional baggage allowance.

Several factors have driven the establishment of airline alliances. Through their alliances, the airlines seek to:

- create a 'seamless network service' for the travelling passenger from origin to destination, especially for business travellers;
- be competitive through economies of scale and scope amid the intense competition which characterises most international airline markets;
- reduce costs and obtain operating efficiencies; and
- eliminate or minimise existing barriers to accessing international markets such as airline traffic rights.

Airline alliances also offer the opportunity for cross-selling each other's services and expanding access to a broader market, with the ability to mobilise network resources through the various partners. For the consumer, a key attraction is the ability to earn frequent flyer points that can be redeemed on all airlines within the group.

Stop and think

What are the relative merits for airlines joining a strategic alliance?

7.4 Non-aligned carriers

Although many major FSNCs, together with a number of selected regional airlines, have opted to become members of one of the major airline alliances, a number of carriers have chosen a deliberate strategy of not aligning themselves to one of these groups. Many of the newly established Gulf State airlines have not joined a major alliance, although Dubai-based Emirates has entered into a partnership with Qantas on routes between Australia and the EU, and Abu Dhabi-based Etihad has established a number of codeshare partners and taken out equity investments in foreign carriers (see Case Study 7.3). Other carriers which were unaligned as of early 2016 were UK-based Virgin Atlantic and India's Jet Airways. Although alliance membership offers a number of potentially attractive benefits, it also obliges member carriers to adopt a particular approach and corporate structure. Remaining independent and non-aligned allows carriers to make rapid decisions – something that is particularly important for rapidly expanding carriers and those that have a geographic advantage they wish to protect.

CASE STUDY 7.3

ETIHAD

The national airline of the United Arab Emirates, Etihad, meaning 'union' in Arabic, was established in 2003. The airline is part of the country's 'Emiratisation' vision to promote participation of Emirati nationals among the workforce. Etihad has won numerous awards for service and hospitality, and a highlight of its product has been the launch of 'The Residence', a high-end luxury three-room 'suite in the sky', comprising a living room, en-suite bathroom and a bedroom. In 2014, Etihad carried 14.3 million passengers to 111 destinations in 60 countries from its base in Abu Dhabi. It has a fleet of 110 aircraft, including the B787 and A380, and has equity investments in multiple airlines including Alitalia, Aer Lingus, Jet Airways, Virgin Australia, Air Serbia and Air Seychelles. Its codeshare partners include Aerolineas Argentinas, GOL, SAS, Air Europa and jetBlue, which delivered 3.5 million passenger to Etihad flights in 2014. While in many aspects competing directly with Emirates, Etihad has focused on establishing a more sustainable growth for its business, while at the same time portraying some of the core values established by Abu Dhabi as a cultural and heritage destination.

7.5 Airline failure

So far this chapter has identified the factors that characterise different business models. However, it is important to note that merely copying an approach that has proved effective elsewhere is no guarantee of long-term success. Business models are not static and must adapt to changing market conditions.

The LCC model has often been considered a quick path to success. However, while the emergence, expansion and evolution of LCCs over the past 35 years have been well documented, the market exit of many start-up carriers has been overlooked. A comprehensive study of low-cost airline failure in Europe between 1992 and 2012 discovered that of the 43 LCCs that took advantage of progressive liberalisation of the European aviation market and commenced flight operations within the continent during the 20-year period, only ten remained operational, a failure rate of 77 per cent (Budd *et al.* 2014).

The main reasons for failure include undercapitalisation, rapid and/or unsustainable expansion, operating the wrong type of aircraft and difficulty in penetrating existing markets. If it is possible to define ingredients for success, the following appear to offer a good start: creating a strong and memorable brand and product; being an early entrant into a market and basing operations in northwest Europe; adhering to the Southwest Airlines model; securing the backing of an existing airline; operating point-to-point routes of 1–2 hours' flight duration with either Boeing 737 or Airbus A320 family aircraft; and avoiding direct competition with rivals.

Airline failure has immediate consequences for the company's employees, its passengers, its suppliers and contractors. The cessation of services also impacts on the airports it served and the regions it flew to. In some cases, airports have been able to attract replacement operators to fill the void left by the failure operator, but this is not possible in every case, and airline start up and failure must be seen as part of a natural cycle of market entry and exit in which only the most innovative airlines with the most attractive product survive.

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Stop and think

Detail the reasons for airline failure, and discuss the management strategies that can be employed to avoid it.

Key points

- A business model explains an airline's purpose, goals and the way it conducts its business.
- Six main types of airline business model can be identified but there is a degree of overlap between them.
- Hybrid airlines adopt elements of different business models and often use product differentiation to attract both price-conscious passengers and business travellers.
- Rising costs have led many airlines to focus on cost reduction and ancillary revenue generation.
- FSNCs, threatened by the rise of LCCs, have adapted their business models, particularly in short-haul markets.
- Some airlines have pursued a CWC strategy and launched their own subsidiary LCCs.
- The 2000s have been characterised by consolidation and cost-cutting for FSNCs in an attempt to return to profitability. For LCCs, their growth may be more limited in that they are reaching saturation point in terms of new routes. LCCs constantly have to find new customers, whereas FSNCs rely more on repeat business from the corporate sector and from their alliance partners.
- The drive by Gulf States airlines to position their destinations as key transfer points between Asia and Europe and Africa and Europe seems set to continue. Chinese airlines will also maintain their growth by obtaining increased capacity and frequencies courtesy of renegotiated bilateral agreements fuelled by the liberalisation of travel for Chinese citizens and their increasing desire to travel overseas.
- A business model needs to be adaptable, flexible and innovative. All airlines need to be vigilant, cost conscious, adaptable and service oriented if they are to succeed in a very cost-conscious, competitive and demanding market.

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CHAPTER 8

$ Airline pricing strategies

Peter Hind and Gareth Kitching

LEARNING OUTCOMES

- To understand the development of airline pricing strategies and the difference between traditional and one-way pricing.
- To identify the difference between long-haul and short-haul pricing.
- To appreciate passenger profiles and their implications for revenue management.
- To recognise the difference between point-to-point and connecting passengers and understand the revenue management implications of these journey types.
- To understand the pricing strategies of low-cost carriers (LCCs) and how they utilise low headline prices to stimulate demand.
- To examine emerging trends in revenue management and the implications these may have on passenger bookings and airport infrastructure.

8.0 Introduction

The disciplines of pricing and revenue management are central to airline business models (➤Chapter 7). They are intrinsically linked functions that, when working in harmony, enable an airline to maximise the revenue from each flight and give it the best chance of operating profitably.

Recent years have seen significant changes in how airlines sell their product, both in terms of the underlying pricing strategies that are used and the way in which it is distributed. The evolution of airline pricing has been an essential response to the dual impacts of deregulation and the advent of the internet

(➤Chapters 2 and 16), both of which have fundamentally changed the industry in a way that could not have been foreseen 20 years ago.

Pricing relates to the fares that are sold on a seat-by-seat basis for each flight. Typically, each route will have a price range that determines the minimum and maximum fare levels that are charged and, within that price range, a series of pre-determined prices (or fares). This is sometimes known as the **tariff**. On a short-haul route, the price range may be £19.99 to £299.99 and, within that, there will be a number of fares (see Table 8.1). This price range changes infrequently, sometimes once a year, sometimes less.

Tariff: a list of pre-determined prices that seats can be sold at.

The principles of revenue management apply to any market segment where there are time limitations to the supply of a product or service. Examples include hotel rooms, railway seats, hire cars or airline seats. Each of these has a value up to a particular point in time, after which it cannot be sold and has no value.

In the airline industry, revenue management is the method through which an airline determines how many seats to sell on each flight at each tariff. For full service network carriers (FSNCs) that operate a frequent flyer programme (FFP) (➤Chapter 9), there is the additional consideration of FFP redemption tickets (how many tickets to make available for FFP redemption in each cabin class). There are a number of considerations that influence the price passengers are prepared to pay, and using a revenue management system an airline can understand these factors and manage the sale of seats accordingly. Airline websites may also track the number of times a potential customer has clicked through the website to view available fares. Some of the key factors to consider are the time of the flight, the day of the week, the time of the year and whether there are any one-off events occurring. A major business convention or sporting event, for example, will increase demand and therefore the price passengers may be willing to pay. Successful airlines pay close attention to these since they can be the difference between profit and loss.

The data in Table 8.2 shows how, from the same tariff, the airline can offer very different fares to passengers. In the off-peak winter example, it sells over 50 per cent of its seats at less than £39.99, because demand is low and it needs to keep prices low in order to sell seats. In

Table 8.1 Example of a price range (tariff) for a short-haul flight

	Fare level
Lead-in fare	**£19.99**
Fare 1	£24.99
Fare 2	£29.99
Fare 3	£39.99
Fare 4	£59.99
Fare 5	£79.99
Fare 6	£99.99
Fare 7	£129.99
Highest fare	**£299.99**

Table 8.2 Applying revenue management profiles to a tariff

		Percentage of seats sold at each fare level		
	Tariff	*Off-peak winter flight (%)*	*Mid-season business destination (%)*	*School holiday leisure flight (%)*
Lead-in fare	**£19.99**	25	0	0
Fare 1	£24.99	15	0	0
Fare 2	£29.99	15	10	0
Fare 3	£39.99	15	15	0
Fare 4	£59.99	10	20	10
Fare 5	£79.99	10	20	20
Fare 6	£99.99	5	15	20
Fare 7	£129.99	3	10	25
Highest fare	**£299.99**	2	10	25

the school holiday example, on a flight operating to a typical holiday destination, demand will be strong and it may not sell any seats below £59.99.

8.1 Pricing

Traditionally, airlines tried to differentiate the price of the journey by identifying passenger journey characteristics and pricing them accordingly. Generally, return fares were offered at a lower total price than the sum of two single fares, on the basis that the airline wanted to fill seats in both directions and most outbound passengers are likely to need to return. This was called **round-trip pricing**. More return (or round-trip) fares were available than one-way fares.

Round-trip pricing: pricing based on a passenger making a return journey purchase with the same airline/same booking.

Minimum stay rule: a booking criterion related to the length of stay (or days of stay) which must be met before a certain tariff is shown to the customer.

Using this approach, which is referred to as the traditional pricing model, the airline will offer a range of different fares, each of which have different booking or travel conditions, in order to maximise revenue from each journey. The more flexibility the passenger needs, the higher the price they must pay. Sometimes these are obvious, for example when the class of travel is different – business class is more expensive than economy class as the in-flight services are more expensive to produce. Other times they are more subtle; for example, if the passenger books a long time in advance of departure, known as 'advanced purchase', it may be cheaper than booking on the day of travel. If they include a Saturday night stay in their itinerary (**minimum stay rule**), it probably indicates the passenger is travelling for leisure purposes and may have less to spend than a passenger travelling for business purposes.

Another way of differentiating the product is to offer a lower price in exchange for more restrictive travel conditions – the passenger may have to stick to the booked flights and not be able to change to an alternative, or the ticket price may not be refundable in the event of cancellation. Fares in the traditional pricing model are usually grouped into normal and special. Special fares are those with restrictive conditions, whereas normal fares have no restrictive conditions but are significantly more expensive.

One-way pricing: pricing each seat on a one-way basis.

The more modern approach, and one which is now almost exclusively observed in short-haul travel, is **one-way pricing**. When this approach began in the mid-1990s (introduced by low-cost carriers (LCCs) as a core element of their pricing strategy and subsequently adopted by FSNCs in response), it marked a significant departure in pricing strategy for the airline industry, and one which has ultimately led to a more competitive marketplace, which offers better value for customers and, importantly for the airlines, fuller (and more profitable) flights.

In the one-way pricing model, the airline makes little attempt to use conditions to determine the fares that are available to passengers; it simply prices each journey on a one-way basis. If the passenger is making a return journey, the fare will be the sum of the prices for A to B and B to A. This is a much simpler approach, but one that relies more heavily on revenue management to ensure the airline maximises revenue. Some airlines may choose to make one-way tickets more expensive than return fares.

In both traditional and one-way pricing models, the airline will use a pricing system to maintain its tariff, and this will, in conjunction with the reservations and revenue management systems, calculate and display the applicable price for a flight when a passenger searches online or at a travel agent. It also explains why prices for the same flight will often change, sometimes quite considerably, over time.

!

Stop and think

What are the main differences between round-trip and one-way pricing, and what are the implications for passengers?

8.2 Revenue management

Yield management: a variable pricing strategy aimed at selling (perishable) products to achieve revenue management principles.

Seat inventory: the number of seats available on any given flight.

Revenue management, sometimes referred to as **yield management**, is the practice of maximising the revenue from each flight by controlling the number of seats that are sold at a particular price or in a particular market (see Table 8.2). It is central to the industry and is an approach that has evolved beyond recognition in recent years. It stimulates competition, and enables aggressive marketing and attractive lead-in prices while ensuring the airline sells every seat on every flight at the highest possible price.

In the early years of computerisation (➤Chapter 16), a simpler approach – called **seat inventory** (or space) control – existed. This was a way of making sure that the number of passenger tickets sold was no more than the inventory (the number of seats available on each flight). In order to control the number of seats available for sale, each flight on each day it operated would be set up in the airline's computer reservation system (CRS) with the seating capacity of the aircraft. Each time a reservation was made on the flight, the number of available seats would be reduced accordingly, ensuring that the airline could not 'overbook' the flight by selling more tickets than it had available seats.

This system has subsequently evolved into a centrepiece of commercial operations, liaising between the marketing and pricing departments to manage and control how the airline sells its seat capacity. While the principle is straightforward, in practice the more an airline understands about passenger behaviour the better it can optimise its price availability for each flight, which, in turn, maximises revenue.

Typically an airline revenue management department will comprise a group of route analysts (who have responsibility for maximising revenue on the routes that they manage) who use a revenue management system. The revenue management system uses complex algorithms that seek to forecast demand for each flight at each price-point by analysing past purchasing behaviour. The system proposes how many seats should be sold on each flight and at what price in order to fill the flight at the optimal revenue. Over time, the revenue management system will re-calibrate its algorithms based on the booking profile of previous flights to constantly refine the booking profiles. Case Study 8.1 demonstrates the importance of airline revenue management.

CASE STUDY 8.1

PEOPLE EXPRESS V AMERICAN AIRLINES: YIELD AND REVENUE MANAGEMENT IN ACTION

American Airlines' CRS (➤Chapter 16) allowed the airline to understand the booking profile of its passengers and use the system's revenue management capabilities to its advantage.

This was demonstrated in pricing competition with People Express in the mid-1980s on services between Chicago and Los Angeles. Both airlines advertised their lead-in fare at US$99, but People Express sold all the seats on its services at that price (Rose *et al.* 2006). In contrast, American Airlines, knowing the booking habits of different customer types, was able to hold back seats for business passengers (who generally have to travel, are not generally paying for their own ticket, and are therefore able/willing to pay a higher fare), therefore increasing the overall average price of a ticket on the service. As People Express had priced all seats the same, they were unable to charge more for passengers that could afford to pay more (and therefore they were unable to maximise revenue from each flight). People Express lost significant revenue and ultimately ceased operations.

One of the key considerations of the revenue management function is to make sure that each flight operates to a high level of occupancy but not with more passengers booked to fly than there are seats on the aircraft. Some airlines will deliberately sell more seats than the aircraft holds, a practice known as **overbooking**, because experience has shown that a certain proportion of passengers will not turn up. These are known as 'no shows'. If the average no show rate on a route is 10 per cent, the airline may sell 5 per cent more seats than it actually has, to ensure the flight will be almost full. Occasionally things will go wrong and too many passengers may turn up for the flight. In Europe, this carries financial penalties for the airline, which awards compensation to passengers who are unable to fly as planned.

> **Overbooking:** the practice of selling more seats than the aircraft holds on the assumption that a certain percentage of passengers will not turn up for their flight.

Other revenue management complexities include: using point-of-sale-pricing to maximise revenue, whereby an airline seeks to charge more in a particular market than another because it knows customers from that country or city have greater disposable income than others; and special event pricing, where one-off events – conferences, sports events or even a large societal event such as a major wedding – create a spike in demand. For example, in an attempt to attract traffic from rival operators, an airline based in country A may charge less for a service to a city in Country B that originates in Country C (but transits through Country A) than it does for a direct flight from A to B.

Stop and think

What are the benefits to airlines of operating a revenue management system?

8.3 Pricing strategies of FSNCs and LCCs

At the outset of the low-cost revolution, there were clear differences between the pricing strategies of full service network carriers (FSNCs) and LCCs. FSNCs used the traditional pricing model, whereas LCCs developed the one-way pricing model. However, FSNCs have been forced to adopt one-way pricing in the markets where they compete with LCCs. This means that, for short-haul flights, there is little difference in the pricing models of most airlines. Conversely, long-haul routes are more commonly operated by FSNCs and retain the traditional pricing model.

The pricing strategies of airlines are based on the type of passengers being carried and the nature of the passenger's flight itinerary (➤Chapter 9). Airlines who target the ultra-price-sensitive leisure market will operate on a volume-driven model, where the objective is to fill every flight to as near 100 per cent load factor as possible; whereas airlines serving largely business-driven markets may be content to operate nearer 80 per cent occupancy but at a high average fare.

It is easier to differentiate passengers by looking at the purpose of travel. Generally, there are three main reasons for travelling – business, where there is no real choice in destination or the date of travel; leisure, where the passenger often has a level of discretion in when they travel, and sometimes where to; and visiting friends and relatives (VFR), where travel might be discretionary but the destination is fixed. Thus, these three groups show different characteristics in their choice, as shown in Table 8.3.

The pricing and revenue management strategies of FSNCs and LCCs are also influenced by differences in their business models:

- FSNCs generally fly both short- and long-haul services;
- FSNCs carry point-to-point traffic as well as passengers **connecting** between short- and long-haul flights at hub airports; and
- FSNC passengers may interline between two different airlines, paying one through fare that covers all flight segments/airlines; whereas
- LCCs generally only handle point-to-point passengers (although a small number do offer through fares via their main airports).

Connecting: (a passenger) flying to a hub airport and connecting onto another service.

Table 8.3 Pricing considerations of different passengers

Passenger type	*Booking profile*	*Journey considerations*	*Other considerations*
Business	• Tend to book closer to date of travel. • Do not necessarily make the booking themselves. • Destination usually driven by need rather than desire.	• Less price sensitive. • Frequency of service important (e.g. enabling a day return). • Convenient airports preferred (shorter journey times).	• Frequent flyer programmes and premium airport products (such as lounge access and fast-track security).
Leisure	• Tend to book further in advance of the travel date. • Range of motivations for travel (destination, tourist offering, price). • Potential flexibility with regards to destination.	• More price sensitive. • More willing to accept disadvantages, including secondary airports and poor flight schedules.	• Some demand for premium (but rarely first class) travel in long-haul markets, particularly in luxury market segments such as flights serving cruise ships.
VFR (visiting friends and relatives)	• Tend to book long in advance of travel. • Flexible in date and time. • Destination driven by location of friend/ relative.	• More price sensitive. • Seek most convenient destination airport.	• May travel frequently or use premium cabins for trips of longer duration on long-haul.

Stop and think

Consider the extent to which passenger segmentation is important as part of a revenue management system.

8.4 Point-to-point revenue management

This concerns generating revenue from a passenger who is being transported between two points and no further. This is the operational model for the majority of LCCs (while some LCCs such as Norwegian do offer through ticketing, this is only a small aspect of their operations), whereas it forms only part of the operational model of FSNCs. Essentially, the only way to fill a flight in the point-to-point model is with passengers that want to fly between the two airports served by the flight. Thus, in periods of low demand, where there is the possibility of the seat flying empty, the carrier will use the pricing and revenue management process to stimulate traffic to attract people to fly when they may not have considered it through offering very low fares. The skill is to manage revenue to ensure that enough people are stimulated/attracted to travel with that airline through low fares while ensuring that revenue is maximised for that sector. Example 8.1 details the impact of booking profiles on LCC fares.

Example 8.1

Impact of booking profile on LCC fares

In 2014, the largest route (by seat volume) operated by LCC Ryanair from London (including Luton, Gatwick and Stansted airports) was to Dublin Airport. Both Dublin and London are major tourist destinations as well as being large business centres. Consequently, both business and leisure passengers use the route. Fare data, collected from Ryanair's website, shows that at three months and one month prior to the date of travel, fares are around 50 per cent lower than the fare advertised one week prior to travel.

Origin	*Destination*	*3 months*	*1 month*	*1 week*
Luton	Dublin	€33.58	€36.53	€74.35
Gatwick	Dublin	€39.01	€43.72	€88.26
Stansted	Dublin	€33.59	€35.57	€75.19

Average 3 months/1 month	*Difference from 1 week*
€35.06	–53%
€41.37	–53%
€34.58	–54%

Source: www.rdcapex.com, December 2014. Data are average for January to September 2014, weighted according to the number of tariffs on each route.

The nature of passenger trips and booking profiles means that, on point-to-point services, airlines need to find a balance between:

Price sensitivity: how sensitive customers are to changes in the price of a product.

- attracting (primarily leisure) passengers to book early (through lower fares); and
- increasing fares closer to the date of travel to take advantage of business passengers' need to travel, often at short notice, and lower **price sensitivity**.

Through careful management of this process, both load factors and revenue are maximised. Higher load factors are important, especially for LCCs, as more people on board not only results in higher ticket revenue but also increases the opportunity to generate extra income through the sale of ancillary items such as seat assignment, on-board purchases, bag fees and priority boarding. This important additional revenue stream enables airlines to bolster their ticket revenues by up to 20 per cent, and in the case of very cheap headline fares, may be the difference between a loss-making and a **breakeven** passenger.

Breakeven: when the revenue covers the costs of providing the seat.

For LCCs, each individual flight may be considered as a stand-alone 'profit centre', with route analysts being challenged to manage routes and even flights to profitability (i.e. where ticket plus ancillary revenues are greater than the sector operating costs). As a result, the pricing policy of LCCs is almost always on the one-way basis as this helps to ensure that the strategy of maximised revenue/load factors is achieved on each flight. It is also a much less labour intensive way of managing pricing.

FSNCs have a more complex series of considerations in their pricing and revenue management. Each flight will contain a mix of point-to-point and connecting passengers, and potentially a mix of pricing strategies – traditional and one-way. Typically, passengers flying non-stop between two points are more cost-effective to carry than connecting passengers, in that they are less likely to miss flights or lose bags (which would result in costs for the airline in terms of compensation and additional administration), and require lower maintenance in terms of pricing complexity. However, the network effect gives carriers the scope to operate in considerably more markets if they carry connecting passengers than a point-to-point airline, especially if they offer interlining or codesharing opportunities (➤Chapter 7).

As Figure 8.1 shows, an airline flying six routes from airport G using an LCC point-to-point model offers six routes (one each from A, B, C, D, E, F to G). Under a network model, whereby the airline offers connections at airport G, it is able to offer 21 city-to-city combinations – six point-to-point (as above) and 15 connecting – A to B, C, D, E, F; B to C, D, E, F; C to D, E, F; D to E, F; and E to F (see Table 8.4).

With the requirement to price in both directions, the LCC will be managing 12 flights and associated tariffs, whereas the network carrier will be managing 42, although it serves the same number of airports.

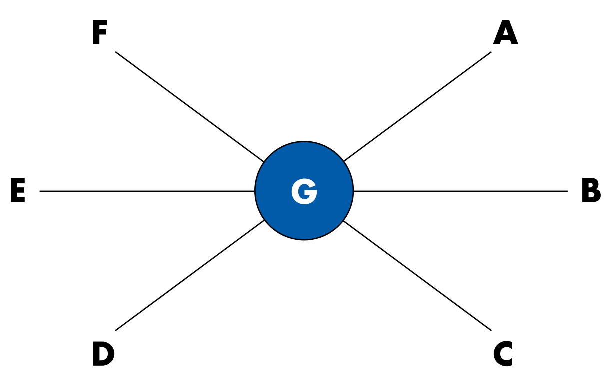

Figure 8.1 Example network and city combinations

Table 8.4 Possible network connections via Airport G

Origin airport	A	B	C	D	E
Transit airport	G	G	G	G	G
Destination airport	B, C, D, E, F	C, D, E, F	D, E, F	E, F	F

Although this means more management time and complexity for the network carrier, it also gives the airline greater scope to be tactical in how it fills its aircraft as it does not have to rely on the traffic flows on six city-pairs because it can carry connecting passengers on a further 15 city-pairs. For the network carrier, the situation is more complex – not only will point-to-point demand and revenue have to be considered as part of the route performance analysis, but also how to allocate the revenue from connecting passengers who pay one fare but fly on two (or more) sectors.

8.5 Connecting passenger revenue management

In general, long-haul services are operated by a network carrier to or from their main hub airport(s). Demand for long-haul services is also lower than for short-haul for a number of reasons – long-haul flights are more expensive to operate and therefore more costly to sell; people tend to take holidays and mini-breaks within a relatively close proximity to their home country; and there are often additional requirements with long-haul travel in the way of visas and the need for vaccinations that further reduce the frequency with which passengers consider flying long-haul. In turn, airlines tend to focus their resources on a small number of origin or hub cities around which they develop a network of air services. In fact, many airports cannot be effectively connected with direct non-stop services (even with modern aircraft types with extended range) because market sizes do not warrant frequent, year-round flights, and so it is seen to be more cost-effective to transfer passengers between flights via the hub airport. In addition, due to operational considerations, long-haul services (and the larger aircraft that are required to operate them) are likely to be consolidated at larger airports that have the necessary infrastructure.

As network airlines will be carrying transfer passengers via a hub airport (and carrying passengers who are only using that service due to the ability to connect), the allocation of revenue for a booking is generally split using a prorate agreement, which uses distance to allocate revenue between the various segments of the trip itinerary. This may mean that revenue allocated to that passenger on a short-haul feed sector (which is connecting on to a long-haul service, such as a domestic feed on to a long-haul international service) will be significantly lower than what a passenger flying point to point on the same short-haul sector may pay. Example 8.2 provides an example of how revenue from connecting tickets may be allocated.

Revenue management for connecting passengers is therefore different from that of point-to-point passengers. The revenue management team within an FSNC must review many more combinations of itinerary to work out how best to fill each flight. These combinations of itinerary are known as origin and destination (OD), and the airline pricing and revenue management analysis will evaluate the pricing on each OD before deciding which markets to

Example 8.2
Example of revenue allocation for connecting tickets

A passenger flies from Glasgow to New York Newark via London Heathrow, paying US$413 for their fare. The sector length between Glasgow and Heathrow is 555km, and the sector length between Heathrow and Newark is 5,576km. The revenue, which is generated from one ticket for the entire journey, needs to be allocated between the two sectors being flown, and this is achieved according to the relative share of the distance of each sector to the overall journey. Therefore, US$37.38 of the fare is allocated to the Glasgow–Heathrow sector based on the sector length divided by the combined length of Glasgow–Heathrow–Newark. The remaining US$375.62 of the fare is allocated to the Heathrow–Newark sector.

However, this revenue allocation is much lower than the average point-to-point fare between Glasgow and Heathrow (US$165). The purpose of carrying the passenger from Glasgow to Heathrow is not primarily to contribute revenue to the first short-haul sector, but to the long-haul sector from Heathrow to Newark.

Source: Fare data reported through IATA AirportIS, 2014.
Distance based on great-circle distance.

prioritise over others. Route analysis will look at these points of sale to ensure that fares are competitively priced to attract passengers to their airline (over their hub) and so need to remain competitive with all of the other airlines flying the same OD via a different hub, while also retaining focus on the overall revenue potential of the passenger across the whole trip itinerary. This also means that a wider network view on profit and loss needs to be considered, rather than looking at single routes in isolation.

8.6 Other revenue management considerations

How an airline approaches its pricing and revenue management will be defined by the market segment it is trying to occupy. Ryanair is an example of an airline that for many years has used price as its main selling point, using slogans such as 'Fly Cheaper' and 'The Low Fares Airline' as centrepieces of its marketing activity. By creating this brand image, the airline has to offer the low fares it promotes. Other airlines adopt more generic straplines. 'Fly the Friendly Skies' (United), 'To Fly. To Serve.' (British Airways) and 'The Reliable Airline' (KLM) are just some that have been used to create a brand proposition rather than a pricing statement (➤Chapter 19).

These marketing positions are important because they determine how a carrier approaches its price-point. Some airlines will want to be market leaders or 'price makers', meaning they have the brand power to be the first to reduce or advertise low prices or fare sales – and are likely to be the first to increase prices as demand grows, while maintaining the perception of lowest cost. This is particularly true of ultra-low-cost carriers (ULCCs) such as Wizz Air. ULCCs use their position as being the cheapest airline to fly between two cities as a key promotional tool to capture initial demand for a service. ULCCs are able to be market leaders in this regard due to their exceptionally low (and industry leading) cost base. ULCCs benefit from the market's perception of them being the lowest cost airline to operate on a particular route in that customers will often go to these airlines' websites before any other airline on the assumption that they will be the lowest cost (among other factors).

On the other hand, other carriers are left being 'price takers', meaning they generally react to moves made by the market leaders or price makers – and they need to constantly monitor the prices these carriers offer in order to increase or decrease their own fares to stay in line with the market.

The other segments that influence revenue management are block bookings and off-tariff agreements. The first of these is where an airline sells a block of seats to a third party to sell on, usually a tour operator looking to offer inclusive package holidays with flight and accommodation included. These tend to be at a pre-agreed volume and price, meaning the airline has some certainty of revenue for part of its flight inventory, but the revenue management analyst has fewer seats to sell to the general public and therefore more skill is required to optimise revenue for a flight.

Off-tariff is where an airline makes a contractual arrangement with a potential provider of traffic in exchange for offering discounts on the standard fares. As with block bookings, this is often a tour operator or travel agent, but one who doesn't want to guarantee a specific number of passengers on a flight. The other type of off-tariff agreement, and one that is essential to the large FSNCs, is the corporate agreement. These are typically negotiated deals with the high-volume corporations that have large, regular amounts of business traffic on single routes or across a range of destinations (e.g. oil companies who regularly need to access oil-rich cities, regions and countries such as Aberdeen, Texas and Nigeria respectively). The airlines seek to lock-in as much spend as possible from these businesses, which can provide significant volumes of traffic and revenue. Again, the pricing and revenue management teams need to work closely to ensure that the right balance of competitive price and seat availability can be offered to such companies.

8.7 Contribution of ancillary revenue to total revenue

Ancillary revenue: the revenue generated from passenger spend on secondary services not associated with the ticket price, such as hold baggage and on-board food and drink purchases.

Ancillary revenue describes additional purchases that may be made by passengers on top of their ticket price. This is a common practice in the LCC one-way pricing model. Examples of primary ancillary services include the purchase of hold baggage, allocated or extra-legroom seating and on-board food and beverages.

In the traditional pricing model, these items and services are usually included within the ticket price, particularly on long-haul routes where it might be considered unreasonable to charge passengers for checking baggage or in-flight meals. These services were first unbundled from headline fares by LCCs as they sought to reduce fares to the lowest possible level in order to stimulate demand, gain customer interest and compete with traditional FSNCs by advertising lower ticket prices that were often justified by charging extra for services which the passenger may not necessary need and therefore shouldn't necessarily pay for.

The revenue generated from these services is a major source of income for airlines, especially for LCCs, and is important from a revenue management perspective. Different passenger types will have different needs/desires for ancillary services. For example, a leisure passenger is more likely to be travelling for a longer period than a business traveller and therefore require additional hold baggage. Families are more likely to pre-assign seats to guarantee sitting together. A business passenger, for example, is more likely to value a seat at the front of the aircraft, as this means disembarking is quicker (and therefore more likely to consider purchasing priority boarding or allocated seating). If each LCC sector is to be considered on a profit and loss basis, revenue management analysts need to consider the potential ancillary revenues from passengers if the overall level of revenue is to be maximised.

FSNCs have started to increase the number of ancillary services they offer (which were traditionally included in ticket prices), especially on short-haul sectors. This is partly in recognition of the level of competition they face from LCCs but also in recognition of the change in travel habits of passengers – as LCCs introduced more and more ancillary services, passengers became more used to them, and now the practice of charging for certain ancillary services, especially hold baggage, is now considered the norm.

Stop and think

What factors have led to ancillary revenues being an important revenue source for airlines, and how might this phenomenon develop in the future?

8.8 The impact of the internet

LCCs were market leaders in terms of developing online booking systems in the late 1990s/early 2000s, moving away from traditional bookings made through Global Distribution Systems (GDSs) used by travel agents and other booking agencies (➤Chapter 16).

Online booking systems gave LCCs a way to directly interact with their customers, cutting out additional costs associated with third-party sales platforms and therefore helping to offer lower fares. This development also supported the addition of ancillary service sales to customers, as well as creating new ways of generating revenue outside the passenger's flight (e.g. through advertising and through receiving commission payments from other companies when the airline's customers book hotels or car hire with third-party providers).

The development of the internet dramatically changed the ways in which airlines could interact with customers. Not only were online bookings cheaper to manage, for the first time airlines had complete control over what the customer was shown in terms of sales options, destination choice and direct marketing opportunities and and had more flexibility to react quickly to changes in competition and market pressures. Customers had the ability to quickly check competitor pricing/pricing by time of day/day of week to find the cheapest flight option for their journey.

The ability for airlines to highlight cheaper fares for flights of interest and new destinations helped them to maximise load factors across their networks, especially for leisure passengers who have more flexibility in terms of flight timing and destination. The promotion of new routes (without passengers having to search for them) opened up new destinations and tourist markets (both inbound and outbound), giving customers a wide choice of options on their expenditure.

LCCs promoted the lowest possible headline fare to generate interest and drive potential customers towards their website. In many instances, this has led to LCCs selling fares below operational cost and at prices that are **loss leaders** (see Example 8.3).

Loss leader: a product marketed and sold at below operational cost to generate interest in the product among consumers.

Example 8.3
Loss-leading LCC fares

In December 2014, Ryanair was advertising one-way fares between London Stansted and Glasgow Airport for £14.99 (inclusive of taxes and airport charges, but excluding optional ancillary services and paying by debit card). From this fare, the airline would need to pay the UK government the standard rate Air Passenger Duty (APD) for a Band A flight of £13 per passenger, which would bring the ticket revenue down to £1.99. From this remaining amount, the airline would need to pay airport charges, fuel costs, crew salaries, lease and insurance costs, and aircraft handling fees. These costs would outweigh the remaining £1.99 left after APD was paid, resulting in that fare being a loss leader.

The airline's commercial model also includes selling extra products such as assigned seating, checked-bags and on-board refreshments. These ancillary revenues are usually cheap to deliver and high margin, meaning that although only a proportion of passengers will buy them, they increase the marginal revenue for each passenger with very little cost. This additional revenue supports the loss leaders.

Additionally, the airline only needs to sell one seat at the lowest advertised price to comply with advertising standards (even if this practice might be frowned upon by local advertising standards agencies) and can quickly increase the available fare once the promotional fare is sold. Again, this comes down to revenue management of the whole sector, rather than considering the profit and loss from one specific customer.

In directing customers towards online booking systems, airlines have been able to collect key information about their journeys and travel preferences, which in turn has aided online marketing strategies. Not only is direct online marketing cheaper than traditional methods of engaging with customers, the information gathered as part of previous booking processes could be tailored to give more intelligence behind marketing messages and further drive more customers towards booking with the airline.

Booking systems continue to evolve as technology advances, resulting in changes in the operation of flights. Airlines such as Ryanair and easyJet pursued online check-in as a way of reducing their core operating costs by reducing the number of staff required to process passengers checking in at the airport. This has subsequently evolved into mobile apps, with boarding passes now being stored electronically rather than needing to be printed out, enabling passengers to manage their travel online. Continued customer engagement with apps gives further information to the airline for marketing purposes (➤Chapter 19).

The resulting impact on these changes means that airport operations have changed too. For example, with more passengers checking in online and travelling with less hold baggage, fewer check-in desks are required. This frees up terminal space and potentially reduces the number of check-in staff that are required but requires Wi-Fi and/or QR readers to operate.

Stop and think

What role has the internet played in changing practices of airline pricing?

8.9 Emerging trends in airline pricing

When LCCs first entered the marketplace, they offered a genuinely different product from network airlines, particularly in the creation of a completely new pricing strategy, followed by the unbundling of services, so that all ancillary services were an additional cost. FSNCs, after losing market share and revenue to their LCC competitors, started to adopt these practices too, albeit where it was not detrimental to the overall service level offered to their main customers, while LCCs have started to loosen their approach towards completely unbundled products. Some LCCs have started to offer fare products that now include hold baggage, allocated seating, priority boarding and flexible tickets, which are more akin to the old traditional pricing approach originally offered by the FSNCs. While it is unlikely that the two pricing models will converge into one universal approach, it is likely that both types will continue to evolve.

LCCs have also moved away from being the sole sales channel for their fares, with both the main European LCCs (easyJet and Ryanair) completing deals with GDS providers to make their products available across third-party sales channels and evaluating participation in the interline and off-tariff markets. This not only gives LCCs visibility to corporate booking agencies (which rely upon GDS feed for their systems) but could also open up the opportunity for LCCs to accept transfer passengers or indeed for LCCs to start their own hub operations in a more formal way.

As the internet is now the primary booking channel within Europe, there is likely to be a continued shift towards providing internet-enabled services that facilitate easier journeys for the customer while simultaneously maximising the type and volume of information airlines are able to gain from them.

Advances in internet technology will offer new opportunities for airlines to maximise their revenues, for example through IP tracking. IP tracking is the practice of using a computer's internet protocol (IP) address to obtain the geographical location of that computer. This information can then be used to tailor products, services and future marketing copy to that consumer.

While not precise, IP tracking could give airlines the chance to differentiate prices by point of sale, thus enabling them to better match prices by customer resource (e.g. a ticket could be priced lower for a passenger who lives or works in a poorer country). Equally, IP addresses can be used to automatically direct passengers to a specific website to better manage revenue. This is particularly important for airlines that price fares in local currencies as customers could potentially seek out and book fares in lower local currency prices.

One future challenge that airlines will face is the ability to further drive down operating costs. The 'quick wins' have already been adopted and finding further cost efficiencies is becoming increasing challenging. This in part is the reason behind the move towards more homogenised fare products. If LCCs are unable to further drive cost efficiencies and more pressure comes from the network side of the industry on base fare costs, LCCs will need to be even more focused on revenue management to ensure each flight is profitable. FSNCs, in contrast, need to be aware of their cost base and the historical legacy of their (traditionally more expensive) IT and HR systems (➤Chapters 16 and 18).

Key points

- Pricing and revenue management are fundamental to airlines, and carriers adopt different approaches depending on their business models.
- Long-haul and short-haul markets are priced differently due to the different cost of producing them and the different customer segments they attract.
- Airlines have moved from traditional and more restrictive pricing models towards more flexible one-way pricing regimes.
- Network operations provide greater potential for connectivity and revenue generation than point-to-point routes, but they are more complex to manage.
- LCCs, in particular, may advertise loss leaders to stimulate demand.

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CHAPTER 9

Airline passengers

Andreas Wittmer and Gieri Hinnen

LEARNING OUTCOMES

- To identify airline passenger segments based on situational, socio-economic, demographic and psychographic characteristics.
- To understand the concept of customer value.
- To recognise different interpretations of utility.
- To identify differences between airline loyalty programmes.
- To be aware of the relative merits of airline loyalty programmes.

9.0 Introduction

Airlines create value for employees, investors, governments, customers and consumers. This chapter focuses on the **customers** and **consumers** of the airline product. Airline customers, who include passengers and **corporate travel providers**, exert considerable market power in the air transport industry through their purchasing decisions and travel behaviour. As a purchaser of a commercial aviation product, customers are responsible for stimulating product and service innovation, and their purchasing decisions ultimately decide which airlines succeed and which fail. As all airlines offer the same basic product – safe carriage by air from A to B – they seek to differentiate themselves from their competitors on price and/or service. Airlines will only be successful if they are able to create sustainable value for their customers. Whereas customers make purchasing decisions, consumers actually experience (consume) the product or service that has been bought. Satisfying the needs of passengers, who may be both customers and consumers, is inherently challenging and complex. This chapter focuses on three management tools that airlines use to

Customer: a person who purchases a good or service for personal use (in the case of a passenger) or on behalf of another person (in the case of a corporate travel provider).

Consumer: a person who consumes the product or service that has been purchased. In the case of air travel, passengers can be both customers and consumers.

Corporate travel provider: a specialist travel company that arranges business travel on behalf of other organisations.

Passenger segmentation: the grouping of passengers according to their stated or revealed preferences and/or buying behaviour.

Situational segmentation: the grouping of passengers according to booking preferences and travel requirements.

Socio-economic and demographic segmentation: the grouping of passengers on the basis of personal and social characteristics.

achieve sustainable competitive advantage: passenger segmentation, passenger value and passenger retention.

9.1 Passenger segmentation

To effectively tailor their products and services to the needs of particular customers, airlines segment their passengers into different groups. The process of **passenger segmentation** seeks to identify groups of customers who share common characteristics. The resulting market segments contain customers with similar preferences and/or buying behaviour. Customer preferences differ between market segments. Criteria including nationality, age and trip motivation (business or leisure) are typically used to segment passengers. Individuals travelling on business, for example, may have very different needs from if they were travelling for leisure purposes. Market segments can be categorised on the basis of situational, socio-economic, demographic or psychographic criteria.

Situational criteria relate to the context in which the customer travels. Typical **situational segmentation** variables include:

- sales channels (such as travel agents, online or phone);
- time/date of flight;
- time of booking;
- location and access of origin and destination (OD) airports;
- seat and ticket availability;
- ticket flexibility;
- loyalty/frequent flyer benefits;
- airport services;
- in-flight services.

Socio-economic and demographic segmentation considers the personal characteristics of individual travellers. Typical criteria are:

- gender (passengers may exhibit different needs and priorities on account of their gender. Some airlines offer female-only airport lounges and on-board lavatories);
- nationality;
- religion;
- age;
- physical (dis)abilities (which may require special assistance such as the use of wheelchairs);
- relationship status;

- income;
- first language;
- occupation;
- education/qualifications;
- whether passengers are travelling alone, in a group, in a family group or with babies or young children.

Psychographic segmentation focuses on trip motivation, engagements, values, attitudes, interests, opinions, personality, behaviour and lifestyle characteristics. These characteristics might indicate why a specific product category is preferred but not why a specific product was chosen. The biggest challenge with psychographic segmentation is that these criteria are often more difficult to measure than demographic segmentation criteria. Psychographic variables include:

Psychographic segmentation: the grouping of passengers on the basis of travel behaviour, motivation, values, attitudes, interests, behaviour, opinions, personality and lifestyle criteria.

- trip motivation: the reason for travelling, such as business or leisure;
- destination;
- length of flight: short- or long-haul;
- length of total time away from home;
- travel class: economy, economy plus, business or first class;
- travel experience: frequency of flying;
- cultural background of the passenger;
- airline preference. This may be based on the business model of the airline (such as a full service, low cost, or charter), its perceived safety and service standards, its brand value and reputation (high quality or low cost), its cultural resonance and familiarity to the passenger, and whether or not it belongs to a global airline alliance;
- membership of an airline or airline alliance loyalty programme, account balance and status level;
- seat preference (whether for a particular seat, an extra-legroom seat, an aisle seat or a seat in a child-free quiet zone);
- environmental considerations: age of the aircraft and the airline's environmental credentials.

The aviation industry uses different variables to segment their passengers. The European aircraft manufacturer Airbus, for example, segments passengers into six groups according to socio-economic, demographic and psychographic variables (see Table 9.1).

Once segments are identified, airlines need to identify the requirements of these customers and explore the most effective way to target and engage them. Conventional market research techniques, such as questionnaires, opinion polls and focus groups, have long investigated

Revealed preference: how customers actually behave.

Stated preference: what customers say they prefer.

Big data: describes large data sets detailing human behaviour or interactions which are too big, complex or dynamic to be handled by traditional data processing methods. Big data also refers to the complex and fast-changing technologies that are used to analyse these data sets.

the relative importance of different product dimensions (including comfort, convenience and price). However, such methods may not accurately reflect true decision behaviour where financial resource restrictions and trade-offs play an important role. Contemporary market research applies sophisticated methods which enable the identification of **revealed preferences** (as opposed to **stated preferences**) or motives which sometimes customers are unable or unwilling to disclose. Innovations in data analysis techniques and the exploitation of **big data** will enable more sophisticated customer segmentation. Airline operators are increasingly using advanced statistical methods to analyse large amounts of customer data in the search for patterns and trends that identify new customer segments and enable them to tailor their products to individual segments.

Table 9.1 Airbus's passenger categorisation

Bargain travellers • Functional/Cheap chic • age: 20–45 • marginal business flyer • occasional leisure flyer • segment size: major	Mainstream travellers • High-street shopper/Travel experiencers • age: 25–45 • occasional business flyer • occasional leisure flyer • segment size: major
Traditional travellers • Conservatives/Habituals • age: 55+ • marginal business flyer • occasional leisure flyer • segment size: major	Trendsetting travellers • Cosmopolitans/Discoverers/Globetrotters • age: 18–99 • frequent business flyer • frequent leisure flyer • segment size: medium
Senior travellers • Corporate seniors • age: 45–70 • frequent business flyer • frequent leisure flyer • segment size: medium	High-society travellers • Company leaders/VIPs/celebrities • age: 20–99 • very frequent business flyer • frequent leisure flyer • segment size: niche

Stop and think

Why do airlines seek to segment their passengers, and what do they use the resulting information for?

9.2 Passenger value

Service quality has become a major issue in the airline industry and is one of the ways in which airlines differentiate themselves and create value for their customers. Major developments in customer service have taken place since the early 1930s, including: the introduction of flight attendants, pressurised aircraft, improvements in in-flight catering and innovations in ground service provision. In the new millennium, there is evidence of a renewed focus on product features and service quality, especially in business and first class. The key drivers of service quality are:

- Growth in demand for business class travel and premium products.
- Technological and digital innovation that enables service features such as individual in-flight entertainment programmes, lie-flat seats and live service updates.
- Stronger focus on long-haul products by full service network carriers (FSNCs) as a reaction to the declining profitability of short-haul routes due to the rise of low-cost carriers (LCCs).
- New competitors such as Emirates, Etihad and Qatar Airways from the Middle East, who specialise in providing superior levels of in-flight service.

New or improved services aim to add customer value. Customer value can be seen as the surplus of customer benefits that occur when examining the utilities that customers experience in the process of consuming a product or service compared to the costs of providing it. Thus, customer value is the subjective value or perceived utility a customer derives from a product or service. Customer value is based on economic utility theory which assumes that human behaviour seeks to maximise individual utility. Customer **utility** can be used to generate strategic competitive advantage. An awareness of different customer value dimensions allows direct investments into specific quality or cost factors. **Customer value** is not to be confused with **customer equity**; customer equity defines the value of the customer to the company.

A long-standing debate focuses on hard versus soft service factors. Hard factors are those such as price and ticket flexibility, which are measurable and similar for all customers. Soft factors are often referred to as convenience factors that are subjectively interpreted and experienced by individual customers. Soft factors are often intangible, such as the perceived friendliness of the cabin crew or the quality of in-flight catering, and in the field of airline services soft factors are increasingly important. The effect of hard and soft factors on customer value can be affected by socio-demographic and contextual demographic variables. For instance, the impact of soft and hard service elements is influenced by the cultural background and previous travel experience of individual passengers.

Service elements have different meanings for different customer segments. First-class travellers show considerably lower price sensitivity in connection with a higher brand affinity and a stronger emphasis on seat comfort. Research has indicated that a specific customer segment is willing to pay a premium for environmental services, such as carbon offsetting (Wittmer and Wegelin 2012).

Passengers invariably show high willingness to pay for safety and ticket flexibility. This can be understood as passengers displaying a high propensity to pay for their wellbeing. Wellbeing is seen as an individualised and subjectively experienced way of being, which is linked to travel-related stress and determined by the behaviour of individual travellers. The higher the travel class, the higher the personal wellbeing.

Utility: a measure of preferences or benefits of an individual over a set of goods or services.

Customer value: the value a customer places on the product or service received. It is the perceived value the customer receives.

Customer equity: the value of the customer to the company. A loyal customer has a higher value to a company, as the revenue derived from that customer is higher and the result of lower marketing and sales costs.

Service element: a tangible or intangible aspect of a service.

Airlines are increasingly tailoring more of their product to individual travellers in an effort to increase customer value (see Case Study 9.1). Such services come in the form of supplementary services, such as on-board internet access, lounge access and ground transport services. Passengers pay an additional fee for such services, generating additional ancillary revenue above the basic airfare. This better enables passengers to customise their air travel and maximise their value. This trend has been accelerated by developments in information communication technology (ICT) and big data methods, which enable airlines to identify and respond to individual customer needs. Ancillary revenues have become an increasingly important revenue stream for all airlines, not just LCCs (➤Chapter 7).

9.3 Passenger retention

Customer relationship marketing (CRM): marketing that aims to create long-term relationships with customers by focusing on customer value and satisfaction rather than quantity of sales.

Some people repeatedly fly with one airline or alliance because it offers them a high level of personal utility. Airlines seek to support repeated purchasing behaviour by building long-term relationships through **customer relationship marketing (CRM)**. CRM places equal or greater emphasis on maintaining relationships with existing customers as it does on its search for new ones, as it is far cheaper and easier to retain existing relationships than to develop new ones.

Airlines spend considerable time and effort on building customer loyalty through frequent flyer programmes (FFPs). The rationale for operating an FFP is to promote customer retention. Loyal customers have a significant impact on company revenue.

Lasting customer relationships are beneficial for companies. Customer retention is important due to increasing competition and developments in ICT which enable customers to compare the products and prices offered by a range of suppliers (➤Chapter 16). The internationalisation and globalisation of markets, liberalisation, shorter product life cycles and continuous development of products further accentuate the problem. This has led airlines to seek to decrease costs and focus on meeting and exceeding the needs of particular customer segments. Focusing on the needs of customers is not an altruistic measure but a business decision based on the knowledge that customer recruitment is more expensive than customer retention. A small increase in customer retention can lead to a significant increase in profits. Over time, airlines have moved away from attempting to satisfy every single customer to prioritising the most valuable customers and influencing the behaviour of less valuable customers to convert them into loyal ones.

An important approach to enhancing customer retention is a customer loyalty programme. Customer loyalty is central to relationship marketing and takes into account how companies can benefit from loyal customers by increasing customer profitability and lower marketing costs. Companies in different industries have established loyalty programmes. The classic examples are retail companies; customers collect points with every purchase which subsequently can be used to purchase discounted products. The mechanism of the loyalty programme in the airline industry is similar. Passengers collect mileage points with every flight which can later be used to purchase flights, upgrades or airline-branded products. In addition, a customer can attain different status levels depending on the number of mileage points collected. The higher the status level, the more benefits the customer receives. The benefits may include the use of a priority check-in, priority security line, priority boarding, priority standby for fully booked flights, a more personalised service, access to higher class lounges, limousine services, higher baggage allowance and upgrades. By having different tiers of membership, airlines engage in

CASE STUDY 9.1

EVOLUTION OF IN-FLIGHT SERVICES AT SWISS INTERNATIONAL AIR LINES

In response to detailed market research, SWISS introduced fully flat seats in business class in 2009. The fully reclining seats feature air cushion technology which enables passengers to modify the softness of their seat. In addition, each seat is equipped with a TV screen and entertainment system. SWISS's long-haul fleet is now equipped with the new business class, thus providing a consistent product. To further create customer value, SWISS spends considerable effort on high-quality on-board catering. This includes its Taste of Switzerland programme.

In 2014, SWISS announced the introduction of 'SWISS Choice', a first step towards more individualised services. Passengers can reserve their seats and order duty free products in advance or can purchase additional baggage allowance. The airline also introduced a new business and first class cabin product in its new Boeing 777s in 2016 (see Figure 9.1).

Figure 9.1 Swiss International Air Lines business class cabin, B777, 2016

Source: Swiss International Air Lines

Aspirational marketing: marketing that creates a desire among consumers to obtain an exclusive or luxury product or service that, in reality, few can afford.

aspirational marketing as benefits increase with each status level. Individual status levels are often named after rare jewels (e.g. sapphire, ruby, emerald or diamond) or precious metals (such as silver, gold and platinum) to suggest exclusivity and value.

Customer retention programmes such as loyalty cards and membership clubs have three main targets which collectively have a positive impact on customer retention and profit:

1 *Customer selection.* A loyalty programme enables a company to better build and understand customer segments. For example, access to a loyalty programme can be limited to a certain customer group. It is also possible to specifically address various

customer segments. By creating incentives such as a status programme, some customers are selected and treated better than others. With a clear structured segmentation, customer satisfaction, customer value and retention can be enhanced and, furthermore, customer information can be improved. Loyalty programmes enable a firm to collect vast amounts of data on their passengers such as flight frequency and purchasing behaviour. The airline can simultaneously profit from increased market awareness, which it can utilise to develop a more targeted marketing plan and individualised services. Gaining this data is of upmost importance to increase **cross-buying activities** and decrease price sensitivity. Information management is important for successful customer relationship management as it helps to segment customers and ultimately increase customer value and loyalty.

Cross-buying activity: where customers cross-buy different services from the same provider.

Company-specific: the benefits go to the company rather than the alliance.

Company-overarching: the benefits are distributed between programme partners.

2 *Interaction and integration through dialogue.* Loyalty programmes require regular contact and interaction with members.

3 *Image improvement and strengthening of identification.* If a customer feels directly and individually targeted by an airline, a certain additional emotional value is generated. Customer programmes can be developed either in a **company-specific** or **company-overarching** way. Company-overarching programmes admittedly decrease the own financial investment and loyalty that is created, as it is distributed between the programme partners rather than only with the own company.

Stop and think

Consider the benefits of FFPs for airlines and passengers.

9.4 Airline alliances and loyalty programmes

Airline alliances are an important factor in passenger loyalty and a key feature of some loyalty programmes. Alliances enable their partner airlines to offer members of their individual loyalty programmes the benefit of being able to collect and redeem frequent flyer points with other carriers in the alliance in addition to granting them access to a wider range of benefits that increase customer value, such as more destinations, improved flight connections, enhanced flight frequencies and access to more airport lounges. Nevertheless, each airline within an alliance retains and administers its own FFP and selects the level of reward and bonuses that it offers. This can make aligning the benefits and rewards of different FFP memberships within one alliance challenging.

Some airlines, for example, may provide passengers who hold a ticket with their airline with some form of preferential service (such as lounge access for a high-status member flying economy class) that is not available to passengers with equivalent FFP status holding tickets issued by a partner airline. This is because the frequent flyer points needed to gain a particular status level with different airlines within an alliance vary. At the time of writing, a Lufthansa passenger needs to collect 100,000 status miles points to become a gold member with Miles & More, whereas an Aegean Airlines passenger only needs to collect 20,000 status miles points to become a gold member of the Aegean Miles+Bonus programme. As a consequence, a passenger might hold an Aegean Miles+Bonus Gold Card despite flying mostly with Lufthansa. This fact has led airlines within an alliance to differentiate benefits for passengers based on their FFP membership and status level.

As Chapter 7 explains, airlines enter alliances to gain increased economies of scale and scope, access to a wider range of markets, and opportunities to increase customer benefits and utility. The aim of an alliance is to allow customers to benefit from the combined geographic coverage and service of all member airlines. Three alliances – Star Alliance, oneworld and SkyTeam – currently dominate the passenger market (see Table 9.2 and Case Study 9.2). Although FSNCs were the first to enter into formal alliance arrangements, they are not the only airlines who seek to create loyalty benefits for customers. A number of LCCs, including Southwest (US), GOL (Brazil) and AirAsia (Malaysia), operate membership or loyalty programmes which offer benefits such as priority boarding or a higher baggage allowance. In addition to the three major alliances, there are also three new regional alliances – Vanilla Alliance (formed in 2015 to increase connectivity in the Indian Ocean), the Chinese U-FLY Alliance (formed in 2016) and the Value Alliance (formed in 2016 by airlines in East Asia and Australia).

Stop and think

Is there an optimum size for an airline alliance, and what issues does alliance membership pose for individual carriers?

Table 9.2 Comparison of main airline alliances, 2015

	Star Alliance	*oneworld*	*SkyTeam*
Formed	May 1997	February 1999	June 2000
Members	28	15 (+24 affiliates)	20
Daily flights	18,500+	14,313	16,270
Destinations	1,330	1,011	1,057
Countries served	192	154	179
Annual passengers (million)	641.1	512.6	665.4
Employees	432,600	386,256	480,000+
Aircraft fleet	4,657	3,414	3,705
Lounges	1,000+	600+	636
Total revenue (US$)	179.05 billion	141,404 million	Not stated

Source: Individual alliance webpages

CASE STUDY 9.2

THE MAJOR AIRLINE ALLIANCES IN 2015 COMPARED

Star Alliance

Star Alliance is the world's largest global airline alliance. It was founded in 1997 by Air Canada, Lufthansa, Scandinavian Airlines, Thai Airways and United Airlines. New members have since joined the alliance, and 27 member carriers currently operate at over 1,320 different airports within 193 countries. Star Alliance categorises its frequent flyer customers into silver, gold and (depending on the issuing airline) platinum or honorary status tiers. This is in addition to the status level that is held with an individual airline's FFP.

Star Alliance Silver status: After reaching the premium level of one of the different airline members, the frequent flyer receives Star Alliance Silver status. This status includes a priority wait listing and a guaranteed seat reservation if a place becomes available on a fully booked flight. Passengers also have priority standby on the next scheduled flight in the event of missing their original flight.

Star Alliance Gold status: Gold status cardholders receive the same benefits as the Silver status members plus five additional benefits. The cardholder receives access to all Star Alliance airport lounges worldwide, regardless of the class of travel. Priority check-in is permitted at all airports and cardholders receive priority boarding and an additional 20kg baggage. Bags belonging to Gold card members get priority handling and are among the first to be unloaded.

oneworld

The oneworld alliance was founded in 1999 by American Airlines, British Airways, Cathay Pacific, Canadian Airlines and Qantas. It has 15 airlines and 24 further partners who collectively serve over 1,000 destinations in 155 countries. Oneworld offers different tier benefits to its customers. Some of the status benefits are intangible, unlike direct discount schemes such as mileage points:

oneworld Ruby status: The lowest tier status is awarded when a customer reaches the first premium level of a members' FFP. In addition to the benefits afforded by the member airline, three oneworld privileges exist. These are: access to business class priority check-in; preferred or pre-reserved seating; and priority standby on fully booked flights.

oneworld Sapphire status: A Sapphire member receives Ruby benefits plus additional privileges. Sapphire members can access business class lounges at every airport, even if they are flying in economy class, and they receive priority boarding and an additional baggage allowance.

oneworld Emerald status: The benefits in the Emerald tier status include those of the Ruby and Sapphire levels and two additional privileges. If first class lounges are available at an airport, cardholders may use them regardless of the class they are flying in. Emerald status cardholders are permitted to check in at the first class priority check-in desks, can access fast-track security lanes and receive an additional baggage allowance.

SkyTeam

SkyTeam was formed in June 2000 by Aeroméxico, Air France, Delta Air Lines and Korean Air and as of 2015 had 20 members. SkyTeam offers different status levels and benefits such as:

SkyTeam Elite: Elite status customers benefit from an extra baggage allowance, priority check-in, priority boarding, preferred seating and priority standby.

Sky Team Elite Plus: Elite Plus offers three additional benefits. Members have access to exclusive member lounges and may invite a guest to accompany them. They are guaranteed an economy class seat on every long-haul flight if they book more than 24 hours in advance of departure, and their luggage receives priority handling.

9.5 Challenges of frequent flyer programmes: induced disloyalty

In response to the rapid accumulation of frequent flyer miles and the legacy of unredeemed miles, some airlines have made the terms and conditions of their loyalty programmes more restrictive. As a consequence, the benefits and status associated with FFPs has, in many cases, decreased since the early 2000s as airlines have switched from using a distance-based metric (how far a passenger flies) to award points to a revenue-based one (how much they pay for their ticket). Although airlines can change the rules of their loyalty programme by reducing the value of mileage points, this might alienate previously loyal customers and carriers need to be aware of the effect of customer disloyalty or relationship ending.

Despite the anticipated benefits of operating an FFP, research has revealed that FFPs can be less successful in creating long-term loyalty than expected. FFPs are expensive to administer and passenger dissatisfaction with loyalty programmes can evoke negative publicity. This can range from low ratings and non-recommendation to switching to other programmes. There is an ongoing debate into the overall effect of loyalty programmes, and the danger is that loyalty programmes may actually destroy customer value over time, rather than create it.

Stop and think

How might FFPs evolve in the future?

Key points

- Only airlines that create long-term value for customers will be able to successfully compete in the marketplace.
- Airlines must identify different customer segments according to different criteria and design tailor-made products to satisfy their needs.
- New data mining techniques and big data will allow airlines to better identify differences between segments.
- Airlines must maximise customer value for each passenger by innovating and offering services that meet or exceed customer expectations.
- Airlines must retain customers, and many use loyalty programmes to increase retention and engender loyalty.

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CHAPTER 10

Airline scheduling and disruption management

Cheng-Lung Wu and Stephen J. Maher

LEARNING OUTCOMES

- To understand the principles of airline scheduling, including schedule generation, fleet assignment, aircraft routing and crew rostering.
- To appreciate the complexity of airline scheduling and optimisation.
- To recognise the role of operational uncertainties and their impact on airlines.
- To assess options in airline recovery and disruption management.

10.0 Introduction

This chapter examines airline schedule planning and includes considerations of: airline scheduling (procedures and methods), airline operations, disruption management and schedule recovery using hypothetical examples. The chapter introduces the major elements of scheduling and the mathematical models that underpin them. It also addresses operational uncertainties and highlights the influence of scheduling practices on managing schedule operations. Disruption management is introduced to demonstrate how schedule disruptions may occur, how airline schedules are recovered and how disruption management can inform schedule planning through feedback.

10.1 Airline schedule planning and resource utilisation

Tasks in schedule planning

The task of airline schedule planning is essentially equivalent to resource allocation and management with a strong focus on the optimisation of resource utilisation. Airline schedule planning comprises four main tasks, which are often conducted sequentially, namely: schedule generation, fleet assignment, aircraft routing and crew rostering. The aim of the schedule generation process is to design a timetable that is competitive, can meet potential travel demands (in terms of departure times, flights frequency and origin/destination airports) and recover delays. The task of fleet assignment is to determine which type of aircraft should fly a particular sector to maximise revenue.

The task of crew scheduling is then to assign individual crew members to flying duties in accordance with their qualifications and working hour limitations. The aim of crew scheduling is to maximise resource efficiency and utilisation while minimising operational expenses (most notably crew expenses since labour is often the second largest cost to an airline, after fuel). It must also satisfy legal requirements of crew competence and minimum crew numbers for each aircraft type.

Resource utilisation

Efficient resource utilisation is the goal of airline scheduling. Aircraft are expensive assets (➤Chapter 11) and airline crew (particularly pilots) are highly skilled and costly to employ (➤Chapter 18). Depending on employment conditions and countries, an A380 captain can receive an employment package worth more than US$250,000 per annum. Given the low net profit margins of global airlines, resource utilisation strongly influences airline scheduling, and as such mathematical models that assist in optimising the tasks of airline scheduling are often employed.

Resource synchronisation

A critical element in airline scheduling is the synchronisation of resources. In this context, synchronisation means the pairing or matching of two or more resources that cannot operate independently. For a given timetable, different fleets are assigned to flights. The resulting fleet assignment is then matched with **routings** in aircraft route planning to synchronise flights with individual aircraft. Crew are then paired with these routings to minimise crewing costs. Rosters for individual crew members are then synchronised with those paired flights (called 'crew pairings') as well as aircraft routings. During flight operations, synchronisation also extends to passenger itineraries that pair with various flights in the network.

Routing: a series of connected flights that are assigned to an aircraft.

Given the nature of resource synchronisation and the pursuit of optimisation, the task of airline scheduling becomes extremely complex. It is because of the need for synchronisation and the benefit of cost minimisation and profit maximisation that planning efficiency can occur at the expense of operational performance. Over-optimisation in the scheduling process can make disruption management of daily operations a complex task. Mathematical models are used to plan for disruptions and aid schedule recovery. Models can be used to assist in the understanding of schedule optimisation.

Stop and think

Detail the processes involved in airline schedule planning and resource utilisation.

10.2 Flight schedule generation and travel demand

Forecasting consumer demand is inherently challenging (➤Chapters 2 and 4). Airlines publish their flight schedules one season in advance. Medium- or long-term demand forecasts are predominately used for route development and fleet planning purposes and may contain forecast errors.

Forecasting travel demands for individual sectors is important. The aim of flight schedule generation is to create a schedule that is appealing to potential travellers while balancing the availability of the operator's aircraft capacity. The travel purpose of a passenger can influence the preference of flight choices, and this in turn determines the demand for a particular sector along with service and product features and related customer expectations. Business travellers tend to leave early in the morning and return in the evening for domestic trips, whereas leisure travellers are more flexible with respect to departure times and often seek cheaper tickets. Therefore, airlines typically provide for more flights for business travellers during their preferred travel hours and charge a premium for those flights. These flights typically depart during morning and evening peak hours. In contrast, flights scheduled during off-peak hours tend to be cheaper and attract more leisure or less-time-sensitive passengers.

Schedule generation (timetabling)

Apart from determining the departure times of flights between an OD pair, the other critical element in schedule generation is to determine the flight frequency for each sector. The 'rule-of-thumb' in determining flight frequency in the industry is that the higher the frequency of a sector, the more appealing this airline (and its flights) will be to travellers, especially for business passengers. This is primarily about market share; the higher the market exposure, the higher the likelihood of achieving a bigger market share. Flight frequency can be calculated using Equation 10.1:

$$frequency = \frac{D_{ij}}{C_k \cdot \rho} \tag{10.1}$$

Where D_{ij} is the forecast demand between airport *i* and *j*; C_k is the capacity of aircraft type *k*; and ρ is the assumed load factor of the sector (often set between 75 per cent and 80 per cent). The importance of aircraft size and flight frequency is described in Example 10.1.

The answer depends on the scheduling strategy of the airline and the limitations of the fleet size. Assuming all three fleets are available to operate the sector, the use of the A380 offers savings by conducting a single flight to meet demand. Hence, the unit cost can be lowered and profits increased.

This strategy consolidates demand on one flight. The lower frequency may limit passenger choices in terms of departure times during any booking day. Often, this type of strategy is used by an airline to 'feed' traffic to a destination hub airport such as HKG. Inbound traffic is then fed to a partner airline based at HKG, which can provide services to other destinations beyond HKG, often through codesharing (➤Chapter 8).

Example 10.1
Aircraft size and flight frequency

In a hypothetical situation, the demand for travel between Sydney (SYD) and Hong Kong (HKG) is 1,000 passengers per day in both directions. An airline operates fleets of A380s (500 seats), A330s (280 seats) and B787s (240 seats). When an A380 is used, the frequency between SYD and HKG is one per day in each direction. A330s can do two flights per day, offering 560 seats each way, and if B787s are utilised, the frequency can be increased to three services per day each way (720 seats each way).

If smaller aircraft are used, the airline can offer a higher frequency for this sector; A330s and B787s can offer two and three flights per day respectively. This strategy maximises the potential market share due to higher 'exposure' to the market, and is also more convenient for passengers in choosing departure times, ideal to cover both leisure passengers, who are less time-sensitive and more cost-sensitive, and business travellers, who are more time-sensitive in choosing departure/arrival times (➤Chapter 9).

Stop and think

How frequently should the airline fly the SYD–HKG sector, and with which fleet?

Schedule generation: (also known as timetabling) a process where an airline tries to use limited aircraft capacity to meet travel demand while staying competitive.

Season: one of two periods in airline scheduling, known as the Northern Summer Season (April to September) and the Northern Winter Season (October to March).

Schedule generation is often conducted about 8–10 months before a new **season** to facilitate early bookings. However, the majority of bookings usually occur three months before the departure date.

10.3 Fleet assignment and aircraft routing

Fleet assignment

After a timetable is drafted, an airline needs to allocate its available aircraft capacity to meet potential demand. These are based on uncertain forecasts. By using aircraft with different capacities, the flight frequency can be adjusted in order to vary the supply of aircraft capacity in an airline network. Large aircraft are often used on trunk routes with a lower frequency where the traffic volume is large, while narrow-body aircraft are deployed where the volume is 'thinner' or where frequency is more valuable in the market. Hence, the task of fleet assignment is to match uncertain demand with a fixed supply of aircraft capacity and to maximise potential profits. The uncertainty of demand and fixed aircraft capacity makes **fleet assignment** an inherently challenging problem (see Example 10.2). It is important to note that the majority of low-cost carriers (LCCs) operate a single fleet and therefore any aircraft can be assigned to any route. Although operating a single fleet offers a number of financial benefits (➤Chapter 7), it reduces scheduling flexibility.

Fleet assignment: the optimisation process that aims to maximise potential revenue by allocating different fleets of aircraft to undertake flights at different levels of demand.

Example 10.2
Optimal fleet assignment

In a hypothetical case, the demand forecast of a sector is 220 passengers per day in each direction. Since demand is uncertain, the forecast is best represented as a random variable following a normal distribution with mean value of 220 passengers and a standard deviation of 25 (i.e. N (220, 25)). The airline has two fleets: B737 (180 seats) and B787 (240 seats). If the airline uses the B737, then there will be excess demand. This means demand will spill: on average, 40 passengers will be turned away. If the airline chooses to use the B787, then there will be no excess demand, but the average seat factor will be lower at 92 per cent.

The operating cost of a large aircraft is higher, and the use of a B787 may result in a lower seat factor and less revenue to the airline compared with using a B737. The B737 has lower operating costs and a higher seat factor, with supply being less than demand and the airline can expect a higher yield by charging more.

For the whole network, optimal aircraft types must be assigned to each sector to maximise total profits of operating a schedule. Hence, the optimal choice of fleet for our hypothetical case can be a B737 or B787 depending on the fleet assignment result for the whole network.

Stop and think

Which is the optimal fleet assignment for this sector?

The fleet assignment model (FAM) is often formulated as an integer programme that aims to minimise the operating costs of the network and maximise profits, as shown in Equation 10.2:

$$\min C = \sum_{j \in J} \sum_{i \in F} c_{i,j} x_{i,j} \qquad (10.2)$$

where C represents the total operating costs of the network; $c_{i,j}$ is the total operating costs if flight i is assigned to fleet type j; $x_{i,j}$ is the binary decision variable of assigning flight i to fleet j. The total operating costs, $c_{i,j}$, include the physical operating cost of flying sector i–j, the expected spill cost of adopting fleet j, and the **recapture** (offsetting the spill costs) of this sector due to adopting fleet j.

Recapture: when a spilled passenger chooses to buy a more expensive ticket on the same flight or change departure time/date and remain with the same airline, this passenger is 'recaptured' and there is no revenue loss for the airline.

There are three sets of constraints when optimising the FAM:

1 *flight coverage*: each flight must be assigned to one aircraft type;

2 *aircraft flow balance*: the total number of inbound aircraft at an airport must equal the total number of outbound aircraft plus any other aircraft remaining on the ground; and

3 *fleet size*: the number of aircraft used must be less than or equal to the total fleet size.

Aircraft routing

The FAM partitions the flight schedule into sub-timetables, one for each fleet. An aircraft routing (AR) problem is then solved on each of these sub-timetables to connect flights into routings. Constraints in the aircraft routing problem include:

- *flow balance*: the destination airport for a flight must be the departure airport for the subsequent flight by the same aircraft;
- *flight coverage*: one aircraft must be assigned to each flight; and
- *slot allocation*: the availability of desired slots (➤Chapter 5) at all the destination airports.

The AR problem is an important component of the sequential planning process. The flight partition related to fleet f is denoted by N^f, with each contained flight indexed by j. Since the objective of this problem is to identify a set of aircraft routings, each decision variable (y_p) identifies a feasible routing. The set of all feasible routings for fleet f is given by P^f and indexed by p. The parameters a_{jp} equal 1 to identify whether flight $j \in N^f$ is contained in routing $p \in P^f$. The aircraft routing problem is given by Equation 10.3.

$$\min \textstyle\sum_{p \in P} c_p y_p \tag{10.3}$$

$$\text{subject to:} \quad \sum_{p \in P} a_{jp} y_p = 1 \qquad \forall j \in N^f,$$

$$y_p \in \{0,1\} \quad \forall p \in P^f$$

Since all aircraft are of the same fleet for each individual aircraft routing model, the cost of flying each aircraft is almost identical. However, there are alternative costs that can be used in the objective function to achieve different optimisation goals. For example, the objective function can be minimising the 'cost' of routing (if certain flight connections are cheaper or more expensive, e.g. direct flights are desired but connections with long transfer times are not), or minimising the requirement of fleet size by creating tight connections to reduce turnaround times and increase aircraft utilisation.

It is also possible to set $c_p = 0$, $\forall p \in P$ and solve AR as a feasibility problem. However, it could still be advantageous to set c_p to some small costs to ensure the number of selected routes, given by $y_p = 1$, is minimised. The first set of constraints ensures that each flight within the schedule partition for fleet is assigned to exactly one aircraft. Finally, the aircraft routing variables (y_p) are binary, which means that they can only take the values 0 (not selected in the final solution) or 1 (selected in the final solution).

The outputs of the AR model are routings for a particular fleet. An example of a domestic B737 routing for a one-day duty in Australia incorporating Sydney (SYD), Brisbane (BNE), Cairns (CNS) and Melbourne (MEL) is: FLT025 (SYD–BNE) – FLT026 (BNE–SYD) – FLT085 (SYD–CNS) – FLT076 (CNS–BNE) – FLT046 (BNE–MEL). The aircraft overnights at MEL after finishing the routing. Routings in international operations tend to be longer and may span several days.

AR is commonly performed two to three months in advance of operations. The results are then passed to the crew planning team for crew scheduling. At this point, routings are specific to a particular fleet but not to any specific aircraft within that fleet. The job of assigning a routing to a particular aircraft on a particular day is called aircraft 'tail assignment'.

Aircraft tail assignment

Each aircraft has a tail number, which is its unique identification or registration number. When routings are assigned to individual aircraft, tail numbers are used to identify each aircraft and its assignments. This process is called tail assignment (TA).

The objective of TA is to assign routings to each individual aircraft and to meet the requirement for aircraft maintenance. Depending on the usage of an aircraft, different categories of maintenance activity are scheduled to maintain airworthiness and meet legal safety requirements. Major maintenance checks can take weeks to finish and require an aircraft to be taken out of service. Routine checks can be performed overnight or between flights. Some maintenance tasks are due by calendar days, while others are required after a certain numbers of flying hours or after a specified number of take-off and landing cycles.

In TA, schedulers need to take into account the maintenance history of individual aircraft leading to the need for a maintenance slot at a maintenance base, and also the projected maintenance activities that need to be carried out over the next one or two months. Then the task of TA is to assign routings to specific aircraft so the aircraft can arrive at a specific maintenance base at the right time, and ideally with some flexibility in the routing schedule.

The challenge in TA is that if there is no option to route an aircraft to a maintenance base before a key maintenance task is due, then either the routings must be modified (revising the solution of AR) or the aircraft must be taken out of service because it is not able to meet the maintenance requirements. Not being able to route an aircraft to a maintenance base in time can be very costly to an airline. However, if an aircraft is brought to a maintenance base too early, then valuable time is 'wasted' and the aircraft may receive more maintenance than needed during its lifespan, costing an airline more (see Example 10.3).

Apart from maintenance requirements, some airlines also require aircraft to experience balanced wear and tear from different operating conditions, such as weather and landing **cycles**. Too much exposure to extreme (cold/hot) weather conditions may cause certain parts of an aircraft to wear more quickly and hence require more frequent maintenance. Other operating conditions such as short flights with a high number of landing cycles may require the airline to service the landing gear more frequently. Hence, schedulers rotate routings

Cycle: one complete take-off and landing.

Example 10.3

Tail assignment buffer planning

Compare the following three hypothetical TA routings:

Route 1: FLT025 (SYD–BNE) – FLT026 (BNE–SYD) – FLT085 (SYD–CNS) – FLT076 (CNS–BNE) – FLT046 (BNE–MEL), arriving in Melbourne at 10pm for a scheduled A check from 11pm to 7am the next day.

Route 2: FLT025 (SYD–BNE) – FLT026 (BNE–SYD) – FLT085 (SYD–CNS) – FLT120 (CNS–MEL), arriving in Melbourne at 4pm for a scheduled A check from 11pm to 7am the next day.

Route 3: FLT025 (SYD–BNE) – FLT026 (BNE–SYD) – FLT090 (SYD–MEL), arriving in Melbourne at 2pm for a scheduled A check from 11pm to 7am the next day.

The optimal choice may seem to be Route 1, because the aircraft arrives at MEL just in time for the A check. However, schedulers may opt for Route 2 or even Route 3 because if any delays happen to earlier flights in Route 1 during the day of operation, then the arrival in MEL may be delayed. For a late arrival to the maintenance base, the available maintenance time is reduced, causing maintenance tasks to be delayed or 'skipped' to the next maintenance opportunity. If critical maintenance tasks cannot be finished during the planned maintenance slot, it may potentially delay the morning operation or disrupt other maintenance tasks in MEL.

However, bringing the aircraft back to base earlier can also be costly. Route 3 contains two fewer flights than Route 1 and may leave the aircraft idle in MEL for nine hours. This idle time can be seen as schedule buffer time in TA with an opportunity cost of earning extra revenue.

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Stop and think

Identify the optimal TA choice.

among aircraft in TA, so over the course of a year each aircraft will encounter most, if not all, operating environments to balance the wear and tear among their fleet.

10.4 Crew scheduling

Crew planning

After AR, flights are synchronised with aircraft. The task of crew planning is then to design a crewing schedule that is able to match crewing requirements of different fleets with routings from AR. Typically the airline crewing problem is broken down into two sub-problems, namely **crew pairing (CP)** and **crew rostering (CR)**. CP is conducted first, and the outputs of CP (called 'pairings') are used in CR – building rosters for individual crew members.

Pairings must meet legal crewing requirements to ensure safe operation of aircraft. Typically, these requirements regulate the working hours of pilots and cabin crew. For instance, the '8-in-24 rule' mandates that a pilot cannot fly more than eight hours within any 24-hour period. In addition to legal mandates, crew bargaining agreements, if applicable, between an airline and its crew unions (➤Chapter 18) also impose further conditions on crewing and are at least equal to and, for most cases, stricter than those conditions imposed by government authorities. For instance, the cap imposed by many aviation authorities on the total flying hours of a pilot per annum is about 1,000 hours, but many crew bargaining agreements adopted by Western airlines impose an 800-hour yearly cap, a productivity reduction (hence, cost increase to airline businesses) of at least 20 per cent.

Minimising pairing costs is important for airline profitability. Given the complex crewing conditions and potential choices in building pairings, CP is a difficult mathematical problem. A typical model form is shown by Equation 10.4:

$$\min C = \sum_{j \in P} c_j x_j \qquad (10.4)$$

where c_j is the cost of choosing pairing x_j, among all possible pairing candidates in set $P(\forall j \in P)$. The only set of constraints for this CP model is the flight coverage in which each flight must be 'covered' only once in the pairing result. This model form is elegant with few constraints. However, the set of potential candidate pairings, $P(\forall j \in P)$, can grow exponentially when a network gets larger and more complex (see Example 10.4).

Crew pairing (CP): (or 'tour of duty') a series of flights that are connected for a single crew member to conduct, start and end at the same crew base, and meet crewing conditions. A pairing can span multiple days but is often capped with a maximum time away from base.

Crew rostering (CR): the task of assigning crew to individual flights so the skill requirements and crew size for a particular aircraft are met.

Example 10.4

Determining the length of a pairing

Compare these three hypothetical pairings for pilots based at Pudong International Airport (PVG) in China and flying to Taipei (TPE), Singapore (SIN), Seoul Incheon (ICN) and Hong Kong (HKG):

Pairing 1: {Day-1: (PVG–TPE) – (TPE–PVG) – (PVG–SIN)} – {overnight at SIN} – {Day-2: (SIN–PVG) – (PVG–ICN) – (ICN–PVG)}; flying hours: 8 hours on day-1 and 8 hours on day-2.

Pairing 2: {Day-1: (PVG–TPE) – (TPE–PVG) – (PVG–HKG) – (HKG–PVG)}; flying hours: 7 hours on day-1.

Pairing 3: {Day-1: (PVG–TPE) – (TPE–PVG)}; flying hours: 3 hours on day-1.

All three pairings start and finish at PVG. Pairing 1 is a two-day pairing with an overnight stay at Singapore, while Pairings 2 and 3 are both one-day pairings. From the viewpoint of crew productivity with the imposed 8-in-24 rule, Pairing 1 is the most productive and efficient pairing. Pairing 2 is less productive, while Pairing 3 is the least productive.

From the 'cost' perspective, for one-day pairings such as P2 and P3 the cost of crewing is mostly from flying hours. Hence, it's ideal to get these pairings as close as possible to the 8-hour daily flying-hour cap. P2 is superior to P3. But P1 might be the best option because it is both long and reaches the daily hour cap for both days of the pairing.

Apart from the costs of flying hours, P1 also involves the overnight expenses of crew in Singapore, such as accommodation costs, ground transport to/from the airport and a living allowance. These expenses can be significant, and it motivated some airlines to establish their own hotel chains in the 1980s and 1990s.

From the cost minimisation perspective, P1 is more expensive than the combination of two P2-type pairings, if feasible, so it is a better choice to break down P1 and replace it with two P2-type one-day pairings. However, this is not always feasible in pairing optimisation since some flight times are longer and it is not always possible to bring crew back to base on the same day.

Stop and think

Which pairing is best?

For crew salaries, many airlines pay crew not only by flying hours but also by **credit hours**.

Cabin crew remuneration may comprise a basic salary based on flying hours and experience which (particularly in the case of LCCs) may be supplemented with commission from on-board sales. An airline pays a **premium** for each pairing depending on how many **synthetic hours** are included in each pairing; the more synthetic hours, the higher the premium and the more expensive a pairing becomes. The impact of premium of crew pairings is demonstrated by Example 10.5.

Credit hours: the total number of pay hours that a crew member may be compensated for. Apart from the flying times, credit hours also include synthetic hours within a duty day of a pairing. Hence, the credit hours are always longer than the flying hours for any pairing.

High premiums are sometimes unavoidable, especially for networks that have many short sectors. While an airline can utilise a narrow-body jet for 12 hours a day, a crew pairing can only cover half of the aircraft routing. Accounting for the turnaround times between flights of a domestic pairing causes the premium to increase; domestic pairings typically have premiums ranging between 45 per cent and 65 per cent, depending on sector lengths. In contrast, long-haul flights tend to have longer flight times, so premiums are typically low, ranging between 15 per cent and 30 per cent.

The outputs from CP are lists of pairings for each fleet type. Some pairings are fleet specific, while others can be more flexible. Regulations mandate that a pilot can hold only one aircraft type certification at any one time, so an A330 pilot can only fly an A330 and not an A320, even though s/he may have previously held an A320 certification. However, if a cabin crew member is qualified to operate both the A319 and A320, then s/he can accept duties from both fleets. This can increase crewing flexibility and reduce crewing costs, although the training itself will be a cost to the airline.

Example 10.5

Pairing cost calculation: the impact of premium

Following on from Example 10.4, we can calculate the cost of each pairing by the following three cost elements: flying time (US$100/hr for pilots and US$50/hr for crew), non-flying time (US$25/hr for all crew) and overnight hotel costs. We calculate the costs of pairings for an A320 with two pilots and four cabin crew.

All turnarounds between flights are assumed to take one hour, and the sign on/off times before starting and finishing a daily duty is one hour. For a set of six crew members for A320 operations, six hotel rooms are required per night at Singapore (assuming no room sharing), costing US$1,200 per night. If this particular flight has a daily frequency between PVG and SIN, then the total accommodation bill for the crew of the PVG–SIN flight to the airline is US$438,000 a year for this particular flight alone. The cost breakdown of each pairing is:

	Flying	*Non-flying*	*Hotel*	*Total costs*	*Premium*
P1	US$6,400	US$900	US$1,200	US$8,500	38%
P2	US$2,800	US$600	US$0	US$3,400	57%
P3	US$1,200	US$300	US$0	US$1,500	67%

From a cost perspective, P1 is the most expensive choice and P3 is the cheapest. However, from a premium perspective, P3 is the least efficient (67 per cent premium) because the flying time (three hours) is relatively short when compared with non-flying time (two hours). On the contrary, P1 is the most efficient pairing with a 38 per cent premium only. Typically, airlines prefer pairings with low premiums because these pairings end up cheaper without paying for excessive synthetic hours.

Premium: the extra cost an airline pays its crew for conducting duties. Premium is calculated as the percentage of the hour difference between credit hours and actual flying hours compared with the flying hours alone.

Synthetic hour: a non-flying work hour such as sign on/off times, downtime between flights and rest times within a duty day.

Stop and think

Which pairing would you choose and why?

To ensure that sufficient crew are positioned to operate the return sectors of long-haul flights, it may be necessary for airlines to **deadhead** crew. While this ensures that the return flight can be operated, the deadheading crew may take up space that could otherwise be occupied by revenue-generating passengers.

deadhead: to fly out flightdeck or cabin crew as passengers so they can operate the aircraft on its return journey.

Crew rostering

Crew pairings are anonymous and not crew member-specific but fleet type-specific. Therefore, in terms of resource allocation, crew are now synchronised with aircraft (AR) and flights (FAM). The task of assigning pairings to individual members of the crew is called crew rostering (CR). The goal of rostering is to ensure that the employment conditions of crew are met, including training days, annual leave entitlements and *ad hoc* leave requests, flying duties (and annual hour caps) and non-flying duties (such as standby duties). The other key aspect of CR is to ensure that each flight has enough qualified crew aboard. The goal of CR is to ensure that all flights are adequately resourced.

Rostering conditions can be complex, and crew bargaining agreements may impose specific crewing conditions such as the maximum number of hours they can be on duty per day and per week (per seven days), days off in between duties, rest days after duties that cross the International Date Line or multiple time zones, and a minimum guaranteed number of working hours per roster period. These crewing conditions and the cap of credit hours or flying hours make the roster problem challenging. The common CR equation is:

$$\min C = \sum_{j \in R} c_j x_j \qquad (10.5)$$

where c_j is the cost of choosing roster x_j, among all possible roster candidates in set $R(\forall j \in R)$. The only set of constraints for this CR model is pairing coverage. In other words, each pairing must be covered by enough crew rosters on each operational day with the right skill mix. The objective of CR optimisation can be the minimisation of crew employment, that is, the minimum crew (base) size, the balance of working hours per roster period among crew and the maximisation of crew productivity (in terms of flying or credit hours).

As the total flying hours of pilots are capped (restricted by law), it is unwise to oblige them to fly too many hours early in the year as they will only have a small number of hours remaining from the cap later in the same year, while an airline is obliged to pay the pilot at least the minimum flying hours for each roster period. If there are 12 roster periods in a year, after taking off six weeks of annual leave, there are only 10.5 **roster periods** remaining. If the total hour cap is 800 hours per annum, then on average a pilot flies less than 80 hours per roster period. If we discount this figure by considering other non-flying duties and anticipated sick leave, then at best a pilot can fly about 70–75 hours per roster period. If the average length of a one-day pairing is seven flying hours, then on average a pilot will work about ten days per roster period; the industry norm is about 10–15 working days for a pilot for each roster period. Similar calculations can be made for cabin crew productivity.

Roster period: the period of time that a crew roster spans. This is typically four weeks for most Western airlines. Crew members are also paid according to roster periods.

Results of CR are rosters for individual crew members that incorporate individual crew requests such as annual leave. Ultimately, all individual rosters must cover each flight and each aircraft operation in the timetable with the right skill mix. Finally, an adequate number of reserve crew is also required at each crew base to respond to unforeseen circumstances such as crew member illness and flight delays.

10.5 Operational uncertainties and disruption management

Uncertainty is observed in daily airline operations and often causes flight delays and cancellations. **Disruption management** is a decision-making process employed by airlines to address these uncertainties and minimise their impact.

The previous sections describe the airline planning process that is routinely undertaken to efficiently allocate the available resources, such as crew and aircraft. Schedule planning is typically conducted under the expectation that the day of operations will be performed without any **schedule perturbations**, however unlikely this may be. For example, an aircraft routing may be designed with very short turnaround times between each pair of flights. While this is an efficient use of expensive resources, a delay on one flight is likely to cause further delays on all subsequent flights. **Delay propagation** results in higher than expected operational costs, and delay propagation is a common (if not daily) occurrence.

Since planning solutions designed with a focus on efficiency are susceptible to significant cost impacts from schedule perturbations, operations controllers are employed to ensure that daily operations are executed close to plan. The process undertaken by operations controllers to achieve this goal in the presence of schedule perturbations is called **schedule recovery**, which is a *reactive* form of disruption management. It is possible, however, to consider schedule perturbations during the airline planning process to reduce their prevalence or impacts. This involves using techniques of **robust planning**. Such methods are described as a *proactive* form of disruption management.

Disruption management: the process and actions taken by an airline to minimise the costs resulting from operational disruptions.

Schedule perturbation: a change to scheduled departure or arrival times during the day of operations. Possible causes include bad weather, late arriving passengers or unplanned maintenance.

Delay propagation: the flow of delays from one flight to the next in an aircraft routing or crew pairing.

Schedule recovery: the reactive interventions undertaken by an airline to return operations to normal following schedule perturbations.

Robust planning: the proactive approaches used during the schedule planning stages to avoid or minimise the potential impact of schedule perturbations.

Proactive disruption management

The main objective of proactive disruption management is to avoid or reduce the potential impacts of schedule perturbations on the day of operations. These may include:

- increasing aircraft turnaround times to provide a greater buffer against delays;
- minimising the impact of propagated delays; and
- introducing aircraft swapping opportunities.

The first approach is conservative and does not take into account any flight or time-of-day specific aspects. The application of this robustness technique involves planning for all aircraft to remain on the ground for longer time periods. For example, an aircraft routing with flights FLT025 (SYD–BNE) – FLT026 (BNE–SYD) – FLT085 (SYD–CNS) may be formed such that a minimum turnaround time of one hour is scheduled between each pair of flights. Assuming the aircraft requires a turnaround time of 40 minutes, this allows for a maximum delay of 20 minutes on each flight without causing departure delays, a 20-minute buffer.

If historical records show that departure of FLT025 (SYD–BNE) is regularly delayed by 30 minutes and FLT026 (BNE–SYD) is rarely delayed, then a uniform turnaround time does not adequately match the expected delays. Setting the minimum turnaround time to 90 minutes for all flights will avoid delays for FLT025, but it is unnecessary for the other services, such as those following FLT025. A drawback of this approach is that it reduces aircraft utilisation, which may result in the need for additional aircraft to operate the flight schedule.

The second approach increases the ground time for aircraft, but only between flights where there is an expectation of delay propagating onto subsequent flights. This expectation is computed by reviewing historical delay data to calculate the probability of delay propagation for every possible pair of connected flights. Assuming the routing above is selected, the expected 30-minute delay for flight FLT025 (SYD–BNE) will impact the on-time performance of FLT026 (BNE–SYD). Hence, it is better to construct a routing where a turnaround time of at least 70 minutes is scheduled for FLT025 (SYD–BNE). By taking into account historical delay data, turnaround buffer times can be more efficiently and effectively allocated to improve the utilisation of the fleet and contain delays to a defined level.

The final technique considers aircraft swapping opportunities. This is possible when at least two aircraft of the same type are planned to be on the ground at a particular airport at the same time. In such a situation, if one aircraft is delayed, it is possible to substitute another aircraft to perform the flights that were originally scheduled for the delayed one. Aircraft swapping is a valuable management technique that is available to operations controllers to minimise the impact of schedule perturbations. Increasing the prevalence of swapping opportunities at the scheduling stage aids schedule recovery, leading to fewer delays and lower operating costs (see Example 10.6).

Example 10.6
Aircraft swapping and schedule recovery

The inclusion of aircraft swapping opportunities is one of the few robust planning approaches already widely employed by airlines. A major reason is that increasing the number of swapping opportunities in aircraft routing imposes very little additional cost to an airline.

The existence of swapping opportunities provides operations controllers with an opportunity to minimise the impact of flight delays, in particular delay propagation in a network. For example, a swapping opportunity exists for aircraft TA011, arriving in SYD at 1200 (operating flight FLT057) and departing at 1415 (flight FLT070), and aircraft TA027, arriving in SYD at 1230 (flight FLT059) and departing at 1445 (flight FLT072). A severe delay of two hours on flight FLT057 will prevent aircraft TA011 from operating FLT070 on time, potentially propagating delays onto subsequent flights. However, because this opportunity exists, TA027 can be swapped to operate FLT070 and continue the remaining routing assigned to TA011. TA011 is then used to operate FLT072 and the remaining routing originally assigned to TA027. An advantage of this swap is that while FLT057 (by TA011) is delayed, this delay does not propagate onto any other flights in the same routing originally assigned to TA011.

!

Stop and think

What are the potential disadvantages of aircraft swapping as an aid to schedule recovery?

Increasing aircraft swapping opportunities in the planning stage is an approach used to improve the recoverability of an airline schedule. By increasing swapping opportunities, a greater number of options are available for the operations controllers in the event of a schedule perturbation.

Reactive disruption management

Reactive disruption management is employed when an event causes a schedule perturbation and prevents the original aircraft routings, crew pairings and even passenger itineraries from being operated as planned. There are many different techniques available to the operations control centre to recover from a schedule perturbation. Such techniques include:

- delaying or cancelling flights;
- rerouting of aircraft and/or crew to operate a different sequence of flights;
- using additional (reserve) crew to operate flights to avoid regular crew exceeding work limits; and
- transporting crew as passengers ('deadheading' crew) to reposition them to operate flights out of different airports.

The employment of these recovery techniques by the operations control centre depends on the nature of the schedule perturbation. Since there are many interconnected resources in an airline's operations, there are conflicting objectives during the recovery process. Primarily these recovery techniques are employed to minimise the additional costs to the airline, which include additional crew costs and lost revenues. However, actions such as delaying and cancelling flights have a significant impact on passenger itineraries and service satisfaction, so must be carefully evaluated in the recovery process. Evaluating the direct and indirect costs of recovery actions is a critical consideration during disruption management, and airlines may employ automated decision support systems (see Example 10.7).

Given the complexity of the airline recovery problem, it is common to focus on each key resource in isolation. Specifically, the airline recovery process involves:

- constructing an updated flight schedule;
- rerouting aircraft to operate the updated schedule;
- allocating crew to the rerouted aircraft schedule; and
- constructing new itineraries to ensure disrupted passengers arrive at their intended destinations.

Example 10.7

Automated decision support systems

The expansion of airline networks and services in the US during the 1980s and 1990s prompted an interest in automated decision support systems. During this period, irregular operations were handled within airline operational control centres by practitioners basing recovery decisions on their experience and intuition. To address the rising incidents of irregular operations, major US airlines invested in automated systems. Initially these systems only collected and displayed operational information and data. This complemented the work performed by the operations controllers by providing up-to-date information about the airline's operations.

The benefits of providing this information were soon apparent, with significant reductions in delays. Over time, automated decision support systems were able to provide operations controllers with suggestions for cancellations, and possible new aircraft routings and crew pairings. These systems have evolved into collaborative decision-making tools (➤Chapter 5). In time, fully automated airline recovery systems will become available.

Disruption scenarios

In order to practise their response to disruption and become more efficient, airlines regularly simulate disruptive events. This enables airline staff to understand the company's internal policies and procedures and for employees to understand their role and that of other stakeholders in recovering normal schedules in order to deliver the best possible service.

Key points

- Scheduling (timetabling) reflects market competition, potential travel demand and the nature of an airline's network (hubbing or non-hubbing).
- Fleet assignment maximises airline profits by minimising the risk associated with the use of fleets that may have different sizes and capacity when travel demand is uncertain.
- Aircraft routing provides the backbone of airline operations by synchronising flights with aircraft. This synchronisation is extended to crewing at a later stage of scheduling.
- Airline crewing is expensive and a fundamentally hard mathematical problem due to complex crewing conditions and regulatory requirements.
- Schedule recovery tactics and strategies are developed to recover disrupted schedules and operations in order to maintain airline service levels and transport passengers to their destinations amid unpredictable operational disruptions.

Further reading

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CHAPTER 11

Airline finance

John Jackson

LEARNING OUTCOMES

- To understand how airlines finance aircraft.
- To consider the relative merits of different sources of finance.
- To interpret airline financial statements.
- To recognise key financial performance indicators.
- To understand how airlines manage their exposure to financial risk.
- To understand the causes and consequences of insolvency, bankruptcy and liquidation.

11.0 Introduction

The availability of appropriate levels of finance and effective financial management are important components of any successful airline operation. Airlines need to be able to access significant amounts of capital to commence operations, expand their fleet of aircraft, invest in new aircraft, develop new in-flight products (such as new seats or aircraft interiors) and serve new markets. Airlines that are not able to adequately finance and sustain their operations are vulnerable to being taken over by other carriers or ceasing to operate.

The aim of this chapter is to highlight selected aspects of airline financing and financial management. It introduces the different sources of finance available to airlines, with a particular focus on how airlines fund the acquisition of aircraft, describes the presentation and content of airline financial statements, and discusses financial ratios, selected financial risk management strategies and the consequences of financial failure and how that can differ depending upon which country you are operating from.

11.1 Sources of airline finance

One of the most significant aspects of airline finance concerns the acquisition of aircraft. In 2014, 1,490 new commercial jet aircraft were delivered and Boeing (2015) predicts that 38,050 new aircraft, valued at US$5,200 billion (at **list prices**), will be required by 2033. The costs associated with acquiring aircraft pose a considerable challenge for airlines. The 2015 list price for a new Boeing 737 MAX 8, for example, was US$110 million (Boeing 2015), while the equivalent list price for a wide-body Airbus A380-800 was US$428 million (Airbus 2015). Although bulk purchase discounts mean airlines rarely pay the full manufacturers' list price, carriers still need to source large amounts of capital to finance the acquisition of these assets. Some second-hand aircraft can retain a relatively high value, and airlines will need to source sufficient finance to cover their acquisition.

Worldwide, the annual financing requirement for aircraft is predicted to increase from US$125 billion in 2016 to US$156 billion by 2019 (Boeing 2014). For an airline such as easyJet, which is acquiring 170 new Airbus A320 family aircraft between 2015 and 2022 at a total list price of US$14.6 billion (easyJet 2014), the importance of informed aircraft finance decision-making is clear.

There are a number of options available to airlines when financing aircraft. A range of **aircraft financing** sources can be used to finance the transaction depending on the type of finance that is required and the duration of any loan. These options include: buying the aircraft using retained earnings, borrowing from banks, export credit loans, additional equity finance, manufacturer support, Islamic finance or leasing. The final selection will depend in part on the availability of funding sources and the alignment of the funding sources and funding costs with the adopted business model (➤Chapter 7). The business model will guide the selection process by clarifying the levels of cost that can be incurred while remaining profitable and the levels of debt (gearing) that can be incurred without endangering the business.

List price: the manufacturer's published price of an aircraft.

Aircraft financing: funding mechanisms for the purchase and, in some cases, operation of aircraft.

Liquidity: the ability of an airline to convert its assets into cash relatively quickly.

Solvency: the ability of an airline to meet its liabilities as they become due.

Overdraft: an authorised deficit in a bank account caused by withdrawing more money than the account holds.

Cash flow: the net amount in cash terms being received and spent by an airline.

Interest: the amount charged by a lender to a borrower for providing them with finance.

Cash

Using cash is arguably the most straightforward method, as aircraft are paid for using internal funds that are available to the business such as retained earnings from previous years. While using internal funds means that the airline doesn't have to take out a loan or find alternative sources of finance, it does reduce the airline's **liquidity** (and potentially also **solvency**). Airlines do use internally generated funds (cash) to partially fund the acquisition of aircraft, blending it with other sources to achieve the most effective combination of equity/debt funding.

Overdrafts

The most obvious source of short-term finance is an **overdraft**. These facilities are designed to provide temporary funding to cover a shortfall in **cash flow**. Overdrafts are typically agreed with commercial banks and often attract a higher rate of **interest** than other loans.

Airlines, however, would not normally use short-term facilities such as overdrafts to fund long-term assets such as the purchase of aircraft. Overdrafts would normally be used to smooth short-term cash-flow demands.

Bank loans

A major source of long-term finance is a bank loan. Typical bank loans might be for a period of up to seven years and provide a source of capital that can be used to fund the purchase of new aircraft or other investments. Loans are set for a fixed period of time and the capital is paid back either over the life of the loan or at the end of the loan. Interest is paid over the course of the loan normally on a monthly or quarterly basis. Features of bank loans include:

- *Regular repayments*. These include **fixed rate** or **variable rates** of interest and have to be made irrespective of whether the company is making a profit.
- *Security*. The lender will normally require security for the loan, which is typically the aircraft. This means the aircraft can be repossessed if repayments are not made on time. This is known as a 'secured loan'.
- *Covenants*. There will normally be conditions included in the loan agreement which are referred to as 'covenants'. These frequently include:
  - a limit on future gearing (see Section 11.3) to agreed levels;
  - a minimum level of profit to debt levels to ensure repayment capability;
  - a minimum level of interest cover to ensure future interest serviceability.

Fixed rate: the interest that is charged does not alter during the loan period.

Variable rate: the interest that is charged changes during the loan period.

Credit worthiness: an assessment of the likelihood of a borrower being able to repay a loan.

In addition to financing new aircraft, airlines can also refinance their existing debt to free up cash that can be reinvested elsewhere in the business and consolidate all their repayments into one single transaction. Airlines will normally try to ensure they have a staggered programme of loan and other funding renewals so they minimise the risk of having to refinance significant amounts of funding in difficult market conditions.

As well as obtaining secured loans, it may be possible for an airline to obtain an unsecured loan (known as a 'corporate facility'), which can provide funding and available resources (i.e. undrawn but available) to support the solvency needs of the business. However, as there are no assets to sell to offer as security for the loan, the loan is considered riskier, and a higher rate of interest will be charged because of this. Unsecured loans are relatively uncommon unless the airline operator is well established with a high level of **credit worthiness** and reliable cash flow.

Export credit finance

These are loans guaranteed by national governments or their appointed agents to support the sales of their country's domestic aircraft manufacturing industry overseas. Export credit loans are particularly important during periods of economic downturn, when commercial banks might reduce their lending. They might cover 85 per cent of an aircraft's value, with the remaining 15 per cent being financed by the airline through other sources.

Equity finance

Equity represents the shareholders' funds in the airline. Raising additional equity finance can be an appropriate way of obtaining additional finance. Its principal advantage is that it is less risky than debt as there is no obligation to pay interest. Its principal disadvantage is that it can dilute the existing shareholders' ownership and earnings. This form of long-term financing involves privatised airlines raising cash by issuing the airline's shares to investors. Several methods of raising equity finance are used by airlines. These include new share issues in the form of initial public offerings and rights issues. In a new share issue, an airline will sell a proportion of the ownership of the airline in the form of shares to investors. Shareholders can be individuals, companies or institutions such as pension schemes, governments or **sovereign wealth funds**. Airlines that are listed on a stock exchange can raise additional new capital through a rights issue in which new shares in the company are offered to existing investors in proportion to their existing shareholding.

Sovereign wealth fund: a state-owned investment fund.

While many state-owned airlines have been privatised by selling shares to investors, the equity of some airlines remains in full or part government ownership. Some countries and regions also have strict rules governing the foreign ownership of airlines and restrict the proportion of shares that can be held by foreign investors (see Table 11.1).

Table 11.1 Maximum permitted foreign ownership of airlines in selected countries and regions

Country/region	*Maximum foreign ownership (%)*
Australia	49.0
Chile	100.0
China	35.0
EU	49.9
India	49.0
Japan	33.33
North America	25.0
South Africa	25.0
Thailand	30.0

Manufacturer support

In order to secure a sale, an aircraft manufacturer (with or without government assistance) might agree to lease an aircraft to an airline or guarantee a residual value for the airframe at the end of a defined loan period.

Islamic finance

In order to be compatible with Islamic principles, aircraft finance packages can be arranged in such a way that no interest is paid on a loan.

Leasing

Rather than the immediate purchase of aircraft, airlines may acquire aircraft with cash or loans with a view to full ownership or choose to **lease** an aircraft from an aircraft leasing specialist. These companies own a range of aircraft which they lease to operators on either short- or long-term contracts. Unlike a loan, the lessor (in this case the leasing company) retains legal ownership of the aircraft, but the lessee (the airline) is able to operate it for the duration of the contract.

Aircraft lease: a contract agreed between an owner (the lessor) and an operator (the lessee) for the right to operate an aircraft.

Leasing an aircraft from a third-party provider offers the same (or in some cases more) benefits as full ownership but without the initial high capital investment. While leasing allows airlines to add additional aircraft to their fleet without the risks associated with ownership, it also poses a number of challenges which are described below. There are two main types of lease, an operating lease and a finance lease. Operating leases are the more common of the two.

Operating lease

Under the terms of an operating lease, an airline hires an aircraft for a defined period of time. An operating lease might last between three and ten years (although wide-body aircraft leases can be longer). This is considerably shorter than the aircraft's useful life. Airlines pay the aircraft's owner (the lessor) a fixed sum to operate the aircraft for the duration of the contract.

The cost of an operating lease is the sum of three factors:

1. *The leasing cost.* Typically set at 1 per cent of the new aircraft cost per month, but this can vary according to the supply and demand of particular aircraft.
2. *Maintenance reserves.* These are paid to the lessor to cover future maintenance activities on the aircraft.
3. *Security deposit.* This is usually equivalent to two to three months of lease payments and is returned to the airline at the end of the lease.

In addition to paying to hire the aircraft, the lessee pays all fuel, air traffic control (ATC) and airport charges. If required, the costs of repainting a leased aircraft in the lessee's corporate livery can be negotiated separately.

Operating leases differ not only in terms of their duration but also in the nature of the lease, and as such they can be classified as one of three types: a dry, damp or wet (ACMI) lease.

- *Dry lease.* The airline hires the aircraft (without crew, maintenance or insurance) from a leasing company such as GE Capital Aviation Services (GECAS) or International Lease Finance Corporation (ILFC) but uses its own flight and cabin crew to operate it.
- *Damp lease.* The airline hires the aircraft plus the flightcrew and maintenance needed to operate it. Cabin crew are provided by the lessee.
- *Wet lease (also called an ACMI lease).* A leasing arrangement in which the owner of the aircraft (the lessor) provides the aircraft, crew (pilots and cabin crew), maintenance and insurance (ACMI). ACMI leases typically last for at least a month (a one-off flight would usually be termed a 'charter service'). They are the most comprehensive (and thus expensive) of the three types and are often used to provide a short-term increase in capacity or meet a shortfall in capacity due to mechanical or technical problems. Wet leases might also be used to enable an airline to operate into a third country where the lessee is forbidden from operating.

Operating leases are tailored to the needs of individual operators, but all types help to preserve an airline's liquidity. They are often employed to provide a short-term increase in capacity during periods of peak demand, launch new routes, fulfil a short-term contract or to provide interim capacity during periods of scheduled maintenance to the usual fleet. In addition, as the aircraft are owned by the lessor, they do not necessarily need to appear on the balance sheet, which can improve an airline's assessed asset performance measures. Potential drawbacks are that they are expensive and, with ACMI leases, the airline can lose control over the level of in-flight service provision, which may adversely affect the airline's reputation.

Operating leases are often used by new entrant airlines that lack the capital required to purchase aircraft outright or the financial history to secure favourable loan terms. They are particularly attractive to airlines that need flexibility and don't want to be committed to long-term aircraft ownership and uncertain future residual and/or re-sale values. Leases may also be used by airlines as an interim measure to cover short-term capacity shortfalls while waiting for new aircraft to be delivered or when there is a long backlog of orders and leasing is the only way to acquire use of a particular aircraft.

Stop and think

Under what conditions might airlines use ACMI leases?

Finance lease

A finance lease for an aircraft normally offers the lessee the option of purchasing the aircraft at the end of the lease. A financing lease is attractive when the cost of borrowing is lower than the airline's required return on capital. Unlike an operating lease, the airline gains ownership of the aircraft as it pays off the loan. Airlines may take out a combination of operating and finance leases to cover their fleet financing requirements (see Case Study 11.1).

CASE STUDY 11.1

EASYJET'S AIRCRAFT OWNERSHIP AND LEASING STRATEGY

UK-based easyJet is Europe's second largest low-cost carrier (LCC). In 2014, it carried 64.8 million passengers on over 760 different routes to more than 130 destinations in Europe, North Africa and the Middle East using a fleet of 226 A320 family aircraft (comprising 156-seat A319s and 180-seat A320s). Of the 226 aircraft, 143 were owned, 72 were on dry operating leases and 11 were on finance leases, an owned-to-leased split of 63:37. The terms of the initial operating leases ranged from five to ten years and aircraft with a net book value of £597 million were mortgaged to lenders as security. 71 per cent of the operating leases were based on fixed interest rates, with the remaining 29 per cent on variable interest rates. As part of the operating lease agreements, easyJet is contractually obliged to perform maintenance on the aircraft. A further 11 aircraft with a net book value of £142 million were held on finance leases with ten-year terms. The finance leases incur interest at both fixed and variable rates linked to LIBOR (London Interbank Offered Rate, i.e. the rate banks charge each other for short-term loans, used as a basis for calculating global interest rates).

Leasing enables easyJet to remove older aircraft from the fleet, protect the residual values of the aircraft and benefit from the flexibility of being able to increase or downsize the number of aircraft in the fleet to as few as 204 or as many as 316 by 2019 according to economic conditions. The new aircraft that are due to enter the fleet between 2015 and 2018 are expected to be funded through a combination of cash flow, sale and leaseback transactions and debt (easyJet 2014).

Sale and leaseback agreements

In addition to conventional operating and finance leases, airlines may choose to sell some or all of their aircraft (whether new or mid-life) to a third party and then immediately lease the aircraft back under an operating lease. The operation of the aircraft is not interrupted and the arrangement releases capital which the airline can reinvest in other areas of the business. There are a number of reasons why airlines might engage in sale and leaseback agreements:

- They can be used as a method of financing fleet expansion as new aircraft can be used as security for a loan.
- They can release the value in an aircraft so that it can be used in other areas of the business.
- They can increase an airline's fleet flexibility.
- They can improve an airline's balance sheet by removing the aircraft and its associated debt from it.
- There may be tax advantages associated with leasing rather than owning an aircraft.
- The risk of a reduction in an aircraft's second-hand value is transferred to the new owner.

Stop and think

Why do airlines require access to different sources of finance, and what are the benefits and limitations associated with the various types of finance?

Leasing trends

The use of operating leases has increased over the last 35 years. In 1980, fewer than 2 per cent of the world's Western-built jet aircraft were leased. This has increased steadily during the intervening years to the point where approximately 50 per cent of the world's aircraft will be leased by 2020. Leasing is a truly global business. It is estimated that there are over 150 leasing companies trading in over 140 countries worldwide, and leasing companies represent in the region of 30–40 per cent of the order backlogs with the major aircraft manufacturers. Indeed, the fleets that are owned by the largest leasing companies are larger than the fleet size of many leading airlines.

Stop and think

Why have leases become an increasingly important source of finance in recent years?

Purchase or lease?

A key decision for airline management is whether to buy or lease aircraft. Table 11.2 identifies the potential advantages and disadvantages of leasing as a form of aircraft acquisition. In order to come to an informed decision about which model is most appropriate, airline managers need to consider their business model, assess the current and likely future external economic and competitive environment in which they operate and evaluate whether leasing or ownership will enable them to deliver their future business development objectives. A number of airlines, including easyJet (see Case Study 11.1), operate both owned and leased aircraft as this offers both the security of owning individual assets and also the flexibility to respond to changing market conditions and new business opportunities.

New or old?

A further decision is whether to acquire new aircraft or second-hand aircraft that have been previously utilised by other operators and at what stage of an aircraft's life it should be replaced. New aircraft are initially more expensive to acquire, but they are also more fuel efficient, more environmentally friendly and have lower operating and maintenance costs than older aircraft. Newer aircraft are often also assumed to be safer. This means that they are

Table 11.2 The relative merits of leasing

Potential advantages	*Potential disadvantages*
• Reduced capital investment • Possible earlier aircraft delivery • Improved balance sheets • Flexible payment terms • Possible tax advantages • Provide short-term or interim capacity • Flexible entry and exit terms • Risk of resale value transferred to lessor • Option to purchase aircraft at the end of the lease (finance leases only) • Services of an aircraft management company	• More expensive than ownership • Exposure to interest rate fluctuations (if variable rates are chosen) • Aircraft may be repossessed • Airline cannot access aircraft equity (operating leases only) • Reputational damage to the brand if the leased aircraft is perceived to have inferior comfort and/or safety standards compared to the airline's regular fleet • On-going maintenance/service charges • Return conditions can be strict • Early return or exit fees may apply • Restrictions may be placed on where and how the asset can be used

cheaper to operate in the medium to long term. An airline may also need to consider their brand reputation when evaluating whether to acquire new or second-hand aircraft as the average age of their fleet may be used by customers to evaluate the safety, comfort, financial health and vitality of an airline when choosing which carrier to use. The airline's business model will again guide these decisions (➤Chapter 7).

11.2 Financial statements

Irrespective of the composition of their aircraft fleet and the business model they adhere to, all airlines must prepare annual financial statements that include details of:

- the airline's profitability in its income statement (also known as profit and loss account or, more recently, the statement of profit and loss and other comprehensive income);
- its statement of financial position (or balance sheet); and
- its statement of cash flows (or cash flow statement).

These statements give an indication of the financial performance of the airline to its stakeholders, such as regulators, current and potential investors, employees and customers.

Although considerable variation exists in the format and presentation of airline financial statements, all contain common elements as they need to convey details of an airline's income in terms of its profit or loss, its financial position (balance sheet) indicating its assets and liabilities, and cash flow. In order to illustrate key points, this section uses extracts from easyJet's 2014 annual report and accounts as an example of how financial information can be presented.

All airline financial statements contain a number of key elements including:

- the income statement, which measures the profit or loss for the year;
- the statement of financial position or balance sheet, which details a company's assets, liabilities and equity at the year end;
- the cash flow statement, which details the movement of cash into and out of the business for the year.

Airlines that are parent companies produce consolidated financial statements which provide details of all of the combined company's assets, liabilities and operating accounts, including those of the parent company and any subsidiaries in which it has a controlling interest. In the case of easyJet, their consolidated financial statement includes details of easyJet plc and its subsidiaries.

Income statement

An airline's income statement is a key document that details the financial performance of the company during a specific time period, usually a year. The income statement shows an airline's revenue and expenses and any profits or losses it has occurred. It may also provide an indication if these profits have been retained or distributed to shareholders. The format and presentation of airline income statements varies according to the complexity of the business that is being reported, but typical headings include:

- *Total revenue.* This is derived from ticket sales, carriage of cargo and ancillary sources such as paid-for in-flight catering, hold baggage and priority seating. Low-cost airlines in particular derive a significant proportion of their revenue from ancillary sales.
- *Total expenses.* Expenses incurred in the process of earning revenue include fuel (which can account for almost half of an airline's total expenditure), crew salaries and expenses, insurance, maintenance, **depreciation** (see Case Study 11.2), airport expenses, navigation and ATC fees, passenger service fees, marketing and other costs.
- *EBITDAR – earnings before interest, taxes, depreciation,* ***amortisation*** *and rent costs.* This can be seen as an indication of the underlying earnings of the company before these charges, which generally, but not always, offers a close approximation to the cash flow being generated by the company.
- *Operating profit/loss.* This describes the profit or loss that is earned before interest and tax is deducted.
- *Profit before tax.* This is a measure of profitability that shows an airline's profits before deducting the costs of any taxes.

Depreciation: the reduction in value of a tangible asset over time.

Amortisation: the reduction in value of an intangible asset over time.

CASE STUDY 11.2

AIRCRAFT DEPRECIATION

Depreciation describes the reduction in value of an asset over time. An aircraft acquired for US$101 million initially appears on the balance sheet as an asset of US$101 million. Twenty years later, it is sold for scrap at US$1 million. Over the 20 years, US$100 million of value has been used to generate revenue and profits. Most airlines use a straight line (constant) rate to depreciate their aircraft. The aircraft in this example therefore depreciates at US$5 million each year (100 ÷ 20 years). The figure in the balance sheet is reduced by US$5 million each year, and an expense of US$5 million is added to the income statement. This reflects the decline in value of the asset and offsets the income generated each year by the aircraft against the cost of its depreciation. If an aircraft only operates for 15 years, the depreciation becomes US$6.7 million a year (US$100 million ÷ 15 years). If the aircraft's working life is extended to 25 years, the expense would be US$4 million each year (US$100 million ÷ 25 years). The estimated useful life of an aircraft varies by airline and the intensity with which the asset is used.

Estimated useful lives of new aircraft

Airline	*Business model*	*Useful life (years)*
AirAsia	Low cost	25
Cathay Pacific	Full service	20
easyJet	Low cost	23
Emirates	Full service	15
Lufthansa	Full service	20
Ryanair	Low cost	23

Source: Airline Annual Reports

An example of an income statement is provided in Table 11.3.

The consolidated income statement shows the airline's performance to the year ended 30 September 2014 and compares it to the previous 12 months. Figures in brackets are costs incurred. The income statement shows that over the year the airline generated revenues of £4,527 million, of which 98.5 per cent came from seat sales and the remainder from non-seat revenue. The company spent £1,251 million on fuel and another £1,107 million on airports and ground handling. Their EBITDAR for the year was £823 million (up from £711 million a year earlier). The company had an operating profit of £581 million (compared with £497 million a year earlier) and paid £131 million in tax. Overall, easyJet's revenues increased by 6 per cent year on year and costs increased by 4 per cent, which resulted in the EBITDAR margin increasing 1 per cent from 17 per cent in 2013 to 18 per cent in 2014.

Table 11.3 easyJet's consolidated income statement, 2014

	Year ended 30 September 2014 £ million	*Year ended 30 September 2013 £ million*
Seat revenue	**4,462**	4,194
Non-seat revenue	**65**	64
Total revenue	**4,527**	4,258
Fuel	**(1,251)**	(1,182)
Airports and ground handling	**(1,107)**	(1,078)
Crew	**(479)**	(454)
Navigation	**(307)**	(294)
Maintenance	**(212)**	(212)
Selling and marketing	**(103)**	(101)
Other costs	**(245)**	(226)
EBITDAR	**823**	711
Aircraft dry leasing	**(124)**	(102)
Depreciation	**(106)**	(102)
Amortisation of intangible assets	**(12)**	(10)
Operating profit	**581**	497
Interest receivable and other financing income	**11**	5
Interest payable and other financing charges	**(11)**	(24)
Net finance charges	**–**	(19)
Profit before tax	**581**	478
Tax charge	**(131)**	(80)
Profit for the year	**450**	398
Earnings per share, pence		
Basic	**114.5**	101.3
Diluted	**113.2**	100.0

Source: Reproduced from easyJet (2014, p98)

Balance sheet

The statement of an airline's financial position (or balance sheet) summarises what the airline owns in term of assets and what it owes in terms of liabilities as at the year-end date. Although the format of balance sheets varies by airline, assets and liabilities are typically defined as being current (meaning they will be realised within 12 months) and non-current (meaning they will not be converted into cash within 12 months). Examples of current assets are cash and deposits, while non-current assets include property, plant and equipment, including any aircraft an airline owns. Current liabilities include borrowings and tax liabilities, while non-current liabilities include maintenance provision and deferred tax liabilities. An example of a financial statement appears in Table 11.4.

Table 11.4 easyJet's consolidated statement of financial position, 2014

	Year ended 30 September 2014 £ million	*Year ended 30 September 2013 £ million*
Non-current assets		
Goodwill	**365**	365
Other intangible assets	**113**	102
Property, plant and equipment	**2,542**	2,280
Derivative financial instruments	**36**	13
Loan notes	**4**	7
Restricted cash	**9**	12
Other non-current assets	**152**	185
	3,221	2,964
Current assets		
Trade and other receivables	**200**	194
Derivate financial instruments	**53**	17
Restricted cash	**23**	–
Money market deposits	**561**	224
Cash and cash equivalents	**424**	1,013
	1,261	1,448

Table 11.4 continued

	Year ended 30 September 2014 £ million	*Year ended 30 September 2013 £ million*
Current liabilities		
Trade and other payables	**(1,110)**	(1,093)
Borrowings	**(91)**	(87)
Derivative financial instruments	**(87)**	(60)
Current tax payable	**(53)**	(58)
Maintenance provisions	**(79)**	(81)
	(1,420)	(1,379)
Net current (liabilities)/assets	**(159)**	69
Non-current liabilities		
Borrowings	**(472)**	(592)
Derivative financial instruments	**(23)**	(41)
Non-current deferred income	**(62)**	(68)
Maintenance provisions	**(147)**	(171)
Deferred tax	**(186)**	(144)
	(890)	(1,016)
Net assets	**2,172**	2,017
Shareholders' equity		
Share capital	**108**	108
Share premium	**658**	657
Hedging reserve	**(17)**	(55)
Translation reserve	**1**	1
Retained earnings	**1,422**	1,306
	2,172	2,017

Source: Reproduced from easyJet (2014, p100)

Cash flow statement

This document details the inflows and outflows of cash over a defined time period and shows the overall (net) change in the airline's cash flow during the reporting period. Together with the income statement and balance sheet, the cash flow statement is a key financial document as it explains changes in the balance sheet over a specified period. Cash flow statements include details of dividend payments to shareholders, the purchase of property, plant and equipment (such as aircraft), repayment of bank loans and proceeds from the sale or leaseback of aircraft. An example of a cash flow statement appears in Table 11.5.

Table 11.5 easyJet's consolidated statement of cash flows, 2014

	Year ended 30 September 2014 £ million	*Year ended 30 September 2013 £ million*
Cash flows from operating activities		
Cash generated from operations (excluding dividends)	**793**	788
Ordinary dividends paid	**(133)**	(85)
Special dividends paid	**(175)**	–
Net interest and other financing charges received/(paid)	**5**	(22)
Tax paid	**(96)**	(65)
Net cash generated from operating activities	**394**	616
Cash flows from investing activities		
Purchase of property, plant and equipment	**(426)**	(400)
Proceeds from sale of property, plant and equipment	**1**	1
Purchase of intangible assets	**(23)**	(21)
Redemption of loan notes	**3**	4
Net cash used by investing activities	**(445)**	(416)
Cash flows from financing activities		
Net proceeds from issue of ordinary share capital	**1**	1
Purchase of own shares for employee share scheme	**(57)**	(26)
Repayment of bank loans	**(104)**	(273)
Repayment of capital element of finance leases	**(8)**	(10)
Net proceeds from sale and operating leaseback of aircraft	**–**	316
Net (increase)/decrease in money market deposits	**(338)**	41
Net (increase)/decrease in restricted cash	**(20)**	148
Net cash (used by)/generated from financing activities	**(526)**	197

Table 11.5 continued

	Year ended 30 September 2014 £ million	*Year ended 30 September 2013 £ million*
Effect of exchange rate changes	**(12)**	(29)
Net (decrease)/increase in cash and equivalents	**(589)**	368
Cash and cash equivalents at the beginning of year	**1,013**	645
Cash and cash equivalents at end of year	**424**	1,013

Source: Reproduced from easyJet (2014, p102)

Cash flow from the business was comparable at £793 million (prior year £788 million), which was used to pay a dividend to shareholders of £308 million (an increase of £223 million over the 2013 dividend), which resulted in a lower net generation of funds at £394 million (prior year £616 million). Investment levels were slightly higher at £445 million (prior year £416 million) and financing activities (after adjusting for money market deposits) consumed £188 million of funds, of which £104 million was used to repay loans. Cash and cash equivalents reduced from £1,013 million to £424 million, as a result of the investment in assets, higher dividends, money market deposits and loan repayments.

11.3 Financial ratios

One way to interpret financial statements and commercial performance is through the use of ratios. Financial ratios provide an indicator of a company's financial performance and they can be used to compare the financial performance of different companies. There are many different types of ratios that can be used to analyse performance. Financial performance ratios include:

- *Performance ratios.* These include operating ratios, net profit margin, return on investment and return on capital employed (ROCE), operating profit margin and asset utilisation ratio.
- *Stock market ratios.* These include dividend cover, dividend yield, market capitalisation, earnings per share, price/earnings ratio and net asset value per share.
- *Risk or gearing ratios.* These provide an indication of the financial strength (or weakness) of a company through debt/equity ratios.
- *Liquidity ratios.* These measure the availability of cash within a company to pay debts. They include the current ratio, the acid test or quick ratio and cash ratio.

Several financial ratios appear in easyJet's accounts (see Table 11.6) – including ROCE and gearing.

'Gearing' is a general term describing a financial ratio that compares the level of a company's debt against its equity capital. It is usually expressed as a percentage. Gearing ratios provide a measure of a company's financial risk and show the extent to which its operations are funded by equity (its owners or shareholders) versus its debts. A gearing ratio can be calculated by dividing a company's debt by its shareholders' equity and multiplying it by 100.

Usually a company with high gearing (high leverage) is considered to be riskier than one with a lower gearing. As with other financial ratios, an acceptable gearing is determined by the performance of other companies in the same industry. A company with high gearing is more vulnerable to economic downturns as it has to continue to pay its debts even when its revenue falls. Higher levels of equity provide more protection from the effects of a downturn (as unlike interest dividends they do not have to be paid to shareholders) and can be seen as a measure of financial strength. Lenders examine an airline's gearing as a high gearing may indicate that their loans are at risk of not being repaid. A company can reduce its gearing ratio by retaining profits, repaying loans, issuing new shares, reducing working capital and, where applicable, converting loans to shares.

Stop and think

What are the benefits of using financial ratios?

11.4 Financial KPIs

Key performance indicators (KPIs) measure factors that are critical to the financial and commercial success of a company. KPIs differ by sector and by company, but typical airline KPIs involve the use of financial ratios and measures of ROCE, and cost and revenue per seat. Evaluating changes in KPIs over time and comparing them to the performance of direct competitors can help a company measure its progress towards its corporate targets. Table 11.6 shows the KPIs used by easyJet. This list is not exhaustive, and there are other KPIs that airlines may consider using, such as seat occupancy, revenue per seat, turnaround time and route kilometres flown, as well as safety and environmental measures.

The ROCE shows a positive trend from 6.9 per cent in 2010 to 20.5 per cent in 2014.

The gearing shows an increase in 2014, reflecting the sale and leaseback in 2013 of £316 million (see the cash flow statement for 2013). Profit per seat shows a positive trend from £2.75 in 2010 to £8.12 in 2014. The major gain was in 2013 (up 46 per cent) on 2012, and while a smaller gain in 2014, it continues to show positive upward movement (up 15 per cent).

The revenue and cost per seat measures are components of the profit per seat measure and show that revenues are increasing faster than the costs over the period. Seats flown continues to grow (reflecting increased capacity).

Table 11.6 easyJet's financial KPIs

KPIs	*2014*	*2013*	*2012*	*2011*	*2010*
Return on capital employed	20.5%	17.4%	11.3%	9.8%	6.9%
Gearing	17%	7%	29%	28%	32%
Net cash/(debt) (£ million)	422	558	(74)	100	(40)
Profit before tax per seat (£)	8.12	7.03	4.81	3.97	2.75
Revenue per seat (£)	63.31	62.58	58.51	55.27	53.07
Cost per seat (£)	55.19	55.55	53.70	51.30	50.32
Cost per seat excluding fuel (£)	37.70	38.17	36.25	36.62	37.23
Seats flown (millions)	71.5	68.0	65.9	62.5	56.0

Source: easyJet (2014, p135)

Stop and think

Why do airlines report different KPIs in their financial statements?

11.5 Financial risk management

Airlines are subject to a range of financial risks that are outside of their control, including changes in foreign exchange rates, variations in interest rates on loans and fluctuations in fuel prices. Such variability can result in either gains or losses. Favourable exchange rates, for example, may enable an airline to make more money, whereas a sudden rise in the price of fuel can add millions of US dollars to an airline's costs and may ultimately result in the airline ceasing operations. To maximise financial gains and minimise losses, financial risk management strategies are required.

Exposure to movements in foreign exchange rates affect airlines' operating, financing and investing activities as large fluctuations in exchange rates may result in an airline paying more or receiving less than had been anticipated. The aim of foreign currency risk management is to reduce the negative effects of exchange rate changes on the business. Foreign exchange exposure can be reduced by matching the payments and receipts that are made in each individual currency and holding deposits in different currencies to provide protection from sudden changes in exchange rates. The effect of exchange rate changes can be considerable, running into millions of pounds per annum. There is also a risk that movement in a currency may impact on demand as it may make a tourist destination more or less attractive.

A further risk comes from the changing price of oil and fuel as fuel comprises one of an airline's biggest cost items. By way of an indication, easyJet spent £1,251 million on fuel in the year ended 30 September 2014, and any increases in fuel price can have a considerable effect on airlines. During 2008, jet fuel prices were highly volatile and a number of airlines worldwide ceased operating as a result.

Many airlines engage in fuel price risk management (or **hedging**) to provide protection against sudden and significant increases in fuel prices and mitigate any volatility in the income statement in the short term. In order to manage their risk exposure, airlines may hedge a proportion of their short-term future fuel requirements at a set price, although there is a cost in undertaking this. If the fuel price increases during the hedging period, the airline enjoys a position of relative financial advantage over carriers that did not hedge. If, however, the fuel price falls during the hedging period, the airline pays more for its fuel than the market rate and is placed at a financial disadvantage against carriers who did not hedge (see Case Study 11.3).

Hedging: a financial management strategy used to offset financial risks.

CASE STUDY 11.3

FUEL HEDGING

An airline believes oil prices will rise to US$100 a barrel and so establishes a hedge to guarantee it at the equivalent of US$80 a barrel for the next year's supply. If the oil price rises above US$80 a barrel that year, the carrier has benefited from the hedge and its fuel costs are kept down. If the oil price drops to US$60 a barrel, the airline loses money compared with the price it could have paid and may be at a competitive disadvantage compared to airlines who didn't hedge. In 2014, easyJet used forward contracts to hedge between 65 per cent and 85 per cent of their estimated exposures up to 12 months in advance and between 45 per cent and 65 per cent of estimated exposure from 13 to 24 months in advance (easyJet, 2014 p17).

Hedging cannot eliminate the underlying risk of long-term fuel price variability, but it can reduce its short-term effects on the business. Hedging can be considered to be a form of insurance and, like any insurance policy, there is a premium to pay and a variety of cover available, meaning that airlines not only have to decide how much of their future fuel requirement to hedge but at what price so that they can achieve the corporate targets they have set.

Stop and think

What are the risks associated with fuel hedging?

Airlines can also be vulnerable to changes in interest rates that are payable on variable interest rate loans. This is especially an issue for carriers with high gearing that rely on large loans to continue their operations. Many companies use **interest rate swaps** to manage their exposure to changes in market rates of interest.

Interest rate swap: an agreement between two parties to exchange interest rate payments over a set time period.

11.6 Financial failure

Airlines operate in a very competitive and volatile market, not least because of the derived demand nature of the product they provide, which can very quickly reduce or disappear, for example during times of recession, war or terrorist attack (➤Chapter 2). When demand does fall away, sharply significant short-term losses arise. Post-9/11, IATA reported airlines lost US$22 billion in revenues over the following three years.

In such a potentially hostile trading environment, airlines must employ robust financial, revenue and cost management strategies. If an airline is unable to service its debts, it becomes insolvent. Creditors may give the company time to pay its debts, but eventually they may require the airline to sell some of its assets. If a debt remains outstanding, the airline may be declared bankrupt. Bankruptcy describes a situation in which a company which cannot meet its obligations to its creditors seeks court protection to continue operating while it restructures or reorganises its business. In the US, this is called entering Chapter 11 bankruptcy protection (see Case Study 11.4), while in the UK it is described as entering administration. The key difference between the two is that under Chapter 11 protection the airline is run by its existing management team, whereas under UK administration an external team of administrators is brought in to reorganise the business to secure the best outcome for the airline's creditors and shareholders.

CASE STUDY 11.4

CHAPTER 11 BANKRUPTCY PROTECTION

If a US-registered airline is unable to service its debts or pay its creditors, it can enter Chapter 11 bankruptcy protection. Chapter 11 refers to the chapter of the US Bankruptcy Code, which permits US-registered businesses (including airlines) to reorganise their activities and continue to operate while being protected from their creditors. Over 180 US airlines have entered Chapter 11 bankruptcy protection since 1990, and a number, including Continental, United, US Airways, Delta and American Airlines, have subsequently emerged as profitable businesses. Some non-US airlines have alleged that Chapter 11 offers US carriers an unfair advantage as it protects them from creditors while they restructure.

Restructuring and reorganisation seek to reduce costs in all areas of the business and may involve:

- returning aircraft to lessors;
- renegotiating aircraft leases on more favourable terms;
- deferring the delivery of new aircraft;
- renegotiating pension arrangements with their employees;
- renegotiating airport charges with airport operators;

- renegotiating employment and ground handling contracts;
- converting loans into shares to reduce interest payments;
- rationalising the route network and withdrawing unprofitable services;
- increasing ancillary revenue generation or introducing additional fuel levies;
- making staff redundant;
- selling assets.

If these measures are unsuccessful, the airline may be forced to sell off any remaining assets to generate cash (a process known as **liquidation**) and leased aircraft may be repossessed. With no aircraft and no assets an airline cannot function and may be forced to leave the market. Market exit is particularly common among new entrant airlines that lack the capital and financial security of more established operators. In Europe, over 75 per cent of the LCCs that started flying between 1992 and 2012 left the market (Budd *et al.* 2014). More-established operators may also leave the market for reasons of new competition, a safety or security incident which damages customer and investor confidence in the business, being merged with or taken over by a rival, or because of external events such as fuel price rises, geopolitical unrest in core markets, terrorist events, global recession or outbreaks of infectious disease.

Liquidation: the process of turning assets into cash in order to raise as many funds as possible towards an airline's debts.

Stop and think

Identify the reasons why airlines might fail.

Key points

- Finance forms a critical and integral part of airline operations and management.
- There are different sources of aircraft finance, namely: the use of retained profits; bank borrowings; export credit finance; equity finance; manufacturer support leasing and Islamic finance.
- Operating leases can be classified as dry, damp or wet leases, and they potentially offer flexibility to an airline's fleet and/or operations.
- Whether to purchase or lease aircraft is a key decision for airline operators.
- Airline operators, as with any company, have to present financial statements on an annual basis, namely an income statement, a statement of financial position and a statement of cash flows.
- Financial ratios, including performance ratios, stock market ratios, risk or solvency ratios and liquidity ratios, can be used as key performance indicators to assess an airline's performance.

- Hedging is a strategy used to protect against the risk of adverse impact of changes in fuel prices, exchange rates or interest rates.
- Airlines operate in a volatile environment, and effective financial management is vital if they are not to be faced with insolvency and, ultimately, potential market exit.
- Insolvency, bankruptcy, liquidation and ultimately market exit are all situations that can face an airline, or indeed any company.

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CHAPTER 12

Aviation safety and security

Mohammed Quddus

LEARNING OUTCOMES

- To understand what is meant by safety and the difference between accidents, incidents and precursors.
- To recognise the principal causes of aircraft accidents.
- To appreciate how accident causation models and safety management systems can be used to improve safety.
- To understand what is meant by security.
- To examine the evolution of aviation security practices worldwide.
- To be aware of the role of international regulations and agencies in the formation and development of aviation safety and security regimes worldwide.

12.0 Introduction

In a little over 100 years, aviation has evolved from a new and hazardous mode of transport into one of the safest forms of long-distance mobility. Progressive developments in aeronautical design and propulsion have enabled the construction of faster, stronger, lighter and more reliable aircraft, which have not only improved safety standards but also reduced the financial cost of flying and stimulated unprecedented consumer demand for flight (➤Chapter 2). However, despite continued innovation, the physical environment 35,000ft (10,650m) above the earth remains hostile and largely unforgiving of mechanical failure or poor decision-making. Perhaps more than any other transport mode, the consequences of an aircraft accident are usually severe and may result in large numbers of people in the air and/or on the ground being fatally or seriously injured.

In recognition of the importance of protecting life and property, this chapter focuses on two distinct but intrinsically interrelated fields: aviation safety and aviation security. The first part of the chapter examines aviation safety. It introduces the concept of safety, details the principal causes of aircraft accidents and describes the causation models that can be used to reduce the likelihood of future occurrences. As aircraft and airports represent a target for terrorist attack, the second part of the chapter focuses on aviation security. It examines why air transport is targeted, discusses the evolution of aviation security regimes and details the security interventions that have been developed to try and protect the industry from acts of unlawful interference.

12.1 Aviation safety

Boarding a scheduled commercial flight operated by a major airline in the developed world using a Western-built commercial aircraft is statistically one of the safest forms of transport. Indeed, passengers are far more likely to be fatally or seriously injured driving to the airport than they are once on board a flight. However, in the unlikely event that something does go wrong, the consequences can be severe, and the infrequency of such events means that safety incidents involving commercial aircraft attract considerable media attention. It is imperative, therefore, that the air transport industry continues to enhance its safety performance through: the development and rigorous testing of new technologies; the training of personnel; thorough accident investigation and learning from past events; cultivating an open and transparent reporting culture in which staff feel supported to raise concerns; and the implementation of safety management systems.

Aviation safety: the theory of accident causation, investigation, categorisation and the analysis of aviation accidents/incidents and their prevention through the introduction of appropriate interventions related to enforcement (regulation), engineering (technologies) and education (training).

Aviation safety is more than simply the absence of an accident or the avoidance of harm. It is a culture, a way of approaching business and a way of performing daily operations that ensure that human life and property is protected. This involves identifying, analysing and eliminating, as far as possible, the development of circumstances that could lead to an accident. Modern aircraft are highly complex and are designed to routinely endure extremes of temperature, pressure and humidity. They encounter turbulence, hail and sandstorms and have to be capable of withstanding lightning bolts, bird strikes, in-flight fires and engine failure. In order to continually improve global aviation safety, international agencies, national regulators, aircraft manufacturers, airlines, airports and special interest groups routinely collate and analyse aviation safety statistics to understand the current situation, identify new trends in the data, make recommendations and issue safety directives to prevent potentially dangerous situations from (re)occurring. Examples of the agencies involved in the collation and analysis of safety statistics are presented in Table 12.1. Understanding how these different groups define and classify accidents is important as it can lead to significant variations in published statistics. Appreciating who compiled the data, when, for whom, and for what purpose is therefore crucial.

At the global level, the International Civil Aviation Organization (ICAO) sets the Standards and Recommended Practices (SARPs) that concern aviation safety, security, efficiency and environmental protection worldwide. The SARPs not only define best practice in these functional areas but also seek to balance the assessed risk against the various risk mitigation strategies that can be imposed.

Table 12.1 Selected examples of agencies involved in the regulation of civil aviation safety and/or the collection and analysis of aviation safety statistics

International agencies	*National regulators*	*Manufacturers*	*Special interest groups*	*Others*
ICAO	FAA, US	Airbus	Flight Safety Foundation	Airport operators
IATA	NTSB (National Transportation Safety Board), US	Boeing	Aviation Safety Network	Air navigation service providers
EASA (European Aviation Safety Agency)	CAA, UK	Rolls-Royce		Ground handling agents
PASO (Pacific Aviation Safety Office)	CASA (Civil Aviation Safety Authority), Australia	GE		Airlines

Accidents, incidents and precursors

Air transport is a safety critical mode in which accidents are rare but their consequences are severe. Accidents in aviation are therefore known as low-frequency, high-consequence hazardous events. Although the use of accident data is adequate in estimating the underlying risk and safety of road transport operations, they are not sufficient in estimating risk in the air transport industry. Consequently, the air transport industry records safety occurrence events known as incidents. This section introduces the concepts of **accidents**, **incidents** and **precursors**.

Accident: an occurrence associated with the operation of an aircraft in which a person is seriously or fatally injured and/or the aircraft is significantly damaged or destroyed.

Incident: a safety event in which an accident is about to happen but does not actually happen due to an intervention.

Precursor: a condition or event that could result in an accident or incident.

Aviation accidents

ICAO Annex 13 – *Aircraft Accident and Incident Investigation* – of the Chicago Convention 1944 (➤Chapter 7) defines an accident as an occurrence associated with the operation of an aircraft which occurs at any point in a journey between a person boarding and disembarking an aircraft in which an individual is fatally or seriously injured as a result of:

- being on board the aircraft (excluding death by natural causes);
- coming into direct contact with the aircraft (or parts that have fallen from an aircraft) or being directly exposed to jet blast (unless self-inflicted); or
- the aircraft sustains damage or experiences structural failure which adversely affects its strength, performance or flight characteristics and which would require major component repair or replacement (contained engine failure and damage to wingtips, antennae, tyres or small dents are excluded); or
- the aircraft is missing or totally inaccessible.

In this context, serious injuries are defined as those which directly result from an occurrence and which require hospitalisation lasting over 48 hours, result in major broken bones, deep lacerations, second- or third-degree burns or burns which cover over 5 per cent of the body, result in exposure to radiation or infectious disease or in which injury to any internal organ is sustained. One accident that resulted in substantial damage to an aircraft but no loss of life occurred in New York in January 2009 (see Case Study 12.1).

CASE STUDY 12.1

US AIRWAYS FLIGHT 1549

US Airways Airbus A320 operating Flight 1549 from New York LaGuardia Airport to Charlotte, North Carolina, on 15 January 2009 struck a flock of geese two minutes after take-off at an altitude of 2,800ft (850m). The impact of the bird strikes damaged both engines and resulted in an almost complete loss of thrust. With power severely degraded and unable either to return to LaGuardia or make the alternative landing site at Teterboro Airport, the captain ditched the aircraft in the Hudson River. All 155 passengers and crew were able to evacuate onto the wings where they were rescued by river boats and ferries. One flight attendant and four passengers suffered serious injuries, and the aircraft was substantially damaged (NTSB 2010). The captain's airmanship and decision-making combined with the flight management system on the A320 and the proximity of emergency responders meant that all the occupants survived.

Aviation incident

An incident is an occurrence, other than an accident, associated with the operation of an aircraft which affects, or could affect, the safety of operation (see Case Study 12.2).

CASE STUDY 12.2

AN AVIATION INCIDENT

On 28 August 2014, the flightcrew of an easyJet service from Liverpool, UK, to Naples, Italy, with 157 passengers and six crew on board spotted smoke coming from the central console and the first officer's footwell while they were climbing through 32,000ft (9,750m). The flight diverted to London Gatwick, where it landed safely. There were no injuries to passengers or crew. Subsequent investigations discovered that equipment in the avionics bay had overheated. The affected equipment was replaced and the aircraft was returned to service (AAIB 2014).

Precursors

These are conditions or events that precede and could result in an accident or incident. The literature often uses the terms 'near misses', 'close calls' or 'partial failures' when referring to precursors. A precursor can be considered as the first deviation from a normal operation or circumstance. This is known as a root event in a causal-effect sequence of the accident or incident development (see Figure 12.1). In a complex causation sequence such as an aviation accident or incident, multiple precursors may be responsible for a top event.

It is important to capture precursor data, and this data is primarily recorded in three ways:

1. *Industry's formal system.* Major aircraft and engine manufacturers developed their formal reporting systems to capture hazards, unsafe conditions and human factors contributing to safety occurrences. Airbus developed the Aircrew Incident Reporting System (AIRS) to help its customers establish their own confidential reporting systems.
2. *Regulator's formal system.* The provisions in Chapter 8 of ICAO Annex 13 require a country's aviation regulator to establish formal safety occurrence reporting systems to facilitate the collection of information on actual or potential safety deficiencies. Examples include the Mandatory Occurrence Reporting (MOR) scheme in the UK and Civil Aviation Daily Occurrence Reporting System (CADORS) in Canada.
3. *Confidential reporting system.* These systems aim to protect the identity of the reporting person to ensure that voluntary reporting systems are non-punitive. Examples include the Aviation Safety Reporting System (ASRS) in the US and the Aviation and Maritime Confidential Incident Reporting (CHIRP) in the UK.

The inherent problems of reporting precursors include: deciding which precursor events should be recorded and by whom, integrating confidential reporting systems with those of

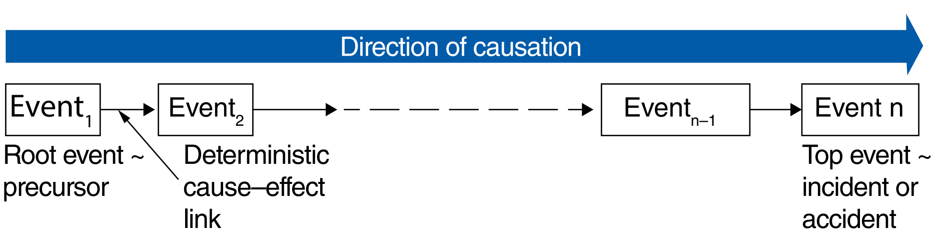

Figure 12.1 Relationship between a precursor, an incident and an accident

Stop and think

Explain the differences between accidents, incidents and precursors in the context of aviation safety occurrences.

industry and ensuring the data is accurate. It is important to be aware of these issues when employing precursor data to:

- understand the structure of a system's risk;
- monitor how risks are changing in one system;
- identify hazards;
- mitigate them before they lead to accidents; and
- provide more safety performance data than is available from accident or incident data alone.

12.2 Safety statistics and trends

Between 1945 and 2014, over 3,600 aviation accidents and 78,400 fatalities were recorded worldwide (Aviation Safety Network 2015). This equates to an average of 52 accidents (one per week) and 1,120 deaths on commercial aircraft per year. However, as Figure 12.2 shows, these figures hide considerable annual variation. The worst year for accidents was 1948 when 87 accidents were recorded. This compares with only 20 in 2014, despite the fact that passenger numbers grew from approximately 24 million in 1948 to over 3.3 billion in 2014.

Given the substantial growth in passenger numbers since 1948, it is necessary to calculate the global accident rate (expressed as the number of accidents per million departures) to enable year-on-year comparisons to be made. In 2013, the global accident rate was 2.8 accidents per million departures, an improvement on the 4.1 accidents per million

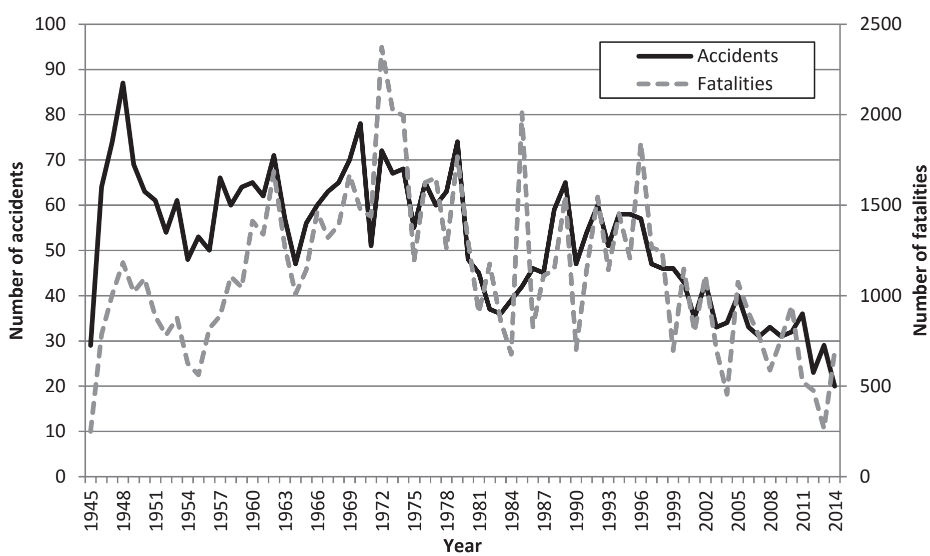

Figure 12.2 Global aviation accidents and fatalities, 1945–2014

Source: Data derived from the Aviation Safety Network (2015) departures recorded in 2009 (ICAO 2014). While the accident rate appears to be improving, the average number of fatalities per accident has increased over time in line with the introduction and utilisation of larger aircraft (see Figure 12.3).

As well as analysing annual trends, it is necessary to consider where these accidents occur as there are considerable variations between world regions (see Table 12.2).

The accident rate in Africa, at 12.9, is much higher than the world average, and the continent accounts for one in ten accidents worldwide despite only accounting for 2 per cent of global air traffic. Other regions, including the Middle East and Asia-Pacific appear to perform much better. There are a number of possible explanations for the observed differences in regional accident rates. These include:

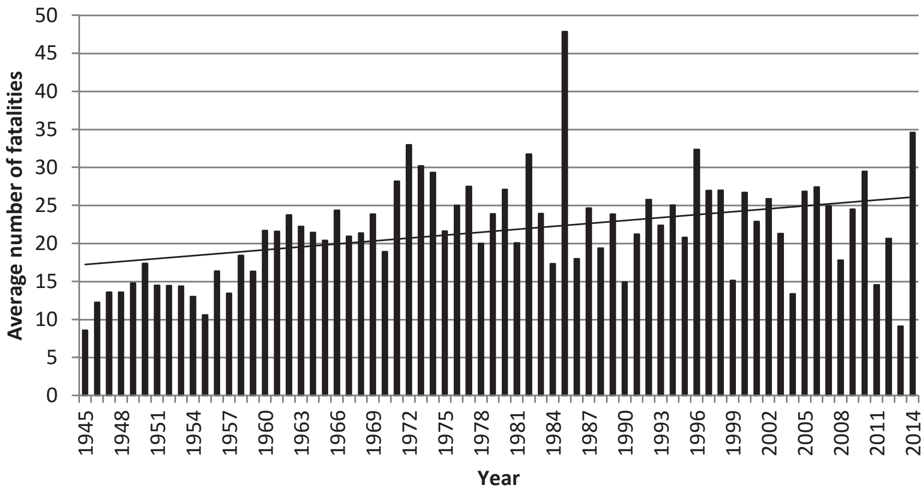

Figure 12.3 Average fatalities per accident, 1945–2014

Source: Data derived from the Aviation Safety Network (2015)

Table 12.2 Accident statistics by world region, 2013

Region	*Estimated departures (in millions)*	*Number of accidents*	*Accident rate*	*% share of world traffic*	*% share of accidents*
Africa	0.7	9	12.9	2	10
Asia-Pacific	8.6	19	2.2	27	21
Europe	7.9	21	2.7	25	23
Middle East	1.1	2	1.8	3	3
Americas	13.8	39	2.8	43	43
World total	**32.1**	**90**	**2.8**		

Source: Data derived from ICAO (2014)

- the age and maintenance record of the airframes and engines being flown;
- levels of staff training, auditing and safety compliance;
- ability of national regulators to oversee and enforce safety standards;
- relative sophistication, availability and serviceability of navigation aids, ATC services, instrument landing systems (ILSs), radar, radio communications and runway lighting;
- frequency of severe weather conditions;
- proximity of hostile terrain to airports;
- provision, capacity and capability of airport rescue and fire fighting services and local emergency services to respond to safety occurrences;
- capacity and capability of local hospitals to treat survivors;
- geopolitical and/or civil unrest and associated security threats.

Stop and think

Why are there regional variations in global accident rates, and what could be done to improve aviation safety in Africa?

12.3 Accident categories

In addition to accurately recording the geographic location and consequence of every aviation safety occurrence, it is vital that there is a universal system for reporting and investigating accidents so that the principal cause(s) can be determined and action taken to reduce the likelihood of a reoccurrence. However, until relatively recently, there was no consensus as to which of the multiple different accident classification systems should be used. At the international level, IATA developed a Threat and Error Management (TEM) approach that focused on operations and human performance, while ICAO developed a taxonomy of 36 occurrence categories grouped into seven functional areas (Table 12.3). Individual countries also had their own classification schemes which made cross-border safety collaboration and data sharing problematic as comparisons could not easily be performed.

In order to improve international reporting and data sharing and enhance safety, ICAO, IATA, the US Department of Transportation and the European Commission established a Global Safety Information Exchange (GSIE) in 2010. The GSIE resulted in a harmonised accident rate being introduced in 2011 which comprises eight accident categories (Table 12.4).

Of these, runway safety occurrences accounted for the largest number of accidents and incidents in 2013, followed by operational damage, ground safety, medical incidents, controlled flight into terrain (CFIT – pronounced 'see fit'), loss of control in-flight (LOC-I),

Table 12.3 Examples of ICAO occurrence categories

Airborne	Aircraft	Ground operations
Abrupt manoeuvre	Airframe system or component failure	Evacuation
Loss of separation	Engine failure	Ground collision
Loss of control in flight	In-flight fire or smoke	Runway excursion
Miscellaneous	**Non-aircraft related**	**Take-off and landing**
Bird strike	Aerodrome factors	Abnormal runway contact
Security related	Air traffic management	Obstacle collision
Medical		Undershoot/overshoot
Weather		
Icing		
Windshear/ thunderstorm		
Turbulence		

Source: Derived from ICAO (2013a)

Table 12.4 GSIE harmonised accident categories

Category	*Description*
Controlled flight into terrain (CFIT)	Aircraft is airworthy but flown into terrain in a controlled manner.
Loss of control in-flight (LOC-I)	Unrecoverable loss of control during the airborne phase of flight.
Runway safety	Includes overshoots and undershoots, runway incursions and excursions, tail strikes and hard landings.
Ground safety	Includes ramp safety, ground collisions, taxi and towing events, ground servicing.
Operational damage	Damage sustained to the aircraft while operating under its own power. Includes in-flight damage and system or component failures.
Injuries to and/or incapacitation of persons	Includes turbulence related injuries, injuries to ground staff and passengers not related to acts of unlawful interference.
Other	Any event that does not fit into one of the other categories.
Unknown	Any event where the exact cause cannot be reasonably determined or there are insufficient facts available to make a conclusive decision regarding classification.

Source: Derived from IATA (2014, p91)

Hull loss: when an aircraft is damaged beyond economic repair.

Cruise: the level portion of a flight between take-off and landing that occurs at a constant airspeed and altitude.

other and unknown. Of these, LOC-I and CFIT events accounted for over 25 per cent and 20 per cent respectively of all fatal accidents involving Western-built commercial jet aircraft between 1994 and 2013, while runway excursions (defined as a veer-off or overrun) accounted for the greatest proportion of **hull losses** (Airbus 2014).

Loss of control in-flight (LOC-I)

LOC-I events can result from adverse weather conditions in the **cruise** (including icing, poor visibility and windshear/gusty winds), pilot error, aircraft system malfunction (such as an engine failure) or maintenance events. While LOC-I occurrences are rare, they are usually catastrophic. Between 2009 and 2013, 95 per cent of LOC-I events resulted in fatalities to passengers or crew, and ICAO (2014) states that LOC-I events represent the highest risk to aviation safety. The introduction of more sophisticated flight management systems and flight protection envelopes (that prevent pilots from performing manoeuvres that would exceed an aircraft's structural and aerodynamic limits), combined with enhanced flightcrew training have resulted in fewer LOC-I events.

Controlled flight into terrain (CFIT)

The category which resulted in the second highest proportion of fatal accidents was CFIT. Most CFIT accidents occur during the approach and landing phases of a flight and may result from aircraft system malfunction or flightcrew errors. The introduction of more accurate global positioning systems (GPS) and terrain awareness and warning systems (TAWS), which alert pilots to nearby terrain, have resulted in a significant reduction in CFIT accidents.

Runway excursions

Runway excursions (in which aircraft veer off to the side of the runway or run off the end) are usually caused by poor aircraft energy management during landing (in which the aircraft is too high or too fast or both) and/or contaminated runway surfaces which reduce friction and braking action. Unlike LOC-I and CFIT events, survivability is high, although the aircraft is invariably damaged beyond repair.

Stop and think

Why is it important to classify aircraft accidents?

12.4 Accidents by flight phase

In addition to descriptive categorisation, accidents can also be classified according to the phase of flight in which they occurred. In 2013, nearly 58 per cent of fatal accidents involving

Western-built commercial jet aircraft occurred during descent/approach/landing and 28 per cent during the take-off/ climb phases of flight. Only 12 per cent occurred during the cruise, and the remaining 2 per cent happened on the ground (Airbus 2014).

During the descent/approach/landing, aircraft are operating closer to the ground and flightcrew have less time and space in which to react if something unexpected occurs. Aircraft are also aerodynamically more vulnerable as flaps and other high-lift devices on the wing will be deployed to slow the aircraft while generating sufficient lift to keep it airborne, and these create additional drag. The engines will generally be on a low or idle power setting and may take a couple of seconds to respond to sudden increases in power requirements. The proximity of terrain and the increased likelihood of encountering adverse weather (such as low visibility, icing, turbulence and windshear) combined with human factors, such as flightcrew fatigue, jet lag, perceived or actual pressure to ensure an on-time arrival and unfamiliarity with the approach procedure, compound the risk. On take-off and climb-out, aircraft are heavy and laden with highly flammable fuel, and the engines are working hard to deliver the required thrust. Any occurrence, such as tyre burst, bird strike or mechanical failure, has the potential to cause an accident.

Stop and think

Why is descent, approach and landing statistically the most dangerous phase of a flight?

12.5 Accident rates by aircraft type

A further factor that needs to be considered when analysing accident statistics is the type of aircraft that is operating the service and whether it was built by a Western or non-Western manufacturer, the aircraft's age, service history and maintenance record. Statistically, **jet** aircraft have a lower accident rate than **turboprops**.

Turboprops are typically smaller and lighter than jet aircraft and are therefore more vulnerable to adverse weather conditions such as windshear and gusty conditions. They typically operate into smaller regional airports (some of which are situated in challenging terrain with associated weather conditions) which may not be equipped with precision navigation aids or ILSs, and serve some of the world's most remote airfields (➤Chapter 20). In addition, turboprops may be flown by less experienced flightcrew who have not acquired sufficient flying hours to operate jets.

Jet: an aircraft propelled by engines that produce forward motion as a consequence of the expulsion of exhaust gases from the rear of the engine.

Turboprop: (abbreviation of 'turbo-propeller') an aircraft propelled by an engine (or engines) that drives an external propeller which produces the principal thrust.

12.6 Type of service

A further factor that can be considered is the type of service. Although the majority of accidents (79 per cent) occur to passenger aircraft, 16 per cent affect cargo aircraft and 5 per cent occur to repositioning flights that are not carrying revenue generating passengers or cargo. The unique operating characteristics of these services mean they may be disproportionately affected by one particular type of safety occurrence. For example, incorrectly loaded or dangerous cargo that catches fire (or, in the case of animals, escapes) can lead to LOC-I events on cargo flights, while incorrect loading on the ground can lead to tail stands (where the aircraft tips back onto its tail) or in-flight instability.

12.7 Accident costs

In addition to preventing accidents, safety has important implications for financial performance and business continuity. The financial cost of aircraft accidents includes not only direct costs such as damage sustained to aircraft and compensation but also indirect costs relating to the reputational damage and loss of consumer and investor confidence that may follow an accident, particularly one in which the airline is found to be negligent or liable. Although the Warsaw Convention (➤Chapter 1) established monetary limits for compensation due to passengers and consigners of air cargo in the event of an accident, even relatively minor incidents can result in substantial repair and compensation bills. In 2013, the estimated financial cost of accidents involving Western-built commercial jet aircraft was just under US$1,500 million, while the comparable cost for Western-built turboprops was over US$100 million (IATA 2014).

12.8 Accident causation models

Aviation is a complex system with many different components and aviation safety can be considered as a system property. The essential question therefore is: why do accidents occur and what causes them? If the source can be identified, then the potential accident can be avoided through the introduction of new interventions and measures related to technology, policy and education/training. Accident causation models have been developed to identify, represent, classify and organise causal factors associated with accidents and incidents. Accident causation models are used by the air transport industry to illustrate how accidents occur and to show the relationship between cause and effect. The models propose that most aircraft accidents are not caused by one single factor or mistake but occur as a consequence of lots of individual problems or errors coming together at the same time that make an accident an unavoidable outcome. While the cause of accidents may be attributed to 'pilot error', individual flightcrew are rarely solely responsible for accidents (unless they are self-inflicted). Air accident investigations have shown that accidents usually result from a combination of active failures, unsafe acts, and latent and local triggering conditions, such as aircraft/airport design factors that may or may not have been reasonably foreseen or predicted.

Accident causation models and the techniques for accident analysis have been developed and refined by researchers from different disciplines, including engineering, psychology, sociology and medicine. HaSPA (2012) provides a historical perspective of accident causation models developed since the 1920s. Their research reveals that the evaluation of accident models exhibits common underpinning principles that can be classified into three distinct phases:

1. *Simple linear models.* These commonly used models contend that accidents result from a series of events or circumstances that occur sequentially. The primary objective is to identify problems and prevent accidents from (re)occurring. An example of a linear model is Heinrich's Domino Theory (1931), which conceptualises accidents occurring as a result of an adverse event, which causes a cascade effect, in much the same way as a line of dominos collapse one after the other when the first one is knocked over.
2. *Complex linear models.* These are the second-generation accident models which contend that accidents result from interactions between real-time unsafe acts by front-line staff and latent organisational conditions (e.g. top-level decision makers, line management) that exist within a complex system coming together in a linear sequence. One of the most famous complex linear accident causation models is the Swiss Cheese Model (SCM). First published by Reason in 1990, it proposes that accidents occur when multiple factors come together at the same time and in the same place. The SCM uses the analogy of individual layers of Swiss cheese piled up on top of each other. In most situations, a hole (i.e. hazard) in one layer that might contribute to an accident is blocked by the layer beneath it but, in certain situations, all the holes line up simultaneously and unwanted outcome results. From a management perspective, the success of the SCM in preventing accidents relies on effective identification of the factors that create the holes in the cheese and then devising interventions to prevent their occurrence. However, complex linear models still adhere to the principles of sequential models as the direction of causality follows a linear path. Moreover, the SCM is insufficiently specific regarding the nature of the holes in the cheese and their interrelationships.
3. *Complex non-linear models.* These are the third generation accident models in which accidents result from complex non-linear interactions of unfamiliar, unanticipated and/or unexpected sequences that may occur concurrently and which may interact with each other in complicated and unexpected ways which designers could not predict and operators cannot comprehend or control without exhaustive modelling or testing. An example of complex non-linear models is the Systems-Theoretic Accident Model and Processes (STAMP) model proposed by Professor Leveson from the Massachusetts Institute of Technology (MIT), who postulated that systems theory is a useful way to analyse accidents. In STAMP, accidents are treated as the result of flawed processes, in which the controls that were in place failed to detect or prevent changes, involving non-linear interactions among people, social and organisational structures, infrastructures and software system components. Table 12.5 analyses the relative merits of the three accident causation models.

So successful has the air transport industry been in utilising causation models and improving safety standards that aspects have been transferred to other safety critical sectors. Recognising the success of pre-flight checklists in reducing incidents of aircraft being incorrectly configured for take-off, pre-operative checklists are now used by medical surgeons to ensure that they are preparing to perform the right procedure on the correct patient and that they

Table 12.5 Relative merits of the three accident models

Model	*Concepts/pros*	*Cons*	*Example*
Simple linear	Models based on a temporal sequence of events, one of which prompts the next until an undesired outcome occurs; simplistic; identifies and eliminates broken links.	Only identifies one cause; too simplistic, especially as the complexity of aviation has increased over time.	Heinrich Domino Theory
Complex linear	Models based on unsafe acts, active failures and latent factors; defences/ barriers against undesired outcomes; defences are dynamic in nature; suitable for complex systems; widely used.	Based on a sequential model, so can only consider one initial event; latent factors are not necessarily identifiable within the model.	SCM
Complex non-linear	Models based on tight coupling and complex non-linear interactions among the system components; capable of handling mutually interacting variables; monitor and control performance variability.	Interactions are not predictable unless data from normal flight operations is gathered.	STAMP

have access to all the equipment they need (or may need in the event of a complication) to complete the operation.

Stop and think

Detail the principal differences between the three basic types of accident causation model and assess their relative merits.

12.9 Safety management systems (SMSs)

Historically, aviation safety management was predominately based on the analysis of past events, but now a more proactive approach has been developed to help air transport service providers identify safety risks and implement strategies to minimise them. **Safety management systems (SMSs)** acknowledge the presence of hazards and provide a clear and comprehensive process for identifying, communicating and managing these risks to improve the overall level of safety.

Safety management system (SMS): a clear, systematic and comprehensive approach to managing risks and improving safety.

The requirements for SMSs for air transport are contained within ICAO Annex 19 – *Safety Management*, which defines the organisational structures, processes of accountability, safety policies and procedures that must be established by air service providers, including aircraft manufacturers, aircraft operators, airports, maintenance, repair and overhaul (MRO) companies, air traffic control (ATC) and flight training schools. SMSs are designed to be an essential and intrinsic part of everyday operations that promote an active safety culture at all levels of the business. At a minimum, SMSs must:

- identify safety hazards at all levels of the business and develop a safety policy;
- manage risks by ensuring that action is taken to maintain an acceptable level of safety;
- monitor and continuously assess safety performance through regular audits;
- promote a proactive safety culture and aim for continuous improvements in safety performance;
- be capable of being overseen by the state.

There are four components to an SMS (CAA 2008):

1. *Safety policy.* A policy statement structures a vision and commitment of an organisation (including senior leadership) to continuous safety improvement. Engagement with all members is required to ensure that the policy is understood and this aids the adoption of shared safety responsibility and formation of a safety culture. A safety policy should also outline the key personnel responsible for the implementation and management of the SMS, emergency response planning and the documentation used.
2. *Safety assurance.* This uses auditing and performance surveillance to monitor an organisation's safety performance against its safety policy (ICAO 2013b). Safety assurance also directs efficient incident and accident data collection and, by sharing this information with stakeholders, subsequent actions become known across the organisation, through safety promotion.
3. *Safety risk management.* If risk cannot be eliminated, it must be minimised. An SMS must identify the hazards, assess and report hazards, evaluate potential consequential risks and support the formation of hazard mitigation strategies.
4. *Safety promotion.* This ensures awareness and understanding of the SMS, including its policies, procedures and structures. This can be achieved through communication, training and management commitment towards the organisation's safety culture.

In addition to ICAO requirements, SMSs have also been incorporated into IATA's Operational Safety Audit (IOSA), an international evaluation programme which assesses airlines' operational management and control systems to improve safety.

12.10 Safety culture

A successful safety culture is essential to ensuring the safety of the air transport industry. Weaknesses in a safety culture often take the form of ineffective organisational structures, unclear communication strategies, inadequate equipment or incorrect technical and operational procedures. These are often fundamental accident triggers. A safety culture has five different elements:

1. *An informed culture.* Safety culture is managed through a top-down approach and senior managers are responsible for emphasising safety and sharing information with front-line staff to develop their understanding of risks and hazards. Clear, concise communication of information is required as otherwise an effective SMS cannot operate.
2. *A reporting culture.* The creation of a reporting culture is essential to ensure that incident and accident data is collected and analysed to assess risks and to enable mitigation to prevent future unsafe acts. Usually, reporting systems are non-punitive to eliminate fear of blame, otherwise incidents and accidents may not be recorded. Industrial, regulatory and confidential reporting systems are used to collect occurrence data.
3. *A learning culture.* Any organisation should learn from previous unsafe acts, to ensure safe operations (ICAO 2013b). This is often sustained through monitoring, reviewing and evaluating mitigations through data collection, also known as a continuous improvement cycle.
4. *A just culture.* While honest errors will not be penalised, intentional and risky behaviour will be subject to disciplinary actions to discourage high risk-taking behaviour (ICAO 2013b). To help facilitate the formation of a just reporting culture, all reporting systems share common non-punitive characteristics.
5. *A flexible culture.* Due to the dynamic nature of the aviation industry, a flexible culture is essential to allow for adapting to new circumstances and operational procedures to execute safe operations.

In some instances, aviation safety incidents are not caused by individual, mechanical or institutional failure but by intentional illegal acts of **terrorism** or sabotage. The second part of this chapter examines the aviation security.

Terrorism: the unofficial, unauthorised and illegal use of violence and intimidation in an attempt to achieve a political objective.

Stop and think

What is a safety culture, and how can airlines develop one?

12.11 Aviation security

Aviation security involves a combination of legal and regulatory measures and human and material resources that are collectively designed to protect civil aviation from acts of unlawful interference. The security threats facing aviation are diverse and take many forms, from the smuggling of people and contraband to the theft of baggage and cargo and the hijacking of aircraft (Table 12.6). Crucially, while some actions are specific to (international) civil aviation, others are more generic criminal activities, such as theft and physical or verbal assaults.

In light of the long history of aviation security threats posed by terrorist activity, much of the contemporary international air transport security regime is focused on trying to identify and prevent terrorists gaining access to aircraft and airports and disrupting the normal mobility of passengers and freight. In order to try and prevent attacks, it is necessary to understand why air transport represents an attractive target.

Why aviation is targeted

There are a number of reasons why aviation is a target for terrorism:

- *Aircraft and airports offer a concentration of people in enclosed environments.* One terrorist or one bomb can thus have a very significant effect. Detonating a bomb inside a pressurised aircraft causes sudden and usually catastrophic depressurisation leading to structural failure, in-flight disintegration of the aircraft and the deaths of those on board.
- *Aircraft offer nationally labelled containers of hostages or victims.* If terrorists want to attack citizens of country X, they target aircraft belonging to the national flag carrier of that country or an aircraft operating a route to/from that country in the knowledge that lots of target citizens will likely be on board.

Table 12.6 Examples of aviation security threats

- Smuggling – of people and goods.
- Theft – of or from passengers' luggage and cargo.
- Sabotage – of aircraft and airport infrastructure.
- Terrorism – including hijacking, bombings, shootings and hostage taking.
- Verbal and physical assaults on passengers and personnel.
- Travelling on invalid or forged documentation.
- Trespass and unauthorised access into airside areas.
- Cyber-crime and cyber-terrorism.
- Ground-based threats resulting from civil unrest (such as surface-to-air missiles).
- Airborne threats resulting from unauthorised access to airspace and unauthorised incursions by unmanned aerial vehicles (UAVs).
- 'Insider' threats posed by rogue personnel.
- Disruptive passengers/air rage.

- *Airlines (especially national flag carriers) symbolise a nation.* If terrorists attack aircraft registered in a particular nation, they are effectively attacking that country and seeking to provoke a response from it.
- *Aircraft represent freedom and facilitate mobility*. Both attributes may be desired by individuals or groups fleeing persecution or seeking asylum abroad.
- *Achieves worldwide publicity*. Rolling 24-hour news channels raise public awareness of the incident and the perpetrator(s) and create fear, which leads to a drop in consumer demand and longer-term adverse economic impacts on travel, trade and tourism.

!

Stop and think

Why are aircraft and airports targets of terrorist activity?

12.12 Terrorist attacks against aircraft

Hijack: the act of illegally seizing an aircraft in-flight and forcing it to divert to another destination or illegally taking control of it, usually involving (threat of) violence.

The first recorded incidents of aircraft **hijack** occurred in the early 1930s, but it was not until the 1960s and 1970s that hijacking became an increasing problem. One of the most infamous incidents occurred in September 1970 when four aircraft were simultaneously hijacked in a coordinated attack by members of the Popular Front for the Liberation of Palestine (PFLP). The Dawson's Field hijack (see Case Study 12.3) fundamentally changed the aviation security regime and made it far more rigorous. X-ray machines were introduced to screen hand baggage and identify weapons or metallic objects that could be used to hijack an aircraft.

CASE STUDY 12.3

DAWSON'S FIELD

On 6 September 1970, three passenger aircraft were hijacked by members of the PFLP. Two of the aircraft were forced to land at Dawson's Field, a remote airstrip in the Jordanian desert where passengers and crew were temporarily held hostage. The Pan Am B747, being too large to land in the desert, was forced to land in Cairo, where it was destroyed by a bomb shortly after the 170 passengers and crew had been evacuated. A fourth aircraft made an emergency landing at London Heathrow after an abortive hijacking. On 9 September, a fifth aircraft was also hijacked and diverted to Dawson's Field. Over the course of the next few days, the hostages were gradually released in exchange for Palestinian prisoners who were being held in prisons in Europe. On 12 September, the three (now empty) aircraft at Dawson's Field were blown up in full view of the world's media.

As the security regime concerning cabin baggage tightened, terrorists began to exploit other loopholes. In June 1985, a bomb that had been placed in an unaccompanied suitcase loaded onto Air India Flight 182 exploded when the B747 was at cruising altitude above the eastern Atlantic Ocean, killing 329 people. In response, ICAO established an Aviation Security Panel to formulate rules and guidelines on aviation security. However, they were unable to prevent the attempted bombing of an El Al B747 in April 1986 (Case Study 12.4) or the successful bombing in December 1988 of Pan Am 103 above the Scottish town of Lockerbie, which resulted in the deaths of all 259 people on the flight and 11 people on the ground. As with Air India 182, Pan Am 103 was destroyed by a bomb in an unaccompanied suitcase. As a consequence, passenger-baggage reconciliation was strengthened to prevent unaccompanied suitcases from being loaded on flights.

CASE STUDY 12.4

HINDAWI AFFAIR

In April 1986, Israeli security guards found plastic explosives hidden in a bag that was being carried by a pregnant female passenger who was attempting to travel with El Al from London to Tel Aviv. The bag had been given to her by Nezar Hindawi, a Jordanian national. Hindawi was arrested, tried and sentenced to prison. The Hindawi Affair changed practices of airport security and led to passengers being asked at check-in to confirm whether they have packed their bags themselves and whether anyone could have interfered with them.

While these and many other terrorist incidents highlighted the need for rigorous security screening, the global aviation security regime was based on the premise that terrorists would not be prepared to die for their cause. However, events in 2001 proved this was unfounded. On 11 September, suicide hijackers simultaneously hijacked four commercial aircraft, flying two into the Twin Towers of the World Trade Center in New York, causing their collapse and a third into the Pentagon in Washington, while the fourth crashed into a field in Pennsylvania after passengers reportedly tried to overpower the hijackers. Then, in December, a passenger attempted to detonate plastic explosives he had hidden in his shoes. The 9/11 attacks resulted in over 3,000 deaths and led to the introduction of heightened pre-departure screening of passengers and luggage, the deployment of armed skymarshals on selected 'high-risk' flights and the reinforcement of flightdeck doors to prevent unauthorised entry. The attempted 'shoe bombing' additionally resulted in passengers often having to remove their shoes at security search.

In August 2006, a plot to destroy aircraft leaving London Heathrow for the US using liquid explosives hidden inside bottles of soft drinks was foiled. However, the attempted attack immediately resulted in heightened airport security, a temporary ban on all liquids in hand luggage and significant disruption and financial costs to the industry. Although passengers are now allowed to carry some liquids, aerosols and gels (LAGs) in their hand luggage, restrictions remain.

On Christmas Day 2009, a passenger tried to destroy a Northwest Airlines aircraft that was coming into land in Detroit, US, using an explosive device concealed in his underwear. As a result, new millimetre wave and backscatter X-ray scanners that could penetrate clothing and detect items hidden in or under clothing were introduced at major airports.

While additional resources were being invested in enhancing passenger security, the security regime for air cargo remained vulnerable (➤Chapter 15). In October 2010, two explosive devices were discovered hidden inside US-bound printer cartridges. One device was discovered at East Midlands Airport in the UK, while the other was intercepted in Dubai. It was reported that both devices were timed to explode when the aircraft were in-flight above the US. As a result, the air cargo security regime has been tightened so that all cargo is routinely screened and shippers are monitored to ensure that all cargo can be traced and accounted for.

12.13 Airline security

In the face of the diverse and multiple security threats, airline security begins on the ground (often long in advance of departure) and continues in the air.

Pre-flight passenger security screening

Passenger profiling and Advanced Passenger Information (API) systems oblige passengers to submit personal details, such as full name, nationality, passport number and date of birth, to their airline in advance of travel. Additional details (such as payment method) may also be attached to the personal information. The airline is then required to share this data with the security services and border officials in the country of destination (and, in some cases, with the security services in countries the service is flying over) before departure. The data is then analysed using sophisticated algorithms and checked against databases of known or suspected criminals and terrorists. The security services then authorise or deny travel to the individuals who are booked on each flight.

Pre-departure passenger security screening

Once passengers arrive at an airport, they and their bags are subject to a number of pre-departure security screening protocols. Typically, these occur in two locations – at check-in and at the security search area. Following the Hindawi Affair (Case Study 12.4), passengers are required to confirm that they packed their bags themselves and that no one has interfered with them. They are also asked to confirm that there are no sharp items or liquids over 100ml in their hand luggage. It is an offence to knowingly give incorrect information or make security threats. Passports or other official identification documents are checked to confirm the identity of the individual who is intending to travel and the validity of any visas.

In order to access the departure lounge, passengers must pass through a security search. This has the purpose of verifying the validity of a passenger's boarding pass and ensuring that passengers do not carry any unauthorised items on their person or in their hand luggage into secure airside areas. Security staff are trained to spot suspicious behaviour or dress and metal-detecting archways, explosive trace-detection systems, sniffer dogs, X-ray machines and millimetre wave scanners are used to identify, respectively, metallic objects on the person, chemical compounds indicative of explosives, narcotics, cash or explosives, prohibited items in hand luggage and prohibited items concealed under the clothing of individual travellers. Despite only having a couple of seconds to view and assess the contents of individual bags, security personnel must be able to identify and remove not only obvious items such as guns or knives but also potentially malicious combinations of individually benign objects. Given the importance of this task, simulated threats are frequently imposed on the images to ensure that individual screeners remain alert to potential threats. Other airport terminal security interventions include the use of CCTV and regular patrols by armed police, undercover security personnel and airport security staff.

In-flight security

In recognition that pre-flight and airport security regimes are not infallible, in-flight security continues in the air. Armed skymarshals are carried on some high-risk flights, and cabin crew are trained in restraint techniques. However, concern has been expressed about the safety implications of carrying armed security staff, not least because a mid-air exchange of fire between skymarshals and terrorists contributed to the destruction of an Iraqi Airways flight in December 1986 with the loss of 71 lives.

Other in-flight security interventions include cabin CCTV and reinforced flightdeck doors that can only be opened from the flightdeck. However, any intervention can have unintended consequences for flight safety. In March 2015, a Germanwings pilot deliberately crashed his aircraft into a French mountain after locking the captain out of the flightdeck.

> **Stop and think**
>
> To what extent could it be argued that aviation security has historically been reactive rather than proactive?

12.14 Airport security

Terrorist activity also occurs against airports. Examples of terrorist attacks at airports include:

- In May 1972, 76 people were killed at Lod International Airport in Israel when gunmen opened fire in the terminal.
- In December 1985, terrorists attacked Rome's Leonardo da Vinci Airport and Vienna Airport with assault rifles and grenades, killing 19 and injuring over 100.
- In June 2007, a car bomb was driven into the front of the terminal at Glasgow Airport in Scotland.

- In January 2011, a suicide bomber killed 35 people and injured over 100 more in the international arrivals hall at Moscow's Domodedovo International Airport.
- In March 2016, suicide bombers detonated two explosive devices inside the check-in area in the main terminal at Brussels Zaventem International Airport and a third bomb at the Maelbeek Metro station in the city centre, killing 32 people and injuring 340.

The security threats facing aviation are diverse and sophisticated. As a result, an international security regime that balances the threat of attack with the cost and inconvenience of mitigation strategies has been established. Based on the SARPs contained within the ICAO Security Manual, Annex 17, airport security regimes have to be clear, comprehensive, robust and flexible enough to identify and prevent emerging threats.

The IATA eight-point system forms the basis of airport security around the world:

- Sterile areas must be established for the boarding of all flights. All personnel and hand luggage entering this area must be screened.
- Direct and discreet communication systems must connect passenger screening points and other access areas to an airport control centre that is capable of responding to unlawful action.
- Armed and authorised law enforcers, equipped with mobile communications, must regularly patrol airports and assist in cases of suspected or actual unlawful interference with aircraft.
- Areas of restricted access must be adequately enclosed and marked to prevent unauthorised entry.
- Positive identification must be worn by all staff in airside areas. Access to airside areas is dependent on valid ID being verified at control points.
- Physical barriers must be installed to separate public areas from all cargo, baggage and mail after it has been accepted for carriage. Facilities should exist to enable these items to be x-rayed.
- Aircraft parking areas must be adequately controlled, protected and well lit to prevent unauthorised access to aircraft.
- All public observation areas that overlook airside areas must be adequately protected to safeguard security.

In addition, airlines and airports have developed dedicated security management systems (SEMS) to identify and nullify emerging threats. SEMS are an integral component of aviation business operations and are designed to create a security culture. SEMS define a company's security policy and its security management strategy and standards. SEMS must comply with national regulatory requirements and protect people and assets from acts of unlawful interference. Given the diverse nature of air service operations worldwide, SEMS must be appropriate to individual operating conditions and security environments.

Stop and think

To what extent can aviation be made totally secure, and where does the balance between safeguarding national security and protecting personal privacy lie?

Key points

- Providing a safe and secure air transport system in the face of diverse and newly emerging safety and security threats is vitally important for the continued operation and financial sustainability of the air transport industry.
- This chapter has provided definitions of aviation safety and security, explored the nature of different threats and introduced the role of accident causation models and SMSs and SEMs in managing and mitigating these risks.
- The air transport industry needs to find a balance between providing optimal levels of safety and security and not unduly inconveniencing passengers, imposing additional financial costs on operators or hindering air transport's continued development.
- If consumers perceive that aviation is unsafe, they may switch to other modes of transport and/or reduce the frequency with which they fly.

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CHAPTER 13

Airspace and air traffic management

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LEARNING OUTCOMES

- To introduce airspace and recognise the importance of airspace sovereignty to air transport operations.
- To appreciate the structure and classification of airspace.
- To understand the function of air traffic control (ATC) and air traffic management (ATM).
- To comprehend the role of different technologies in the formation and maintenance of airspace.
- To distinguish the difference between horizontal and vertical flight inefficiencies and discuss how they might be addressed.
- To assess current challenges and future innovations in ATM.

13.0 Introduction

Airspace is the medium through which aircraft fly. The configuration of, and control over, airspace results in: operational restrictions on, and safety implications for, different users; significant financial implications for airline operators and nation states; geopolitical tensions between countries; potentially severe social and environmental impacts for people and ecosystems on the ground; and degradation to the global climate. The purpose of this chapter is to introduce the concept of airspace, explain how it is configured and controlled, and detail how processes of air traffic management (ATM) ensure the safe and efficient utilisation of available airspace in accordance with strict international regulations under a situation of growing consumer demand for flights and increased capacity constraints. The chapter begins by introducing the concept of airspace and explaining how the sky is structured and classified. The role of air traffic control (ATC), ATC technologies and ATM are then discussed. The chapter concludes by assessing current and future challenges in the provision of airspace and air traffic services. Although international protocols govern many aspects of airspace and ATM, each country has its own particular rules and regulations. Examples in this chapter are based on the situation in the UK. Different units of imperial and metric measurement are used to describe distance and/or vertical height above the earth. In each case, the unit used reflects the terminology that is used in the industry.

13.1 Airspace

Airspace: a three-dimensional volume of the earth's atmosphere in which aircraft and aerial objects fly.

Airspace is a defined three-dimensional volume of sky in which commercial, military and general aviation aircraft and other airborne objects, including hot-air balloons, gliders, kites, birds and insects, fly. Far from being 'free' and 'open', airspace is subject to numerous international regulations that govern its use to ensure safety and bring order to the air. Although international airspace administration and governance borrows much from maritime law, it is only within the last 100 years following the development of heavier-than-air powered aircraft that systematic international agreement regarding the use of airspace has been required.

The commencement of regular powered flights at the beginning of the twentieth century caused countries to recognise that the aerial territory above them represented an important strategic, military and commercial asset that needed to be strictly delimited and, if necessary, defended from incursions by unauthorised or otherwise unwanted or unwelcome users.

The formation of early airspace legislation

As long as a pilot took off, flew within a country's navigable airspace and landed within its national borders, there was no problem, but the challenge international services posed to the territorial integrity of individual states produced one of the longest and most contentious debates in aeronautical politics, with each state seeking to seize control of as much airspace as possible while maintaining control of their borders for reasons of defence, national security and commercial advantage.

However, while national claims to land, lakes, rivers and adjoining seas had been made for many centuries, claims to aerial territory (or airspace) were entirely new concepts. Nevertheless, it was agreed that some form of international regulation was required (➤Chapter 1). The first attempt at airspace regulation occurred in 1909 when the French government suggested that a code governing international air navigation should be formulated to prevent unauthorised flights by foreign aircraft over French territory. This was followed, in Paris in 1910, by an attempt to bring international air services under unified control. However, the mutually incompatible positions of different states meant that agreement was not forthcoming. The most pressing issue concerned the right of access to airspace, and while some countries argued for complete freedom of the air above all territories, others maintained that the air was capable of private ownership, just like land. The resulting debate was similar to challenges that had been encountered in the formation of international maritime law, which sought to reconcile the sea as a site of international transport, recreation and resource harvesting with the territorial aspirations and defence of individual nation-states.

In 1911, the British government passed the British Aerial Navigation Act, which declared that Britain's airspace (including that of overseas colonies, dominions and mandates) was sovereign territory and therefore inviolable. Although aircraft only saw limited use during the First World War, it was considered necessary to formulate international agreements concerning access to, and use of, airspace during times of peace.

The right of individual countries to claim sovereignty over their aerial territory (their airspace) was formally enshrined in the Paris Convention 1919. Chapter One of the Convention stated, 'The high contracting parties recognise that every power has complete and exclusive sovereignty over the air space above its territory … and the territorial waters adjacent thereto.' However, in recognition of the need to facilitate the orderly development of international air services, Chapter Two stipulated that, during times of peace, states would grant 'freedom of innocent passage' through their airspace to aircraft registered in another country. However, the establishment of international services was still subject to the consent of the states over which aircraft fly.

The lateral extent of airspace

Although the Paris Convention 1919 acknowledged the right to sovereignty of airspace, it failed to define its lateral or vertical extent, and it was not until 1944 that the Chicago Convention (➤Chapter 1) provided the first definitive delimitation of the physical boundaries of national airspace. This was reaffirmed and strengthened in the 1982 United Nations Convention on the Law of the Sea (UNCLOS), which stipulates that sovereignty of territorial waters extends to the airspace above.

According to international law, a country's sovereign airspace corresponds to the maritime definition of territorial waters and so extends for 12 nautical miles (22km) from a coastline. Airspace that is not within a country's territorial limit is classed as international airspace and is not sovereign territory. An individual country may, however, subject to international agreement, assume responsibility for controlling sections of international airspace where it is considered in the global interest for them to do so.

The vertical extent of airspace

Although the UNCLOS defined the lateral extent of territorial waters and airspace, there is no internationally agreed limit on the vertical extent of sovereign airspace. The international non-governmental organisation Fédération Aéronautique Internationale, uses what is called the Karman line, an invisible boundary 100km above the earth, to define the upper limit of airspace or the division between the earth's atmosphere and space. This limit is politically and strategically important as it concerns boundary security. Beyond the Karman line, the atmosphere is so thin that aerodynamic lift becomes impossible and aeronautical activities (that require an atmosphere to generate aerodynamic lift) give way to astronautics (which relies on rocket propulsion, orbits and gravity). Consequently, a country can only defend and enforce its aerial boundaries up to this height. However, 100km far exceeds the maximum altitude that can be attained by commercial aircraft (which only regularly cruise up to around 39,000ft (11,900m) above the earth) and military aircraft (which can fly much higher). For this reason, most states define the upper limit of airspace as being at an altitude of anywhere between 60,000 and 66,000ft (18,300–20,100m).

In addition to discussing the maximum vertical extent of airspace, consideration was also given to the lower extent of airspace. While most states agree that airspace starts at the surface of the ground and extends up to a defined level, they have found it necessary to strictly regulate air traffic operations that occur close to densely populated urban areas to protect public safety and personal privacy and minimise noise disturbance on the ground. These two issues are becoming increasingly acute owing to the rise of privately operated drones and remote-controlled unmanned aerial vehicles (UAVs).

13.2 The structure and classification of airspace

To fulfil its role as a medium of flight, airspace has to be:

- safe (both for airspace users and for those on the ground);
- capable of being monitored, controlled and defended for reasons of safety, efficiency, national security and defence;
- flexible and able to accommodate the diverse (and often conflicting) operational requirements of different user groups (including commercial air traffic, military aircraft, general aviation pilots and wildlife);
- structured and regulated in such a way as to minimise the adverse environmental impacts of air traffic movements (including noise and pollution) on people and wildlife below.

Like any transport network, there are constant fluctuations in demand (and hence flow of air traffic) depending on the season, the day of the week and the time of day. In order to separate and safely manage this traffic, airspace has been divided into a number of discrete yet interfacing sectors (or zones) which are subject to different degrees of monitoring and surveillance. All sovereign airspace that is used by commercial traffic is divided into a number of flight information regions (FIRs). FIRs extend vertically upwards from the ground to a predetermined upper limit or flight level (see Example 13.1). Airspace above this level is known as 'upper airspace' and called an upper flight information region (UIR). This basic division is used worldwide, although the boundary between FIRs and UIRs varies between states (see Example 13.2).

Within each FIR, airspace is further subdivided and classified as being controlled, uncontrolled or special-use airspace, depending on the volume, density and type of air traffic that uses it. Areas that are subject to high traffic volumes (such as those near major airports) require strict monitoring and control, while more peripheral areas require less surveillance and pilots have more flexibility to operate as they wish, providing they adhere to basic aeronautical regulations. Special-use airspace describes areas in which certain types of air traffic are temporarily or permanently restricted. These include:

- prohibited areas within which all aircraft are banned. Examples include airspace immediately adjacent to nuclear power stations and around certain military installations;
- danger areas that present a significant hazard to aircraft. Examples include airspace immediately above oil rig flare stacks and those around wildlife sanctuaries, where there is a high risk of bird strike;
- restricted areas within which aircraft operations are only permitted under certain conditions. Examples include military air traffic zones and one-off events such as air shows and major sporting events.

Airspace within each FIR is categorised into one of seven classes in accordance with ICAO's seven-tier classification system. The seven classes are identified by the letters A to G inclusive,

Example 13.1

Altimeters, altitude and flight levels

Altimeters are flightdeck instruments that detect changing atmospheric pressure. As an aircraft climbs, atmospheric pressure falls, and this change is measured on a scale by an altimeter, which is calibrated to indicate hundreds and thousands of feet. However, as atmospheric pressure can fluctuate, an international standard atmospheric pressure setting of 1013.25 hPa (hectopascals) is used when aircraft reach a specified transition level (typically between 3,000ft (900m) and 6,000ft (1,850m) above mean sea level (AMSL)), irrespective of the actual local barometric pressure. As all aircraft above the transition level are using the same pressure setting, any variation in the actual barometric pressure is common to all aircraft, and this ensures safe vertical separation is maintained. Above the transition level, the vertical height of an aircraft is expressed as a flight level (FL). Flight levels can be converted into approximate altitudes by adding or subtracting two zeros (e.g. FL350 is equivalent to 35,000ft (10,650m), while 7,500ft (2,300m) is FL75).

Example 13.2

UK airspace structure

UK airspace is divided into two FIRs, London and Scottish. Both extend from the ground surface up to, but not including, FL245, while UIRs are effective from FL245 to FL660. In order to control large volumes of air traffic, FIRs are divided into a number of sectors (defined by latitude, longitude, altitude and time). This creates an invisible aerial patchwork of different control areas, each of which is subject to different degrees of surveillance. Usually the names of these sectors have some basis in terrestrial geography.

where Class A is subject to the most control and Class G the least. These classes determine the type of air traffic that can access the airspace, the conditions under which flights can operate and the level of air traffic service (if any) that is provided. Different weather criteria apply to each class. Classes A–E inclusive are controlled airspace, while Classes F and G are uncontrolled. Special-use airspace has its own designation and is not included in the seven-tier classification system.

Controlled airspace (CAS)

There are five classes of controlled airspace: Class A, B, C, D and E (see Table 13.1).

In addition to belonging to one of these five classes, controlled airspace can further be categorised as being a control zone, a control area, a terminal control area or an airway.

- Control zones are established around certain aerodromes, and ATC is provided to all flights. They extend upwards from the ground surface to a specific upper limit which varies from aerodrome to aerodrome.
- A control area is controlled airspace in which ATC services are provided. They extend upwards from a defined flight level and may or may not have a defined upper limit.

Table 13.1 Controlled airspace classes

Class A: Used where air traffic flows are at their densest and most complicated in terms of the trajectory and vertical movements of air traffic. Aircraft are not permitted to enter Class A airspace unless they are equipped with certain identification and navigational features, have filed a flight plan with air traffic control indicating their intended route and are piloted by individuals holding a valid IFR rating (see Section 13.3). In Class A airspace, pilots are provided with an ATC service and are separated from each other.
Class B: Also subject to a high degree of control, but both IFR and VFR flights are permitted. Aircraft are provided with an ATC service and are separated from each other.
Class C: Both IFR and VFR flights are permitted. All flights are provided with an ATC service, and IFR flights are separated from other IFR flights and VFR traffic. VFR flights are separated from IFR flights and receive traffic information in respect of other VFR flights. There is no speed limit for IFR aircraft, but VFR aircraft are limited to 250kt (NM/hr) below FL100. Two-way radio communication is mandatory. Clearances from ATC must be issued.
Class D: Less busy areas of controlled airspace. Both IFR and VFR flights are permitted, and all flights are provided with an ATC service. In the UK, Class D airspace surrounds many regional airports and may extend from the surface to a specified altitude (often the base of Class A airspace).
Class E: Both IFR and VFR flights are permitted, and IFR flights are provided with an ATC service and separated from other IFR flights. All flights receive traffic information as far as is practical.

- Terminal control areas (also known as 'terminal manoeuvring areas' in Europe) may be established in the vicinity of one or more major airports.
- Airways are controlled areas of airspace between major airports that are used by aircraft in the cruise. They are delineated by radio beacons and radio navigation aids and are the equivalent of aerial highways in the sky.

Uncontrolled airspace

There are two classes of uncontrolled airspace: F and G (see Table 13.2).

Table 13.2 Uncontrolled airspace classes

Class F: Advisory routes. IFR and VFR flights are permitted. All participating IFR flights receive an air traffic advisory service, and all flights receive flight information service if requested.
Class G: Falls under none of the aforementioned categories and is considered 'open', 'free', and uncontrolled. Pilots using Class G airspace still have to adhere to basic aeronautical regulations (the equivalent of a highway code for the air), but they are otherwise free to fly in accordance with their licence restrictions. Both IFR and VFR flights are permitted, and a flight information service is available if requested.

Stop and think

Why is it necessary to structure and classify airspace?

13.3 The rules of the air

All civilian air traffic is flown in accordance with one of two distinct rules of the air, Visual Flight Rules (VFR) or Instrument Flight Rules (IFR). These rules, which can be considered to be a highway code for the air, determine which types of airspace can be accessed, by whom, when and the conditions under which that airspace can be used.

VFR

All qualified pilots can fly under VFR. Under VFR, the pilot in command is solely responsible for:

- the safety of the aircraft and its occupants;
- maintaining adequate separation from other aircraft (using the principle of see-and-avoid), both on the ground and in the air to prevent collision;
- keeping clear of, and avoiding, terrain;

- navigation;
- ensuring adequate visibility and distance from cloud is maintained.

Under VFR, pilots must be able to remain clear of clouds by a distance of at least 5,000ft (1,500m) horizontally and at least 1,000ft (300m) vertically and maintain forward visibility of at least 8km. For certain flights in some areas of airspace and at low altitudes, the requirements are less stringent. An aircraft cannot be flown at night or above 20,000ft (6,100m) without special permission. VFR flights can only be performed if the visual meteorological conditions (VMC) minima, which describe the distance from cloud, cloud ceiling (height) and visibility, are met. When the view from an aircraft is restricted and navigation cannot be performed visually with reference to the ground, instrument meteorological conditions (IMC) must be followed. IMC minima are below those specified for VMC, and pilots can only fly under IMC if they hold a valid instrument rating.

IFR

In adverse weather conditions or Class A airspace, flights must be operated in accordance with IFR. IFR training, qualification and equipment requirements are more stringent than for VFR. Aircraft must be equipped with suitable flight instruments and navigation equipment appropriate to the route being flown, and the pilot must hold a valid instrument rating. Unlike VFR, IFR flights can operate in all classes of airspace.

13.4 Airspace charts

The boundary between different sectors of airspace, as well as information about the location of individual airways, waypoints and airports, is depicted on dedicated airspace charts. These are published in different scales and reflect the specific aerial navigation needs of VFR and IFR traffic. VFR charts are akin to regular terrestrial maps in that they use different colours and symbols to show the location of major roads, railways, rivers, estuaries and urban areas, but they also have the boundaries of different airspace classes and the location of any restricted airspace or danger areas overlaid on top. The scales used for VFR charts are larger than the charts that are produced for IFR traffic that is navigating with reference to radio beacons and waypoints rather than physical features on the ground. In the UK, 1:250,000 and 1:500,000 scales are used.

The scale used for IFR charts depends on the density of information that they have to convey. Unlike VFR charts, IFR charts feature little by way of terrestrial information (other than the location of coastlines, airports and information about minimum safe operating altitudes) as aircraft are navigating by instruments rather than by reference to the ground below. IFR charts are designed to be read easily in different lighting conditions and so the most important information on airways, waypoints and very high frequency omnidirectional range (VOR) beacons is depicted in black. Specific cartographic symbols depict the location of airports, airspace boundaries and areas of restricted or dangerous airspace. Figure 13.1 is an extract of a 1:750,000 high/low altitude IFR chart showing the complexity of airways above part of central Europe.

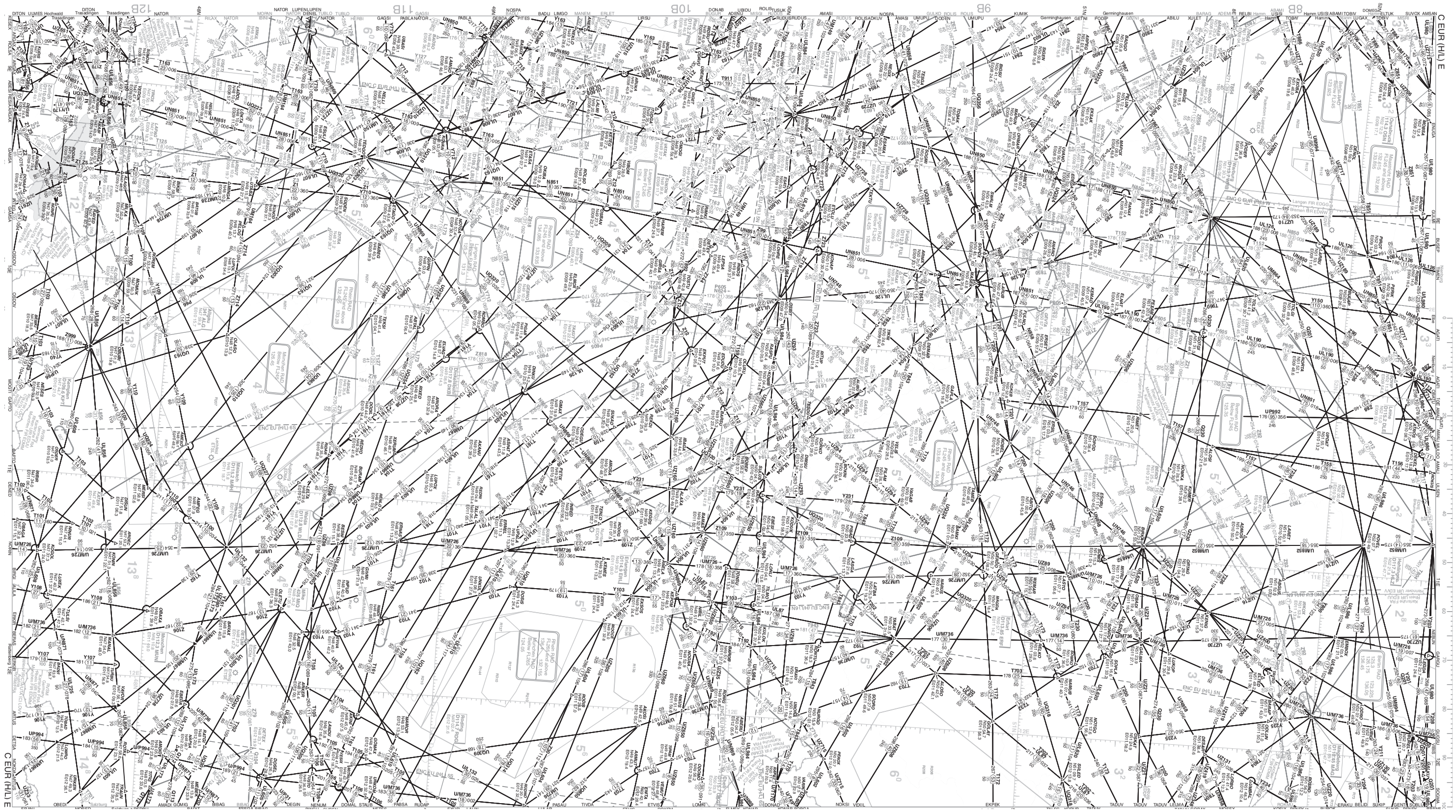

Figure 13.1 Extract of a high/low altitude IFR chart showing the airspace above part of central Europe

Source: Navtech Inc.

Electronic flight bag (EFB): an integrated electronic flightdeck information management system used by pilots to fulfil flight management functions including navigation and flight performance calculations.

A further group of charts depict the arrival and departure procedures that must be followed at each individual airport, as well as the location of taxiways, aircraft manoeuvring areas and individual stands on the airfield. Like VFR and IFR charts, aerodrome charts are regularly updated to reflect changes in airspace, operating practices and new airport infrastructure. Originally, all airspace charts were printed on paper, but they are now increasingly appearing on tablet computers as part of an aircraft's **electronic flight bag (EFB)**. Replacing paper-based flightdeck manuals and charts with EFBs confers considerable cost and weight savings for the airlines. For example, a B777-200ER without an EFB would require almost 35kg of paper to be carried in the flightdeck. An EFB typically weighs under 2kg.

Stop and think

What is the different between VFR and IFR, and to what extent do they influence the airspace pilots can access?

13.5 Air traffic services (ATS)

The global and safety-critical nature of airspace management means international protocols and procedures have been devised and implemented to ensure that available airspace is used safely and efficiently. The international Standards and Recommended Practices (SARPs) concerning the classification and maintenance of airspace, the provision of ATS, ATC and other related services that ensure the safe and efficient flow of air traffic are described in ICAO Annex 11 – *Air Traffic Services*.

ATS provision is designed to:

- ensure the safety of aircraft, their occupants, and people and property on the ground by preventing collisions between aircraft that are in the air and on the ground;
- prevent collisions from occurring between aircraft and objects on an airfield;
- provide information and advice to pilots to aid the safe and efficient conduct of air services;
- maintain a safe and orderly flow of air traffic through the airspace;
- notify and liaise with national emergency services and military agencies in respect of search and rescue activities and unauthorised airspace incursion by foreign aircraft.

The level of service provided depends on: the airspace class; the volume, density and type of traffic it accommodates; and local weather conditions. ATS differs from ATC as the former is a service that provides advice to pilots, whereas ATC is more active and interventionist as it issues clearances and ensures separation for aircraft operating in controlled airspace in addition to providing an advisory service to aircraft in uncontrolled airspace.

Stop and think

Why are ATC services provided, and what might happen if they were not?

13.6 ATC technologies

To safely and efficiently handle aircraft, a range of communication, navigation and surveillance (CNS) equipment has been developed. This section identifies an important example of each.

Radio

Radio is a vital medium of spoken communication through which instructions, requests and observations between pilots and controllers are passed and acknowledged. The introduction of two-way radios marked an important phase in the development of aviation as they enabled pilots to remain in contact with controllers while airborne. To ensure global comprehension and compliance, radiotelephony procedures have been standardised, English has been adopted as the universal language of aviation and the English alphabet is spoken phonetically to ensure that phrases, words and numerals are clearly understood.

Numbers involving altitude, cloud height, visibility or runway visual range, which contain whole hundreds and whole thousands, are spoken individually (i.e. 'two thousand five hundred feet' not 'two and a half thousand feet'), while numbers in aircraft call signs, altimeter settings, flight levels (except FL100), headings, windspeeds and radio frequencies are all spoken separately. Thus, a controller addressing a United Airlines flight would say 'United nine one five, contact London on one one nine decimal seven two five' not 'United nine hundred and fifteen contact London on one hundred and nineteen point seven hundred and twenty five'). Strict protocols determine which words can be used when and the order in which they must be spoken. Pilots, controllers and airfield operations staff have to be trained and examined to ensure that they deliver concise, clear and accurate information.

Radio messages are transmitted on dedicated airband frequencies, which are typically in the range 110–140MHz to avoid interference from public radio stations. Each sector of airspace is administered using a different frequency and, at major airports, different frequencies are used for arriving, departing and taxiing aircraft. All users are able to hear all the transmissions that are occurring on their frequency, enabling them to determine the relative position of other aircraft.

To ensure unambiguous communication, all commercial flights are allocated a call sign and a flight number. The call sign refers to the aircraft operator (e.g. the call sign of easyJet flights is 'easy', while international British Airways flights are prefixed by 'Speedbird') and the individual flight. This corporate identifier is then followed by a numeric or alphanumeric designator. After establishing the identity of the flight being addressed, the controller then articulates his/her commands, including altitude and heading changes, speed restrictions, route clearances, taxiing or stand information, take-off or landing clearances and other information of relevance to the safe conduct of that flight. Air traffic controllers try to limit the number of instructions in any transmission to three. Pilots read back the message to ensure that it has been received and understood correctly. Radio is thus used to authorise clearances, decline requests and discipline pilots, while flightcrew use it both to communicate with controllers to request new headings and/or altitudes and to (re)confirm instructions and to communicate with pilots of other aircraft in the vicinity.

Radio beacons

Despite the introduction of increasingly sophisticated satellite navigation systems, the network of ground-based radio beacons developed shortly after the Second World War is still used for navigation. The most common radio transmitters are VOR beacons. These transmit a very high frequency (VHF) signal on a specific radio frequency (which is indicated on navigation charts and programmed into aircraft's internal navigation systems), along each 1° radial of a 360° circle. Receivers on the flightdeck capture these signals and determine the aircraft's bearing from the beacon, allowing it to 'home in' on them from any direction and turn corners at the intersection of two or more beams, marking the aeronautical equivalent of junctions in the sky. VOR beacons are identified by a name and three-letter abbreviation, which, like the airspace sectors above them, often have a basis in real-world local geography.

Given the large distances involved, airways (which are identified by a set of letters and numbers) have a number of reporting points and/or waypoints located along them to help pilots and controllers monitor a flight's progress. The locations of these waypoints are defined by geographical coordinates as their positions are not demarcated by ground-based installations. Waypoints are identified by five-letter names, which, unlike a VOR, are not necessarily related to cultural features on the ground. In the UK, some en-route waypoints have a basis in 'real-world' geography, including 'LESTA', near the city of Leicester, and 'FORTY' above the North Sea shipping area called 'Forties'. However, as traffic volumes have grown, and additional routes have been introduced, new names have emerged which bear no relationship to ground-based features below. The waypoints en route to the scientific bases in Antarctica, for example, are named after the dogs and ponies that hauled the original sleds on the earliest Antarctic explorations.

Radar

Radar (radio detection and ranging) was developed in the 1930s to identify the presence and location of airborne aircraft using radio waves. Two complementary radar systems – primary surveillance radar (PSR) and secondary surveillance radar (SSR) – are currently used. PSR sends electromagnetic radiation in the form of ultra-high frequency (UHF) radio waves from a rotating parabolic dish into the atmosphere at almost the speed of light (around 300,000km per second). If the radio waves encounter an obstruction (an aircraft, high ground, storm clouds) some of the original energy is reflected back to the dish in the form of an echo. Measuring the time that elapsed between the pulse being sent and the echo being returned determines the object's distance from the radar installation. The direction of the returned echo is also captured. This information is displayed as a blip on the radar screen. Each rotation of the radar dish updates the blips so controllers can determine whether an object is moving and, if it is moving, its relative direction of travel. PSR has a number of advantages but also limitations (see Table 13.3).

SSR helps to address some of the limitations of PSR. Unlike PSR, which relies on the strength of a reflected signal, SSR uses small radio transmitters in the aircraft. These transponders (transmitting responders) automatically respond to interrogation from ground-based radar pulses and send a unique coded identification 'squawk' signal back to the ground that uniquely identifies the aircraft. Squawks are transmitted on a different frequency from the ground station pulses so SSR signals are stronger and more reliable. The word 'squawk' is believed to come from the forerunner of the SSR system that was developed during the Second World War and which 'squawked' like a parrot when interrogated.

Modern squawk codes consist of four digits (such as 6425) which are produced and assigned to a particular flight before take-off. Some codes, including 7500 and 7600, are reserved for emergencies (and indicate radio failure and hijacking respectively) or for use by the military.

Ground-based decoders translate the transponder squawk back into flight data, providing controllers with information about the operator, altitude, call sign, origin/destination, aircraft type, air and ground speed, vertical speed (if it exceeds 500ft (150m) per minute) and the nature of any emergency. This additional information is then displayed alongside the relevant PSR blip. The principal advantages of SSR are:

- it enables controllers to positively identify individual aircraft on the radar screen;
- it is not subject to radar clutter or signal degradation in bad weather;
- it can be used to identify aircraft in distress;
- all aircraft appear as the same size on the radar screen.

Modern developments include multilateration radar, which uses signals from multiple ground-based radar stations to pinpoint the location of aircraft more accurately.

Table 13.3 Advantages and disadvantages of PSR

Advantages	*Disadvantages*
• Determines position of all objects within range of receiver • Determines range of all objects within range of receiver • Determines the relative speed and direction of travel of all objects within range of the receiver • Aircraft do not require any special equipment to be detected	• Only works on 'line of sight' and can suffer from blind spots • Returned image can suffer from clutter from wind turbines, high ground or precipitation • Different aircraft can provide unevenly sized returns • Range is limited by curvature of the earth and high ground interrupting transmitted pulse • No way of determining what has created the radar echo

Stop and think

Detail the technologies air traffic controllers use to manage flows of aircraft. How could the system be improved in future?

13.7 Air traffic management (ATM)

While ATS describes the current and short-term tactical provision of airspace, a third acronym, ATM, concerns the current and future dynamic management of airspace and the safe and efficient flows of aircraft within it. ATM consists of different functional elements including:

- air traffic services (including ATC);
- airspace management (ASM) – to maximise the utilisation of available airspace through sharing and segregation;
- air traffic flow management (ATFM) – to ensure the optimum flow of aircraft through an airspace when demand exceeds capacity;
- aeronautical information service (AIS) – to provide information and advice to pilots.

ATM affects not only air traffic but also public safety and is a public service for which the state is responsible. Some countries have retained public control and ownership of their ATM services, while others have wholly or partially transferred the provision of ATM services to private institutions. Providing ATM infrastructure and personnel is expensive and, in most countries, the cost of ATM provision is met by the users (aircraft operators) in the form of charges.

Stop and think

Explain the difference between ATC, ATS and ATM.

Airspace charging

The majority of countries charge commercial aircraft operators for the ATM services they receive while flying in their territory. In Europe, the cost of providing the infrastructure, staff, training, maintenance and other ATM services is funded through air navigation charges which are levied on aircraft operators who use European airspace. These are in addition to the landing fees levied by airports. Three different ATM charges are levied. These are en-route charges, terminal navigation fees and communication charges. The latter two are collected and administered locally, whereas the route charges are administered centrally by Eurocontrol on behalf of European member states. These route charges are non-discriminatory (the same charging rules and calculations are applied to all users), equitable (the user pays) and straightforward as a single currency unit is used to pay the charges directly to a single entity – Eurocontrol's Central Route Charges Office (CRCO). However, as the cost of delivering ATM services in individual countries differs, each country sets its own unit rate that enables them to recover their costs. The standard airspace charging formula that is applied and administered within Europe is based on the unit rate, the distance flown and the maximum take-off weight of the aircraft.

Although all flights are technically liable for route charges, aircraft weighing less than two metric tonnes, flights operated on behalf of national governments, reigning monarchs or heads of state, and aerial search and rescue activities are exempt. Although the charging mechanism facilitates streamlined billing and payment collection, aircraft may fly further than the great circle route in a region, and so the charging formula does not penalise environmentally inefficient tracks. Indeed, research has indicated that differences in airspace charges between nation states affect airline behaviour (see Case Study 13.1).

CASE STUDY 13.1

THE TANGO ROUTE FROM THE UK TO THE CANARY ISLANDS

In December 2007, it was reported that some UK charter airlines were flying longer routes between the UK and the Canary Islands to avoid higher route charges. It was claimed that the 160km diversion, known as the TANGO route, could produce an extra three tonnes of CO_2 per flight, but the costs of the additional fuel burn were offset by the lower airspace charges. The airlines claimed that the TANGO route enabled them to avoid congested airspace and to maintain their schedules. Subsequent research showed that a small number of other intra-European routes offered airlines a cost incentive to fly further, although this effect diminished as fuel prices rose and ATM charging differentials went down.

Flight inefficiency

One of the ways in which inefficiencies in ATM can be assessed is by using a flight inefficiency metric. These commonly used ATM performance indicators to quantify the difference between the theoretical minimum distance that could be flown and the actual distance that is flown between two points on the earth's surface to determine the average route extension over the great circle distance and hence the inefficiency of the system. The flight inefficiency metric is:

$$\text{Horizontal flight inefficiency} = \frac{\text{Actual distance — optimal distance}}{\text{Optimal distance}} \times 100$$

Using this calculation, flying 200 miles (300km) further than the great circle distance on an 800-mile (1,200km) route would equal 25 per cent inefficiency. However, this metric is only sensitive to track extension over the ground, not inefficiencies in the vertical dimension such as cruising at a sub-optimal flight level. The NATS 3Di metric addresses this limitation by determining both the horizontal and vertical inefficiency of a flight relative to its optimal trajectory in both the horizontal and vertical plane (see Case Study 13.2).

Possible sources of flight inefficiency vary by flight stage but all have the potential to increase fuel burn, increase airline costs, lengthen flight times and create more pollution.

- *Departure phase.* Sources of inefficiency include: long taxi routes; noise preferential routes (NPRs) that are effective from the runway end to 3,000–4,000ft (900–1,200m) in the UK and which oblige aircraft to fly sub-optimal routes to avoid densely populated areas and lower the acoustic impact of aircraft operations on the ground; and sub-optimal climb trajectories that require aircraft to 'step up' to their cruising altitude through intermediate flight levels.

CASE STUDY 13.2

THE NATS 3DI INEFFICIENCY METRIC

NATS, the UK's Air Navigation Service Provider, developed a sophisticated three-dimension inefficiency score (known as 3Di) to measure the environmental performance of flights in UK airspace. Unlike other inefficiency metrics, 3Di measures both horizontal and vertical inefficiencies. The horizontal inefficiency is calculated in terms of track extension above the great circle distance, while the vertical inefficiency compares the actual vertical profile of a flight against the airlines' preferred trajectory. As aircraft performance varies during a flight, the 3Di metric applies different weightings to climb, cruise and descent. These factors are then used to give a combined 3Di score for each flight in UK airspace. Scores range from 0 (no inefficiency) to over 100. NATS's target is to reduce 3Di from 29.7 to 27.7 by the end of 2019 (NATS 2015).

- *En route.* Sources of inefficiency include: aircraft being assigned to sub-optimal cruise altitudes; convective weather (such as thunderstorms) that have to be avoided; routing round restricted airspace; and avoiding expensive airspace.
- *Descent/landing.* Sources of inefficiency include: stepped descents from cruising altitude; holding and vectoring in a stack before landing; standard terminal arrival routes (STARs); and long taxi times to the terminal.

Owing to national ownership and control, the world's airspace comprises a number of discrete but interfacing zones of sovereign control. This fragmentation means that airspace is not optimised for efficiency or environmental performance. The situation is particularly acute in Europe owing to the close proximity of multiple relatively small sovereign states.

In February 2004, Eurocontrol received formal backing from European governments to develop a Single European Sky (SES) to increase capacity and harmonise the continent's fragmented airspace structure. In anticipation of the SES initiative, reduced vertical separation minima (RVSM) were introduced in European airspace in 2001. By halving the vertical separation distance between aircraft from 2,000ft (600m) to 1,000ft (300m), six new flight levels were created and airspace capacity increased by 15 per cent. Advances in altimeters meant there was no significant increased risk of collision.

13.8 The future

There is a need to accommodate existing best practice techniques, including CCOs (continuous climb operations, in which an aircraft is cleared to an initial cruising altitude without needing to 'step up' through intermediate flight levels), CDOs (continuous descent operations, the opposite of CCOs, in which aircraft descend at a continuous rate from the cruising altitude to the runway at the destination airport) and user defined trajectories (in which the aircraft's operator defines the optimum track based on current weather conditions and the weight of the aircraft). However, achieving these techniques within the confines of the present airspace structure using existing technology can be problematic. While technological developments will drive new safety and efficiency improvements in ATM in the future, some obstacles remain.

13.9 Barriers to change

Barriers to change fall into six main areas:

1. *Technology.* New technology is expensive to develop and install. It requires extensive testing and training and adoption can take a long time.
2. *Political.* Airspace is still divided up along national lines and arguably few governments would consent to handing over control of their airspace to a foreign nation even if it did improve efficiency.
3. *Commercial.* The needs of commercial users do not necessarily align with those of other airspace users like the military and general aviation. Reconciling the diverse operational requirements without unduly hindering the activities of one user group is challenging and controversial.
4. *Social.* Communities living near an airport or airway may oppose airspace expansion, flight path changes and aircraft noise, making airspace use a socially contentious and political issue.
5. *Safety parameters and protocols.* These are designed to ensure the safety of the ATM system. Although capacity could be increased by introducing new airways or flight levels, the safety case for doing so needs to be robust and will dictate future ATM developments.
6. *Existing airport and runway alignment/capacity.* Runways are generally aligned into the direction of the prevailing wind which, in the case of the UK, means runways are aligned east–west. If the majority of the traffic flows are north–south, then aircraft need to turn in the direction of travel on departure and turn to line up with the runway on arrival. Given the operational necessity of landing into the wind whenever possible and the sunk costs of runway infrastructure, this represents an inefficiency which cannot be resolved.

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Stop and think

Detail the main sources of flight inefficiency, and identify which inefficiencies may not be capable of being resolved.

Key points

- Airspace is a medium of flight that has been designed to ensure the safety and efficiency of all types of airborne aircraft and people on the ground.
- National airspace is sovereign territory that is subject to multiple regulations and jurisdictions governing its operation and use.
- Airspace is classified as being either controlled or uncontrolled, and different operating restrictions apply to each.
- Technologies, in particular radio waves that are used for spoken communications, navigation and radar, are vital for the construction and safe use of airspace.
- Global airspace is often highly fragmented and there are many sources of horizontal and vertical flight inefficiency, some of which are incapable of being resolved.

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CHAPTER 14

Aircraft manufacturing and technology

David Pritchard

LEARNING OUTCOMES

- To identify the scale, scope and location of aircraft manufacturing and technological development.
- To recognise that global outsourcing drives technology transfer and production.
- To appreciate the role of changing materials and manufacturing processes in new aircraft programmes.
- To understand the evolution of commercial aircraft manufacturers from components and sub-assembly producers to system integrators.
- To appreciate the importance of government intervention in developing domestic aircraft manufacturing capabilities in emerging markets.

14.0 Introduction

The commercial aircraft industry is a symbol of a country's export leadership in product-markets that require high levels of design and engineering innovation. Aircraft manufacturing has been a leading export sector in many countries for more than six decades, and many of the advanced technologies that have been developed have been successfully adopted by other industries, including automotive engineering and electronics manufacturing. The aircraft industry has long been an important sector of the US and European economies in terms of skilled production employment, value-added and exports. In recent years, however,

Industrial offset: an agreement allowing the transfer of technology to a foreign company to enable it to manufacture part of an aircraft. This normally takes the form of subcontracting, co-production or licensed production.

Original equipment manufacturer (OEM): a company that makes/assembles a final product.

Tacit knowledge: information gained through experience and which cannot be formally taught.

industrial offsets have become commonplace and the aircraft currently being manufactured by **original equipment manufacturers (OEMs)** are being constructed from components produced all over the world. Leading global OEMs, including Boeing and Airbus, have opted for a 'systems integration' mode of production in which key components and sub-assemblies are designed and manufactured by external risk-sharing partners and suppliers. While this represents a logical financial strategy, a potential drawback is that foreign subcontractors and/or risk-sharing partners must receive transfer of technology or **tacit knowledge** from the systems integrator to make the business model work, and overseeing complex supply chains, often at a distance, can be challenging.

This chapter examines the industrial and international trade potential within the commercial aircraft manufacturing industry and its effects on global manufacturing. It begins by examining the reasons for the historical location of OEMs and the role of industrial offset agreements in the global decentralisation of commercial aircraft production. Particular attention is given to the manufacturing processes involved in the design and assembly of large commercial jet aircraft seating 100 or more passengers (see Table 14.1).

The current geography of aircraft production at the global level is being shaped by a new international distribution of input costs and technological capability. Specifically, low-cost producers within several of the emerging markets have acquired manufacturing expertise as a direct result of industrial offset contracts and/or other forms of technology transfer, such as international joint ventures and imports of advanced manufacturing technologies. The growth of international offset agreements sees the transformation of the four largest OEMs – Boeing, Airbus, Bombardier and Embraer – from aircraft manufacturers to systems

Table 14.1 Development of new commercial aircraft programmes (over 100 seats)

Country/ region	*Commercial aircraft OEM*	*Entry into service*	*Model*	*Seat capacity*
US	Boeing Commercial Airplanes	2011	787	280–360
		2017	737Max	130–190
		2020	777X	350–400
Europe	Airbus Group	2014	A350XWB	300–350
		2015	A320neo	140–200
		2017	A330neo	250–310
		TBD*	A380neo	400–650
Canada	Bombardier Aerospace	2016	C Series	110–135
Brazil	Embraer	2018	E Jet E2 Series	90–140
China	Commercial Aircraft Corporation of China (COMAC)	2015	ARJ21 Regional Jet	100–120
		2018	C919	170–200
Russia	United Aircraft Corporation	2011	Sukhoi Superjet	80–110
		2018	Irkut MC21	150–230

Note: *At the time of writing, no formal announcement of the A380neo launch had been made integrators. The chapter concludes by discussing future trends in aircraft manufacturing technologies in emerging markets.

14.1 Industrial location of aircraft OEMs

Aircraft manufacture demands significant sources of capital for research and development and access to highly skilled labour, manufacturing materials, components and markets. There are three main factors which affect the industrial location of commercial aircraft OEMs:

- *Demand.* Historically, major aircraft OEMs were located in countries that had a strong domestic demand for air transport and/or countries that had advanced military aircraft manufacturing capability. The last few decades have seen a progressive consolidation of the global aircraft manufacturing sector as large OEMs have taken over (or merged with) their former competitors to gain increased market share and access to more markets. In 1967, the US-based McDonnell Douglas Corporation was formed as the result of a merger between McDonnell Aircraft Corporation (a leading manufacturer of military aircraft) and the Douglas Aircraft Company (a commercial aircraft manufacturer). McDonnell Douglas was, in turn, taken over by Boeing in 1997. Similar consolidation has occurred in Europe.
- *Funding.* Government policies and funding to support the development of their domestic aerospace industries provides incentives for OEMs and their suppliers to locate production in that country. Faced with an increasingly competitive market, commercial aircraft OEMs have responded through downscaling, joint ventures, mergers and various types of international **subcontracting** arrangements.
- *Lowering costs.* OEMs seek to lower final assembly costs and costs in their global **tier 1 and 2 supply chain**. The OEMs transfer technology through outsourcing, and this has had a major impact on developing the build and design capabilities of the global aerospace industry. This has resulted in an evolution from a simple 'build to print' subcontractor relationship to a full 'design and build' risk-sharing partnership. These contracts have allowed global partners of the OEMs to develop new capabilities for production capacity, tooling, design and final assembly. This is leading to a restructuring of the commercial aircraft industry and a change in industrial location, regional markets and, ultimately, jobs.

Subcontracting: a business practice in which one company hires the services of another to perform part of its activities.

Tier 1 supplier: a company that directly supplies OEMs.

Tier 2 supplier: a company that supplies tier 1 companies.

Stop and think

Identify the factors that affect the industrial location of aircraft OEMs worldwide.

14.2 Industrial offsets

One of the ways in which commercial aircraft OEMs have sought to lower their costs is through 'offshoring' some of their production to an overseas country that has lower labour costs and/or a more favourable tax regime. Industrial offsets refer to a form of compensatory trade agreement whereby the exporter (in this case the aircraft OEM) grants concessions to the importer (a supplier in an overseas country). These concessions typically take the form of production-sharing agreements. The first major industrial offsets in aircraft manufacturing occurred in the 1960s when the US-based Douglas Aircraft Company subcontracted the fuselage assemblies for its DC-9 and DC-10 jetliners to Alenia in Italy. As a result of these transactions, Douglas secured substantial sales of aircraft to Alitalia, the flag carrier of Italy. One of Boeing's early offsets was with Japan in 1974, when Mitsubishi was given contracts to produce inboard flaps for the Boeing 747. Major sales of 747s to Japan followed.

Today, the foreign content of the Boeing 787 is around 30 per cent. This compares with 2 per cent on the B727 in the 1960s. Although the proportion of foreign content in Boeing products is likely to increase (as order backlogs for older Boeing models that have a higher domestic content are low and more production of later models has been outsourced to foreign suppliers/partners (see Table 14.2)), this has more to do with cost savings than it does with securing sales to foreign airlines.

Figure 14.1 shows the evolution of structure suppliers for the B737 Classic, the B747 series and the B787. Between 1967 and 2009, the proportion of aircraft structures manufactured directly by Boeing workers in the US has declined to the point where all the major structures on the B787 (bar the tail fin and wing-to-body fairing) are manufactured by external suppliers in countries including South Korea, Japan, France, Italy, Australia and the UK.

Table 14.2 Foreign content of selected Boeing airframes

Airframe	*737 (1964)*	*747 (1966)*	*777 (1990)*	*787 (2004)*
Wing assembly	US	US	US	Japan
Centre wing box	US	US	Japan	Japan
Front fuselage	US	US	Japan	Japan/US
Aft fuselage	US	US	Japan	Italy
Empennage (tail)	China	US	US	Italy/US
Nose assembly	US	US	US	US
Final assembly	US	US	US	US

Note: ( ) designates the launch year of the programme

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Stop and think

Why is the foreign content of aircraft increasing, and is this trend likely to continue?

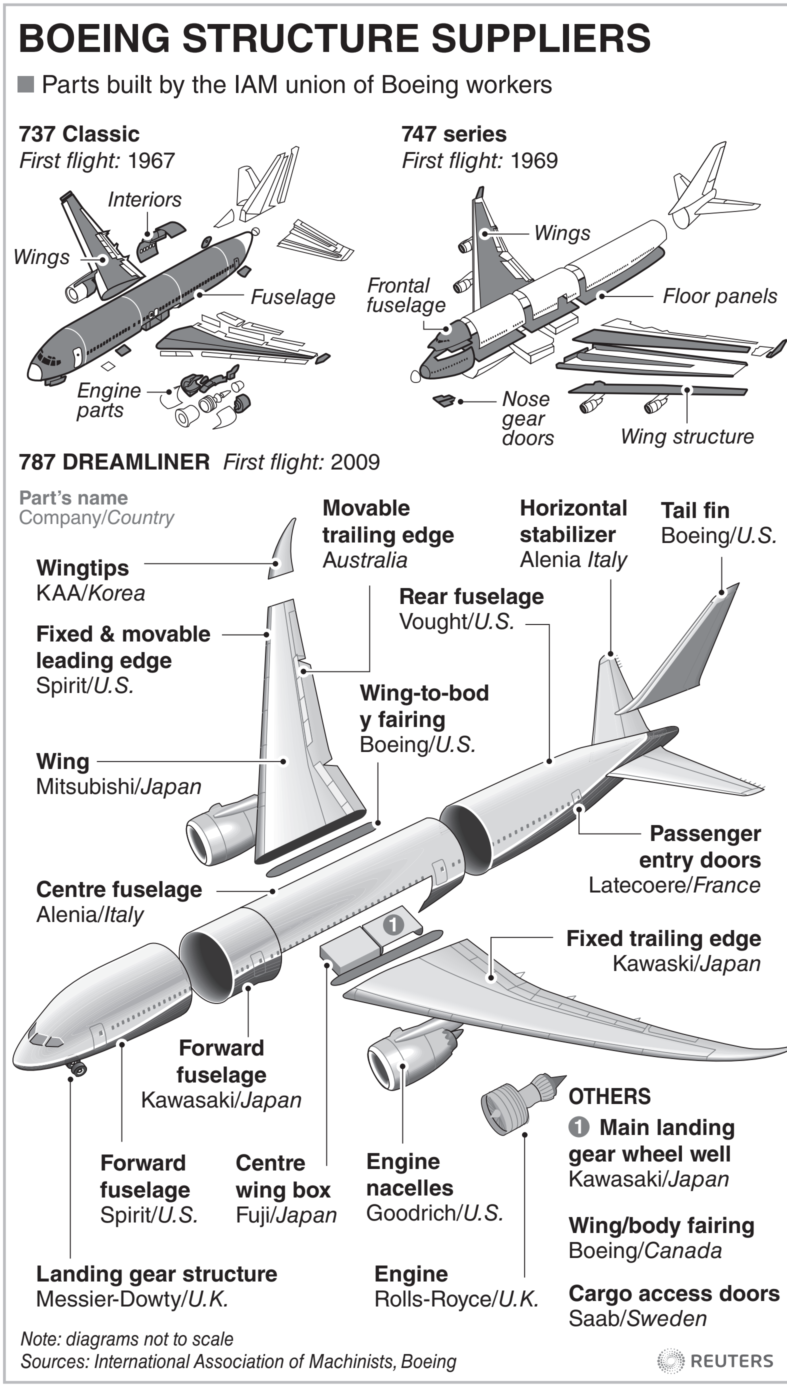

Figure 14.1 Evolution of structure suppliers for selected Boeing airframes, 1967–2009

Source: Reuters News Graphics Service

14.3 New technology

One characteristic of aircraft manufacture has been constant innovation. This innovation is driven by the need to lower costs at all stages of the supply chain and construct aircraft that are more fuel efficient and have lower operating costs. One way to reduce operating costs is to reduce the weight of the airframe by replacing heavy metal alloys with new lighter weight composite materials. The adoption of new composites and manufacturing technologies (see Case Study 14.1) has changed manufacturing processes, lowered lead times and reduced the costs of manufacturing commercial aircraft.

CASE STUDY 14.1

BOEING'S ADOPTION OF ROBOT ASSEMBLY TECHNOLOGY

When the Boeing 777X goes into full production in 2020, the final assembly of forward and aft sections will be performed by a robotic pulse production line, known as the fuselage automated upright build (FAUB). This will replace manual production work that was previously performed on the B777 by Boeing workers. The robots will install up to 60,000 fasteners per aircraft more quickly, more cheaply and more accurately than the manual workers they replace. The increased use of automated assembly lines has implications for employment as fewer people are required and the nature of their work will change. Increased use of automation also produces a more efficient and clean manufacturing environment as the volume of waste is minimised. This reduces costs for both the OEM and the customer.

Individual aircraft sub-assemblies and specific components are joined together and tested on final assembly lines (FALs). Owing to the size, weight, value and complexity of commercial aircraft, specialist handling and transport facilities are required and the FALs are equipped with overhead cranes and jigs to move assemblies around the factory and enable different parts of the aircraft to be joined in sequence (see Figure 14.2).

Composite materials are lighter and stronger than conventional aircraft-grade aluminium alloys and they confer significant efficiency improvements for aircraft operators. They also offer other design advantages such as higher cabin pressure, large windows and higher humidity. Disadvantages include the difficulty of reclaiming and recycling composite material at the end of an aircraft's useful life and the release of toxic particles and fibres in the event of a fire.

The use of composite materials on commercial aircraft dates back to the use of fibreglass on the Boeing 707 in the 1950s. In the 1980s, the Airbus A310-300 contained 5 per cent composite material, and by the 1990s 12 per cent of the Boeing 777 was constructed from composite material. These proportions have continued to increase and today over 50 per cent of the Boeing 787 and Airbus A350XWB are made from composite material (see Table 14.3).

Since 2005, the commercial aircraft industry has begun to adopt aluminium-lithium alloys in their new aircraft programmes as the cost and availability of this material has improved. However, there is a limit on the application of aluminium-lithium material, and metal is still required on the leading edges of the wing and the engine pylons for resilience to bird strikes and fire protection. Although composites are now widely used on wide-body aircraft, composites do not yet downscale for single-aisle fuselage applications.

Figure 14.2 The A330 final assembly line at Toulouse, France, showing three aircraft at different stages of final assembly

Source: © Airbus SAS 2015 – photo by master films/H. Goussé

Table 14.3 New commercial aircraft programmes airframe technology (over 100 seats)

	Airbus A350XWB	*Boeing 787*	*Boeing 777X*	*Bombardier C Series*	*COMAC C919*	*Irkut MC 21*
Nose	Composite	Composite	Aluminium	Alum-Lith*	Alum-Lith	Aluminium
Fuselage	Composite	Composite	Aluminium	Alum-Lith	Alum-Lith	Alum-Lith
Wing	Composite	Composite	Composite	Composite	Aluminium	Composite
Empennage	Composite	Composite	Composite	Alum-Lith	Composite	Composite

Note: *Alum-Lith designates Aluminium Lithium material

Stop and think

What are the advantages and disadvantages of constructing aircraft from composite materials?

14.4 Global shifts in commercial aircraft manufacturing

In terms of the global market share for large passenger aircraft, the US has moved from an almost complete monopoly in the 1960s to a much weaker position by 2015. Part of this shift can be explained by the emergence of the pan-European OEM Airbus which moved from zero market share in 1970 to 50 per cent by 2014. Another part of this global shift is the entry of Bombardier (Canada), Embraer (Brazil) and COMAC (China) into the single-aisle passenger aircraft market. While once it seemed inconceivable for the US to lose market share to a European competitor, the next major shift will be from West to East, with increased commercial aircraft deliveries going to the Asia-Pacific region and countries in Latin America and Asia developing their own aircraft manufacturing capabilities.

United States

The commercial aircraft industry is a crucial part of the US industrial base in terms of skilled production jobs, applied research, foreign exports and inter-industry multiplier effects. With the rise of Airbus, Boeing, the US's sole remaining producer of large passenger jets, has opted for a 'systems integration' mode of production to reduce unit costs, simplify the final assembly procedures and speed up product development. Under systems integration, risk and costs are spread across a network of domestic and foreign partners. While the final product is assembled within the US, major parts of the airframe are subcontracted to foreign suppliers.

In the past, international outsourcing was guided by industrial offset agreements that provided guaranteed sales for new aircraft. Today, however, the costs associated with launching a new aircraft in the large commercial aircraft category (over 100 seats) are so high that systems integration based on cost-minimisation makes good financial sense – at least over the short-run. As an example, 70 per cent of Boeing 787 components are outsourced to manufacturers worldwide, and Boeing developed a three-tier supply chain involving over 50 Tier 1 suppliers (see Tang and Zimmerman 2009). However, while systems integration has the potential to lower costs and lead time (Boeing estimates that the 787's development time was reduced from six to four years and from US$10 billion to US$6 billion by adopting this approach), it also has its disadvantages. Outsourcing production potentially leads to outsourcing profit. Core technology must be transferred to outside suppliers in order to make the final assembly task feasible. In addition, managing complex tiers of multiple suppliers worldwide needs significant management coordination and oversight. It can also lead to delays and lack of coordination between suppliers.

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Stop and think

Assess the relative merits of outsourcing as a manufacturing strategy.

Canada

Bombardier Aerospace, part of Bombardier based in Montreal, designs and manufactures commercial, business, specialised and amphibious aircraft. Bombardier manufactures the C series of commercial jet aircraft (seating 100–149 seats), the CRJ regional jet series (seating 60–99) and the Q series of turboprops (seating up to 86). Like Boeing, Bombardier works with a range of overseas suppliers (currently around 3,000 suppliers) based in 17 countries worldwide, including Brazil, China, India, Japan and the UK. At the time of writing, the new C Series aircraft has a backlog of over 240, with a planned monthly production rate of up to 12 aircraft. The aircraft features advanced new structural materials that confer significant weight savings. The C Series' final assembly line and nose assembly is located in Montreal, with major sections of the aircraft being shipped from around the globe.

Although Canada has historically enjoyed a strong comparative advantage in regional jet aircraft production, this advantage is weakening in light of growing international competition from lower cost competitors in Brazil, Russia and China.

Europe

Historically, almost every major European economy had its own domestic commercial aircraft manufacturing industry. Over time, consolidation has occurred and independent OEMs have been taken over, merged or ceased commercial aircraft production. Consequently, once-familiar names in European aircraft manufacturing, including British Aerospace and de Havilland (UK), Fokker (Netherlands), Saab (Sweden), Junkers (Germany) and Aérospatiale (France), are no more.

The main OEM of large commercial passenger aircraft is Airbus. Airbus has a product line of aircraft ranging from 100 to 500 seats. Its single-aisle aircraft is the A320 series, which includes the A319, A320/A320neo (new engine option) and A321/A321neo models. The company's wide-body aircraft include the A330/A330neo, A340 family, A350XWB and A380 superjumbo. By July 2015, Airbus had delivered over 9,000 aircraft and attracted 15,500 orders (Airbus 2015). Production is based at dedicated production sites in the UK, France, Germany and Spain (see Table 14.4). Components are shipped between the sites by air on dedicated A300-600 Super Transporters, road and water (on roll on-roll off ferries and river barges).

The Airbus production sites utilise advance machine tools for metallic structures, advance composite tape layering equipment (that use computer-guided robotics to lay one or several layers of carbon fibre tape), robotic assembly and laser alignment tooling in final assembly. The goal for Airbus across all their commercial aircraft models is to reduce production lead times by using lean manufacturing methods to eliminate non-value-added activities and 're-designing to cost' to improve delivery and quality.

A second important European OEM is Avions de Transport Régional (ATR). Based in Toulouse, ATR is a joint partnership between the Airbus Group and Italian company Alenia Aermacchi and is a world leading manufacturer of regional aircraft, having sold over 1,500 airframes by 2015. ATR manufacture regional turboprop aircraft so are not in competition with Airbus as their aircraft families serve different markets and customers.

Table 14.4 Airbus's production sites, 2015

Country	*Site*	*Responsibilities*
France	Toulouse	Engineering design, testing, flight tests Final assembly lines for A320, A350XWB, A330 and A380
	Saint-Nazaire	Structural assembly Forward fuselage assembly of A320 Forward and central fuselage assembly of A330 and A380 Nose fuselage of A350XWB
	Nantes	Central wing boxes Carbon fibre reinforced plastic structural parts Radomes, ailerons and air inlets for A350XWB, A380 and A320neo
Germany	Hamburg	Structural assembly and outfitting of A320 Major component assembly of A380 Manufactures rear fuselage sections for A330 and A350XWB
	Bremen	Design and manufacturing of high-lift wing devices for all aircraft
	Stade	Vertical tail planes for all aircraft Carbon fibre reinforced plastic components
	Buxtehude	Electronic communications and cabin management systems
UK	Broughton	Wing production
	Filton	Engineering research and development
Spain	Getafe	Aeronautical component engineering, design, production and assembly
	Illescas	Manufactures composite components
	Puerto Real	Automated assembly of rudders Horizontal tail plane of A380

Source: Derived from Airbus (2015)

Brazil

In 2015, Embraer was the third largest manufacturer of commercial jet aircraft and one of Brazil's largest exporters of industrial products. Embraer has a global workforce of over 19,000 employees and has delivered over 1,000 E-Jets. In 2013, Embraer launched the E2 series, which is a new variant of their E-Jet family of commercial aircraft that seats 80–132 passengers. The E2 aircraft has new technologies, including full fly-by-wire, Pratt & Whitney geared turbofan (GTF) engines and high-aspect ratio wings with swept tips, giving it a 16 per cent improvement in fuel consumption. The first E2 test flight is scheduled for 2016 and it is due to enter into service in 2018. The E-Jet metallic fuselage and wing manufacturing and sourcing remains unchanged except that Triumph Aerostructures – Vought Aircraft Division will design and build the centre fuselage. In 2014, Embraer made a decision not to use composites on the E2's wing primary structure after several studies showed aluminium was the most cost-effective material for this size of aircraft.

Embraer has been making foreign direct investments (FDI) in Portugal and the US. Embraer's FDI strategy is based on expanding components and assembling manufacturing as part of a global strategy to compete in many international markets. In Portugal, Embraer has three industrial operations that produce metal and composite airframe structures for their commercial aircraft, executive jets and military aircraft.

China

China is projected to be the largest market for commercial passenger aircraft in the next 20 years. This, combined with lower labour costs, has led major aircraft OEMs to outsource some of their assembly to Chinese aerospace companies. Western aircraft sub-assemblies and parts in production at Chinese aircraft factories currently include:

- A320: final assembly in Tianjin under a joint venture agreement (see Case Study 14.2); nose parts and rear passenger doors at Chengdu Aircraft Industries; wing panels at Xian Aircraft Company;
- A330 completion and delivery centre in Tianjin;
- Airbus passenger emergency exit doors at Shenyang Aircraft Company;
- Airbus access doors for wide-body aircraft at Xian Aircraft Company;
- B737, 777 and 787 composite components at BHA Aero Composite Parts, Tianjin;
- B737: forward-entry and over-wing exit doors at Chengdu Aircraft Industries; horizontal stabilisers at Shanghai Aviation Industry Company; aft fuselage sub-assemblies at Shenyang Aircraft Company; and B737 Next Generation vertical fins at Xian Aircraft Company;
- B787: rudders at Chengdu Aircraft Industries, and panels for wing-to-body fairing at Hafei Aircraft Industries.

CASE STUDY 14.2

AIRBUS A320 FINAL ASSEMBLY LINE, TIANJIN, CHINA

In 2008, Airbus China, Aviation Industry Corporation of China (AVIC) and Tianjin Free Trade Zone Company (TFTZC) signed a joint venture agreement for an A320 final assembly line to be located in Tianjin. The factory is a 'copy' of Airbus's Hamburg plant (Airbus owns the tooling and TFTZC owns the building). The current production rate is four A320s a month, which are sold to Chinese airlines. In December 2014, the A320 Tianjin final assembly line celebrated its 200th delivery.

China is also actively developing its aircraft OEM capability by investing in research and development to support the production of Chinese mid-size passenger aircraft. In May 2008, a new state-owned company, Commercial Aircraft Corporation of China (COMAC), was created to develop, manufacture and commercialise Chinese passenger aircraft. COMAC is overseeing the development and production of the C919 aircraft (seats 168–190) and ARJ21 regional jet (seats 75–90).

China has a long-term commitment to developing a family of aircraft that meet Western certification standards. With the aim of becoming more competitive as a low-cost producer with high quality and better productivity, the Chinese commercial aircraft industry has decided to take advantage of its centres of competence from decades of industrial cooperation with the main global OEMs. These strategic alliances and joint ventures allow the Chinese to develop leaner cost structures.

Russia

In 2007, the Russian government consolidated the civil aircraft industry into one state-owned enterprise, the United Aircraft Corporation (UAC). UAC is majority owned by the Russian government (80 per cent) and ranks sixth among the major aircraft manufacturers. The UAC aims to:

- create a system of sales and technical services for domestic and international aircraft markets;
- develop the Russian aircraft industry into a strong player able to compete in the international markets for aircraft products;
- overcome the gap in technology between the Russian aircraft industry and leaders in the market and to work with international collaboration;
- create a modern research and development infrastructure for the aircraft industry organisation.

The UAC has two new civil programmes: the Sukhoi Superjet 100 (80–110 seats), now in production; and the Irkut MC 21 (150–230 seats), which is now under development, with the first flight scheduled for 2018. The main problem facing all Russian civil aircraft has been out of country service support for foreign airline customers. The Sukhoi Superjet 100 programme is trying to address this by partnering internationally with the Italian–Russian Superjet International joint venture.

Both Boeing and Airbus have developed international collaboration with Russia. Boeing has a Russian technical research centre and a design centre that work on research projects and structural design, and, since 2001, Boeing has advised on management, marketing, certification and after-sales support for the Sukhoi Superjet 100 programme.

Mexico

The development of Mexico's aerospace clusters is due to a national strategic programme to trade market access for co-design and production of Western-certified aircraft sub-assemblies and components. In 2013, 96 Mexican suppliers were supporting Airbus, Bombardier, Boeing and Embraer.

Since the FAA's US–Mexico Bilateral Aviation Safety Agreement was passed in 2007, which allowed aircraft sub-assemblies, components and parts produced in Mexico to be certified by the FAA and exported globally, Mexico's aerospace employment has increased from 10,500 in 2004 to over 34,000 by 2013. Mexico predicts that growth in FDI and increase in employment will result in the country supporting 450 companies, 110,000 employees and US$4.6 billion annually in FDI by 2020. Mexico plans on increasing their aerospace exports from US$4.5 billion in 2013 to over US$12 billion by 2020. Mexico's national strategic programme for the aerospace industry seeks an average future annual growth of 14 per cent and accumulate over US$4.8 trillion in FDI by 2020, as well as to have a new foreign aircraft built with over 50 per cent of its components made in Mexico.

India

India is another country with a rapidly emerging commercial aircraft manufacturing industry. The Indian government plans to develop indigenous programmes for commercial aircraft. Specifically, the Indian government's Ministry of Aviation seeks to:

- develop and produce a 20-seat turboprop;
- develop aircraft material processing and quality standards;
- encourage international joint ventures and allocate land for factories;
- establish tax benefits to attract foreign manufacturers;
- establish a National Aviation University to address education and training requirements for aerospace engineers.

Stop and think

To what extent do you think Boeing and Airbus might lose market share to OEMs in emerging economies?

14.5 Future trends

Alongside the established providers and the emerging economies in Russia, China and Central/South America, Turkey and Japan are among other countries actively developing their own domestic aircraft construction capabilities. This globalisation of commercial aircraft OEMs will have profound implications for the future of aircraft manufacture. While some mergers and consolidations are likely, the established OEMs are likely to witness some erosion to their market share. It is possible that supply chains will become more complex, automation will continue and costs will fall, but only up to a point. There is a risk that continually driving down costs will create sub-standard products that do not deliver the operational cost savings they promise and reputational damage will result. It is thus critical that OEMs, if they pursue a strategy of global outsourcing, manage and monitor their suppliers and contractors to ensure that products are delivered to time, to budget and, crucially, to the specified manufacturing standard.

Key points

- The commercial aircraft industry is a symbol of a nation's innovation and technology prowess.
- Aircraft design, development and manufacturing is highly capital intensive.
- Historically, countries with a large domestic air transport market and military requirement led commercial aircraft manufacture.
- Consolidation has been a feature of the global OEMs industry, and currently four OEMs dominate.
- Large commercial aircraft manufacture is dominated by Boeing and Airbus.
- Bombardier and Embraer dominate the regional and specialist aircraft market.
- New technologies and automated production processes are lowering lead times and production costs.
- Commercial aircraft OEMs have evolved into system integrators that outsource to foreign suppliers/risk-sharing partners.
- Outsourcing confers both benefits and risks to OEMs.
- China, Russia, India and Mexico are actively developing OEM capability through state subsidy and state-sponsored technological support.
- Rapid innovation in materials, production techniques and supply chains will continue.

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CHAPTER 15

Air cargo and logistics

Martin Dresner and Li Zou

LEARNING OUTCOMES

- To identify the functions of companies involved in air cargo operations.
- To make the business case for air freight shipments and highlight past industry growth.
- To appreciate the type of products that are shipped by air.
- To highlight the differences between air cargo and air passenger operations.
- To understand innovations, challenges and future prospects in the air cargo industry.

15.0 Introduction

On 19 September 2014, Apple released the latest versions of its popular smartphone, the iPhone 6 and iPhone 6 Plus. At the time of the product launch, it was expected that 60 million of these devices would be shipped from assembly sites in Chinese cities, including Shenzhen and Zhengzhou, to customers in 115 countries by the end of the year. Nearly all of these shipments would be by air. Tim Worstall, a contributor to Forbes.com, asks why these devices are being shipped by air when sea transportation is much cheaper. According to his calculations, a large container ship could transport more than 180 million iPhones, three times as many as would be needed to satisfy demand during the first four months of sales. Given then-current fuel prices, he calculated the cost to ship the iPhones to Europe at about 1.2 cents per device. The shipment time from Shanghai to Rotterdam would be about 25 days. Add another five days for customs clearance and to transport the shipment to an inland city, such as Paris or Frankfurt, and the total transit time would be 30 days. On the other hand, an all-cargo Boeing 777F, such as the type of aircraft employed by the express air freight company FedEx, can carry about 450,000 iPhones on a single trip. If Apple chartered a 777F, Worstall calculates the cost of transporting an iPhone to Europe at about 54 cents per device. The transit time is approximately 15 hours by air. He then poses the obvious question: why is it worthwhile for Apple to pay 50 times the ocean freight price to ship the iPhones by air, only to save 30 days of transit time?

According to IATA, air cargo accounts for over one-third of world trade by product value. In 2013, global air cargo traffic measured by revenue tonne kilometres (RTKs) was 207.8 billion. The total value of goods handled each year is valued at over US$6.4 trillion, about 33 per cent of world trade. Over the 40 years from 1971 to 2010, global air cargo traffic (measured by RTKs) expanded at an average of 7 per cent per year, higher than the 4.4 per cent annual growth in world gross domestic product (GDP) and the 2.5 per cent annual growth in world industrial production. However, since 2001, global economic uncertainty has meant growth in air cargo has slowed, and an increasing number of shippers have switched to lower-cost surface transport modes to reduce transport costs. Overall, growth in world air cargo has continued to outpace growth in global GDP, although not growth in international merchandise exports (see Figure 15.1).

Although cargo volumes have started to recover, more than one-third of the largest cargo airports worldwide have not yet recovered to their pre-recession activity levels (see Table 15.1). In contrast, some airports, including Dubai International (DXB), Beijing Capital International (PEK) and Guangzhou Baiyun International (CAN) reported substantial increases in cargo traffic from 2007 to 2013.

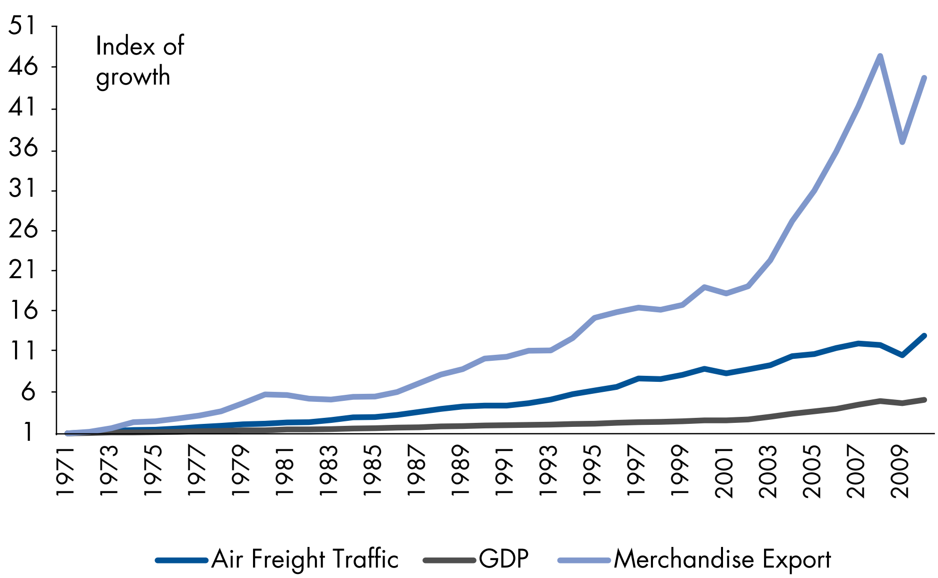

Figure 15.1 The historical growth of world air freight traffic, GDP, merchandise export and industrial production

Source: World Bank; ICAO

Table 15.1 The world's top 30 cargo airports ranked by metric tonnes (millions), 2013 (2007)

Rank	*Airport*	*Cargo*	*Change*	*Rank*	*Airport*	*Cargo*	*Change*
1 (2)	Hong Kong, HK	4.16 (3.77)	10.34%	16 (14)	Amsterdam, NL	1.57 (1.65)	−4.85%
2 (1)	Memphis, US	4.14 (3.84)	7.81%	17 (18)	London Heathrow, GB	1.52 (1.40)	8.57%
3 (4)	Shanghai, CN	2.93 (2.56)	14.45%	18 (30)	Guangzhou, CN	1.31 (0.69)	89.86%
4 (5)	Incheon, KR	2.46 (2.56)	−3.91%	19 (15)	New York JFK, US	1.30 (1.61)	−19.25%
5 (13)	Dubai, AE	2.44 (1.67)	46.11%	20 (19)	Bangkok, TH	1.24 (1.22)	1.64%
6 (3)	Anchorage, US	2.42 (2.83)	−14.49%	21 (17)	Chicago, US	1.23 (1.53)	−19.61%
7 (9)	Louisville, US	2.22 (2.08)	6.73%	22 (21)	Indianapolis, US	0.99 (1.10)	−10.00%
8 (8)	Frankfurt, DE	2.10 (2.17)	−3.23%	23 (24)	Tokyo Haneda, JP	0.95 (0.85)	11.76%
9 (6)	Paris Charles de Gaulle, FR	2.07 (2.30)	−10.00%	24	Shenzhen, CN	0.91	NA
10 (7)	Tokyo Narita, JP	2.02 (2.25)	−10.22%	25	Doha, QA	0.88	NA
11 (10)	Miami, US	1.95 (1.92)	1.56%	26	Leipzig, DE	0.88	NA
12 (11)	Singapore, SG	1.89 (1.92)	−1.56%	27 (29)	Cologne, DE	0.72 (0.71)	1.41%
13 (20)	Beijing, CN	1.84 (1.19)	54.62%	28	Kuala Lumpur, MY	0.71	NA
14 (12)	Los Angeles, US	1.75 (1.85)	−5.41%	29	Abu Dhabi, AE	0.71	NA
15 (16)	Taipei, TW	1.57 (1.61)	−2.48%	30 (25)	Osaka, JP	0.68 (0.85)	−20.00%

Source: ACI-NA (2014)

The following sections discuss the business case for shipping by air cargo and provide an overview of the air cargo market. The characteristics of the air cargo system as well as the types of companies that facilitate the movement of cargo by air are reviewed, and insights into the future of air cargo are offered.

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Stop and think

Outline the relationship between air cargo growth and global GDP.

15.1 The business case for air cargo

The time value of money

In evaluating the cost-time trade-off faced by shippers, shippers need to consider:

- the cost of having funds invested in products that are stuck in transit;
- the perishability or speed of obsolesce of the product.

The value of centralised distribution

Fast fashion retailers rely on getting their product to market as quickly as possible in order to take advantage of the latest fashion trends. These companies recognise the time value of money. Missing shipment deadlines to retailers for the spring season can result in large inventory discounts, as retailers move onto the next season's fashions. So, delivery speed is very important. Companies may, therefore, decide to transport their products to market by air.

An alternative model would be to establish distribution centres in their major markets, ship their product by sea to these distribution centres and then supply individual stores from the closest distribution centre. In theory, an order placed, for example, from a Houston, Texas, store could be delivered from a nearby distribution centre by truck faster than it could be delivered by air from a centralised distribution centre in Europe or Asia.

There are other advantages to centralised distribution that outweigh the potential time savings from a decentralised distribution network. In particular, centralised distribution allows a company to operate with less inventory and lower warehousing expenses than a decentralised system does. Fashion retailers can save considerable capital and operating expenses by centralising their inventory and distribution capabilities and using air cargo to ship their merchandise worldwide. Centralised distribution systems allow companies to ship new fashions faster than a decentralised system would. The elapsed time from product design to in-store is reduced as is the possibility of inventory obsolescence. Although a decentralised system can result in a shorter transit time once an order is received, considerable time will elapse in shipping products to geographically dispersed warehouses by sea. In a fast changing fashion industry, styles and demands could change while the product is in transit, rendering the inventory obsolete.

The value of certainty and the reduction in delivery time variability

Although increasing delivery speed is important in achieving high levels of customer service and minimising inventory costs, reducing the variance in delivery times can be as important.

If a transit option via sea takes an average of 30 days with a standard deviation of three days, the shipper can only be 97.5 per cent sure that the shipment will arrive within 36 days. Therefore, the cautious shipper, or its customer, not only has to finance 30 days of inventory associated with normal sea transit time, but an additional 6 days of inventory, called safety stock. If the safety stock is not financed, the customer faces an increased risk that its business will be disrupted due to non-receipt of goods. On the other hand, if the mean transit time by air is 15 hours, and the standard deviation is 1.5 hours, the shipper can be 97.5 per cent certain that the shipment will arrive within 18 hours. Given the cost differential between an extra three hours of inventory versus an extra six days of inventory, it is even more beneficial to ship goods by air.

The value of security and the mitigation of loss

Shippers are increasingly concerned about the security of their goods. As business has become increasingly globalised, goods are being transported over much greater distances, thereby increasing the risk to the products in transit. Many natural or human interventions can damage goods in transit. Goods can be lost or stolen, dropped or mishandled. The goods can be transported at too hot or too cold a temperature, causing deterioration in quality. The chances of goods being lost, stolen or damaged are much higher when being transported by sea than they are by air. The transit time with sea transport is not only longer, but goods travelling via sea tend to sit in warehouses or on docks for much longer than goods travelling by air. Water damage and piracy are also much more prevalent for sea transportation.

Although the rates charged by ocean shipping carriers are generally much lower than the charges for air cargo, there is a business case to be made for shipping many products by air instead of sea. The next section discusses the characteristics of shipments that may be most cost-effective to ship by air.

Stop and think

Discuss the relative merits of transporting goods by air.

15.2 Characteristics of air cargo

The previous sections of this chapter discussed two types of products that are often shipped to their destination by air – consumer electronics and fast fashion clothing items. This section discusses more generally the characteristics of products that lend themselves to transit by air.

Air cargo products have three key characteristics.

1 *High value-to-weight ratio*. Gold, for example, would more likely be shipped by air than coal. Insurance considerations aside, the shipping cost for 1,000kg of gold should be approximately equivalent to the shipping cost of 1,000kg of coal. However, the purchase cost of coal is about US$55 for 1,000kg. On the other hand, at the time

this chapter was being written, gold was trading for about US$42,000/kg. The 1,000kg shipment of gold would, therefore, be valued at US$42 million. Clearly, a shipper sending goods valued at US$42 million would be much less worried about transportation costs and much more worried about inventory costs and the potential for loss or damage than would a shipper with products valued at US$55. Conversely, the coal shipper would be much more concerned about transit costs, given that these costs may surpass the actual value of the product being shipped. As a result, a 1,000kg intercontinental gold shipment would most certainly travel by air, while a similar mass of coal would almost certainly travel by sea. Although a high value-to-weight ratio is a good judge of products that may be suitable for air cargo shipments, some products that fit this description but which have a low density are expensive to transport by air. Household goods are a good example. Assembled furniture may have considerable value, especially to its owner, and may not weigh that much compared to other similarly sized shipments. This is because assembled furniture consists of mainly empty space. Given space constraints on aircraft, airlines charge for shipments on the basis of **dimensional or volumetric weight**; that is, heavier products are assessed on the basis of their weight, while less dense products are assessed on the basis of their dimensions or volume. Consequently, a product that consumes considerable space will be very expensive to ship by air, even if its weight is fairly low.

Dimensional or volumetric weight: a calculation of the volume of the shipment compared with the actual weight. The higher value is used to calculate the cost.

2 *Time sensitive*. A time-sensitive product will quickly diminish in value as time elapses. Fresh flowers, seafood and certain pharmaceutical products, for example, are perishable. They have a very limited shelf-life and will deteriorate as time elapses. Time-sensitive products need to get to their destination as soon as possible to maximise returns for their sellers and are often shipped by air.

3 *Uncertain demand*. For example, sophisticated production machinery, such as the kind necessary to operate electric power plants, may break down. Some parts that are prone to regular wear and tear will have readily available replacements on-site or close by. However, other parts that seldom break down may not be kept close by. The demand for these parts may be difficult to predict, and replacements could be needed only once a year at most. However, if these parts are crucial to the operations of the power plant, they need to be ordered and installed as soon as possible. If air freight is the fastest means for acquiring these parts, then they will be transported by air, even at a much higher cost than surface freight alternatives.

Even if a product meets all three characteristics, it still may not be shipped to its destination by air. If the product is manufactured only a short distance away from the customer and there is a good highway or railway connecting the two, then the product is much more likely to be shipped by road or rail than by air. Distance between origin and destination and the relative speed and difficulty of using surface transport modes must also be considered. The faster and cheaper the surface alternative, the more likely it is to be chosen over air freight.

Stop and think

Identify goods that would not normally be transported by air, and discuss the reasons why they might be unsuitable for aerial shipment.

15.3 The air cargo industry

The air cargo industry consists of many different types of companies. The most well known are the **integrators**, such as FedEx, UPS, TNT and DHL Express, who provide customers with door-to-door service for mainly time-sensitive and relatively small shipments. The integrators own large fleets of aircraft devoted entirely to the carriage of air cargo. Integrators also use other cargo carriers to provide additional capacity on a contractual basis. The integrators also own or work with trucking firms to pick up and drop off shipments, to transport cargo to its final destination and to carry packages that are not particularly time sensitive.

In addition to integrators, air cargo is carried by airlines that operate dedicated freighter aircraft and by airlines that carry both air passengers and air freight in the same aircraft. The first type is called pure cargo and the second type is called belly-hold cargo as cargo is carried in the hold (the belly) of passenger flights. Finally, there are companies that facilitate the carriage of air freight, although they do not own any aircraft themselves. These companies, known as the 'travel agencies' for air cargo, are called **air freight forwarders**. Table 15.2 provides a listing of the world's largest air cargo operators, while Table 15.3 details the largest air freight forwarders. In both cases, the world's largest air cargo operators and air freight

Integrator: a company that offers an integrated door-to-door service, normally using their own fleet of aircraft and road vehicles.

Air freight forwarder: a company responsible for arranging the entire shipment of goods from A to B using a range of transport providers.

Table 15.2 The world's top ten air cargo operators by RTK, 2014

Rank	*Airline*	*RTK (million)*	*Number of freighter aircraft in service*	*Types of freighter aircraft*
1	FedEx	16,020	346	B747/757/777; A300; MD-11; DC-10
2	Emirates	11,240	14	B747/757/767; A300; MD-11
3	UPS Airlines	10,936	237	B747/777
4	Cathay Pacific Airways	9,464	21	B747
5	Korean Air Lines	8,079	21	B747/777
6	Lufthansa	7,054	19	B777; MD-11
7	Singapore Airlines	6,019	8	B747
8	Qatar Airways	5,997	20	B747
9	Cargolux	5,753	10	B777; A330
10	China Airlines	5,266	18	B747

Source: World Air Transport Statistics (2014), IATA (2015); fleet data retrieved from IATA (2014)

Table 15.3 Top 25 air freight forwarders by air freight tonnage, 2014

Rank	*Freight forwarder*	*Air freight tonnes*	*Gross revenue (US$) (in millions)*
1	DHL Supply Chain & Global Forwarding	2,272,000	32,193
2	Kuehne + Nagel	1,194,000	23,293
3	DB Schenker Logistics	1,112,000	19,861
4	UPS Supply Chain Solutions	912,500	5,758
5	Kintetsu World Express	872,300	2,942
6	Panalpina	858,000	7,338
7	Expeditors	823,094	6,565
8	Nippon Express	654,101	17,916
9	SDV (Bolloré Group)	550,000	7,483
10	Hellmann Worldwide Logistics	507,361	3,800
11	CEVA Logistics	495,600	7,864
12	Sinotrans	481,900	7,463
13	Agility	372,700	4,300
14	UTi Worldwide	368,000	4,180
15	Yusen Logistics	310,000	3,945
16	DSV	287,662	8,661
17	Kerry Logistics	282,200	2,723
18	GEODIS	270,600	5,960
19	NNR Global Logistics	252,068	1,745
20	FedEx TradeNetworks and FedEx Supply Chain	250,000	1,462
21	Dimerco Express	204,332	560
22	Pilot Freight Services	200,000	548
23	Damco	190,000	3,212
24	Hitachi Transport System	170,000	5,920
25	Logwin	146,000	1,501

Source: Woods and Ball (2015)

forwarders are concentrated in Asia, Europe and North America, reflecting the air cargo demand on the trade routes between these continents. However, the rise of Emirates from the ninth largest cargo operator in 2007 to second in 2014, and Qatar from 34th in 2007 to eighth in 2014, reflects the dramatic growth of Gulf carriers in recent years.

Compared to air cargo operators that rely on freight forwarders to sell their cargo space, integrators have two advantages: fully integrated operations; and direct interface with clients.

These enable integrators to differentiate their services from other air cargo operators by providing:

- increased efficiency in cargo handling and movement;
- reduced dwell time and in-transit time;
- enhanced security monitoring and control;
- elimination of duplicate paper documentation and handling processes;
- transparent information sharing, including provision of real-time tracking and tracing options to shippers; and
- improved on-time performance and flexibility in handling customer requests.

By offering fast, reliable, seamless, end-to-end and value-added services to customers, integrators have been successful in differentiating their services. In less than 20 years, integrators have grown into the largest air cargo operators worldwide (see Case Study 15.1).

CASE STUDY 15.1

THE RISE OF FEDEX

Before the deregulation of the US domestic air travel market in 1978, UPS was the dominant firm in the express package industry, holding a market share of 80 to 90 per cent. Its main competitor, the US Postal Service (USPS), was not capable of competing on service quality and rates without government subsidies. The conventional wisdom is that firms in a regulated industry with high barriers to entry exploit a stable industry setting to achieve economies of scale and higher profits due to a lack of competition. In a market with limited competition, firms may not be innovative. As organisations grow in size, they often become more hierarchical, rigid and slower to adapt to the changing environment. In a regulated environment, both UPS and USPS provided standard services with little thought to a customer-driven value chain.

Deregulation lowered the entry barriers faced by new entrant airlines and stimulated competition. Benefiting from the rapid development of information technologies, the express package rival FedEx (then known as Federal Express), which was established in 1971, grew dramatically. FedEx entered a package delivery market sector overlooked by UPS and USPS – overnight air express. By 1983, FedEx was generating US$1 billion in revenue, more than any other air delivery carrier in the US, and had overtaken UPS in the express market. Since then, UPS has worked hard to catch up with FedEx. In particular, UPS has been successful in focusing on international markets. Between 2000 and 2010, UPS increased its international traffic (measured by RTKs) by 144 per cent, more than the 55 per cent increase achieved by FedEx. The focus on international markets helped UPS grow faster and narrow the gap with FedEx in terms of both operating revenue and profitability.

Passenger-cargo combination carriers

Payload: the total weight of people and cargo carried on an aircraft.

Unit load device (ULD): a container or pallet used to load freight and luggage on wide-body and some types of narrow-body freighter aircraft.

Most passenger airlines carry belly freight in their cargo holds. Wide-body aircraft are especially capable of carrying large **payloads**. Much of this freight travels in specially designed air cargo containers called **unit load devices (ULDs)** which allow a large number of individual items of freight to be packed in a single unit. Some passenger airlines also operate dedicated cargo aircraft. The most popular types of freighter aircraft operated by passenger–cargo combination airlines are long-range, high-capacity aircraft, including the Boeing 747 and 777 families (see Table 15.2). Compared to integrators, passenger–cargo combination airlines (e.g. Cathay Pacific, Korean Air) or their fully owned cargo subsidiaries (e.g. Emirates SkyCargo, Lufthansa Cargo, Singapore Airlines Cargo) have much smaller fleets of freighter aircraft. Nevertheless, the access to the belly holds on passenger flights and extensive route networks with frequent scheduling options provide a distinct advantage for passenger–cargo combination airlines. As a result, it is estimated that about 75 per cent of all international air cargo traffic is carried by aircraft that are also carrying passengers, using their belly-hold capacity. The carriage of belly-hold cargo can complement passenger services and can make an otherwise unprofitable route into a sustainable one (see Case Study 15.2).

CASE STUDY 15.2

LAN'S CARGO OPERATIONS

LAN Airlines of Chile carries air cargo traffic using the belly-hold capacity of wide-body passenger aircraft on international routes between Latin America and the US and Europe. The cargo LAN carries from Latin America to the US and Europe consists mainly of perishable goods, such as seafood, flowers and vegetables. The majority of return shipments are high-value, low-weight merchandise, including computer hardware, smartphones and auto parts. The benefits from operating cargo and passenger services in tandem include: increased utilisation of aircraft assets; reduced break-even load factors; and more diversified revenue streams. By strengthening its operations, LAN has been able to preclude entry by potential competitors and obtain relatively high freight yields as a result.

Although the global air cargo market has not recovered to the pre-recession levels of 2007, cargo operations account for up to 23 per cent of the total revenue for airlines such as Cathay Pacific and Korean Air. In contrast, many US airlines derive only small revenue shares from cargo. This is because many US airlines use narrow-body aircraft with limited belly-hold capacity on many of their domestic routes and have short turnaround times between flights which do not allow for the loading and unloading of cargo.

All-cargo operators

All-cargo operators, sometimes called traditional cargo carriers, provide point-to-point services on a scheduled or charter basis. Since these operators use freighter aircraft, they can often take shipments of large items, such as oil and gas drilling parts or power generators.

Indeed, much of their traffic consists of heavy-lift shipments. In addition, the all-cargo carriers will often transport items to remote regions, far from the nearest airports served by the regularly scheduled carriers. Since all-cargo carriers often do not provide door-to-door service or have extensive marketing departments, they rely on air freight forwarders to book loads and to arrange for freight pick-up and delivery.

One of the keys to success for the surviving all-cargo operators will be to provide excellent service to shippers. According to the European Shipper's Council (ESC), there are four areas where shippers expect carriers to provide improved services:

1. more reliable, efficient, door-to-door seamless logistics services;
2. paperless chain of air cargo flow from consignor to consignee;
3. fair, transparent and reasonable surcharges;
4. industry-wide standards for carbon emissions and information on emissions on a shipment basis so shippers can compare environmental performance among airlines.

To address the gap between shipper expectations and the service provision of air cargo operators, the ESC advocates strategic collaboration and cooperation between shippers, freight forwarders, cargo handlers and cargo airlines.

Air freight forwarders

Air freight forwarders are central to air cargo operations as they connect suppliers and customers. Freight forwarders will typically reserve space on cargo flights and consolidate deliveries from multiple shippers, arranging for the consolidated loads to arrive at the airport of departure ready for shipping and delivering shipments to end destinations from the arrival airports. Since the air freight operators provide high-volume shipments to air cargo operators, they can often obtain lower rates than can individual shippers. Freight forwarders may charge shippers for providing value-added services, such as documentation, customs processing, insurance, goods storage, packing, handling and distribution.

Around 40,000 freight forwarders are members of the International Federation of Freight Forwarders Associations (FIATA). While the majority of them are small, non-asset-based businesses, the world's top air forwarding companies have extensive geographic coverage, large-scale operations, provide diversified logistics services and enjoy dominant positions in the rail, sea, road and air cargo markets.

Stop and think

Detail the structure and organisation of the global air cargo industry.

15.4 Global air cargo operations

Air cargo traffic differs from air passenger traffic in several important respects:

- Air passengers tend to travel in even flows from Point A to Point B and from Point B to Point A, balancing the flow of traffic on any given city pair. In contrast, most cargo goes in one direction only, giving rise to a unidirectional demand for cargo capacity. For example, the volume of air cargo traffic moving eastbound from Asia to North America far exceeds the cargo flow moving westbound. To deal with the problem of unbalanced traffic volume, it is important for cargo operators, especially those with dedicated freighter aircraft, to implement the seventh freedom of air (➤Chapter 1) on international routes so that they can make multiple stops, picking up and dropping off cargo en route to their final destination. Here are some examples of 'round-the-world' routes operated by AeroLogic Boeing 777Fs (Hong Kong–Cincinnati–Bahrain–Hong Kong and Hong Kong–Los Angeles–Leipzig–Hong Kong) and Cargolux (which operates a B747-8F on a three-day trip, Luxembourg–New York–Mexico City–Houston–New York–Lagos, Nigeria–Accra, Ghana–Nairobi, Kenya–Maastricht–Luxembourg).
- Air travellers prefer to fly non-stop, directly to their destinations whenever possible. If a transfer is needed, short connecting times are desired. In contrast, air cargo customers may be indifferent to where a transfer is made as long as the shipment arrives at its destination on time. Several factors may impact the transit time or dwell time (waiting time for cargo on the ground) of a cargo shipment. These factors include connecting flight schedules, airport congestion, weather conditions and the capability and efficiency of ground handlers in breaking and rebuilding air cargo containers/pallets. Unlike air passengers, the transfer of cargo from one flight to another requires additional unloading and reloading.
- Air cargo revenue management may be more complex than passenger revenue management as a result of cargo's three-dimensional characteristics, greater demand uncertainty and a greater variety of cargo rates and routing options.

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Stop and think

Why do passenger and air cargo services differ?

15.5 Specialised air cargo

While the air cargo market for general cargo has experienced overcapacity and stagnant demand, there has been a very strong, lucrative and growing market for shipping specialised products, including live seafood, fresh produce, pharmaceutical goods and temperature-sensitive goods. According to Air Cargo World (2014c), perishable and pharmaceutical goods now account for about 12 per cent of the total revenue of the world's air cargo industry and have a much higher growth rate in traffic volume than does general cargo. Moreover, the average cargo yield for pharmaceutical goods is about three times as high as that for general cargo. Case Studies 15.3 and 15.4 describe speciality shipments facilitated by two cargo operators.

CASE STUDY 15.3

EMIRATES SKYCARGO COOL CHAIN OPERATIONS

To ensure a cool chain environment for perishable goods during a shipment, Emirates SkyCargo has invested millions of dollars in special equipment and facilities both in the air and on the ground. Investments have been made in temperature-controlled containers, cool dollies and temperature controlled handling and storage facilities. The airline provides three types of the cool chain services, including Cool Chain – Basic, Cool Chain – Advanced and Cool Chain – Premium, which enable customers to monitor product temperatures online for transporting a variety of perishable produce, meat, dairy products, pharmaceuticals, chemicals and other products from originating countries to destinations around the world. In September 2014, Emirates SkyCargo opened a new daily flight service between its home city, Dubai, and Oslo, in Norway, the world's second largest seafood exporting country. With a one-stop connection at Dubai, the airline is able to ship up to 23 tonnes of seafood per day from Norway to Asian markets. In 2012, Emirates surpassed FedEx to become the world's largest air cargo carrier by international traffic volume as measured by tonnage (Patel 2014).

CASE STUDY 15.4

SHIPPING SEAFOOD BY KOREAN AIR

As a leading country in lobster fishing, processing and shipping, Canada exports lobsters to 50 countries, and the lobster industry is estimated to have a US$1.7 billion annual impact on the country's economy. In July 2014, Korean Air started a cargo route between its hub at Seoul Incheon and Halifax, Canada, using Boeing 777F aircraft shipping a minimum of 40 tons of live lobster every Sunday during the lobster harvesting season. This new cargo service is offered to leverage the growing appetite for live lobsters among Asian consumers. Trade will be further boosted with the signing of a free trade agreement between Canada and South Korea in September 2014. In addition to seafood, there is a growing demand for air freighting fruit products, such as berries and cherries, to Asia as Asian consumers seek high-quality, pollution-free imported produce. In 2013, Alibaba, the largest e-commerce platform provider in the world, sold 150 tons of cherries, 80 tons of nuts, and 50 tons of Alaskan seafood shipped from the US to China (Air Cargo World 2014a).

Other niche products have also been driving air cargo growth. For example, Lufthansa Cargo has focused on carrying potentially hazardous but high-yielding goods. In 2013, they carried about 45,000 tons of hazardous goods, including flammable chemicals and lithium batteries. Cathay Pacific has also diversified its cargo services to reduce reliance on traditional air cargo and carried 236,000 tons of hazardous goods in 2013. Outsized cargo, such as oil and gas equipment for offshore drilling, accounts for 5 to 10 per cent of the total cargo carried by Cargolux.

Stop and think

Outline the benefits to airlines of specialising in particular types of cargo shipment.

15.6 Airports as air cargo logistics nodes

Airports provide a vital connection for the movement of air cargo. To accommodate the continued expansion of freighter aircraft and the growing adoption of cargo-friendly wide-body aircraft, several airports worldwide have expanded or modified their infrastructure. These investments are designed to attract more cargo. Case Study 15.5 details how two airports are facilitating growth in air cargo.

CASE STUDY 15.5

AIRPORTS AND AIR CARGO

In 2010, Memphis International Airport (MEM), the primary hub airport for FedEx, was surpassed by Hong Kong International Airport (HKG) in terms of cargo volume. Since then, HKG has remained the world's largest airport by cargo throughput (measured in metric tonnes) in the world. HKG now handles about 37 per cent of Hong Kong's international trade by product value and has a total of 7.4 million tonnes of annual cargo handling capacity. The airport offers two tiers of cargo handling services. The first tier services are provided through four cargo-dedicated terminals for cargo loading/unloading onto and from aircraft, while the second tier facilities include the Air Mail Centre, Airport Freight Forwarding Centre, Marine Cargo Terminal and Tradeport Logistics Centre. These centres are designed to provide multimodal transportation and other value-added logistics operations.

The Middle East is projected to have the highest growth rate in international freight volume from 2014 to 2018. By 2018, the UAE will replace Germany as the third largest country in international air cargo volume, after the US and China. With hubs located at the crossroads of Europe, Asia and Africa, carriers in the Middle East have been very successful in implementing sixth freedom air routes (➤Chapter 1) and providing one-stop connections via their hubs for traffic moving between east and west and north and south. From 2007 to 2013, Emirates almost doubled its cargo volume, increasing its total freight tonne kilometres (FTKs) from 5.4 billion to 10.2 billion; Qatar Airways almost quadrupled its cargo volume; and Etihad more than tripled its cargo volume. At the same time, other major cargo operators experienced shrinking cargo volume or, at best, slow growth. For example, Korean Air, Singapore Airlines, Cargolux and China Airlines lost a total of 5.1 billion FTKs, collectively, during this period.

The dramatic growth of cargo volume that the big three Gulf carriers (Emirates, Qatar and Etihad) have experienced is driven by their ever-growing route networks, flight frequency increases, fleet expansion (especially in the wide-body aircraft category), cooperation with other cargo operators for filling their aircraft capacity and, last but not least, the cargo handling capabilities, airport infrastructure and supporting logistics services offered at their hubs (see Case Study 15.6).

CASE STUDY 15.6

DUBAI LOGISTICS HUB

In May 2014, Emirates SkyCargo started using its new cargo terminal at Al Maktoum International Airport for freighter operations. As the centrepiece of Dubai World Central (DWC), Al Maktoum International Airport is projected to have an annual capacity of 12 million tonnes of cargo and 160 million passengers at its final phase of construction. Surrounding the focal airport are seven other districts of the DWC that provide logistics, aviation, humanitarian, residential, commercial, leisure, exhibition and commercial services. With the vision to help Dubai become a leading trade centre and important gateway to the Middle East, Southeast Europe, North Africa, South Asia and the Commonwealth of Independent States (CIS) region, the government of Dubai led the initiatives in developing the DWC as a multimodal logistics centre with direct connections to the main highway, railway and port. The DWC and Jebel Ali Free Zone will be connected via a fully dedicated Dubai logistics corridor, forming an integrated free trade zone with a total area of about 200km^2. This aviation-driven 'aerotropolis' (➤Chapter 6) has also been followed by other countries in the Gulf Cooperation Council (GCC). In addition to the programmes at Dubai and Abu Dhabi, there are major projects to build, expand or modernise the airports in Bahrain, Oman and Qatar. This new infrastructure and capacity will allow for the continued cargo growth of the carriers in the Gulf region.

Stop and think

Why has there been a growth in airports specialising in air cargo operations, and what are the benefits of this to airline operators?

15.7 Air cargo: challenges and opportunities

Security

An important challenge is to provide optimum security for cargo shipments and the least disruption and delay to the flow of goods. In October 2010, explosives were found in printer cartridges carried on freighter aircraft bound for the US. This incident raised concerns about the vulnerability of air cargo to security threats. In response, the EU imposed a new security rule that requires carriers not to accept cargo unless it has been fully screened and secured and they are aware of the contents, the origin and the transit history of the shipment.

The environment

The global aviation industry generated 705 million tonnes of carbon dioxide (CO_2) emissions in 2013, representing about 2 per cent of all human-generated carbon dioxide and 12 per cent of the carbon emissions produced by the transportation sector. Both IATA and ICAO have set a goal of carbon-neutral growth from 2020. The air cargo industry is committed to helping achieve this target. Many cargo operators are replacing old, noisy and inefficient aircraft with more fuel efficient and quieter ones. The greening of the air freight business has also been embraced by air freight forwarders, and some shippers are offered the opportunity to participate in carbon-offset programs. As the global leading air freight forwarder, DHL Global Forwarding shares with its customers very detailed carbon footprint reports analysing the amount of CO_2 emitted at the shipment level, and helps customers to optimise their supply chains for carbon emission reductions (Putzger 2011).

Innovations

Air cargo operators have been innovative in the use of technology for assuring on-time, fast and reliable cargo delivery. Modernising documentation (e.g. with electronic air waybills (AWBs)) has been a goal of the air cargo industry for some time. Waybills provide key information on the cargo that is being shipped, such as shipper, destination and contents. In January 2015, over 75 per cent of AWBs were still issued in paper format. The goal is to increase electronic air waybill use to 90 per cent by 2017.

Other innovations are connected with new transportation routes. For example, DHL Express has launched helicopter services in cities such as Los Angeles, New York and London to move important documents and small packages from major airports directly to a heliport in the city centre to avoid traffic congestion (Air Cargo World 2014b). Other innovations may include the use of drones for small package deliveries and airships for heavy lift.

Hybrid transport such as sea-air, rail-air and express truck-air may become more popular as their complementary services provide customers with increased speed, cost efficiency and market reach. Many shippers can now choose multimodal shipping options that include air services. For example, Athens International Airport has collaborated with COSCO, a Chinese shipping company. Goods are shipped via COSCO from the Middle East to the seaports in Greece. On arrival in Greece, the goods are trucked to an airport and then shipped to Northern Europe or elsewhere by air.

15.8 The future of air cargo

Despite the challenges facing the air cargo industry, the outlook is optimistic. With the increasing growth of internet commerce, companies that provide direct shipments of small packages to customers, the continuing importance of global trade, the growth in sales of high-value consumer electronics, the shrinking size of many products, which makes them more amenable to air shipments (such as mobile devices that have supplanted laptops, which in turn replaced desktop computers), shorter product life cycles, and the emphasis on customer service by shippers, there should be a strong place for air cargo in the future transportation system.

Stop and think

What might the global air cargo industry look like in the future?

Key points

- Air cargo is an important but often overlooked aspect of the commercial air transport industry.
- Air cargo enables the routine and ad hoc movement of high value-to-weight, time-sensitive and/or perishable products from their point of origin to their point of consumption.
- Air cargo services are provided by dedicated cargo airlines, integrators and passenger–cargo combination carriers.
- Air cargo can be shipped as belly-hold freight on scheduled passenger flights or as pure freight on freighter aircraft. Outsized and hazardous cargo may be transported by specialist operators.
- Air cargo offers a number of advantages over surface modes, including faster delivery, lower transit times and reduced likelihood of theft and mishandling.
- Airports that handle large volumes of air cargo need specialist warehousing and customs facilities, and a number of airports have developed to primarily serve the particular needs of air cargo operators.
- Air cargo faces a number of challenges, including the introduction of new security directives, volatile fuel prices and global economic uncertainty, which have depressed demand and led to a rise in alternative forms of cheaper land and sea transport.
- Air cargo needs to be flexible in its approach and innovative in its business approach to take advantage of new opportunities that are presented by changing patterns of consumer demand and the introduction of new technology such as drones and airships.

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CHAPTER 16

Airlines, information communication technology and social media

Lucy Budd

LEARNING OUTCOMES

- To describe what is meant by ICT and social media and discern their relevance for airlines.
- To identify the diversity and importance of airline ICT applications.
- To recognise the evolution and function of computer reservation systems (CRS) and Global Distribution Systems (GDSs).
- To appreciate the importance of online distribution, the internet and social media to airlines.
- To understand ICT's role in flight operations and corporate control functions.
- To evaluate future airline ICT trends.

16.0 Introduction

The commercial airline industry is an advanced user of information communication technology (ICT). Airlines have driven innovation in ICT development and application since the early 1940s to reduce costs, improve efficiency and generate additional revenue. ICT is the foundation of airline operations. Every process, from flight planning and customer reservations to crew rosters and strategic procurement, relies on the continual real-time functioning of sophisticated ICT applications and global networked computer systems.

This chapter describes how ICT is used by airlines. It identifies the diversity and importance of ICT applications and shows how ICT systems have evolved in response to new technologies and changing commercial environments. The role of ICT in revenue management, corporate control and flight operations purposes is discussed. Particular attention is given to how airlines use social media and the relative benefits to airlines of engaging with customers online. The chapter documents the extent to which airlines rely on ICT and shows how airlines have both shaped the development of computer technology and, in turn, been shaped by its application. The chapter concludes by looking at likely future trends in airline ICT.

16.1 What is ICT?

ICT describes equipment and software that integrate telecommunication systems (including landline and mobile telephones) with computer networks to enable data to be conveyed, manipulated, stored and retrieved electronically. Almost every aspect of modern industrialised society, from healthcare and finance to transportation and entertainment, is facilitated and managed by the provision and application of sophisticated ICT systems, and air transport is no exception.

16.2 Airlines and ICT

ICT is deeply embedded within the corporate structure of airlines, and it has become essential to the safe, efficient and cost-effective delivery of air services. Airlines rely on ICT applications to fulfil numerous functions associated with: distribution and revenue management; business strategy and corporate control; and flight operations (Table 16.1).

One of the most important areas of ICT application for airlines is **distribution** and revenue management, where ICT assists in reducing costs, driving efficiency improvements, optimising yields and maximising revenue across multiple **direct** and **indirect distribution channels**.

> **Distribution:** the means by which goods or services reach the consumer.
>
> **Direct distribution channels:** internet sales made directly between an airline and a customer.
>
> **Indirect distribution channels:** sales made through intermediaries such as travel agents.
>
> **Real-time information:** information that is immediately and continually updated to reflect current operating conditions.

Distribution and revenue management functions

One of the most important pieces of ICT infrastructure for airline distribution and revenue management is the computer reservation system (CRS). CRSs display **real-time information** about flight schedules and fares, process reservations, manage seat inventories, enable airlines to price discriminate and practise differential pricing (➤Chapter 8) and store commercially valuable data on customer preferences and purchasing behaviour.

Table 16.1 Principal functions of airline ICT applications

Distribution and revenue management

- display information about flights and seat availability across multiple platforms (including the internet, third-party travel websites, travel agencies and internal company intranets);
- handle complex fare inquiries;
- process multiple sector trip itineraries;
- manage and interrogate millions of unique passenger reservations;
- update individual passenger's frequent flyer accounts;
- process secure financial transactions and engage in real-time revenue and yield management;
- monitor competitors' fares and the external operating environment and react accordingly;
- reduce reliance on intermediaries and lower costs; and
- monitor present yields and forecast future demand.

Business strategy and corporate control

- develop and manage business models;
- communicate and build external and internal relationships with customers, staff, sub-contractors and suppliers around the world;
- undertake strategic and tactical marketing;
- design new products, plan new routes and promote new products and services;
- analyse revenue streams and manage capacity;
- fulfil financial accounting, invoicing, procurement and regulatory reporting obligations;
- manage abnormal operating conditions and aid schedule recovery following disruption; and
- automate payroll, HR and other backroom office activities.

Flight operations

- plan and manage daily flight operations;
- file flight plans and optimise flight tracks according to weather conditions, traffic density and payload;
- compile and instantly update cargo and passenger manifests;
- create and circulate staff duty rosters; and
- coordinate aircraft maintenance activities.

The development of CRSs has been driven by the introduction of larger and faster aircraft and the dramatic growth in passenger numbers that occurred after the Second World War. Prior to this, all passenger reservations had been processed by hand at airports or airline reservations offices on handwritten ledgers and blackboards. However, by the late 1940s, growing numbers of flights and passengers combined with the introduction of domestic telephones put significant strain on these manual systems.

By the early 1950s, passengers were telephoning airlines to inquire about seat availability and fares. Carriers were obliged to lease expensive telephone lines and employ large numbers of telephone clerks at their reservations offices. As the volume of calls grew, the process of manually checking flight and seat availability boards on the walls of reservations offices and then manually confirming each reservation by hand became too expensive, time consuming and labour intensive. It was also highly inefficient. Each reservation could take up to 90 minutes to process, and many incoming telephone calls went unanswered, resulting in lost revenue.

The introduction of jet aircraft in the late 1950s placed additional demands on the already overstretched manual systems. New aircraft, including the Boeing 707 and Douglas DC-8, were much bigger and faster than the piston and propeller powered aircraft they replaced. This meant that flights, each potentially seating 100 or more passengers, could arrive at their destination before the passenger inventory had been updated. The new jet aircraft were also more expensive to operate, and this gave airlines an additional commercial imperative to reduce the number of empty seats they flew to improve yields and maximise the revenue each service generated.

Although major airlines had starting experimenting with automating some of their reservation functions from the mid-1940s (see Case Study 16.1), it was not until the development of networked computer processors and magnetic data storage devices in the late 1950s that it became possible to develop real-time electronic computerised reservations systems.

CASE STUDY 16.1

AMERICAN AIRLINES' EARLY ATTEMPTS AT AUTOMATION

American Airlines' first attempt to automate their reservations function involved a large electro-mechanical device that controlled seat inventory by means of marbles in glass tubes. Each marble represented an available seat on a flight and every time a reservation was received for that flight, an electronic signal was sent to the hatch underneath the relevant tube, which allowed one marble to fall out. This made it easy for reservations clerks to tell whether there were any seats remaining on a given flight, but there was no way to cancel or amend a booking. This system was replaced in 1952 by an electronic memory device called the Magnetronic Reservisor, which stored reservations data in the form of electrical charges on a spinning disk. This enabled reservations clerks to determine seat availability and automatically sell and cancel seats. However, it could not attach passenger details to individual reservations and was ultimately replaced in 1962 by a new and more sophisticated system called SABRE.

The world's first computerised airline reservation system became fully operational in 1962. Developed by American Airlines (AA) and IBM, SABRE comprised two IBM 7090 computers (each with a 32,000-word core memory), which were linked via telephone lines to remote terminals in AA's reservations offices in over 50 US cities. SABRE stored up-to-date schedule and fare information, maintained a real-time inventory of passenger reservations and seat availability on all AA flights, and possessed an indexing system that facilitated the rapid retrieval of reservations records. SABRE could instantly update the seat availability on each flight, enable reservation clerks to confirm, cancel and amend reservations in a matter of seconds, propose alternative flights if the desired service was unavailable, and attach the name, address, contact details and passenger service information to individual reservations for the first time.

SABRE could handle 85,000 telephone inquiries per day and by 1964 was processing 7,500 reservations an hour, making it the largest private real-time data processing system in the world. SABRE caused the average transaction time to drop from 90 minutes to three seconds. Cancellations, no-shows (customers who buy a ticket but then don't check in for the flight) and standby passenger lists were processed immediately and accurately, meaning AA carried higher loads and fewer empty seats, while data on passengers' travel and purchasing behaviour was used to develop new products and services.

Recognising the potential to lower costs and confer competitive advantage, other major carriers including Delta, Pan Am, TWA and United Airlines also developed CRS capability during the 1960s. Like SABRE, their CRSs were airline-specific and only contained information about the host airline's services. This was a crucial point. By the early 1970s, travel agents were becoming an increasingly powerful force in the US airline business. They processed half of all airline tickets sales and were proposing to develop a rival independent CRS to give them access to multiple carriers' schedules and fares.

AA and United, afraid of losing control of this lucrative distribution channel and concerned about competition from rival systems, responded by installing their own CRS terminals in travel agencies from 1976. That year also saw the launch of Travicom, the world's first multi-access airline CRS. Travicom allowed two (and eventually 49) subscribing airlines to communicate with travel agents using a central computerised reservations platform and a common software language.

AA subsequently expanded SABRE to include not only AA's flights and fares but also those of other subscribing carriers. SABRE's flight scoring algorithms were programmed to search the schedules and fares of all subscribing carriers. The service that most closely matched the defined search parameters was then displayed on the first page of results (but not necessarily first on the list) irrespective of whether it was an American Airlines' flight. SABRE's scoring algorithms were programmed to ensure that an AA flight always appeared top of the list even when it wasn't the best match. AA also introduced financial incentives to encourage clerks to book AA flights rather than those of a competitor. By the late 1970s, SABRE was installed in over 2,000 US travel agencies. SABRE enabled AA to:

- capture increased market share on key routes by ensuring competitor's flights never appeared top of the list on routes AA also flew;
- introduce sophisticated **revenue management** techniques to maximise the return on their assets; and
- earn additional revenue by charging other airlines (who couldn't afford the capital costs of developing a CRS) to use the system.

Revenue management: variable pricing strategies which adjust the price of a product according to demand to maximise revenue and, ultimately, profit.

By the mid-1980s, travel agents were demanding access to multiple CRSs and more transparent information on fares. In response, and taking advantage of increased economies of scale and lower development costs, three new international multi-airline CRS platforms, Galileo, Amadeus and Worldspan, were developed (Table 16.2).

Table 16.2 The development of major CRS platforms

Name	*Founding airlines*	*Date*	*Comments*
Galileo	Consortium of nine European full service carriers including British Airways, KLM and Swissair	1987	Merged with Worldspan in 2007 to form Travelport
Amadeus	Consortium including full service carriers Air France, SAS and Lufthansa	1987	Now one of the three major GDS platforms (see Example 16.1)
Worldspan	Consortium including US full service carriers Delta, Northwest and TWA	1990	Merged with Galileo in 2007 to form Travelport

By the 1990s, ICT advances meant that in addition to displaying flight information and processing reservations, CRSs could also display information about other travel products including accommodation and car hire. This enabled the three major CRSs – SABRE, Amadeus and Travelport (formed as a result of the merger of Galileo and Worldspan) – to evolve into Global Distribution Systems (GDSs), which offer far more functionality than the original airline-specific CRSs. GDSs consolidate information from hundreds of different travel providers to allow customers to browse and purchase all their travel needs from a single digital marketplace (see Example 16.1).

Example 16.1
Amadeus GDS

Amadeus is one of the world's largest GDSs. As of early 2015, it served 195 countries worldwide and contained schedule data and fare information for 690 airlines, 32 car rental companies, 38,000 car rental locations, 20 cruise lines, 30 ferry companies, 300,000 individual hotels, 288 hotel chains, 100 rail operators and over 240 tour operators. At peak times, it can process over 27,000 transactions per second. Amadeus handles 24 billion inquiries a day and possesses 20 petabytes (a unit of memory equivalent to 20,000 million million (10^{15}) bytes) of storage.

16.3 Airlines online: the impact of the internet

While progressive ICT developments were enhancing the functionality and capability of GDSs through the 1990s, a new technology started to revolutionise airline operations. The advent and rapid global uptake of the internet in industrialised economies from the mid-1990s onwards forced airlines to refocus their business and distribution strategies. The emergence of low-cost carriers (LCCs) in the US and Europe at this time (➤Chapter 7) was also instrumental as LCCs recognised that the internet could reduce their distribution costs and change how passengers purchased tickets.

In some respects, airlines are inherently suited to e-commerce. Direct web sales enable carriers to directly sell large quantities of a perishable product (a seat) to a large number of spatially and temporally distributed purchasers while reducing their reliance on expensive intermediaries and lowering their distribution costs. However, e-commerce also poses a number of challenges for airlines, not least because of the number of different types of internet distribution channels that have emerged and the ease with which customers can compare prices and products.

By the end of the 1990s, internet sales had become an important part of the airline business and had been responsible for introducing a number of product and service innovations. A typical passenger visits numerous websites during multiple browsing sessions before booking a ticket, and many travellers use the internet to plan their journeys. Price-sensitive consumers, especially, may consult price comparison sites and monitor airfares in order to identify the best deals.

Currently, four main types of internet distribution exist:

1. Airline-owned and airline-specific multilingual websites such as Ryanair.com or AA.com.
2. Travel websites and price comparison sites such as Expedia, Opodo and Skyscanner – these may be independently owned or linked to specific airlines/GDSs.
3. Auction sites, such as Skyauction.com, which enable travellers to bid for tickets online as well as purchase fixed price deals.
4. Distressed capacity sites which sell heavily discounted tickets close to departure.

The first airline-specific websites appeared in the mid-1990s and reproduced route and schedule information that was available elsewhere. However, rapid developments in internet technology enabled them to evolve into highly flexible, interactive and secure reservations systems and communication tools. By the end of the decade, websites had not only become an intrinsic part of many airline brands but were also handling high volumes of reservations. By the 2010s, airlines had expanded their online and digital offerings to include a range of sophisticated management tools that not only improved customer loyalty but which also drove revenue growth (see Case Study 16.2).

The internet has resulted in a number of product and service innovations. Many of these were pioneered by LCCs before being adopted by other airlines and include:

- *E-ticketing.* Alphanumeric booking references began replacing printed paper flight coupons in 1994. Customers receive immediate e-mail confirmation of their booking, and airlines avoid expensive printing and postage costs. Savings may be passed on to consumers in the form of lower fares.
- *The removal of minimum stay and Saturday night restrictions.* Liberalisation (➤Chapters 2 and 8) and the growth of internet reservations removed minimum stay requirements and allowed passengers to access lower fares irrespective of the duration or timing of their trip.

CASE STUDY 16.2

EASYJET: DRIVING REVENUE GROWTH THROUGH DIGITAL MEDIA

In 1995, a new London Luton-based LCC called easyJet performed its first flight. In 1997, it launched its eponymous website, easyjet.com. Direct internet sales were promoted from April 1998 with a £2.50 discount off each one-way flight. By 2004, 98 per cent of all tickets were being sold online, substantially reducing the airline's expenditure on reservations and distribution. The website expanded to offer accommodation, travel insurance, car hire and package holidays, and in the 12 months to October 2012 attracted over 392 million visits (of which 60 per cent were from outside the UK).

In October 2012, easyJet unveiled a new digital strategy. This sought to increase revenue, extend the airline's reach and further cut costs through the application of digital and online media. Revenue growth was driven via an online content management system and customer personalisation strategy that not only automatically tailored the appearance of the website to individual customers according to past purchase and travel history but which also provided dynamic pricing and customised online check-in (over 60 per cent of passengers now check in online). To expand their reach, easyJet increased the number of languages their website is available in to 20 (including Hebrew and Chinese), launched a dedicated US website that accepts bookings in US dollars and introduced mobile apps for Android and Apple platforms that have been downloaded over 2.9 million times. easyJet calculate that over £42 million of revenue has come from mobile apps, while the US site has attracted over US$55.5 million in bookings. In addition to offering online check-in and reservation management functions, easyJet's digital offerings also include live online flight tracking, travel inspiration guides and iBeacons at major airports that trigger notifications on a passenger's journey on their smartphone.

Source: easyJet (2012, 2014)

- *The ability to purchase one-way tickets without penalty.* Previously airlines sold return tickets and charged a premium for single journeys.
- *The use of financial incentives for DIY (do-it-yourself) bookings.* By offering discounts for online reservations, airlines were able to change passengers' purchasing behaviour, reduce their costs and pass on the savings to consumers.
- *The development of à la carte pricing.* The internet helped to unbundle the cost of air travel, with passengers only being charged for the services they require.
- *The development of customer relationship marketing (CRM), context-relevant web marketing and online promotions.* The internet, and the use of cookies that remember user preferences, enable personalised emails and promotions to be sent to individual customers. Synthetic personalisation (in which travellers are made to feel as if they are valued individuals) can be employed to enhance customer loyalty and drive revenue growth.
- *Crisis management communication.* Websites and social media sites can be updated instantly and used to convey information on delays and schedule recovery following disruption.

- *Online check-in.* Passengers can check in online the day before their flight, select seats, and download and print off their boarding pass or have it sent to their smartphone or other mobile devices. Passengers can then bypass conventional check-in and proceed directly to security.
- *Use of mobile devices and ticketless travel.* The first ticketless flight was performed in 2008. Boarding passes and reservations can be sent directly to a customer's mobile device in the form of e-mails or **QR codes**, avoiding the need for conventional travel documents. Additional information about transfers, delays and airport lounges can also be accessed through mobile devices which further increases customer utility and decreases the airline's costs.
- *Reactive yield and revenue management.* The internet enables airlines to monitor competitors' prices in real time and rapidly respond. The integration of online reservations with the central CRS also allows airlines to monitor demand for individual flights and raise or lower prices to maximise revenues and yields. This means that passengers will often pay a different price for the same flight depending on when they made their reservation. As a result, some customers benefit from cheap fares while others will pay more (➤Chapter 9).

QR code: a machine-readable code consisting of black and white squares that stores information which can be read and decoded by a camera on a mobile device.

The principal advantages to airlines of internet distribution are:

- increased market reach (anyone in the world with an internet connection can access their services);
- reduced costs, which can be passed onto consumers in the form of lower fares (e-tickets are up to 80 per cent cheaper to process than paper ones), which can undercut rivals and help grow market share;
- elimination of expensive intermediaries and greater control of distribution costs;
- enhanced opportunities for CRM and management;
- improved yields and revenue maximisation;
- ability to monitor competitors fares and respond accordingly;
- relative ease of providing and updating multilingual websites; and
- the ability to sell distressed (unsold) capacity cheaply close to departure.

The principal advantages to consumers of internet distribution include:

- ability to purchase tickets, amend reservations and view booking history 24 hours a day, 365 days a year;
- ability to compare the prices and products offered by different providers;
- enhanced competition between airlines keeps prices low;
- access to cheaper fares, online-only promotions and last minute seat sales;

- greater flexibility – the internet has unbundled air travel and allowed customers to only purchase the services they require; and
- the ability to check in online and proceed directly to security on arrival at the airport.

Key challenges of internet distribution for airlines include:

- the ease with which consumers can compare prices and products and choose an alternative supplier;
- diminishing brand loyalty – consumer purchasing behaviour may be motivated purely by price;
- need to ensure the continued security and resilience of online systems and customer transactions and protect systems from cyber-attack;
- challenge of keeping up with technology and investing in popular applications such as mobile apps. Evidence suggests that passengers want to be able to purchase and amend reservations instantly using mobile devices;
- not all customers have mobile devices and access to the internet;
- passenger acceptance and utilisation of new technology is unpredictable and variable and airlines might need to introduce incentives to alter consumer behaviour;
- consumer backlash against perceptions of non-transparent pricing (compulsory taxes and charges are not always quoted in the headline fare) and 'hard sell' of additional products. Ryanair changed their website and corporate strategy in 2014 because of this.
- overselling – airlines routinely assume that some passengers will not check in for any given flight so may sell more tickets than there are seats on the aircraft. This presents a problem when everyone turns up;
- lack of internet, 3G or Wi-Fi connectivity at airports and/or the absence of QR scanners for mobile boarding passes mean passengers are unable to use mobile devices to check in.

The main disadvantages of internet distribution for consumers include:

- limited customer support when things go wrong;
- cheapest fares can often only be accessed online and require payment by debit/credit card;
- poorly designed websites may act as a deterrent to booking;
- some airlines (particularly LCCs) are not fully integrated into GDS websites, meaning that passengers may still not have access to the full range of fares and services available;
- lack of confidence at using online technology or concerns about web security may dissuade passengers from booking online.

In addition to understanding the benefits and potential disadvantages of the internet for distribution and revenue management, airlines have also had to adapt to the growth of social media.

16.4 Social media

The rapid development of mobile technology, including smartphones and tablets, and the growing popularity of **social media** have changed the nature of company–customer interaction. Social media sites such as Facebook (launched in 2004), Twitter (2006), Instagram (2010) and Google+ (2011), which enable users to access real-time information on the move and create, upload and share text, photo, video and audio content, continue to grow in popularity and functionality. By 2014, over 1 billion Facebook accounts had been created and up to 200 million tweets were being posted on Twitter daily.

Social media: websites and mobile applications (apps) that enable users to create, upload and share text, photo, audio and video content on the internet and engage in instantaneous social networking.

Consumers now expect companies to have a strong social media presence and airlines recognise the importance of social media to their marketing and communications strategies. When used effectively, social media can help airlines to:

- enhance the passenger experience by providing real-time information and service updates;
- proactively engage with customers through innovative social media campaigns;
- build brand loyalty in an increasingly price competitive marketplace; and
- drive revenue growth.

One airline which has been at the forefront of social and digital media innovation is KLM, the national flag carrier of the Netherlands (see Case Study 16.3).

However, in addition to the potential benefits, a number of challenges associated with social media use exist. These include:

- the cost of employing dedicated staff to monitor multiple social media sites, regularly update content and rapidly respond to customers in multiple languages;
- identifying appropriate and relevant content;
- ensuring brand consistency across multiple platforms;
- keeping up to date with changes in the social media environment and the popularity of individual sites;
- recognising that some social media sites may be location specific and only work in some world regions;
- effectively responding to critical content;
- minimising the potential for inappropriate images or content to be posted which may damage the brand; and
- the risk of accounts being hacked.

CASE STUDY 16.3

KLM'S USE OF SOCIAL AND DIGITAL MEDIA

KLM has been active on social media since 2009. Its digital and social media strategy involves its website and its Facebook, Google+, KLM blog, KLM YouTube channel, Instagram, Pinterest and Twitter pages. In October 2010, KLM established a dedicated social media hub to manage its growing online presence. By July 2011, this had become a 24/7 operation run by dedicated staff who were collectively able to respond to customer comments and questions in Dutch, English, German, Japanese and Spanish. By 2014, the hub was handling 2,000 conversations a week and aimed to answer customer queries within an hour and find a solution within 24 hours. As of July 2015, KLM had over 9.3 million 'likes' on Facebook and had a team available 24/7 who could respond to customers in 14 languages. In addition, KLM had posted over 608,000 tweets on its global Twitter account.

KLM uses social media to publicise new routes, provide corporate information, share customer stories, inform passengers about service disruption and launch innovative marketing campaigns, which have included:

KLM surprise – in November 2010, the airline harnessed the power of social sharing and accessed the social media accounts of some of its passengers. Having viewed their profiles, the airline purchased personalised gifts and presented them to surprised passengers at the boarding gate. The results were captured and shared on Twitter.

Fly to Miami – In March 2011, KLM launched a direct service between Amsterdam and Miami a week earlier than planned following a social media challenge by a Dutch DJ who wanted to go to the Ultra Music Festival in Florida. KLM offered to operate the service if sufficient seats could be sold. A post on social media led to hundreds of bookings by music fans. According to KLM, this was the first time an airline had added a flight to its schedule following a social media request.

Tile and inspire – In April 2011, KLM invited its Facebook fans to design and submit a blue Dutch delft tile. Over 4,000 entries were subsequently displayed on a company B777-200. The YouTube 'making of' video has been viewed in excess of 810,000 times.

Meet and seat – From May 2012, passengers were offered the chance to select who they sat next to on their flight by accessing other consenting passengers' social media profiles and choosing who they wanted to sit next to (see Figure 16.1).

Aviation empire – In June 2013, KLM launched a 3D strategy game which enabled players to experience running their own airline.

Beacon technology – From September 2014, passengers arriving at Amsterdam Schiphol could use a free route planner on their smartphone to navigate around the airport. The provision of beacon technology and free airport Wi-Fi enables users to be given advice on the route they need to take to find the next gate and how long it will take them to walk to it.

Jets – In May 2015, KLM launched a second online game. Available for free from the Apple App Store and Google Play Store, players fly a digital paper aircraft through the centre of Amsterdam to open new missions, collect items and obtain high scores (see Figure 16.2). A multiplayer version enables users to compete against their friends and share their successes on social media.

Figure 16.1 KLM's 'meet and seat' campaign

Source: KLM

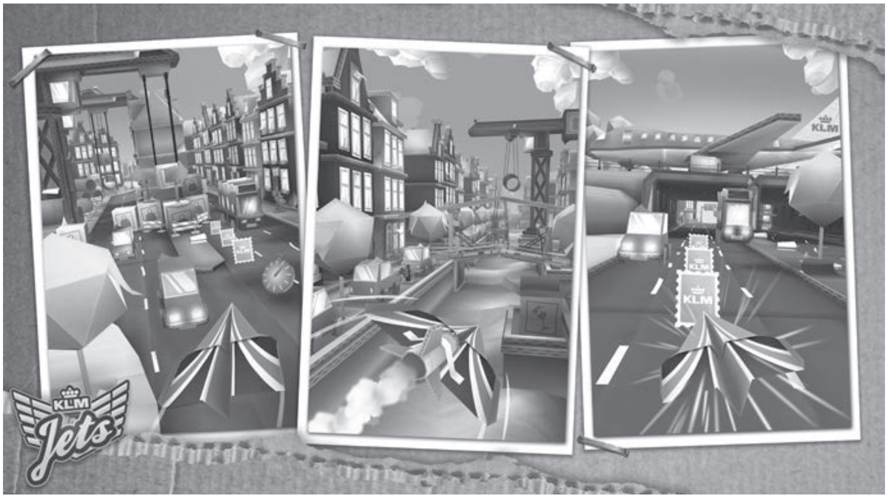

Figure 16.2 In-game screenshots of KLM Jets

Source: KLM

It is therefore essential that airlines who want to utilise social media understand the opportunities and risks associated with the online environment, devise and apply a consistent brand message across all platforms and be flexible and innovative in their approach.

16.5 Business strategy and corporate control functions

In addition to performing a vital role in reservations and distribution, ICT is also employed for airline business strategy and corporate control functions. Airlines use ICT decision support tools, software and systems to:

- develop and manage their business model;
- communicate with customers, staff, subcontractors and suppliers worldwide;
- devise and undertake strategic and tactical marketing;
- design new products, routes and services; analyse revenue and manage capacity;
- fulfil accounting, invoicing, procurement and regulatory reporting obligations;
- manage abnormal operating conditions and aid schedule recovery following disruption; and
- comply with data governance legislation and perform payroll, HR and other backroom office activities.

16.6 Flight operations functions

ICT is also heavily embedded in daily flight operations. Here sophisticated control systems enable airlines to plan flight schedules, file flight plans, coordinate crew activities, and identify and resolve problems quickly and safely. Real-time decision support tools monitor the flow of aircraft, staff, passengers and cargo around the carrier's network and analyse the performance of subcontractors and supplies to ensure consistent service delivery and continuity of complex supply chains.

Getting the right aircraft to the right gate at the right airport at the right time on the correct day fully serviced, crewed and catered for an on-time departure relies on tens of thousands of electronic exchanges and networked ICT systems. Flight planning departments file electronic flight plans which are verified, approved and automatically sent to all the en-route air traffic control (ATC) centres that will handle that flight. Weather forecasts will be obtained and printed, weight and fuel calculations computed and route data entered into the aircraft's flight management computer. In the airport terminal, ICTs responsible for check-in, baggage handling, security screening and customer service delivery will ensure that all the passengers and any accompanying baggage and cargo are security screened and arrive at the aircraft in time to facilitate an on-time departure.

As part of this process, passengers interface (either knowingly or unknowingly) with multiple different agencies and ICT systems at all points of their journey. These include internet service providers, airline CRSs, national security services (who cross-reference the names and backgrounds of prospective travellers against terrorist and criminal watchlists), and financial institutions, who authorise travel and process secure electronic payments. As part of the reservations process, passengers may request a special meal or wheelchair assistance, redeem frequent flyer points or choose a specific seat. All this information is captured in advance of departure and processed to ensure that the customer not only has a seat on the flight they desire on the date they wish to depart but also that they have a positive experience of the airline and patronise it again. Considering the volume of information that is required to facilitate the aerial mobility of just one passenger on one flight, the need for airlines (who may operate thousands of flights and transport tens of millions of passengers a year) to invest in ICT is obvious.

Commercial air travel is unique in obliging passengers to check in and be physically separated from the majority of their belongings during their journey. The process of checking in not only confirms a passenger's intention to travel on a particular flight but also marks the point at which the airline assumes responsibility for passengers and their hold luggage. Owing to advances in ICT, passengers can now check in using a variety of methods. These include online and mobile check-in, self-service kiosks or in person at a staffed check-in desk. This process ensures that the correct passengers have checked in for the flight and that their hold luggage has been correctly tagged through to their destination. These tags detail the owner, the flight and the intended destination and contain machine-readable barcodes that enable the luggage to be automatically sorted and dispatched to the correct aircraft. Once all the passengers are checked in, aircraft load and balance sheets can be prepared and the aircraft weight and fuel requirements computed.

After check-in, passengers are encouraged to proceed to security, another area of operations that relies heavily on computer systems to process passengers, minimise delays and optimise security. In the early days of passenger flight, there was no need for any formal security screening but, following a number of high-profile terrorist incidents against aircraft and airports from the 1960s onwards and the threat of international criminal activity and smuggling, the intensity of security searches has increased. As a consequence, a range of security interventions, including, but not limited to, advanced passenger profiling, metal detecting archways, X-ray machines, passenger baggage reconciliation, terrorist watch lists, biometric passports and millimetre wave full-body scanners, have been deployed (➤Chapter 12).

Airlines are also required to share personal information about individual passengers with the security services in the countries of origin, destination and (in some instances) overflight. This information typically includes the passenger's full name, date and place of birth, permanent address, passport number, travel history and payment method. This information is requested during the booking process before being encrypted and sent to the relevant authorities in advance of departure. The information is then processed and analysed to ensure the passenger does not represent a security risk. If the information is not received in time or the profiling algorithms identify a potential problem, travel may be denied. In addition to these pre-departure checks, networks of CCTV cameras and behavioural recognition software monitor terminal buildings to identify potential threats.

At the same time, other ICT systems are monitoring the progress of individual flights and updating flight information screens in the terminal with information on the status of departing and arriving services. Real-time information on check-in, gate number, boarding time and departure is required by passengers, staff, visitors and non-travelling members of the public. Once through security, ICT systems are required to deliver diverse retail, customer service and terminal ambience (such as heating, lighting and air conditioning) functions. These processes range from the mundane and familiar (such as credit card transactions in shops) to aviation-specific activities like passenger boarding. However, reliance on ICT makes airlines vulnerable to failure and cyber-attack of their own systems as well as those of the airports, ATC and secure online payment portals on which they rely. As a result, ICT systems must be highly resilient to power failure and malfunction, possess multiple back-ups and be resistant to cyber-attack.

16.7 The future

Mobile apps, websites and social media are likely to remain key areas of investment for airlines. Growing numbers of business and leisure travellers will use mobile devices to access travel information online and the growing uptake of smartphone and other mobile devices will continue to drive growth and innovation on mobile platforms. Airline websites will become more interactive and sophisticated, while a new range of mobile applications, including flight tracking apps and airline apps, will transform the information that is available to consumers. Although some carriers have embraced social media, others have only recently entered this domain, and so further growth and investment is likely.

Certainly, most airlines are actively investing in mobile applications for flight reservations, mobile boarding, shopping and ancillary revenue generation. Electronic passport readers, e-gates and self-service baggage management (such as self-service baggage tag printing and missing bag reporting) are also likely to be areas where further ICT application is likely. A further area for future ICT application is in disruption management. However, as air travel becomes ever more reliant on automated systems, it also arguably becomes more vulnerable to disruption (➤Chapter 10), whether malicious or unintended.

Crucially, while increased access to mobile information and bespoke travel management options may empower passengers to make more informed choices and take greater control of their mobility, it will also pose challenges for airlines and require strategies for dealing with immediate (and often critical) online consumer feedback in a way that protects and enhances the airline's reputation. Ironically, the need for airlines to employ staff to monitor and respond to social media posts negates some of the cost advantages of direct distribution and may ultimately contribute to higher costs. It is imperative that airlines and other air transport service providers work to identify the most efficient, resilient and intuitive ICT systems that will benefit both their operation and, ultimately, the consumers of the air transport product.

Key points

- Airlines are advanced and intensive users of ICT.
- Airlines have driven the development of ICT and been shaped by its application.
- ICT powers everything from revenue management and reservations functions to flight planning and daily operations.
- The internet has developed into a key distribution channel, and almost every airline has an online presence.
- Smartphones, mobile applications and social media have presented airlines with new business challenges and opportunities. Some carriers have embraced the online environment and have made it an intrinsic part of their brand, but the online environment is challenging and has the potential to backfire.
- Airlines will continue to drive ICT innovation to reduce costs, enhance safety, improve environmental performance and proactively engage with customers.

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CHAPTER 17

Environmental impacts and mitigation

Thomas Budd

LEARNING OUTCOMES

- To examine the environmental impacts of air transport operations at global and local levels.
- To assess mitigation strategies that can be adopted by airlines, airport operators, manufacturers and Air Navigation Service Providers (ANSPs) to manage their environmental impacts.
- To evaluate policies for improving air transport's environmental performance.

17.0 Introduction

Addressing air transport's environmental impacts is one of the key challenges facing the industry. Environmental protection not only has a moral and ethical dimension but may also have significant commercial implications as environmental considerations have the potential to constrain growth. Many airlines, airport operators, aircraft manufacturers and ANSPs appreciate that what is good for the environment is also often very good for business, and they are working to actively address their environmental impacts in a cost-efficient and socially responsible manner.

This chapter considers the environmental impacts of air transport and assesses different mitigation strategies and policy options that are available to address them. It sets the context for contemporary debates about air transport and the environment. The key global and local environmental impacts, including climate change, noise, local air quality, energy, water and waste management, biodiversity, landscape and visual impact, and archaeology and cultural heritage are then examined. This is followed by an assessment of the types of mitigation strategies for managing these challenges. The chapter concludes with an evaluation of different environmental policy options, including regulatory approaches, market-based measures and voluntary schemes.

17.1 Air transport and the environment

Anthropogenic: caused by human activity.

Public and political debates surrounding aviation's impact on the environment are dynamic and contested. At a global scale, emissions of carbon dioxide (CO_2), nitrous oxides (NO_x), particulates, water vapour and other atmospheric pollutants affect the global climate. Although commercial aircraft are only responsible for 2 per cent of global **anthropogenic** CO_2 emissions (IPCC 1999), as other industrial sectors decarbonise and air travel demand grows, aviation's contribution is likely to increase.

Despite improved engine and airframe design progressively reducing aircraft noise and emissions, public awareness of air transport's environmental impact has increased and pressure on the aviation industry to improve its environmental performance has grown. Noise is a highly political subject and is the issue most likely to elicit reaction and complaint from communities living near airports. At the same time, increased concentration of hydrocarbons, carbon monoxide and nitrous oxides in the immediate vicinity of airports have affected local air quality and could present a risk to human health.

17.2 The environmental impacts of air transport

The environmental impacts of air transport occur at both a global and a local level (see Table 17.1).

There can be a temptation to think that local impacts demand attention in the short term while global impacts can be addressed at some non-specified future date. This is because local impacts are felt immediately and so are more likely to demand attention, while the processes involved in assessing aviation's global environmental impacts typically take longer to develop and cross international boundaries. However, air transport has environmental impacts at both the local and global level, and will continue to do so. The dynamics of atmospheric and oceanic systems mean that if environmental issues are not addressed, irreversible changes in the earth's climate may occur.

Table 17.1 Air transport's principal environmental effects

Global impacts	Local impacts
Climate change, leading to:	Noise
• rising sea levels	Local air quality
• changing frequency of storms	Odour
• changing severity of storms	Energy demands
• changing precipitation patterns	Water consumption
	Waste generation and disposal
	Biodiversity and landscape effects
	Visual impacts
	Cultural heritage and archaeology
	Human health impacts

This chapter addresses the global and local environmental impacts of air transport separately, although, in reality, the two are inextricably linked. Local environmental impacts affect, and in turn are affected by, processes operating at the global scale. For example, local air quality issues around airports contribute to global issues relating to climate change, while a changing climate will affect energy, waste and water management at individual airports owing to new patterns of temperature and precipitation.

17.3 Global impacts

Climate change

Global air transport currently relies almost exclusively on the combustion of carbon-based fossil fuels (primarily kerosene). When it is burnt in aircraft engines, jet fuel emits a range of **greenhouse gases (GHGs)**, including carbon dioxide, nitrous oxides and water vapour, which alter the chemical composition of the atmosphere and contribute to **global warming** and **climate change**.

Air transport's climate impact is measured using a metric called **radiative forcing (RF)**, which is measured in Watts per square metre (W/m^2). Radiative forcing can be either positive (leading to atmospheric warming) or negative (leading to atmospheric cooling). Net radiative forcing describes the total effect. The radiative forcing components created by air transport operations, the relative impact, the scale at which they operate and the current level of scientific understanding surrounding them is provided in Table 17.2.

Greenhouse gases (GHGs): gases which contribute to the greenhouse effect by absorbing infrared radiation and warming the earth's surface.

Global warming: the increase in the earth's surface temperature caused by rising concentrations of GHGs.

Climate change: long-term alterations in the global climate.

Radiative forcing (RF): a measure of the influence a particular pollutant has in altering the balance of incoming and outgoing energy in the atmosphere.

Stop and think

Identify the principal RF components and detail their effect on the global climate.

Climate change has altered both natural and human systems, and its effects often disproportionately affect people and communities already disadvantaged by poverty, inequality and uneven economic development. The Intergovernmental Panel on Climate Change (IPCC 2014), the leading international body for assessing climate change, identifies the following risks associated with climate change with a high degree of confidence:

- Risk to lives and livelihoods in low-lying coastal zones and small islands due to storm surges, coastal flooding and sea level rise.
- Risks of extreme heat exposure, especially for vulnerable urban populations and those working outdoors.
- Disruption caused by inland flooding.
- Food insecurity (especially for poorer populations) linked to warming, drought, flooding and precipitation variability and extremes.

Table 17.2 Summary of the main RF components

RF component	*Summary*	*RF impact*	*Scale*	*Level of scientific understanding*
Carbon dioxide (CO_2)	CO_2 represents a large share of the net radiative forcing. CO_2 also has the longest atmospheric lifetime of any of the RF components taking decades (via uptake by oceans) to millennia (via rock weathering) to be removed from the atmosphere. CO_2 has a similar impact on RF regardless of the location or altitude at which it is emitted.	+++	Global	High
Nitrous oxides (NO_x)	Reactive nitrogen (NO_x) is emitted from aircraft engines in the form of nitrogen oxide (NO) and nitrogen dioxide (NO_2). These alter the levels of ozone (O_3) and methane (CH_4). O_3 causes positive RF and is produced more abundantly when NO_x is released at altitude. Increased NO_x can also lead to reduced CH_4 levels via complex photochemical reactions leading to negative RF. However, overall the RF of NO_x is positive.	+ O_3 = +++ CH_4 = ––	Global	Medium–low
Water vapour (H_2O)	Emissions of water vapour can promote the formation of condensation trails, or contrails. These are the easily recognisable white linear trails that form in cold humid conditions at high altitudes (low level contrail formation is rare). Contrails can induce cirrus cloud formation. It is thought that water vapour leads to positive RF as, although incoming short-wave radiation is reflected back out into space, it traps outgoing long-wave radiation and leads to warming.	+	Global	Low
Particulates	Particulate matter is emitted from aircraft engines. The two main classes of particulate matter are black carbon (or soot) and sulphate particles. Although their combined RF impact is relatively small, soot particles absorb radiation and have a warming effect, while sulphate particles reflect radiation and have a slight cooling effect. Together, particulates may also lead to increased cirrus cloud formation, as water vapour from the engine plume condenses around them.	+/– Soot = + Sulphate = –	Local to Global	Low
Total aviation		++++	Local to Global	Low

Source: Derived and adapted from Lee *et al.* (2009, 2010); Wilcox *et al.* (2012)

Note: ++++ = strong positive impact and –––– = strong negative impact.

- Damage to marine and coastal ecosystems and related economies.
- Loss of terrestrial and inland water systems and biodiversity, and the goods, functions and services they provide.
- Systemic risks due to extreme weather events, leading to breakdown of infrastructure networks and critical services such as electricity, water supply, health and emergency services.

The air transport industry is not immune to the effects of a changing climate. The built environment of an airport, including its runways, taxiways, aprons, terminal buildings and ground access systems, as well as its energy demands, telecommunications and security systems, may all be affected by a changing climate. Changes in temperature and precipitation patterns, increased snow and ice and more frequent extreme weather events may also impact air transport operations. In 2011, the US experienced 12 weather/climate-related disasters, including Tropical Storm Irene which forced the temporary closure of all the major airports in New York and the cancellation of over 10,000 flights. Overall, it is estimated that 70 per cent of all airport delays are the result of extreme weather, a situation that is likely to increase (Baglin 2012).

Warmer climates can lead to increased damage to aircraft tyres and airfield pavements, and aircraft may require additional thrust (and hence fuel burn) to take-off in warmer, thinner air. Warmer temperatures can also melt airfield tarmac and roads and require more energy to cool terminal buildings. Many airports now have to publish strategies for managing and mitigating the impacts of climate change on their operations. In the UK, large infrastructure companies and organisations, including airports, are required to produce and maintain plans that assess how they will adapt to climate change.

Stop and think

Discuss the ways in which air transport operations affect and are affected by climate change.

17.4 Local impacts

Noise

Aircraft noise (whether from aircraft in flight, during take-off and landing, or when taxiing on the ground) is one of the air transport industry's most immediate and challenging environmental issues as it is the factor that is most likely to provoke reaction from local communities. Aircraft noise has been an emotive, politicised and highly controversial issue since the introduction of jet aircraft in the 1950s and it is likely to remain so. Aircraft noise has become central to debates about airport development and expansion, and it represents a significant constraint to growth. Limiting or reducing the number of people affected by noise is a key priority.

Prolonged exposure to aircraft noise causes a range of adverse physiological effects, including increased blood pressure and noise-induced sleep disturbance, the severity of which is influenced by factors such as an individual's age, their general health, social conditions, lifestyle characteristics and the time of day or night when the noise event occurs. Adverse psychological effects can be triggered by feelings of resentment, anger, discomfort or helplessness, when a person's thoughts, feelings or activities are disrupted. While psychological responses to noise are harder to measure than physiological reactions, their consideration is key to understanding issues of noise (see Example 17.1).

Example 17.1
What's in a name? Sound v noise

Sound describes acoustic vibrations that can be detected by the human ear, whereas noise is unwanted or intrusive sound. Sound can be measured objectively, in terms of levels of acoustic energy (typically measured in terms of average sound exposure in decibels over a given period of time (dB(A)). Noise, on the other hand, is highly subjective, culturally specific and difficult to quantify. The way in which different sounds are perceived, and framed, depends on a host of factors relating to its source and the time and place in which it occurs. For example, while sound from road traffic and industrial operations are typically considered intrusive, in the past they were considered to represent the sounds of prosperity and economic development.

One of the challenges associated with aircraft noise is the number of different methodological techniques and metrics that can be used to quantify it. The simplest measure of a noise event, such as an aircraft in flight, is the maximum sound level that occurred during the event, measured in dB(A) (i.e. its highest sound level), where the greater the value, the greater the risk of disturbance. The sound exposure level (SEL) of a noise event is the sound level in dB(A) that would be measured if the energy of the entire event were compressed into a constant sound level lasting one second. However, measuring the levels of individual aircraft noise events in this way does not assess the full impact of the noise exposure, as it cannot take account of the combined impact of many aircraft over longer periods of time.

In the UK, the Noise and Number Index (NNI) was employed until 1990. This calculated the number of noise events and the sound level at any given location. However, the NNI failed to take into account the duration of individual events and was superseded by the 'equivalent continuous sound level', or Leq. This reflects the average sound levels for a specific location over a set period of time (in the UK this period is 0700–2300). Following a number of studies, the UK government agreed that an equivalent continuous sound level of 57dBA represents the onset of 'significant noise annoyance'. In the EU, a similar measure is used, but the average Leq is taken over a 24-hour period and additional weightings of 5dBA are applied for noise events that occur during the evening (1900–2300) and 10bBA for noise events during the night (2300–0700). The impacts of noise are, typically, presented as contours on a map, showing the location of an airport and the areas and number of people affected.

The highly subjective nature of noise annoyance means there may be little correlation between recorded noise levels and community annoyance. Indeed, while improved engine technology, airframe design and operational changes have reduced levels of aircraft noise, public tolerance of noise has also decreased. The reasons for this are numerous and complex, but growth in air traffic and the increasing number of people living near airports are contributory factors. The difficulty of measuring the non-acoustic impacts of aircraft noise, combined with wider problems surrounding a lack of trust between airports and local communities, has manifested itself in the form of protest groups seeking to limit current operations and/or prevent future expansion.

Stop and think

Why is aircraft noise contentious and what are the challenges associated with measuring it?

Local air quality

While the atmospheric impacts of air transport are commonly framed in terms of their global impacts, it is important not to overlook local air quality issues. Gaseous emissions of CO_2, NO_x, carbon monoxide (CO) and particulates from aircraft, ground access transport, power generation and on-site ground transport vehicles, all negatively affect local air quality. Poor air quality has potential health implications for people living and working around airports, in terms of increased risk of contracting or exacerbating existing cardiorespiratory conditions. As a result, tighter regulatory controls on standards of local air quality have been imposed in Europe and North America.

Although air quality regulation varies by country, airport operators increasingly record and report emissions in terms of Scope 1, 2 or 3 emissions:

- **Scope 1.** Direct emissions from sources owned and/or controlled by the airport, including airside vehicles or airport buildings.
- **Scope 2.** Indirect emissions, predominantly the purchase of electricity (for use at the airport) that has been generated elsewhere.
- **Scope 3.** Indirect and/or optional emissions that result as a consequence of the airport's operation, including aircraft and ground access travel.

Scope 3 emissions represent the largest share of emissions at an airport, but they are also those over which the airport operator, generally, has the least control. This is due to the myriad of different tenant companies, government agencies, ground access transport operators and other stakeholders involved in airport operations. Inevitably, this can make the task of reducing emissions extremely challenging. Table 17.3 shows the distribution of CO_2 emissions at Seattle–Tacoma Airport in the US. Significantly, 96.5 per cent do not fall under the direct control of the airport operator.

Table 17.3 Summary of airport derived emissions from Seattle–Tacoma International Airport, 2012

Scope	*Entity*	*Source*	*CO_2 (tonnes)*	*Share of CO_2 (%)*
1	Airport operator	Airport airside vehicles	1,249	0.2
		Airport buildings (gas/oil/coal)	14,435	2.4
		Airport emergency generator	17	0.0
		Scope 1 sub-total	*15,701*	*2.6*
2	Airport operator	Electricity purchase	4,537	0.8
		Scope 2 sub-total	*4,537*	*0.8*
3	Tenants	Aircraft (landing, take-off, taxiing)	316,316	53.7
		Aircraft auxiliary power unit (APU)	43,359	7.4
		Aircraft engine run-ups	469	0.1
		Airside vehicles	9,211	1.6
		Tenant buildings (gas/oil/coal)	2,837	0.5
		Tenant fire training	170	0.0
		Landside vehicles	50,024	8.5
		On-site employee vehicles	3,246	0.6
	Public	Ground access travel	143,308	24.3
		Scope 3 sub-total	*568,940*	*96.5*
		Total	589,180	100

Source: ICAO (2013)

As well as recording total emissions, air quality can also be measured according to the atmospheric concentrations of individual pollutants at different locations. These concentrations are commonly expressed in terms of micrograms per cubic metre (µg/m^3) and are logged at air quality monitoring stations positioned around an airport. In the same way that noise contours can be applied to reflect grades of aircraft noise, so too can air quality contours show spatial variations in air quality around an airport. For simplicity and to aid dissemination, air quality is commonly reported according to a specified scale or index. In the UK, air pollution levels are reported on a 1–10 index (divided into four bands of 'Low', 'Moderate', 'High' and 'Very High'), indicating relative pollution levels and the associated risk to human health. Some airports make this information freely available online so people can access real-time information and historical air quality data.

Two sources of poor air quality that airport operators are increasingly focusing on is from ground access travel to/from the airport and on-site ground transport. Airports have increasingly sought to reduce the share of passengers, employees and other airport users accessing the airport by private vehicles, and at the same time increase ground access by public transport. For passengers, there is particular focus on the need to reduce the share of drop-off/pick-up journeys (as these generate additional vehicle trips and exacerbate problems of congestion) and increase public transport ridership. However, such initiatives also need to be balanced against the service requirements of passengers in terms of their ground access travel, or putting an airport at a competitive disadvantage in any way. Employee travel is also dominated by private vehicle journeys and, as a result, many airports are exploring ways to reduce single occupancy vehicle use via incentives such as interest-free loans for purchasing season tickets, cheaper public transport ticketing initiatives, preferential parking arrangements for employees who car share and dedicated secure cycle parking and showering facilities for employees. Encouraging employee use of public transport can be very challenging, not least because public transport services may not be available for certain communities or operate 24 hours a day.

Stop and think

How can airport operators improve local air quality?

Energy, water and waste management

The environmental impacts of air transport extend to issues of energy, water and waste management. The scale of airport buildings, the airfield and the wider airport site means that airports are large consumers of electrical energy. The largest sources of energy consumption are the maintenance of ambient air temperature (heating and cooling) and air quality inside the terminal building, followed by terminal and airfield lighting. The increasing commercial importance of retail activities can also prove challenging. Retailers will generally require that their products are brightly lit, so that they appear attractive to potential shoppers. High levels of luminescence increase energy demand for lighting but also for air conditioning to remove the additional heat that has been generated from the lights. The majority of electricity at airports is imported rather than generated on-site. This provides financial incentives for airports to reduce their energy consumption and/or increase the share of electricity generated on-site from renewable sources such as solar, biomass and wind power.

Airports are also large consumers of water. Water is used for drinking, catering and cleaning. As well as monitoring total consumption, surface drainage must be managed to help mitigate flooding and prevent the pollution of watercourses by spilt fuel, hydraulic fluid, de- and anti-icing compounds and fire retardants from emergency simulation exercises. Large balancing ponds are required to hold and treat contaminated water before it can be discharged. Any failure in the contaminated water management system can be lengthy and expensive to resolve and potentially hazardous to local ecosystems and human health (see Table 17.4).

Air transport operations also generate large quantities of solid waste (see Table 17.5). It is estimated that London Heathrow Airport produces 110,000 tonnes of solid waste every year, a figure equivalent to the volume of waste generated by all the households in a typical London Borough over the same period (Heathrow Airport 2012).

Sources of waste can be divided into five main areas; airside, terminal, landside, infrastructure development and in-flight operations. Airport operators will, typically, have

Table 17.4 Summary of water management issues at airports

- Main sources of water consumption
- Potable (drinking) water
- Catering and retail operations
- Cleaning
- Toilets and hand basins
- Airfield and terminal maintenance

- Areas requiring monitoring and management
- Airfield and terminal hard surfaces and run-off
- Aircraft maintenance and ground handling
- Washing aircraft on stand
- Airfield maintenance
- Winter operations and de-icing
- Fire service training

Table 17.5 Summary of waste management sources and managerial responsibilities

Source	*Managerial responsibility*	*Example types of waste*
Airside	Airport operator Airline/service provider	Foreign object debris (FOD) Green waste from airfield operations Hazardous waste such as oil/hydraulic fluid
Terminal	Airport operator	Office waste Security operations (including discarded personal items and obsolete screening equipment) Packaging Food/catering Retail Human waste Check-in operations
Landside	Airport operator and individual ground transport service providers	Retail Food/catering Ground transport
Infrastructure development	Third-party contractor	Construction Inert/hardcore
In-flight operations	Airline/service provider	Food/catering Newspapers and magazines Human waste Retail

greater managerial control over waste derived from office administration, engineering and security operations, as well as green waste from airfield maintenance (such as grass clippings). In contrast, airlines and other service providers will be responsible for the waste generated from in-flight catering, cleaning and retail activities. International regulations mean that it can be difficult or illegal to recycle certain types of waste. For example, food waste from international flights arriving in the UK has to go to deep landfill rather than being composted in case it is contaminated with foreign pathogens or pests.

Stop and think

Why is airport waste management such a complex issue?

Biodiversity and landscape and visual impacts

Airports are intentionally designed to be unattractive to animal and bird life for safety reasons. However, due to the nature of airport operations and the need for large areas of land, they are often situated in areas of ecological value. It is important that assessment and monitoring programmes are used to safeguard the airfield from incursions of animals or birds which may endanger aircraft safety. Aerodrome safeguarding (➤Chapter 3) must also consider the impacts on adjacent habitats. Land and ecological management also extends beyond the airport perimeter, and airport operators have to work closely with local landowners and farmers in this regard. Airport development or expansion can also impact on the local landscape character and affect local views and the visual impact, including the loss of trees or woodland.

Archaeology and cultural heritage

The development or expansion of an airport can impact on local archaeology or affect a local building or monument of cultural heritage and importance. The airport operator needs to consider surveys and investigations to assess the importance of such sites, which may be costly and delay a development scheme.

17.5 Environmental mitigation strategies

Airlines, airport operators, aircraft manufacturers, air navigation and ATC service providers and regulators all have an important role to play in mitigating the environmental impacts of air transport. As well as having clear environmental benefits, effective strategies, together with a range of policies, programmes and measures, should also enable improved anticipation and response to environmental issues and constraints, limit environmental liabilities and maximise any potential advantages or commercial opportunities. Environmental mitigation strategies can be broadly split between technological innovations, improved management, monitoring and operational practices, alternative fuel sources, and societal and community relations. These are considered in terms of both aircraft and airport operations and are applicable for tackling environmental issues at both the global and local level.

Technological innovations

Progressive advances in aircraft design technology have made aircraft quieter and more fuel efficient (see Table 17.6). Air transport is now a technologically 'mature' industry and future developments are likely to be incremental rather than revolutionary.

Table 17.6 Summary of aircraft-based technological innovations

Area	*Explanation*
Materials	Carbon-fibre composites, formed from carbon fibres set in a protective matrix of epoxy resin, are used extensively in modern aircraft. The Boeing 787 is the first commercial passenger aircraft to have a fuselage constructed entirely of composite fibre. A new composite material, currently under development, is glass fibre reinforced aluminium. This is reported to be 25% stronger than conventional airframe grade aluminium, and 20% lighter. Aside from the high cost of development, possible drawbacks include increased costs of maintenance and repairs, and safety considerations around spotting potential failures.
Engine and propulsion systems	While incremental changes in current engine technology is possible, there are some proposals for the adoption of a new generation of open rotor or propfan engines (similar to those used in early aircraft engines). While it is estimated that these could achieve fuel savings of up to 30%, they are generally noisier and slower than present jet engines. There are also safety issues to consider, as a failure could theoretically lead to blades striking the fuselage.
Aircraft design and airframe configuration	Improving the aerodynamic efficiency of the airframe by reducing drag is a fundamental aspect of aircraft design. Modern aircraft design and configuration has changed relatively little over the past 50–60 years; with a narrow fuselage, under-wing mounted turbofan engines and swept-back wings predominating. Possible alternatives include blended and strut-based wings. Unlike standard aircraft, the wings of blended-wing aircraft are incorporated into the main structure of the aircraft, resembling a delta wing when viewed from above. Strut-based wings involve a supporting strut being fitted between the wing and the fuselage. This allows the wings to be lighter and longer, which increases the lifting area of the wing. However, radical developments like this are expensive to develop, and practical issues such as cabin space, passenger acceptance and aircraft stability must be considered. A shorter-term solution may include the addition of raked wingtips or wingtip fences. These are installed at the end of the wings to smooth the interface between the turbulent airflows above and below the wings, to help reduce drag. It is often possible to retrofit them onto existing aircraft.
Other technology	A further wing-based innovation is laminar flow control. Laminar flow describes the layer of air that passes over the wings and fuselage. The smoother the layer of air, the lower the drag and fuel burn. Laminar flow control works by detecting and then sucking turbulent air into the airframe, via thousands of tiny holes, thus 'smoothing' the airflow. It is estimated that this can reduce drag by up to 20% and result in fuel savings of 10%. However, the cost of developing and implementing such systems presently outweighs the potential benefits of them.

Technological innovation can also play an important role for airport operators. For example, advanced or 'smart' energy monitoring and control systems have been introduced at a number of airports to control heating and lighting systems. Such systems also allow escalators and walkways to operate 'on demand', rather than continually throughout the day or night. For on-site energy generation, the use of photovoltaic (or solar) panels or aero-generators (including wind turbines, where appropriate in terms of potential impacts on radar systems, e.g. East Midlands Airport in the UK) is also becoming increasingly common. Glycol-based de-icing fluids are widely used for removing snow and ice from aircraft, although they pose an environmental problem if they are allowed to reach surface or groundwater sources. An alternative, albeit expensive, option is for airport operators to consult infrared de-icing systems. These systems are carefully calibrated so that the infrared waves used for the de-icing process only heat the snow and ice, and not the airframe itself.

While the benefits of technologically driven strategies can, in some cases, be significant, the air transport industry can be resistant to change unless technologies can be slotted into existing systems or supply chains. **Technological 'lock-in'** represents a significant obstacle to wider adoption of innovative technologies for the air transport industry. More generally, it is important that technology is not relied upon as a 'quick fix' to environmental problems or used as a means to absolve the responsibility of decision makers for implementing robust strategies and policy measures.

Technological 'lock-in': the process whereby prevailing social and/or economic systems create barriers to technological change and innovation. This can occur where a particular product is dominant within a market and decision-makers are influenced by its market power rather than by its inherent qualities or value. This situation may be reinforced further by positive feedback loops, such as improved economies of scale of production, learning effects and infrastructure availability, which collectively act to prohibit the adoption new technologies or practices.

Management, monitoring and operations

Environmental management, monitoring and operational processes are deeply embedded within the business strategies of most air transport providers. While it is true that growing public and political pressure and increasing legislation have stimulated the industry to pay closer attention to environmental mitigation, business leaders and decision makers are also recognising the potential competitive and financial advantages that can be accrued from more efficient resource management.

Environmental management systems (EMSs) have been widely adopted to provide terms of reference to ensure coordinated responses to a range of environmental issues. Each EMS includes a range of specific objectives and targets and will typically operate on a rolling basis over a set period of time. An example of an EMS is the 'waste hierarchy' (see Example 17.2), which is widely adopted by airport operators to manage waste.

Stop and think

What are the challenges of relying solely on technology to address air transport's environmental impacts?

Example 17.2

The waste hierarchy: an example of an EMS

Air transport operations can generate large volumes of waste. Typically, much of the responsibility for managing this waste falls on the airport operator (see Table 17.4), and many adhere to what is commonly referred to as the 'waste hierarchy'. This outlines, in order of environmental preference, the priorities for how waste should be managed.

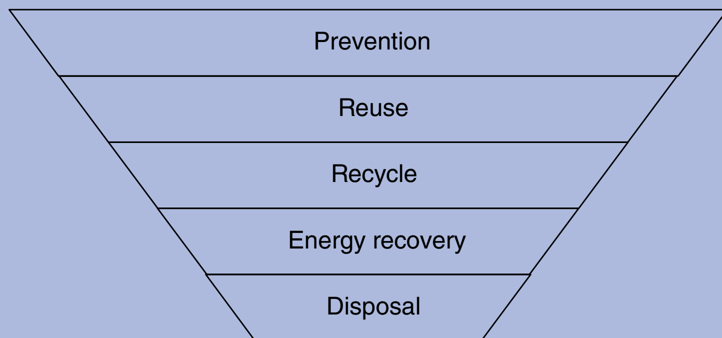

Figure 17.1 The waste hierarchy

Airport operators will aim to prevent the creation of waste at source, for example through bulk purchasing of materials to minimise packaging waste. Where waste generation is unavoidable, the reuse, recycling or recovery of energy from waste is preferable to waste disposal, which has environmental and financial cost implications. Objectives and targets for waste management can be agreed by the airport operator and related stakeholders. London Heathrow Airport aims to recycle 70 per cent of airport waste by 2020 (Heathrow Airport 2014). The integrated nature of air transport operations, and the large number of stakeholders involved, means that it is important that environmental management systems receive full buy-in from all the parties involved in the process, with mechanisms for effective communication and collaborative decision-making established from the outset.

Where an airport operator is considering a development scheme or expansion, it may be required to conduct an environmental impact assessment (EIA) as part of the planning approval process. EIAs are widely used to identify the likely environmental impacts of a development scheme or expansion project on local biodiversity. From this, a range of mitigation measures and policies around biodiversity issues may be necessary. For example, in the development of an airport or its expansion, as part of the EIA process and assessment of the proposed developments, impacts on local biodiversity and flora and fauna will need to be made. From this, a range of mitigation measures and policies may be necessary. While perimeter fencing is used to prevent animals getting onto the airfield and bird management programmes are used to deter and scare birds, other mitigation measures may be necessary in terms of wildlife relocation, conservation programmes or habitat recreation.

Stop and think

What is the difference between an EMS and an EIA, and how can they be used to mitigate the environmental effects of air transport?

Formal approval of EMSs can be sought by conforming to the International Environmental Management System standard ISO 14001. This is an internationally recognised standard which requires an organisation to effectively manage its environmental impacts via commitments to reduce pollution, comply with legislation and show continual improvement. In 2002, East Midlands Airport was the first airport in the UK to achieve ISO 14001 certification for its EMS. In addition to formulating an environmental policy and setting targets and objectives, one of the key aspects of achieving ISO 14001 accreditation is ensuring that a range of appropriate metrics and measures are used, so that progress can be monitored through time. Ideally, these metrics need to be simple and easy to replicate and understand, with the ability to help identify trends over time. However, it is often the case that different parties will adopt their own specific metrics or will collect data using contrasting methods or varying timescales. This can make comparisons of environmental performance between different sites or areas of the air transport industry very challenging.

Establishing reliable and replicable monitoring regimes inevitably represents a vital component of both EMSs and EIAs. In Europe, large airports place considerable importance on their noise monitoring procedures as they are required to prepare and submit noise action plans for government approval under the EU Environmental Noise Directive (European Commission 2002). Flight-track monitoring of arrival/departure profiles is widely used to develop and enforce noise preferential routes (NPRs) (➤Chapter 13) which route aircraft away from densely populated areas to minimise noise disturbance. Penalties or fines are administered to airlines that do not comply with the NPRs and the proceeds may then be used for soundproofing nearby homes or other community projects. Noise-monitoring equipment is also used to calculate noise contours and help enforce noise limits. These are also used to help establish and enforce operating restrictions at airports for different types of aircraft or during particular times of the day or night.

As with noise mitigation measures, it is important that airlines, airports and other related stakeholders work closely to reduce emissions and maintain air quality. In some instances, mitigation strategies may represent a 'win-win', whereby both noise and emissions are reduced. Examples of these strategies include the implementation of single engine or reduced engine taxiing by aircraft on the ground, or the replacement of old, diesel powered ground vehicles with newer electric or hybrid models. Improved management and monitoring procedures should, ideally, go hand in hand with enhancements to operational procedures. One area where there is particular scope for improvement relates to air traffic control (ATC) (➤Chapter 13).

Fuel burn and emissions can also be reduced by adopting the following mitigation/abatement procedures:

- Avoid queuing aircraft in the air or on the ground, where possible.
- Reduce the use of auxiliary power units (APUs) when aircraft are on the ground and use fixed electrical ground power (FEGP) instead.
- Regularly wash airframes and engines and ensure aircraft are efficiently maintained.
- Single-engine taxi.

Alternative fuels

Biofuel: fuel derived from renewable biological feedstocks.

The potential for alternative fuels such as **biofuels** or solar power to complement or replace traditional jet fuel has increased significantly in the past decade, and a number of successful test flights have been performed. As well as having potential environmental benefits, alternative fuels have the added benefit of reducing reliance on expensive, unpredictable and finite oil reserves.

Before biofuels can be used, they must satisfy a number of vital criteria. They must:

- be compatible with conventional jet fuel and use the same infrastructure and supply lines;
- not require adaptation to existing aircraft or engines;
- meet or exceed the specification of conventional jet fuel, in terms of its high energy content and freezing point;
- lead to lifecycle carbon reductions, require little use of fresh water and not compete with other land uses.

Biofuels are less carbon intensive than jet fuel. This is because feedstocks absorb CO_2 as they grow, which acts to offset the carbon released when they are eventually burnt. While not entirely carbon neutral (CO_2 is emitted during refining and transport to markets), the lifecycle of biofuels is cyclical and renewable, unlike conventional fuels (see Figure 17.2).

There are also a number of non-biofuel alternatives for traditional jet fuel. Possible options include exploiting the substantial methane clathrate reserves residing in deep oceans (essentially crystalline structures containing high volumes of methane), although it is unclear whether doing so would have other climatic impacts. Hydrogen has also been suggested as a possible longer-term alternative fuel source, although it is likely that the high volumes of cryogenic hydrogen that would be required to power an aircraft would necessitate the design of new airframes, which would, inevitably, prove to be an expensive process. Further non-biofuel options include conversion of alcohol to jet fuel (ATJ), the creation of synthetic kerosene and electrical or solar powered aircraft.

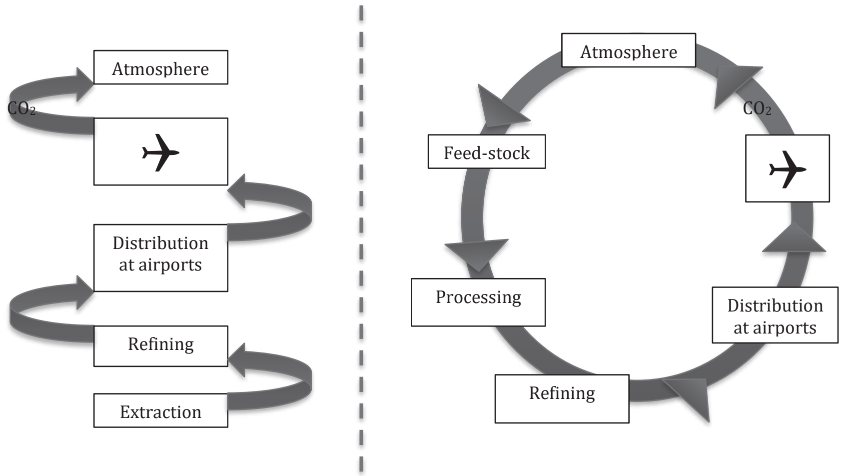

Figure 17.2 Comparative carbon lifecycles of fossil fuels and biofuels

In many respects, the challenges associated with alternative fuels are similar to those relating to innovative technological solutions. While these fuels are technically feasible, there are often commercial and political barriers that need to be overcome before they can enter widespread use. Currently, demand for alternative fuels is relatively low, largely because their adoption involves significantly greater expense and levels of capital investment than using traditional fuel. Incentives may have an important role to play in fostering greater investment in alternative fuel development and increasing production capacity.

Stop and think

What challenges need to be overcome before biofuels can replace conventional jet fuel?

Societal and community relations

Local and formal public meetings can be useful by way of promoting dialogue between airports, airlines and local communities. There need to be formal processes through which local residents can articulate concerns or complaints about noise or other impacts. Local residents immediately under the approach for an airport may also incur damage to their properties from aircraft wake vortices, where airport operators need to have procedures in place to investigate damage and make repairs if required. In the UK, Birmingham, London Heathrow and Manchester airports operate wake vortex repair and roof protection schemes for local residents.

17.6 Environmental policy assessment

Environmental policies can be broadly defined into one of three categories (see Daley and Preston 2009):

- regulatory approaches;
- market-based measures;
- voluntary schemes.

Regulatory approaches describe a broad set of policy instruments that seek to control behaviour via the implementation of laws, regulations or standards, as set by government, regional/local government or a regulatory body. Compliance is generally compulsory, with non-compliance often penalised via some form of legal sanction or fines and financial penalties.

Market-based measures describe economic instruments that provide financial incentives or disincentives to behave in certain ways, with compliance being either mandatory or voluntary, depending on the measure in question. These include the use of taxes, emission charges, subsidies or tradable permits.

Voluntary schemes, by their very nature, are neither enforceable nor provide defined economic incentives/disincentives for compliance. Instead, they depend on self-regulation and awareness of shared responsibilities towards key environmental issues (see Table 17.7).

Regulatory approaches

Environmental regulation involves a regulatory body, such as a government agency or department, defining a set of standards concerning a particular issue and, then, putting in place mechanisms for monitoring and evaluating subsequent performance against those standards. If standards are not met, then processes are usually put in place to sanction the perpetrator appropriately. For example, ICAO is responsible for the environmental regulation of international commercial aviation. Particular focus is given to the regulation of aircraft noise and the impact of harmful emissions. Consequently, all aircraft have to meet

Table 17.7 Environmental policies

	Regulatory approaches	Market-based approaches	Voluntary measures
Compliance	Mandatory	Usually mandatory, but some approaches act as voluntary incentives (e.g. subsidies)	Voluntary
Enforceable	Yes, usually via sanctions, fines or penalties	Yes, with the exception of subsidies	No
Examples	ICAO noise and emissions certification standards	Air Passenger Duty EU Emissions Trading System	Carbon offsetting Airport Carbon Accreditation

stringent ICAO certification standards for noise and emissions before they are allowed to operate. Other examples where environmental regulation may be used, include ambient air quality or management of storm water run-off and drainage.

National governments can also introduce legislation, regulations and directions/ directives/orders in terms of environmental impact issues which may affect air transport, while regional or local government (as the planning authority) can introduce measures through the planning process, with planning conditions and obligations concerning environmental impact issues incorporated as part of planning approval for airport development or expansion projects.

While regulatory standards may appear fairly straightforward to implement, there are a number of potential issues that require consideration. A key question relates to the ability of regulators to define and agree the level at which standards should be set. This may be especially problematic where levels of scientific understanding are disputed or incomplete, as is the case with issues such as climate change. Additionally, difficulties may arise involving what is considered 'acceptable' or 'tolerable' with regards to certain issues. For example, considerable disparities may exist between what is considered an 'acceptable' level of noise from a scientific or medical standpoint, with what is considered tolerable by communities who live and work near airports. Further issues may arise from the difficulty of enforcement of standards in different regulatory regimes, as well as the ability of regulatory bodies to monitor and then meaningfully enforce standards. This can be especially challenging when having to deal with multisource, widespread and/or long-term factors, such as levels of atmospheric CO_2. In cases such as this there may be very real practical difficulties associated with monitoring and enforcement. Notwithstanding these potential problems, regulatory measures will remain a key part of environmental policy in air transport for the foreseeable future, with the possible introduction of emission caps or stringent emission reductions targets.

In the planning process, there will be negotiations between the planning authority, where it represents the interests of local communities and local residents and those affected by environmental impact issues, and the airport operator proposing an airport development or expansion. In terms of a planning decision, the negotiations will need to balance the value of the proposed development or expansion (in terms of issues such as need, demand for air travel, forecasts, economic impact, supporting economic growth and employment) with the potential environmental impact (across a range of environmental issues, as identified though an environmental impact assessment) and the need for development control or mitigation, where planning approval can be granted in return for planning conditions and obligations on the proposed development or expansion.

Market-based measures

Market-based approaches describe the use of economic instruments for incentivising or discouraging certain actions. Participation or compliance may be compulsory or voluntary, depending on the approach used.

One such market-based approach concerns environmental taxation. This follows the 'polluter pays principle', where polluters are charged for the environmental impact they cause. Compliance is generally compulsory. Given aviation's reliance on kerosene and its sensitivity to price fluctuations, the introduction of fuel taxation has long been suggested as a means of addressing the air transport industry's environmental externalities. Aviation is unusual in that the fuel used for international air travel is exempt from tax, and only a small number of countries impose taxes on fuel for domestic air travel. This is principally a legacy of the Chicago Convention 1944 (➤Chapter 1), which enshrined fuel tax exemption for air travel into international law. While there have been concerted efforts to re-address this situation, there remain significant obstacles relating to the creation of the necessary legal framework, the renegotiation of existing bilateral air service agreements between nations and the need to ensure that taxes are applied universally and uniformly to enable fair and equitable implementation.

An alternative to taxation is direct emission charging. This is where polluters are charged according to the level of emissions they generate. While emission charges are, in some respects, similar to taxation, by charging polluters according to their level of emissions, rather than their fuel use, the former may avoid some of the considerable legal barriers concerning taxation on fuel. If charges are applied on a per route basis, rather than on a per country or region basis, then it could also reduce possible incentives for airlines to selectively purchase fuel in areas where fuel taxation is lower. This practice, known as 'tankering', increases fuel burn and emissions as aircraft are heavier on account of flying with more fuel than is necessary for the flight.

An example of a non-fuel-based aviation tax is UK Air Passenger Duty (APD). This is levied on all passengers travelling from airports in the UK on aircraft with a take-off weight of 10 tonnes or more than 20 seats (HMRC 2014). While it has been claimed that APD could lead to a reduction in emissions via the hypothecation (or 'ring-fencing') of revenue for environmental mitigation, APD has been criticised as being an air travel tax (Cairns and Newson 2006).

Subsidies may also be used as a way to encourage the adoption of pro-environmental corporate policies and/or as a means to reduce the financial burden for companies obligated to comply with new regulations. For example, favourable loans or tax allowances may be introduced to encourage increased development of alternative fuel sources, the purchasing of more fuel-efficient aircraft or the implementation of certain strategies such as in-flight recycling. While subsidies may be easier to implement than regulatory or market-based instruments, and generally do not require any enforcement, it is important that they are only used selectively, in order to avoid the potential for distorting the market or artificially suppressing competition. Subsidies are, arguably, less successful when they are relied upon as the status quo, rather than offered as a finite incentive.

Tradable permits are another market-based approach. These provide financial incentives for participants to reduce their environmental impacts through the creation of specialised markets, which work by assigning monetary values to particular pollutants. Each permit represents a licence (or allowance) for the polluter to produce a certain quantity of pollution. The total number of permits in any region/market is capped, according to an agreed overall level, and they are then distributed among the various polluters, either freely or via auction. At the commencement of trading, polluters are then able to buy or sell permits, depending on whether they are operating at an emissions surplus or shortfall. This creates incentives for the polluters to improve their environmental performance, to free up permits, which they can then sell for financial gain. If a company is unable to submit sufficient permits at the end of each year to cover its emissions, then a fine is imposed. This type of tradable permit scheme is also commonly referred to as a 'cap-and-trade' system. The success of such schemes depends on the ability to maintain a sufficiently high and stable price for permits, which provide incentives for companies to undertake environmental mitigation strategies and invest in lower carbon technology. The EU's Emissions Trading System (ETS) is an example of a cap-and-trade system (see Case Study 17.1).

CASE STUDY 17.1

THE EU ETS

The EU ETS is perhaps the most well-known example of a tradable permit scheme. It was established in 2005 and is currently the largest emissions trading scheme worldwide, and the only one that crosses international borders. It incorporates a range of industries, including the energy, mineral and paper industries and currently accounts for around 50 per cent of EU carbon emissions. The European Parliament decided that aviation would join the EU ETS in 2012 as part of 'Phase 2' of the programme. However, aviation's inclusion in the scheme was met with opposition from some non-EU countries.

Voluntary schemes

Voluntary schemes are environmental policies that are subject to neither direct regulatory control nor explicit economic incentives, but instead rely on organisations and individuals taking the initiative to adopt strategies for addressing environmental concerns under their own volition. While this approach may appear to be wishful thinking, especially in an industry as competitive as air transport, there are a number of reasons why voluntary measures may be attractive. Possible benefits may include greater cooperation with decision makers and, by association, greater influence over the wider regulatory process. Voluntary measures may be adopted early by organisations, in anticipation of future regulatory or market-based measures being introduced at a later date, with a view to providing 'first mover advantage', while there may also be 'peer pressure' from competitors to introduce such measures.

Voluntary measures may be adopted to promote corporate social responsibility or a 'green' brand image, especially if this is perceived to be an important factor for particular customers or investors. However, there is only limited evidence suggesting that an airport's or airline's environmental credentials are key factors in passenger choice. Other potential limitations include the use of vague or overly aspirational agreements, or where there is monitoring of progress and such monitoring is handled internally, rather than being subject to more rigorous external verification.

A well-known example of a voluntary environmental measure is carbon offsetting. This involves passengers (and, in some cases, companies and governments) voluntarily purchasing carbon offsets equivalent to their personal carbon or greenhouse gas emissions. This process is undertaken online, using dedicated carbon offsetting websites or as an additional part of the booking process. The money raised is invested in renewable energy, forestry or resource conservation projects that seek to reduce (i.e. offset) levels of carbon and greenhouse gas emissions in the atmosphere. While popular in the mid- to late 2000s, the popularity of voluntary carbon offsetting has declined, arguably as a result of criticism about the legitimacy and credibility of the process. A key concern relates to the view that carbon offsetting does not, in itself, address the environmental problems associated with air transport and, to some extent, has been used to absolve the responsibility of the polluter. Other issues concerned the difficulty of accurately calculating the emissions and agreeing how they were charged, as well as concerns about the lack of regulation and possible unintended impacts of offsetting schemes.

A more recent example of a voluntary environmental measure is the Airport Carbon Accreditation programme, which was launched in 2009 by Airports Council International (ACI). It provides a programme for airports to reduce carbon emissions and address environmental issues. There are four stages for attaining full accreditation (see Table 17.8).

Table 17.8 Airport Carbon Accreditation process

Stage	*Description*	*Example requirements*
Stage 1	Mapping	Determine the operational boundary of the airport and the sources of Scope 1 and Scope 2 emissions. Collect data and calculate the annual carbon emissions from these sources for the previous year. Engage an independent third party to verify the report.
Stage 2	Reduction	Completion of Stage 1. Evidence of target setting and carbon reduction over consecutive years. Ensure a senior committee/body has responsibility for environmental issues. Communicate emissions performance to relevant stakeholders. Conduct environmental training programmes for staff.
Stage 3	Optimisation	Completion of Stages 1 and 2. Widen scope of carbon footprint to include Scope 3 emissions (e.g. including landing and take-off cycles and ground access). A clear implementation plan for stakeholder engagement, including proposed actions and timings. Implementation of awareness and behavioural change initiatives, to raise the profile of energy efficiency and low carbon practices. Building-in carbon and energy considerations into existing third-party lease and contractual conditions.
Stage 3+	Neutrality	Completion of Stages 1, 2 and 3. Offsetting of remaining Scope 1 and Scope 2 emissions, using recognised offsetting instruments.

Source: ACI (2014)

The number of airports participating in the Airport Carbon Accreditation programme has risen from 17 in 2009 to 116 in 2015 (90 in Europe, 22 in Asia, two in North America, one in Latin America and one in Africa). All 19 of those achieving the highest level of accreditation are located in Europe.

Stop and think

What are the relative merits of regulatory, market-based and voluntary approaches in addressing air transport's environmental impact?

Key points

- Addressing the complex and interrelated environmental impacts of air transport represents one of the key challenges facing the industry.
- Aviation's environmental effects range from climate change at the global level to concerns about noise, air quality, drainage and water quality and other factors at the local level.
- A range of mitigation strategies, including technological innovations, management, monitoring and operational changes, and alternative fuel sources, have been proposed as a way to mitigate aviation's environmental impacts.
- While these measures each hold the potential to facilitate positive change in their own right, their benefits are likely to be felt most when (or if) they are implemented in a coherent and cohesive fashion across the air transport industry.
- There is a need for an integrated policy approach that draws on a range of different instruments and is consistent with wider economic, societal and environmental sustainability objectives.

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CHAPTER 18

Human resource management and industrial relations

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LEARNING OUTCOMES

- To understand the importance of effective human resource management (HRM) and industrial relations (IR) strategies for airlines.
- To appreciate why people management is a difficult task.
- To be aware of key developments in the industry over the last 20 years, specifically legislative change and industry crises, and evaluate their impacts on the nature of work within the airline industry.
- To assess the prevailing model of employment relations in European airlines.
- To evaluate the sustainability of different systems of employment relations in civil aviation.

18.0 Introduction

The global air transport industry directly employs 8.7 million people and supports a further 49.4 million jobs (ATAG 2014). Civil aviation is a service industry and many airline employees, including cabin crew and ground staff, are front-line service sector workers. Effective people management is crucial to the success of airlines, irrespective of whether they adhere to a full-service or a low-cost business model (➤Chapter 7). Full service network carriers (FSNCs) that compete on service quality require a high level of customer service from their staff, whereas operators that compete on price require high levels of productivity and efficiency from their staff (see Section 18.1). Consequently, airlines have experimented with a range of people management strategies. Some of these have been enduringly successful and have enabled certain carriers, including Southwest Airlines in the US, to secure and maintain an enviable competitive advantage. Other airlines which have adopted a different approach to people management have been less successful in the long term.

This chapter describes four interconnected factors inherent to airline operations that illustrate the importance of effective people management:

1 the cyclical demand for air transport;
2 the perishability of the airline product;
3 the proportion and pliancy (flexibility) of labour costs; and
4 the importance of employee performance and productivity.

Critical events that have impacted on the industry and affected people management over recent decades are then identified. Recent developments in civil aviation and the prevailing ‘low road’ trend in employment relations on people management are examined, before the implications of the alternative ‘high road’ system of employment relations pursued by Southwest Airlines and other carriers is considered.

18.1 People management in the airline industry

People management is incredibly important since employees enable an airline to deliver its service. People are at the heart of airline differentiation strategies – staff provide high levels of customer service at FSNCs and staff are also central to the low-cost model because high staff productivity at low-cost carriers (LCCs) reduces unit costs and enables these savings to be passed onto consumers in the form of lower fares. However, employment relations strategies are also complicated by factors that are peculiar to civil aviation.

Cyclical demand

Demand for air transportation (expressed as revenue passenger kilometres (RPKs)) is cyclical (Figure 18.1) and is linked to fluctuations in economic growth (expressed by gross domestic product (GDP)), with demand increasing or decreasing as GDP grows or contracts, but at a much faster rate (➤Chapter 2). Business class travel is especially sensitive to economic fluctuations because firms are less inclined to spend scarce financial resources on the premium charged for service and comfort by FSNCs. This has a disproportionate impact on full-service airlines’ revenue and profitability.

The cyclical nature of air transport demand can lead to the expectations of management and labour being out of sync with one another with respect to current and future market conditions. When an airline experiences a downturn in demand, costs will be controlled more tightly and employees may be expected to make greater concessions such as accepting a pay freeze, pay cuts or the suspension of staff travel allowances. However, when demand returns, airline managers are typically cautious and, anticipating the next downturn in an

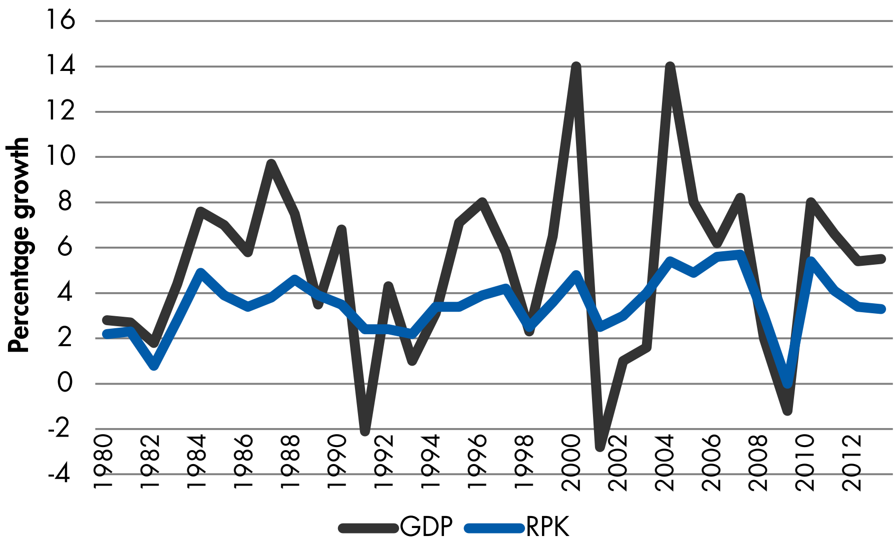

Figure 18.1 The cyclical demand for air transport

Source: International Monetary Fund (global GDP) and Airlines for America (global RPK)

increasingly competitive environment, are unlikely to reciprocate (at least in the short-term) with improved terms and conditions of employment. Employees, in contrast, expect concessions to be lifted and improvements in terms and conditions to reflect the prosperity of the airline, which seems evident to front-line staff who handle more passengers. This mismatch in perception is highly problematic, particularly at the peak of the business cycle when employee expectations are still rising but airline management foresee or face falling demand or a decline in advance bookings.

The LCCs that emerged as a result of deregulation of the US domestic airline industry in the late 1970s and the single European aviation market in the 1990s have a much greater seasonal (cyclical) variation in demand to accommodate. For LCCs, passengers visiting friends and relatives and leisure travellers remain important customer segments, despite the efforts of some more established low-cost operators to attract business customers (➤Chapter 9). Consequently, LCCs experience a spike in demand in the summer months and encounter a more pronounced trough in the winter in comparison to most full-service airlines. As a result, LCCs employ many flight and cabin crew on short-term seasonal or temporary contracts who may be recruited through an agency rather than being directly employed by the airline, and many ground services such as ground handling, catering, fuelling and check-in are subcontracted to third parties to reduce costs (see Harvey and Turnbull 2012, 2014).

Perishability

An airline's seat inventory is a perishable commodity as carriers cannot stockpile seats on cancelled flights for use on another occasion. Flight cancellations have an immediate and direct impact on an airline's performance, and so industrial action taken by airline employees can be highly detrimental to the company's reputation and profitability. Industrial action by Lufthansa and Air France pilots in 2014, for example, cost the airlines an estimated €174 million and €500 million, respectively. Even the threat of a strike can lead to a loss of revenue as passengers transfer to other airlines to avoid any possible disruption or inconvenience to their journeys. In this context, the cooperation and the consent of the workforce are paramount: disgruntled staff are bad for customer service, while disruptive staff are disastrous for the bottom line.

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Stop and think

Why is the financial cost of industrial action so high?

Proportion and pliancy of labour costs

Traditionally, labour costs have amounted to a sizeable proportion of an airline's operating costs. For most legacy (full-service) airlines, labour typically accounts for around one-third of total costs. Pilots are especially well paid (around £90,000 a year on average, which, according to the Office for National Statistics, puts them among the highest paid workers in the UK). Legacy carrier cadet pilot schemes only accept a small number of applicants each year and some pilots start their careers with debts of up to £100,000 and no guarantee of employment once their training ends. In addition, some airlines expect their new first officers to pay for their type-rate training, which can increase their debts by another £20,000 or more.

Unlike fuel, landing charges, aircraft and many other capital costs, labour costs are one of the few pliable costs over which airline management exerts a level of control. This is not to suggest that savings elsewhere cannot be achieved. For example, deals can be negotiated with airports to reduce or subsidise landing charges (➤Chapter 5), bulk purchasing aircraft may attract a reduction from aircraft manufacturers and airlines might negotiate advantageous fuel hedge contracts (➤Chapter 11). Nonetheless, most operating costs are (quasi-)fixed, at least in the short term. Thus, airline cost-cutting initiatives invariably focus on labour (see Harvey and Turnbull 2009). It is unsurprising, then, that the figure for labour costs as a percentage of total operating costs has diminished in recent years in the US, Europe and Asia-Pacific. LCCs are leaders on this metric, with labour costs accounting for less than 10 per cent of revenue at Vueling and Ryanair, and less than 13 per cent at easyJet, compared to almost 24 per cent at International Airlines Group (IAG), which includes British Airways, Iberia and Vueling.

Performance and productivity

There is a very clear relationship between employee performance and the competitive advantage of airlines. Employees at full service (legacy) airlines that compete on the basis of service quality are responsible for personifying the brand and delivering a distinctive level of service (LOS). Employee productivity, on the other hand, is a common indicator of airline cost-effectiveness. On this metric, the difference between the FSNCs and LCCs is clear. Data from airline financial statements for 2012 compiled by the CAPA Centre for Aviation illustrates the sheer size of this particular 'performance gap': the operating profit per employee at Ryanair (€80,943) was more than ten times that of British Airways (€8,030).

An important dimension of an airline's strategy for enhancing employee performance and productivity is its relationship, or lack thereof, with trade unions that represent workers in the industry. In the UK, many airlines formally recognise **trade unions** for the purposes of collective bargaining – the process through which the terms and conditions of work are determined. However, management at some airlines have opposed trade union participation in the decision-making processes (see Harvey and Turnbull 2015; Gunnigle and O'Sullivan 2009).

Trade union: an organisation that is independent of the company it negotiates with over the terms and conditions of its members employed therein. Its primary purpose is to represent the interests of its members.

18.2 Liberalisation, industry crises and LCCs

Labour costs and productivity became even more important following the liberalisation of the civil aviation industry and two major industry crises at the start of the new millennium. Prior to liberalisation, air transportation was organised according to bilateral agreements between governments (➤Chapter 1). These agreements specified the airlines that could fly particular routes and the tariffs they could charge. Bilateral agreements effectively prevented price competition and restricted market entry. Liberalisation made for a more volatile and dynamic aviation market wherein extant airline restructuring and the employment contracts offered by the new entrants invariably and detrimentally impacted on labour. Management teams at full-service airlines were presented with both the motive and the opportunity to exploit the pliancy of labour costs and seek concessions from staff in order to meet the challenge of the new competitive environment (see Blyton *et al.* 1998). Moreover, an enduring strategic aim of the FSNCs is service quality differentiation, and so alongside initiatives to reduce the cost of labour, many legacy airlines have also sought performance increments, or intensified **emotional labour**, from their staff. In part, the new entrant airlines sought cost savings they would pass onto their customers by employing staff on inferior terms and conditions. The productivity of staff at the new entrant LCCs gives these airlines a competitive (price) advantage and much higher profits.

Emotional labour: the management of emotions in line with commercial requirements in order to engender a positive customer experience and benefit the organisation.

Stop and think

Why are staff costs at LCCs typically much lower than those of FSNCs?

An important innovation that is intrinsically linked with the LCC business model, and one that has direct consequences for employment in the airline industry, is subcontracting. Stelios Haji-Ioannou, the founder of easyJet, explained that his company believes 'relationships with entrepreneurial companies out there to make a profit are more efficient than having a bunch of employees yourself' (quoted by Sull 1999: 25). This innovation has been adopted and adapted to a varying extent, and in different ways, by FSNCs. British

Airways, for example, faced considerable resistance from its employees when the 'virtual airline' model was proposed in the mid-1990s as part of the Business Efficiency Programme, whereby the airline would retain only central functions and operate aircraft supplied and staffed under wet lease arrangements with other airlines (➤Chapter 11). Following the proposals, members of the British Airline Pilots' Association (BALPA) threatened to strike in 1996, while their cabin crew colleagues, who were members of the British Air Stewards and Stewardesses Association (BASSA) took industrial action in the following year. The airline had successfully detached elements of its non-core business on franchise agreements with other firms (not necessarily airlines), enabling the airline to operate with 'much lower costs, minimal investment, and fewer objections from the competition authorities' (Blyton *et al.* 1998: 11). The airline also succeeded in a degree of disintegration, which is at the heart of the virtual airline model, by outsourcing activities such as catering, vehicle management, and maintenance and ticket services.

Following considerable growth in demand for air transport in the early 1990s, demand decreased significantly from 1995 onwards and had not recovered when the 11 September 2001 terrorist attacks on the US exacerbated what had been a very difficult period for many airlines (see Figure 18.1). While the consequences of 9/11 were highly detrimental for FSNCs, the crisis also served as an opportunity to introduce significant cost-reduction measures that led to accusations of opportunism from many aviation trade unions (Harvey and Turnbull 2012). However, according to the director general and CEO of IATA at the time, the airline industry was ill-prepared to deal with even a mild economic downturn. Post-crisis cost-reduction measures invariably focused on labour.

Analysis of airlines' response to the crisis revealed that many airlines across the globe, especially in liberal market economies such as the US and UK, moved quickly to reduce labour costs by offering voluntary redundancy to (and imposing compulsory redundancy on) staff, alongside voluntary and compulsory furlough (the requirement that staff take unpaid leave). In Europe and Asia-Pacific, cost reduction initiatives also impacted severely on junior and temporary workers, as there was widespread non-renewal of temporary contracts and probationary staff not being transferred onto full-time contracts. These measures, taken in response to the crisis, whether they reflected necessity or opportunism, were to have a profound impact on employment relations at many airlines. The response to the crisis served to increase tensions between labour and management, lower trust between both parties and provided the backdrop for future conflict. A dispute that resulted in strike action by ground services workers at Sabena, the former national Belgian flag carrier, contributed to the airline's demise.

In the wake of the 9/11 crisis, the true extent of the competitive threat facing FSNCs from the LCCs was becoming clear. The response of many legacy airlines to the emergence of the LCCs in the 1990s might be described as 'studied neglect' as the new entrant operators rarely competed head on with the legacy airlines. Where competition existed (e.g. on routes between London Stansted, Luton, Gatwick and Heathrow airports and those serving Barcelona – Barcelona, Girona and Reus), the LCCs initially generated new markets rather than cannibalised those of the legacy airlines (Harvey and Turnbull 2014). At the turn of the millennium, LCCs accounted for only 5 per cent of the intra-European market, but they survived the economic crisis of 2001–02 far better than their legacy counterparts. In the last quarter of 2001, the passenger traffic carried by the European LCCs easyJet, Ryanair and Go increased by around 30 per cent.

By 2008, LCCs were responsible for almost 30 per cent of the US domestic market and around 40 per cent of the intra-European market. It is in this context of increasing LCC market share that civil aviation was once again plunged into turmoil following the global financial crisis that eclipsed the problems encountered after 9/11. Whereas airline revenue fell by 7 per cent in the crisis that followed 9/11, revenues plummeted by 15 per cent in 2009, with the operating losses of the world's top 150 airlines totalling US$15 billion (compared with profits of US$29 billion in 2007). Several airlines ceased trading and many more responded with cost-reduction strategies that once again directly impacted on labour, with staff-reduction programmes alongside leaves of absence (furloughs) and a reduction in training. Data from studies conducted in 2001 and 2009 suggest an increased incidence of redundancy (voluntary and compulsory) in the latter period, despite the opposition of trade unions to compulsory redundancy (see Harvey and Turnbull 2010).

Whereas the financial crisis impacted on the success of the principal European LCCs in terms of passengers carried, these airlines have recovered quickly. Immediately prior to the current financial crisis (2007–08), all the largest (top ten) network airlines were profitable while nine of the top ten LCCs were making money. In 2008, seven of the top ten network airlines lost money compared to just three of the top ten LCCs. A year later, nine of the top ten network airlines were in the red compared to only two of the leading LCCs.

Stop and think

Why are LCCs more resilient to financial downturns than FSNCs?

18.3 Contemporary people management in civil aviation

By 2013, LCCs carried more than half of the domestic passengers in Spain, the Netherlands and Italy, and more than half of the international traffic originating in Latvia, Slovakia, Lithuania, Poland, Hungary and Spain. In the decade to May 2014, European LCCs grew at an average of 14 per cent per annum, whereas legacy airlines grew by only 1 per cent per annum. In a single European aviation market there are far greater opportunities for 'social dumping', a 'strategy geared towards the lowering of wage or social standards for the sake of enhanced competitiveness' (Bernaciak 2012), because airlines can readily take advantage of the competition between workers in different geographical regions. As previously noted, the low-cost model is synonymous with various forms of subcontracting and the increased use of agency or temporary workers, whereby direct employees are replaced with 'self-employed' workers and other staff hired on more precarious fixed-term or seasonal employment contracts. Indeed, Ryanair was found guilty by French courts in 2014 for paying less than 11 per cent of the requisite 45 per cent social security cost for its staff based in the country.

However, aside from increasing numbers of people in the industry working for the LCCs, the success of LCCs has further impacted on employment within the industry in two main ways. The increased competitive pressure exerted by LCCs on FSNCs renewed the latter's efforts to replicate elements of the low-cost model. Whereas abortive attempts were made by several airlines in the late 1990s to replicate the low-cost model via a carrier-within-a-carrier (CWC) subsidiary such as British Airways' Go and KLM's Buzz (➤Chapter 7), more recent ventures by Lufthansa (Germanwings) and KLM–Air France (Transavia) have been more successful, especially in terms of reducing labour costs. Cabin crew at Germanwings (now Eurowings), for example, are paid around 40 per cent less than their colleagues in the Lufthansa mainline operation and experience a much slower progression up the pay scale. British Airways has pioneered an approach whereby a new workforce has been created inside the airline with new staff hired on inferior terms and conditions of employment. Alongside its Euro and Worldwide Fleets, the airline now has a third, Mixed Fleet. Unlike the physical separation of Germanwings from Lufthansa mainline, British Airways' Mixed Fleet operates both short-haul European and long-haul intercontinental flights from London Heathrow.

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Stop and think

What are the advantages and disadvantages of FSNCs offering staff working in their low-cost subsidiaries less preferential terms and conditions of employment?

The second development is a consequence of the diminishing returns from the low-cost model. This is manifest both in terms of the introduction of longer and thinner lower demand routes as the LCCs seek out new markets that are more costly to service and the (inevitable) limits to continually cutting labour costs: at some point the low motivation of poorly paid and insecure staff will result in a decline in (even basic) service quality that will outweigh any savings from lower unit labour costs. It comes as no surprise, then, that LCCs such as easyJet now differentiate their service in terms of the tariff, with FLEXI fares that include allocated seating, 'Speedy Boarding' and one piece of hold luggage. Consequently, if the options for continuous cost reductions diminish, the only financial alternative is to grow revenue. This can be achieved by 'adding value' through offering ancillary products and services such as travel insurance, car hire, hotel accommodation, surface transport, on-board and online gambling, and in-flight sales and/or targeting different passenger groups, especially those with more disposable income. Ryanair, for example, earned around 20 per cent of its revenue from ancillary products and services in 2013, including excess baggage charges, which is higher than other LCCs (a comparable figure for Norwegian Air Shuttle was 11 per cent).

Ryanair's dependency on ancillary revenues is demonstrated by the fact that, based on ticket revenue alone, the airline needed to sell 98 per cent of seats to break even in 2008, whereas it actually sold only 81 per cent. The company therefore returned a profit on the back of ancillary revenues. By unbundling the different components of air travel, LCCs not only turn the flight experience into a commodity for the passenger, with payment for all the different elements of the flight (including seat choice, checked-in baggage, and in-flight food and drinks), they also change the nature and expectations of work for staff. Indeed, a significant component of pay for cabin crew is often now based on in-flight sales performance. Most LCCs use some form of variable pay for cabin crew, which often comprises more than half the employee's monthly pay (Harvey and Turnbull 2012).

These developments explain why the business strategies of LCCs are evolving by, for example, facilitating transfers, entering alliances and acquiring other airlines, and why the experience of work for aircrew will differ not only between legacy and LCCs but also between different legacy and low-cost operators. For example, LCCs such as easyJet, with a denser route network and access to more and higher value passengers at primary airports, will have different expectations of staff and a more stable roster throughout the year with less variation between summer and winter schedules.

While easyJet and Vueling target higher value passengers and primary airports, the self-styled ultra-low-cost-carriers (ULCCs) (Ryanair and Wizz Air) will no doubt continue to reduce labour costs, and staff will find themselves working right up to the maximum flight and duty time during the busy summer schedule, with enforced lay-offs or unpaid leave becoming the norm during the winter when aircraft are grounded. Ryanair, for example, now 'flex' the fleet between winter and summer schedules and typically ground between 60 and 80 aircraft each winter, principally because the carrier no longer makes a profit during the winter and relies on summer profits to offset winter losses.

It is clear that the continued success of the LCCs, through a strategy of increasingly direct competition with legacy airlines at primary airports for the same passenger groups, will also impact on staff at the legacy airlines. easyJet already poses a direct competitive challenge to many legacy airlines as the company has invested heavily in frequent services to/from primary airports while maintaining a low-cost operating base. In some EU member states, easyJet is now the benchmark used by management calling for a reduction in legacy labour costs, but in other member states it is an employer of choice for many aspiring cabin crew, including many staff who work for British Airways Mixed Fleet. Direct competition from Ryanair is rather more challenging. When legacy airlines with a much higher (legacy) cost base face 'social dumping' by a ULCC, the pressure on revenue and staff costs can be considerable.

The churn created by low-cost competition for legacy airline staff is not confined to the low-cost version of the main brand (e.g. staff employed by British Airways Mixed Fleet, Iberia Express, Germanwings and Transavia). A combination of more fuel-efficient aircraft and open skies agreements with neighbouring countries has enabled LCCs to extend the geographic reach of their route network to many of the attractive and lucrative 'long-haul' destinations traditionally served by legacy airlines. EasyJet offers flights to Egypt, Jordan, Turkey and Morocco. From a multibase network, LCCs can retain the cost advantages of their original business model on these routes.

No low-cost airline has ever survived a full economic cycle on a long-haul (intercontinental) route. However, new market opportunities are being created through the negotiation of open skies agreements with non-EU countries, most notably the US. With the commission of a European sovereign state (an Air Operator's Certificate), European LCCs are now able to adopt and adapt the maritime practice of Flags of Convenience (FoC) and Crews of Convenience (CoC) as a way of redefining employment relationships, exerting control over labour, and extracting surplus value. The clearest example of this strategy – the creation of

Norwegian Air International (NAI), a subsidiary of Norwegian Air Shuttle (NAS) – became a cause célèbre on both sides of the Atlantic (see Case Study 18.1).

CASE STUDY 18.1

NORWEGIAN AIR INTERNATIONAL (NAI)

Norwegian Air Shuttle (NAS) is one of Europe's largest LCCs, flying around 18 million passengers per annum from 11 bases across Scandinavia, Europe and Bangkok. Around 50 per cent of the airline's flights are now between 'foreign' countries as they neither start nor end in Norway. Bangkok is used as a base for flights between Asia and Europe and then onwards to the USA, with aircrew hired via agencies in Singapore and Thailand. To completely break all ties between labour, location and (operating) licence, the airline's new subsidiary, NAI, has acquired an Irish Air Operator's Certificate (AOC), even though the company has no plans to operate out of Ireland. Irish registration is simply a convenient flag as NAS shifts the sovereign regulatory regime under which social relations take place, enabling NAI to escape from national (Nordic) class compromises and exploit the EU–US open skies agreement.

NAS claims that the company's application for an Irish AOC was motivated mainly by access to existing and future traffic rights to and from the EU (EU open skies agreements with Israel and Canada) as well as Ireland's adoption of the Cape Town Convention on International Interests in Mobile Equipment, a treaty which was designed to standardise transactions involving movable assets and property, including aircraft. In contrast, trade unions have pointed out that NAI's international base strategy is estimated to save around 50 per cent on salary costs, with Thai crews paid only NOK3,000 per month (around €370 per month), which is below the minimum wage in Norway and many other parts of Europe. With the entry of an LCC into the trans-Atlantic market, the challenge for organised labour on both sides of the ocean is clear:

> NAS is using the unique nature of EU aviation laws to effectively shop around for the labour laws and regulations that best suit its bottom line. It's using a 'Flag of Convenience' strategy at the expense of decent labour standards. In addition to subjecting its own workforce to substandard wages and conditions, the NAS model threatens the US aviation workforce … undercutting US carriers and their employees that serve [routes from London to New York City, Fort Lauderdale, Los Angeles, Oakland and Orlando] by as much as 50 per cent.
>
> (Transport Trades Department, AFL-CIO, 29 October 2013)

18.4 An alternative approach to people management

This chapter has focused primarily on the ways in which many European airlines have taken a 'low road' approach to employment relations based on eroding the terms and conditions of work for staff. However, it is important to reiterate that people are crucial to the success (or otherwise) of airlines. Indeed, the examples of low road employment relations cited here are instructive in terms of the dangers inherent in this approach. The CEO of Norwegian Airline Group, Bjorn Kjos, has commented that the protracted consideration by the US Department of Transport of his bid to gain access to more US airports (due largely to protests by organised labour) is costing the airline 'a fortune'. The recent innovations by European FSNCs to operate what staff regard as 'main-line services' via a low-cost subsidiary led to industrial action and significant costs at both Lufthansa and Air France. In 2014, British Airways experienced disquiet in its Mixed Fleet, and narrowly avoided industrial action after a ballot that returned 95 per cent in favour of industrial sanctions. Had the action been taken, then the airline might have encountered similar losses to those experienced in 2010 when Unite the Union coordinated industrial action among cabin crew and the airline estimated the cost of the action at £7 million per day.

Then, of course, there is Ryanair. As the airline does not recognise unions, strike action against the Irish carrier is unlikely, though not inconceivable. As unions press for representation at Ryanair, a succession of legal challenges have been launched in respect of workers' terms and conditions of employment, especially on the part of staff hired via an agency, who now constitute the majority of Ryanair's workforce. Such disquiet casts doubt on the sustainability of the low road employment model in civil aviation.

Whereas most LCCs have copied the original low-cost business model developed by Southwest Airlines (SWA), to a greater or lesser extent, very few have copied the airline's 'high road' approach to HRM and IR, despite the fact that the company's people strategy is at the heart of its sustained competitive advantage. SWA is now the largest US domestic carrier, with a market share of over 70 per cent of the top 100 city-pairs in the USA and around 25 per cent of the total market. It has recorded 40 years of consecutive profitability, with an average profit margin of just under 9 per cent between 1999 and 2008. This success has been achieved in no small part due to the 'Fun-LUVing attitude' and 'warrior spirit' of its staff who are keen to demonstrate their 'servant's heart' to provide passengers with a novel flight experience (Southwest Airlines 2015).

The employment relations system adopted by the airline is exemplified by the former CEO, Herb Kelleher, who encapsulated the airline's approach towards staff in the following statement: 'You put your employees first. If you truly treat your employees that way, they will treat your customers well, your customers will come back, and that's what makes your shareholders happy' (Herb Kelleher, quoted by McDermott *et al.* 2013: 306). Treating staff well includes industry-leading pay and benefits. In 2012, SWA recorded over 520,000 hours of health and safety training (over 11 hours per employee), over 17,000 hours on employees' human rights (1-in-5 employees participated in this training), and the company's training programmes routinely cover environmental stewardship and sustainability. The airline's 'University for People' provides training and career development to help employees 'learn and grow'.

SWA is the most highly unionised airline in America – union density currently stands at around 83 per cent – and unions are treated as 'business partners' not 'third parties'. To illustrate how opportunities to participate in decision-making (such as on pay and benefits) can directly enhance the performance of the organisation, consider the process of collective bargaining and how this might affect customer service (such as delays caused by strikes or other forms of industrial action) or passengers' perceptions of the reliability of a particular airline (e.g. adversarial contract negotiations reported in the media that might lead to future flight cancellations if the parties cannot reach an amicable settlement). SWA leads the way in timely contract negotiations in the US through its partnership approach with trade unions.

In its 40-year history the airline has only ever experienced one strike (Gittell *et al.* 2004). US industry data indicates that efforts by airlines to avoid unions are not likely to produce a sustained improvement in either service quality or financial performance.

Stop and think

Outline the benefits of airline operators treating unions as business partners.

Key points

- Airlines, irrespective of their business strategy, are reliant on the performance of their staff and, as such, employment relations play a crucial role in the success of airlines.
- People management is a task made difficult by the peculiarities of civil aviation, in particular the pro-cyclical demand for air transport and the perishability of the 'product'.
- Market degregulation and liberalisation combined with economic crises have highlighted the importance of HRM and IR. In the highly competitive European airline market, the business strategies and associated HRM and IR polices of the LCCs have proven most successful, creating challenges for FSNCs who have struggled to reduce their legacy (labour) cost. Here too, therefore, airline management have focused on labour productivity as the key to a sustainable competitive future.
- In this context, we would caution against both legacy and low-cost airlines progressing down the low road – costs might fall, especially in the short term, but so too can employee morale, motivation and customer service, certainly to the point of customer dissatisfaction and intolerance, regardless of the ticket price and possibly to the point of costly industrial action. In contrast, as SWA, the original low-cost airline, most aptly illustrates, there is a high road to creating both satisfying work and satisfied customers, and airline managers need to be alert to this.

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CHAPTER 19

Air transport marketing

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LEARNING OUTCOMES

- To identify the principles of air transport marketing with an emphasis on marketing communications.
- To recognise how marketing communications have been influenced by the changing media and messages of marketing copy.
- To understand the basic principles of engagement marketing.
- To examine a range of initiatives used by airlines and airports to engage consumers.
- To assess possible future trends.

19.0 Introduction

As previous chapters have shown, the air transport market is characterised by sustained long-term growth but also saturation in some markets (➤Chapter 2). Deregulation and liberalisation have changed the competitive environment and led to a transfer of ownership and control of airlines, and to some extent airports, from the public to the private sector (➤Chapters 5 and 6). These factors have contributed to a more open and contested commercial market where airlines and airports are under increasing pressure to grow their business through marketing.

The purpose of this chapter is to discuss key issues relating to air transport marketing. The focus is on how both airlines and now, increasingly, airports market themselves to passengers. Air cargo is also important. However, air cargo is sent by individuals or organisations that, unlike passengers, rarely come into contact with an airline or an airport. Instead, they tend to deal with forwarders or integrators

(➤Chapter 15). As a result, approaches to marketing air cargo differ from passenger marketing and are beyond the scope of this chapter.

This chapter considers the principles of air transport marketing including services marketing, marketing communications, and the changing media and messages of marketing copy. A range of marketing initiatives that can be used by airlines and airports to engage particular consumers are then examined before possible future trends are considered.

19.1 Principles of air transport marketing

Services marketing and marketing communications

The UK Chartered Institute of Marketing defines marketing as 'the management process responsible for identifying, anticipating and satisfying customer requirements profitably'. Marketing is a management process that has clearly defined objectives and outcomes. The objectives include flexible long-term efforts to understand and anticipate customer requirements and short-term efforts to satisfy those requirements. Profitability is the desired and intended outcome.

This definition provides a useful starting point. However, air transport is essentially a service that, in the case of passengers, offers three main benefits:

1. *Mobility.* Being able to travel by air between two points (in the case of airlines) or to board or disembark an aircraft (in the case of airports).
2. *Product features.* For airlines, this includes fare levels and conditions, destinations served and routings, frequency, timing, punctuality, aircraft type and configuration, and in-flight entertainment. For airports, this includes ground transport, people mover systems, check-in desks and self-service kiosks, baggage handling, information services, security, customs and immigration.
3. *Augmented benefits.* Additional product features, including lounges, loyalty schemes, shopping and catering, and transfer services.

Marketing mix: the combination of tactical and controllable decisions made by companies about their product/service, price, promotion, place, processes, people and physical environment in order to produce the desired response from target markets.

Marketing plays a different role for service providers than it does for companies dealing purely with goods (see Table 19.1). In particular, services marketing focuses on exchanging offerings of value with customers rather than simply seeking profits. It also seeks to develop and maintain close relationships, reinforce brand identity, encourage loyalty and develop tangible cues that provide evidence of the benefits available.

Marketing communications are a specific type of marketing practice that is fundamental to a company´s marketing efforts. It is concerned with the media (the tools that are used to store and deliver information) and the messages used to communicate with target markets, and is therefore associated with the promotional mix – a subset of the **marketing mix** that consists of promotional activities that are combined and used by companies to communicate with target markets and produce the desired response from them (see Table 19.2).

Table 19.1 Characteristics of a service and implications for marketing

Service characteristic	*Implications for marketing*
Inseparable. Service is often produced and consumed at the same time and through interaction between providers and consumers.	Important to develop and maintain close relationships with consumers because interaction determines the service outcome.
No transfer of ownership. Consumers rarely gain personal access to what they pay for.	Important to reinforce brand identity and encourage loyalty.
Intangible. Generally have no substance – not seen, tasted or touched.	Important to develop tangible cues for the benefits available such as quality of service.
Heterogeneous. Quality depends on where, when and how they are provided and by whom.	Important to invest in quality, including staff training and management systems.
Perishable. Generally cannot be stored for later sale or use.	Important to anticipate future demand and use the marketing mix to influence and respond to change.

Table 19.2 Traditional activities included in the promotional mix

Activity	*Main strengths*	*Main weaknesses*
Advertising. Mass communication via radio, television, print or display.	• Reaches a large audience • Repeatable • Expressive	• Not personal • General messages • Lacks persuasiveness • Limited control over who views it • Expensive
Direct marketing. Direct communication via post or telephone.	• Quick and effective • Can be targeted • Can customise messages • Develops personal relationships	• Requires a mailing list • Expense of printing and postage
Personal selling. Face-to-face communications at company offices or networking events.	• Personal contact • Targeted and persuasive • Can provide detailed information and answers • Immediate feedback	• Time-consuming and costly • Long-term commitment • Effectiveness determined by the salesperson
Sales promotion. Short-term incentives such as competitions, samples or discounts.	• Grabs attention • Stimulates demand • Initially effective	• Limited long-term effect • Does not always reflect genuine value • Can lead to price wars
Public relations/publicity. Indirect communications, often via a third party such as the press.	• Includes free or paid efforts • Often viewed as credible	• Difficult to generate • Limited control over content • Hype may not be met

Stop and think

To what extent does marketing differ from selling?

The main objectives for marketing communications are to create awareness, inform target markets about the brand, influence attitudes and buyer behaviour, and encourage preference, repeat business and loyalty. The focus is therefore generally on the brand. This compares to related concepts such as corporate communications (which focus on the company), crisis communications (which focus on dealing with disruptive events or crises), and customer services (which focus on enhancing customer satisfaction). However, there is a great deal of overlap between the different concepts because no matter how effective a company is with marketing communications, the success or failure of a brand can still be influenced by the company's ability to communicate, and problems can arise if brand promises are not met. This happened when London Heathrow Airport's new Terminal 5 opened for passenger use on 28 March 2008. Marketing communications and public relations efforts had promoted the new terminal extensively, emphasising how successful it was going to be. However, when the terminal opened problems were experienced due to malfunctioning equipment and a lack of staff and training. It resulted in overcrowding and flight delays and cancellations. The media coverage was extensive and largely critical of how the airport operator and British Airways handled the situation (see Case Study 19.1).

CASE STUDY 19.1

MARKETING AND PUBLIC PERCEPTIONS: THE CASE OF T5

YouGov's BrandIndex tracks the daily public perception of thousands of brands worldwide and has tracked British Airways since 2005. The BrandIndex is based on public responses to perceived quality, value, satisfaction, corporate reputation, recommendation and general impression of the brand. Scores range from +100 to –100, depending on whether the response is positive (+), neutral (0) or negative (–). The BrandIndex score for British Airways declined from about +15 to 0 in the few days leading up to the opening of T5. It then declined to more than –50, a record low for the company, after the terminal had been open for five days.

Managing marketing communications is a complex process because each source of information – whether it's a department or an individual within an airline or airport – has the potential to use different forms of media to communicate their own, and possibly conflicting, messages about the **brand**. It is therefore important for airlines and airports to integrate communications throughout the organisation to ensure that consistent and compelling messages are communicated via appropriate media. In order to develop effective communications, it is important to have a clear understanding of the target market; identify the response sought; construct a message with effective content and structure; select relevant media; and research market awareness, satisfaction and response to communications.

Effective marketing communications can be time-consuming and costly. Airlines and airports will always need to make trade-offs between what they would like to do and what they can afford to do. Effective communication is further challenged by the diverse range of customers who are served by airlines and airports, because they need to communicate not only with passengers that consume their products and services in different markets, languages and cultural contexts but also with other stakeholders such as freight forwarders and integrators, travel agents, tour operators and employees. Airports have a particularly wide range of customers that also includes airlines, tenants and concessionaires, and visitors to the airport (➤Chapter 6). In addition, air transport tends to be a derived demand (➤Chapter 2). This means that airlines and airports need to be aware of the marketing objectives of different stakeholders and may benefit from entering into collaborations that facilitate the pooling of resources and the development of an integrated approach to marketing.

Brand: the name, term, logo, symbol, design, style and other tangible and intangible features that stand for the qualities of the product or service and help to distinguish it from others and encourage customer preference, behaviour and loyalty.

Changing media and messages of marketing copy

Changes in the business environment are affecting the marketing communications landscape and encouraging a shift away from traditional marketing activities that, with the exception of personal selling, are largely mass media-orientated and intended to reach a large and general audience.

One key change has been the fragmentation of mass markets as air travellers have become more diverse, knowledgeable and discerning. This has been encouraged by the growth and expansion of air travel as more people fly more frequently and air travel becomes accessible to more regions and sections of society. This reduces the effectiveness of mass media communications because the all-inclusive approach does not work when markets are fragmented. As a result, airlines and airports need to develop more targeted communications that encourage closer relationships with consumers in more narrowly defined markets. This is problematic because airlines and airports cater to a wide range of passenger segments. Some airlines address this by offering differentiated products and services, while others operate multiple brands in order to provide passengers with distinct and separate choices. Singapore Airlines, for example, operates four brands for different passenger segments: Singapore Airlines for premium long-haul, Silk Air for premium short-haul, Scoot for low-cost long-haul, and Tigerair (as a minority owner) for low-cost short-haul. However, in general, companies rarely achieve the necessary levels of differentiation because passengers still associate the individual brands with a single company.

Perhaps the greatest change has come from the development of new technologies (➤Chapter 16) that allow airlines and airports to collect detailed information about passengers and target more narrowly defined markets with specific messages via, for instance, digital media. The marketing **media mix** has therefore become broader and more complicated, and while digital media is often associated with relatively new forms of communication such as the internet, mobile technologies and social media, it is important to note that it increasingly encompasses all media channels due to the introduction of digital radio, television, print and display.

Media mix: the combination of channels used to meet marketing objectives. This includes traditional (radio, television, print or display) and digital media (the internet, mobile applications and social media).

The internet has encouraged a shift away from mass marketing to transactional marketing, where the focus has changed from creating general messages for a wide audience to encouraging click-through behaviour where consumers can follow a link from an advert on a website to make a transaction. Low-cost airlines were innovators here by focusing on the internet for advertising and distribution. However, the transition from static to interactive websites, commonly referred to as the transition from Web 1.0 to Web 2.0, and recent developments in mobile technologies have encouraged a new approach to communications. This has been further influenced by developments in social media that allow users to create, share and exchange content in a virtual community or network (see Table 19.3). Marketing communications have therefore shifted away from communicating to customers and focusing on **transaction marketing** to engaging with them through **relationship marketing** in order to develop more personal, meaningful and long-term relationships.

Transaction marketing: marketing that focuses on the efficiency and volume of sales.

Relationship marketing: marketing that focuses on customer retention and satisfaction.

Touch point: a point of human or physical contact a customer has with a brand.

Developments in technology have given airlines and airports more opportunities to interact and quickly share information with people, directly or indirectly. The nature of such interactions can often be more persuasive than traditional forms of communication, and the potential reach from people sharing information with their own communities and networks is enormous. It also allows airlines and airports to engage with consumers across the entire travel chain and via a much broader range of potential customer **touch points**.

New technologies have had a particular impact on airports because they have given airports the opportunity to engage directly with passengers and gather intelligence on their preferences and buying behaviour. Traditionally, passengers were viewed as airline customers, while airlines were an airport's customer. Airports are still focused on marketing to airlines (see Halpern and Graham 2015). However, they also now directly target passengers. This has enabled airports to develop their own passenger loyalty programmes, which typically offer members discounts on car parking and retail concessions.

Traditional activities (listed in Table 19.2) will continue to be important. However, they need to evolve and coexist with new forms of communication in a way that allows companies to target more narrowly defined markets with specific messages rather than targeting a wide audience with general messages. It is also important for companies to develop marketing tactics that include online and offline spaces (see Case Study 19.2).

Copywriting

As companies adapt to a broader and more complicated media mix, they need to consider the messages of the marketing copy that they use because digital media has expanded the range of **copywriting** opportunities to include web content, emails, blogs, posts, tweets and other forms of electronic communication. Writing for digital media differs from traditional media because the content needs to be more concise (there is a 140-character limit on Twitter) and subsequent dialogue or the co-creation of messages is likely. There is also a certain style, and a growing list of online acronyms and terms, that copywriters need to be familiar with.

Copywriting: producing copy (written material) that can be used for marketing purposes to influence customer opinions and/or purchasing behaviour.

Table 19.3 Main categories of social media used by airlines and airports

Categories	Description and examples
Social networks	Allow users to develop and contribute to online social networks. Examples: Facebook, Google+, Momo
Location-based networks	Provide information or entertainment services via mobile devices. Examples: Foursquare, Yelp
Blogs	Online sites that can be updated with regular entries of content. Examples: Blogger, WordPress, Blogs
Microblogs	Allow users to exchange short elements of content online. Examples: Twitter, Tumblr, Jaiku
Content communities	Allow users to share multimedia online. Examples: YouTube, Pinterest, Instagram

Source: Adapted from Halpern (2012)

CASE STUDY 19.2

FLY MANCHESTER CAMPAIGN

The main objective of this campaign was to promote Manchester Airport in North West England as an alternative to London airports for long-haul flights to/from the UK. The campaign included offline advertising on the exteriors of buses and on 48 displays (billboards) in one of the key target areas – the region of West Yorkshire. Metropolitan rivalry between the cities of Manchester and nearby Liverpool was used to generate publicity on local television.

Online advertising employed targeting tools such as Google DoubleClick, which provides internet advertising services such as DoubleClick Ad Exchange – a remarketing tool that allows advertisements and messages to be personalised to visitors on websites. The airport's homepage and social media accounts were also used. The airport's Twitter account had an audience of 65,000, while Facebook had 42,000.

The campaign, launched in 2013, was visible to up to 8.4 million people via print, digital and social media. Market research suggests that the campaign was successful. The airport achieved 16 consecutive months of passenger growth during the campaign, representing a 5.2 per cent increase on the previous year compared to a national average of 3.8 per cent.

Despite the changes, some of the traditional principles of copywriting still apply. In the context of airline marketing, Shaw (2011) states that copy should reflect the specific objectives of the campaign. It should catch people's attention through a bold headline promising them a worthwhile benefit; interest them in a proposition that shows an understanding of their problems; present a solution in a persuasive and credible way that anticipates possible objections; and propose a course of action with clear information on how to follow it. Shaw (2011) also suggests that short sentences and paragraphs are needed, and these should be broken up by frequent subheadings. In situations where long copy is needed, the style used should ensure that resistance to reading it is reduced. Plain language must be used, and well-written footnotes (e.g. containing the terms and conditions of a fare or a promotion) can be used to address any dissonance people may feel about carrying out the proposed actions.

19.2 Principles of engagement marketing

Engagement marketing: marketing used by companies to engage consumers, involve them in the production and co-creation of marketing programmes, and encourage them to actively connect with the brand to shape the way in which it is developed and form a long-term relationship with it.

Brand advocate: a person who voluntarily promotes a brand or product through word-of-mouth or online.

It is no longer enough to simply communicate to consumers. Instead, it is necessary to interact with and engage them. The concept of **engagement marketing** has become increasingly important for marketing communications.

Engagement marketing represents a shift from mass to niche communications. Decisions therefore need to be based on a detailed knowledge and understanding of the target market, and the objectives for engagement marketing should be clear and measurable. With the exception of personal selling, many traditional campaigns were characterised by disconnected, point-in-time communications. Engagement marketing offers a more continuous approach that seeks to nurture long-term relationships. It should not only seek to engage consumers but also involve them in the production and co-creation of marketing programmes and encourage them to actively connect with the brand.

Initiatives for engagement may be delivered outside or inside an aviation setting. Outside initiatives may provide live interactions that help to develop **brand advocates**, while initiatives inside tend to drive purchases and satisfaction at the point of consumption. Traditional initiatives based on the activities listed in Table 19.2 are still used by airlines and airports, especially when the objective is to reach a mass audience. However, the more innovative and engaging campaigns tend to incorporate new technologies. For example, British Airways' #lookup advertising campaign in 2013 was delivered via outdoor displays located in prominent positions under the flight path of London Heathrow Airport, including Piccadilly Circus in central London. When British Airways' aircraft flew over the digital displays they triggered a creative that showed a person standing up (or running over) and pointing at the aircraft along a display showing real-time aircraft data such as the flight number and origin/destination (see Figure 19.1).

Figure 19.1 British Airways' #lookup campaign and creative, 2013

Source: British Airways

Common engagement initiatives used by airlines and airports are shown in Table 19.4. Initiatives can be delivered offline and online – preferably using an integrated, multichannel approach that may, for instance, deliver an offline initiative that provides a real interaction which is then supported and strengthened by online initiatives that create a **marketing buzz**, or vice versa. Benchmark reports on airline and airport marketing initiatives are published on a regular basis, and provide examples of engagement initiatives.

Marketing buzz: where consumers amplify and/or alter an original marketing message by generating a sense of anticipation, energy or excitement.

Table 19.4 Common engagement marketing initiatives

Mainly offline – experiential	*Mainly online – digital*
• Mobile marketing	• Online advertising
• Street marketing	• Email marketing
• Marketing through amenities	• Mobile technologies
• Events and micro-events	• Social media
• Thematic marketing	• Crowdsourcing

Experiential initiatives

Experiential initiatives involve giving customers a physical or emotional experience of the brand through direct exposure to and interaction with it. Mobile marketing takes the brand to the consumer and provides opportunities for interaction and real experiences. These events may occur outside of an aviation setting and use custom-branded vehicles to draw attention to the offering. The vehicles act as mobile displays but can also stop and provide brand experiences, for instance in town centres, car parks or at events. As part of their promotional activities for a new route between Houston and Seoul in May 2014, Korean Air offered free samples of their in-flight meals from a Korean Air themed food truck. The truck visited key business locations throughout Houston's energy corridor (a district where a number of major energy industry-related companies are located) and at events in the Houston area for about a month, allowing people to sample what awaited them on a Korean Air flight.

Street marketing is similar to mobile marketing in that companies tend to use spaces in a non-aviation setting to draw attention to their offering, for instance, by providing competitions or real brand experiences. As part of their promotional activities for a route between Hong Kong and the Philippines, Cebu Pacific launched a campaign in 2014 based on the lack of sunshine in Hong Kong during the summer monsoon season as compared to the Philippines. Advertisements that became visible when it rained were located on the ground in the streets of Hong Kong with the slogan 'It's Sunny in the Philippines'. A QR code (➤Chapter 16) was included in the advertisement that directed passers-by to follow it to access discounts with Cebu Pacific. In a similar initiative in 2012, Norwegian installed a rain gauge board on bus shelters in Oslo that recorded how much rain fell in the city – this is a form of marketing through amenities. The rain gauge board was accompanied by traditional displays advertising sunnier destinations served by the airline.

Viral marketing events are often used to capture the public's imagination. They may be one-off or recurring events that take place inside or outside an aviation setting. They sometimes include an element of surprise and creativity such as a 'flash mob' and may

Viral marketing: using social networking sites or other technologies to pursue marketing objectives such as increased brand awareness through a process of self-replication. This may be achieved when a message (in any form such as text, an image or a video) that is placed by a company or individual, for instance, on a social networking site, website or email, is spread rapidly to a wider audience as a result of being copied and passed on by others.

include an element of generosity, for instance buying gifts for passengers (see Case Study 19.3) or making charitable donations that demonstrate an investment in shared values with the target market. Some events are recorded on camera and have gone viral when posted on social media sites such as YouTube. Smaller micro-events at an airport or on board an aircraft are also used to surprise passengers. Examples include Virgin America's Mile High Fashion Shows.

As Case Study 19.3 shows, thematic initiatives are often used. These may be concept based and so time-limited but offer an effective and fun way of engaging people. Thematic initiatives may also be based on a subject such as a famous film or character. In December 2014, Taipei-based Eva Air launched a Hello Kitty-themed aircraft for its routes between Los Angeles and Paris to Taiwan, while Brussels Airlines launched a Tintin-themed aircraft in 2015 that they called 'Rackham' (see Figure 19.2). Rackham has a 37m-long shark painted along its fuselage that is based on Professor Calculus's shark submarine in the Tintin cartoon adventure *Red*

CASE STUDY 19.3

WESTJET'S CHRISTMAS MIRACLES

In December 2012, WestJet surprised passengers at Calgary International Airport waiting to board a flight to Toronto with a Christmas flash mob of carol singers, elves, snowmen, fairies, reindeer, Santa and gifts. The video 'WestJet Christmas Flash Mob' had over 1.5 million views on YouTube by the end of 2014. In December 2013, they surprised more than 250 passengers on two flights to Calgary International Airport. Passengers were asked to tell Santa via a video screen what gifts they wished for that Christmas before departing for Calgary. The gifts were then waiting for them as they arrived in the baggage hall. The video 'WestJet Christmas Miracles: Real-Time Giving' had over 37 million views on YouTube by the end of 2014. In November 2014, they placed a sled in the town centre of Nuevo Renacer in the Dominican Republic – one of the destinations WestJet serves in the country. The sled included a video screen where residents could tell Santa what they wished for that Christmas. The next day, residents were invited to a Christmas-themed party on a beach where the gifts they had wished for were waiting for them. WestJet also unveiled a small playground in the town centre. The video 'WestJet Christmas Miracles: Spirit of Giving' had over 3 million views on YouTube by the end of 2014.

Rackham's Treasure. The words 'We fly you to the home of Tintin' are also printed along the fuselage. The Tintin-themed aircraft forms part of the airline's 'Belgitude' efforts to position the carrier as a flying ambassador for Belgium, which includes gourmet cuisine, Belgian chocolate, Belgian beers and the Tomorrowland music festival.

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Stop and think

Why do airlines engage in experiential and thematic initiatives, and to what extent do you consider them to be effective marketing tools?

Figure 19.2 Brussels Airlines' Tintin-themed aircraft

Source: Brussels Airlines

Another initiative associated with thematic concepts or subjects is the art of **storytelling**. Storytelling has always played an important role in society as a means of entertainment, education and the preservation of cultures. It has also become recognised for the role it can play in marketing communications. Stories provide an effective way of communicating messages about a brand and can create strong emotional bonds with consumers that enhance their loyalty to the brand. When told in the correct way, stories can be a good way of simplifying and communicating complex messages in a memorable way. The stories will be particularly compelling when conveyed by independent voices – thereby building trust through transparency and authenticity. This compares to traditional ways of communicating messages that may evoke counter arguments or be quickly forgotten. Of course, there are some potential weaknesses. Sequencing and progression of the story will be important, especially if it is part of a multiple narrative, and care should be taken to make sure that the story does not distract people from core messages about the brand. Complex stories will require too much effort to digest and people will quickly lose interest. In addition, people may be wary of stories that are told from a single viewpoint.

Storytelling: initiatives used by companies to convey illustrative and memorable events in words and/or images in order to create strong emotional bonds with consumers and enhance their loyalty to the brand.

The Scandinavian airline SAS used storytelling for its 2014 campaign 'We are travelers', which was based on the stories of real passengers (see Figure 19.3). A number of airports have commissioned television crews or writers-in-residence to convey illustrative and memorable stories about airport users. In 2009, the Anglo-Swiss philosopher Alain de Botton was invited to be a writer-in-residence at London Heathrow. During his week-long residency, he observed passengers and staff and published a book entitled *A Week at the Airport*. In 2011, Vancouver Airport Authority held a contest to select a correspondent to live, eat and

Figure 19.3 SAS's 'We are travelers' campaign, 2014

Source: SAS

sleep at the airport for 80 days and write about the experience. Jaeger Mah won the contest, and during the 80 days he produced 52 feature stories, wrote 34 blog posts and engaged in online conversations on Facebook and Twitter.

Stop and think

Why might airlines want to personalise their marketing messages, and what are the potential disadvantages of this approach?

Remarking: reintroducing a product or service to existing customers to remind them about the brand.

Flow advertising: adjusting the way in which various elements of a marketing campaign are delivered in real time based on signals from consumers.

Digital initiatives

According to SITA (2014), 95 per cent of airline passengers use websites for some part of their travel arrangements. Offering online services via airline or airport websites has become widespread practice. In addition, online advertising initiatives that make use of targeted and **remarketing** tools to target users with personal messages are also used.

Flow advertising is also used to adjust elements of a company's online advertising in real time based on signals from the consumer, such as the device that they are using, the amount of time that they spend watching an advertisement or the search that they perform after viewing an advertisement. This is a more dynamic type of sequential advertising, which is when a campaign is delivered over a series of pre-determined stages. Web 3.0, which is described as the next stage in the evolution of the internet from interactive to **semantic websites**, may also be used in the future. These will enable airlines and airports to be more effective in responding to complex web-based searches such as 'find me a flight from London to New York with my favourite airline'.

Semantic websites: intelligent and intuitive websites that are better able to serve user needs.

The rapid growth of emails as a form of communication facilitated considerable interest in email marketing. This form of direct marketing shares many of the strengths and weaknesses listed in Table 19.2. The idea is that companies customise messages in electronic form that can be sent by email to a target market. Individuals can then be encouraged to share the messages by forwarding the email on to their own contacts. Approximately 200 billion emails are sent and received each day worldwide, so marketers need to find ways to get their email seen and may benefit from combining their email campaign with other activities. A good example of this is provided by Monarch Airlines, who combined email marketing with direct marketing by post and the use of innovative mobile technologies and social media (see Case Study 19.4).

CASE STUDY 19.4

MONARCH AIRLINES 'FRESH ROUTES – FRESH POWDER' DIRECT MARKETING CAMPAIGN

In September 2012, London Luton-based Monarch Airlines launched an integrated campaign using online and offline channels to generate awareness and bookings for the airline's new ski offering. An extensive profiling exercise was conducted by going through the Ski Club of Great Britain's database in order to establish a detailed understanding of British skiers. This enabled the company to find relevant prospects for the new ski routes from within Monarch's own databases and in third-party lists. A creative, engaging and targeted campaign was then delivered. It started with a teaser email asking people to look out for something exciting in the post. They were then sent an interactive pack by post that used Blippar augmented reality technology that converted the pack into content rich, interactive experiences when viewed through the relevant mobile application. Monarch's pack included a virtual mountain with ski slopes, high-quality graphics and a 360° view with snow and sound effects. People were able to watch ski videos, view the latest snow reports and enter a competition by posting a virtual, personalised postcard to friends via social media – thereby expanding the reach of the campaign. Monarch Airlines claims to have achieved about 39,000 site visits, 7,200 bookings and £2.2 million in revenue from the campaign.

19.3 Marketing through mobile technologies

Air travellers are increasingly connected to mobile technologies. SITA (2014) found that 97 per cent of air passengers carry a laptop, tablet device or mobile phone when they travel. 18 per cent travel with all three. Approximately four in five passengers have a smartphone and 76 per cent of smartphone users have travel-related mobile applications on their phone (➤Chapter 16). The number of airlines and airports that have developed dedicated and branded mobile applications has increased dramatically in recent years. All but three of the world's 25 largest passenger airlines offered mobile applications by 2012 and in 2014 164

European airports, who collectively serve 73 per cent of European passengers, had mobile applications (ACI Europe 2014).

Common services on airline mobile applications include flight search and booking, mobile check-in and boarding passes, flight status and loyalty programmes. For airports, common services include flight status and airport information on wayfinding, public transport links, and support for passengers with reduced mobility (ACI Europe 2014). In the future, mobile applications are likely to be used to advertise sales promotions, distribute non-aviation-related products and services (such as duty free purchases or the pre-booking of airport car parking) and provide links to social media.

Mobile technologies are used to support a wide range of initiatives, such as Dallas/Fort Worth International Airport's location-based initiative (see Table 19.5), advertising via QR codes, such as with Cebu Pacific's 'It's Sunny in the Philippines' campaign, and Monarch's use of augmented reality in Case Study 19.4. Another interesting initiative was Lufthansa's 'Selfie Advertising Unit' that was launched in 2014 and was based on the selfie craze, which involves people take a self-portrait photograph using a smartphone or tablet device and then sharing it on social media. Lufthansa's mobile unit presented images of destinations served by the airline. A user could then make a postcard by taking a selfie of themselves and inserting it into the unit so that it looked like they were in the destination. Users were then encouraged to share their postcards on social media, therefore extending the reach of the campaign, and inspiring people to fly to the destination with Lufthansa.

Table 19.5 Example airline and airport campaigns on social media

Category	*Example campaign*
Social networks	Eindhoven Airport launched a Facebook VIP scheme in 2013 in which anyone who liked their Facebook page and was due to fly from the airport could sign up to its VIP scheme. Two members were selected each month and offered benefits such as a free airport meal, fast-track security screening and free car parking near the terminal entrance.
Location-based networks	Dallas/Fort Worth International Airport launched a programme in 2011 that integrated Foursquare and Facebook Places with the airport's concessions offerings. Customers who checked in via social networking at any of the airport's passenger terminals gained access to concessions deals and discounts offered within a few yards of their location.
Blogs/microblogs	KLM announced the re-opening of their route between Amsterdam and Miami on Twitter in 2011. Dutch DJ/producer Sied van Riel and film-maker Wilco Jung replied that this would be too late for Spring Break events such as the Ultra Music Festival and said they could easily fill a flight. KLM agreed that if they could gather 150 pre-registrations within seven days they would fly earlier. Within five hours, all 150 subscriptions had been gathered and KLM honoured their promise (see Case Study 16.3).
Content communities	Turkish Airlines topped the rankings for the most popular global video advertisement on YouTube in 2014 with 137.5 million views between 1 March 2013 and 30 April 2014. The video was of a 'selfie shootout' between basketballer Kobe Bryant and footballer Lionel Messi. The video shows them competing to take self-portrait photographs at destinations that the airline flies to.

Growth in the use of social media during the last decade has been remarkable, and social media has provided new instantaneous online engagement opportunities for airlines and airports. According to the respective sites, the number of active monthly users at the end of May 2016 was approximately 1.65 billion on Facebook, 300 million on Twitter, 1 billion on YouTube, 300 million on Instagram and over 300 million on Google+. The number of airlines and airports that use social media has also grown rapidly. For instance, few airports in Europe had a social media presence before 2010. ACI Europe (2014) estimates that, of their 450 member airports in 2014, 289 were on Facebook (serving 86 per cent of European passengers), 292 were on Twitter (87 per cent), 141 were on YouTube (55 per cent), 77 were using Google+ (22 per cent), 38 used Instagram (35 per cent) and 12 used Pinterest (22 per cent).

Launching social media campaigns is relatively cheap, quick and easy to do. Many companies subsequently rush into using social media without setting clear and measurable objectives or using **marketing analytics** to assess and optimise their performance. Companies often find that it takes a great deal of time and resources to maintain and manage social media efforts effectively, especially given the vast range of platforms that can be used. A particular challenge with using social media is that the quality of content can vary, and it can be misused, abused and attract negative comments from users (see Example 19.1). However, negative comments do not inevitably damage a brand as quick and appropriate responses can transform a potentially negative situation into a positive message. Social network aggregation can integrate many of the platforms in use, and various social media management systems such as Hootsuite, Buffer, Spredfast and Sprout Social can be used to manage online brands and submit messages to a range of social media platforms such as Twitter and Facebook.

Marketing analytics: assess the performance of marketing efforts so that they can be adjusted to provide the optimal return on investment. Analytics assess and optimise efforts delivered via offline spaces such as television, radio, printed and outdoor media and online spaces such as websites and social networking sites. The latter include on-site analytics that relate to a company's own sites and off-site analytics that relate to what is happening on other sites and in online spaces in general.

Example 19.1
The challenge of Twitter

On 14 April 2014, US Airways received a complaint on its Twitter account from a customer regarding a flight delay they had experienced. US Airways responded promptly with an apology. After a further tweet from the customer complaining that the airline had failed to follow-up on previous tweets, US Airways tweeted the customer again to suggest that she submit feedback to the airline by following a link that they included in the tweet. The link was to an extremely graphic and inappropriate image. The tweet remained on the US Airways twitter account for almost an hour before being removed and followed up with an apology. However, by then it had been visible to the 420,000 followers of the US Airways Twitter account, retweeted many times and #USAirways became one of the top ten trending topics on Twitter that day. US Airways reported that the graphic image had been posted into their feed by another user. They had captured the tweet to flag it as inappropriate but inadvertently included it in the response to the customer.

Stop and think

What challenges does social media use pose for airlines and airports, and how can social media be used to transform negative customer experiences into positive ones?

Crowdsourcing: the process of obtaining intelligence by soliciting ideas and opinions from a large audience, and then using that intelligence to make business decisions, for instance, on new or improved products. It should also seek to engage people in a way that encourages them to associate with the brand and develop loyalty towards it.

Crowdsourcing is increasingly being used by airlines and airports as a tool for engagement. It is listed under digital initiatives because developments in technology have made it easier for companies to create online crowdsourcing initiatives. However, it can be conducted online or offline, or via a hybrid approach that combines both. The aim is to solicit ideas and opinions from a large audience, and then to use that intelligence to make business decisions. The aim is to develop loyalty to the brand through a process that engages people and encourages them to associate with it (see Case Study 19.5). It should complement, rather than replace, more traditional feedback mechanisms.

The need to track and assess effectiveness comes in part from concerns that consumers' responses to brands are not always associated with the level of engagement that is experienced. This is especially the case with social media because, while campaigns may go viral, boosting the number of followers on the company's social media sites and extending exposure to their brand, they do not necessarily result in a desired response. Airlines and airports therefore need to try to build real-world relationships and not just relationships developed over social media, which is why it will be necessary to focus on integrated, multichannel initiatives in the future that are delivered across both online and offline spaces.

CASE STUDY 19.5

MY SAS IDEA AND CPH IDEAS

SAS uses a platform called 'My SAS Idea' (https://mysasidea.flysas.net/). Launched in 2012, it is an online crowdsourcing portal where users can suggest ways to improve the passenger experience. Users can then vote on the different suggestions. Ideas that attract the most votes are then considered for implementation by the airline. Suggestions that have been put forward include lounge access to EuroBonus Gold members who are flying on a domestic route, free refreshments when a flight is delayed, and complimentary Wi-Fi and electrical power outlets on all flights.

In a similar initiative, Copenhagen Airport launched a platform called CPH Ideas in 2014 (https://expanding.cph.dk/cphideas/), where users can suggest ideas for the airport of the future. Users can then vote on whether they like the idea or not, and the most popular suggestions are then considered for implementation. Suggestions that have been put forward include an observation deck for passengers, a roof terrace, an aviation experience centre and more charging stations for passengers' electronic devices.

Stop and think

How can airlines turn social media into a revenue stream?

Key points

- Changing consumer trends and new technologies are influencing how airlines and airports market themselves to consumers.
- Marketing emphasis has switched from communicating with customers to actively engaging with them in order to develop more personal, meaningful and long-term relationships.
- Traditional, experiential and digital initiatives can be used, and each approach offers a number of benefits.
- Markets are increasingly crowded with messages, and airlines and airports need to find innovative ways to break through the marketing clutter and be more effective in delivering their messages to the right people through the right media at the right time. To help facilitate this, they will need to have a clearer understanding of their customers and their willingness to engage in different media and provide them with offers of true value.
- The shift from traditional to digital media and from desktop to mobile internet, possibly via wearable technology, is likely to continue. This will increase opportunities for engagement across the entire travel chain.
- Airlines and airports need to focus less on the types of media that they use, and more on how they can develop creative and compelling messages to engage consumers. Messages that spark excitement, tell the brand's story or strike an emotional chord with consumers are likely to be popular.
- E-commerce-driving-engagement initiatives will also remain important as a means of growing ancillary revenues for airlines and airports.
- Social media has become widely used for marketing communications. However, relentless and potentially damaging effects of social media also mean that companies that do use it need to remain vigilant at all times. Problems can quickly go viral and heavy-handed responses or attempts to cover them up often only make things worse.
- Airlines and airports therefore need to manage such communications in a calm, transparent and timely manner, which can help to build trust and develop brand advocates.

- While airlines and airports should embrace new opportunities and experiment with new technologies, they must integrate the range of messages and media that they use and track their effectiveness against clear objectives.
- Marketing analytics help understand and influence market responses and maximise returns on marketing investment in terms of sales and profits.

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CHAPTER 20

Air transport in remote regions

Rico Merkert

LEARNING OUTCOMES

- To recognise the social and economic importance of aviation to remote regions.
- To understand the management challenges of providing air services in remote regions.
- To evaluate aircraft types, operational challenges, financial viability and franchising.
- To appreciate how public support, subsidies and Public Service Obligation (PSO) routes operate.
- To assess future developments in this market segment.

20.0 Introduction

Air transport in remote regions is often seen as a niche market with very low margins and services that are more exotic than meaningful in terms of volumes. However, given their niche character and often monopoly situation, some services, such as those contracted in by primary industries, including mining and mineral exploration, are highly lucrative. Even the many regular scheduled air services on low-volume routes that are not commercially viable without public support are much more than a niche product to the communities and businesses that depend on them. To these regions, air services are much more than a business; they are the connection to the next island, the mainland, the regional centre and the world. Air transport to and within remote regions is a market segment that goes beyond profit margins as it delivers tangible economic and social benefits. Indeed, it can be argued that without aero-medical services and regular public flights (also referred to as air buses), many remote communities would become marginalised and even more isolated.

It is widely accepted that aviation plays a vital role in the regional, rural and remote (RRR) context. Local businesses, airline operators and remote airports frequently highlight the substantial economic impacts of air transport to geographically remote or isolated regions. IATA has recognised the wider economic benefits of aviation in small island developing states (SIDS), particularly its role in developing tourism. Economic impacts usually refer to employment and income generated and include four main types: direct impacts (generated by the direct construction and operation of remote aviation); indirect impacts (generated by the chain of suppliers of goods and services related to remote aviation); induced impacts (generated by employees spending their income); and catalytic impacts (generated by the role of air transport in remote regions as a driver of productivity growth and an attractor of new firms). Research on these impacts has occurred in Europe, where in Norway it has been shown that remote airports are important catalysts for local investment (see Halpern and Bråthen 2011), and in Canada, the US and Australia, where Baker *et al.* (2015) discovered a strong bidirectional relationship between regional aviation and economic growth.

This chapter will explore the management of air transport in remote regions. The provision of safe and successful operation of such services demands particular management strategies that are adapted to the unique social, commercial and natural environment of small communities, small island states and other remote regions. The role of government subsidies, PSO routes, franchising and aero-medical services will be discussed.

20.1 Market segments of air services to remote regions

Most research on air transport in remote regions has focused on regular passenger flights that are not commercially viable unless subsidised by public money. While this is certainly an important market segment with a number of interesting contractual, economic and social implications, air transport in remote regions is more diverse and complex than that. There are, for instance, regular/scheduled passenger air services that are operated on denser, commercially viable routes to remote centres and tourist destinations. These air services don't require public support and are therefore an entirely different proposition for airline management. Often more viable are charter tourism and corporate flights to remote destinations, which include the recently rapidly growing fly-in fly-out (FIFO) operations for mining and natural resource companies around the world, most notably in Australia, Canada, Russia, Africa, Brazil, Norway and the US. New South Wales and Western Australia, for example, have experienced significant development in the mining sector, and remote airports play an important role in the construction and operation of the mine as well as the economic development of these regions and the movement of skilled labour, machinery, supplies and services.

Another dimension of air transport to remote regions worthy of consideration is cargo. While most of the cargo is limited to small consignments due to the limited capacity of the aircraft in operation, mail and newspapers have always been very important aspects and revenue streams of the remote airline business model. Perishable freight (including fresh seafood from northern Scotland) can also be readily exported to world markets. Further aspects of air transport in remote regions are government and military traffic as well as surveillance, border and maritime patrols. Emergency and general medical services, such as those provided by the Royal Flying Doctors in Australia, add to the variety of remote air transport applications. Finally, air transport in remote regions is also of importance to supply chain resilience, disaster relief and humanitarian missions.

Another fact that makes consideration of air transport in remote regions a multifaceted one is that there is no universal definition of what constitutes a remote region. In the context of public support for scheduled public air services, the only indication of 'remoteness' appears in the documents that govern public support for remote air services in the US and Europe, but even here the definitions differ. The US Essential Air Service (EAS) programme only funds services to communities that are located at least 70 miles (110km) from the nearest hub, while the European **Public Service Obligation (PSO)** scheme allows member states to impose PSOs on routes to peripheral areas and airports where air services are vital for the economic and social development of the surrounding region. The EU definition includes economically underdeveloped regions, including some in France, that do not have to be at the periphery or on an island. A more specific definition of remoteness is that without air services it would not be possible to achieve a day business trip to the next largest regional centre.

Public Service Obligation (PSO): air services that operate to remote or economically underdeveloped regions which are regulated and/or financially supported by governments.

What all these definitions have in common is that the region in question is highly dependent on air transport as alternative ground transport provision is not available or incurs significant travel time penalties. Whether or not these characteristics translate into sufficient demand for commercially viable transport services is another matter and not part of the definition of remoteness. Another way of defining the scope of air transport in remote regions is to focus on the airports that are located in those regions. For example, the Australian Airports Association clusters its member airports into the following:

- Tier 1 State Capital City Airports;
- Tier 2 Non-Capital International Gateway Airports;
- Tier 3 Major Regional Airports with direct interstate services;
- Tier 4 Major Regional Regular Passenger Transport Airports without direct interstate services (with more than 20,000 passengers);
- Tier 5 Regional Airports without direct interstate services (with less than 20,000 passengers);
- Tier 6 Regional Airports without Regular Passenger Transport services (general aviation operations only); and
- Tier 7 Remote Community Aerodromes (which exist for community service aviation and medical emergency flights).

While only Tier 1 airports are regulated, it is Tier 4–6 and particularly Tier 7 airports that are of interest here. That said, given that Perth is the most isolated city in the world, one could argue that despite its Tier 1 and regional hub airport status, the airport still faces challenges owing to its remote geographic location on the west coast of Australia. In general, the airports of concern here include many facilities that are classified as regional, rural and remote airports. All of these provide services that are vital to the communities they serve.

Out of the 2,000 aerodromes in Australia, only around 250 airports receive regular passenger services. The other, often much smaller, airfields and landing strips are, however, vital as they support important connecting flights, emergency services, pilot training (general aviation), maintenance, mail and freight. However, as with most other countries, only 50 per cent of regional airports in Australia are able to cover the cost of their operations. This fact has long-term implications for their commercial viability and hence the provision of passenger, freight and emergency services. While air transport to remote regions presents many opportunities and significant economic and social impacts to the communities and businesses they serve, it also poses a number of particular operational and financial challenges. However, even though regular public air transport services and loss-making remote airports have received considerable political and academic attention (principally owing to the need to justify the public support they receive), the overall market for remote air services is diverse and complex, as Case Study 20.1 details.

CASE STUDY 20.1

HIGHLAND AIRWAYS

Highland Airways was a small airline based in Inverness in the north of Scotland. It was founded as Air Alba in 1991 as a flying school and diversified to become a significant operator of remote air services in the UK before it entered voluntary administration in March 2010. At the height of its operation Highland Airways employed 110 staff, had a fleet of 11 aircraft (including Cessna F406, BAe Jetstream and BN2 Islander aircraft) and operated scheduled as well as ad hoc charter services for leisure and corporate clients. It operated six scheduled passenger routes (most of them PSOs) in Scotland, including Stornoway–Benbecula and Oban–Inner Hebrides, as well as Cardiff–Anglesey in Wales and Lappeenranta–Helsinki in Finland. It was also involved in air freight charter services (including daily newspaper distribution to Orkney, Shetland and the Western Isles of Scotland, and also Royal Mail charters). It also operated a five-year contract for the Scottish Fisheries Protection Agency. From 1998, it was involved in seasonal contract charter flights for the oil industry, connecting Aberdeen-based oil rig workers with the rest of the UK, Ireland and Norway. It flew corporate shuttles for both naval and air force supply contractors and fulfilled complex UK itineraries between small private airports.

Despite its niche market experience and a management buyout in 2007, the airline did not survive the oil price rise in 2008 as it had not hedged its fuel requirements (➤Chapter 11) and did not have reactive fuel price adjustor clauses built into some of its long-term PSO and industry contracts. The airline experienced difficulties transferring from their J31 and C406 aircraft to larger aircraft. Operating different aircraft from several remote bases with limited spares and operational resilience when technical problems were experienced proved to be challenging, and the business model was ultimately unsustainable. Most of its former services are currently operated by Loganair and Flybe.

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Stop and think

What are the key characteristics of air services to remote regions?

20.2 Management challenges of providing air services to remote regions

Providing air services to remote regions is often challenging. Low temperatures, hazardous terrain, limited infrastructure, **Short Take-Off and Landing (STOL)** and unprepared runways, low visibility, inclement weather conditions, low demand and high costs are just some of the challenges that operators face. In order to assess the market risks (some of which also apply to leasing companies, Global Distribution Systems (GDSs), travel agents and ground handlers in this market segment), it is necessary to discuss airlines and airports separately. Airlines and airports both face significant financial challenges, as evidenced by the long list of airline failures (Skytrans in Queensland ceased operation in early 2015) and RRR airport closures (including Blackpool, Filton, Manston and Plymouth airports in the UK, where the land has been proposed for real estate development). While the market challenges can differ according to geographical context, the biggest concern for both airlines and airports is usually low and often seasonal volumes. For airports in particular, the seasonal or peak demand aspect of remote air services is often a challenge. Although individual airports may average low passenger volumes over prolonged periods of times, demand peaks, such as the construction of a new mine in the area, can result in serious capacity shortfalls.

Short Take-Off and Landing (STOL): an aircraft with specific performance characteristics that enables it to operate from short runways that may be constructed from snow, ice, or gravel.

For airlines, one challenge is managing the volatility and complexity that derive from unregulated air transport services in remote regions alongside their diverse product portfolio. Many airlines have to invest in expensive and specialised equipment to operate from remote airports with limited infrastructure (such as gravel runways) or low visibility, but if they lose the contract to provide that service they cannot easily reassign these assets to other routes. These sunk costs increase the financial risks of operating the services and puts potential clients in a relative position of power from which to negotiate on price. One approach to this problem for procured regular passenger air services to remote regions is that the procuring transport authorities should own the aircraft and lease them to the winning bidder of the tender for the duration of the contract. Both the Shetland Islands Council and Transport Scotland have adopted this approach. This ensures that the risk is minimised and shifted away from the private sector. Arguably it is the public sector who should control that risk as ultimately the route is owned and re-tendered by the public transport authorities and not the airlines.

Airlines serving remote regions need to maximise the utilisation of their aircraft, and even those that operate regular high-demand scheduled routes will often also fly charter, corporate and freight assignments as part of their business strategy. Although the majority of charter and many of the scheduled public air services to remote regions are undertaken by small airlines, carriers range in size from very small independent operators to large international airlines. Some FSNCs (including Air France) operate some to remote regions or have franchises (such as Brit Air, which is owned by Air France/KLM) or subsidiaries (such as QantasLink, which is owned by Qantas) that operate in those markets. However, large operators are the exception rather than the norm.

Stop and think

Why do relatively few large airlines operate dedicated regional subsidiaries?

Once small carriers have diversified into a number of niche markets, their often limited financial and management capabilities combined with their limited experience of risk management techniques may leave them exposed to sudden changes in demand and cost shocks, such as the jet fuel price spike and subsequent global financial crisis in 2008 demonstrated. Most airlines serving remote regions do not have sufficiently robust balance sheets or the financial ability to engage in fuel hedging, and many of their long-term corporate or PSO contracts did not (but often do now) include fuel cost indices that would have protected them to some extent from rapid rises in the price of this essential commodity. However, fuel hedging can only protect from sudden price increases and cannot insulate a carrier from the effect of a price rise indefinitely (which can cause problems if these price rises are mid-contract). The key issue is therefore attracting high-calibre staff such as engineers and experienced managers to operate in what may be perceived to be less glamorous and less well-paid positions. The various skills needed to run an airline – including yield management, safety compliance, effective HR, financial planning and quality management practices – are often delivered in a multitasked, often self-taught, way.

Low or volatile demand is, however, only one part of the problem. Another, interrelated challenge is that operating aircraft in remote regions is relatively expensive when assessed on a per seat basis. Small aircraft and relatively short sectors (such as the famous 45-second scheduled flight between the islands of Westray and Papa Westray in Scotland), shorter operational windows (because thin routes can only bear low frequencies) and limited bargaining power with suppliers mean remote airlines are not able to spread their operating cost over the 500 seats in an A380 but the 12–30 seats typical of a small regional aircraft. This results in relatively high costs per seat and per available seat kilometre which translates into significantly higher fares. This affects consumer demand for the services and forces regional residents who rely on the services to pay more for their tickets.

The unfavourable cost structures which result from diseconomies of scale and scope do not have to be a profitability challenge as long as the airlines can secure sufficiently high yields. Although high yields can be obtained from the corporate, charter tourism and mining sectors, airlines operating in remote regions remain heavily dependent on regional economic development and the prosperity of a specific industry or economic sector. If one of their key corporate clients changes their operation, or if the airline loses key publicly subsidised transport contracts, the lack of alternative revenue sources means that the airline may enter administration (➤Chapter 11). For this reason, airlines operating in remote regions try to diversify their operation to geographically and operationally spread the risk.

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Stop and think

What are the potential disbenefits for airlines that arise from operational diversification?

Challenges that are specific to airlines that provide publicly procured remote air services include the lack of access to GDSs and sophisticated IT systems that can support their revenue management functions (➤Chapter 16). This is despite many PSO contracts requiring the airline to have an interline agreement in place at the larger airport the PSO serves. Recent research (Merkert and O'Fee 2013) suggests that managers of airlines operating remote routes in Europe often find it difficult to operate in an environment where public transport authorities are not prepared to accept any risk on the demand or cost side. What is more, there is often no effective marketing or route development for remote air services, and PSO contracts often offer few incentives to grow patronage. Ideally, local transport authorities need to 'own' rather than simply administer their PSO route portfolios and include marketing and tourism campaigns that would enable the route to develop into a profitable venture that does not rely on public subsidy.

Barriers to entry, which effectively prevent them from accessing larger hub airports, are another problem remote airlines encounter. In the US and Europe particularly, continued consolidation has resulted in hubs becoming even more congested, and incumbent airlines have reassigned valuable slots to more lucrative and higher-yielding long-haul routes. For major hubs, it is much more profitable to have wide-body aircraft operating into the facility than a 19-seat airframe and, as a result, many regional and remote airlines have been priced out of key hubs. As a consequence, many remote regions have lost their direct connection to global markets, and passengers are required to connect via secondary airports, which adds additional time and cost to the journey. As an example, the number of domestic UK destinations served from London Heathrow fell from 18 in 1990 to seven in 2015, and three times as many UK regional airports are served by direct flights to Amsterdam than London Heathrow. Some airports, such as Sydney Kingsford Smith, are regulated in such a way as to ensure that regional/remote carriers are always allocated a certain proportion of available slots, a process that is called ring fencing.

Stop and think

To what extent could ring fencing slots for regional services at major airports be considered anticompetitive?

For RRR airports, connections to large airports and regional airport networks are of equal importance. As with remote airlines, remote airports are often subject to low, seasonal or volatile traffic volumes and are invariably loss-making. Unlike the large international hubs (which now generate up to 50 per cent of their revenues from non-aeronautical activities such as car parking and duty free), remote airports rely much more extensively on aeronautical revenues (either direct or indirect through departure taxes). Changeable and extreme weather conditions necessitate the provision of de- and anti-icing (or anti-flooding) facilities and snow removal equipment, which add to the operating costs. These costs have risen further in recent years as new safety, security, environmental and regulatory compliance measures have been imposed. From a market perspective, cost presents the biggest challenge to remote airports (again, mainly due to low or volatile passenger demand), many of which are owned and operated by local councils. In Australia, recent figures suggest that more than 50 per cent of RRR airports are unable to cover their operating costs and this places additional pressure on local council budgets. It is hardly surprising that local councils, private airport owners and operators try to find innovative ways of minimising operating costs (see Example 20.1).

Example 20.1

Remote towers

The biggest challenge for regional and remote airports is high fixed costs. Staff costs per departing/arriving passenger are usually high and, as they are usually under management control, most cost-efficiency innovations at remote airports concern staffing. The remote tower concept enables air traffic control (ATC) services and aerodrome flight information services to be provided to remote aerodromes from a central facility that is geographically distant from the airport. For facilities with limited demand and/or restricted operating hours, a remote tower offers significant cost-saving potential and can confer important social and economic benefits to remote regions. Air Navigation Service Providers (ANSPs) around the world are very interested in this innovation as they are all trying to reduce costs without affecting safety or operational availability.

Remote tower trials have been conducted in Sweden at Ängelholm Airport (with ATC services remotely provided from Malmö Airport 100km away) and Göteborg Landvetter Airport (the second largest airport in Sweden) and also at two airports in northern Norway (where aerodrome flight information services were provided by Bodø Airport). Approval to operate the new technology at Sundsvall Remote Tower Centre to provide ATC for Örnsköldsvik Airport, 150km away, has also been granted. These trials have confirmed the operational feasibility and safety of the systems as well as their ability to deliver cost savings of up to 60 per cent as staff does not need to be employed at individual sites. Airservices Australia have also tested a remote tower at Alice Springs Airport, which is remotely controlled from Adelaide, over 1,500km away.

A key challenge for remote airports' cost management is the high and unavoidable sunk capital cost of airport infrastructure. Airports try therefore to save elsewhere, particularly with staff, which is their second largest cost component. Airports seek to improve labour productivity by obliging their staff to undertake a diverse number of activities. An airport baggage handler at a remote airport could, in addition to their primary role, also be responsible for fire-fighting or airfield operation duties. In terms of human resource management, a further key challenge for remote airports is attracting and retaining skilled staff. Many potential employees migrate to larger towns and cities in search of education and employment and leave a skills gap.

From a cost, risk management and business development perspective, another challenge facing regional airports is the fact that the majority of them are served by only one airline operator. For example, more than 70 per cent of Australia's regional airports are only served by one airline. This demonstrates the economic power that these airlines hold over the remote airports and vice versa. Increased airline competition would therefore be beneficial.

Stop and think

Consider the relative merits of the strategies remote airports can use to minimise their operating costs.

20.3 Aircraft types and operational considerations

The types of aircraft that are operated in remote regions are as diverse as the destinations they fly to as a consequence of the services' unique demand and operating profiles. In remote areas, it is not uncommon for the operator to have to invest in STOL aircraft, such as the de Havilland Canada DHC-6 Twin Otter, or, in the case of oil rigs or very mountainous terrain, helicopters. Before ceasing operations in 2012, British International Helicopters used the Sikorsky S-61 helicopter (which can accommodate up to 30 passengers) for its scheduled services between Penzance Heliport on the UK mainland and St Mary's on the Isles of Scilly. Helicopters are also used on some PSO services (such as those that serve the Lofoten islands in Norway) but more typically for medical purposes or to connect offshore oil rigs with the mainland. Bristow has substantial fleets of helicopters based in Aberdeen, UK, and Houston, US, to serve the North Sea and Gulf of Mexico oil and gas installations. While it is appreciated that the helicopter (or rotary wing) RRR market is not insignificant, the remainder of this chapter will focus on fixed-wing aircraft.

The aircraft that are used in remote regions vary depending on the demand, available infrastructure and the operating environment. Research on PSO air services in Europe has, for example, shown that aircraft as big as Airbus A320s and Boeing 777-300ERs are operated to tourist destinations such as Corsica Bastia. Although France, Italy and Portugal operate high-demand routes using the PSO mechanism, PSO services are normally flown by much smaller aircraft (see Figure 20.1). UK operators, for instance, typically employ aircraft smaller than 20 seats on PSO routes.

A good example of such operations is UK operator Skybus, which operates a fleet of three Britten-Norman Islander eight-seater aircraft and four DHC-6 de Havilland Twin Otter 19-seater aircraft to provide regular scheduled flights between the Isles of Scilly and Land's End, Newquay and Exeter airports on the UK mainland. These relatively simple and mechanically robust turboprops are not only reliable but can operate routes that are often challenging in terms of infrastructure and weather conditions. Flights to the Scottish island of Barra, for example, require aircraft to land on the beach, and scheduling is dependent on the tide (see Figure 20.2). Some of these aircraft can be fitted with specific equipment to enable them to operate as land or seaplanes (see Case Study 20.2).

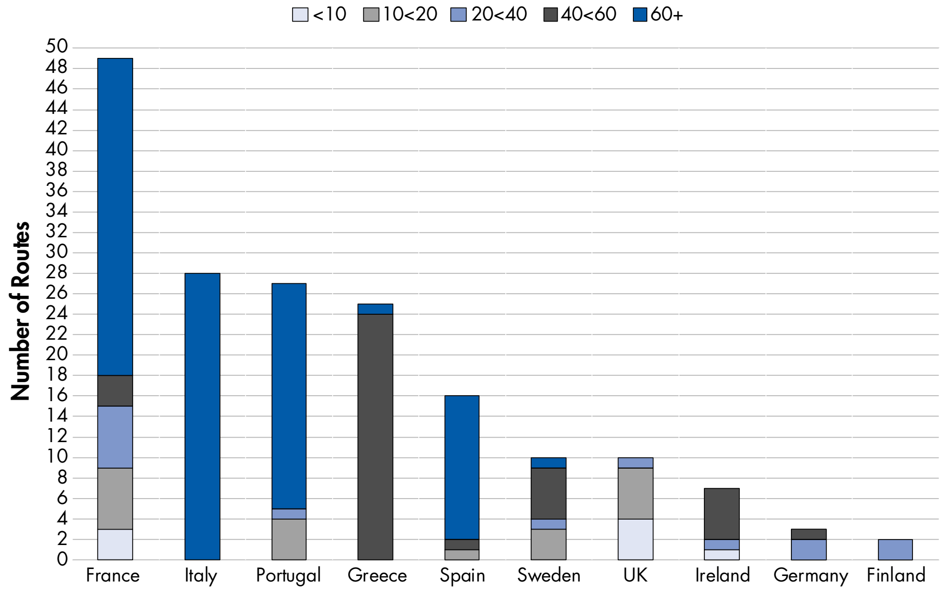

Figure 20.1 The seating capacity of aircraft used on European PSO air services

Source: Merkert and Williams (2013)

Figure 20.2 A DHC-6-400 Twin Otter, owned by Highlands and Islands Airports Ltd and operated by Loganair, on the beach at Barra Airport, Scotland

Source: Transport Scotland

Table 20.1 details the most popular aircraft in the sub-30 seat market segment. The DHC-6 (Twin Otter) is the most popular. This aircraft is ideal for remote air services not only because of its size but also because it can operate in all climates. It can be fitted with floats or skis and as a consequence is utilised in Norway, the UK, Antarctica and tropical islands in Asia. A key challenge for operators of these aircraft is their age and associated high maintenance costs. Many Twin Otters are over 35 years old, and the need for a replacement is becoming increasingly acute as production ceased in 1988. This created significant challenges for the airlines and remote communities who feared that they would lose their service if cost-efficient alternative airframes could not be found. This market gap was identified by Viking Air, who, in 2006, began manufacturing replacement parts for all of the out-of-production de Havilland Canada aircraft but also the fully re-designed Series 400 (of which more than 60 had been produced by the end of 2014). The benefits of sub-20 aircraft are not only operational but also commercial as they often receive tax benefits or regulatory exemptions (e.g. they do not attract Air Passenger Duty in the UK and are exempt from the EU Emissions Trading System).

Table 20.1 Sub-30 seat fleet in service, 2013

Manufacturer	*Variant*	*Seats*	*No.*
de Havilland Canada	DHC6	12–20	312
Beech Aircraft Corporation	B1900	16–19	265
British Aerospace	BAE3100-BAE4100	12–29	112
Cessna Aircraft Company	CARAVAN (208)	6–14	103
Swearingen Corporation	METRO23-METRO III	10–19	50
Britten-Norman	BN2 (incl. Trislander)	8–15	38
Beech Aircraft Corporation	B100-B200 (incl. King Air)	6–9	36
Dornier	DO228	17–20	35
Let	L410	14–19	35
Embraer	EMB110	12–21	24
Cessna Aircraft Company	CARAVAN II (F406)	12	27
Yakovlev	YAK40	16–29	18
Pilatus Aircraft	PC6	7–9	17
Harbin Aircraft Industries Group	Y12	17–19	8
CASA	CASA212	22	7
Antonov	AN26-AN38	10–26	6
Boeing/McDonnell Douglas	DC3T	27	6
Saab	SAAB340	17–25	6
Bombardier	DHC-8Q	25–27	5

Source: Author's analysis based on CAPA and aircraft manufacturer data as of August 2013

Note: Some of these aircraft (e.g. SAAB340 or DHC-8-102) are operated in larger numbers but in configurations that increase their capacity above 29 seats

While the majority of remote services are provided by small aircraft, some services are operated by larger aircraft and an upsizing trend (to 60–120 seats) is apparent in some RRR markets. Table 20.2 illustrates the most popular sub-120 seat turboprop and jet-powered aircraft.

Table 20.2 Popular sub-120 seat aircraft in service, 2015

Turboprops	*Jets*
30–60 seats	**30–60 seats**
ATR42	ERJ-135/140/145
DHC8-100/200/300	CRJ 100/200
EMB-120	
Saab 340/2000	
61–90 seats	**61–90 seats**
ATR72	E170/175
DHC8-400	CRJ 700/705/900
	Mitsubishi MRJ
	Avro RJ70/85
	AVIC ARJ21-700
	B717-200
91–120 seats	**91–120 seats**
TBD Turboprop	E190/195
	A318
	B737-200/500/600
	Fokker 100
	BAe146-300
	Avro RJ100
	SSJ100
	CSeries CS100
	CRJ 1000
	AVIC ARJ21-900

Given the operational challenges that come with many remote routes, niche aircraft or aircraft with specific equipment will always be in demand, as Case Study 20.2 shows.

CASE STUDY 20.2

COBHAM AVIATION SERVICES, AUSTRALIA

Jet Systems, trading as Cobham Aviation Services Australia, is a diversified and successful niche market player based in Adelaide, Australia. In addition to lucrative FIFO and charter operations throughout Australasia, they also provide freight (mainly for Australian Air Express, a joint venture of Qantas and Australian Post) and regular scheduled passenger services. Their key selling points are flexibility, safety and reliability. With their fleet of 18 Boeing 717-200 (employed on passenger services operated on behalf of QantasLink), Bombardier Dash 8 turboprops (mainly for surveillance flights), 14 British Aerospace BAe 146 Regional Jets (mainly freight), one Fokker 100 and one Embraer E190, they can operate flights seating between four and 100 passengers. Their corporate clients can determine their own itineraries, and this attracts not only government, civilian aerial surveillance programmes and aerial tours but also big resource companies such as Santos, Chevron, Rio Tinto and BHP Billiton. For these clients, Cobham is often the only possible option. One of Cobham's 82-seat BAe 146 aircraft is equipped with a gravel kit that allows the jet to land on unprepared gravel runways close to mines or potential mining sites.

Stop and think

What are the cost implications of utilising small aircraft on RRR routes, and how might they be managed?

20.4 Financial viability, franchising, public subsidies and PSO routes

On account of the substantial economic and social impact of remote air services, many jurisdictions have decided that it is in the public interest to support the airlines, the airports or (indirectly) the residents that live in remote regions, for example through subsidised airfares (which often just inflate the overall uncapped fares and distort economic welfare). It is argued that public authorities who have an interest in the economic and social development of the (often thinly populated but still strategically important) regions in question can achieve this most effectively by directly supporting aviation that connects these regions with the world rather than through indirect economic support. Recent econometric evidence from Australia supports this. Public support can include direct or indirect subsidies, marketing support, tax breaks or protection from competition on regulated monopoly routes.

Airlines usually bid in a competitive tender processes for the right to operate regulated and/or subsidised routes. The most prominent examples of these schemes are the Essential Air Service (EAS) programme and the Small Community Air Service Development Program (SCASDP) in the US, the Remote Air Services Subsidy (RASS) Scheme in Australia and the European Public Service Obligation (PSO) air service mechanism, the latter of which supports the routes shown in Figure 20.3. While public subsidy can be justified on the grounds of aviation being a merit good in the remote aviation context, the resulting principal (transport authority) agent (airline) contractual relationship and the potential for

Figure 20.3 European landscape of approved PSO air routes (as of Dec 2011). There are currently 269 potential, historic and approved PSO routes in Europe. Nine EU countries and two EEA states (Iceland and Norway) currently operate PSO routes.

Source: Merkert and O'Fee (2013), p119

(mis)interpretation of policy guidelines can result in inefficiencies, inappropriate incentives and a lack of competition for contracts.

Similar schemes of airline support can be found in Canada, Russia, India, China and New Zealand, although these often do not involve competitive tendering and are targeted more at specific airports or specific objectives. Direct financial support for remote airports exists in most countries, and the most researched one is the Route Development Fund (RDF), developed in Scotland and later replicated in other parts of the UK. Australia is another interesting example for airport support. While the RASS Scheme provides more than 350 communities in remote and isolated areas of Australia with improved access through the subsidy of a regular air transport services (only six small airlines operate on those thin routes and are so far apart from each other that they don't compete), the umbrella government's Regional Aviation Access Programme (RAAP) also includes the Remote Aviation Infrastructure Fund (RAIF), the Remote Airstrip Upgrade (RAU) Programme, the Remote Aerodrome Safety Programme (RASP) and the Remote Aerodrome Inspection (RAI) Programme. In addition, there is also the Airservices Australia Enroute Charges Payment Scheme, which provides a subsidy to air operators providing aero-medical services to regional and remote locations, which includes reimbursement of en-route air navigation charges. On the airline side, it is only the thin routes where public authorities support scheduled regular air services, while on the airport side direct and indirect public support benefits all types of air transport to remote regions.

Stop and think

What are the advantages and disadvantages of PSO routes (and non-European equivalents) to remote regions for airlines, airports, passengers and remote regions?

20.5 The future

Although jet fuel prices have fallen since the end of 2014, it is likely that they will go up again given the increased scarcity of oil. It is therefore likely that, in the future, fuel prices will present an even higher share of airlines' operating costs and if no fuel adjustors or hedging mechanisms are available, the volatility of fuel prices will mean that air transport to remoter regions will become even more risky and even less commercially viable. Changing (and often ageing) remote populations and increasing safety and security compliance costs will all contribute to this. The other key challenge will be a shortage of technical staff at remote airports and of pilots in remote airlines. While in the remote airline context training is much less of an issue as pilots use this flying as their training ground and hour-building environment, retaining them is far more problematic. In the remote airport context, staff training and retention will become ever more challenging regardless of the route. All of this points to an increasing need for public support, be it through subsidies, regulation, regional development or aviation friendly policymaking. It is also likely that the aviation industry will, as so often in the past, try and help itself, particularly with regards to productivity and environmental challenges. Innovation is the key to this, and Example 20.1 provides an illustration of the potential for such innovative technologies and processes.

Key points

- No single definition of a 'remote region' exists, and individual countries use their own definitions.
- Air transport in remote regions is of crucial importance to the communities and businesses it serves. RRR services are often considered to be a lifeline as without them some remote communities could not continue to exist in their present form.
- Air transport in remote regions includes publicly supported passenger routes as well as charter services and corporate flights related to tourism and the resources sector.
- Remote air services are operated by both FSNCs and specialist niche operators using a range of fixed-wing and rotary-wing aircraft. Although a range of aircraft types are used, most fixed-wing aircraft used on remote services have fewer than 30 seats and some are specifically equipped to operate from short and/or unprepared runways.
- Air transport provides substantial direct, indirect, induced and catalytic benefits to remote regions, but the services pose significant operational and market challenges.
- The low demand for air services and the consequent precarious financial state of some remote airlines and airports means public support for certain routes may be required.
- Managing remote airports poses unique challenges and requires particular skills. Remote airports are seeking ways to minimise operating costs, and the remote tower concept is one way in which greater efficiencies and cost savings may be achieved.
- Innovation, increased marketing and route/business development efforts, as well as more appropriate risk sharing between all stakeholders, will help to secure the future of air transport in remote regions and promote the economic and social viability and vitality of communities and businesses they serve.

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