ICAO

Doc 9976

Flight Planning and Fuel Management (FPFM) Manual

First Edition — 2015

Approved by and published under the authority of the Secretary General

INTERNATIONAL CIVIL AVIATION ORGANIZATION

Doc 9976

Flight Planning and Fuel Management (FPFM) Manual

First Edition — 2015

Approved by and published under the authority of the Secretary General

INTERNATIONAL CIVIL AVIATION ORGANIZATION

Published in separate English, Arabic, Chinese, French, Russian
and Spanish editions by the
INTERNATIONAL CIVIL AVIATION ORGANIZATION
999 Robert-Bourassa Boulevard, Montréal, Quebec, Canada H3C 5H7

For ordering information and for a complete listing of sales agents
and booksellers, please go to the ICAO website at www.icao.int

First edition, 2015

Doc 9976, *Flight Planning and Fuel Management (FPFM) Manual*
Order Number: 9976
ISBN 978-92-9249-838-2

AMENDMENTS

Amendments are announced in the supplements to the *Products and Services Catalogue;* the Catalogue and its supplements are available on the ICAO website at www.icao.int. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS		
No.	Date	Entered by

CORRIGENDA		
No.	Date	Entered by

FOREWORD

This manual, referenced in ICAO Annex 6 — *Operation of Aircraft*, Part I — *International Commercial Air Transport — Aeroplanes*, provides operational guidance material that addresses the specific safety risks associated with alternate aerodrome selection, fuel planning and in-flight fuel management. It also provides guidance material to assist States, civil aviation authorities, and the operators under their jurisdiction, in the development and/or implementation of prescriptive regulations and performance-based variations to such regulations based on Sections 4.3.4, 4.3.5, 4.3.6 and 4.3.7 of Annex 6, Part I.

In a rapidly changing global economy, the international air transport industry must continuously adapt to new trends and increasingly competitive market conditions. While technological improvements in aviation continue to increase reliability and predictability, economic and environmental concerns will continue to compel operators to use fuel more efficiently. Consequently all operators, including those leveraging existing technologies and those investing in new technologies to meet operational challenges, should be afforded the opportunity to receive a return on their investments.

The technological leaps in aviation made over the last century would not have been possible without parallel achievements in the control and reduction of safety risks. It is only through the disciplined application of the best safety risk management practices that the frequency and severity of aviation occurrences can continue to decline.

Until recently, ICAO Annex 6, Part I, provided very general guidance for alternate aerodrome selection and fuel planning. It distinguished between propeller and jet aeroplanes without sufficient justification, and alternate aerodrome selection criteria and contingency fuel requirements were not sufficiently detailed. This lack of detail in Annex 6 may have resulted in the implementation of extremely conservative and prescriptive national policies for flight planning that are not adaptable to a rapidly changing and increasingly complex operating environment.

Amendment 36 to Annex 6, Part I, ushered in a new era where operators can improve overall operational efficiency and reduce emissions by implementing national regulations based on globalized prescriptive standards or operational variations from such standards based on an individual operator's ability to achieve target levels of safety performance. These variations from precise guidance are contingent on the use of hard data and the application of safety risk management principles. The challenge remains, however, for civil aviation authorities to define appropriately all of the regulations that allow operators to optimize fuel carriage while maintaining safe flight operations.

Many modern civil aviation authorities are also increasing emphasis on performance-based approaches to regulatory compliance. Many modern-day operators also have the capability and resources necessary to analyse operational hazards, manage safety risks to levels as low as reasonably practicable and achieve target levels of safety performance. Taken together, these elements provide operational flexibility and form the framework for a proactive, self-correcting and continually improving safety system.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY

As work progressed on the amendment proposal to Annex 6, Part I, it became evident that the scope and permanency of related guidance materials made them suitable for inclusion in a manual. As such, under the direction of the Secretariat and during the Twelfth Meeting of the Operations Panel Working Group of the Whole (OPSPWG/WHL/12) in November 2010, the Fuel Use Sub-Group (FUSG) of the Operations Panel was charged with the creation and ongoing revision of the *Flight Planning and Fuel Management (FPFM) Manual*.

This manual aims to accomplish two things: first and foremost, it provides the expanded guidance material necessary to support the implementation of national regulations based on each Standard and Recommended Practice in Amendment 36 to Annex 6, Part I. Additionally and more specifically, it provides overall and extensive guidance on how civil aviation authorities (CAAs) and operators can cooperate to derive the greatest benefit from their collective flight operations and fuel planning experiences.

The manual contains a short history of the development of the amendment as well as expanded explanations of the new texts relating to alternate aerodrome selection, fuel planning and operational variations. It also provides guidance on how to conduct in-flight fuel management, including re-planning, re-dispatch, decision point and isolated aerodrome planning. Additional sections detail the relationships among safety, environment, and efficiency, as well as discuss how safety risk management (SRM) principles can be applied to achieve target levels of safety performance.

The primary goal in formulating the manual is to maintain the safety of flight operations. A secondary goal is to improve operational efficiency by reducing fuel uplift and the resultant aircraft operating mass. To accomplish these goals, the manual was developed using two parallel and equally important approaches.

The first, or regulatory approach, sought to take full advantage of the experiences and expertise of the State regulators that participated in the FUSG. As fuel planning is relatively mature at the regulatory level, the FUSG was able to leverage years of experience in implementing baseline prescriptive requirements as well as allowable operational variations from such requirements that are contingent on the demonstrable capabilities of each individual operator.

The second, or industry approach, involved leveraging the collective operational experience of air carriers around the world as expressed by industry advisors to the FUSG. This effort explored industry best practices in implementing flexible alternate aerodrome selection and fuel policies that produce operational efficiencies while maintaining proven levels of safety performance.

These two approaches were merged by the FUSG to create a seamless document that begins by introducing the perspective of several national models for alternate aerodrome selection and fuel planning regulations. These models were introduced to support both Amendment 36 to Annex 6, Part I, and the guidance in this manual. They demonstrate how modern prescriptive and performance-based approaches to safety can be incorporated into national regulations. The manual is also amply supported by Appendices that provide additional and extensive supplementary material including guidance on how to implement operational variations that are based on an individual operator's performance and demonstrable capabilities.

GLOSSARY

ACRONYMS AND ABBREVIATIONS

ACARS	Aircraft Communications Addressing and Reporting System
ACF	Analysed Contingency Fuel
ADS	Automatic dependent surveillance
ADS-B	Automatic dependent surveillance – Broadcast
ADS-C	Automatic dependent surveillance – Contract
AEO	All Engines Operating
AFIS	Aerodrome Flight Information Service
AFM	Aeroplane flight manual
ALARP	As low as reasonably practicable
ANSP	Air Navigation Service Provider
AOM	Aeroplane Operations Manual
APM	Aircraft Performance Monitoring
ASF	Aircraft Stable Frame
ATC	Air Traffic Control
ATM	Air traffic management
ATS	Air traffic services
AWS	Automatic Weather System
CAA	Civil Aviation Authority
CAT I	Category I
CAT II	Category II
CAT III	Category III
CB	Cumulonimbus
CDL	Configuration Deviation List
CDM	Collaborative Decision Making
CFR	Code of Federal Regulations
CFS	Critical fuel scenario
DA/H	Decision Altitude/Height
DARP	Dynamic Airborne Re-route Procedure
DP	Decision Point
EDTO	Extended Diversion Time Operations
EFC	Expect further clearance
ERA	En-route Alternate
ETA	Estimated Time of Arrival
ETD	Estimated Time of Departure
ETP	Equal Time Point
EU-OPS	European Operations
EUROCONTROL	European Organization for the Safety of Air Navigation
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FCM	Fuel Consumption Monitoring
FL	Flight Level
FMS	Flight Management System
FOO	Flight Operations Officer
FPFM	Flight Planning and Fuel Management

FUSG	Fuel Use Sub-Group
GBAS	Ground Based Augmentation System
GLS	GBAS Landing System
GNSS	Global Navigation Satellite System
GPS/WAAS	Global Positioning System with Wide Area Augmentation
IAF	Initial approach fix
IAP	Instrument Approach Procedure
IATA	International Air Transport Association
IFR	Instrument flight rules
IFSDR	In-flight shut down rate
ILS	Instrument landing system
ISO	International Organization for Standardization
JAR-OPS	Joint Aviation Requirement for the operation of commercial air transport
LNAV	Lateral Navigation
LPV	Localizer Performance with Vertical Guidance
m	metre
MDA/H	Minimum Descent Altitude/Height
MEL	Minimum Equipment List
METAR	Aerodrome routine meteorological report
NAVAID	Navigation Aid
NOTAM	Notice to Airmen
OEI	One Engine Inoperative
OEM	Original equipment manufacturer
OFP	Operational Flight Plan
OPMET	Operational meteorological information
OpSpecs	Operations Specifications
PBN	Performance-based navigation
PDP	Pre-determined Point Procedure
PIC	Pilot in Command
PNR	Point of no return
RCF	Reduced Contingency Fuel Procedure
RNAV	Area Navigation
RNP	Required Navigation Performance
RNP AR	Required Navigation Performance – Approval Required
RVR	Runway Visual Range
SA	Safety Assurance
SAR	Specific Air Range
SARPs	Standards and Recommended Practices (ICAO)
SATCOM	Satellite Communications
SBAS	Satellite Based Augmentation System
SCF	Statistical Contingency Fuel
SELCAL	Selective Calling
SFC	Specific Fuel Consumption
SIGMET	Information concerning the occurrence or expected occurrence of specified en-route weather phenomena which may affect the safety of aircraft operations
SME	Subject Matter Expert
SMM	Safety Management Manual (Doc 9859)
SMS	Safety Management System
SOP	Standard operating procedure
SPECI	Aerodrome special meteorological report
SPI	Safety performance indicator
SRM	Safety Risk Management
SSP	State Safety Programme

TAF	Aerodrome Forecast
TEMPO	Temporary or temporarily
TMU	Traffic Management Unit
TSO	Technical Standard Order
UPR	User Preferred Route
VFR	Visual Flight Rules
VMC	Visual meteorological conditions
VOR	Very high frequency omnidirectional range
WAAS	Wide Area Augmentation System
WP sr	Point of Sole Reliance
Wx	Weather conditions
ZFW	Zero fuel weight

DEFINITIONS

When the following terms are used in this manual, they have the following meanings:

Alert level. An established line of demarcation outside of the acceptable operating range that requires an adjustment or evaluation but does not necessarily indicate a process failure.

Note.— Alert levels are related to specific operational activities and are established by regulators and operators for the purposes of adjustment and/or evaluation prior to the exceedance of an operational parameter or limit.

City-pair. Route flown between an origin aerodrome to a planned destination aerodrome.

Commencement of flight. The moment an aeroplane first moves for the purpose of taking off.

Compliance-based regulatory oversight. The conventional and prescriptive method of ensuring safety used by a State's Civil Aviation Authority (CAA) that requires strict conformance to pre-established, non-variable regulations by the operator.

Contingency fuel. An amount of fuel required to compensate for unforeseen factors, which is five per cent of the planned trip fuel or of the fuel required from the point of in-flight re-planning based on the consumption rate used to plan the trip fuel, but in any case shall not be lower than the amount required to fly for five minutes at holding speed at 450 m (1 500 ft) above the destination aerodrome in standard conditions.

Note.— For the purposes of applying the provisions, the terms "point of in-flight re-planning", "re-release point", "re-dispatch point" and "decision point" are synonymous.

Decision point. The nominated point, or points, en route beyond which a flight can proceed provided defined operational requirements, including fuel, are met. If these requirements cannot be met, the flight will proceed to a nominated alternate aerodrome.

Note 1.— The operational requirements to be met are specified by the operator and approved, if required, by the State.

Note 2.— Once past the final decision point, the flight may not have the ability to divert and may be committed to landing at the destination aerodrome.

Flight following. The recording in real time of departure and arrival messages by operational personnel to ensure that a flight is operating and has arrived at the destination aerodrome.

Flight monitoring. In addition to requirements defined for *flight following*, flight monitoring includes the:

1) operational monitoring of flights by suitably qualified operational control personnel from the point of departure throughout all phases of flight;

2) communication of all available and relevant safety information between the operational control personnel on the ground and the flight crew; and

3) provision of critical assistance to the flight crew in the event of an in-flight emergency or security issue or at the request of the flight crew.

Flight watch. In addition to all of the elements defined for *flight following* and *flight monitoring*, flight watch includes the active tracking of a flight by suitably qualified operational control personnel throughout all phases of the flight to ensure that it is following its prescribed route, without unplanned deviation, diversion or delay and in order to satisfy State requirements.

Hazard. A condition or an object with the potential to cause injuries to personnel, damage to equipment or structures, loss of material, or a reduction in the ability to perform a prescribed function. A consequence of a hazard is defined as the potential outcome(s) of a hazard. The damaging potential of a hazard materializes through its consequence(s).

Note.— Examples of hazards relevant to flight planning and fuel management include: meteorological conditions (adverse, extreme and space), geophysical events (volcanic eruptions, earthquakes, tsunami), air traffic management (ATM) congestion, mechanical failure, geography (adverse terrain, large bodies of water), aerodrome constraints (isolated, runway closure), and any other condition with undesirable potential consequences.

Operation Specifications (OpSpecs). The authorizations, conditions and limitations associated with the air operator certificate and subject to the conditions in the operations manual.

Note.— Operational variations from prescriptive regulations, if permitted by a State's CAA, are often expressed in OpSpecs, Deviations, Alternative Means of Compliance (AMC), Exemptions, Concessions, Special Authorizations or other instruments.

Operational control. The direction and regulation of flight operations. The direction is in the form of policy and procedure in compliance with regulation. Regulation is the statutory requirement stipulated by the CAA of the State of the Operator.

Note.— An operator, in exercising operational control, exercises the authority over the initiation, continuation, diversion or termination of a flight in the interest of the safety of the aircraft and the regularity and efficiency of the flight.

Operational flight plan. The operator's plan for the safe conduct of the flight based on considerations of aeroplane performance, other operating limitations and relevant expected conditions on the route to be followed and at the aerodromes concerned.

Operational variations. Deviations, Alternative Means of Compliance (AMC), Exemptions, Concessions, Special Authorizations or other instruments used by a CAA to approve performance-based alternatives to prescriptive regulations.

Note 1.— Operational variations to the alternate aerodrome selection and fuel planning provisions are described in Annex 6, Part I, 4.3.4.4 and 4.3.6.6.

Note 2.— For the purposes of this manual the terms "variation", "operational variation" and "performance-based variation" are synonymous and can be used interchangeably.

Performance-based compliance. A safety-risk-based approach to regulatory compliance that involves the setting or application of target levels of safety performance of a system or process, which in turn facilitates the implementation of variable regulations or operational variations from existing prescriptive regulations.

Note.— Performance-based compliance is supported by proactive operator processes that constantly monitor the real-time performance, hazards and safety risks of a system.

Performance-based regulatory oversight. A method, supplementary to the compliance-based oversight method, taken by a State's CAA, which supports the implementation of variable regulations or variations from existing prescriptive regulations, based on the demonstrable capabilities of the operator and the incorporation of safety-risk-based methods for the setting or application of target levels of safety performance.

Note.— Performance-based regulatory oversight components rely on State processes that constantly monitor the real-time performance, hazards and risks of a system to assure that target levels of safety performance are achieved in an air transportation system.

Point of in-flight re-planning. A geographic point at which an aeroplane can continue to the aerodrome of intended landing (planned destination) or divert to an intermediate (alternate) aerodrome if the flight arrives at the point with inadequate fuel to complete the flight to the planned destination while maintaining the required fuel including reserve.

Prescriptive compliance. A conventional means of achieving target levels of safety performance of a system or process based on operator compliance with pre-established, non-variable standards or limitations.

Safety. The state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management.

Safety indicator. A collation of high-consequence safety-related data for the purpose of monitoring, measuring or analysis.

Note.— Examples of relevant safety data may include: hull losses due to fuel starvation and occurrences of landing with less than final reserve fuel.

Safety measurement. Refers to the measurement of selected high-level, high-consequence outcomes, such as accident and serious incidents.

Note.— Example of a relevant safety measurement: [insert number] hull losses due to fuel exhaustion in [insert number] operations.

Safety performance indicator. A collation of lower consequence safety-related data for the purpose of monitoring, measuring or analysis.

Note.— Examples of relevant safety data may include: occurrences of the complete consumption of contingency fuel (plus discretionary, if applicable), diversions due to fuel, and occurrences of trip fuel over-burn.

Safety performance measurement. Refers to the measurement of selected lower consequence outcomes, such as routine incidents or surveillance findings.

Note 1.— Example of a relevant safety performance measurement: [insert number] occurrences of the complete consumption of contingency fuel (plus discretionary, if applicable) per [insert number] operations.

Note 2.— The complete consumption of contingency fuel may be considered a high-consequence event depending on the operational context (e.g. no alternate aerodrome nominated).

Safety risk. The composite of predicted severity (how bad) and likelihood (how probable) of the potential effect of a hazard in its worst credible (reasonable or believable) system state.

Note.— For the purposes of this manual, the terms "safety risk" and "risk" are interchangeable.

Safety risk control. A characteristic of a system that reduces the potential undesirable effects of a hazard. Controls may include process design, equipment modification, work procedures, training or protective devices. Safety risk controls are written in the form of requirements, are measurable, and are monitored to ensure effectiveness.

Safety target value. The concrete objective of the level of safety.

Note.— Example of a relevant safety target value: Reduce by [insert number] the occurrences of landing with less than final reserve fuel per [insert number] operations.

Target level of safety performance. The minimum degree of safety of an operational activity, expressed through safety performance indicators, which has been established by the State and is practically assured by an operator through the achievement of safety targets.

Chapter 1

INTRODUCTION AND OVERVIEW OF THE MANUAL

1.1 HISTORY

1.1.1 The provisions on alternate aerodrome selection and fuel planning that became Amendment 36 to Annex 6, Part I, were part of a joint IATA and ICAO initiative to improve aeroplane fuel efficiency and reduce emissions. A realistic, modern approach was needed that would take into account operational experience, new technologies and advanced aeroplane capabilities while providing for safe operations through the use of modern methods including operational data analysis and safety risk management (SRM). The task to draft the amendment was undertaken by the Operations Panel in 2008 and progressed through a series of meetings and correspondence among members.

1.1.2 The principal purpose of Amendment 36 was to introduce globally harmonized planning criteria for the selection of alternate aerodromes and the pre-flight computation of total fuel supply. Additionally, new Standards and Recommended Practices were added to describe the responsibilities of the operator and the duties of the pilot-in-command (PIC) with respect to in-flight fuel management. Of particular note is better guidance for the PIC with regard to declaring minimum fuel and a new requirement for the PIC to declare an emergency when the predicted usable fuel upon landing at the nearest aerodrome, where a safe landing can be made, is less than the planned final reserve fuel. This gives the PIC a clear course of action to be followed when actual fuel use results in the likelihood of a landing with less than final reserve fuel.

1.1.3 Finally, it is recognized that many States and operators often employ statistically driven performance-based methods and SRM principles when developing or applying alternate aerodrome selection and fuel planning regulations, systems or processes. Such methods complement conventional approaches to regulatory compliance and are used to achieve and maintain target levels of safety performance that are acceptable to the State and the operator.

1.2 RELATIONSHIP TO ANNEX 6, PART I, SARPS AND OTHER ICAO DOCUMENTS

This manual provides guidance material for alternate aerodrome selection, fuel planning and in-flight fuel management in accordance with the International Standards and Recommended Practices (SARPs) of Annex 6 — *Operation of Aircraft*, Part I — *International Commercial Air Transport — Aeroplanes*. It also borrows from ICAO's *Safety Management Manual (SMM)* (Doc 9859) but places the SRM concepts espoused in Doc 9859 into an operationally relevant context.

1.3 SCOPE

The scope of this manual is limited to providing detailed information related to the alternate aerodrome selection, fuel planning and in-flight fuel management SARPs in Annex 6, Part I, and to support the implementation of:

a) prescriptive alternate aerodrome selection, fuel planning and in-flight fuel management regulations based on Annex 6, Part I, 4.3.4, 4.3.5, 4.3.6 and 4.3.7;

b) operational variations to prescriptive alternate aerodrome selection regulations in accordance with Annex 6, Part I, 4.3.4.4; and

c) operational variations to prescriptive fuel planning and fuel management regulations in accordance with Annex 6, Part I, 4.3.6.6, including performance-based measures in which assessment of historical fuel use can substantiate a safety case supporting a reduction in contingency fuel to be carried on board an aeroplane.

Note.— The content of this manual does not relieve operators from their obligations under relevant national regulations, nor does it relieve States from those Standards arising from the Convention on International Civil Aviation *(ICAO Doc 7300) and its Annexes.*

1.4 OBJECTIVES

1.4.1 Annex 6, Part I, SARPs provide the basis for prescriptive alternate aerodrome selection, flight planning and fuel management regulations and operational variations from such regulations if an operator can implement performance-based methods acceptable to the State. Annex 6, however, does not provide specific details for States and operators to optimize the selection of alternate aerodromes or the carriage of fuel based on the implementation of either method. With this in mind, the objectives of this manual are to provide States and operators with:

a) detailed guidance material to support Annex 6, Part I, prescriptive alternate aerodrome selection, fuel planning and in-flight fuel management SARPs;

b) different means of conformance with the applicable Annex 6, Part I, SARPs intended to assist operators and CAAs to ensure the safe conduct of flights;

c) guidance material for the development of prescriptive and performance-based compliance methods;

d) guidance on the application of operational variations including knowledge of implementation strategies, criteria requirements, processes, controls and data/collection requirements;

e) knowledge of the necessary expertise, sophistication, technology, experience and other attributes of States and operators needed to develop, approve or implement performance-based regulations or variations from existing prescriptive regulations. Such guidance is provided for the purpose of differentiating between States and operators capable of implementing performance-based methods and those that should initially use a well-defined prescriptive method;

f) knowledge of the components of operational control systems that support implementation of performance-based regulations or variations from existing prescriptive regulations;

g) knowledge of the SRM principles necessary to implement performance-based methods, systems, measures, planning or variations;

h) operationally specific guidance material related to identifying hazards and managing safety risks including guidance for the development of operationally specific data analysis, safety risk analysis and assessment tools;

i) specific details on how to calculate the total fuel required to complete a planned flight safely;

j) knowledge of the means for the operator to optimize the carriage of fuel based on prescriptive and/or performance-based compliance with regulations; and

k) guidance material to assist in the development of procedures for operational personnel involved with in-flight fuel monitoring and management.

1.4.2 Alternate aerodrome selection and fuel planning should be considered within the context of the required flight preparation activities provided in Annex 6, Part I. Therefore, the information presented in this manual should be used in conjunction with an operational control system approved by the State's CAA, implemented by the operator and, if appropriate, with applicable Extended Diversion Time Operations (EDTO) requirements.

1.5 CONCEPT

1.5.1 This manual is organized using a building block concept designed to accomplish the objectives of Section 1.4 (see Figure 1.1). The manual initially presents the basic operational realities that underlie the development of alternate aerodrome selection and fuel management regulations by a CAA. These realities are then framed within the context of the two predominant approaches to regulatory compliance and safety: the conventional prescriptive approach and the contemporary performance-based approach.

1.5.2 The manual then defines the attributes of those States and operators with the capabilities to adopt performance-based approaches to regulatory compliance and those that would be better served by following a well-defined and prescriptive approach. It accomplishes this by first explaining the prescriptive SARPs of Annex 6, Part I. The manual then identifies the additional components necessary to support performance-based regulations or performance-based compliance with existing prescriptive regulations. All of this is accomplished with the intent to build a bridge from the conventional approach to safety to the contemporary approach that uses process-based production methods and SRM principles.

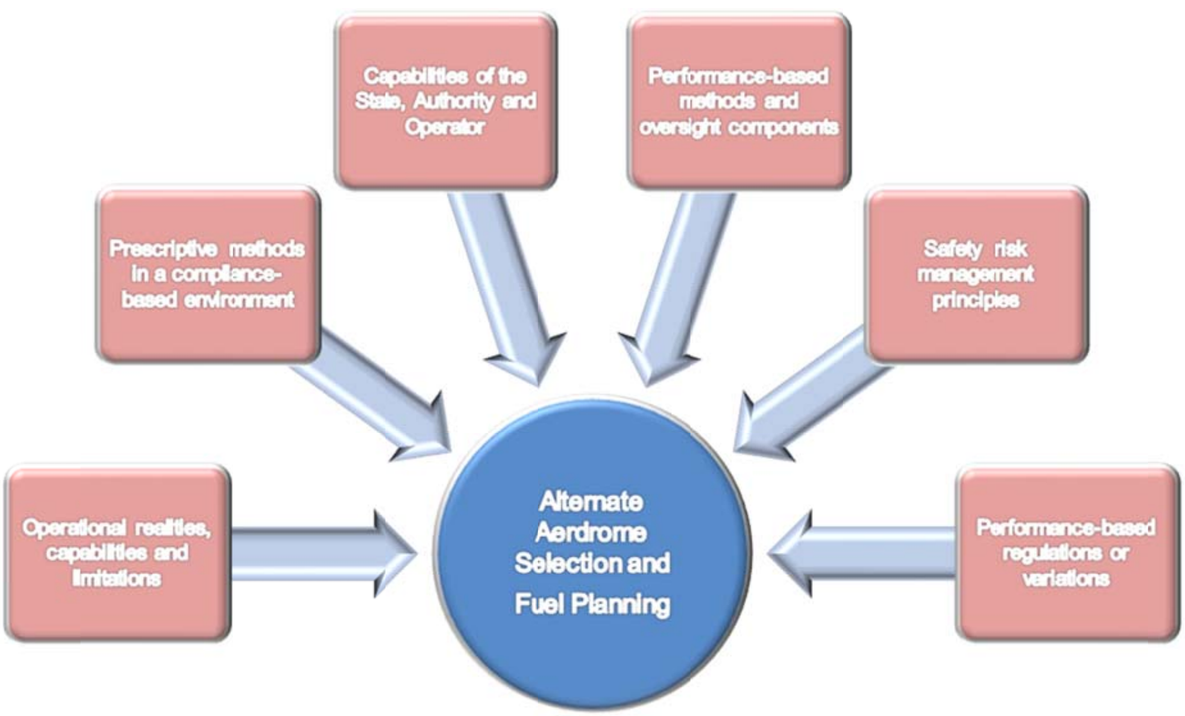


Figure 1-1. Manual concept

1.6 STRUCTURE OF THE MANUAL

1.6.1 Chapters 1 through 3 form the foundation of the manual and provide the context for the expanded guidance in the succeeding chapters. Chapters 4 through 6 follow the structure of Annex 6, Part I, very closely and provide specific references to the SARPs and external documents, where appropriate. Chapters are also supported, where necessary, by appendices that further expand chapter guidance and/or provide supportive examples derived from existing national practices in alternate aerodrome selection and fuel planning. The appendices appear immediately following the chapter they support.

1.6.2 Chapter 4 provides expanded guidance related to the prescriptive alternate aerodrome selection and fuel planning SARPs of Annex 6, Part I. It is intended to assist States and operators in implementing prescriptive regulations in compliance-based regulatory environments. It also identifies, by example, means of compliance that may be used by a State or an operator to conform to the provisions of Annex 6.

1.6.3 Chapter 5 fleshes out the concept of the performance-based approach to safety as it relates to alternate aerodrome selection and fuel planning. It is intended to support the introduction of performance-based regulations or variations from existing prescriptive regulations as described in Annex 6, Part I. The chapter begins by identifying the organizational and operational capabilities required to implement performance-based variations. It goes on to identify elements common to all performance-based systems, programmes and/or processes as well as identify, by example, the additional elements necessary to implement specific variations.

1.6.4 Chapter 5 does not attempt to address every potential variation sought by an operator or accepted by a State. More importantly, it seeks to define precisely the components of performance-based methods, the capabilities of an operator necessary to support those methods and the capabilities of a State to monitor their efficacy. This was done specifically to ensure that the components that underlie the performance-based approach to safety are appropriately and effectively implemented prior to the application of any operational variation.

1.6.5 Chapter 6 completes the manual with an expansion of the in-flight fuel management provisions of Annex 6, Part I, including those related to the protection of final reserve fuel and the declarations of minimum fuel and a fuel emergency.

Chapter 2

SAFETY, OPERATIONAL EFFICIENCY AND EMISSION REDUCTION

2.1 THE RELATIONSHIP BETWEEN SAFETY, EFFICIENCY AND THE ENVIRONMENT

2.1.1 Although the contribution of aviation emissions to the total CO_2 emissions is relatively small, scheduled aviation traffic continues to grow. Scheduled traffic is currently growing at a rate of 5.8 per cent per year and is projected to grow at a rate of 4.6 per cent per year through 2025[1]. This growth rate raises questions regarding the future contributions of global aviation activities, their environmental impact and the most effective way of addressing carbon emissions.

2.1.2 Growing financial competition has also encouraged many airlines to implement fuel conservation and operational efficiency programmes. The use of such programmes continues to increase, and they tend to form the cornerstones of an airline's emission-reduction efforts. It is important to note, however, that such programmes seek to reduce overall fuel consumption without compromising the safety of flight operations. In order to ensure safety as an outcome of an operational activity, airlines rely on the structured application of safety risk management principles.

2.1.3 With this in mind, the modern aviation community increasingly recognizes the need to complement existing compliance-based approaches to safety with a performance-based component as a means to increase overall operational efficiency. This potential for increased efficiency requires a measure of operational flexibility that may not be possible in a purely compliance-based environment. In the proper environment, however, such flexibility can yield significant efficiencies while maintaining or improving levels of safety. As such, many consider the incorporation of performance-based elements into the regulatory framework as an important step in minimizing the environmental impact of aviation emissions.

2.1.4 With Amendment 36 to Annex 6, Part I, CAAs can work with operators to improve overall operational efficiency and reduce emissions by introducing a performance-based approach to regulatory compliance. Such an approach can foster statistically driven and risk-managed alternatives to prescriptive alternate aerodrome selection and fuel planning regulations. These alternatives complement existing compliance-based regulations and can be effectively utilized within the greater context of reactive, predictive and proactive regulatory environments that understand, apply and assess the efficacy of continuous SRM.

2.2 ADVANCES IN OPERATIONAL AND FUEL PLANNING

2.2.1 The origins of the previous Annex 6, Part I, fuel provisions are traceable as far back as 1949 when meteorological reports were far less reliable, in-flight fuel use was less predictable, and assistance from dispatch services to update pre-flight planning assumptions was inconsistent or non-existent. The fuel planning criteria were also outdated, and the provisions were insufficient to support the use of modern planning tools or to maximize efficiency. As a result, operators often carried excess fuel.

---

1. For additional information regarding aviation emission reduction, please refer to ICAO's *Operational Opportunities to Minimize Fuel Use and Reduce Emissions* (Cir 303).

2.2.2 Advances in computerized flight planning and flight management systems (FMS) bring increased accuracy and predictability to operational and fuel planning. These systems also provide reanalysis capabilities based on actual conditions. Statistically-based fuel consumption programmes accurately predict fuel burn and contingency fuel use. Alternate aerodrome selection and fuel planning methodologies have also evolved steadily over decades of continuous use. Finally, advances in flight following, flight monitoring and/or flight watch capabilities provide systemic defenses against numerous safety risks while providing increased opportunities for operational efficiency.

2.2.3 These and other developments have increased operational reliability and predictability significantly over decades while increasing the efficacy of both prescriptive and performance-based compliance with regulation. Either method of regulatory compliance when properly employed by operators with demonstrable capabilities can optimize alternate aerodrome selection and flight planning without compromising the safety of flight operations.

2.3 OPPORTUNITIES FOR OPERATIONAL EFFICIENCY IN A PERFORMANCE-BASED REGULATORY ENVIRONMENT

2.3.1 Today, fuel represents a significant portion of the operational costs of an airline. Therefore, the efficient use of fuel is increasingly important to the cost-effectiveness of airline operations. If the amount of fuel carried on any given flight can be reduced, through prescriptive compliance with globally harmonized regulations and/or while maintaining target levels of safety performance, the mass-savings will be directly translated to reduced fuel burn. Reduced fuel burn equates directly to lower operating costs and lower emissions.

2.3.2 Some States may have only prescriptive regulations and compliance-based oversight capabilities that do not allow operators the operational flexibility to take full advantage of modern flight planning and flight management capabilities. Other States, however, that have adopted a performance-based approach to safety, can enable operators to optimize flight planning using modern methods and technologies to further minimize their impact on the environment. It is this synergy that can allow operators additional opportunities to achieve efficiencies that may not be possible within the confines of a solely prescriptive regulatory framework. It is important for States to ensure, however, that regardless of the methods used, safety remains the central theme in any efforts to achieve operational efficiencies or minimize the impact on the environment (Figure 2-1).

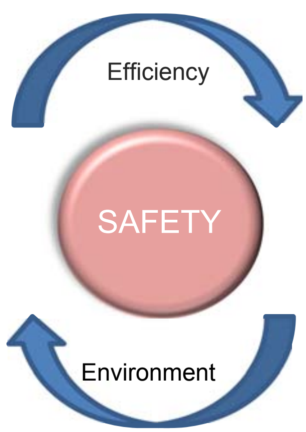


Figure 2-1. The relationship between safety, efficiency and the environment

Chapter 3

PRESCRIPTIVE AND PERFORMANCE-BASED COMPLIANCE WITH REGULATION

3.1 INTRODUCTION

3.1.1 The development of any national regulation should take into account the overall capabilities of an Authority and of the operators it oversees. In assessing such capabilities, a State will consider many operational factors including but not limited to:

a) available infrastructure;

b) capabilities of the air traffic management (ATM) system;

c) availability and quality of aerodrome infrastructure and condition reporting;

d) availability and quality of meteorological reporting and forecasting;

e) the use of available advanced technologies and data analysis capabilities; and

f) operational control, flight following, flight monitoring and flight watch capabilities of individual operators.

3.1.2 Additionally, the safety oversight capabilities of an Authority coupled with the overall operational and SRM capabilities of individual operators can help determine the means of oversight necessary to ensure operator compliance with baseline regulations. In some cases, an Authority may rely solely on strict operator compliance with conventional and well-defined prescriptive requirements (prescriptive compliance) to maintain safe operations. In other cases, capable authorities can work together with capable operators to introduce variations from prescriptive regulations (as described in Annex 6, Part I, 4.3.4.4 or 4.3.6.6). Such variations assume that compliance with a regulation based on an operator's safety performance will, at a minimum, be equivalent to prescriptive compliance with the same regulation.

3.1.3 This approach to regulatory compliance is based on a belief within the aviation community that existing prescriptive and compliance-based approaches to safety should be complemented by a performance-based approach. This belief arises from the notion that prescriptive rules may not have the fidelity or flexibility to address every potential nuance in the operations overseen by an Authority. As such, a safety data driven and risk-based approach may be more appropriate as well as provide the added benefit of continuous improvement in the level of safety performance achieved by an operator.

3.1.4 In any case, the amended Annex 6, Part I, provisions establish, inter alia, that CAAs define regulations containing criteria and operators establish the means, approved by the State, for the purposes of ensuring:

a) sufficient alternate aerodromes are designated, when required;

b) operations into isolated aerodromes are planned such that a safe landing can be made at the destination or en-route alternate aerodrome at the estimated time of aerodrome use;

c) flights are conducted in accordance with the flight rules and operating minima appropriate for the meteorological conditions anticipated at the estimated time of aerodrome use;

d) flights are planned such that an adequate margin of safety is observed in determining whether or not an approach and landing can be carried out at each alternate aerodrome;

e) flights are planned and, when applicable, re-planned in flight to ensure that the aeroplane carries sufficient fuel, including final reserve fuel, to complete the planned flight safely;

f) sufficient fuel is carried to allow for deviations from the planned operation and that the pre-flight calculation of usable fuel required includes: taxi fuel, trip fuel, contingency fuel, final reserve fuel, and when required, alternate fuel, additional fuel, and discretionary fuel; and

g) in-flight fuel checks are performed and fuel is managed in flight so as to ensure a flight can proceed, with the planned final reserve fuel on board, to an aerodrome where a safe landing can be made.

3.2 NATIONAL ALTERNATE AERODROME SELECTION AND FUEL PLANNING REGULATIONS

3.2.1 Many commercial aviation regulations, whether originally rooted in Annex 6, Part I, or developed independently by a State's CAA, ultimately evolved to reflect specific operational experiences and regional concerns. This evolution was inevitable as States and operators sought to find the appropriate balance between the ability to sustain services and the safety risks generated as a result of those services. One result of this evolutionary process was the realization that regulations formulated for use in one area of the world might not be transferrable to other areas of the world that have varying levels of resources, operator experience, infrastructure and technology.

3.2.2 This disparity in operational capability or resources may in turn have led to the further evolution of domestic national regulations apart from those required under the jurisdiction of a foreign authority or over the high seas. This may have occurred absent concise guidance to deal with such disparities and illustrates one of the difficulties of developing globally harmonized and implementable alternate aerodrome selection and fuel planning Standards and Recommended Practices.

3.2.3 The primary purpose of Annex 6, Part I, remains, however, to contribute to the safety, efficiency and regularity of international air transportation by providing clear and concise criteria for the development of safe national regulations. It accomplishes these aims by encouraging ICAO's Member States to facilitate the passage over their territories of commercial aeroplanes belonging to other countries that operate in conformity with ICAO's Standards and Recommended Practices. This philosophy also provides some assurance that all operators, including those that do not fall under the immediate jurisdiction of a local authority, are conforming to globally accepted safety standards.

3.2.4 The alternate aerodrome selection and fuel planning SARPs of Annex 6, Part I, no longer preclude the development of national regulations which, due to their performance-based nature, may be more suitable in a particular operating environment than their prescriptive counterparts. In such cases, operators in cooperation with CAAs can develop performance-based policies or programmes that take full advantage of available operational and systemic capabilities. It is important to note, however, that in all phases of aeroplane operations, minimum statutory standards remain necessary as they make commercial aviation viable without prejudicing safety.

3.3 FACTORS THAT DRIVE DIFFERENCES IN ALTERNATE AERODROME AND FUEL PLANNING REGULATIONS

National regulations are developed and implemented by individual States in order to ensure aviation activities conducted within their area of jurisdiction maintain acceptable levels of safety performance. The remaining sections of this chapter provide a brief synopsis of the operational challenges and related hazards faced by States and operators in many parts of the world. Examples are also provided when necessary to illustrate how prescriptive and performance-based compliance with regulations can provide systemic defenses with the potential to lessen the severity of hazards or mitigate potential safety risks.

3.4 THE ROLE OF INFRASTRUCTURE

3.4.1 Many States enjoy sophisticated, multi-layered defenses imbedded in their infrastructure that mitigate many of the safety risks associated with alternate aerodrome selection and fuel planning. Other States, however, lack the resources for infrastructure development or do not possess the technical ability to implement advanced systems or techniques. Such disparities in infrastructure and associated capabilities must be routinely considered by States that seek to effectively mitigate the safety risks resulting from flight operations through the enforcement of prescriptive and/or performance-based compliance with regulations.

3.4.2 For example, one of the goals of any regulation related to the nomination of an alternate aerodrome would be to assure, to the extent reasonably practicable, that a suitable runway will be available to an aeroplane when needed. In compliance-based regulatory environments such an assurance is typically predicated on an operator's compliance with well-defined, prescriptive and conservative regulations. Such regulations typically define the specific conditions that require the nomination of one or more alternates. Such regulations, by definition, do not lend themselves to interpretation nor do they typically take into account differences in flight planning methods, operational capabilities, available infrastructure, or the operational requirements of aeroplanes (e.g. Class "F" aeroplanes) that approach the limits of available infrastructure.

3.4.3 In performance-based regulatory environments, performance-based compliance with regulations or "variations" can be permitted by the State's CAA based on the application of SRM methods. The effectiveness of such methods, however, is largely contingent on an individual operator's ability to define the operational processes, procedures, systemic defenses and risk controls necessary to maintain acceptable levels of safety performance. Any permissible variations from prescriptive regulations therefore are then predicated on an operator's ability to demonstrate (to the State) that the aeroplanes it operates, and the internal systems, processes, procedures and controls it has in place, can effectively mitigate the resultant safety risks (including those associated with implementing new processes).

3.4.4 Continuing with the example, an operator, due to the limitations of infrastructure associated with a proposed route, may wish to operate into an aerodrome with a single suitable runway without nominating a destination alternate aerodrome as prescribed in an applicable regulation. In order to use a performance-based approach and apply a variation to the regulation that prescribes alternate aerodrome selection, the operator applies SRM methods to determine the level of safety performance associated with the proposed operations. The safety risk assessment may or may not indicate that safety risk controls and/or mitigation measures are necessary to maintain a level of safety performance that is equivalent to prescriptive compliance. If required, however, such controls and measures would take into account any new hazards resulting from the application of risk mitigation and could also address, as applicable:

a) variations in fuel policy to account for unforeseen occurrences;

b) flight planning policies that use decision point planning to a destination;

c) aerodrome and runway condition monitoring;

d) variations in exposure time to potential runway closures that affect the flight;

e) meteorological conditions monitoring including the potential for phenomena other than ceiling and visibility to affect the successful completion of the flight (e.g. thunderstorms, dust storms, wind);

f) multiple approach and landing options and adjustments to landing minima to ensure, to the greatest extent practicable, that an approach and landing can be accomplished at the destination or alternate aerodrome, as applicable;

g) the designation of emergency aerodromes not suitable for designation as alternates during flight planning or for use in normal operations but available in the event of an emergency; and

h) flight crew procedures that specifically address limited landing option scenarios.

3.5 CAPABILITY OF THE AIR TRAFFIC MANAGEMENT (ATM) SYSTEM AND ASSOCIATED INFRASTRUCTURE

The capabilities of the ATM system should play a role in the development or implementation of any national regulation. Assessing the capabilities of the ATM systems encountered in operations and analysing inherent hazards is also an important step in assessing safety risks, as less advanced ATM systems in particular have the added potential to invalidate assumptions made by operators during flight planning. Conversely, advanced navigation, surveillance and ATM systems can provide systemic defenses and are typically characterized by their abilities to accomplish one or more of the following:

a) optimize the use of available airspace and aerodrome capacity;

b) monitor flight progress and control flights safely and efficiently;

c) improve the navigation of aeroplanes by providing direct, optimum or preferred aeroplane routing;

d) safely and efficiently separate aeroplanes, reduce delays and reduce fuel consumption;

e) access advanced communication systems; and

f) access technology that can reliably fix an aeroplane’s position en route and display real-time meteorological conditions.

3.6 AERODROME INFRASTRUCTURE AND CONDITION REPORTING (QUALITY OF NOTAM INFORMATION)

The ready access to timely and accurate aerodrome condition information is essential to operations and provides a systemic defense that protects against the safety risks associated with operations to any aerodrome. States and operators with ready access to such information are characterized by the ability to reliably provide or obtain information that, to the extent possible, is indicative of the condition of required aerodromes, landing surfaces and associated services or facilities. Internal operator processes are also required to continually update such information, assess its validity and feed other related operational and SRM processes. As such, assessing the availability and reliability of NOTAM information is another important step during the safety risk assessment activities associated with the development of national regulations.

3.7 QUALITY OF METEOROLOGICAL REPORTING AND FORECASTING

3.7.1 Meteorological conditions support services, including the capability to provide reliable and accurate meteorological reports and forecasts, vary from State to State. Operations in areas of the world with sophisticated meteorological conditions support services enjoy reliable, high-quality meteorological reporting while operations in regions of the world with poor meteorological reporting and observational network infrastructure may have to rely on less sophisticated information and/or routinely plan for worst-case meteorological scenarios.

3.7.2 Obtaining accurate meteorological information as well the ability to monitor en-route meteorological conditions, and destination meteorological and aerodrome conditions, is essential in order for pilots and operational control personnel to dynamically re-evaluate, reanalyse and revalidate pre-flight planning assumptions. This capability augments what is typically available to the PIC in less robust systems and closes gaps in coverage where such information may not be readily attainable by the flight crew en route.

3.8 ADVANCED TECHNOLOGIES AND DATA ANALYSIS CAPABILITIES

3.8.1 Civil aviation authorities and operators with access to advanced technologies and sophisticated data analysis tools are best positioned to implement or apply performance-based methods of regulatory compliance. Technological advances, by design, mitigate many of the safety risks inherent in human systems. In many parts of the world and for many operators, such defenses are built into the system to protect against fluctuations in human performance or decisions. Conversely, it is important to note that the absence of such systemic defenses can expose a flight to additional safety risks and may require greater reliance on safety risk controls, mitigation measures or very well defined prescriptive criteria.

3.8.2 CAAs typically consider certain technologies and capabilities during system design and SRM activities associated with the implementation of prescriptive or performance-based methods of regulatory compliance. Access to the following technologies and capabilities are characteristic of advanced operators and operating environments:

a) ***Technological advances in aeroplane capability and reliability.*** Advanced aeroplanes with on-board flight management systems, advanced navigation capabilities and reliable propulsion systems that increase the fidelity of flight planning systems, improve operational flexibility and support advanced methods of data collection and analysis.

b) ***Technological advances in aerodrome approach systems, capability and reliability.*** The proliferation of CAT II, CAT III, RNAV/RNP AR, GNSS, GBAS, SBAS and other approach systems that increase the likelihood of a flight terminating in a successful approach and landing.

c) ***Advances in in-flight planning systems and technology.*** Automated flight planning systems that use operator-specific historical and real-time data to optimize routes and add accuracy and efficiency to flight planning.

d) ***Advanced systems for the collection of operational/safety data and data analysis tools.*** Routine and extensive data collection, beyond accident and incident data, is an essential part of maximizing operational efficiency but is especially important to support safety management activities and performance-based programmes. As a consequence of the need to maintain a steady volume of data, expanded collection systems are required. In such systems, safety data from low-severity events, for example, become available through mandatory and voluntary reporting programmes. In terms of safety data acquisition, these newer systems are proactive, since the triggering events required for launching the safety data collection process are of significantly lesser consequence than those that trigger the accident and serious incident safety data capture process.

3.9 OPERATIONAL CONTROL, FLIGHT FOLLOWING, FLIGHT MONITORING AND FLIGHT WATCH CAPABILITIES

3.9.1 Advances in the operational control of flights improve operational reliability and flight monitoring, and provide real-time flight support. Such operational control systems ensure the continuous and independent surveillance of flights while en route and lessen the likelihood that unforeseen events could invalidate assumptions made during alternate aerodrome planning and fuel planning. They may also provide for independent en-route re-analysis capability for the purposes of continually validating or modifying flight planning assumptions.

3.9.2 Many operators also have access to technologies that can reliably fix an aeroplane's position en route. Such technologies, coupled with rapid and reliable communication systems, provide significant systemic defenses against the hazards encountered by aeroplanes in operations. Such operators often have the capability to communicate rapidly with emergency services, air traffic control (ATC) centres, aerodrome authorities and other entities that could facilitate a successful conclusion to a planned operation that has encountered unforeseen hazards.

3.9.3 Operational control and flight following, flight monitoring and flight watch capabilities vary widely, and many CAAs and operators are not positioned to make the significant investments necessary to maintain advanced systems. Authorities and operators alike should assess their capabilities in the context of the most advanced systems in use worldwide. Such systems are described in detail in Chapter 4 but are typically characterized by the ability to continuously monitor relevant operational information, fix an aeroplane's position and, when necessary, contact flights while en route.

3.10 SUMMARY

3.10.1 Purely conventional and compliance-based regulatory environments are typically quite rigid and require prescriptive safety regulations to be used as administrative controls. This type of regulatory framework is supported by inspections and audits to assure regulatory compliance. Alternatively, the aim of performance-based approaches to safety is to introduce supplementary regulator and operator processes that will result in equally effective control of safety risks.

3.10.2 Regulatory environments that support a performance-based approach to safety allow for the introduction of performance-based elements within a compliance-based framework. This in turn allows for more flexible, risk-based and dynamic operator performance with respect to the underlying and baseline prescriptive regulations. This type of regulatory framework relies on State as well as operator processes for safety performance monitoring and measurement. It also allows individual operators to select the safety monitoring indicators, relevant alert levels and targets that are appropriate for their operation, performance history and expectations.

3.10.3 In short, prescriptive and performance-based national regulations are formulated to produce equivalent outcomes. They differ, however, in the means used to achieve desired outcomes or objectives. Prescriptive regulations or prescriptive compliance with regulations rely heavily on stipulating the means to achieve an outcome or the "how" and "what" must be achieved. To achieve this aim, such approaches tend to focus on prescriptive criteria, processes, techniques or procedures in order to ensure an acceptable outcome.

3.10.4 Performance-based regulation or performance-based compliance with existing regulation, on the other hand, is focused primarily on the outcome or "what" must be achieved. This approach relies heavily on measurable outcomes rather than prescriptive criteria or processes. Performance-based regulation, therefore, is inherently flexible allowing operators with demonstrable capabilities to choose the most efficient means of achieving an objective.

3.10.5 Ultimately, the oversight capabilities of the Authority coupled with the operational capabilities of individual operators determine the methods of compliance necessary to support safe flight operations. Prescriptive compliance affords operators that lack sophisticated technologies or systems the structure and direction necessary to sustain operations in a manner consistent with the prescriptive requirements of the Authority. Performance-based compliance achieves the same objective for operators with access to sophisticated systems or technologies, albeit with added and inherent flexibility but retaining an equivalent level of safety.

Note 1.— Appendix 1 to this chapter contains examples of how national regulations have evolved within the context of regional concerns, available infrastructure and the capabilities of CAAs and the operators they oversee.

Note 2.— Appendix 2 contains an example of a United States Operations Specification (OpSpec) that illustrates how the capabilities of the operator and access to extensive infrastructure, reliable advanced meteorological reporting technologies and modern operational control methods can be leveraged using performance-based compliance with existing prescriptive regulations.

— — — — — — — —

Appendix 1 to Chapter 3

NATIONAL ALTERNATE AERODROME SELECTION AND FUEL PLANNING REGULATION MODELS

1. THE EUROPEAN MODEL

Although Europe's operating environment shares many similarities with other regions of the world, there are some clear distinctions. The main driving factors for airline operations in Europe are:

- ***Meteorological conditions.*** Europe's operating environment is dominated by Atlantic frontal systems, requiring procedures and flow rates to be based on Instrument Flight Rules (IFR) procedures with little reliance on Visual Flight Rules (VFR) conditions for capacity planning. Navigation infrastructure is also advanced, with the widespread use of Category III capability. In fact, for many large operators the proportion of sectors operated to Category III aerodromes exceeds 90 per cent.

- ***High population density.*** Space is at a premium in Europe making development of new runways infrequent and new aerodrome development practically unknown. High population density also imposes restrictions on routing which, in turn, causes congestion at many main hubs.

- ***Air Traffic System fragmentation.*** Europe has approximately 40 Air Navigation Service Providers (ANSPs), which makes collaborative decision making (CDM) difficult. A Central Flow Management Unit run by EUROCONTROL also manages flows with a view towards avoiding sector overloads, which may not represent the optimal solution for either provider or user.

Information flow between operators and ATC Centres is also relatively restricted compared to the United States, thus limiting the use of proactive flight dispatch departments. Consequently in-flight fuel and diversion decisions are almost entirely the responsibility of the PIC causing operators to be more reactive rather than proactive or predictive in coping with traffic flow disruption.

2. STATIC AND PRESCRIPTIVE MINIMUM REQUIREMENTS

In Europe, prescriptive alternate aerodrome selection and fuel planning regulations follow Annex 6, Part I, SARPs closely, and national differences were largely eliminated by the adoption of JAR-OPS in 1994, although differences of interpretation continue. For example, under EU policy, two prescriptive methods for contingency fuel are generally accepted:

- Five per cent of the planned trip fuel or, in the event of in-flight re-planning, five per cent of the trip fuel from the point of re-planning to the destination; **or**

- Not less than three per cent of the planned trip fuel or, in the event of in-flight re-planning, three per cent of the trip fuel for the remainder of the flight, provided that an En Route Alternate (ERA) aerodrome is available for the second part of the trip.

Alternate aerodrome requirements are also closely aligned with Annex 6, Part I, SARPs with few minor differences.

3. ALLOWANCES FOR STATISTICALLY DRIVEN CONTINGENCY FUEL PLANNING

Unlike the United States, where numerous operational variations from national alternate aerodrome and fuel regulations are possible, European Operations (EU-OPS) regulations recognize variations from prescriptive regulations related to the carriage of contingency fuel only. Such regulations currently contain two performance-based variations from prescriptive contingency fuel regulations. The variations allow for contingency fuel to be:

- an amount of fuel sufficient for 20 minutes flying time based upon the planned trip fuel consumption provided that the operator has established a fuel consumption monitoring programme for individual aeroplanes and uses valid data determined by means of such a programme for fuel calculation; or

- an amount of fuel based on a statistical method which ensures an appropriate statistical coverage of the deviation from the planned to the actual trip fuel. This method is used to monitor the fuel consumption on each city-pair/aeroplane combination and the operator uses these data for a statistical analysis to calculate contingency fuel for that city-pair/aeroplane combination.

The first permissible variation for contingency fuel planning is not widely used. The second variation has been adopted by a number of operators with the resources to gather and interpret the requisite data. Such Statistical Contingency Fuel (SCF) programmes recognize that routes differ in their variability and that by allocating more fuel to those routes with higher variability and reducing fuel for those less variable, both fuel uplift and disruption can be reduced.

Actual SCF coverage values are chosen by the operator according to its commercial requirements and can differ according to the specific operational characteristics of the destination aerodrome (proximity of alternates, transport links, etc.). One EU-OPS authority also requires that an SCF planning programme achieve approximately the same coverage (i.e. the proportion of flights that burn all their contingency fuel) that fixed contingency fuel planning provides. Finally, SCF coverage values used by operators typically range between 90 and 99 per cent of the maximum recorded contingency fuel used.

It is important to note that the use of SCF alone does not attempt to achieve a target level of safety performance but merely replaces fixed contingency fuel planning with a more scientific method. The inherent flexibility of the system and the ability to change coverage figures instantly also means that coverage percentages can be altered if evidence from the operator's SRM processes suggests it is necessary. As data requirements for SCF planning are high and not instantly achievable for new routes, operators are required to revert to conventional contingency fuel planning until sufficient data are acquired.

4. THE UNITED STATES MODEL

Current alternate aerodrome selection and fuel planning regulations in the United States evolved within one of the most highly developed and complex operating environments in the world. This environment is characterized by numerous systemic defenses that guard against foreseeable fuel over-burn scenarios. Operations in the United States are further characterized by:

- ***Extensive and mature infrastructure.*** Commercial operators in the United States enjoy access to an extensive network of suitable aerodromes, accurate meteorological reporting systems and reliable aerodrome condition monitoring programmes.

- ***Shared systems of operational control.*** Most commercial operators in the United States operate under shared systems of operational control whereby a flight operations officer (FOO) or designated member of management shares operational control authority with the PIC. Such shared systems ensure the continuous and independent surveillance of flights while en route and lessen the likelihood that unforeseen events could invalidate assumptions made during alternate aerodrome and fuel planning.

- ***Enhanced flight following, flight monitoring and flight watch.*** Operators in the United States have access to sophisticated technologies that can reliably fix an aeroplane's position en route. This facilitates the active and continuous tracking of flights by operational control personnel, which in turn ensures that flights follow their prescribed routing without unplanned deviation or delay.

- ***Air Traffic Management.*** Communication, navigation and surveillance systems used by ATM in the United States also improve flight safety and optimize the use of available airspace and aerodrome capacity. These systems improve the navigation of aeroplanes and increase ATC's ability to monitor and control flights safely and efficiently. They also have the potential to reduce delays by providing more direct and efficient aeroplane routing. Additionally, airspace and aerodrome capacity optimization reduces flight, holding and taxi times, distance flown and associated fuel consumption by employing direct or preferential routes.

- ***Advanced communication systems.*** Another unique element of the United States operating environment is the widespread use of advanced communication systems to enhance communications between and among aircraft, air traffic controllers, and flight operations officers/flight followers. These and other methodologies support a system of rapid and reliable communications between aeroplanes and those entities with the real-time reanalysis capabilities necessary to continually validate flight planning assumptions.

5. STATIC AND PRESCRIPTIVE MINIMUM REQUIREMENTS FORM PRESCRIPTIVE FOUNDATION

In the United States, the Code of Federal Regulations (CFR) 14 governs the determination of alternate aerodrome selection, fuel supply and in-flight fuel management. Numerous regulations contained in CFR 14 form the prescriptive foundation or basis for alternate aerodrome selection and fuel planning methods in use by United States air carriers. The origins of many of these regulations can be traced back to 1936 and part 61 of the Civil Aviation Regulations (CAR).

The Federal Aviation Administration (FAA), rather than routinely modifying CFR 14 regulations, grants capable operators deviations or exemptions from prescriptive elements of alternate aerodrome selection and fuel planning regulations. In considering requests for deviations or exemptions, the FAA reviews the history of a regulation. This is done to determine if the reasons why the regulation was first established are still valid, and if literal continued compliance with the regulation is required in order to ensure that the level of safety currently provided would not be decreased by the proposed deviation or exemption.

This is a fundamental tenet of the performance-based method of regulatory compliance and the first step in determining whether or not an operator can "vary" from a prescriptive regulation. Such deviations or exemptions are subject to performance criteria found in contractual arrangements known as Operations Specifications (OpSpecs) or letters of exemption. As such, the means to maintain regulatory compliance and/or guidance material related to the application of an individual regulation may be found in documents apart from the core regulation(s).

A United States air carrier's Air Operator Certificate includes the OpSpecs applicable to the operator. The OpSpecs contain the exemptions from, authorizations to deviate from, or the conditions necessary to comply with, a specific regulation. Such deviations, exemptions, or means of compliance augment and, in some cases, supersede the related regulations. It is important to note that uninterrupted OpSpec approval is based upon ongoing conformance with the additional specifications stipulated in conjunction with an operator's original approval.

6. VARIATIONS FROM PRESCRIPTIVE REGULATIONS ARE PERMITTED BY DEVIATION OR EXEMPTION

The contractual OpSpecs approval and exemption petition process is the current means by which the FAA is able to grant variations from the prescriptive alternate aerodrome selection and fuel planning regulations found in CFR 14. The FAA grants such variations by OpSpec approval or exemption subject to the presence of specific systemic defenses or risk controls. Examples of OpSpec approvals or regulatory exemptions include but are not limited to:

- (B043), an OpSpec for "Special Fuel Reserves in International Operations", which permits a deviation from the fuel carriage requirements of CFR 14 Part 121.645 if the conditions within the specification are met;
- (B044) an OpSpec for "Planned Redispatch or Rerelease En Route", which stipulates the conditions necessary for an operator to comply with CFR 14 Part 121.631(f);
- (B0343) an OpSpec for "Fuel Reserves for Flag and Supplemental Operations", which is a nonstandard authorization for certain fuel reserves for flag and supplemental operations;
- (C355) an exemption which authorizes a reduction in the minimum ceiling and visibility, prescribed by FAR 121.619, for the destination airport before an alternate must be designated;
- (C055) an OpSpec for the determination and application of alternate airport planning minima;
- (3585) an exemption which allows airlines to dispatch or release a flight under FAR 121.613 when meteorological reports or forecasts indicate meteorological conditions are forecasted to be below authorized weather minimums at the estimated time of arrival.

Each of the aforementioned examples, to varying extents, specifies the additional means required to mitigate or control the risks associated with the application of the deviation or exemption. Additionally, at least two of the examples contain the type of data that must be collected and provided to the FAA in order for the deviation or exemption to remain in force. Such flexibility is only afforded to operators with the demonstrable ability to manage safety risks associated with the approval as is possible within a regulatory framework with a performance-based oversight component.

Note.— OpSpec 355 contains many of the attributes of a contemporary performance-based variation from prescriptive regulation and is included for illustrative purposes in Appendix 2 to Chapter 3.

7. THE REALITIES OF OTHER NATIONAL MODELS

The resources available to States and the oversight capabilities of CAAs vary widely in the world of international commercial aviation. Additionally, many States have yet to implement the safety assurance and oversight components necessary to complement an operator's SRM processes. Even more States continue to rely solely on compliance-based methods of regulatory oversight with few resources to introduce complementary performance-based components.

Although recent developments in SRM continue to question the pervasive notion that safety can be guaranteed as long as rules are followed, the importance of regulatory compliance cannot be denied. And while compliance-based regulatory approaches have their limitations as mainstays of safety in an operational system as open and dynamic as aviation, compliance with safety regulations is fundamental to the development of sound safety practices.

One emphasis of this manual, however, is simply to reinforce the concept that the historical approach to the management of safety based solely upon regulatory compliance should be complemented where possible by a performance-based component that will assess the actual performance of activities critical to safety against existing organizational controls.

8. THE AVAILABILITY OF INFRASTRUCTURE AND TECHNOLOGIES

The operating environments within the United States and Europe are characterized by the availability of extensive infrastructure and the widespread use of advanced technologies in aeroplanes, ATM, meteorological reporting, communication and operational control systems. Access to such advanced systemic defenses is simply not possible in many other parts of the world. Such limitations should be considered by CAAs when developing alternate aerodrome selection and fuel planning policies in order to effectively mitigate the safety risks associated with a lack of advanced systemic defenses.

Civil aviation authorities in the United States and Europe also draft national regulations with the knowledge that operators under their jurisdiction already have access to advanced technology, highly developed infrastructure and high levels of operational experience. As a result, the criteria prescribed by these regulations are typically addressed (by operators) without undue cost given their current level of sophistication. This may not be the case in other parts of the world.

States that lack highly developed infrastructure or access to advanced technologies must strive to achieve the appropriate balance between their ability to sustain commercial aviation services and the safety risks generated as a result of the production of those services. With this need for balance in mind, the following list details some of the factors that a State should consider when determining the appropriateness of national regulations or adapting the regulations of another State:

- ***Lack of available aerodromes.*** A lack of available aerodromes affects an operator’s ability to nominate alternates within an economically sustainable distance to the destination. While there would be few examples where an aeroplane could not conceivably carry sufficient fuel to reach an alternate aerodrome, doing so may not be possible without the offload of revenue payload. Air transport is a vital service in many parts of the world and in some cases the only means of transportation. Operators may find it necessary to conduct operations where no alternate aerodrome is available provided the State, and the operator, can demonstrate there is a reasonable certainty that an alternate will not be required.

- ***Predominance of non-precision approaches.*** States outside Europe and North America frequently contain aerodromes that use non-precision approaches for the primary approach. While non-precision approaches may not significantly impact operations in some parts of the world, fuel planning should take into account the higher minima associated with such approaches. Additionally, the fuel policy or operational procedures should consider the lack of redundancy and the potential for an aid to fail. As such, the prescribed minima should allow for the failure of a navigation aid and allow an approach to be completed successfully using either a procedure that terminates in a visual segment or another navigation aid.

- ***Routine use of circling or visual approaches.*** Due to the lack of navigation aids, or a lack of redundancy, States may be required to prescribe alternate minima for a particular aerodrome that are based on the conduct of a visual approach. Such an approach may be the culmination of an arrival procedure for which there is no navigation aid guidance or the result of a requirement to conduct a circling approach. While there is a general movement away from such approaches in States with modern infrastructure, they remain a primary procedure in regions that do not enjoy such advanced development. As such, they remain a viable method of maintaining air services as long as approach minima and fuel policies consider the inherent limitations of such procedures.

- ***Concentration of populations.*** Some States, despite large land masses, have their populations concentrated in small areas. As a result, distances between available aerodromes may be large and the availability of en-route alternate aerodromes limited. Civil aviation authorities and operators should consider en-route system failures in the development of national and operational policies. The lack of available alternate aerodromes, however, may make the provision of additional flexibility an operational necessity in order to sustain viable commercial air services.

- ***Remote and isolated aerodromes.*** States that have jurisdiction over aerodromes that are physically removed from available alternate aerodromes may consider specifying additional fuel carriage requirements for operations to these aerodromes. Remote and isolated aerodromes can be island based or be located on continental land masses. Operators may elect to nominate a specific aerodrome as isolated or remote if, by complying with the State requirements for such operations, less fuel uplift would result without compromising the target level of safety performance for the planned operation.

9. STATIC AND PRESCRIPTIVE MINIMUM REQUIREMENTS

All States should prescribe, or where such prescription is not legislated, approve or accept the minimum alternate aerodrome and fuel planning requirements for aeroplanes operating within their airspace. These regulations form one of the core elements in ensuring the safety of flight operations. Many States may choose to adopt, either in entirety or in part, the regulatory framework specified in the Federal Aviation Regulations (FARs) or the EU-OPS. The use of these regulatory frameworks and methods of regulatory compliance may prove, particularly in theatres where long distances to limited infrastructure aerodromes exist, to be unreasonably restrictive in some operational environments.

The exact nature of the prescriptive requirements may vary from State to State but in all cases they should ensure that, to the greatest extent possible, the lack of a suitable aerodrome or fuel exhaustion will not be a determining factor in an aeroplane incident or accident. Balanced against this need for safety, States should not attempt to legislate in an unreasonable or capricious manner in an attempt to mitigate human error or events that are statistically insignificant.

10. OPERATIONAL VARIATIONS THAT RECOGNIZE LIMITATIONS OF INFRASTRUCTURE AND TECHNOLOGIES

States that do not enjoy the availability of extensive infrastructure and/or the widespread use of advanced technologies may choose to implement operational (performance-based) variations from prescriptive regulations if operators have the demonstrable ability to manage operational safety risks. In many cases, however, the technical and operational abilities of individual operators may exceed those of the respective State. Where this is the case, operators should still be able to demonstrate that proposed practices using existing or pending infrastructure developments maintain acceptable levels of safety performance. This allows for the introduction of new technologies vital to the development of aviation in many States.

Operators wishing to implement performance-based variations should be able to work with CAAs to implement new systemic defenses or take full advantage of existing defenses if deemed appropriate and effective in mitigating the safety risks of operations. Such defenses or safety risk controls may include, but are not limited to the following:

- ***Satellite-based navigation systems.*** The use of satellite-based navigation systems can be used as a basis for prescribing lower operating minima provided the operator can demonstrate that operational policies and procedures effectively manage safety risks associated with such operations.

- ***Lower traffic densities.*** The lower traffic densities associated with specific routes may result in less altitude blockages, traffic holding or track diversions. A State, when setting or considering variations to national fuel policy, should consider such operational realities. In conjunction with such variations, operators should also be able to continually demonstrate that their route structure is such that the consequences of hazards associated with the traffic densities along proposed routes do not produce unmitigated safety risks.

- ***User preferred routes.*** The operation of flights along a User Preferred Route (UPR) may also result in less traffic congestion, more efficient routing of aeroplanes and lower fuel burn. The State may take this into account, when approving an operator's fuel policy, if the operator can continually demonstrate the operational ability to conduct such operations.

11. THE OPERATIONAL REALITIES OF LONG-HAUL AND ULTRA-LONG-HAUL OPERATIONS

Long-haul and ultra-long-haul operations are specialized operations undertaken by relatively few air carriers. Strict adherence to prescriptive requirements, particularly regarding the provision of destination alternate aerodromes, may be particularly problematic in these operations due to the inability of an aeroplane to physically carry the fuel required. This is normally applicable to all long-range aeroplanes as well as short- to medium-range aeroplanes when operating to the limits of their available range.

The mechanisms necessary for the safe conduct of such operations may be beyond the capabilities of some operators, particularly if they have no previous and operationally specific experience. However performance-based variations from prescriptive regulations may be appropriate where an operator is able to continually demonstrate a level of operational sophistication and experience that ensures potential hazards have been properly considered and safety risks mitigated. In some cases a planned long-haul operation will not be possible without such relief. In these cases, the State may require a demonstration of operational capability to ensure acceptable levels of safety performance can be maintained before relief from the prescriptive requirements of national alternate aerodrome selection and fuel planning regulations can be granted.

Note.— Chapter 5 of this manual contains specific core criteria requirements that typify capable operators as well as additional guidance related to the development and implementation of performance-based regulations for alternate aerodrome selection and fuel planning.

— — — — — — — —

Appendix 2 to Chapter 3

EXAMPLE OF A UNITED STATES OPSPEC THAT PROVIDES CONDITIONAL RELIEF FROM IFR NO-ALTERNATE REQUIREMENTS (PARAGRAPH C355, ALTERNATE AIRPORT IFR WEATHER MINIMUMS: 14 CFR PART 121)

1. SUMMARIZING PERFORMANCE-BASED COMPLIANCE WITH FAA OPSPEC C355

FAA OpSpec C355 is representative of an operational variation to existing prescriptive regulations, in the United States, that contains many of the attributes of a performance-based methodology for the designation of alternate aerodromes. It contains an exhaustive compilation of criteria requirements, mitigation measures, and safety risk controls that far exceed the criteria of the prescriptive regulations it is formulated to address. It is provided here as a means to illustrate the scope, breadth and potential of performance-based compliance methods.

2. FAR 121.619 FORMS THE BASIS FOR THE OPERATIONAL VARIATION CONVENTIONAL PRESCRIPTIVE

While it is possible for a basic regulation to be performance-based, it is far more typical for a State's Authority to grant performance-based variations from established or existing prescriptive regulations. In the case of OpSpec C355, FAR 121.619 forms the basis for the operational variation:

"FAR 121.619 Alternate airport for destination: IFR or over-the-top: Domestic operations.

(a) No person may dispatch an airplane under IFR or over-the-top unless he lists at least one alternate airport for each destination airport in the dispatch release. When the weather conditions forecast for the destination and first alternate airport are marginal at least one additional alternate must be designated. However, no alternate airport is required if for at least 1 hour before and 1 hour after the estimated time of arrival at the destination airport the appropriate weather reports or forecasts, or any combination of them, indicate—

(1) The ceiling will be at least 2,000 feet above the airport elevation; and

(2) Visibility will be at least 3 miles.

(b) For the purposes of paragraph (a) of this section, the weather conditions at the alternate airport must meet the requirements of FAR121.625.

(c) No person may dispatch a flight unless he lists each required alternate airport in the dispatch release."

3. OPSPEC C355 ALLOWS CAPABLE OPERATORS TO VARY FROM FAR 121.619

Contractual OpSpec approval and the exemption petition process used by the FAA allow operational variations from prescriptive criteria based on continual conformance with the conditions outlined in the exemption. Such conditions represent specific systemic defenses, mitigation measures and/or safety risk controls used to ensure a level of safety at least as good as the prescriptive requirement:

"C355. Exemption to FAR 121.619 for Domestic Alternate Airport Requirements

a) The certificate holder is authorized to dispatch flights in accordance with Grant of exemption(s) listed in Table I below, as may be amended, which grant(s) relief from 14 CFR Sections 121.619(a)(1) and (2) for domestic operations. All operations under the exemption are subject to compliance with the conditions and limitations set forth in the exemption and this operations specification.

b) In accordance with the provisions and limitations of the exemption(s) listed in Table 1 below, the certificate holder is allowed to reduce the destination airport weather requirement of Section 121.619(a)(1) and (2) for designating an alternate airport from the current CFR requirement of at least 2 000-foot ceilings and at least 3 miles visibility to at least 1 000-foot ceilings and the visibility listed in Table 1 below based on the applicable exemption and the limitations and provisions of this operations specification.

Table 1 — Authorized Exemptions

Grant of Exemption No.	*Ceiling and Visibility Required Per Exemption*	*Must maintain at least CAT I or CAT II Approach Capability as Req'd*
XXXX (Distinct No. assigned to each operator)	1 000-ft ceiling and 2sm visibility	CAT II
XXXX (Distinct No. assigned to each operator)	1 000-ft ceiling and 3sm visibility	CAT I

c) This authorization is applicable to only those destination airports within the 48 contiguous United States.

d) This authorization may be used in operations to airports within the contiguous United States in accordance with operations specification A012 if issued.

e) All operations under this authorization must be conducted while using a qualified dispatcher.

1) The certificate holder must provide a copy of pertinent parts of the exemption and documentation, with respect to the conditions and limitations of this operations specification, acceptable to the POI, to each dispatcher, and pilot-in-command who conducts operations under the exemption.

2) Each dispatcher must have a computer monitoring system or systems to display the location of each flight and current significant weather that is capable of showing the following:

i) The aircraft's present position updated at least once every three minutes.

ii) Overlays of weather radar returns updated at least once every five minutes.

iii) Specific routing of the airplane as assigned by ATC and actual filed flight plan routing.

iv) Other airborne airplane including those of other operators.

v) Planned and actual fuel at regular intervals along the route and the difference between planned and actual fuel.

vi) Automatically alerts the dispatcher to a special weather update, changes in weather reports, forecasts and/or other significant weather-related reports which can be expeditiously relayed to the flight crews while conducting operations under this exemption.

3) Each dispatcher must have the capability to access the services of a qualified meteorologist approved by the POI or the certificate holder must have an approved EWINS programme.

4) Each dispatcher must have the capability to expeditiously re-compute projected arrival fuel from a "point aloft" to the intended destination in the event conditions, including those required to be reported in subparagraph l. below, occur that negatively impact the flight.

5) Each dispatcher must have data available that will show airplane status, including the airplane capability to conduct CAT I, CAT II or CAT III operations as applicable to the exemption being used.

6) The dispatch release will contain a statement for each flight dispatched under this exemption such as: "ALTN WEATHER EXEMPTION APPLIED. REFERENCE (APPROPRIATE DOCUMENT SUCH AS FOM, GOM, etc.). The certificate holder may choose to use other wording, if desired, but the meaning must be clear.

f) The reporting requirements of the flight crews listed in subparagraph l., Mandatory Pilot Reports, below and the required dispatch flight planning and tracking systems in subparagraph e. above must be used to determine the feasibility of dispatching the flight under this exemption and/or continuing the flight after dispatch.

g) Approved Procedures. If the use of these systems, reports or the occurrence of other factors indicate that the conditions under which the flight was originally dispatched have changed and may negatively impact the flight, the dispatcher and flight crew must re-evaluate the continued operation of the flight using approved procedures, and if necessary, agree on an alternate plan as soon as practicable after the occurrence of any of the following:

1) En route holding or delaying vectors, airspeed changes, altitude changes, or re-routings.

2) Unplanned or sustained use of deicing and anti-icing systems or other factors directly relating to fuel consumption that may have a negative effect on trip fuel requirements.

3) The deterioration of destination weather below a 1 000-foot ceiling and 2-mile visibility if using an exemption that requires at least 3 statute miles visibility as listed in Table I above.

4) The deterioration of destination weather below a 1 000-foot ceiling and 1-mile visibility if using an exemption that requires for at least 2 statute miles visibility as listed in Table I above.

h) If granted an exemption that allows for 1 000-foot ceiling and at least 2 statute miles visibility as listed in the granted exemption and Table 1 above, the certificate holder shall maintain at least CAT II approach authorization (operations specification C059) for those fleets to which this exemption applies and the following:

1) At the time of dispatch the flight crew must be qualified and the airplane equipped with operational avionics to conduct a CAT II approach.

2) The intended destination airport must have at least one operational CAT II or CAT III ILS approach that is available for use if needed.

3) Pilots in command (PIC) with less than the requisite minimum hours specified in Section 121.652 shall not be utilized in operations under this exemption unless the operator also holds Exemption 5549, the PIC has been trained in accordance with the requirements of that exemption, and all of the conditions specified by Exemption 5549 are met.

i) If granted an exemption that allows for 1 000-foot ceiling and at least 3 statute miles visibility as listed in the granted exemption and Table 1 above, the certificate holder shall maintain at least CAT I approach authorization (operations specification C052 and C074) for those fleets and flight crews to which the exemption would apply as well as the following:

1) At the time of dispatch the airplane avionics equipment required to conduct CAT I ILS approach must be installed and operational. At the time of dispatch the flight crew must be qualified to conduct a CAT I approach to minima of at least 200 feet and RVR 2 000 or lower, if published.

2) The intended destination airport must have at least one operational CAT I ILS approach with minima of at least 200 feet and RVR 2 000 that is available for use if needed.

3) PIC with less than the requisite minimum hours specified in Section 121.652 shall not be utilized in operations under this exemption unless the operator also holds Exemption 5549, the PIC has been trained in accordance with the requirements of that exemption, and all of the conditions specified by Exemption 5549 are met.

j) The exemption(s) referenced in Table 1 above cannot be used if thunderstorms are forecast in either the main body of a weather report or in the remarks section of the forecast between one hour before to one hour after the estimated time of arrival at the destination airport.

k) In the event any of the monitoring or capability requirements become inoperative after dispatch, the pilot-in-command and dispatcher will determine whether the degradation would preclude a safe landing at the destination airport.

l) Mandatory; Pilot Reports. Pilots will notify Dispatch as soon as practicable in the event of any of the following:

1) Lateral deviation from the planned route by greater than 100 NM.

2) Vertical deviation from the planned altitude by greater than 4 000 feet.

3) ETA will exceed planned by greater than 15 minutes.

4) Fuel consumption in excess of planned that may have a negative effect on trip fuel requirements.

5) Fuel system component failure or apparent malfunction that may have a negative effect on trip fuel requirements.

6) The flight encounters weather significantly different than forecast, to include turbulence.

7) The flight is assigned en route or arrival holding.

8) Unplanned or sustained use of deicing or anti-icing systems.

m) The certificate holder shall maintain a system for trend-tracking of all diversions. For at least the first 24 months of operations under the exemption(s) referenced in Table 1 above, or for such longer period of time as the POI deems necessary in order to thoroughly evaluate operational performance, the certificate holder must provide the Administrator, by the 15th of each month, reports, formatted in chronological order and by fleet type, that fully document each diversion from the previous calendar month and include at least the following:

1) The total number of flights operated under domestic rules to destinations within the 48 contiguous states by the certificate holder.

2) The total number of flights in subparagraph m.(1) above that divert to an alternate airport.

3) Total number of flights operated under the exemption(s) referenced in Table 1 above including those flights conducted under the appropriate provisions and limitations of` operations specification A012.

For each flight operated the following information must be included:

i) Dates

ii) Airport pairs

iii) Flight numbers

iv) Airplane M/M/S

v) Trended or graphical summary of flight planned fuel versus actual arrival fuel and the contingency fuel carried

vi) Emergency declared and reason

vii) Any occurrence of a low fuel state which results in actions being taken by ATC and/or dispatch in order to provide priority handling, even if no emergency is declared.

4) Diversions Under The Exemption(s). The flight numbers and the airport pairs where flights were diverted to an alternate airport that are operated under the exemption(s) referenced in Table 1 above, and the following:

i) Date of each diversion.

ii) Airplane M/M/S.

iii) The reason for each diversion, such as but not limited to, weather conditions, mechanical problem, fuel quantity, passenger problems, air traffic, flight crew, or any other reason.

iv) Fuel remaining at the diversion airfield.

v) Original weather forecast for original destination.

vi) Air traffic control priority and the reason for the assignment, if applicable.”

Chapter 4

UNDERSTANDING PRESCRIPTIVE COMPLIANCE

4.1 INTRODUCTION

4.1.1 The purpose of this chapter is to introduce the Annex 6, Part I, SARPs 4.3.4, 4.3.5, 4.3.6 related to the selection of alternate aerodromes, meteorological conditions required to operate in accordance with VFR and IFR, and pre-flight fuel planning. The prescriptive criteria contained in these SARPs are representative of the most basic systemic defenses of an aviation system in addition to others such as training and technology. Such criteria also provide the basis for a sensible and well-defined regulatory framework for use in complex operating environments as well as form the foundation for the development of sound SRM practices.

4.1.2 In a purely compliance-based regulatory environment, the State's Authority prescribes the minimum statutory requirements an operator must comply with when planning a flight. Such requirements are typically expressed as regulations defining the operating conditions that necessitate the selection of alternate aerodromes and fuel quantities to be carried. This prescriptive approach, reflected in the SARPs, is used by many Authorities as it contributes significantly to ensuring the safe completion of flights. It also offers economic advantages to Authorities and operators that may lack the sophisticated systems, advanced technologies or specialized knowledge necessary to support performance-based compliance with regulation.

4.1.3 Prescriptive compliance with regulation does, however, still require some specialized knowledge as it typically:

a) requires operators to identify the minimum statutory requirement acceptable to an Authority and to represent the starting point for the operator's flight preparation activities. It is important to note that while a regulation may prescribe a minimum amount of contingency fuel, for example, it is up to the operator's flight crews and Flight Operations Officers (if applicable) to determine, for a particular flight, if the prescribed regulatory minimum is sufficient to provide an adequate safety margin (e.g. through the uplift of discretionary fuel by the PIC or use of SCF). This concept should be reflected in the operator's flight preparation policy, process and procedure to ensure the adaption of safety margins in day-to-day operations;

b) requires operators to consider the operating conditions under which a flight will be conducted including computed aeroplane mass, expected meteorological conditions and anticipated ATC restrictions and delays; and

c) is contingent on the use of fuel consumption data provided by the aeroplane manufacturer.

4.1.4 This chapter explains the SARPs in Annex 6 that can be used as the basis to develop prescriptive national regulations as well as to form the baseline for performance-based variations from such regulations as described in Annex 6, Part I, 4.3.4.4 and 4.3.6.6.

Note.— Although closely related, fuel planning and in-flight fuel management are addressed separately in this manual.

4.2 HISTORY

4.2.1 Conventional prescriptive flight planning regulations and associated methods typically assume the following principal hazards affecting the outcome of flights. While aeroplanes and aids to navigation have advanced over time permitting the development of lower operating minima, the same underlying assumptions remain:

a) ***Need to land immediately after take-off.*** The development of take-off alternate aerodrome criteria likely stemmed from operator experience with high-power piston engines, when take-off fires were more common. It was recognized that take-offs were routinely performed in lower visibilities than were permitted for landings and that a return to point of departure was not always possible. This resulted in a requirement to provide for a "return alternate" within a specified flight time as a means of mitigating the safety risks associated with the inability to return to the point of departure.

b) ***Meteorological conditions at destination.*** It was generally assumed that if visual meteorological conditions (VMC) existed at the destination, a safe approach would always be possible and an alternate aerodrome would not be required. Conversely, if VMC were not forecast for the destination, not only would an alternate aerodrome be required, but the meteorological conditions at the alternate would have to be much less likely to prevent a safe approach than at the destination. This led to the development of "alternate minima", which is more restrictive than normal operating minima. The underlying assumption was that meteorological conditions were the major, if not the only, cause of diversion to the alternate aerodrome, and the prescriptive regulation in and of itself, did not attempt to mitigate other causal factors (e.g. ATC disruption).

c) ***In-flight contingency.*** The designation of contingency fuel was established to compensate for unforeseen factors that could influence fuel burn to the destination aerodrome. Such factors included, for example, deviations of an individual aeroplane from expected fuel consumption data, or deviations from forecast meteorological conditions or planned routings and cruising altitudes/levels.

   Contingency fuel has traditionally been computed as a percentage of trip fuel, a carry-over from a time when both consumption data and forecast wind components were less accurate than they are today. Contingency fuel requirements also typically specify a minimum cut-off value in terms of flight time, recognizing that some contingencies occur once per flight (e.g. take-off and landing delays) and are not proportional to flight time.

   Amendment 36 to Annex 6, Part I, defines contingency fuel allowing the use of it, to compensate for unforeseen factors, from the moment that an aeroplane first moves for the purpose of taking off. Thus, under some circumstances, it may be used prior to take-off. It is important to note that the definition of trip fuel includes compensation for *foreseen* factors such as meteorological conditions, air traffic services procedures, restrictions, anticipated delays and NOTAMS.

4.2.2 It should be noted that hazards, other than the aforementioned deviations accounted for in contingency fuel calculations, may not typically be considered by an operator that is strictly complying with prescriptive alternate aerodrome selection and fuel planning regulations. Such hazards that typically cannot be planned for, anticipated or are beyond the control of the operator include, but are not limited to:

a) human error or distractions;

b) loss of situational awareness;

c) workload spikes;

d) inaccurate prognostics (meteorological);

e) equipment failures;

f) database failures;

g) ATM failures;

h) ATM saturation and tactical measures; and

i) incidents/accidents resulting in infrastructure closures.

4.2.3 It is also important to note that such hazards are unlikely to be mitigated by prescriptive compliance with regulation, the designation of an alternate aerodrome or the carriage of extra fuel. Although these hazards cannot typically be planned for or anticipated, their consequences can and should be effectively identified and, where necessary, mitigated by other means including the application of SRM practices, advanced technologies, operator policies and procedures, operational control methods, increased awareness and training.

4.3 OBJECTIVES OF PRESCRIPTIVE COMPLIANCE

4.3.1 In a compliance-based regulatory environment, the State's Authority prescribes the statutory requirements for the operator to use in flight planning and re-planning. Such requirements are static in that they typically do not contain any performance-based elements or statistical analysis to aid in the precise determination of alternate aerodrome requirements, alternate minima or fuel reserves. They should, however, set clear, understandable and concise requirements for pre-flight planning and in-flight fuel usage, as well as specifically define the actions necessary to protect final reserve fuel.

4.3.2 Authorities that rely on prescriptive operator compliance with regulations also rely on reactive investigative processes to determine the root causes of incidents or accidents. As an example, typical reactive processes may require unplanned diversions, low fuel states and/or instances of landing below final reserve fuel to be reported to and/or investigated by the applicable Authority. The results of such investigative processes are then analysed to determine if changes to prescriptive regulations are warranted in order to maintain safe flight operations.

4.4 PRESCRIPTIVE ALTERNATE AERODROME SELECTION AND FUEL PLANNING PROVISIONS OF ANNEX 6, PART I

4.4.1 Annex 6, Part I, 4.3.4, 4.3.5 and 4.3.6 contain SARPs related to alternate aerodrome selection and fuel planning. Like many prescriptive national regulations these Standards were developed to provide for baseline operator performance in the following areas:

a) ***Take-off alternate aerodromes.*** Selection and specification on the operational flight plan (OFP) and prescribed distance from aerodrome of departure;

b) ***En-route alternate aerodromes.*** Selection and specification on the operational and ATS flight plan;

c) ***Destination alternate aerodromes.*** Selection and specification on the operational and ATS flight plans;

d) ***Isolated aerodromes.*** Planning requirements and special operational considerations for operations to isolated aerodromes;

e) ***Meteorological conditions.*** Prescribed meteorological conditions for VFR flight and to commence or continue an IFR flight including operating minima for take-off, destination and alternate aerodromes;

f) ***Alternate aerodrome planning minima.*** Criteria for establishing incremental values to be added to aerodrome operating minima and defining the estimated time of use of an alternate aerodrome;

g) ***Pre-flight fuel planning.*** Criteria to address deviations from the planned operation, basic fuel planning, the pre-flight calculation of required usable fuel, EDTO critical fuel and final reserve fuel.

4.4.2 Each Annex 6, Part I, SARP in the aforementioned areas will be explained and expanded in the ensuing sections of this chapter. It is important to note, however, that the performance-based variations from these Standards described in Annex 6, Part I, 4.3.4.4 and 4.3.6.6 will be explained in Chapter 5.

4.5 TAKE-OFF ALTERNATE AERODROMES — SELECTION AND SPECIFICATION

4.5.1 Annex 6, Part I, 4.3.4.1.1 states:

> 4.3.4.1 *Take-off alternate aerodrome*
>
> 4.3.4.1.1 A take-off alternate aerodrome shall be selected and specified in the operational flight plan if either the meteorological conditions at the aerodrome of departure are below the operator's established aerodrome landing minima for that operation or if it would not be possible to return to the aerodrome of departure for other reasons.

4.5.2 Conformance with this Standard requires an operator to select and specify a take-off alternate aerodrome in the OFP under the conditions specified. It is intended to address an emergency during or immediately after take-off that requires the flight crew to land the aeroplane as soon as possible. An engine failure or fire is an example of such an emergency, as the likelihood of this occurrence during take-off is higher than during other phases of flight. An additional consideration is that the approach and landing capability of the aeroplane may be degraded after an engine failure or fire. The result is likelihood that the minima that permitted the take-off from the departure aerodrome will be lower than the applicable minima for landing, if, for example, the departure aerodrome, either:

a) is not equipped with a precision approach; or

b) has only a Category I precision approach; or

c) has a Category II or III precision approach but the aeroplane is not certificated to land in Category II or III conditions with one engine inoperative; or

d) wind or terrain conditions do not allow the aeroplane to use a favourable approach.

4.5.3 In this case, the "*operator's established aerodrome operating minima for that operation*" typically refers to the minimum ceiling and/or runway visual range for landing with an engine inoperative as established by the operator. As such landings are assumed to occur within a relatively short period after take-off, it is typically unnecessary to apply additional margins to operating minima in order to allow for deterioration in meteorological conditions or uncertainty in the meteorological forecast.

Note.— Conformance with this Standard would also require the operator to establish operating minima in accordance with Annex 6, Part I, 4.3.4.1.3.

4.6 TAKE-OFF ALTERNATE AERODROMES — DISTANCE FROM AERODROME OF DEPARTURE

4.6.1 Annex 6, Part I, 4.3.4.1.2, states:

> 4.3.4.1 *Take-off alternate aerodrome*
>
> …
>
> 4.3.4.1.2 The take-off alternate aerodrome shall be located within the following flight time from the aerodrome of departure:
>
> a) for aeroplanes with two engines, one hour of flight time at a one engine-inoperative cruising speed, determined from the aircraft operating manual, calculated in ISA [International Standard Atmosphere] and still-air conditions using the actual take-off mass; or
>
> b) for aeroplanes with three or more engines, two hours of flight time at an all engines operating cruising speed, determined from the aircraft operating manual, calculated in ISA and still-air conditions using the actual take-off mass; or
>
> c) for aeroplanes engaged in extended diversion time operations (EDTO) where an alternate aerodrome meeting the distance criteria of a) or b) is not available, the first available alternate aerodrome located within the distance of the operator's approved maximum diversion time considering the actual take-off mass.

4.6.2 This Standard defines the location of the take-off alternate aerodrome (specified in accordance with Annex 6, Part I, 4.3.4.1.1) in relation to the aerodrome of departure. This location is expressed in terms of the time required to reach the alternate under the conditions specified. Allowances are made for the specific range of aeroplanes with inoperative engines or engaged in EDTO. Item c), for example, recognizes that aeroplanes engaged in EDTO are subject to stringent reliability requirements and that diversion times to an alternate aerodrome associated with such operations are inherently longer. To be *engaged in extended diversion time operations* means that the aeroplane and operator have been approved for EDTO, and the aeroplane has been dispatched in accordance with applicable EDTO requirements.

4.6.3 Conformance with this Standard requires an operator to calculate maximum diversion flight time distance for each aeroplane type and ensure that a take-off alternate aerodrome, when required in accordance with Annex 6, Part I, 4.3.4.1.1, is located within the prescribed distance from the aerodrome of departure. The operator would then select and specify in the OFP the available alternate or alternates within the diversion time distance calculated at one engine inoperative cruising speed under standard conditions in still air using the actual take-off mass.

Note.— Such calculations may be adjusted to align them with pre-existing and approved (by the applicable Authority) EDTO calculations for the determination of maximum diversion time expressed in distance. For example, operators may be permitted to define diversion distances for each aeroplane type, rounded up to easily recalled figures, that are based on take-off masses representative of those used in operations. Refer to Chapter 5 and its Appendix 1 for information related to variations in the way maximum diversion distances can be calculated in accordance with Annex 6, Part I, 4.3.4.4.

4.7 TAKE-OFF ALTERNATE AERODROMES — OPERATING MINIMA AT ESTIMATED TIME OF USE

4.7.1 Annex 6, Part I, 4.3.4.1.3 states:

> 4.3.4.1 *Take-off alternate aerodrome*
>
> …
>
> 4.3.4.1.3 For an aerodrome to be selected as a take-off alternate the available information shall indicate that, at the estimated time of use, the conditions will be at or above the operator's established aerodrome operating minima for that operation.

4.7.2 Conformance with this Standard requires an operator to determine, with a reasonable degree of certainty, that the take-off alternate aerodrome selected and specified in the OFP will be at or above the operator's established operating minima at the *estimated time of use*. The estimated time of use is established in accordance Annex 6, Part I, 4.3.5.4 (See 4.15 of this chapter) and should take into account the flying time at the appropriate speed (one engine inoperative for twins, all engines operating for three- and four-engine aeroplanes or the approved EDTO diversion speed, as applicable) with a suitable margin for variable factors including:

a) change in take-off time (e.g. if the take-off time changes and exceeds the margin defined by the State of the Operator for the estimated time of use, then the estimated time of use for the take-off alternate aerodrome should be updated);

b) uncertainty in the timing of meteorological changes.

4.7.3 The reference in the Standard to the *operator's established aerodrome operating minima for that operation* is understood to have the same meaning as the minima required at the aerodrome of departure, that is the minima appropriate for a one engine inoperative landing. This should not be confused with "*planning minima*" which refers to the operating minima plus incremental values of ceiling and visibility as determined by the State of the Operator and in accordance with Annex 6, Part I, 4.3.5.3.

4.8 EN-ROUTE ALTERNATE AERODROME SELECTION AND SPECIFICATION

4.8.1 Annex 6, Part I, 4.3.4.2 states:

> 4.3.4.2 *En-route alternate aerodromes*
>
> En-route alternate aerodromes, required by 4.7 for extended diversion time operations by aeroplanes with two turbine engines, shall be selected and specified in the operational and air traffic services (ATS) flight plans.

4.8.2 Conformance with this Standard requires an operator to identify and specify, in the operational and ATS flight plans, en-route alternate aerodromes required in accordance with Annex 6, Part I, 4.7.1.1 (b) and 4.7.2.5, which stipulate that twin turbine engine aeroplanes shall not proceed beyond 60 minutes to an en-route alternate aerodrome, and that twin turbine engine aeroplanes as well as aeroplanes with more than two turbine engines shall not proceed beyond the EDTO threshold unless the required en-route alternate aerodrome(s) will be available, and available information indicates that conditions at those aerodromes will be at or above the operator's established aerodrome operating minima for the operation at the estimated time of use.

4.8.3 To practically define the "estimated time of use" of an aerodrome and identify en-route alternates at the flight planning stage, the operator would need to first determine the earliest and latest Estimated Time of Arrival (ETA) for each selected en-route alternate aerodrome(s). This time window is referred to as the "estimated time of use" in the Standards and is defined as the period of time between the earliest and latest ETA for a given en-route alternate aerodrome. In order to "identify and specify" such an aerodrome as an EDTO en-route alternate, the operator, at the flight planning stage, would also need to verify that the meteorological forecast (over the applicable time window) is equal or above the applicable planning minima.

4.8.4 Although "estimated time of use" is addressed for any aerodrome in Annex 6, Part I, 4.3.5.3, and discussed in detail in 4.15 of this chapter, the complexities of EDTO and the associated identification of en-route alternate aerodromes warrant special attention. For example, a commonly accepted method for determining the earliest and latest ETA for a given en-route alternate or "estimated time of use" is as follows (Figure 4-1):

a) for the earliest ETA: consider a medical emergency diversion (no failure, All Engines Operating — AEO) starting at the first Equal Time Point (ETP).

b) for the latest ETA: consider diversion following depressurization (FL100), One Engine Inoperative (OEI) or AEO, starting at the second ETP.

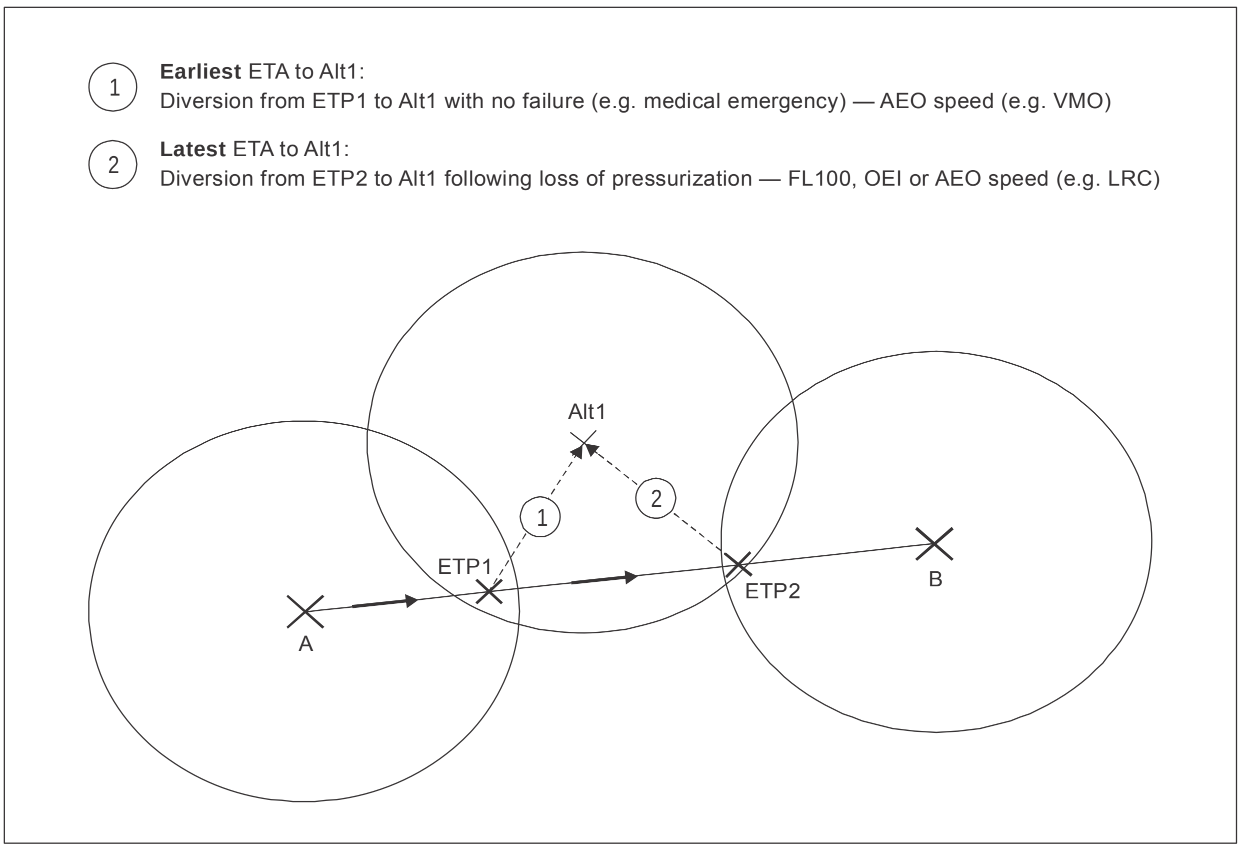


Figure 4-1. Method 1 for determining the time window for alternate 1 (flight from A to B)

4.8.5 For additional conservatism, the method in Figure 4-1 uses two different speeds and Flight Levels (FL) for the diversions, e.g. AEO speed/FL for diversion 1 and OEI (or AEO) speed/FL100 for diversion 2. Nevertheless, it may be acceptable to use the same speed/FL for both diversions. Another commonly accepted method of determining the earliest and latest ETA for each required en-route alternate aerodrome(s) is to consider the entry and exit point instead of the ETPs, as illustrated in Figure 4-2:

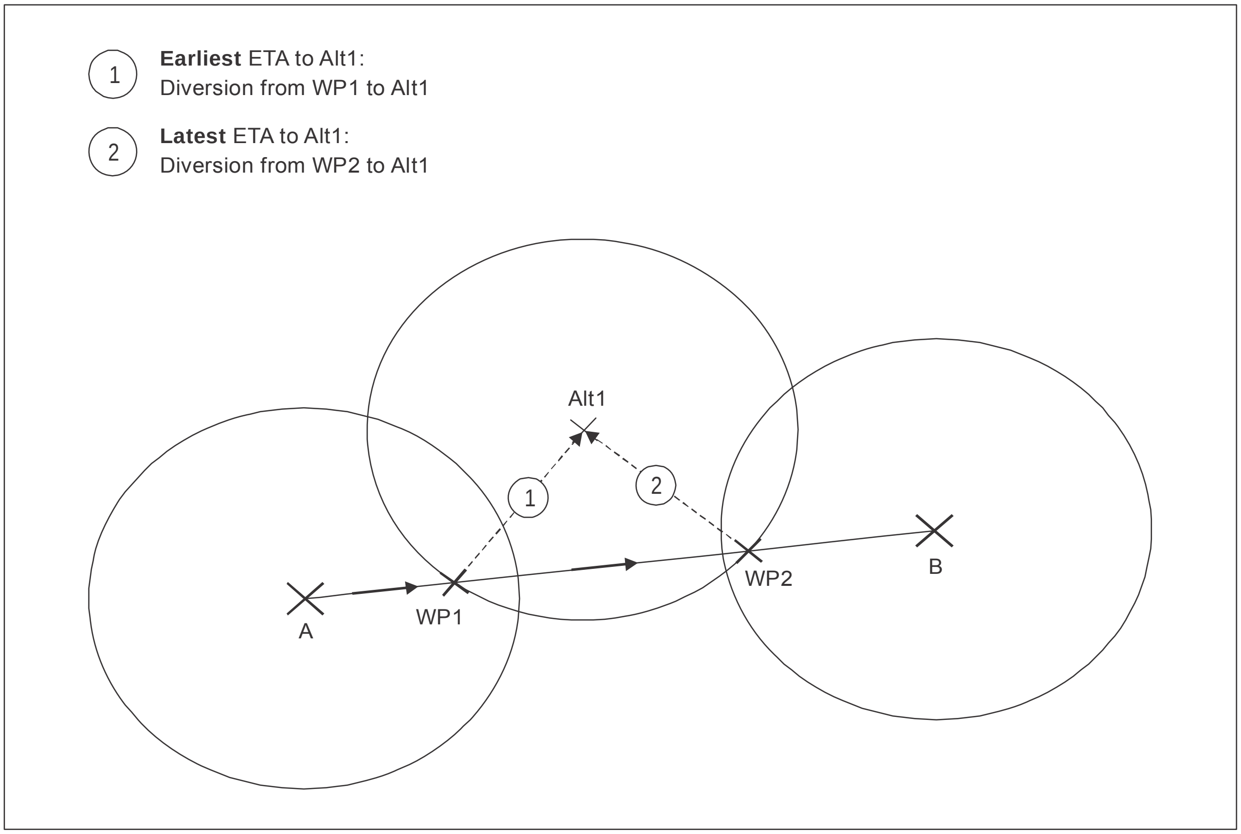


Figure 4-2. Method 2 for determining the time window for alternate 1 (flight from A to B)

4.8.6 It should be noted that the speed/FL used for the determination of estimated time of use in either method is for flight preparation purposes only. The use of a speed/FL during flight preparation does not imply that the same speed/FL must be used in the event of a diversion. In other words, it is perfectly acceptable for the flight crew to select a more appropriate speed/FL for an actual diversion.

4.8.7 There is one less common but accepted methodology for the identification and specification of an en-route alternate aerodrome that permits the dispatch of an EDTO flight when a forecast for the estimated time of use of the en-route alternate is not available at the planning stage. It presumes an aeroplane will not proceed beyond the point of sole reliance (WP sr) unless the flight crew obtains a valid meteorological forecast for the en-route alternate aerodrome that satisfies the applicable planning minima (Figure 4-3).

4.8.8 In summary:

a) The time window for a given en-route alternate aerodrome is the period of time between the earliest and latest ETA for a given en-route alternate aerodrome;

b) This time window is referred to as the “estimated time of use” in various Standards;

c) There are at least two commonly accepted methods for the determination of "estimated time of use" for EDTO en-route alternates (Figures 4-1 and 4-2);

d) At flight planning stage or, if applicable, before proceeding beyond the WP sr, the operator or flight crew checks that the meteorological forecast (over the applicable time window) is equal to or above the applicable planning minima;

Note.— EDTO are subject to higher meteorological minima requirements than operating minima, used for en-route decision making. This is to cater for uncertainty of the meteorological forecasts.

e) The estimated time of use is based on the Estimated Time of Departure (ETD). Should a significant delay occur (e.g. ETD delayed by more than one hour), the time windows for the selected en-route alternate aerodromes should be updated accordingly and the meteorological forecast verified again considering the updated time window;

f) If a valid meteorological forecast is unavailable at the planning stage for a prospective EDTO en-route alternate aerodrome, some CAAs may permit the dispatch of an EDTO flight based on the determination and use of a WP sr (Figure 4-3).

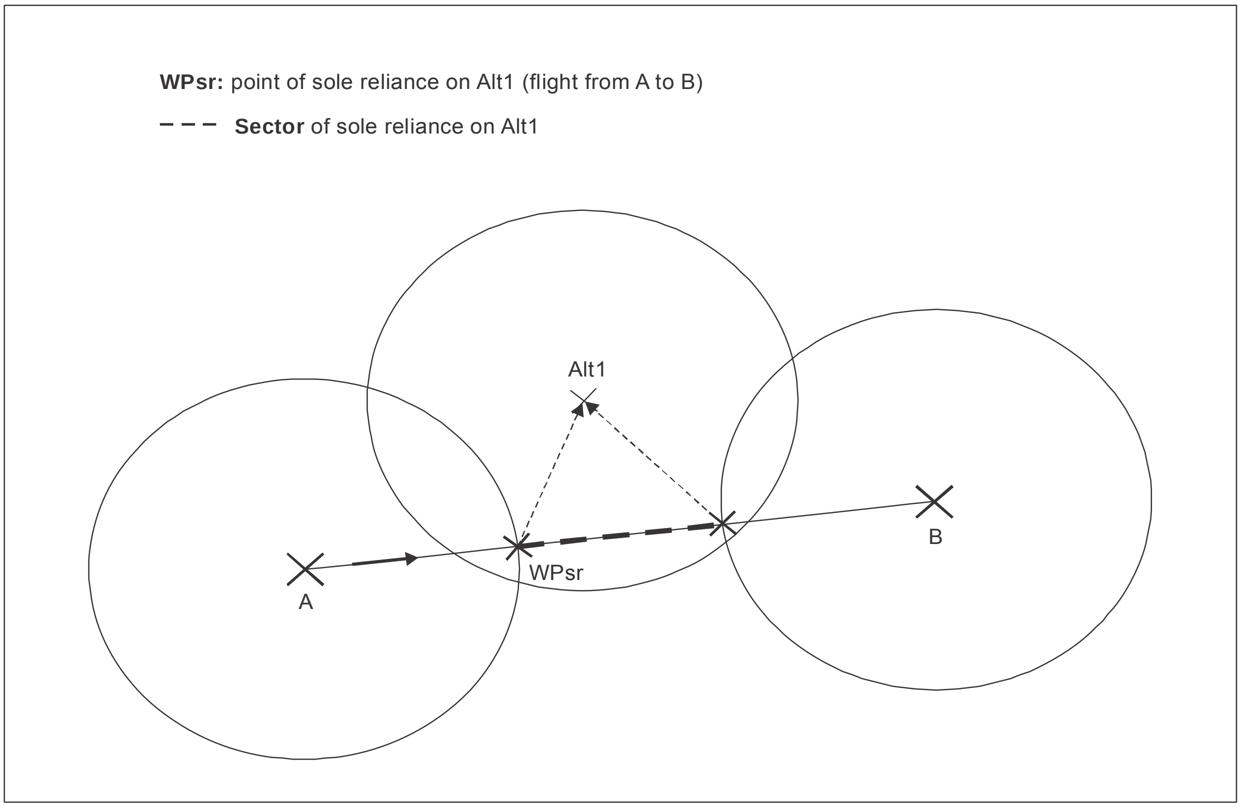


Figure 4-3. Point of sole reliance on an en-route alternate aerodrome (flight A to B)

4.9 DESTINATION ALTERNATE AERODROMES — SELECTION AND SPECIFICATION: ONE DESTINATION ALTERNATE

4.9.1 Annex 6, Part I, 4.3.4.3.1 a), states:

4.3.4.3 *Destination alternate aerodromes*

4.3.4.3.1 For a flight to be conducted in accordance with the instrument flight rules, at least one destination alternate aerodrome shall be selected and specified in the operational and ATS flight plans, unless:

a) the duration of the flight from the departure aerodrome, or from the point of in-flight re-planning to the destination aerodrome is such that, taking into account all meteorological conditions and operational information relevant to the flight, at the estimated time of use, a reasonable certainty exists that:

1) the approach and landing may be made under visual meteorological conditions; and

2) separate runways are usable at the estimated time of use of the destination aerodrome with at least one runway having an operational instrument approach procedure; or

…

4.9.2 This Standard contains the criteria for consideration during the selection and specification of destination alternate aerodromes as well as the conditions for operating into isolated aerodromes. Annex 6, Part I, 4.3.4.3.1 a) 1) stipulates that in order to forgo the selection and specification of a destination alternate aerodrome, a reasonable certainty must exist that at the estimated time of use of the destination aerodrome, an approach and landing can be made in VMC as defined by the State of the Operator. Provision 4.3.4.3.1 a) 2) further stipulates that two separate usable runways, with at least one having an operational instrument approach procedure, be available at the destination aerodrome at the estimated time of use. “Separate runways” are defined in Note 1 and are commonly considered to be two distinct paved surfaces which may cross one another but not considered opposite ends of one runway (e.g. one runway direction and its reciprocal do not constitute separate runways).

4.9.3 Practical conformance with 4.3.4.3.1 requires an operator to ensure at least one destination alternate aerodrome is selected and specified in the OFP and ATS flight plan in accordance with the provisions of 4.3.4.3.1 a) unless the destination aerodrome is isolated in accordance with 4.3.4.3.1 b). Provision 4.3.4.3.1 b) goes on to define criteria applicable to operations into isolated aerodromes that are explained in 4.10 of this chapter.

Note 1.— The “estimated time of use” of the destination aerodrome is established in accordance with Annex 6, Part I, 4.3.5.4 and explained in detail in 4.15 of this chapter.

Note 2.— Refer to Chapter 5 and its Appendix 2 for information related to variations in the way alternate aerodromes can be selected and specified in accordance with Annex 6, Part I, 4.3.4.4.

4.10 DESTINATION ALTERNATE AERODROMES — ISOLATED AERODROME PLANNING AND POINT OF NO RETURN (PNR)

4.10.1 Annex 6, Part I, 4.3.4.3.1 b) states:

4.3.4.3 *Destination alternate aerodromes*

4.3.4.3.1 For a flight to be conducted in accordance with the instrument flight rules, at least one destination alternate aerodrome shall be selected and specified in the operational and ATS flight plans, unless:

…

b) the aerodrome is isolated. Operations into isolated aerodromes do not require the selection of a destination alternate aerodrome(s) and shall be planned in accordance with 4.3.6.3 d) 4):

1) for each flight into an isolated aerodrome a point of no return shall be determined; and

2) a flight to be conducted to an isolated aerodrome shall not be continued past the point of no return unless a current assessment of meteorological conditions, traffic and other operational conditions indicate that a safe landing can be made at the estimated time of use.

Note 1.— Separate runways are two or more runways at the same aerodrome configured such that if one runway is closed, operations to the other runway(s) can be conducted.

Note 2.— Guidance on planning operations to isolated aerodromes is contained in the Flight Planning and Fuel Management Manual *(Doc 9976).*

4.10.2 This Standard and associated notes refer specifically to operations into isolated aerodromes that preclude the selection and specification of a destination alternate aerodrome. An isolated aerodrome is defined in the SARPs as a destination aerodrome for which there is no destination alternate aerodrome suitable for a given aeroplane type. As a practical matter, however, destination aerodromes may be considered isolated by a State's Authority when the fuel required to go-around from Decision Altitude/Height (DA/H) or the Missed Approach Point at the destination aerodrome and then divert to the nearest suitable alternate exceeds, for a turbine-engined aeroplane, the fuel required to hold at the destination aerodrome for 90 minutes.

Note.— The aforementioned example presumes the protection of 30 minutes final reserve fuel at any aerodrome.

4.10.3 This assumption is validated by Annex 6, Part I, 4.3.4.3.1 b), which stipulates that operations into isolated aerodromes shall be planned in accordance with 4.3.6.3 d) 4), which in turn stipulates that where the aerodrome of intended landing is an isolated aerodrome a turbine-engined aeroplane shall have sufficient fuel to fly for two hours at normal cruise consumption above the destination aerodrome, including final reserve fuel. Final reserve fuel in accordance with 4.3.6.3 e) 2) is further defined for a turbine-engined aeroplane as fuel to fly for 30 minutes at holding speed at 450 m (1 500 ft) above aerodrome elevation in standard conditions. Therefore, fuel for two hours at isolated aerodrome, required in accordance with 4.3.6.3 d) 4), minus 30 minutes final reserve fuel required in accordance with 4.3.6.3 e) 2) equals (approximately) 90 minutes hold over destination.

Note 1.— The examples in 4.10.2.and 4.10.3 presume, for illustrative purposes, that the difference in fuel flow rate for a representative turbine aircraft at cruising altitude versus holding at 450 m is negligible.

Note 2.— For reciprocating engine aeroplane operations, isolated aerodrome fuel is the amount of fuel required to fly for 45 minutes plus 15 per cent of the flight time planned to be spent at cruising level, including final reserve fuel, or two hours, whichever is less. Again, assuming for illustrative purposes, that the difference in fuel flow rate at cruise versus holding altitude for a representative aircraft is negligible and assuming the 2-hour maximum is reached, approximately 75 minutes of hold fuel over destination would be available for a reciprocating engine aeroplane in order to protect 45 minutes of final reserve fuel. It is also important to note that this is a best-case example, as significantly less fuel could be allocated for isolated aerodrome operations for flights with relatively shorter cruise segments.

4.10.4 In addition to the computation and carriage of isolated aerodrome fuel in accordance with 4.3.6.3 d) 4), conformance with 4.3.4.3.1 b) requires the determination of a point of no return [PNR]. In the context of isolated aerodrome operations, a PNR is the point of last possible diversion to an en-route alternate aerodrome (Figure 4-4). The Standard specifies that this point is to be determined on each flight to an isolated aerodrome. While this point can be calculated and specified in the OFP, such a calculation does not typically take into account any discretionary fuel, or the real-time changes in fuel consumption that will occur after departure.

4.10.5 The actual PNR will therefore often be reached later in the flight than the point originally calculated in the OFP. Operators should therefore provide practical instructions so that the flight crew can calculate the actual position of the PNR. These, for example, may take the form of a fuel plotting chart or practical instruction in the use of the calculating capabilities of the FMS.

Note 1.— Refer to Chapter 6 of this manual for practical instructions regarding the in-flight computation of the PNR.

Note 2.— A PNR may coincide with the Final Decision Point used in DP Planning or the Pre-Determined Point used in PDP planning. These flight planning methodologies are explained in detail in Appendix 3 to Chapter 5.

4.11 DESTINATION ALTERNATE AERODROMES — SELECTION AND SPECIFICATION: TWO DESTINATION ALTERNATES

4.11.1 Annex 6, Part I, 4.3.4.3.2 states:

> 4.3.4.3 *Destination alternate aerodromes*
>
> …
>
> 4.3.4.3.2 Two destination alternate aerodromes shall be selected and specified in the operational and ATS flight plans when, for the destination aerodrome:
>
> a) meteorological conditions at the estimated time of use will be below the operator’s established aerodrome operating minima for that operation; or
>
> b) meteorological information is not available.

4.11.2 Conformance with this Standard requires the operator to select and specify in the OFP, at the point of departure, a minimum of two alternate aerodromes if the destination aerodrome, at the estimated time of use, is forecast to be below minima, or forecast meteorological information is unavailable.

Note.— Appendix 2 to Chapter 5 addresses alternative methodologies for the selection and specification of destination alternate aerodromes.

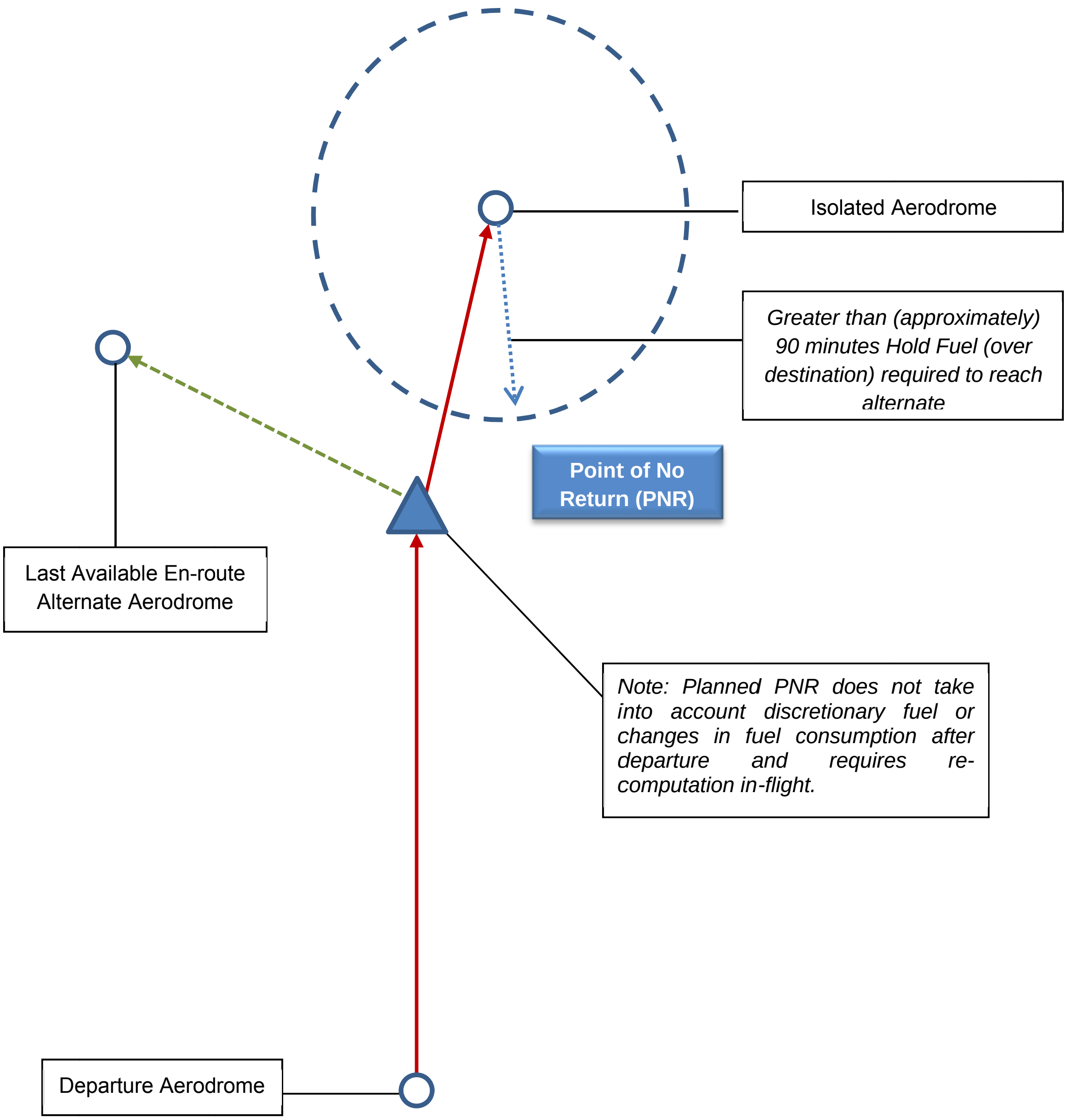


Figure 4-4. Point of No Return (PNR)

4.12 METEOROLOGICAL CONDITIONS — VFR FLIGHT

4.12.1 Annex 6, Part I, 4.3.5.1 states:

> 4.3.5 Meteorological conditions
>
> 4.3.5.1 A flight to be conducted in accordance with the visual flight rules shall not be commenced unless current meteorological reports or a combination of current reports and forecasts indicate that the meteorological conditions along the route or that part of the route to be flown under the visual flight rules will, at the appropriate time, be such as to enable compliance with these rules.

4.12.2 Conformance with this Standard requires the operator to have a means to determine if operations planned in accordance with Visual Flight Rules (VFR) can be conducted such that, at the appropriate time during the flight, the meteorological conditions encountered make compliance with VFR, as defined by the State, possible.

4.12.3 Practically speaking such a means would entail identifying the VFR segments of a proposed route, obtaining reliable and accurate meteorological reports and forecasts at the planning stage and ensuring, to the greatest practical extent, that VFR operations will remain possible at the estimated time of use of the segment. Confidence in pre-flight planning activities would be contingent on monitoring of en-route meteorological conditions by the flight crew and operational control personnel to validate assumptions made during pre-flight planning.

4.13 METEOROLOGICAL CONDITIONS — COMMENCING OR CONTINUING AN IFR FLIGHT

4.13.1 Annex 6, Part I, 4.3.5.2 states:

> 4.3.5 Meteorological conditions
>
> …
>
> 4.3.5.2 A flight to be conducted in accordance with the instrument flight rules shall not:
>
> a) take off from the departure aerodrome unless the meteorological conditions, at the time of use, are at or above the operator's established aerodrome operating minima for that operation; and
>
> b) take off or continue beyond the point of in-flight re-planning unless at the aerodrome of intended landing or at each alternate aerodrome to be selected in compliance with 4.3.4, current meteorological reports or a combination of current reports and forecasts indicate that the meteorological conditions will be, at the estimated time of use, at or above the operator's established aerodrome operating minima for that operation.

4.13.2 Conformance with Annex 6, Part I, 4.3.5.2 a) requires an operator to have a means to ensure, in order for operations to be conducted in accordance with Instrument Flight Rules (IFR), that a flight cannot take off unless current meteorological conditions are at or above the operator's established aerodrome take-off operating minima for the operation.

4.13.3 Conformance with Annex 6, Part I, 4.3.5.2 b) requires an operator to have a means to ensure, in order for operations to be conducted in accordance with IFR, that a flight cannot take off or continue from the point of in-flight re-planning unless current meteorological conditions are forecast to be at or above the operator's established aerodrome operating minima for the planned operation at the estimated time of use of the destination, en-route alternate aerodrome, or destination alternate, as applicable. The "estimated time of use" of the destination and/or each alternate aerodrome is established in accordance with Annex 6, Part I, 4.3.5.4 and explained in detail in 4.15 of this chapter.

4.14 ALTERNATE AERODROME PLANNING MINIMA — ESTABLISHING INCREMENTAL VALUES FOR CEILING AND VISIBILITY

4.14.1 Annex 6, Part I, 4.3.5.3, states:

4.3.5 Meteorological conditions

…

4.3.5.3 To ensure that an adequate margin of safety is observed in determining whether or not an approach and landing can be safely carried out at each alternate aerodrome, the operator shall specify appropriate incremental values for height of cloud base and visibility, acceptable to the State of the Operator, to be added to the operator's established aerodrome operating minima.

Note.— Guidance on the selection of these incremental values is contained in the Flight Planning and Fuel Management Manual *(Doc 9976).*

4.14.2 The operator's established *aerodrome operating minima* specify the limits of usability of an aerodrome for:

a) take-off, expressed in terms of runway visual range and/or visibility and, if necessary, cloud conditions;

b) landing in instrument approach and landing operations, expressed in terms of cloud conditions (if necessary), visibility and/or runway visual range and Decision Altitude/Height (DA/H) or Minimum Descent Altitude/Height (MDA/H), as appropriate.

4.14.3 Annex 6, Part I, 4.3.5.3, refers to the addition of appropriate incremental values for height of cloud base and visibility to aerodrome operating minima. Such minima, however, are predominantly defined in terms of required ceiling, DA/H, MDA/H, visibility and/or runway visual range, as applicable. As such, the incremental values specified in the Standard functionally refer to additions to the expressions used by the operator to define operating minima.

Note.— Ceiling is defined as the height above the ground or water, expressed in metres or feet, of the lowest cloud base below 6 000 m (20 000 ft) covering more than half the sky and is typically reported as broken or overcast in meteorological reports.

4.14.4 Conformance with this Standard requires an operator to have a means to ensure, with a reasonable degree of certainty, that at the estimated time of use of an alternate aerodrome, the meteorological conditions will be at or above the operator's established operating minima for an instrument approach. Because of the natural variability of meteorological conditions with time, as well as the need to determine the suitability of an alternate aerodrome before departure, the minima used for planning purposes or "planning minima" are always higher than the operating minima required to initiate an instrument approach. As such, operators use planning minima to provide for deterioration in meteorological conditions after the planning stage and to increase the probability that the flight will land safely after a diversion to an alternate aerodrome. This is especially important in cases where the time period during which the aerodrome is either required to be available, or the interval from the point of flight planning to the potential use of the alternate aerodrome, is considerable.

4.14.5 In order to practically conform to Annex 6, Part I, 4.3.5.3, an operator would have detailed instructions in its operations manual for determining the suitability of alternate aerodromes. Such instructions should specify that suitable increments be applied to the operator's established operating minima for planning purposes. Planning minima are usually expressed in a table that contains incremental increases to the expressions that define the operating minima for an approach such as ceiling, DA/H, MDA/H, visibility and/or runway visual range. The increments are typically expressed as a number of metres, feet or miles to be added as adjustments to the operating minima. It is important to note that these increments may not be the same for all alternate aerodromes as different types of alternates (take-off, destination and en route) may have different and distinct planning minima.

4.14.6 In its simplest form, a planning minima table may be based on straightforward additions to the DA/H, MDA and visibility associated with the applicable operating minima for a particular type of approach. This is true in the case of an EDTO alternate planning minima table used in Europe that is provided for illustrative purposes only in Table 4-1.

Note.— EDTO may be referred to as ETOPS in some documents.

4.14.7 Another type of planning minima table addresses potential failures of airborne or ground-based navigation systems and is constructed based on what is commonly referred to as the "one step down method." These types of tables, also used predominantly in Europe, take into account the possibility that a system malfunction, on the ground or in the aeroplane, may result in higher operating minima required for the remaining available instrument approach and landing. Table 4-2 is an example of such a table provided for illustrative purposes only.

Table 4-1. (EC) No 859/2008 Planning Minima — EDTO

Approach facility	*Alternate airfield ceiling*	*Meteorological minima Visibility/RVR*
Precision approach procedure	Authorized DH/DA plus an increment of 200 ft	Authorized visibility plus an increment of 800 m
Non-precision approach or circling approach	Authorized MDH/MDA plus an increment of 400 ft	Authorized visibility plus an increment of 1 500 m

Table 4-2. (EC) No 859/2008 Planning Minima — Planning minima — Destination alternate aerodrome, Isolated destination aerodrome, 3% ERA and En-route alternate aerodrome

Type of approach	*Planning minima*
Cat II and III	Cat I *(Note 1)*
Cat I	Non-precision *(Notes 1 and 2)*
Non-precision	Non-precision *(Notes 1 and 2)* plus 200 ft / 1 000 m
Circling	Circling
Note 1.— RVR. *Note 2.*— The ceiling must be at or above the MDH.	

4.14.8 A type of planning minima table used predominately in the United States is commonly referred to as a "One NAVAID, Two NAVAID table." This type of table considers the number of navigational facilities providing precision or non-precision approach capability. It also considers the number of different, and in the case of EDTO, separate runways available for use at an aerodrome. Table 4-3 is an example of an alternate planning minima table used in the United States and is provided for illustrative purposes only. The complete table including the context for its use is included in Appendix 1 to this chapter.

Note.— EDTO may be referred to as ETOPS in some documents.

Table 4-3. United States Alternate Airport IFR Weather Minima

Approach Facility Configuration	*Alternate Airport IFR Weather Minima*	
	Ceiling	*Visibility*
For airports with at least one operational navigational facility providing a straight-in non-precision approach procedure, or Category I precision approach, or, when applicable, a circling manoeuvre from an IAP.	Add 400 ft to MDA(H) or DA(H), as applicable.	Add 1 statute mile or 1 600 m to the landing minimum.
For airports with at least two operational navigational facilities, each providing a straight-in approach procedure to different * suitable runways.	Add 200 ft to higher DA(H) or MDA(H) of the two approaches used.	Add ½ sm or 800 m to the higher authorized landing minimum of the two approaches used.
* In this context, a "different runway" is any runway with a different runway number, whereas separate runways cannot be different ends of the same runway.		

4.14.9 There are advantages and disadvantages to all of these methods used to determine planning minima. For example, a simple addition to the required (operating) ceiling and visibility as illustrated in Table 4-1 protects against deterioration of meteorological conditions up to the difference between the established operating minima and the planning minima. This margin, however, may be insufficient to cover the loss of a precision approach capability with the consequent switch to a non-precision approach with particularly high minima.

4.14.10 Conversely if the "next step down" method is used as illustrated in Table 4-2 and an approach happens to have minima close to the lower limits of the precision approach (e.g. at an aerodrome relatively free from obstacles), the planning minima margins may not cover a plausible unforecast deterioration of meteorological conditions. Additionally, many of the conventional planning minima methodologies do not yet account for advances in technology such as RNP-AR, GLS and others.

4.14.11 As there are no simple solutions that will ensure an aerodrome will be at or above operating minima at the estimated time of use, any methodology used should be combined with other methods designed to properly mitigate the safety risks associated with flight planning (e.g. airport condition monitoring, operational control systems, flight monitoring, fuel planning, advanced communication systems, advanced technologies).

4.14.12 Finally, Annex 6, Part I, provisions require, inter alia, that operators establish processes approved by the State of the Operator for the purposes of ensuring alternate aerodromes, to the greatest practical extent, will be available for use when needed. To this end, alternate aerodrome planning minima tables should take the following into consideration, as applicable:

a) estimated time of use;

b) increments to be added to operating landing ceiling and/or visibility;

c) one engine inoperative operations in the case of take-off planning minima;

d) type of approaches available;

e) number of navigational aids upon which approaches are based;

f) EDTO; and

g) additional criteria requirements for designating alternates with Required Navigation Performance — Approval Required (e.g. RNP, RNP AR, SBAS, GBAS or GLS approaches);

Note.— Appendix 1 to this chapter contains an example of a United States OpSpec, provided for illustrative purposes. The OpSpec combines many of the attributes of the conventional methods for determining planning minima discussed in this chapter with contemporary criteria with the potential to increase the likelihood that an approach and landing will be safely accomplished at an alternate aerodrome, when necessary.

4.15 ALTERNATE AERODROME PLANNING MINIMA — ESTABLISHING ESTIMATED TIME OF USE

4.15.1 Annex 6, Part I, 4.3.5.4, states:

> 4.3.5 Meteorological conditions
>
> …
>
> 4.3.5.4 The State of the Operator shall approve a margin of time established by the operator for the estimated time of use of an aerodrome.
>
> *Note.— Guidance on establishing an appropriate margin of time for the estimated time of use of an aerodrome is contained in the* Flight Planning and Fuel Management Manual *(Doc 9976).*

4.15.2 Conformance with Annex 6, Part I, 4.3.5.4, and several other SARPs discussed in this chapter requires an operator to have a means to establish the “expected time of use” of an alternate aerodrome. In order to accomplish this aim, a common meaning of this term should be established by the State of the Operator and understood by the operator. While the estimated time of use, for example, of a destination aerodrome may simply be given by its ETA, the time period required for an en-route alternate aerodrome can be extended from the earliest to latest possible time of diversion (see 4.8 “En-route alternate aerodrome selection and specification” in this chapter). In addition, the margin referred to in 4.3.5.3 would be added to cover uncertainty of flight time estimates due to ground and airborne delays and/or the uncertainty in the timing of meteorological events.

4.15.3 As such, and in order to conform with 4.3.5.4, the State of the Operator should require the operator to define and apply margins to the estimated time(s) of arrival to allow for unexpected variations in departure time, flight time, and timing of change in meteorological conditions. Additionally, the operator should consider the time of applicability of temporary or transient events.

4.15.4 A widely accepted and acceptable time margin used by many national authorities is one hour before and after earliest and latest time of arrival. This may be reduced in special circumstances, e.g. if the meteorological forecast is only valid for the time of operation of the aerodrome and does not cover the period before opening.

4.15.5 Table 4-4 is an “Application of Aerodrome Forecasts to Pre-Flight Planning” chart used in Europe and provided for illustrative purposes. It represents a comprehensive treatment of the many issues related to the selection of alternate aerodromes and the application of time margins in order to define the estimated time of use. It also differentiates between take-off, destination, en-route and EDTO alternates as well as provides guidance as to how forecasts should be interpreted and/or applied at the planning stage. Operators may choose to simplify this for ease of use, but the resulting instructions to crews should be no less restrictive.

Table 4-4. AR AMC-OPS 1.297 — Application of Aerodrome Forecasts Table

APPLICATION OF AERODROME FORECASTS (TAF & TREND) TO PRE-FLIGHT PLANNING (ICAO ANNEX 3 refers)

1. APPLICATION OF INITIAL PART OF TAF (For aerodrome planning minima see JAR-OPS 1.297)

a) *Applicable time period:* From the start of the TAF validity period up to the time of applicability of the first subsequent "FM…*" or "BECMG" or, if no "FM" or "BECMG" is given, up to the end of the validity period of the TAF.

b) *Application of forecast:* The prevailing weather conditions forecast in the initial part of the TAF should be fully applied with the exception of the mean wind and gusts (and crosswind) which should be applied in accordance with the policy in the column "BECMG AT and FM" in the table below. This may however be overruled temporarily by a "TEMPO" or "PROB" if applicable acc. to the table below.

2. APPLICATION OF FORECAST FOLLOWING CHANGE INDICATORS IN TAF AND TREND

TAF or TREND for AERODROME PLANNED AS:	FM (alone) and BECMG AT:	BECMG (alone), BECMG FM, BECMG TL, BECMG FM…* TL in case of:		TEMPO (alone), TEMPO FM, TEMPO TL, TEMPO FM … TL, PROB30/40 (alone)			PROB TEMPO
	Deterioration and Improvement	Deterioration	Improvement	Deterioration		Improvement in any case	Deterioration and Improvement
				Transient/Showery Conditions in connection with short-lived weather phenomena, e.g. thunderstorms, showers	Persistent Conditions in connection with e.g. haze, mist, fog, dust/sandstorm, continuous precipitation		
DESTINATION at ETA ± 1 HR TAKE-OFF ALTERNATE at ETA ± 1 HR DEST. ALTERNATE at ETA ± 1 HR EN-ROUTE ALTERNATE at ETA ± 1 HR (See JAR-OPS AMC 1.255)	Applicable from the start of the change. Mean wind: Should be within required limits. Gusts: May be disregarded.	Applicable from the time of start of the change. Mean wind: Should be within required limits. Gusts: May be disregarded	Applicable from the time of end of the change. Mean wind: Should be within required limits. Gusts: May be disregarded	Not applicable Mean wind and gusts exceeding required limits may be disregarded.	Applicable Mean wind: Should be within required limits. Gusts: May be disregarded.	Should be disregarded.	Deterioration may be disregarded; Improvement should be disregarded including mean wind and gusts.
ETOPS ENRT ALTN at earliest/latest ETA ± 1 HR	Applicable from the time of start of change. Mean wind: Should be within required limits. Gusts exceeding crosswind limits should be fully applied.	Applicable from the time of start of change. Mean wind: Should be within required limits. Gusts exceeding crosswind limits should be fully applied.	Applicable from the time of end of the change. Mean wind: Should be within required limits. Gusts exceeding crosswind limits should be fully applied.	Applicable if below applicable landing minima Mean wind: Should be within required limits. Gusts exceeding crosswind limits should be fully applied.	Applicable if below applicable landing minima Mean wind: Should be within required limits. Gusts exceeding crosswind limits should be fully applied.		

Note 1.— "Required limits" are those contained in the Operations Manual.

Note 2.— If promulgated aerodrome forecasts do not comply with the requirements of ICAO Annex 3, operators should ensure that guidance in the application of these reports is provided.

* The space following "FM" should always include a time group e.g. "FM1030".

4.16 PRE-FLIGHT FUEL PLANNING — BASIC FUEL PLANNING AND DEVIATIONS FROM THE PLANNED OPERATION

4.16.1 Annex 6, Part I, 4.3.6.1, states:

4.3.6 Fuel requirements

4.3.6.1 An aeroplane shall carry a sufficient amount of usable fuel to complete the planned flight safely and to allow for deviations from the planned operation.

4.16.2 This Standard prescribes the baseline criteria for any methodology used to determine usable fuel required. Simply put, it requires operators to carry sufficient fuel to complete a flight safely while taking into account;

a) aeroplane-specific data in accordance with 4.3.6.2 a),

b) operating conditions for the planned operation in accordance with 4.3.6.2 b), and;

c) deviations from the planned operation as defined by 4.3.6.3 c).

4.16.3 Overall conformance with this Standard requires conformance with the remaining applicable criteria of 4.3.6.3 to be considered in the pre-flight computation of usable fuel required to complete the planned flight. A planned flight begins from the moment an aeroplane first moves for the purpose of taking off. The State of the Operator, however, can approve operational variations from selected criteria of 4.3.6.3 as described in 4.3.6.6. Such variations do not, however, relieve an operator of the responsibility to conform to the criteria of 4.3.6.1 and are described in detail in Chapter 5 and related appendices.

4.17 PRE-FLIGHT FUEL PLANNING — BASIS FOR CALCULATION OF REQUIRED USABLE FUEL

4.17.1 Annex 6, Part I, 4.3.6.2, states:

4.3.6 Fuel requirements

…

4.3.6.2 The amount of usable fuel to be carried shall, as a minimum, be based on:

a) the following data;

  1) current aeroplane-specific data derived from a fuel consumption monitoring system, if available; or

  2) if current aeroplane-specific data are not available, data provided by the aeroplane manufacturer; and

b) the operating conditions for the planned flight including:

  1) anticipated aeroplane mass;

  2) Notices to Airmen;

  3) current meteorological reports or a combination of current reports and forecasts;

4) air traffic services procedures, restrictions and anticipated delays; and

5) the effects of deferred maintenance items and/or configuration deviations.

4.17.2 Annex 6, Part I, 4.3.6.2 a) defines the aeroplane-specific or manufacturer data that would be considered during the pre-flight computation of the usable fuel required to satisfy the specifications of 4.3.6.1. Conformance with this provision requires operators to use the fuel consumption data provided by the aeroplane manufacturer as the basis for calculating the applicable components of the usable fuel required to safely complete a planned flight. Alternatively, an operator may base this calculation on aeroplane-specific data derived from a Fuel Consumption Monitoring (FCM) system. The attributes of an FCM system are explained in detail in Appendix 5 to this chapter. Provision 4.3.6.2 b) goes on to further define the operating conditions to be considered during the flight planning stage including computed aeroplane mass, expected meteorological conditions and anticipated ATC restrictions and delays. It is important to note that the fuel requirements to address foreseen factors that may affect operation conditions as described in 4.3.6.2 b) are considered part of the required trip fuel per 4.3.6.3 b).

4.17.3 Together, 4.3.6.1 and 4.3.6.2 form the basic foundation for the means to complete the pre-flight calculation of usable fuel required in accordance with the criteria of 4.3.6.3. Strict conformance to such criteria have and can continue to contribute significantly to ensuring sufficient fuel is carried to complete flights safely. Such an approach also offers advantages to regulators and operators that rely on prescriptive compliance with regulation as it does not require sophisticated systems or specialized knowledge in either use or monitoring. That is, unless operators can avail themselves of efficiencies to be gained through the deployment of a fuel consumption monitoring programme.

4.18 PRE-FLIGHT FUEL PLANNING — COMPONENTS OF THE PRE-FLIGHT CALCULATION OF REQUIRED USABLE FUEL

4.18.1 Fundamentally, Annex 6, Part I, 4.3.6.3, defines the terms that comprise the pre-flight calculation of usable fuel required to complete a flight safely. Furthermore it comprises the fuel which is required to be on board the aeroplane from the moment it first moves for the purpose of taking off. These terms are used throughout this manual to represent the variables in an equation that must be solved prior to each flight.

4.18.2 Annex 6, Part I, 4.3.6.3, states:

4.3.6 Fuel requirements

…

4.3.6.3 The pre-flight calculation of usable fuel required shall include:

a) *taxi fuel*, which shall be an amount of fuel expected to be consumed before take-off;

b) *trip fuel*, which shall be the amount of fuel required to enable the aeroplane to fly from take-off or the point of in-flight re-planning until landing at the destination aerodrome taking into account the operating conditions of 4.3.6.2 b);

c) *contingency fuel*, which shall be the amount of fuel required to compensate for unforeseen factors. It shall be five per cent of the planned trip fuel or of the fuel required from the point of in-flight re-planning based on the consumption rate used to plan the trip fuel but, in any case, shall not be lower than the amount required to fly for five minutes at holding speed at 450 m (1 500 ft) above the destination aerodrome in standard conditions;

Note.— Unforeseen factors are those which could have an influence on the fuel consumption to the destination aerodrome, such as deviations of an individual aeroplane from the expected fuel consumption data, deviations from forecast meteorological conditions, extended taxi times before take-off, and deviations from planned routings and/or cruising levels/altitudes.

d) *destination alternate fuel*, which shall be:

1) where a destination alternate aerodrome is required, the amount of fuel required to enable the aeroplane to:

i) perform a missed approach at the destination aerodrome;

ii) climb to the expected cruising altitude;

iii) fly the expected routing;

iv) descend to the point where the expected approach is initiated; and

v) conduct the approach and landing at the destination alternate aerodrome; or

2) where two destination alternate aerodromes are required, the amount of fuel, as calculated in 4.3.6.3 d) 1), required to enable the aeroplane to proceed to the destination alternate aerodrome which requires the greater amount of alternate fuel; or

3) where a flight is operated without a destination alternate aerodrome, the amount of fuel required to enable the aeroplane to fly for 15 minutes at holding speed at 450 m (1 500 ft) above destination aerodrome elevation in standard conditions; or

4) where the aerodrome of intended landing is an isolated aerodrome:

i) for a reciprocating engine aeroplane, the amount of fuel required to fly for 45 minutes plus 15 per cent of the flight time planned to be spent at cruising level, including final reserve fuel, or two hours, whichever is less; or

ii) for a turbine-engined aeroplane, the amount of fuel required to fly for two hours at normal cruise consumption above the destination aerodrome, including final reserve fuel;

e) *final reserve fuel*, which shall be the amount of fuel calculated using the estimated mass on arrival at the destination alternate aerodrome or the destination aerodrome, when no destination alternate aerodrome is required:

1) for a reciprocating engine aeroplane, the amount of fuel required to fly 45 minutes, under speed and altitude conditions specified by the State of the Operator; or

2) for a turbine-engined aeroplane, the amount of fuel to fly for 30 minutes at holding speed at 450 m (1 500 ft) above aerodrome elevation in standard conditions;

f) *additional fuel*, which shall be the supplementary amount of fuel required if the minimum fuel calculated in accordance with 4.3.6.3 b), c), d) and e) is not sufficient to:

1) allow the aeroplane to descend as necessary and proceed to an alternate aerodrome in the event of engine failure or loss of pressurization, whichever requires the greater amount of fuel based on the assumption that such a failure occurs at the most critical point along the route;

i) fly for 15 minutes at holding speed at 450 m (1 500 ft) above aerodrome elevation in standard conditions; and

ii) make an approach and landing;

2) allow an aeroplane engaged in EDTO to comply with the EDTO critical fuel scenario as established by the State of the Operator;

3) meet additional requirements not covered above;

Note 1.— Fuel planning for a failure that occurs at the most critical point along a route (4.3.6.3 f) 1)) may place the aeroplane in a fuel emergency situation based on 4.3.7.2.

Note 2.— Guidance on EDTO critical fuel scenarios are contained in Attachment D;

g) *discretionary fuel*, which shall be the extra amount of fuel to be carried at the discretion of the pilot-in-command.

4.18.3 It is likely that up until very recently, the terms used in Annex 6, Part I, 4.3.6.3, were not universally understood or applied. This is the primary reason why they are presented in great detail. While, many of the terms require little additional explanation, others require clarification to ensure they are not misunderstood or misapplied. “Contingency fuel” and “additional fuel”, for example, are two such terms with the potential to cause confusion that will be explained in detail later in this chapter.

4.18.4 It is important for authorities and operators to have a clear and common understanding of the terms used in fuel planning as such an understanding is the key to regulatory oversight and operator compliance. This is equally true for operators using a prescriptive approach to compliance as it is for those using a performance-based approach. It is especially important for States of the Operator that permit performance-based compliance in accordance with 4.3.6.6, as such an approach is dependent on the clear and consistent definition and understanding of an operational baseline described in 4.3.6.3.

4.18.5 Consider, for example, a State’s Authority that is trying to determine if an operator is in overall conformance with a regulation based on Annex 6, Part I, 4.3.6.3. Prescriptive compliance to regulation could easily be determined in this case if the operator could demonstrate to the satisfaction of the Authority that fuel is allocated as described in the SARPs. Operators that use significantly different terms than those prescribed in the SARPs, however, may have difficulty with such a demonstration. The difficulty arises when the Authority cannot discern, due to differences in terminology, whether the terms used by the operator are substantially equivalent, allocate fuel in a similar fashion, and, when combined, result in an equivalent or greater amount of fuel.

4.18.6 Another, more precise, example involves an operator that does not carry five per cent contingency fuel exactly as defined in Annex 6, Part I, 4.3.6.3 c). An Authority may consider an operator in prescriptive compliance without the need for an operational variation if the terminology and contingency fuel calculation method used results in a demonstrably equivalent (or greater) amount of fuel. Conversely, an operator may be deemed out of compliance or require an operational variation if the terminology used is largely inconsistent with 4.3.6.3 c) and/or the calculation method used results in a lesser amount of fuel.

4.18.7 It is important to note that there are many such scenarios that require careful scrutiny of the criteria in 4.3.6.3 to determine if the pre-flight calculation of the usable fuel produces the desired result. It is also important to understand that the provisions are not intended to create duplication if, for example, an operator chooses to allocate fuel for holding apart from contingency fuel or uses a variable fuel reserve to encompass contingency and final reserve fuel. In short, the SARPs provide the basic variables for an equation that will result in the prescribed amount of usable fuel but it is up to the State of the Operator, the Authority and the operator to ensure, regardless of the variables used, that sufficient usable fuel is uplifted in accordance with the applicable statutory requirements and to complete the planned flight safely.

Note 1.— Appendix 2 to this chapter provides an example of prescriptive fuel planning, used by a State's Authority that conforms to Annex 6, Part I, 4.3.6.3, but uses different terms to comprise the equation for the pre-flight calculation of usable fuel required to complete a flight safely.

Note 2.— Operational variations applicable to the calculation of taxi, trip, contingency, destination alternate aerodrome, and additional fuel in accordance with Annex 6, Part I, 4.3.6.6, are described in detail in Chapter 5 and related appendices.

4.19 PRE-FLIGHT FUEL PLANNING — TAXI FUEL

4.19.1 Annex 6, Part I, 4.3.6.3 a) defines *taxi fuel* as the amount of fuel expected to be consumed before take-off which typically takes into account "local conditions" at the departure aerodrome and auxiliary power unit (APU) fuel consumption. Practically speaking, this includes the fuel required for engine start and to move an aircraft under its own power considering the route to the departure runway based on known taxi times (when available) for specific airports and runway configurations.

4.19.2 For the purpose of taxi fuel calculations "local conditions" must typically also be taken into account and refer to conditions or occurrences that would contribute to increased fuel consumption prior to take-off including but not limited to "foreseeable" occurrences such as:

a) ground holding;

b) ATC metering programmes;

c) remote de/anti-icing;

d) aircraft engine and wing anti-ice use;

e) single runway operations; and

f) any other occurrence with the potential to increase taxi time.

4.19.3 It is important for operators to promote the accurate and, where possible, "predictive" computation of *taxi fuel* in order to ensure foreseeable occurrences are appropriately taken into account at the planning stage. To this end each *taxi fuel* calculation is typically based on a detailed analysis that considers the aforementioned criteria as well as the aircraft type, time of day, and historical seasonal performance data. In the absence of a more detailed analysis, however, certain predefined taxi fuel values may be established which cover normal operations for a specific operating environment. Table 4-5 is an example of how predefined taxi fuels, based on an aircraft manufacturer's all-engine taxi fuel flow rates, can be established by an operator.

Table 4-5. Example of predefined taxi fuels by aircraft type

Aircraft Type	*Taxi fuel for 10 minutes at all engine consumption rates, startup, and pre-departure APU run-up (kilograms)*	*Taxi fuel for 20 minutes at all engine consumption rates, startup, and pre-departure APU run-up (kilograms)*
A319	15 kg/minute; normally 200 kg including 30 kg for APU	15 kg/minute; normally 400 kg including 30 kg for APU
B747	70 kg/minute; normally 1 000 kg including 300 kg for APU	70 kg/minute; normally 1 700 kg including 300 kg for APU

4.19.4 It is important to note that *taxi fuel* does not account for delays that were unknown at the planning stage. Fuel to account for such occurrences would normally be added by the PIC just prior to departure as *discretionary fuel* or accounted for in *contingency fuel*. This is important as the burning of fuel over and above the planned *taxi fuel* before take-off can affect the remaining quantities in the usable fuel equation (see Annex 6, Part I, 4.3.6.3 b), c), d), e) or f)) or the decision to continue a flight after commencement (e.g. to take-off or to continue from the point of in-flight re-planning).

4.19.5 The decision, therefore, to burn into other fuels, including *contingency fuel,* should be carefully considered to ensure the remaining fuel is sufficient for the flight taking into account any conceivable occurrences that would require re-analysis and, if necessary, adjustment of the planned operation.

Note.— Appendix 6 to Chapter 5 contains an example of a statistical taxi fuel programme that conforms to Annex 6, Part I, 4.3.6.3 a) and in accordance with Annex 6, Part I, 4.3.6.6.

4.20 PRE-FLIGHT FUEL PLANNING — TRIP FUEL

4.20.1 *Trip fuel* is simply defined by Annex 6, Part I, 4.3.6.3 b) as the fuel required to fly from the departure aerodrome or from the point of in-flight re-planning to the destination aerodrome, taking into account the aeroplane-specific or manufacturer data specified in 4.3.6.2 a) and operating conditions of 4.3.6.2 b). In actual practice, however, the calculation of trip fuel is typically a complex process that is dependent on numerous underlying and interdependent activities. In the end, however, the intent of every trip fuel calculation is to ensure, to the greatest practical extent, that the planned fuel burn is equal to or greater than the actual fuel burn.

4.20.2 Assumptions made during the calculation of trip fuel also directly impact the determination of other fuels such as contingency fuel and discretionary fuel. It is therefore important that operational control personnel and flight crew are aware of any such assumptions with the potential to validate or invalidate decisions made subsequent to the pre-flight calculation of trip fuel. For example, operators may:

a) Use a hull-specific Fuel Consumption Monitoring (FCM) that is based on airframe drag and engine degradation over a specific rolling (e.g. 90-day) time period, via Aircraft Performance Monitoring (APM) programmes from the original equipment manufacturers (OEMs). Such monitoring programmes typically use actual fuel consumption rates for all phases of flight (take-off, climb, cruise, descent, approach and landing) and bring a level of accuracy to trip fuel calculations that cannot be attained in their absence.

For example, if an operator does not use an FCM programme and uses fuel burn data from the OEM without an accurate correction for degradation in hull performance, the planned trip fuel is unlikely to be equal to or greater than the actual. Such operators may therefore use a conservative (e.g. 4 per cent) fleet average fuel burn correction, due to a lack of APM availability, as it is conservative and covers all of the hulls in a particular fleet. Alternatively, such operators may choose to increase contingency fuel to account for an “unknown” degradation in specific hull performance;

b) Generate flight plans 2-3 hours before scheduled departure based on a forecast ZFW/payload that uses a blend of booked and historical passengers, baggage and cargo. These assumptions can result in trip fuel amounts that are either optimistic or conservative depending on actual outcomes. A lower than planned ZFW at pushback, for example, could result in a 3 per cent/hour trip fuel reduction (e.g. assuming a 3 000 kg/hour average fuel consumption rate, 3 tons less ZFW on a 10-hour trip could reduce the trip fuel by 900 kg);

c) Base flight plans and trip fuel on lengthy IFR departure and arrival routing procedures (longest RNAV SID to longest RNAV STAR). In the real world, these routings may rarely occur, thus introducing some conservatism into the trip fuel calculation. Conversely, those operators capable of assessing the probability of which SID/STAR combination will be used on a given city pair, including the likely track miles to be flown, may account for some or all of the fuel for such procedures as part of SCF, discretionary fuel or extra fuel. This would make the trip fuel calculation less conservative and more reflective of real-world performance based on statistical analysis.

Another example of lengthy arrival procedures that may or may not be flown are Point Merge STAR procedures. “Point Merge” is used by ATS units in some States in lieu of racetrack pattern holding, DME Arcs, delaying vectors or other traditional forms of air traffic sequencing. Simply put, Point Merge STAR procedures are but one variation of linear holding that exploits performance-based navigation (PBN) equipment and procedures. There are other variations of linear holding (e.g. “tromboning”) that are similar to Point Merge in that they include a prescribed ground track that may or may not be flown based on traffic density. It is important to note, however, that ATS units implementing Point Merge STARs (or similar PBN procedures) typically publish statistics showing the portion of the Merge Point Arc flown by arriving aircraft during the different hourly bands of the day or the week.

When planning for a Point Merge STAR, fuel for the direct STAR to the merge point may be included in the trip fuel but the fuel required to account for the probability that the entire merge point procedure would be flown could be accounted for in other fuels such as in the contingency fuel calculated in accordance with Annex 6, Part I, 4.3.6.6 and Appendix 4 to Chapter 5 of this manual. The foundation for such calculations is the availability of relevant data related to the average part of the merge point procedure to be flown obtained either from internal or external sources (operator and/or ATS unit).

From the operator perspective, such information could come from internal data collection processes that support SCF calculations. From the perspective of an ATS unit that has implemented procedures to support Point Merge, such information could be provided in the form of regularly published statistics allowing high levels of predictability regarding the sections of the linear hold on the Point Merge Arc which may be flown. In either case, these statistics will allow pilots to determine, according to the expected time of arrival, the contingency/discretionary/extra fuel (as applicable) needed for safe flight completion.

It is important to note, however, that operators lacking the requisite skills, expertise and knowledge to support SCF calculations or to otherwise predict the likelihood that an entire procedure will be flown may account for the entire flight plan track to the destination, including potential SID/STAR combinations, in trip fuel and discretionary fuel in accordance with Annex 6, Part I, 4.3.6.3 b) and g), respectively. In either case, operational control personnel and flight crew must be aware of how fuel for such procedures is accounted for in order to determine the level of conservatism built into the trip fuel calculation.

d) Generate “Speed Up” flight plans at the planning stage to protect on-time performance. Such flight plans manipulate Cost Index/Mach to achieve a certain required time of arrival with the obvious cost of increased fuel burn. Conversely, a return to more economical Cost Index/Mach would yield a trip fuel reduction;

e) Voluntarily or based on operational requirements (e.g. in-flight re-planning) choose to “protect” some or all of the contingency fuel to the destination aerodrome which would require an increase in the trip fuel. In other words, if an operator chooses to protect 5 per cent of the trip fuel as contingency fuel to the destination then the trip fuel will need to be adjusted upward to account for the extra weight. For example, 5 per cent of a 100-ton trip burn is 5 tons. If an operator plans to carry 5 tons of contingency fuel to destination an additional 2 tons of trip fuel may be needed to carry it, so on a 10-hour flight an operator could board 7 tons; 5 tons for the 5 per cent contingency fuel + 2 tons additional trip fuel to carry and protect it all the way to destination.

   In cases where contingency fuel is not protected to the destination aerodrome there is no adjustment made to the trip fuel, and fuel for contingencies is simply added as a straight percentage of the trip fuel. The concept, therefore, of “protected” and “unprotected” contingency fuel, if applicable, must be clearly understood as any given flight may have more or less (fuel) buffer when flights do not unfold as originally planned.

4.20.3 These are only a few of the factors that contribute to the computation of trip fuel as well as the confidence operators and flight crews have in its accuracy. It is this confidence that further ensures any decisions made subsequent to the initial planning stage will yield the intended outcomes. In the end, however, the intent of every trip fuel calculation is to ensure, to the greatest practical extent, that the planned fuel burn to the destination is equal to or greater than the actual fuel burn.

Note.— An example of an FCM programme used to conform to Annex 6, Part I, 4.3.6.2 a) and/or Annex 6, Part I, 4.3.6.6 b) can be found in Appendix 5 to Chapter 5.

4.21 PRE-FLIGHT FUEL PLANNING — CONTINGENCY FUEL

4.21.1 Fundamentally, Annex 6, Part I, 4.3.6.3 c) defines *contingency fuel* as the fuel required to compensate for factors that cannot be foreseen during flight planning. Such factors include, but are not necessarily limited to, deviations from flight plan that could influence the total fuel consumed en route to the destination such as:

a) deviations of an individual aeroplane from the expected fuel consumption data;

b) unforeseen meteorological conditions;

c) extended delays (on the ground or in the air); or

d) deviations from planned routings and/or cruising levels/altitudes.

4.21.2 From a safety risk management perspective, contingency fuel is used to mitigate the risks associated with operational factors or hazards that cannot be planned, anticipated or controlled. The risk associated with the improper calculation or complete consumption of contingency fuel is that of creating a diversion or low fuel state requiring to declare it as MINIMUM FUEL or MAYDAY FUEL (4.3.7.2.2 and 4.3.7.2.3) that may subsequently impact ATM and other aeroplanes. Using a prescriptive approach to compliance, the Authority prescribes the contingency fuel for the operator to use in planning as described in Annex 6, Part I, 4.3.6.3 c).

4.21.3 Regardless of the regulatory approach to compliance, the importance of understanding contingency fuel cannot be understated. As an example, the deterioration of an airframe/engine combination is a contingency that must be accounted for if it is unmonitored (i.e., unknown). Conversely, if it is monitored (i.e., known) then it should be accounted for in trip fuel. This basic example illustrates how the impact of a very specific operational concern can be accounted for in different ways. It also clearly illustrates the difference between unforeseeable and foreseeable factors. In this case, the difference is rooted in an operator's capability to monitor and ultimately predict specific hull performance.

4.21.4 Contingency fuel can also be unprotected, which assumes that not all contingency fuel is planned to be carried to the destination airport. In the fuel calculation, the consumed portion of the contingency fuel is included in the trip fuel. Practically speaking this means the fuel for transport is not considered, and the contingency fuel remaining over the destination can be reduced. The decision to "protect" or "unprotect" some or all of the planned contingency fuel can be driven by numerous factors which include but are not limited to:

a) fuel preservation to account for unforeseen occurrences en route or over destination;

b) re-planning, re-dispatch, decision point planning requirements;

c) reduced contingency fuel (RCF) procedure requirements;

d) EDTO critical fuel scenario/diversion planning requirements unless additional fuel in accordance with 4.3.6.3 f) is already protected;

e) SCF planning requirements or outcomes;

f) a prediction that contingency fuel will be used during the en-route phase of flight and thus not required over destination.

Note.— The hazards, safety risks and mitigation strategies associated with contingency fuel planning are described in detail in Chapter 5 of this manual.

4.22 PRE-FLIGHT FUEL PLANNING — ALTERNATE FUEL

4.22.1 Annex 6, Part I, 4.3.6.3 d) defines *alternate fuel* as the fuel required to account for several separate and distinct operational scenarios as follows:

a) destination alternate aerodrome is required:

b) two destination alternate aerodromes are required;

c) flights operated without a destination alternate aerodrome;

d) aerodrome of intended landing is an isolated aerodrome.

4.22.2 In each case *alternate fuel* is intended to mitigate the safety risks associated with the unavailability of the destination, first destination alternate or isolated aerodrome, as applicable. In order to practically conform to 4.3.6.3 d), an operator would require system, process and procedures for destination alternate selection that are commensurate with the complexity and scope of its operations. In determining *alternate fuel*, the aeroplane-specific or manufacturer data specified in 4.3.6.2 a) and operating conditions of 4.3.6.2 b) would also be considered.

4.23 PRE-FLIGHT FUEL PLANNING — FINAL RESERVE FUEL

4.23.1 Annex 6, Part I, 4.3.6.3 e) defines the *final reserve fuel* amounts for turbine and reciprocating engine aeroplanes. This amount of fuel, calculated during pre-flight planning, is based on the estimated aeroplane mass on arrival at the destination alternate aerodrome or the destination aerodrome (when no destination alternate aerodrome is required). Additional criteria upon which this calculation is based include the time, speed and altitude conditions specified under 4.3.6.3 e) 1) or 4.3.6.3 e) 2), as applicable.

4.23.2 In addition to the precise calculation of final reserve fuel for the purposes of pre-flight planning, Annex 6, Part I, 4.3.6.4 recommends that operators determine approximate final reserve fuel values for each aeroplane type and variant in their fleet.

4.23.3 Annex 6, Part I, 4.3.6.4, states:

4.3.6 Fuel requirements

…

> 4.3.6.4 ***Recommendation.—*** *Operators should determine one final reserve fuel value for each aeroplane type and variant in their fleet rounded up to an easily recalled figure.*

4.23.4 Conformance with this Recommended Practice would require an operator to determine conservative (rounded up) final reserve fuel values for each type and variant of aeroplane used in operations. The intent of this recommendation is two-fold, it provides:

a) a reference value to compare to pre-flight fuel planning computations and for the purposes of a “gross error” check;

b) flight crews with easily referenced and recallable final reserve fuel figures to assist in in-flight fuel monitoring and decision-making activities.

Note.— Guidance on the development and presentation of such values as well as the protection of final reserve fuel is discussed in Chapter 6.

4.24 PRE-FLIGHT FUEL PLANNING — ADDITIONAL FUEL

4.24.1 Basic fuel planning represented by the sum of Annex 6, Part I, 4.3.6.3 a) through e), is predicated on the termination of a flight at the destination or destination alternate aerodrome. As such, it takes into account only foreseen and unforeseen factors (excluding system failures) that could influence fuel consumption to the planned destination or destination alternate aerodrome. Provision 4.3.6.3 f) 1) defines the “additional fuel” required to protect against the very unlikely event of an engine failure or depressurization at the most critical point in the flight and presumes that the majority of the fuel used in basic fuel planning will be available for use in proceeding to the en-route alternate aerodrome.

4.24.2 The sum of 4.3.6.3 b) + c) + d) + e) forms the equation used for comparison purposes with 4.3.6.3 f) to determine if indeed the basic flight plan fuel is sufficient to account for the critical fuel scenario(s) or if “additional fuel” is required. The purpose of this comparison is therefore to ensure that “additional fuel” is uplifted when the basic flight plan fuel is insufficient, considering the most critical failure at the most critical point, to proceed to an en-route alternate aerodrome, hold at 1 500 ft for 15 minutes, conduct an approach and land. It is important to note that whilst contingency fuel may be used on the ground, this would not be the case if some or all contingency fuel is used in the equation to determine the required additional fuel. In other words, if some or all contingency fuel is part of the equation to determine the required additional fuel, it may not be used on the ground and must be available at take-off or the point of in-flight re-planning as described in 4.3.6.5.

4.24.3 The following examples illustrate the circumstances that may or may not require "additional fuel" as described in 4.3.6.3 f). In the first example (Figure 4-5), additional fuel is *not* required as basic fuel planning. The sum of 4.3.6.3 b) + c) + d) + e) results in sufficient fuel to account for the critical fuel scenario. Note that some of the contingency fuel may be used on the ground or prior to reaching the point of in-flight re-planning.

4.24.4 In the second example (Figure 4-6), additional fuel *is* required as basic fuel planning. The sum of 4.3.6.3 b) + c) + d) + e) does not yield sufficient fuel to account for the critical fuel scenario. Note that all of the contingency fuel is considered in the equation; therefore none of it may be used on the ground or prior to reaching the point of in-flight re-planning.

4.24.5 It is important to note that although 4.3.6.3 f) 1) is applicable to all flights, 4.3.6.3 f) 2) is an additional requirement that applies only to all aeroplanes engaged in EDTO. It further defines the fuel necessary to comply with the EDTO critical fuel scenario as established by the State of the Operator. Such scenarios include additional controls to ensure sufficient fuel is uplifted (to account for: engine failure alone or combined with a loss of pressurization, icing, errors in wind forecasting, deterioration in cruise fuel burn performance, and APU use if applicable, 15 minutes hold, approach and landing). These controls, described in Annex 6, Part I, Attachment D further ensure that for EDTO, the sum of 4.3.6.3 f) 1) i) + ii) will be on board the aeroplane upon arrival at the en-route alternate aerodrome.

4.24.6 Additionally, the note to 4.3.6.3 f) 1) addresses the scenario of an event occurring precisely at the most critical point of the route. If that were the case, the aeroplane may be in an emergency situation since the planned fuel available to be on board at that point of the route may not guarantee that planned final reserve fuel would be available upon landing.

4.25 PRE-FLIGHT FUEL PLANNING — DISCRETIONARY FUEL

4.25.1 Annex 6, Part I, 4.3.6.3 g) defines *discretionary fuel* as an extra amount of fuel to be carried at the discretion of the PIC. While *contingency fuel* is typically defined early during pre-flight fuel planning in order to account for unforeseeable occurrences, *discretionary fuel* may be loaded later in the process by the PIC, Flight Operations Officer (if applicable), or as directed by the operator.

4.25.2 The widespread use of *discretionary fuel* is more typical in cases where the operator (or regulator) simply prescribes the minimum fuel required and then relies on the PIC to adjust that minimum as necessary based on actual operational conditions. It is therefore, important to note that adding accuracy to fuel computations (e.g. statistical taxi and/or contingency fuel) at the planning stage is likely to diminish the need for the uplift of discretionary fuel.

4.25.3 In any case, discretionary fuel is often used to ensure operational fuel load precision during scenarios that are (historically) likely to increase fuel consumption to the destination aerodrome. Such scenarios are numerous; however, drivers leading to increased (over plan) fuel consumption typically include (listed in order of probability):

a) forecast payload accuracy: higher than anticipated take-off gross weight;

b) ATC constraints: arrival demand exceeding arrival capacity at the destination aerodrome;

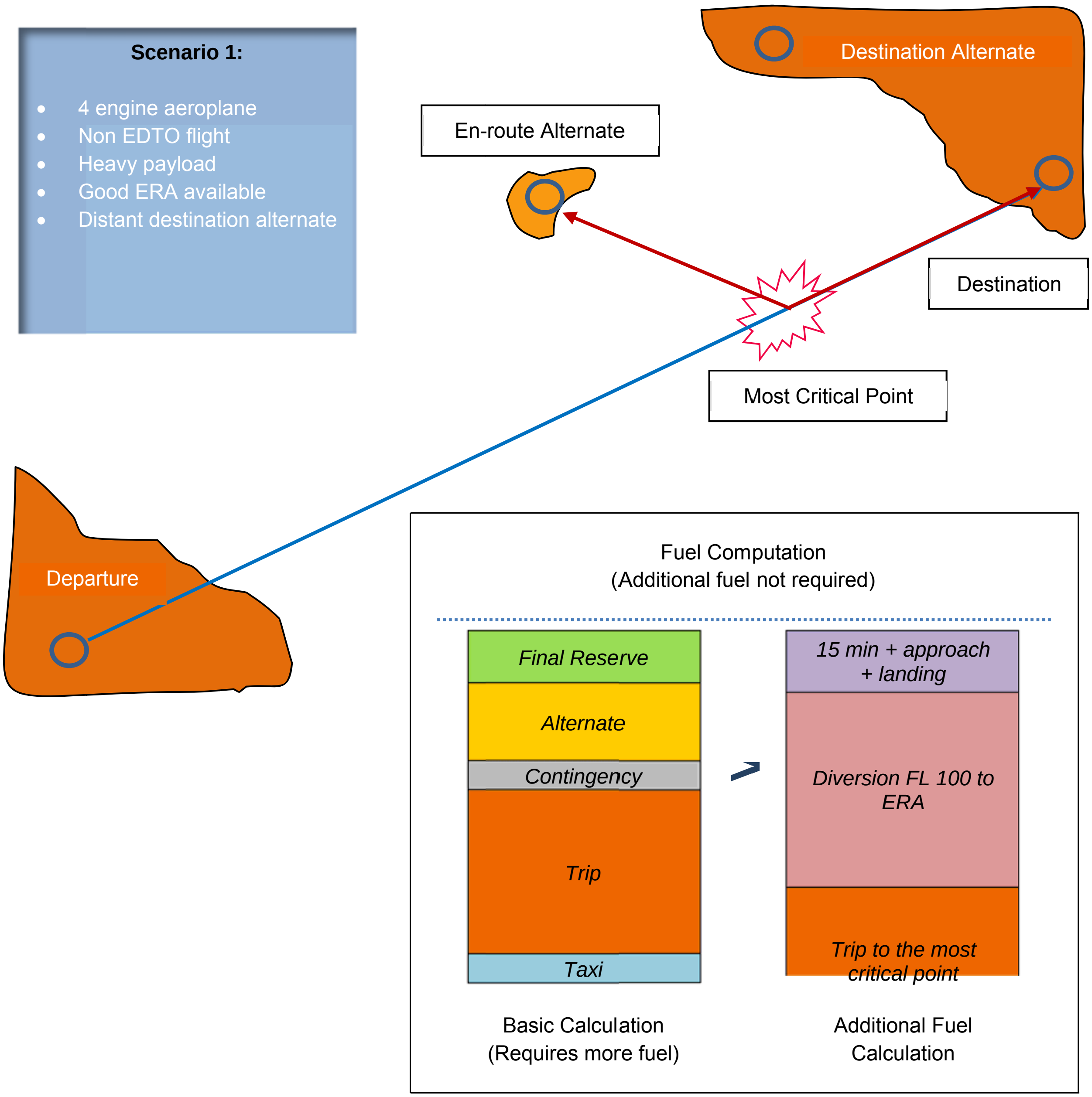


Figure 4-5. Additional fuel not required

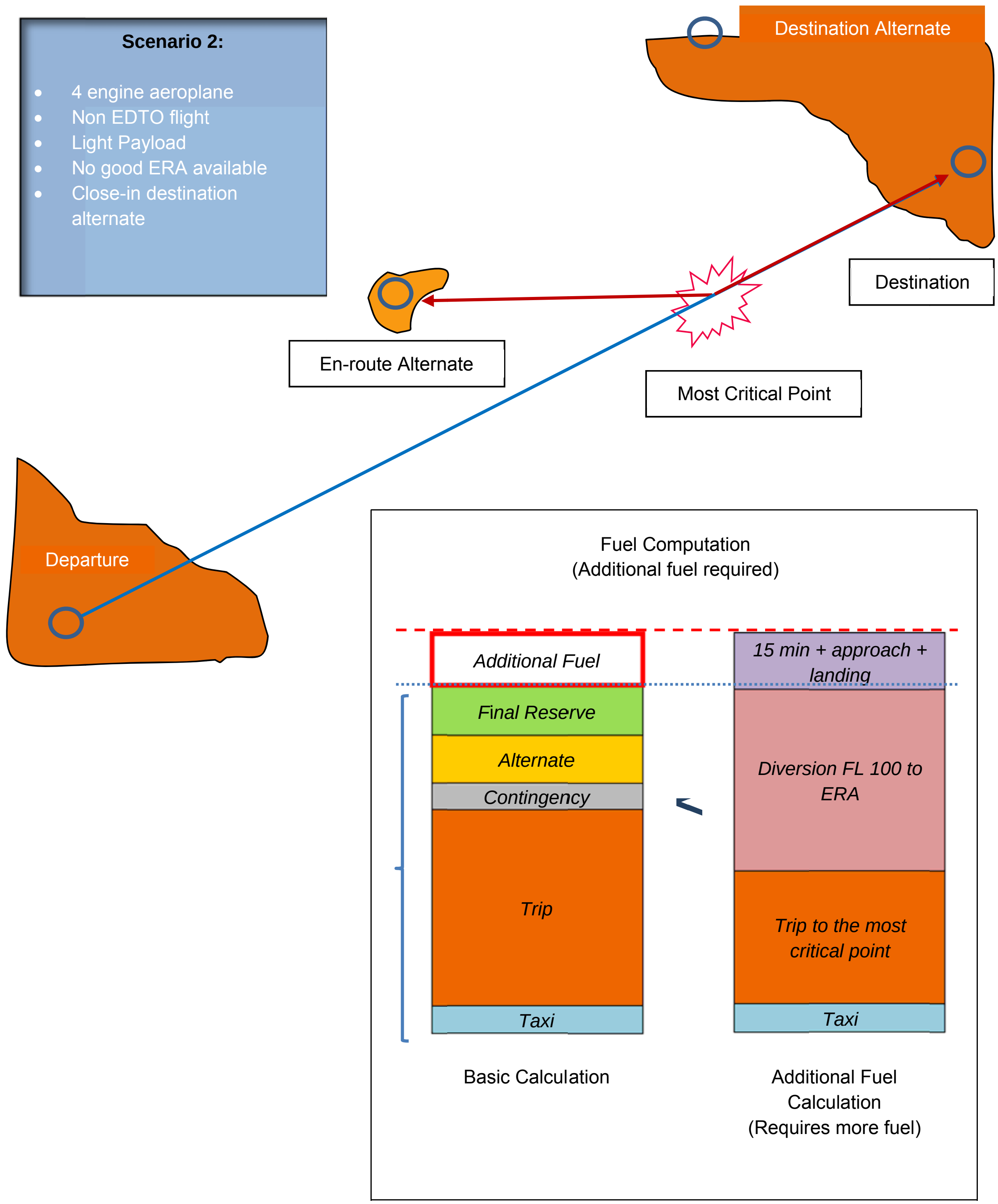


Figure 4-6. Additional fuel required

c) weather impacts at destination or en-route:

1) destination aerodrome with variable arrival acceptance rates due to single runway operations and/or inclement weather (e.g. risk of thunderstorm in the forecast, severe low-level turbulence, freezing precipitation, runway contamination);

2) en-route adverse meteorological phenomena, resulting in lateral and/or vertical route and altitude deviations (e.g. solid thunderstorms, volcanic ash, severe icing, dust storms, typhoons, cyclones, and hurricanes).

4.25.4 When considering the uplift of discretionary fuel based on such known operational factors, a best practice approach is to use a predefined table for determining fuel amounts based upon anticipated conditions. Any table figures should be based on aeroplane flight manual (AFM) data, as well as actual operational performance data. Table 4-6 is one example of how predefined fuel amounts, based on an aircraft manufacturer's fuel flow rates, can be established by an operator.

Table 4-6. Example discretionary fuel table

Aircraft type	**1 minute of additional fuel (kilograms)**	**1 minute of additional all-engine taxi fuel (kilograms)**
A319	40 kg/minute	15 kg/minute
B747	140 kg/minute	70 kg/minute

Note.— The following example figures are provided for the purpose of deriving the appropriate amount of fuel for anticipated en-route weather hazards.

Lateral Deviation Fuel
A 50 NM deviation around adverse meteorological phenomena is an additional 5 minutes of fuel burn (for each area where a deviation is necessary) or 200 kilograms (A319) as derived from the above table.

Altitude Deviation Fuel
A cruise 4 000 ft above or below the planned altitude is an additional 3 minutes of fuel burn per hour of affected flight time or 120 kilograms (A319) as derived from the above table. Generally this fuel is to accommodate for altitude flexibility when turbulence of moderate or greater intensity is known or forecast to be encountered at planned cruise altitude(s).

4.26 PRE-FLIGHT FUEL PLANNING — MINIMUM FUEL FOR COMMENCEMENT OF FLIGHT AND/OR TO CONTINUE FROM THE POINT OF IN-FLIGHT RE-PLANNING

4.26.1 Annex 6, Part I, 4.3.6.5, states:

4.3.6 Fuel requirements

…

4.3.6.5 A flight shall not commence unless the usable fuel on board meets the requirements in 4.3.6.3 a), b), c), d), e) and f) if required and shall not continue from the point of in-flight re-planning unless the usable fuel on board meets the requirements in 4.3.6.3 b), c), d), e) and f) if required.

4.26.2 This Standard identifies the components of usable fuel that must be on board an aeroplane prior to commencement of flight and/or prior to continuing a flight beyond the point of in-flight re-planning. Fundamentally, the Standard provides the practical means for the safe completion of each flight in conformance with 4.3.6.1 and forms the foundation for the protection of final reserve fuel in accordance with 4.3.7.2. It is important to note that practical conformance with this Standard is dependent on a clear understanding of the computation, application and use of each component in the usable fuel equation.

4.26.3 The primary intent of this Standard is to ensure that the fuel allocated during pre-flight planning and for the purposes described in Standard 4.3.6.3 is accurately calculated, on board and usable at the appropriate time. It also underscores the notion that the pre-flight calculation of usable fuel must take into account the data requirements and operating conditions of 4.3.6.2 a) and b). Finally, the Standard marks the transition from planning to in-flight fuel management. These critical activities require constant monitoring, re-analysis and adjustment in order to ensure adequate safety margins can be maintained continually throughout the conduct of each flight in accordance with 4.3.6.1 and 4.3.7.2.

4.26.4 The first step in assuring sufficient fuel is on board to complete a planned flight safely is the accurate computation of taxi fuel. To achieve this aim, the planned taxi fuel quantity (4.3.6.3 a)) takes into account foreseeable taxi conditions and delays, and to the greatest practical extent, represents an amount of fuel predicted to equal or exceed the actual fuel consumed before take-off. Additionally, operators should have the demonstrable capability, using historical data collection and analysis tools, to adjust taxi times to ensure continuous improvement in future pre-flight taxi fuel calculations. States should monitor this capability when conducting operator surveillance activities by reviewing data collected from the operations manual, operational flight plan records, actual versus planned taxi time reports, flight inspections, and, if available, flight data analysis reports.

4.26.5 It is important to note that every usable fuel calculation must take into account foreseen and unforeseen deviations from the planned operation. Foreseeable deviations are those that result in increased fuel consumption based on the data and operating conditions of 4.3.6.2 a) and b). Fuel to compensate for these factors (e.g. aeroplane fuel burn rate, expected meteorological conditions, anticipated ATC restrictions and expected delays) are part of the trip fuel calculation in accordance with 4.3.6.3 b) and are always required to be on board prior to take-off and/or prior to continuing a flight beyond the point of in-flight re-planning. Operators, in determining whether or not they are in conformance with 4.3.6.5, should not confuse the foreseen factors considered in accordance with 4.3.6.2 a) and b) with the unforeseen factors specified in 4.3.6.3 c).

4.26.6 Contingency fuel calculated in accordance with 4.3.6.3 c) is intended to compensate for unforeseen deviations in the planned operation that occur after a flight commences. The decision to use contingency fuel on the ground or at any point in the flight, however, must be carefully weighed against the need to compensate for the many unforeseeable occurrences that may be encountered once airborne. Other considerations include, for example, the operational necessity to protect contingency fuel for in-flight re-planning purposes or the need to protect fuel for the critical fuel scenario in accordance with 4.3.6.3 f).

4.26.7 Practically speaking, 4.3.6.5 allows for the consumption of contingency fuel once a flight has commenced and prior to take-off so long as it will not be required to proceed beyond a point of in-flight re-planning and/or it is not considered part of the additional fuel calculated in accordance with 4.3.6.3 f). It is important to note:

a) In the case of in-flight re-planning; a flight dispatched with an in-flight re-planning point (e.g. re-release point, re-dispatch point, decision point) may not proceed beyond that point without the required contingency fuel on board. Furthermore, if in-flight re-planning is conducted after the commencement of flight, the usable fuel required on board to proceed beyond the new in-flight re-planning point must meet the requirements in 4.3.6.3 b), c), d), e) and f), if required;

b) In the case of a flight that is dispatched with contingency fuel included in the basis for the computation of required additional fuel, that portion of the contingency fuel is intended to be available at the critical decision point(s) designated along a route segment that gives rise to the Critical Fuel Scenario (CFS).

4.26.8 In summary, practical conformance with this Standard begins, to the extent reasonably practicable, with the use of realistic taxi times as basis for the calculation of taxi fuel as well as the uplift of discretionary fuel when deemed necessary by the PIC. Occasionally, unpredicted prolonged taxi times may consume the planned taxi fuel and burn into the contingency fuel leaving the flight crew with fewer options, once airborne, to compensate for any other unforeseen factor(s). The PIC, in making the decision to continue a flight, must consider this and all other operational factors that may affect his or her ability to safely complete the planned operation and protect final reserve fuel.

4.26.9 In the case of unforeseen taxi delays, for example, it may be possible to take off having burned into the contingency fuel in order to avoid a very long delay. Conversely, a return to the gate for more fuel may be prudent if continuing the flight means having to make a fuel stop prior to reaching the intended commercial destination. Whatever decision is made should not impact the safety of the operation in conformance with 4.3.6.1 and 4.3.7.2. In order to achieve this aim, operators should have clearly defined policy and procedures that address the minimum fuel required for take-off and, if applicable, to continue beyond the point of in-flight re-planning.

Note 1.— This Standard is also applicable to contingency fuel derived using a performance-based method per 4.3.6.6.

Note 2.— Examples of flight planning and in-flight re-planning processes currently in widespread use around the world can be found in the appendices to Chapters 4 and 5 of this manual.

Note 3.— Guidance on the development of flight crew policy and procedure, including flight crew responsibilities related to in-flight re-planning and fuel management can be found in Chapter 6 of this manual.

4.27 PRE-FLIGHT FUEL PLANNING — BASIC PRESCRIPTIVE CALCULATION EXAMPLE

Using the prescriptive approach to regulatory compliance, the State's Authority may approve an operator's fuel policy and/or prescribe the fuel requirements for the operator to use in planning, including specific contingency, alternate and reserve quantities to be carried. Figure 4-7 is an example of a basic fuel planning regulation for a twin turbine-engined aeroplane engaged in EDTO with a destination alternate aerodrome. It uses the Annex 6, Part I, definitions for each prescribed component in the calculation as follows:

BASIC EDTO FUEL POLICY
(Destination Alternate Required)

a) When calculating the fuel required, an operator shall, on the basis of the fuel consumption data provided by the aircraft manufacturer include at least taxi fuel + trip fuel (including fuel for foreseen contingencies) + mandated reserves.

b) Mandated reserves would consist of:

1) Contingency fuel (5% of the planned trip fuel or of the fuel required from the point of in-flight re-planning based on the consumption rate used to plan the trip but not less than the amount required to fly for five minutes at holding speed at 450 m (1 500 ft) above the destination aerodrome in standard conditions);

2) Destination alternate fuel;

3) Additional fuel if trip + contingency + alternate + final reserve fuel is insufficient to:

i) allow the aeroplane to descend as necessary and proceed to an alternate aerodrome in the event of engine failure or loss of pressurization, whichever requires the greater amount of fuel based on the assumption that such a failure occurs at the most critical point along the route, fly for 15 minutes at holding speed at 450 m (1 500 ft) above aerodrome elevation in standard conditions and make an approach and landing;

ii) allow an aeroplane engaged in EDTO to comply with the EDTO critical fuel scenario as established by the State of the Operator;

4) Discretionary fuel:

5) Final reserve fuel.

Note.— Trip fuel calculations would include MEL/CDL fuel, as well as fuel for known ATC, meteorology, and other known delays.

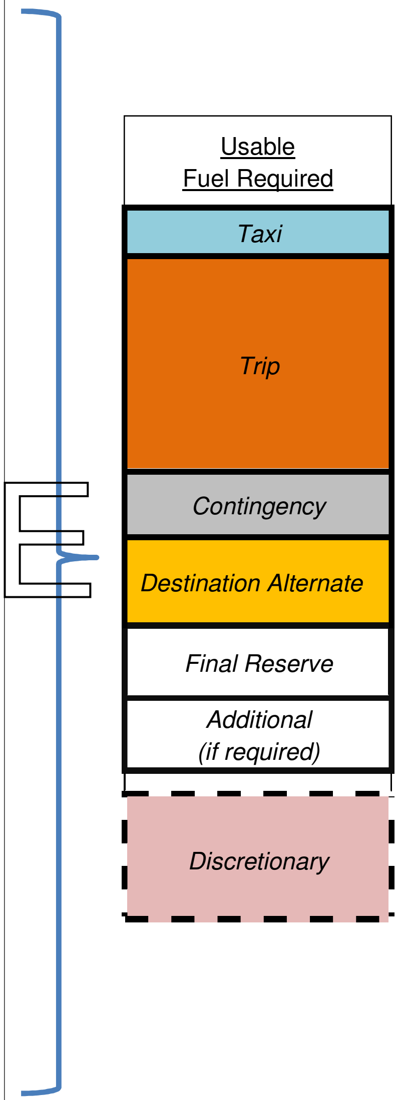


Figure 4-7. Example EDTO fuel policy

4.28 THE USE OF FUEL AFTER FLIGHT COMMENCEMENT

4.28.1 Annex 6, Part I, 4.3.6.7 states:

4.3.6 Fuel requirements

…

4.3.6.7 The use of fuel after flight commencement for purposes other than originally intended during pre-flight planning shall require a re-analysis and, if applicable, adjustment of the planned operation.

Note.— Guidance on procedures for in-flight fuel management including re-analysis, adjustment and/or re-planning considerations when a flight begins to consume contingency fuel before take-off is contained in the Flight Planning and Fuel Management Manual *(Doc 9976).*

4.28.2 The Annex 6, Part I, fuel planning Standards provide the framework for comprehensive, accurate and, where possible, predictive pre-flight fuel planning. Such planning forms the foundation of an operator's fuel policy but is only one component of the balanced approach necessary to foster the culture of "continuous fuel state awareness and proactive fuel management" described in detail in Chapter 6 of this manual.

4.28.3 Annex 6, Part I, 4.3.6.7, closes the loop on pre-flight planning by addressing the need to find an appropriate basis for the continuation of any operation that does not unfold as originally planned. It also reinforces the notion that there must be a methodology to reconcile differences in the actual versus the planned operation in order to ultimately ensure safe flight completion in accordance with 4.3.6.1 and 4.3.7.2.

4.28.4 It is important to acknowledge that there may be a point in any flight, after commencement, when the minimum fuel required to complete the planned flight safely is no longer on board the aircraft. This reinforces the notion that in order to safely complete an operation as planned, fuel should, to the greatest practical extent, be used as allocated during pre-flight planning. Alternatively, if after flight commencement, insufficient fuel remains at any point to operate a flight as planned, the plan must be revisited, analysed and adjusted, as necessary.

4.28.5 This is not to say that there will be a degradation in the safety performance of every flight that does not operate exactly as planned. It does, however, speak to the operational reality that the SARPs address a broad spectrum of potential operations, using aircraft with varying capabilities, operating in areas or on routes with varying levels of infrastructure. The net result is that while some flights may demonstrate rather generous safety margins when it comes to fuel planning, others may not. It is precisely this disparity that justifies the need for re-analysis and adjustment, when in the judgment of the PIC (or PIC and FOO in shared systems of operational control), the plan is invalidated.

4.28.6 To achieve this aim there should be a trigger rooted in the operator's fuel policy for a reconciliation of the planned versus the actual operation at critical points in the flight (e.g. before take-off or to continue beyond the point of in-flight re-planning). At its core, this process of reconciliation is part of the in-flight management activities as defined by Annex 6 and explained in Chapter 6 of this manual. These activities must be clearly defined as there will be implications if flight crews are confused about when to intervene as necessary to preclude taking a known and potentially consequential fuel shortage into the air or deeper into the flight.

4.28.7 While the overriding intent of 4.3.6.7 is to ensure there is always sufficient fuel on board an aircraft to continue a planned flight safely, it is important to note that the extent of any re-analysis and/or adjustment required be commensurate with the scope and complexity of the planned operation. Equally important is the notion that any foreseeable changes to the planned operation are typically accomplished in accordance with well-established in-flight re-planning policy and procedures. What may be overlooked are those unforeseen occurrences that cause the partial or complete depletion of contingency fuel and require the use of other fuels for purposes other than originally intended.

Note.— Refer to Chapter 6 of this manual for practical instructions regarding in-flight fuel management.

4.29 SUMMARY

4.29.1 The precise alternate aerodrome selection and fuel planning specifications contained in Annex 6, Part I, are intended for use in regulatory environments wherein the approach to safety is based primarily on strict regulatory compliance. They do not take into account the operational capabilities of operators, technological capabilities of aeroplanes or infrastructure, or other operational realities detailed in this manual. They do, however, provide a solid foundation for safe flight operations as well as support the future development of sound SRM practices. They also provide efficiencies and economic opportunities for States that have yet to develop robust fuel regulations and/or lack the requisite knowledge, expertise and resources to implement performance-based alternatives.

4.29.2 The prescriptive SARPs provide the opportunity for operators to achieve efficiencies commensurate with their operational experience and capabilities. Many operators can achieve incremental efficiencies by prescriptive compliance with regulation without investing in advanced technologies, sophisticated data collection systems or the other means necessary to support performance-based methods. Others, however, having made significant investments in new methods and technologies should be permitted to derive greater efficiencies from the inherent flexibility of performance-based compliance with regulation. In either case, a measured and incremental approach to the implementation of any new policy is required in order for operators to continually achieve equivalent levels of safety that are acceptable to the State.

Note 1.— Examples of national prescriptive flight planning regulations that conform to Annex 6, Part I, 4.3.6.1, can be found in Appendix 2 to this chapter.

Note 2.— Refer to Chapter 5 of this manual for guidance related to performance-based compliance with alternate aerodrome selection and fuel planning regulations.

— — — — — — — —

Appendix 1 to Chapter 4

EXAMPLE OF A UNITED STATES OPSPEC FOR THE APPLICATION OF PLANNING MINIMA

Note.— The following example of a United States OpSpec combines many of the elements used in contemporary planning minima tables and is provided for illustrative purposes only. It is also important to note that although not required to conform to Annex 6, Part I, 4.3.4.1.3, the FAA also prescribes the use of planning minima as the determinant for the nomination of a take-off alternate aerodrome. This is done for commonality with destination alternate aerodrome selection requirements and/or to ensure a greater likelihood that the take-off alternate will be at or above operating minima at the estimated time of use. It may also be done with the presumption that take-off alternates are located at or near the maximum distances prescribed in Annex 6, Part I, 4.3.4.1.2.

In cases where the take-off alternate aerodrome is relatively close to the departure aerodrome the use of planning minima as the determinant for the selection of a take-off alternate may not be deemed necessary by a State's Authority. In these cases the margin prescribed in Annex 6, Part I, 4.3.5.3, should be deemed sufficient to ensure the take-off alternate aerodrome will be at or above operating minima at the estimated time of use.

"OpSpec Paragraph C055, Alternate Airport IFR Weather Minimums: 14 CFR Part 121)

a. The certificate holder is authorized to derive alternate airport weather minimums from Table 1 below.

b. Special limitations and provisions.

(1) In no case shall the certificate holder use an alternate airport weather minimum other than any applicable minimum derived from this table.

(2) In determining alternate airport weather minimums, the certificate holder shall not use any published IAP which specifies that alternate airport weather minimums are not authorized.

Note.— Paragraphs (3) and (4) are selectables.

(3) Credit for alternate minima based on CAT II or CAT III capability is predicated on authorization for engine inoperative CAT III operations for the certificate holder, aircraft type, and qualification of flightcrew for the respective CAT II or CAT III minima applicable to the alternate airport.

(4) Alternate Airport GPS wide area augmentation system (WAAS) Usage. The certificate holder may plan to use any instrument approach authorized for use with GPS WAAS avionics at a required alternate if the aircraft is equipped with such equipment certified in accordance with Technical Standard Order (TSO) C145a/C146a (or later revision that meets or exceeds the accuracy of this TSO revision as approved by the Administrator). This flight planning, however, must be based on flying the RNAV (GPS) (or RNAV (GNSS) for foreign approaches) LNAV minima line, or the minima on a GPS approach procedure or conventional approach procedure with "… or GPS" in the title. Additionally, RNAV (GPS) (or RNAV (GNSS)) are based on a single navigational facility when determining the approach facility configuration in Table 1 below. Upon arrival at an alternate, if the GPS WAAS

navigation system indicates that LNAV/VNAV or LPV service is available, vertical guidance may be used to complete the approach using the displayed level of service.

Note.— The final two rows of Table 1 are selectables.

Table 1. Alternate Airport IFR Weather Minimums

Approach Facility Configuration[1]	*Ceiling*[2]	*Visibility*[3]
For airports with at least one operational navigational facility providing a straight-in non-precision approach procedure, or Category I precision approach, or, when applicable, a circling maneuver from an IAP.	Add 400 ft to MDA(H) or DA(H), as applicable.	Add 1 statute mile or 1 600 m to the landing minimum.
For airports with at least two operational navigational facilities, each providing a straight-in approach procedure to different suitable runways.	Add 200 ft to higher DA(H) or MDA(H) of the two approaches used.	Add ½ sm or 800 m[1] to the higher authorized landing minimum of the two approaches used.
One usable authorized Category II ILS IAP.	300 feet	¾ statute mile (1200 m) or RVR 4000 feet (1200 m).
One usable authorized Category III ILS IAP.	200 feet	½ statute mile (800 m) or RVR 1800 feet (550 m).

1. When determining the suitability of a runway, wind including gust must be forecast to be within operating limits, including reduced visibility limits, and should be within the manufacturer's maximum demonstrated crosswind.

2. All conditional forecast elements below the lowest applicable operating minima must be taken into account. Additives are applied only to the height value (H) to determine the required ceiling.

3. When dispatching under the provisions of the MEL, those MEL limitations affecting instrument approach minima must be considered in determining alternate minima."

— — — — — — — —

Appendix 2 to Chapter 4

EXAMPLES OF PRESCRIPTIVE FLIGHT PLANNING PROCESSES THAT CONFORM TO ANNEX 6, PART I, 4.3.6.1

1. INTRODUCTION

The proper definition of the flight planning methods used by an operator is a fundamental operational activity. If designed and implemented properly, flight planning systems, policies, processes and procedures represent a basic systemic defense against the hazards encountered in flight operations. In compliance-based regulatory environments, the State's Authority prescribes the fuel requirements for the operator to use in planning. This approach to compliance is explained in detail in Chapter 4, and regulators have been using it since the end of the Second World War.

This appendix describes the reduced contingency fuel (RCF) and (B044) Re-dispatch/Re-release planning methods which are representative of the national fuel regulation models described in Chapter 3 of this manual. These methods and associated regulations were independently developed in Europe and the United States and address the minimum fuel requirements of Annex 6, Part I, 4.3.6, to ensure an aeroplane carries sufficient fuel, including contingency and final reserve fuel, to complete a planned flight safely.

These planning methods also address some of the most basic operational realities faced by operators and considered by States during the development of national regulations. The limitations of such methods, however, also highlight a need for additional flexibility in flight planning that may prompt States to grant variations based on an operator's desired efficiency gains and/or operational necessities. As such, they can also provide the operational context and basis for the variations typically implemented in conjunction with the performance-based planning methods described in Chapter 5 of this manual.

The following descriptions of RCF and (B044) Re-Dispatch/Re-Release planning methods are provided for guidance purposes only as exact specifications may vary and should be developed by States and operators in conformance with the requirements of the applicable Authority. Additionally, the following examples do not encompass every potential planning method that may be approved by a State's Authority or implemented by an operator. When considered in the context of the applicable Annex 6, Part I, SARPs, however, these methods should provide a solid foundation for an acceptable fuel policy.

2. REDUCED CONTINGENCY FUEL (RCF) PLANNING

RCF is a means of conformance with Annex 6, Part I, Standard 4.3.6.1, which requires an operator to establish a process for the purpose of in-flight re-planning to ensure an aeroplane carries sufficient fuel (Figure 4-A2-1). RCF takes advantage of in-flight re-planning and is based on the qualitative and quantitative assumption that the contingency fuel allotted to the first part of the flight from departure to a decision point will not be used.

RCF is a combination of two standard OFPs. The term "standard OFP" refers to a flight plan in conformance with all fuel prescriptive planning requirements in Annex 6, Part I. Until reaching the decision point, the flight uses a standard OFP (No. 1). After the decision point it continues with standard flight plan No. 1 to the Destination 1 aerodrome (the optional refuel destination) or, if remaining fuel on board is sufficient, it re-plans using another standard OFP (No. 2) to Destination 2 aerodrome (the intended commercial destination).

The longer the flight is and the closer the decision point is to the commercial intended destination (Destination 2), the more contingency fuel can be reduced (if re-planning to Destination 2 remains possible). The following required fuel calculation example illustrates how total fuel is derived to conform to the minimum fuel requirements of Annex 6, Part I, 4.3.6.

If an operator's fuel policy includes pre-flight planning to a Destination 2 aerodrome (commercial destination) with an RCF procedure using a decision point along the route and a Destination 1 aerodrome (optional refuel destination), the amount of usable fuel on board for departure should be the greater of 1 or 2:

1. sum of:

a) taxi fuel;
b) trip fuel to the Destination 2 aerodrome (including fuel for foreseen contingencies), via the decision point;
c) contingency fuel equal to not less than 5 per cent of the estimated fuel consumption from the decision point to the Destination 2 aerodrome, including any foreseen factors;
d) alternate fuel if required for Destination 2 in accordance with Annex 6, Part I, 4.3.6.3 d);
e) final reserve fuel;
f) additional fuel, if required; and
g) discretionary fuel if required by the PIC.

or

2. sum of:

a) taxi fuel;
b) trip fuel to the Destination 1 aerodrome (including fuel for foreseen contingencies), via the decision point;
c) contingency fuel equal to not less than the amount calculated in accordance with Annex 6, Part I, 4.3.6.3 c) from departure aerodrome to the Destination 1 aerodrome;
d) alternate fuel, if required for Destination 1 in accordance with Annex 6, Part I, 4.3.6.3 d);
e) final reserve fuel;
f) additional fuel, if required; and
g) discretionary fuel if required by the PIC.

3. RE-DISPATCH OR RE-RELEASE EN-ROUTE (B044) PLANNING

(B044) Re-dispatch planning is a means of conformance with Annex 6, Part I, 4.3.6, which requires an operator to establish a process for the purpose of in-flight re-planning to ensure an aeroplane carries sufficient fuel. Like RCF, (B044) Re-dispatch takes advantage of in-flight re-planning and is based on a qualitative and quantitative determination that more conservative or prescriptive planning methods result in the carriage of excess fuel on long-haul flights. Such determinations are based on continual monitoring of fuel at destination for all flights to ensure, to the extent reasonably practicable, that future flights carry sufficient fuel, including contingency fuel and final reserve fuel, to complete the planned flight safely.

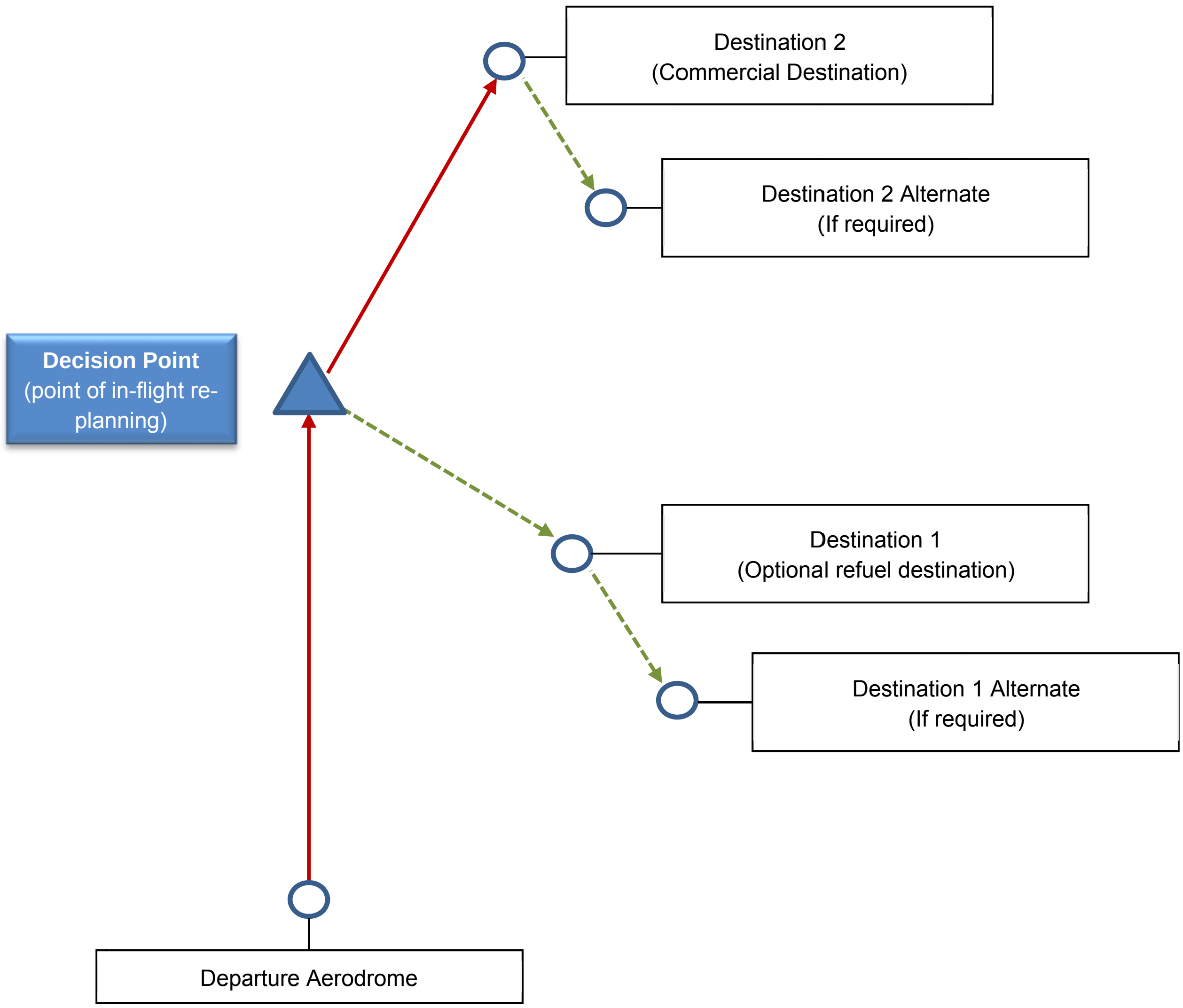


Figure 4-A2-1. Reduced contingency fuel (RCF) planning

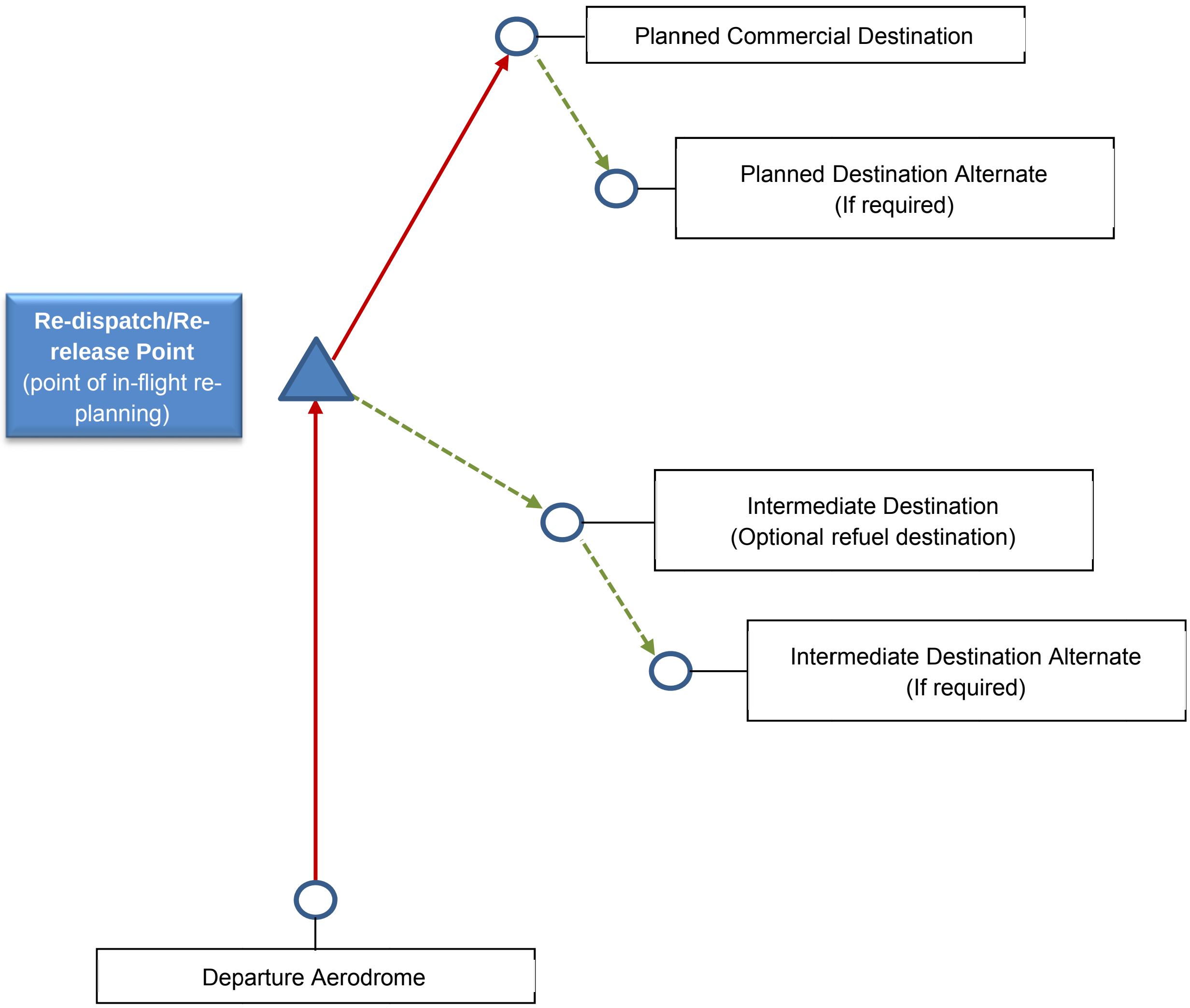


Figure 4-A2-2. Re-dispatch or re-release en-route (B044) planning

The re-dispatch flight profile is very similar to RCF with some differences in terminology (Figure 4-A2-2). Under re-dispatch the flight crew plans to fly to the re-dispatch point (RDP) under part 1 of a two-part flight plan. The RDP is the point where the decision is made to continue to the planned commercial destination or an intermediate aerodrome based on a determination of sufficient fuel remaining to complete the flight safely. The flight may proceed beyond the RDP to the planned destination provided all requirements applicable to original dispatch or flight release, including meteorology, terminal and en-route facilities, and fuel supply requirements are met at the time of re-dispatch or re-release.

The following required fuel calculation example illustrates how total fuel is derived to conform to the minimum fuel requirements of Annex 6, Part I, 4.3.6. If an operator's fuel policy includes pre-flight planning to a planned destination aerodrome with a re-dispatch procedure using an RDP and an intermediate aerodrome (optional refuel destination), the amount of usable fuel on board for departure should be the greater of 1 or 2:

1. sum of:

a) taxi fuel;
b) trip fuel to the planned destination (including fuel for foreseen contingencies);
c) contingency fuel to fly for a period of 10 per cent of the total time required to fly from the RDP to the planned destination including any foreseen factors;
d) alternate fuel, if required for the planned destination;
e) final reserve fuel;
f) additional fuel; and
g) discretionary fuel if required by the PIC.

or

2. sum of:

a) taxi fuel;
b) trip fuel to the intermediate aerodrome (including fuel for foreseen contingencies);
c) contingency fuel based on 10 per cent of the en-route flight time, including any foreseen factors, to the intermediate aerodrome to which the flight is initially released;
d) alternate fuel, if required for the intermediate aerodrome;
e) final reserve fuel;
f) additional fuel, if required; and
g) discretionary fuel if required by the PIC.

The fuel savings realized under re-dispatch are the difference between the planned re-dispatch contingency fuel and the contingency fuel for the total planned flight time from the departure aerodrome to the planned destination aerodrome required under a standard flight plan.

4. CRITERIA REQUIREMENTS FOR ALL IN-FLIGHT RE-PLANNING METHODS

An operator using RCF or (B044) Re-dispatch planning could comply with Annex 6, Part I, 4.3.6.1and 4.3.6.3 c) using in-flight re-planning methods and associated methodologies for determining contingency fuel without the need for the performance-based variations described in Chapter 5 of this manual subject to the following additional criteria:

- ***Contingency fuel*** is calculated in accordance with, is equivalent to, or exceeds the fuel required in 4.3.6.3 c).

- ***Fuel consumption monitoring.*** The operator should employ an FCM programme to monitor the actual fuel consumption rates of the specific aeroplane utilizing in-flight re-planning.

- ***In-flight fuel management policy in accordance with Annex 6, Part I, 4.3.7***. An operator should implement an in-flight fuel policy that will support the practical management of in-flight re-planning procedures. The policy should give the flight crew clear instructions, depending on the remaining fuel on board, to divert to an intermediate destination (Destination 2) and refuel or to continue to the planned commercial destination. Additionally, any such policy should give the flight crew specific instructions regarding the best course of action when contingency fuel is completely consumed before reaching the planned commercial destination.

5. ADDITIONAL CRITERIA REQUIREMENTS FOR (B044) RE-DISPATCH PLANNING

A flight should be re-planned using re-dispatch subject to the presence of the following criteria in addition to those prescribed in 4:

- Separate operational analyses (which include alternate aerodromes, the fuel required, the routes to be flown, and the estimated times en route) are prepared for the route of flight from the departure aerodrome to the destination aerodrome specified in the original dispatch or flight release, and for the route(s) of flight from the departure aerodrome to the destination aerodrome(s) specified in the planned re-dispatch.

- The operational analyses specified above are provided to both the PIC, flight operations officer and/or flight follower, as applicable.

- Any planned re-dispatch or re-release point is specified in the original dispatch or flight release and in the required operational analyses.

- Any re-dispatch or re-release point should be a position common to the routes specified by the operational analyses.

- When designating destination and alternate aerodromes in the planned re-dispatch or re-release, the flight operations officer or flight follower, as applicable, will provide to the PIC all available current reports or information on aerodrome conditions and irregularities of navigation facilities that may affect the safety of the flight.

- Before beginning a flight, the flight operations officer or flight follower, as applicable, will provide the PIC with all available meteorological reports and forecasts of meteorological phenomena that may affect the safety of flight, including adverse meteorological phenomena, such as clear air turbulence, thunderstorms, and low altitude wind shear, for each route to be flown and each aerodrome to be used.

- In operations that do not utilize a flight operations officer, before beginning a flight, each PIC will obtain all available current reports or information on aerodrome conditions and irregularities of navigation facilities that may affect the safety of the flight.

- Within two hours of the flight's arrival at any designated re-dispatch or re-release point, and prior to executing the re-dispatch or re-release, the PIC is provided with the additional information concerning meteorological conditions, ground facilities, and services at the destination and alternate aerodromes specified in the re-dispatch or re-release. If the route of flight to be used to the new destination aerodrome is different from the planned route, the new route of flight should be specified.

- Upon reaching any re-dispatch or re-release point specified in a dispatch or release, the certificate holder should operate the flight as dispatched or released unless the PIC receives and explicitly accepts the re-dispatch or re-release to the new destination aerodrome. The operator should not authorize the flight to proceed to a new destination aerodrome unless the PIC of that flight forwards a message to the company through an aeronautical communications service specifically stating concurrence with the re-dispatch or re-release.

6. PROCESS AND CONTROLS

Operators who wish to conform to Annex 6, Part I, 4.3.6.1 and 4.3.6.3 c) should demonstrate the following processes and controls:

- ***Actions at the Re-dispatch/Re-release/Re-planning Point****.* Process to ensure that when approaching the decision point or re-dispatch point, meteorology at the planned commercial destination and associated alternate, if required, is assessed. In-flight re-planning to the planned commercial destination is permitted only if the conditions of Annex 6, Part I, 4.3.5.3, or those accepted by the applicable CAAs are fulfilled.

7. DEMONSTRABLE ABILITY TO REPORT, MEASURE AND ANALYSE ESSENTIAL DATA

Operators that cannot conform with Annex 6, Part I, 4.3.6.1 and 4.3.6.3 c) using in-flight re-planning methods without associated performance-based methodologies for determining contingency fuel should demonstrate the ability to report, measure and analyse the essential data for the identification, analysis and mitigation of potential safety risks that could affect the outcome of flights in accordance with Chapter 5 of this manual.

Chapter 5

PERFORMANCE-BASED COMPLIANCE

5.1 INTRODUCTION

5.1.1 This chapter supports the Annex 6, Part I, 4.3.4.4 and 4.3.6.6 SARPs with operationally specific guidance material. The guidance provides assistance to States, CAAs and operators in their self-examination to determine if they are prepared to supplement prescriptive-compliance to regulation with a performance-based component. This process of examination is the first of many steps in the transition from a purely compliance-based approach to an approach that includes the performance-based components necessary to support proactive and continuous safety risk management. This chapter also outlines core criteria for “capable operators” that address the organizational, operational, SRM and oversight components necessary to implement and support performance-based regulations. These attributes, among others, represent prerequisites for performance-based compliance that should be in place and evaluated by CAAs prior to the approval of any operational variation.

5.1.2 Chapter 5 is supported by appendices that contain additional details related to the implementation or approval of specific operational variations. Appendices 1, 2, 4, 5 and 6 to Chapter 5, in particular, contain additional criteria requirements, controls and mitigation measures related to operational variations in take-off alternate aerodrome selection, destination alternate aerodrome selection and contingency fuel calculations. Appendix 3 to Chapter 5 contains additional operational context in the form of the flight planning methods that are dependent on the advanced use of alternate aerodromes. Such methods may require authorities to consider operational variations from the prescriptive criteria. Finally, Appendix 7 to Chapter 5 contains a performance-based planning job-aid designed for use by an approving Authority.

5.2 UNDERSTANDING PERFORMANCE-BASED COMPLIANCE

5.2.1 ICAO’s *Safety Management Manual (SMM)* (Doc 9859), comprehensively describes a safety paradigm wherein States and operators, using a performance-based approach to safety, can proactively manage the safety risks that are the by-product of flight operations. Such States and operators, rather than relying solely on prescriptive compliance with regulations, continuously monitor and manage the real-time performance of the many operational systems or processes that influence overall levels of organizational and operational (tactical) safety risk. Annex 6, Part I, also acknowledges this evolution by recognizing that operational variations from the prescriptive SARPs on alternate aerodrome selection and fuel planning may be approved by an Authority based on an individual operator’s demonstrable capability to monitor, measure and maintain levels of safety performance related to specified alert and targets levels.

5.2.2 Nowhere is this paradigm more evident than within the management systems of many commercial air carriers that have decades of operational experience. Their internal systems and process management methods have evolved over time and out of operational necessity. Methods related to Quality Assurance (QA), International Standards (ISO), Quality Management Systems (QMS), Safety Risk Management (SRM), and most recently, Safety Management Systems (SMS) are now incorporated into what are typically very sophisticated, functional and effective corporate systems.

5.2.3 Operational SMS and the SRM process, in particular, are such that they are now imbedded in many existing organizational systems and subsystems. This in turn required the formal SMS attributes of responsibility, authority, process, procedures, controls, process measures, and interfaces to be identified in existing operator systems. Other organizational components, elements and processes were also identified for the purpose of analysis and continuous improvement. Finally, existing system design and performance was examined and adjusted to place emphasis on the real-time management of safety risks. This organizational evolution is representative of the progression necessary to support the performance-based approach to regulatory compliance that underlies the development and implementation of operational variations.

5.2.4 One of the prerequisites to implementing performance-based regulation is to define the performance measurement criteria to be developed in consultation with both the regulator and an operator. Practically speaking, this means regulators and operators work together to identify clearly the safety indicators that will track the performance of a particular process. One example of an appropriate safety indicator could be the number of occurrences of reserve fuel planning miscalculation. Recording this occurrence rate would then be used to measure nonconformance or deviations from prescribed requirements. These data are collected regularly so as to record the occurrences over a given period of time. It is important to note that occurrences should be tracked on an occurrence rate trend monitoring basis rather than absolute numbers.

5.2.5 Once substantial data are collected, the baseline safety performance for that particular indicator can be established and set as a reference for future performance. Understanding this concept is critical in order to evaluate whether or not an "equivalent" or "improved" level of safety performance is achieved in operations. It is also important to note that the reference level or baseline performance is continually updated based on past data for the indicator being considered.

5.2.6 The next step involves setting "alert" and "target" levels of safety performance as benchmarks relative to the baseline performance for a given indicator. An alert level is the line of demarcation between an unacceptable and an acceptable occurrence rate. In other words, it is the breach level for the safety indicator defined.

5.2.7 As an example, an alert could be triggered if the reserve fuel planning miscalculation rate exceeds three consecutive rate points above the [Mean + 1 SD] alert line on the Safety Performance Indicator (SPI) trend chart (Doc 9859, Appendix 6 to Chapter 4, Table 4-A4-5 "Alert level trigger"). The target level, in contrast, serves as the desired level of improvement for that indicator. The operator would then aim to achieve this improved target level, for example, by reducing the mean occurrence rate (at the end of a new monitoring period) by a certain percentage (e.g. 10 per cent) below the recent or original baseline mean rate (Doc 9859, Appendix 6 to Chapter 4, Table 4-A4-5, "Target Achievement").

5.2.8 For certain non-data-based monitoring SPIs, it is possible that alert and target levels may be qualitative in nature. This is provided that such SPIs are indeed relevant for such a specific FPFM process performance monitoring and measurement purpose in the first place. It is important to remember, however, that the SPIs and alert/target levels need to be acceptable to the Authority and are typically defined by each operator within the context of its operational expectations and safety performance history.

5.2.9 With all the performance tracking parameters set, the operator can measure and monitor, over a given period of time, the performance results of each defined safety indicator. It is important to note that the baseline performance may change during the period of performance being measured. Practically speaking, this means that if safety performance of an SPI was maintained or improved, post implementation of a performance-based component, then the set performance criteria are successful. Where, however, there is a degradation of performance, post implementation (alert level triggered), remedial action would need to be taken in order to recalibrate either the performance criteria or verify causal factors within the process itself. This would also imply investigating the corresponding data that caused the alert level, identifying hazards and setting into motion the risk mitigation process.

5.2.10 For further details on how to calculate standard deviation, deriving baseline performances and setting alert/ target levels, refer to Doc 9859, Appendices 4 and 6 to Chapter 4.

Equivalent Level of Safety

5.2.11 The basis upon which Annex 6, Part I, allows the State of the Operator to approve operational variations using performance-based methods is contingent upon the operator meeting an “equivalent level of safety” to the prescriptive approach. Practically speaking, this means any operational variation described in this manual is contingent on the assumption that the safety performance of an applicable operational activity will not be degraded by the use of performance-based methods or the introduction of performance-based elements. In other words, the outcomes (expressed in terms of safety performance using safety indicators) of an operational activity achieved after the introduction of a performance-based component should be “equivalent to” or exceed the outcomes achieved using a purely prescriptive approach.

5.2.12 To determine if such equivalence has indeed been achieved, the safety performance of operational activities before and after the application of an operational variation should be carefully compared. For example, the average incident rate of alternate aerodrome selection and fuel planning failures or non-conformities, as defined by the State and the operator, should not increase after the introduction of performance-based components. This comparison assures that post-implementation performance meets or exceeds the baseline performance achieved using the purely prescriptive approach to compliance with regulation.

5.2.13 Conversely, where such comparisons indicate that safety performance has degraded, the operator should work with the Authority to determine root causes and take whatever actions are necessary to restore safety performance relative to specified targets. Such actions may include modification of one or more performance-based components or, where necessary, a return to prescriptive compliance. Details of how appropriate safety indicators can be defined and safety performance can be measured are addressed further in 5.5 of this chapter.

5.2.14 This performance-based approach is results-oriented and is designed to ensure a high probability of specific (desirable) outcomes. These outcomes, proactively managed and achieved by the operator, are then compared to standards of performance as defined by the State and the operator. As these positive performance measurement outcomes (i.e. consecutively no target levels have been breached and desired target improvements are regularly met) are data driven, they form a sound basis upon which an operator can justify the subsequent adjustments to prescriptive requirements.

The role of prescriptive regulations in a performance driven environment

5.2.15 In the early days of safety management, aviation was loosely regulated and characterized by underdeveloped technology, lack of appropriate infrastructure, limited oversight and an insufficient understanding of inherent hazards. As aviation matured, however, technological improvements and the proliferation of infrastructure quickly outpaced the ability of prescriptive regulations to cope effectively with such advances. This led to a growing realization within the aviation community that prescriptive regulations may not address every conceivable operational scenario in a system as open and dynamic as aviation.

5.2.16 This realization coupled with the ever-increasing complexity of airline operations is driving CAAs and operators to complement conventional (compliance-based) regulatory approaches to safety with a contemporary (performance-based) component. As previously mentioned, this contemporary approach to regulatory compliance seeks to achieve a realistic implementation of operational practices through process control and continual SRM. It does not minimize the need, however, for compliance-based components that ensure adherence to minimum standards and the development of the sound safety practices that remain fundamental to modern SRM.

5.2.17 While prescriptive regulations continue to offer advantages to States and operators alike, they do not typically take into account the capabilities of a particular operator, modern flight planning methods, new technologies, available infrastructure and the many other factors that influence operational efficiency and safety. Fundamentally, however, prescriptive regulations related to alternate aerodrome selection or fuel planning will continue to form the baseline against which their performance-based counterparts are measured.

State Safety Programmes (SSP) and Safety Management Systems (SMS)

5.2.18 It is important to note that SSP and SMS can provide the framework for the implementation of performance-based methods that support operational variations from some Standards and Recommended Practices. Additionally, the implementation of performance-based methods and the resultant levels of safety performance achieved or desired should not conflict with the overall safety management objectives of an SSP and SMS, if present.

5.2.19 SSP and SMS are the systemic means used to manage safety within States and organizations. A State's safety oversight function becomes part of an SSP and is a fundamental safety assurance component. In the absence of an SSP, the objectives of the State's safety oversight function are typically satisfied through administrative controls (inspections, audits and surveys) regularly carried out by CAAs and may not necessarily constitute safety risk controls. An SSP, however, is typically necessary to turn the outcomes of safety oversight into safety risk controls.

5.2.20 For example, a State's safety oversight function may at present verify that a State has a system of regulations, but neither requires a safety risk analysis to produce such regulations nor monitors the effectiveness of regulations as safety risk controls. The SSP, on the other hand, would consider regulations as safety risk controls and require, through its SRM component, that the process of rulemaking be done using principles of SRM. This is accomplished by identifying hazards, assessing the safety risks and developing regulations that provide acceptable mitigation and control of the hazards.

5.2.21 An SMS, on the other hand, can be likened to a toolbox that contains the tools an operator needs in order to control the safety risks it faces during operations. It is important to acknowledge that an SMS is simply a toolbox in which the actual tools employed to conduct the two basic SRM processes (hazard identification and risk management) are contained and protected. Additionally, an SMS ensures a toolbox that is appropriate in size and complexity for the operator.

5.2.22 The relationship between the SSP and the SMS can be expressed as follows: States are responsible for developing and establishing an SSP, and operators are responsible for developing and establishing an SMS. States are responsible, as part of the activities of their SSP, to accept and oversee the development, implementation and operational performance of the operator's SMS.

5.2.23 This interrelationship between the oversight activities of a State and the SRM activities of an operator may begin at a tactical level and prior to the full deployment of an SSP and SMS. For example, the deployment of performance-based variations to prescriptive regulations may be contingent on assurances that mitigation strategies associated with the safety risks, which are the result of a specific operational activity, achieve target levels of safety performance. These assurances can be achieved typically through complementary State and operator monitoring processes that are the precursors to SSP and SMS.

The challenges of performance-based compliance

5.2.24 Performance-based regulatory approaches and performance-based compliance to regulations pose a different set of challenges to Authorities and operators. An Authority using a performance-based approach, for example, cannot simply monitor operator compliance with prescribed requirements but must identify acceptable performance outcomes and validate the means by which such outcomes are achieved. Conversely, an operator using performance-based compliance cannot simply adhere to prescribed limitations in order to ensure the safe execution of an operational activity.

5.2.25 This shift in the approach for managing safety requires the application of very specific knowledge, skills and resources to ensure operational outcomes continue to meet or exceed those that would result from a purely prescriptive approach. More importantly, from the regulator's perspective, it requires thorough monitoring, interaction and negotiation with each operator to ensure a continuous and complete assessment of its performance-based processes.

5.2.26 In compliance-based regulatory environments, authorities can rely solely on prescriptive operator compliance with regulations that focus on “what” must be accomplished as well as “how” it is to be accomplished. The rationale is that as long as prescribed limits are not exceeded, an operational activity can be considered safe. On the other hand, in a performance-based regulatory environment, authorities can focus on “what” must be accomplished while allowing for some operational flexibility as to “how” it is to be accomplished. Regardless of the method of an operator’s compliance, the outcomes of its compliance should be substantially similar and demonstrate equivalent or enhanced levels of safety performance. Figure 5-1 illustrates the evolution of regulatory compliance.

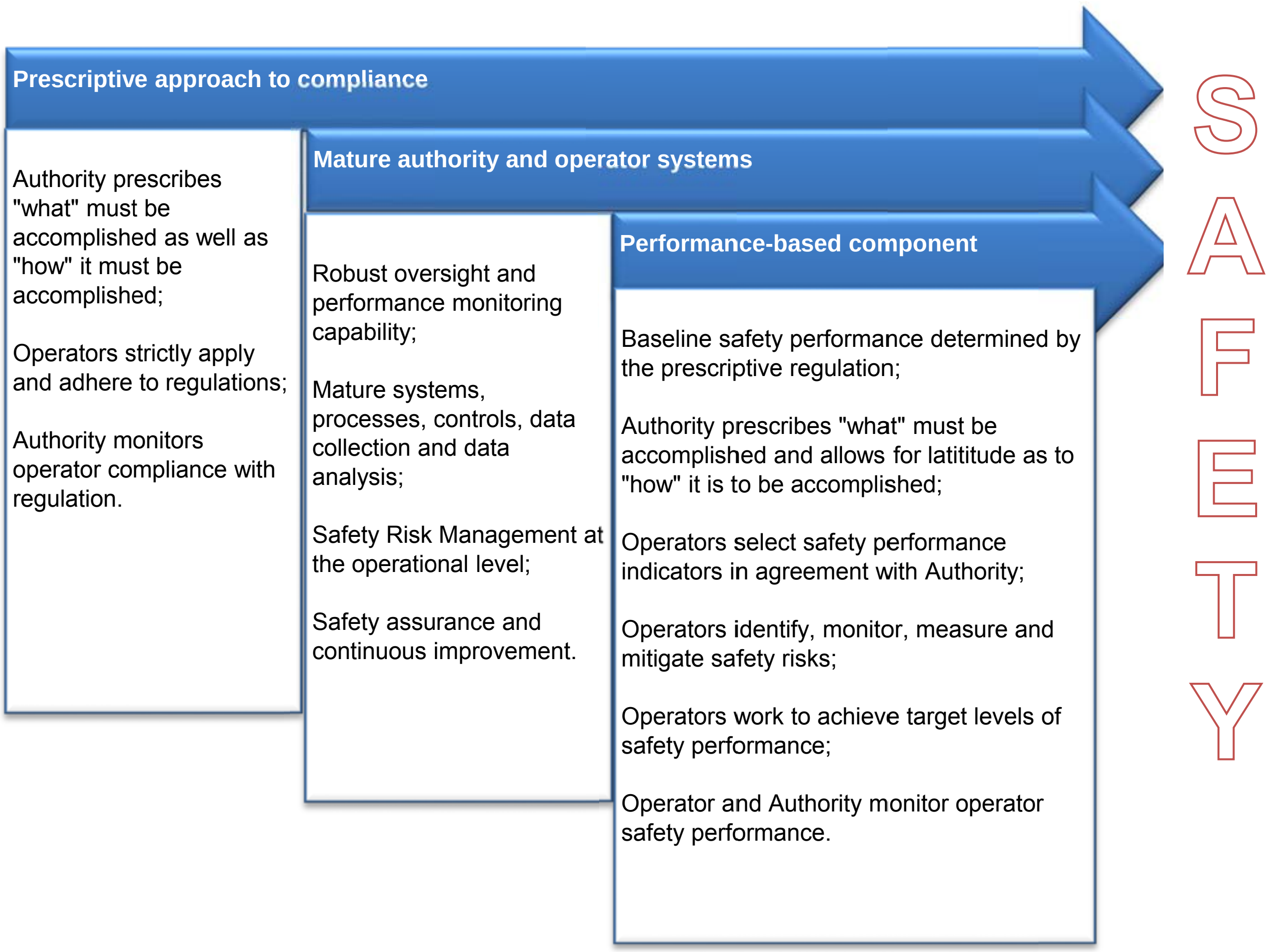


Figure 5-1. The evolution of regulatory compliance

5.2.27 For example, the end result or outcome of a regulation related to the nomination of an alternate aerodrome is to assure, to the extent reasonably practicable, that an appropriate runway will be available to an aeroplane when needed. It is this outcome that must be achieved using either the prescriptive or performance-based approach to regulation. Performance-based compliance, however, additionally aims to continually reduce safety risks and achieve continuous improvement in the safety performance related to this activity. In other words, it provides a process-based framework designed to continuously drive safety risks to lower levels. Such reductions are made possible by operator processes that employ multilayered defensive strategies to manage safety risks proactively and continuously. Such processes are typically data-driven, ongoing and adaptable. They systemically identify hazards and trigger the development, implementation, evaluation and monitoring of safety risk controls and/or mitigation measures.

5.2.28 One of the most difficult issues facing a State wishing to implement performance-based regulations or approving performance-based compliance with existing regulations is the practical definition of safety indicators and setting associated alert and target levels of safety performance in flight operations. When setting safety indicators, operators should consider, for example, which aspects are useful based on the nature of the risks in their activity together with the nature of their operations.

5.2.29 The safety indicators need to be representative in that they objectively reflect the strengths and weaknesses of the operational activity concerned. Secondly, they need to be very specific to the activity that they are going to measure in order to show the progress or trend. The indicators also need to represent objective data-based performance criteria.

5.2.30 This is also the case when setting alert and target levels. If the operator does not set realistic alert levels, the performance outcomes would not accurately reflect the risks or hazards within the process. Similarly, if the set target levels do not correspond to realistic goals, then the outcomes would not show any improvement in process performance.

5.2.31 Under the performance-based approach, any specific operational variations from prescriptive regulations will allow for greater flexibility so long as the safety performance is not degraded. These specific operational variations are based on the results of a safety risk assessment completed in accordance with Annex 6, Part I, 4.3.4.4 or 4.3.6.6, as applicable. Each determination that an operator will be able to reach a target level, or not exceed alert levels, of safety performance necessary to ensure safety, is dependent on numerous operational factors. Such factors should be carefully considered by the Authority and each individual operator within a context that considers the availability of resources to address any deficiencies in safety performance.

5.2.32 Another challenge is managing the shift in safety oversight from a regulatory perspective. Since the safety performance of any operational variation is typically established separately between an applicable Authority and the operators it oversees, Authorities should work closely with operators to develop safety indicators and alerts and targets that address the specific hazards to be faced in operations. This interactive relationship then fosters the development of performance-based oversight methods that complement performance-based compliance which should be clearly understood by both the operator and the Authority in order for effective SRM to occur.

5.2.33 Achieving consensus on suitable safety indicators and alert and target levels agreeable to the State, the Authority and the operator can be a challenge. The working relationship necessary to achieve such agreement, however, is the hallmark of contemporary SRM. It also represents one of the many challenges to be overcome by CAAs and operators wishing to transition from a purely prescriptive and reactive regulatory culture to the proactive and predictive culture required to sustain performance-based approaches.

5.3 ANNEX 6, PART I, PROVISIONS FOR VARIATIONS IN ALTERNATE AERODROME SELECTION AND FUEL PLANNING

5.3.1 Operational variations in alternate aerodrome selection are applicable to:

a) take-off alternate aerodromes (4.3.4.1);

b) en-route alternate aerodromes (4.3.4.2); and

c) destination alternate aerodromes (4.3.4.3).

5.3.2 Annex 6, Part I, 4.3.4.4, states:

> 4.3.4.4 Notwithstanding the provisions in 4.3.4.1, 4.3.4.2, and 4.3.4.3; the State of the Operator may, based on the results of a specific safety risk assessment conducted by the operator which demonstrates how an equivalent level of safety will be maintained, approve operational variations to alternate aerodrome selection criteria. The specific safety risk assessment shall include at least the:
>
> a) capabilities of the operator;
>
> b) overall capability of the aeroplane and its systems;
>
> c) available aerodrome technologies, capabilities and infrastructure;
>
> d) quality and reliability of meteorological information;
>
> e) identified hazards and safety risks associated with each alternate aerodrome variation; and
>
> f) specific mitigation measures.
>
> *Note.— Guidance on performing a safety risk assessment and on determining variations, including examples of variations, are contained in the* Flight Planning and Fuel Management Manual *(Doc 9976) and the* Safety Management Manual (SMM) *(Doc 9859).*

5.3.3 The intent of this Standard is to provide the framework for performance-based compliance with Annex 6, Part I, 4.3.4.1, 4.3.4.2, and 4.3.4.3, which contain the prescriptive criteria for the selection of alternate aerodromes. The State of the Operator may, for certain circumstances, approve variations based on this Standard. Such approvals are possible as long as an equivalent level of safety can be maintained. This equivalence is based on a comparison of the outcome(s) to be achieved in operations using either the prescriptive regulation or a performance-based approach to compliance with the same regulations based on the additional criteria contained in Annex 6, Part I, SARPs.

5.3.4 In the case of alternate aerodrome SARPs, the outcome to be achieved in operations is a reasonable certainty that an aerodrome where a safe landing can be made will be available at the estimated time of use. As such, the result of either means of compliance is a substantially similar or greater certainty that such an aerodrome will be available when needed. Additionally, and in order to fully conform to Annex 6, Part I, 4.3.4.4, an operator’s safety case in support of an operational variation would at a minimum address the criteria of 4.3.4.4 a) through f) which are addressed in this manual and related appendices as outlined in Table 5-1.

Table 5-1.

Factors to be considered during safety risk assessment activities related to alternate aerodrome selection	*Doc 9976 References*
• 4.3.4.4 a) capabilities of the operator; • 4.3.4.4 b) overall capability of the aeroplane and its systems; • 4.3.4.4 c) available aerodrome technologies, capabilities and infrastructure; • 4.3.4.4 d) quality and reliability of meteorological information.	• Chapter 5 Section 5.3 — Details the prerequisites for performance–based compliance with regulations including operator, aeroplane, aerodrome and meteorological (reporting) capabilities.
• 4.3.4.4 e) identified hazards and safety risks associated with each alternate aerodrome variation; and • 4.3.4.4 f) specific mitigation measures.	• Chapter 5 Sections 5.4, 5.5 and 5.6 describe the operational Safety Risk Management processes and safety assurance by operator and by State; • Chapter 5 Appendices 1 and 2 outline additional operator capabilities, criteria requirements and mitigation measures related to specific operational variations from prescriptive alternate aerodrome selection criteria.
***** *Note.— Appendices 1 and 2 to Chapter 5 contain additional criteria requirements, controls and mitigation measures related to operational variations in take-off alternate aerodrome selection and destination alternate selection.*	

5.3.5 While it is beyond the scope of this manual to address every potential variation in alternate aerodrome selection, many examples of variations, within the scope of Annex 6, Part I, 4.3.5.3, are provided for illustrative purposes in the appendices to this chapter. The examples contained in the appendices should be used in conjunction with the balance of this chapter and other suitable references to form the basis for the development or validation of similar operational variations. In short, the specifications of Annex 6, Part I, 4.3.4.4 and Appendices 1 and 2 to this chapter recognize the potential for operational variations from prescriptive take-off, en-route and destination alternate aerodrome selection criteria that include but are not limited to:

a) take-off alternate aerodrome selection criteria based on the use of a fixed speed schedule rather than derived from the actual take-off mass of the aeroplane;

b) no-destination alternate operations to aerodromes without two separate runways or without a nominated instrument approach procedure;

c) no-destination alternate operations to destinations with forecast to below VMC;

d) no-destination alternate operations to destinations with CAT III or CAT II capability;

e) no-destination alternate operations associated with a State-approved OpSpec;

f) no-destination alternate operations for operators that use Decision Point (DP) planning;

g) single-destination alternate operations to aerodromes (when, for the destination aerodrome, meteorological conditions at the estimated time of use will be below the operator's established operating minima or no meteorological information is available); and

h) destination alternate operations associated with an applicable State-approved exemption.

5.3.6 Operational variations in fuel planning are applicable to:

a) taxi fuel (4.3.6.3 a));

b) trip fuel (4.3.6.3 b));

c) contingency fuel (4.3.6.3 c));

d) destination alternate fuel (4.3.6.3 d)); and

e) additional fuel (4.3.6.3 f)).

5.3.7 Annex 6, Part I, 4.3.6.6, states:

> 4.3.6.6 Notwithstanding the provisions in 4.3.6.3 a), b), c), d), and f); the State of the Operator may, based on the results of a specific safety risk assessment conducted by the operator which demonstrates how an equivalent level of safety will be maintained, approve variations to the pre-flight fuel calculation of taxi fuel, trip fuel, contingency fuel, destination alternate fuel, and additional fuel. The specific safety risk assessment shall include at least the:
>
> a) flight fuel calculations;
>
> b) capabilities of the operator to include:
>
> i) a data-driven method that includes a fuel consumption monitoring programme; and/or
>
> ii) the advanced use of alternate aerodromes; and
>
> c) specific mitigation measures.
>
> *Note.— Guidance for the specific safety risk assessment, fuel consumption monitoring programmes and the advanced use of alternate aerodromes is contained in the* Flight Planning and Fuel Management Manual *(Doc 9976).*

5.3.8 The intent of this Standard is to provide the framework for performance-based compliance with Annex 6, Part I, 4.3.6.3 a), b), c), d), and f), which contain the prescriptive criteria for the pre-flight fuel calculation of taxi fuel, trip fuel, contingency fuel, destination alternate fuel, and additional fuel as long as an equivalent level of safety can be maintained. The State of the Operator may, for certain circumstances, approve variations based on this Standard. As with alternate aerodrome selection, this equivalence is based on a comparison of the outcome(s) to be achieved in operations using either the prescriptive regulation or a performance-based approach to compliance with the same regulations based on the additional criteria contained in Annex 6, Part I, SARPs.

5.3.9 In the case of required fuel supply SARPs, the outcome to be achieved in operations is: a reasonable certainty that the pre-flight calculation of usable fuel required will provide sufficient fuel to complete the planned flight safely and allow for deviations from the planned operation. Thereby either means of compliance should result in a substantially similar or greater certainty that sufficient fuel will be uplifted for each planned flight. Additionally, and in order to fully conform to Annex 6, Part I, 4.3.6.6, the operator's safety case in support of an operational variation, would at a minimum address the criteria in 4.3.6.6 a) through c) which are addressed in this manual and related appendices as outlined in Table 5-2.

Table 5-2.

Factors to be considered during safety risk assessment activities related to fuel planning	*Doc 9976 References*
• 4.3.4.6.6 a) flight fuel calculations;	• Chapter 4, 4.16 through 4.27; • Appendix 2 to Chapter 4, as applicable; • Appendices 3 and 4 to Chapter 5, as applicable.*****
• 4.3.4.6.6 b) capabilities of the operator to include:	• Chapter 5, 5.4 — Details the prerequisites for implementing performance–based compliance by an operator that includes its organizational and operational capabilities.
i) a data-driven method that includes a fuel consumption monitoring programme; and/or	• Appendices 4 and 5 to Chapter 5, as applicable.*****
ii) the advanced use of alternate aerodromes; and	• Appendix 2 to Chapter 4, as applicable; • Appendices 3 and 4 to Chapter 5, as applicable.*****
• 4.3.4.6.6 c) specific mitigation measures.	• Chapter 5, 5.4, 5.5 and 5.6 describe the operational Safety Risk Management processes and safety assurance by operator and by State; • Appendices to Chapter 5***.**
***** *Note.— Appendix 2 to Chapter 4 contains examples of flight planning processes that conform to Annex 6, Part I, 4.3.6.1. Appendix 2 to Chapter 5 contains additional criteria requirements, controls and mitigation measures related to operational variations in take-off alternate aerodrome selection and destination alternate selection. Appendices 3 and 5 to Chapter 5 contain examples of flight planning processes that are dependent on the advanced use of alternate aerodromes and an FCM programme, respectively.*	

5.3.10 While it is beyond the scope of this manual to address every potential variation in fuel planning, many examples of variations and related programmes within the scope of Annex 6, Part I, 4.3.6.6, are provided in appendices to this chapter. The examples in the appendices should be used in conjunction with the balance of this chapter and other suitable references to support the development or validation of performance-based fuel planning. In short, the specifications of Annex 6, Part I, 4.3.6.6, recognize the potential for variations from prescriptive fuel planning criteria that include but are not limited to those related to the application and use of:

a) Decision Point (DP) planning;

b) Pre-determined Point (PDP) planning;

c) 3% En-route Alternate (ERA) contingency fuel planning;

d) Statistical Contingency Fuel (SCF) planning;

e) Special Fuel Reserves in International Operations Reserve (B043) fuel planning;

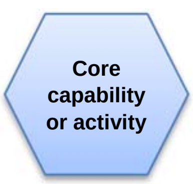
f) Flag and Supplemental Operations (B0343) reserve fuel.

5.4 CORE CRITERIA FOR CAPABLE OPERATORS

5.4.1 Annex 6, Part I, 4.3.4.4 and 4.3.6.6 both require the “capabilities of the operator” to be considered during safety risk assessment activities associated with operational variations. Practically speaking this means that operators must assess whether or not they possess the requisite knowledge, skills and resources to implement and oversee the systems and processes required to support performance-based compliance. To assist in these aims, the following criteria that typify capable operators are provided and should be considered within the context of a variation implementation by an operator and approval process by Authorities.

5.4.2 Figure 5-2 illustrates the philosophy that underlies how information is presented in the balance of this chapter and related appendices as well as the framework necessary to support the development and deployment of operational variations. It is important to note, however, that the information presented in this chapter should be considered only within the context of regulatory environments where the management of safety is based upon regulatory compliance complemented by a performance-based component that can assess the actual performance of an operator’s activities critical to safety against existing organizational controls. Only through assurance of effective implementation of such approaches can target levels of safety performance and the overall objective of continuous improvement of safety be achieved.

Figure 5-2. Chapter 5 core criteria for the development and implementation of operational variations



Note.— The hexagon symbol identifies the capabilities and activities required to support the development, implementation and monitoring of operational variations. When used in the appendices to this chapter, the symbol identifies additional capabilities or requirements associated with specific operational variations that should be considered within the overall context of the information provided in the body of the manual.

Operator's commitment and responsibility

5.4.3 Before any specific activities related to performance-based compliance can begin, an operator must be able to demonstrate that it exerts sufficient organizational control over internal systems and processes and the use of resources. This is important as contemporary performance-based compliance with regulation relies heavily on process management to control operational outcomes based on performance. As such, the ability of an operator to control the outcome of key organizational and operational processes becomes integral to the production of services as well as the effective management of the safety risks associated with those services. To achieve these aims management must:

Core Capability: Operator internal process management and control

a) clearly identify applicable procedures, policies and tasking;

b) establish procedures to perform activities and processes;

c) hire, train and supervise employees;

d) allocate appropriate resources; and

e) ensure staff adhere to the standard operating procedures (SOPs).

5.4.4 In particular the focus on process management and control also makes it possible for different systems to provide acceptable outcomes as any number of potential variations in process could provide the desired results. This attribute of performance-based systems also allows operators to consider their operating environment and factor in unique operating requirements as long as operational and safety performance alerts and target levels are respected. It also explains how significant differences in process can yield a similar and acceptable result.

5.4.5 The organizational processes and behaviour are, to a degree, an indication of the safety performance standards. Some of these organizational processes, as illustrated in Figure 5-3, are:

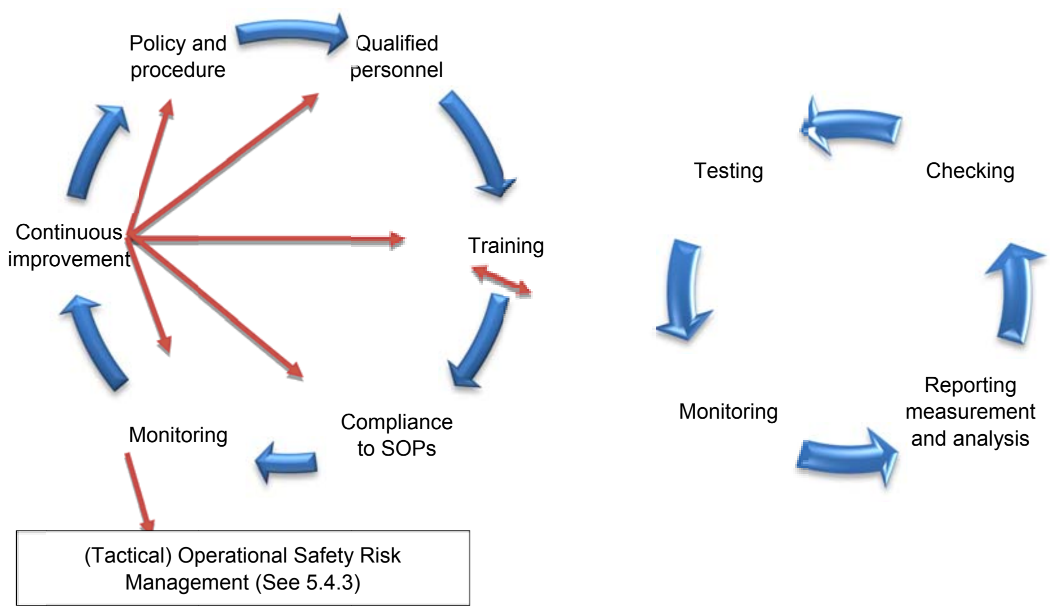


Figure 5-3. Organizational processes

Policy and procedures

5.4.6 The development of concise policy and procedure or direction from the operator that demonstrates compliance with the regulation of the State's Authority and for the purpose of controlling an operational activity.

5.4.7 The operator should define and document the many systems, processes, policies and procedures used in support of flight operations. Such documentation should also clearly identify each operational activity to which an operational variation may be applied as well as address the core criteria for the production of services including related performance-based subsystems or processes. Additionally, operator documentation should address the reporting, measurement and analysis of essential data to support each system or process. Applicable systems or processes include but are not limited to:

Core capability: FPFM policy and procedure

a) aerodrome selection processes including those used to manage the associated safety risks and to ensure a reasonable certainty exists that a suitable runway will be available at the take-off, destination and/or alternate aerodrome, as applicable;

b) flight planning and in-flight re-planning systems and/or processes including those used to manage the associated safety risks and to ensure an aeroplane carries sufficient fuel to complete a planned flight safely and allow for deviations from the planned route;

c) fuel computation processes used to determine the total fuel required to complete each planned flight safely including a performance-based process for the computation of reserve fuel including contingency fuel.

Qualified personnel

5.4.8 The staffing of positions with a sufficient number of appropriately qualified personnel empowered with the responsibility and authority to support the operational activity as well as foster continuous improvement.

Core capability: Qualified personnel

Training

5.4.9 Training to the operator's policy and procedure to ensure personnel are current, competent and qualified. Such training should apply, at a minimum, to flight crew and flight operations officers or other relevant operational control personnel, as applicable, and emphasize the specific requirements associated with each operational activity.

Core capability: Training

Compliance to Standard Operating Procedures (SOPs)

5.4.10 Ensuring that implementation of each operational activity is measurable and occurs in accordance with policy and procedure. Dependent systems should also be capable of supporting the operational activity (e.g. flight planning systems should be capable of supporting complex calculations as necessary to support flight planning methods).

Core capability: Compliance to SOPs

Monitoring

5.4.11 The operator should establish a process of monitoring the effectiveness and efficiency of both organizational and operational procedures. Through data collection and analysis processes that include the demonstrable reporting, measurement and analysis capabilities necessary to isolate and extract information for adjustment. Such processes should also:

Core capability: Monitoring operational data collection and analysis

a) use operationally relevant and meaningful performance and quality indicators;

b) isolate and extract the appropriate data for analysis;

c) be sufficiently sophisticated to collect the large volumes of operational data necessary to support quantitative decision making in alternate aerodrome selection, flight planning refinement/re-analysis, statistical contingency fuel calculations (as applicable), effective SRM and other applicable organizational and operational processes.

   The ability to collect, analyse and apply operational data is a fundamental operational and SRM activity, and operators should have the demonstrable ability to routinely collect and/or effectively use operational data in one or more of the ways listed in Table 5-3.

d) use statistical and trend analysis methods during the analysis of aeroplane performance data; however, it is recognized that there are occasions where nominative comparisons, simulation or expert advice may be required to interpret the data appropriately;

e) retain all data used in the selection of alternate aerodromes or the preparation of the flight plan for a period of time as required by the State of the Operator; and

f) interface with organizational and SRM data collection systems, as necessary.

Continuous improvement

5.4.12 Continuous improvement through an adjustment component or subsystem that responds to any underperformance or deviation identified through internal or external quality assurance and safety assurance processes, and to facilitate improvement of the system or subsystem. It is important to note that reporting, measurement and analysis may validate desired performance, negating the need for adjustment.

Table 5-3.

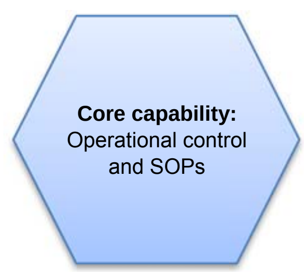
Automated data collection and dissemination
Automated collection of information for input to a Fuel Consumption Monitoring (FCM) programme; Automated collection of OUT/OFF/ON/IN data including times, fuel on board, aeroplane mass, flight path, speeds and any other operational data points supplied by an aeroplane's on-board systems; Automated collection of en-route data including planned versus actual altitude, planned versus actual fuel, planned versus actual route of flight and data points supplied by an aeroplane's on-board systems; Incorporation of FCM data into flight planning systems and aeroplane flight management systems; The collection and analysis of route-specific fuel bias information; Automated route, wind, mass and/or performance data uplinks to on-board systems.
Dynamic operational and flight planning
The use of Dynamic Airborne Re-route Procedure (DARP); En-route re-clearance capability; Recalculation of critical decision points; Re-planning in the event of system failure; Altitude availability analysis; Use of aeroplane intent data; Refined use of Cost Index; Trending and averaging; Dynamic aeroplane, engine, and route-specific fuel calculations; Dynamic MEL/CDL performance calculation.

Operational, aeroplane, aerodrome and meteorological capabilities

5.4.13 Annex 6, Part I, 4.3.4.4 and 4.3.6.6, each to varying extents, identify the attributes of “capable” operators that should be considered during SRM activities. Although the Standards differentiate between operational variations in alternate aerodrome selection and fuel planning, an assessment of an operator's operational control capability, the capabilities of individual aeroplanes, aerodrome capability, available infrastructure and the reliability of meteorological information should be intrinsic in operational and SRM activities related to all operational variations. With this in mind, the following descriptions of additional operator core capabilities are provided and should be considered by Authorities and operators within the context of any operational variation approval and implementation process. See Figure 5-4.

Figure 5-4. Operational capabilities necessary to support operational variations

Operational control systems and Standard Operating Procedures (SOPs)



5.4.14 This provides the direction for the conduct of flight operations. Such direction is usually determined by an individual or accountable executive. The direction or philosophy contains the overarching view from the company's management on how they want to operate. The SOPs are influenced by economic factors such as the markets to be served and the aeroplanes to be operated. Such direction is communicated to management and front line personnel in the form of strategic objectives, policies and procedures.

5.4.15 It is this direction, defined by policy and procedure, that creates the environment within which operational control personnel including the PIC, flight operations officer and/or flight followers, as applicable, must work.

5.4.16 Direction, in the form of policy and procedure nurtured by an organizational philosophy and safety culture that respects regulation, should produce a support structure that allows pilots and the applicable operational control personnel the authority to operate in compliance with policy, procedure and regulation. This in turn creates an environment where operational control can be exercised by the PIC and other appropriately trained and qualified personnel as intended and/or required by the State's Authority.

5.4.17 Some air carrier operations are so complex or large that specialization in traditional operational control functions becomes necessary. Every specialized aspect of operational control, however, should still support the PIC and, if applicable, the flight operations officer (e.g. ATC coordination, NOTAM collection and dissemination, equipment routing, mass and balance, flight monitoring, field condition monitoring, meteorological condition monitoring). Such specialization, by design, should also ensure each specialized function supports but does not impede the PIC's and, if applicable, the flight operations officer's authority and allows such personnel to conduct the operation in compliance with the applicable regulations.

Flight monitoring

5.4.18 In order to effectively exercise operational control, an operator should actively monitor each flight as well as conditions at the destination, en-route, en-route alternate and destination alternate aerodromes (as applicable) nominated for use by the flight up until the flight is no longer dependent on the use of the applicable aerodromes. The operator should also have procedures in place to ensure that information that may affect the conduct of the flight is available to the aeroplane.

Core capability:
Flight monitoring

5.4.19 Flight monitoring is conducted for the purposes of providing real-time operational support for aeroplane en-route and continually validating pre-flight planning assumptions. Many operators make significant investments in the technologies necessary to reliably fix an aeroplane's position en-route and monitor actual aeroplane performance. Such activities can lessen the severity of potential hazards or mitigate the safety risks associated with operational variations. Monitoring activities typically include, but are not limited to, the monitoring of:

a) OUT/OFF/ON/IN data including times, fuel on board, aeroplane mass and any other operational data points supplied by an aeroplane's on-board systems;

b) en-route position data including planned versus actual altitude, planned versus actual fuel, planned versus actual route of flight;

c) meteorological conditions at departure/arrival aerodrome, route of flight, alternate aerodromes (destination and en-route);

d) aerodrome conditions at the destination, en-route, en-route alternate and destination alternate aerodromes (as applicable) nominated for use by the flight up until the flight is no longer dependent on the use of the applicable aerodromes; and

e) the maintenance status of aeroplanes for possible Minimum Equipment List (MEL)/Configuration Deviation List (CDL) restrictions.

Communication systems

5.4.20 The demonstrable ability of an operator to rapidly and reliably contact an aeroplane en route forms the foundation of modern operational control systems. Present-day operators have access to multiple and redundant means of communication to ensure gaps in coverage are minimized or eliminated. Such redundancies when used in conjunction with other operational control processes can lessen the severity of potential hazards or mitigate safety risks associated with operational variations. Available means to contact aeroplanes typically include, but are not limited to, the use of:

Core capability:
Communication systems

a) SATCOM;

b) VHF and HF (with/without SELCAL) company frequencies;

c) ACARS;

d) VHF/HF datalink; and

e) satellite datalink.

Ground-based and airborne systems

5.4.21 Management personnel, flight crews, flight operations officers, operational control personnel and other entities in a position to mitigate potential safety risks benefit from the use of the latest tools and technologies. Modern-day operators systematically use these tools to re-assess assumptions made during flight planning and to continually adapt to changing conditions. Situational awareness and other tools are typically used by operators to fully exploit the capabilities of aeroplanes, aerodromes and available infrastructure and include one or more of the following:

Core Capability:
Ground-based and Airborne Systems

a) advanced on-board flight management and navigation systems;

b) CAT I, CAT II, CAT III approach capability and supporting infrastructure;

c) RNAV/RNP APCH LNAV and LNAV/VNAV, RNP AR, LPV, GNSS, GBAS, SBAS approach capability;

d) ADS-C/ADS-B aeroplane air and runway/taxiway positioning;

e) aircraft situation display, real-time graphical flight monitoring or tracking tools utilizing ATC radar data for the purposes of reliably fixing an aeroplane's position en-route;

f) AO - FMS position report capability;

g) access to HF/VHF position reporting by ANSP via Aeronautical Fixed Telecommunication Network;

h) access to on-line technical logs;

i) on-board terrain escape tools that provide real-time lateral and vertical guidance in cases of depressurization, engine failure or other event that requires a change in the route or a descent in areas of critical terrain;

j) aerodrome and airspace security analysis;

k) Air Traffic Flow Management and/or participation with ATM in collaborative decision making;

l) access to 24-hour international news for the purpose of hazard identification;

m) access to ANSP web portal information;

n) flight planning systems with constant monitoring and measuring of information affecting flight track and aerodromes (OPMET and NOTAM); and

o) disruption/event analysis/decision-making tools.

Reliable meteorological and aerodrome information

5.4.22 Obtaining accurate meteorological information as well as the ability to monitor en-route meteorological conditions, destination meteorological and aerodrome conditions is essential in order for pilots and operational control personnel to dynamically re-evaluate, reanalyse and revalidate pre-flight planning assumptions. This capability augments what is typically available to the PIC in less robust systems and closes gaps in coverage where such information may not be readily attainable by the flight crew en route. Additionally, the operational control personnel involved in the monitoring and analysis of such information effectively expand the team of people dedicated to the safe completion of a flight.

Core capability:
Reliable MET and aerodrome information

5.4.23 The most sophisticated operational control, flight following, flight monitoring and flight watch systems are characterized by their ability to monitor information on any applicable destination meteorological and aerodrome condition that may pose a hazard to a flight or invalidate pre-flight planning. Many employ dedicated meteorologists as well as ground-based observers in areas where reliable monitoring is not available by any other means. Finally, the most sophisticated operational control systems are characterized by their ability to monitor continuously, as applicable:

a) destination and alternate (destination and en-route) meteorological and aerodrome conditions;

b) tropical cyclone advisories;

c) Airport Automatic Weather Systems (AWS);

d) volcanic ash advisories, earthquake events and tsunami;

e) gridded data turbulence, icing and CB;

f) aerodrome operating minima including reported RVRs;

g) SIGMET, METAR/SPECI, TAF;

h) NOTAM and runway contaminations (e.g. snow/ice/standing water);

i) blowing dust or other advisories related to limited visibility; and

j) other foreseeable meteorological phenomena or aerodrome condition(s) that may pose a hazard.

5.4.24 In summary, an operator must have a solid foundation upon which to build the framework that can support performance-based compliance with regulation. Such a foundation is rooted in modern methods and technologies related to the:

a) production of services;

b) operational control of flights, flight monitoring and in-flight communications;

c) exploitation of airborne and ground-based systems;

d) exploitation of available aerodromes and infrastructure; and

e) reliability and accessibility of meteorological reporting, meteorological forecasting and field condition monitoring.

5.4.25 In fact and as previously stated, an assessment of the hazards posed by the absence or presence of such methods or technologies is a prerequisite for obtaining approval for operational variations.

Safety Risk Management (Operational)

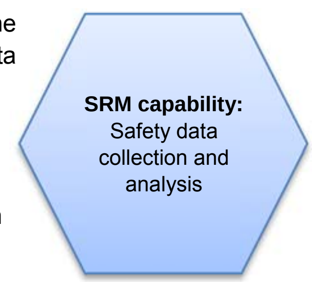
5.4.26 Operational or “tactical” SRM is the subsystem that interfaces with the internal production system component (to a specific performance-based system or process) for data reporting, measurement and analysis. This includes the interfaces with SMS and quality systems to ensure operational systems and processes are subjected to the organization’s overarching safety and quality assurance processes (see Figure 5-5).

5.4.27 It is important to note that ICAO’s *Safety Management Manual (SMM)* (Doc 9859) and other applicable publications provide extensive guidance related to the use of SRM principles, implementation of SMS and the maintenance of SSPs. This chapter makes extensive use of the information contained in such publications to provide the necessary guidance for the operationally practical and tactical application of SRM principles during alternate aerodrome selection, flight planning and fuel management activities. It also provides a general overview of the elements of successful SRM that can be used for the purposes of bringing these specific operational processes under organizational control.

5.4.28 Operator processes for the tactical assessment and management of operational safety risks should have sufficient maturity, fidelity and sophistication to qualitatively and/or quantitatively assess the safety risks inherent in alternate aerodrome selection, flight planning and fuel management. In all cases the aim of the operator’s internal processes and controls should be to ensure that, as a result of each operational variation, there is, to the greatest extent practicable, no increase in safety risk to the operation. SRM activities at the operational level should also interface with SRM activities at the organizational level. Much like organizational SRM or SMS, the tactical SRM of operational activities relies on process management and control and should address at a minimum:

Safety data collection and analysis

5.4.29 Central to subsequent operational hazard identification and analysis is the supporting data used in the operator’s processes. The importance of actionable data cannot be understated. Safety data collected during the course of operations, for example, is used to identify latent hazards and subsequently to determine the safety risks that may require mitigation. Data reliability is therefore critical, and lacking sufficient reliability can lead to flawed assumptions, incorrect hazard identification, inadequate safety risk assessment, inappropriate mitigation and, in the worst case, can introduce hazards that are more serious than those originally present.



5.4.30 Data are used both in reactive and proactive hazard identification and in mature systems may be used as a predictive measure to anticipate future hazards. Due to the critical nature of safety data collection, operators should be able to demonstrate that the data they use in policy and procedure development have the required integrity. To this end the operator should be able to demonstrate a continuous process of data collection, verification and analysis. As data will inevitably be accessed from a variety of sources, each will require an assessment by the operator as to its suitability for use in operational decision making.

5.4.31 It is important to note that in order to achieve target levels of operational and safety performance, large volumes of safety and operational data must be acquired. The acquisition of safety data in particular requires the development of predictive data collection systems to complement existing reactive and proactive collection systems. To that end, electronic data acquisition systems and non-jeopardy self-reporting programmes should be present to collect safety data from normal operations, with and without the need for triggering events that launch the safety data collection processes.

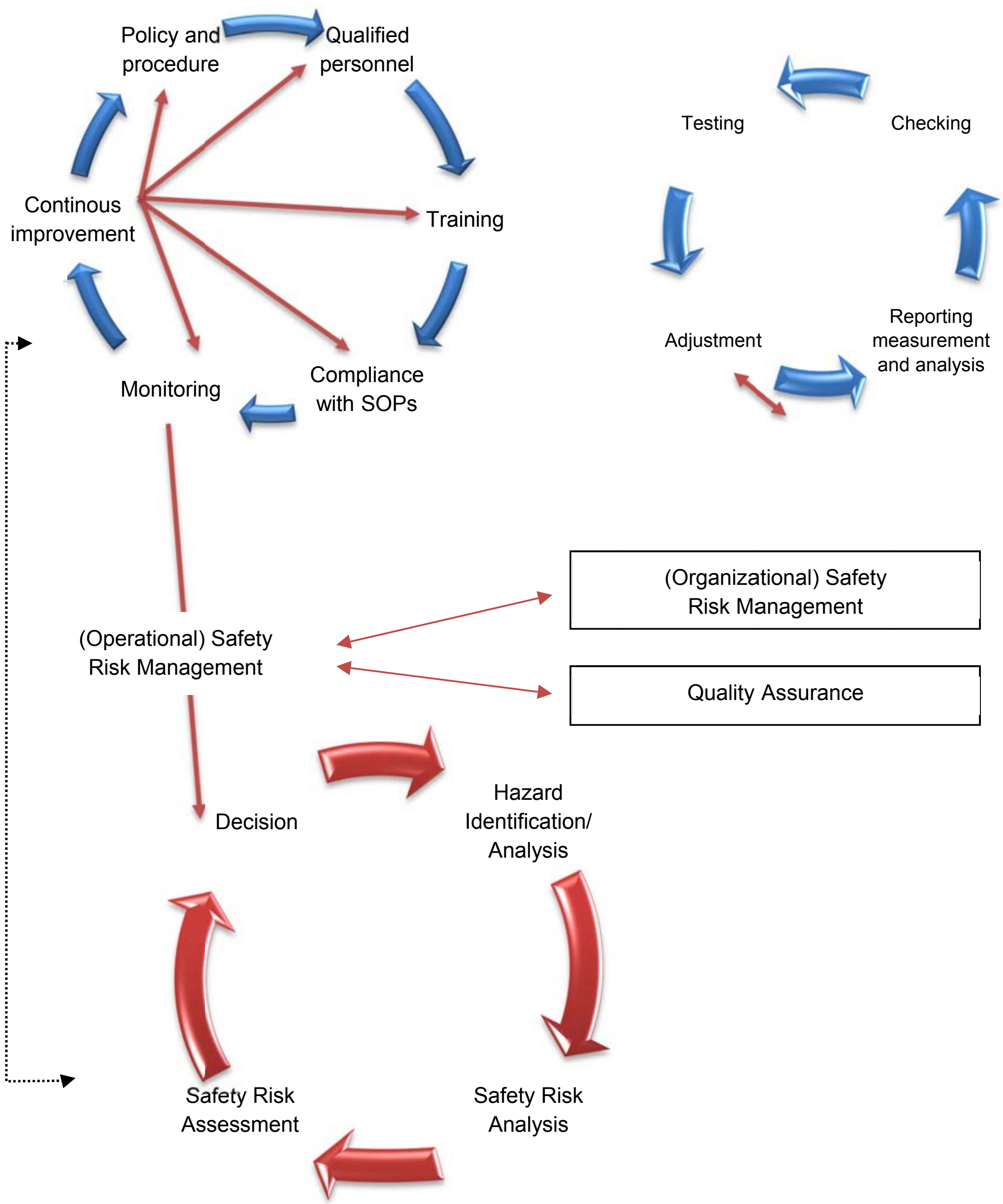


Figure 5-5. The relationship between Operational SRM and Organizational SRM (SMS)

5.4.32 In summary, safety data collection processes should interface with operational reporting systems related to the production of services, address each operational variation and be sufficiently sophisticated to collect the requisite volume of operational and safety data necessary to support effective SRM of the operational activity. They should:

a) ***isolate and extract the appropriate data*** from a variety of sources (related to the operational activity) for analysis. Data sources include but are not limited to those contained in Table 5-4.

Table 5-4.

State/Official sources
States provide much of the data used in aviation. Due to controls put in place by the State the data are generally, but not always, reliable. Examples of State sources that supply data are: State Meteorology Authorities; • World Area Forecast Centres (WAFC); • Tropical Cyclone Advisory Centres (TCWC); • Meteorological Watch Offices; • State NOTAM Offices; • Volcanic Ash Advisory Centres (VAAC); • Air Traffic Control Centres and Airport Authorities.
Operator-derived data
Operators have access to large amounts of data specific to their unique operations. Unlike State/official sources, the operator assumes the responsibility of ensuring data accuracy. Examples of operator derived data are: • Hull-specific fuel burn data; • Flight planning fuel and operating statistics including data to support contingency fuel calculations; • Monitoring of aeroplane operations (taxi times, holding times, average flight time, fuel burn, ground distance from the arrival fix to the airport/runway, diversion rates, etc.); • Incident reports; • Crew reports; • Aerodrome and route surveillance and monitoring.
Other sources
Operators may use data from a variety of other sources, some of which will provide data with the required integrity, and some of which will not. In many cases the ability to verify the accuracy of the data gained may be difficult in which case operators should exercise extreme care before using it as the basis of an operational decision. Examples of other sources are: • IATA; • ICAO; • Aeroplane manufacturers; • News services; • Third Party providers; • Consultants.
Note.— These are recommended data points only. Actual data points may vary based on the availability of data for collection and analysis.

b) ***include a process to receive, collate and analyse all reports*** made by flight crew, dispatch staff or from any other person or source that could indicate a potential degradation in the safety of flights related to the implementation of each operational variation. Such safety reporting systems take many forms but typically have a web- or server-based component coupled with a centralized database. This type of electronic reporting system allows for the remote submission of reports by operational personnel, the systematic processing of those reports, and the automatic generation of trend and performance data.

Fully integrated web-based reporting systems can also allow operational personnel to complete a prescribed reporting template containing all of the data points necessary for effective hazard reporting from anywhere in the world. While fundamental, this type of reporting system dramatically improves the ability of operators to identify trends, follow up on events, and identify opportunities for operational improvements while collecting data in a manner consistent with the processes of hazard identification and safety risk management;

c) ***provide feedback and control references*** against which to measure hazard analysis and consequence management, as well as the efficiency of the sources or methods of safety information collection;

d) ***provide material for root cause and safety trend analyses***, as well as for safety education and flight crew training purposes; and

e) ***collect data relevant to the mitigation of the specific safety risks*** associated with alternate aerodrome selection and fuel planning including but not limited to the data specified in Table 5-5.

Table 5-5.

Examples of data in relation to city-pair
• Actual versus planned taxi times;
• Taxi and ground delays;
• En-route speed restrictions (ATC, turbulence, etc.);
• En-route deviations (route and altitude for ATC, Wx, etc.);
• Air traffic delays experienced;
• ATC flow management and aerodrome capacity/congestion and demand;
• Runway closures or reductions in aerodrome capacity;
• Any ATC or aerodrome factors that could contribute to the planned fuel consumption being exceeded;
• 100 per cent consumption of contingency fuel;
• 100 per cent consumption of holding fuel;
• Low fuel state (as defined by operator or Authority);
• Minimum fuel state (as defined by operator or Authority);
• Emergency fuel state (as defined by operator or Authority);

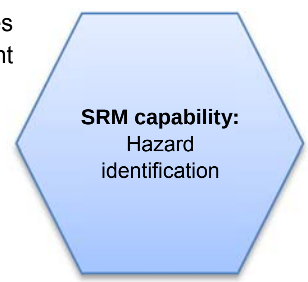
Examples of data in relation to city-pair

- Less than final reserve fuel remaining;
- Actual versus planned time spent holding;
- Actual versus planned SID/STAR ground track flown (including portion of Point Merge STAR actually flown, if applicable);
- Missed approaches;
- Additional approaches;
- Proceeding to destination alternate aerodrome or diversions prior to destination;
- Proceeding to en-route alternate aerodrome (e.g. due to in-flight re-dispatch or re-planning)
- Ground-based approach facilities malfunctions;
- Destination or alternate aerodrome meteorological conditions below forecast conditions;
- Other factors or occurrences identified by the Authority or the operator as having caused delays, diversions, additional fuel consumption or other undesirable outcomes.

Note.— This is not a comprehensive list of required data points to be collected by an operator but merely representative of the type of data that may be relevant in the analysis of safety risks. It is understood that the collection of such data may prove problematic to individual operators based on their operating environments and data collection capabilities.

Hazard identification

5.4.33 Hazard identification and safety risk management are two core processes involved in the overall management of safety. This section presents operationally relevant guidance for the identification and analysis of the hazards to be considered during the development or application of alternate aerodrome selection and fuel planning policy and process. While this section focuses primarily on hazards, the ensuing sections discuss the safety risks associated with the outcomes of identified hazards.



5.4.34 Hazard identification processes rely heavily on the subordinate data collection processes, address each operational variation, and are designed to identify the foreseeable hazards that could increase the safety risk to a flight or series of flights. Aeroplane operations comprise numerous hazards, many of which are complex in nature and interrelated. An operator's alternate aerodrome selection and fuel planning processes can be primary methods of mitigating the safety risks inherent in operations. If these and associated processes are to achieve target levels of safety performance, however, the operator must systemically record and classify the hazards that will be encountered during routine operations. A non-exhaustive list of potential hazards for consideration is contained in Table 5-6.

Table 5-6.

Potential hazards to be considered during alternate aerodrome selection and fuel planning	
• Routine adverse meteorological conditions	• Natural hazards that take many forms and include, but are not limited to: tropical storms, winter storms, droughts, tornadoes, thunderstorms, icing, freezing precipitation, heavy rain, snow, winds, restricted visibility, lightning, wind shear or any other relevant meteorological phenomena
• Extreme meteorological conditions	• Natural hazards such as tropical cyclones, tornadoes, snow and dust storms
• Geophysical events	• Natural disasters that are difficult to predict such as volcanic eruptions, earthquakes or tsunami
• Space weather	• A natural hazard linked to variations in solar activity, the consequences of which include its effect on aeroplane communications, satellite communications and navigation and, at high latitudes, the potential impact on human health. Identification of hazards related to space weather is especially important with the increase in satellite-based navigation procedures that use operational minima predicated on the availability of satellites.
• ATM congestion	• A technical hazard, on the ground and in the air, and a significant contributor to fuel usage
• Mechanical failure of aeroplane systems	• A technical hazard when failures result in a reduction of an aeroplane's specific ground range or approach and landing capability
• Geography	• Natural hazards such as adverse terrain or large bodies of water
• Isolated aerodromes	• Aerodromes are typically considered isolated if the fuel required (alternate plus final reserve fuel) to the nearest alternate aerodrome is more than the fuel to fly for two hours at normal cruise consumption above the destination aerodrome, including final reserve fuel
• Runway or airspace closure	• A technical hazard that increases fuel consumption and/or limits landing options
• Political unrest	• Examples: political unrest or terrorism
• Organizational or operational change	• Examples: changes to key personnel, rapid growth, rapid contraction, corporate mergers, equipment changes or other systemic changes
• Any other hazard related to the capability of the operator, aerodromes or related infrastructure	• Examples: limitations related to ATC, aerodromes, field condition reporting, meteorological reporting/forecasting, technology, operational control, flight following, flight monitoring/watch

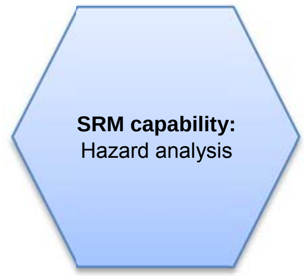
5.4.35 In summary, hazard identification processes should address each operational variation, be sufficiently sophisticated to ensure that target levels of safety performance can be achieved by ensuing safety risk management activities and:

a) interface with subordinate operational and safety data collection processes; and

b) identify the foreseeable hazards that could increase the safety risk to a flight or series of flights.

Hazard analysis

5.4.36 Once a hazard has been identified it must be analysed in order to determine its effect on the development or application of policy and procedure. Not all operations will be affected to the same degree due to the consequences of a given hazard. For example, the absence of VMC at an aerodrome that is served by a VOR and an ILS approach may prevent the operation of aeroplanes that do not carry the required equipment. Conversely, there may be no effect on the operation of aeroplanes that are fitted with ILS and VOR receivers. Hazard analysis, therefore, will establish the operational context and provide the basis for determining the appropriate safety risk mitigation.



5.4.37 Fundamentally, hazard analysis consists of the identification of a generic or top-level hazard, breaking down the generic hazard into an operationally specific component and linking operationally specific hazards to specific potential outcomes. For illustrative purposes, Table 5-7 analyses three hazards derived from the list of foreseeable hazards in Table 5-6. It limits the correlation of potential outcomes to the lower-level operational consequences of hazards as necessary to ensure the development of effective safety risk mitigation strategies.

5.4.38 Hazard analysis should be sufficiently sophisticated to ensure that acceptable levels of safety performance can be maintained by the ensuing SRM activities of the operator. By not fully analysing the available data, an operator may draw premature or inaccurate conclusions during a safety risk assessment of an operational activity. Notwithstanding the need for detailed data analysis there will be occasions where the time available is limited. Operators should have a range of decision analysis tools including those that allow them to adapt expeditiously to hazards that are presented without warning.

Table 5-7.

Breaking down hazards		
Generic hazard	*Operationally specific hazard*	*Potential outcomes*
Meteorology	Tropical storms, winter storms, droughts, tornadoes, thunderstorms, icing, freezing precipitation, heavy rain, snow, winds, restricted visibility, lightning, wind shear and any other relevant meteorological phenomena	• Invalidation of flight planning assumptions • Re-routes • Contingency fuel use • Contingency fuel exhaustion • Unplanned diversion • Low fuel state • Emergency landing • Injury to personnel
Extreme meteorological conditions	Tropical cyclones, tornadoes, snow and dust storms	
Geophysical events	Volcanic eruptions, earthquakes or tsunami	

5.4.39 In summary, hazard analysis processes should address each operational variation, be sufficiently sophisticated to ensure that acceptable levels of safety performance can be maintained by ensuing safety risk management activities and:

a) ***interface with subordinate hazard identification processes****.*

b) ***analyse all identified hazards*** for the purpose of subsequent risk assessment, mitigation and management.

c) ***include, but not be limited to, proactive and predictive processes for tracking incident rates*** associated with flight planning failures including flight diversions and other relevant indicators of safety performance, as applicable to each operational variation. Such processes should have sufficient fidelity to discern if low fuel states, diversions or other undesired states were the result of process failures or inadequate mitigation strategies. They should also identify and emphasize lower level process failures with potentially damaging consequences to operations in order to encourage the development of effective mitigation strategies.

Note.— An analysis of the data derived from these processes can be also used to determine the extent to which the high-level safety objectives of the safety interventions of mitigation strategies have been achieved and provide a measure of the actual operational performance of tactical SRM activities. Additionally, the data can be used to customize safety risk assessment tools.

d) ***address hazards that manifest themselves without warning*** such as geophysical events. In order to cope with such hazards, operators may need to acquire data from sources that would be considered unreliable under normal circumstances. Such data may be confused and contradictory at times and, due to time constraints, a proper analysis may not be possible or prudent. Despite these constraints, an operator should be able to determine an appropriate course of action given the data that are available, and hazard identification processes should allow for such eventualities.

Additionally, and as part of post-incident processes related to geophysical events (or other hazards that manifest themselves without warning), the operator should conduct an analysis of the data received to determine its value in the event of similar (future) events. This would lead to additional analysis of the impact on operations to determine if new or added safety risk mitigation strategies are required. Standard hazard identification models may be difficult to apply in such cases requiring an operator that has an increased exposure to certain geophysical events to pre-plan its responses to an event.

For example, consider an operator that conducts operations within an island nation subject to tsunami. The generic, or top level hazard, would be a geophysical event. The specific operational hazard may be aerodrome inundation resulting in the aerodrome of intended landing not being available for an extended period of time. Further, all normally available landing areas may be inundated forcing the aeroplane to use a landing surface not normally approved. An operator may mitigate the outcomes of these hazards by having available a list of emergency landing surfaces available at higher elevations that could be used in the case of such an emergency.

e) ***consider the limitations of quantitative data****.* Hazard analysis processes typically involve the use of both qualitative and quantitative data. Due to the complexities of dynamic operating environments, operators often have to rely on qualitative data when making operational decisions. Ideally, quantitative data are typically preferred, as they are considered objective and repeatable given a constant set of conditions and constraints.

Data presented in a quantitative form, such as a numerical rate, should actually have the underlying attributes required to ensure objectivity. This is necessary to ensure ongoing user confidence in the accuracy and suitability of the data relative to the intended application.

For example, while historical data are often presented in a numerical form (e.g. events/period of time) and initially considered quantitative; it could be easily argued that such data are more qualitative in nature. In assessing the degree to which the data are actually quantitative or qualitative, an operator should consider the following:

1) Were stable conditions present throughout the time frame for which the data were captured?

2) Were all possible variables excluded?

3) Were there changes to procedures or technology that could explain variations over time?

4) Were sufficient data points used to justify the conclusions made?

5) Are the data repeatable?

If the answer to any of these questions is no, the data may be largely qualitative in nature and their ability to predict future events is limited. For example, an operator may claim that in one year of operations it had an overall fuel incident rate of 1.8 per 100 000 departures while the year before the rate was 2.6 per 100 000 departures. Was there an improvement in safety performance? The answer cannot be determined simply from an examination of the numerical data presented.

An analyst wishing to make such a determination would need to establish that the data for the two years of operation were comparable. Variations in route structure, meteorological conditions, aerodrome facilities and numerous other factors may all have contributed to the reduced incident rate, however the operator's underlying safety organization or culture may not have changed. Conversely, an operator that has a sophisticated FCM programme is entitled to state that the average fuel usage has decreased by 1.5 per cent if it can demonstrate consistency of data, absence of variation and removal of bias.

The limitations of data should be clearly understood, however, if data are to be used effectively as a predictor of future events. Hazard analysis and the safety risk assessment activities that follow inevitably involve the use of qualitative data as it may be impossible to accurately quantify probability in complex systems due to the number of variables involved. For this reason the analysis of hazards, and their associated risk, will always involve an assessment by individuals within an operator's organization. If the operator is to maintain a level of consistency in the decision-making process then specific processes and instructions need to be provided to such individuals. Such processes are vital if the operator's risk appetite is to be reflected in decisions made by individuals charged with the identification and analysis of hazards.

f) ***document the hazards*** that are normal components or elements of operations. Hazards are integral to the operating environment of the operator and should not be viewed as rarities or one-off events. Therefore the documentation of a hazard, along with the analysis and mitigation measures taken, will reduce the management resources required when the hazard recurs. It is important that operators maintain a consistency of action if post-event review and analysis as to the effectiveness of mitigation strategies and controls are to produce meaningful outcomes. Such consistency is the result of sound documentation techniques.

Operators should develop processes to record hazards in a manner that facilitates their review. Ideally, by recording hazards in a database system, higher level statistical evaluation of the hazards encountered during routine operations would be facilitated. This allows a process of prioritization that would commit operators to address hazards that have the greatest operational impact. Such prioritization is possible only within a system that efficiently documents the hazards, analysis and mitigation that takes place in the support of an operational activity.

Note.— Operators that do not maintain a system of documentation risk the loss of operational knowledge, repetition of preventable incidents, and the inability to apply effective mitigation strategies consistently.

5.4.40 For illustrative purposes, an example safety risk assessment begins with a hazard analysis as follows: An operator is substituting a B767-300 for an A330-300 on its route from Caracas (SVMI) to London Heathrow (EGLL) to adjust for a seasonal decrease in demand.

5.4.41 The operator has CAA approval to operate the route using a variation from a prescriptive regulation related to the carriage of contingency fuel. The variation allows the operator to optimize fuel for the route based on numerous demonstrable capabilities and the outcome of specific safety risk assessment. This is a new route for the B767, however, and the route of flight has limited en-route diversion options and traverses the Inter-tropical Convergence Zone known for severe convective activity. The change in aeroplane type also coincides with the onset of winter in the United Kingdom.

5.4.42 After completing a hazard analysis (Table 5-8), the operator determines that the specific hazards related to the change in type are:

a) insufficient type-specific flight planning data for the route;

b) inexperience of B767 flight crews and operational control personnel with the new route;

c) the route is near the maximum range of the aeroplane with maximum payload and mandated reserves; and

d) meteorological conditions en-route and at the destination (EGLL).

5.4.43 Some of the potential consequences of the hazard of primary concern to the operator are the over burn of trip fuel, contingency fuel exhaustion, diversions or other occurrences that could result in a landing at an aerodrome with less than final reserve fuel. The identification of these undesirable outcomes completes the process of hazard analysis and forms the foundation for safety risk assessment. During this assessment, the consequences of these hazards, expressed in terms of probability and severity (as an alphanumerical convention) will quantify the safety risk.

Table 5-8.

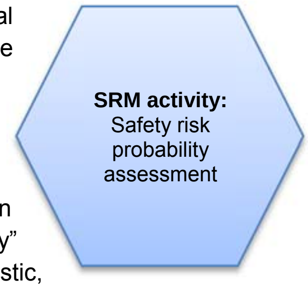
Example hazard analysis: New service for aeroplane type		
Generic hazard	*Operationally specific hazards*	*Potential outcomes*
New service for aeroplane type (B767)	• Insufficient type-specific fuel planning experience that may result in inaccurate or inappropriate: 1) total fuel calculation; 2) taxi and trip fuel calculations; 3) reserve fuel calculations including contingency fuel; 4) nomination of alternate aerodromes or alternate fuel calculations; 5) additional fuel or calculations; 6) discretionary fuel calculations; • Flight crew for new aeroplane type unfamiliar with route; • Route near maximum range of the aeroplane; • Meteorological conditions along the route and at destination.	• Invalidation of flight planning assumptions • Loss of confidence in planning processes • Over-burn of trip fuel • Re-routes • Contingency fuel use • Contingency fuel exhaustion • Unplanned diversion • Low fuel state • Emergency landing • Injury to personnel
Note.— Potential outcomes related to operationally specific hazards can be used as the basis for the definition of safety indicators used to measure and monitor system performance. This concept will be explained later in this chapter.		

Safety risk assessment and mitigation

5.4.44 Safety risk analysis/assessment is a core SRM activity, besides hazard identification/analysis, that supports the management of safety risks and contributes to other, indirectly related operational and organizational processes. Before the process of managing any safety risks can begin, it is essential to somehow measure the seriousness of the consequences of inherent hazards. By quantifying the consequences of hazards, the safety risk management process begins and provides the operator with a basis for the safety risk decisions that will subsequently contain or limit the damaging potential of hazards.

5.4.45 It is important to note that safety risk is simply a construct intended to measure the seriousness of, or "put a number" on, the consequences of hazards. As such, safety risk is an assessment, typically expressed in alpha-numeric terms of predicted probability and severity, of the consequences of a hazard. The definition of safety risk allows operators to link specific safety risks with hazards and consequences in order to complete an initial safety risk assessment.

Safety risk probability assessment.



5.4.46 Operators continue the process of bringing safety risks under organizational control by assessing the probability that the consequences of hazards will materialize during flight operations. This is known as assessing the safety risk probability or assessing the likelihood that an unsafe event or condition might occur, and it is typically qualitatively or quantitatively expressed in terms of frequency of occurrence.

5.4.47 In assessing the probability or likelihood that an unsafe event might occur, an operator should make use of all the relevant historical data contained in its "safety library" as well as consult with subject-matter experts (SMEs). The establishment of realistic, qualitatively- and, when feasible, quantitatively-derived categories denoting the probability (of an occurrence) and the relationship between the observed events and undesirable outcomes are the keys to the development of effective probability assessment tools. When using qualitative analyses to determine the probability of occurrences, the descriptions in Figure 5-6 are commonly accepted aids to judgment.

5.4.48 Returning to the example safety risk assessment scenario, the operator forms a team comprised of SMEs from the A330 and B767 fleet departments to consider the probability that any or all of the potential outcomes related to the previously identified hazards will materialize during operations. The team initially reviews all available information and data from both fleets to determine, based on the previous initiation of service with the A330, if occurrences of unplanned fuel use resulted in any of the undesirable outcomes identified during hazard analysis.

5.4.49 For illustrative purposes, the team of SMEs determines that although undesirable outcomes such as landing at an aerodrome other than the planned commercial destination, due to unexpected fuel consumption, occurred infrequently on the A330, such outcomes were somewhat more likely to occur with the assignment of the B767 to the route. As such, the initial qualitative assessment of frequency was subsequently categorized as "Occasional" using the operator's predefined qualitative risk probability criteria (see Figure 5-6).

5.4.50 As previously mentioned the probability or likelihood of an occurrence can also be expressed quantitatively (Figure 5-7).

FREQUENCY OF OCCURRENCE

(5) FREQUENT: Likely to occur many times or has occurred frequently.

(4) OCCASIONAL: Likely to occur sometimes or has occurred infrequently.

(3) REMOTE: Unlikely to occur, but possible or has occurred rarely.

(2) IMPROBABLE: Very unlikely to occur (not known to have occurred).

(1) EXTREMELY IMPROBABLE: Almost inconceivable that the event will occur.

Figure 5-6. Example

FREQUENCY OF OCCURRENCE	
Qualitative	*Quantitative*
(5) Frequent:	• those occurrences having an average probability per operation (sector) of the order of 1x 10^{-4} or greater
(4) Occasional:	• those occurrences having an average probability per operation (sector) of the order of 1x 10^{-4} or less, but greater than of the order of 1 x 10^{-6}
(3) Remote:	• those occurrences having an average probability per operation (sector) of the order of 1x 10^{-6} or less, but greater than of the order of 1 x 10^{-7}
(2) Improbable:	• those occurrences having an average probability per operation (sector) of the order of 1x 10^{-7} or less, but greater than of the order of 1 x 10^{-9}
(1) Extremely Improbable:	• those occurrences having an average probability per operation (sector) of the order of 1x 10^{-9} or less

Conversion Table

10^{-9}	**10^{-8}**	**10^{-7}**	**10^{-6}**	**10^{-5}**	**10^{-4}**	**10^{-3}**	**10^{-2}**	**10^{-1}**
1/1 000 000 000	1/100 000 000	1/10 000 000	1/1 000 000	1/100 000	1/10 000	1/1 000	1/100	1/10
.000000001	.00000001	.0000001	.000001	.00001	.0001	.001	.01	.1

Figure 5-7. Example

5.4.51 This allows safety risk probability assessments to be further refined by operators to include quantitative data and requires the qualitative descriptors for frequency of occurrence to be assigned quantitative values. In other words, the terms frequent, occasional, remote, improbable, and extremely improbable are assigned numerical values as appropriate to reflect the historical frequency of occurrences. Such refinements can significantly increase the accuracy of the probability assessments and would be especially useful during system safety performance monitoring and measurement activities.

Safety risk severity assessment

SRM activity:
Safety risk severity assessment

5.4.52 Once the likelihood that an unsafe event or condition might occur has been assessed in terms of probability, the third step in the process of bringing specific safety risks under organizational control is an assessment of the severity of the hazards if their damaging potential materializes during flight operations. This is known as assessing the safety risk severity.

5.4.53 Safety risk severity is the potential consequence of an unsafe event or condition using the worst foreseeable consequence as the upper limit. The generic Hazard Severity table contained in Figure 5-8 includes five vertical columns that contain categories to denote the level of severity of an occurrence, the meaning of each category, and the assignment of a value to each category. The definitions of all the terms related to severity are provided for illustrative purposes, and operators should ensure they are appropriately defined in a manner consistent with operational requirements and the requirements of the State's civil aviation oversight authority.

EXAMPLE ONLY				
HAZARD SEVERITY				
CATASTROPHIC	**HAZARDOUS**	**MAJOR**	**MINOR**	**NEGLIGIBLE**
Hull loss, equipment destroyed, multiple deaths	A large reduction in safety margins, physical distress, excessive crew workload, serious injury, or major damage to equipment	A significant reduction in safety margins, significant increase in crew workload, serious incident or injury to persons	Nuisance or minor incident, slight reduction in safety margins, slight increases in crew workload	Little or no safety effect to the operational capability of the aeroplane or flight crew
A	**B**	**C**	**D**	**E**

Figure 5-8.

5.4.54 Continuing with the example scenario, the operator's team of SMEs assesses the potential consequences of trip fuel over-burn, contingency fuel exhaustion and unplanned diversions resulting in landings with less than final reserve fuel. This assessment could be further refined via statistical analysis if sufficient relevant data existed to reach a quantitative conclusion. In this case, and for illustrative purposes, the team qualitatively determines that the consequences of unplanned fuel use could result in a large reduction of safety margins (landing at a suitable aerodrome with less than final reserve fuel remaining). Such large reductions in safety margins are categorized as *Hazardous* in the operator's safety risk assessment policy. They also determine that the potential rates of unplanned fuel use are insufficient to maintain the safety risks of a catastrophic outcome at tolerable levels.

Safety risk tolerability assessment

5.4.55 The fourth step in the process of bringing specific safety risks under organizational control is the assessment of safety risk tolerability and is a two-step process.

5.4.56 Figure 5-9 presents an example of a (qualitative) five-point Safety Risk Assessment Matrix. In this case, it can be used to determine the safety risk index or to "put a number" in terms of probability and severity on the consequences of a hazard. Although the matrix, including elements of severity, risk assessment and tolerability represents industry standards, the level of detail and complexity of a matrix should be adapted and commensurate with the particular needs and complexities of a specific operator and in accordance with the requirements of the Authority.

Note.— The matrix in Figure 5-9 differs slightly from typical matrices in that it has been adapted to accommodate the concept of a level of risk that may require action and/or be considered acceptable upon review by the appropriate manager, SME or Authority.

5.4.57 Again referring to the example, the team of SMEs assigned the task of assessing the safety risk to operations initially determined that the probability of unplanned fuel use posing a hazard was *Occasional*. The team also assessed that the severity of the consequences associated with the potential for a landing at a suitable aerodrome with less than final reserve fuel remaining was *Hazardous*.

EXAMPLE ONLY

QUALITATIVE SAFETY RISK ASSESSMENT MATRIX

HAZARD PROBABILITY	*HAZARD SEVERITY*				
FREQUENCY OF OCCURRENCE	CATASTROPHIC Hull loss, equipment destroyed, multiple deaths A	HAZARDOUS A large reduction in safety margins, physical distress, excessive crew workload, serious injury, or major damage to equipment B	MAJOR A significant reduction in safety margins, significant increase in crew workload, serious incident or injury to persons C	MINOR Nuisance or minor incident, slight reduction in safety margins, slight increases in crew workload D	NEGLIGIBLE Little or no safety effect to the operational capability of the aeroplane or flight crew E
(5) FREQUENT Likely to occur many times or has occurred frequently	5A	5B	5C	5D	5E
(4) OCCASIONAL Likely to occur sometimes or has occurred infrequently	4A	4B	4C	4D	4E
(3) REMOTE Unlikely to occur, but possible or has occurred rarely	3A	3B	3C	3D	3E
(2) IMPROBABLE Very unlikely to occur (not known to have occurred)	2A	2B	2C	2D	2E
(1) EXTREMELY IMPROBABLE Almost inconceivable that the event will occur	1A	1B	1C	1D	1E

Safety Risk Assessment Index

Risk Level

5A, 5B, 5C, 4A, 4B, 3A Unacceptable risk under current circumstances–Immediate action required

5D, 4C, 4D, 3B, 3C, 2A, 2B Risk is **Tolerable** based on mitigation

5E, 4E, 3D, 2C, 1B, 1A **Acceptable risk with review** by the appropriate Manager, SME or Authority

3E, 2D, 2E, 1C, 1D, 1E Risk is **Acceptable** as it currently stands

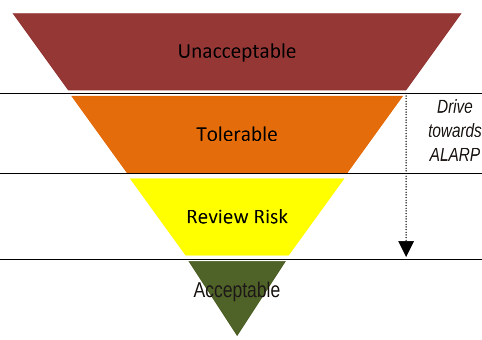


Figure 5-9.

5.4.58 In order to determine the safety risk index associated with the planned operation it is first necessary to use a matrix that combines the fundamentals of safety risk management into one illustrative tool (see Figure 5-9). In the example, a specific hazard probability has been assessed as **Occasional (4)**, and the specific hazard severity has been assessed as **Hazardous (B)**. The composite of probability and severity **(4B)** is the safety risk of the consequences of the hazard under consideration (safety risk index).

5.4.59 Second, the tolerability of the safety risk index is assessed. In the example, the positioning of **(4B)** in the matrix and the colour code (red) indicate that the risk is "unacceptable under current circumstances". The colour coding in the matrix simply reflects the tolerability regions in the risk level indicator (inverted triangle). It is important to note that the shading as well as other specific indicators in the matrix are defined by each State and individual operator.

Safety risk control and mitigation

5.4.60 The fifth and final step in the process of bringing specific safety risks under organizational control is the deployment of safety risk control and mitigation strategies. Such strategies are deployed by operators to address the specific hazards and drive the safety risk index toward a target level of safety performance.

5.4.61 Continuing with the example scenario, hazards with a safety risk index of **(4B)** (unacceptable under current circumstances) would require an action plan to be developed in order to drive the index out of the red range and towards the acceptable or green range. Action plans for safety risk mitigation/control employ three basic strategies: *Avoidance* (of the operation), *Reduction* (in frequency of the operation or magnitude of consequences) and *Segregation* (of exposure by limiting operations to appropriately qualified flight crew members or appropriately capable aeroplanes).

5.4.62 To bring the example safety risk assessment scenario to its conclusion, it would be necessary for the operator in this case to accomplish one of the following mitigation strategies in order to move the index towards the acceptable (green) range:

a) cancel the new service if mitigation is not possible (*Avoidance*);

b) allocate resources to reduce the exposure to the consequences of the hazards by: limiting the payload on the new type, carrying additional fuel, obtaining type-specific data from other operators, training operational personnel, identifying emergency diversion aerodromes, planning for an en-route alternate aerodrome, limiting operations during unfavourable meteorological conditions, etc. (*Reduction*);

c) allocate resources to isolate the effects of the consequences of the hazards by delaying the introduction of the new aeroplane type, limiting operations to another aeroplane with specific capabilities or requiring route qualification for flight crews (*Segregation*).

5.4.63 Additional safety risk control/mitigation strategies for specific operational activities would typically be based on the existence, reinforcement or deployment of safety (systemic and tactical) defenses. Such defenses are discussed extensively throughout this manual but generally refer to deployment of policies, processes, technologies, systems, improved training or additional regulations. Table 5-9 provides some examples of organizational and operational-level mitigation strategies for the operational hazards discussed in this chapter. These are examples related to the scenario used in this chapter and not exhaustive lists.

Table 5-9.

Example controls and mitigations		
Operationally specific hazard	*Controls*	*Mitigations*
Insufficient type-specific fuel planning experience may result in inaccurate or inappropriate: • total fuel calculation; • taxi and trip fuel calculations; • reserve fuel calculations including contingency fuel; • nomination of alternate aerodromes or alternate fuel calculations; • additional fuel or calculations; • discretionary fuel calculations.	Cross divisional policy and process for new service: • precludes initiation of service until subordinate (divisional) processes complete; • requires evaluation by a cross-divisional team of SMEs; • requires benchmarking other operators. Flight operations department policy initially requires a default to most conservative alternate aerodrome and fuel planning for the type.	Flight planning software: • precludes the planning of new service until SME evaluation complete; • automatically defaults to most conservative fuel planning criteria; • triggers data collection sub-processes used to support future operational variations with the potential to improve operational efficiency.
Flight crews unfamiliar with new route	Flight operations department policy requires: • SMEs from current and previous aeroplane types to collaborate to create training and familiarization materials; • requires that line pilots assigned to new route complete familiarization training; • service to be initiated by or under the supervision of specially qualified pilots.	Rostering software precludes the assignment of roster including new route to a crew member who has not completed required familiarization training.
Route near maximum range of the aeroplane	Fuel and alternate aerodrome planning policy requires safety margins be maintained. Where safety margins cannot be maintained, flight operations policy requires equipment substitution.	Flight planning software automatically limits payload on aeroplane to maintain adequate margins.

Example controls and mitigations		
Operationally specific hazard	*Controls*	*Mitigations*
Meteorological conditions along the route and at destination	Flight planning policy specifically addresses en-route deviations for meteorological conditions and requires flight crew to coordinate with operational control personnel for the purposes of re-analysis. Flight planning policy identifies weather conditions or criteria above regulatory requirements that must be met to initiate service.	En-route and destination meteorological conditions and field condition reports automatically forwarded to aeroplane en route.

5.4.64 In summary, the safety risk analysis, risk assessment and decision-making processes that are part of the operational SRM subsystem of production should address each operational variation, be sufficiently sophisticated, use the concepts of probability, severity and tolerability, and (in relation to each related operational activity):

a) ***interface with subordinate processes*** for hazard identification and analysis;

b) ***assess the likelihood that an unsafe event or condition might occur*** in qualitative or quantitative terms of frequency of occurrence;

c) ***assess the severity of identified hazards*** if their damaging potential materializes during flight operations;

d) ***identify the potential safety risks*** to a flight or series of flights;

e) ***determine the safety risk index*** for a flight or series of flights;

f) ***include processes for implementing appropriate controls and mitigation strategies*** to address safety risks and to ensure such risks are managed to acceptable levels and in relation to target levels of safety performance;

g) ***include processes for recording, classifying (taxonomy) and analysing risks***;

h) ***include processes to record the outcomes of the specific safety risk assessments*** related to alternate aerodrome selection and fuel planning;

i) ***ensure flight crew and dispatch staff are made aware of any potential safety risks*** to a flight or series of flights.

Note.— For additional and fundamental guidance related to hazard identification and analysis and safety risk assessments, please refer to Doc 9859, Chapters 4 and 5, respectively.

Safety assurance — by operator

5.4.65 Safety assurance consists of a host of activities and processes undertaken by both the State and the operator to determine whether the implementation of an operational variation is operating in accordance with expectations and requirements. Practically speaking this requires the monitoring and measurement of the effectiveness an operator's safety risk controls and mitigation measures related to the specific operational activity.

5.4.66 In order to ensure safety, effective operator monitoring and measurement of a performance-based system should be done through relevant safety indicators that continuously track system safety performance. As such, and to complement the organization's SMS level safety indicators, it is necessary to define a set of measurable safety performance outcomes to determine whether an operator's system is truly operating in accordance with design expectations. The definition of a set of measurable safety performance outcomes facilitates the identification of actions necessary to maintain operational performance of a system in relation to alert and target levels of safety performance. Measurable safety performance outcomes also permit the actual performance of activities critical to safety to be assessed against existing controls, so that safety risks can be managed effectively in accordance with the requirements of the State and the operator.

5.4.67 Practically speaking, this ensures that if controls and mitigations perform to an acceptable standard (e.g. SPIs alert levels are not breached, improvement targets are achieved), that is, they bring safety risks into the tolerable region, they can become part of the related operational system or process (e.g. alternate aerodrome selection or flight planning). If, however, the controls and mitigations do not perform to an acceptable standard, then it will be necessary to review SRM activities related to the operational activity. This typically requires the gathering of additional information and data, and/or re-evaluation of the operational hazard and the associated risks, and/or identification, implementation and evaluation of new or revised controls and mitigations.

5.4.68 An operator's organizational and tactical SRM components should continuously ensure remedial action or adjustment in order to maintain safety performance. This requires an operator to implement the internal processes necessary to continuously monitor or assess the safety performance of operational activities and validate the effectiveness of safety risks controls and strategies. This also assists a State's performance-based oversight component to continually assess the actual performance of an operator's mitigation measures against defined levels of safety performance.

5.4.69 In order to monitor the processes or systems performance, the operator needs to gather information or data through various sources such as auditing, surveys, incident reporting systems and safety reviews. The data collected will then be used to develop selective measurable indicators. The indicators may be occurrence outcomes, deviations or event types that indicate the safety or risk level of the process. These performance indicators are selected in agreement with the Authority to minimize the expected versus the actual results of these performance monitoring outcomes. This is discussed in detail in the next sections.

5.4.70 Another aspect is the application of quality assurance (QA) principles to SRM processes that will ensure the requisite tactical and system-wide safety measures have been taken to support the achievement of safety objectives. However, QA cannot by itself assure safety. It is the integration of QA principles and concepts under a safety assurance component that assists CAAs and operators in ensuring the necessary standardization of processes to achieve the overarching objective of managing the safety risks confronted during specific operational activities related to flight operations.

5.4.71 As such, safety should be considered as a continuous, ongoing activity for the purposes of:

a) ensuring that the initial identification of hazards and assumptions in relation to the assessment of the consequences of safety risks, and the defenses that exist in the system as a means of control, remain valid and applicable as the system evolves over time; and/or

b) introducing changes in the defenses, as necessary.

5.4.72 Safety assurance is typically composed of three elements: safety performance monitoring and measurement, change management, and continuous improvement. These are defined as follows:

a) ***Safety performance monitoring and measurement*** requires operators to develop and maintain the means to verify safety performance and the efficacy of safety risk controls;

b) ***Change management*** is a formal process to identify changes within an organization that may affect a previously established process. Such a process ensures safety performance is maintained when changes occur and modifies or eliminates safety risk controls as necessary to maintain safety performance;

c) ***Continuous improvement*** is a formal process to identify causes of poor performance that do not meet the specifications of an operational activity and to determine the actions necessary to ensure safety performance meets or exceeds expectations.

Note.— Please refer to Doc 9859 for additional and extensive guidance for the establishment and maintenance of a safety assurance component.

Selecting Safety Performance Indicators (SPIs)

Core activity:
Selecting safety performance indicators

5.4.73 The selection of appropriate safety indicators by an operator in agreement with the State and Authority is one of the keys to the measurement and monitoring of safety performance of a specific performance-based system or process. Such selection is a function of the degree of detail required to represent a level of system safety and should encompass both high- and low-level process outcomes. Meaningful safety indicators should be representative of the outcomes, processes and functions that characterize the safety of an operator's system. Differences in national regulations and operator flight planning systems make it particularly important that operators select indicators that are meaningful in the context of their operating environment.

Note.— Actual historical data gathered by the operator, if available, will form the basis of the indicators selected which would then be plotted on a trending graph that tracks the specific flight planning and fuel management (FPFM) processes' non-conformance, deviations, or occurrence outcomes. Together with alert and target levels set for each indicator, the safety performance of that particular activity can be monitored and measured over a given period of time.

5.4.74 For example, an operator in order to verify safety performance should identify operationally relevant high-level/high-consequence and low-level/low-consequence safety indicators which refer to the parameters that characterize the level of safety of a particular system. As previously mentioned, the potential outcomes of operationally specific hazards can provide the starting point for the development of relevant safety indicators. With this in mind, the safety indicators that may be used to characterize the level of safety in alternate aerodrome selection and fuel planning systems typically include, but are not limited to, occurrences such as:

a) landings with less than final reserve fuel remaining;

b) flights with 100 per cent consumption of contingency (plus discretionary, if applicable) fuel;

c) minimum fuel states (as defined by the operator or applicable Authority);

d) emergency fuel states (as defined by the operator or applicable Authority);

e) flight deviations (or flight completion not accomplished) on specific city pairings, due to inadequate fuel supply;

f) flights that proceeded to an alternate aerodrome to protect final reserve fuel (alternate specified in the OFP);

g) diversions to protect final reserve fuel (no alternate aerodrome specified in the OFP);

h) flights that proceeded to an en-route alternate aerodrome at decision, re-release or re-dispatch point (flights that did not continue to planned commercial destination);

i) any other indicator with the potential to typify the validity or invalidity of alternate aerodrome and fuel planning policy.

5.4.75 The safety performance of an operational activity is not typically related to the quantification of high-consequence outcomes but rather to the quantification of lower-consequence outcomes (safety performance measurement). Safety performance expresses the safety objectives related to a specific operational activity, in the form of measurable safety outcomes of specific lower-level processes. It is the quantification of the outcomes of lower-level, lower-consequence processes that provide a measure of the realistic implementation of an individual operational process beyond accident rates or regulatory compliance.

5.4.76 For example, an operator could approach an Authority with efficiency concerns related to a prescriptive fuel planning regulation applicable to its operations. The operator in our example is seeking operational flexibility in the way it conforms to a prescriptive fuel planning regulation. The Authority, on the other hand, has concerns that have arisen as the result of the outcomes or consequences related to undesired fuel states (e.g. diversions or low fuel states that impact ATM or other aeroplanes), which have occurred in other operations it oversees.

5.4.77 The Authority, in cooperation with the operator and as a prerequisite to granting an operational variation to the prescriptive regulation related to fuel planning, identifies the safety indicators in Table 5-10 derived from the operator's suite of available indicators for evaluation:

Table 5-10.

Safety performance worksheet		
Safety indicator	*Occurrence rate*	*Target*
• Landings with less than final reserve fuel remaining.	_____ instances per ____ operations	Reduce to ___ instances per ____ operations
• Flights with 100 per cent consumption of contingency (plus discretionary, if applicable) fuel.	_____ instances per ____ operations	Reduce to ___ instances per ____ operations
• Minimum fuel states (as defined by the operator or applicable Authority).	_____ instances per ____ operations	Reduce to ___ instances per ____ operations
• Emergency fuel states (as defined by the operator or applicable Authority).	_____ instances per ____ operations	Reduce to ___ instances per ____ operations
• Diversions to protect final reserve fuel (no alternate aerodrome specified in the OFP).	_____ instances per ____ operations	Reduce to ___ instances per ____ operations

5.4.78 The safety indicator values required to populate this worksheet are typically determined over a predefined monitoring period, assume prescriptive compliance with the requirements of the Authority and may include a quantitative analysis of occurrence rates for other operators in the region. For illustrative purposes, the Authority and the operator have established (during a recent monitoring period) that the contingency fuel related occurrence rate was two per 10 000 departures. This rate is then taken as the baseline performance.

Note.— This value is provided simply for illustrative purposes and does not reflect the results of an actual quantitative analysis.

5.4.79 It is important to note that any number of appropriate safety indicators (e.g. minimum fuel states, diversion rates) or a composite of all applicable indicators (e.g. total fuel planning process failures) could be used to quantify safety performance. For the purposes of this example, however, this value will be used to effectively represent the current state of operator safety performance in the region and in relation to the prescriptive fuel planning regulation. It also represents the basis for the definition of alert levels and targets that would subsequently be used to manage and monitor the performance of an operational variation. It is also important to note that although this example uses a quantitative safety performance indicator, such indicators can be expressed qualitatively or quantitatively.

5.4.80 Furthermore, once safety indicators have been selected for each corresponding indicator, an “alert” level as well as a desired improvement or “target” level need to be set. Such levels define abnormal or unacceptable occurrence rates as well as the desired or target rate for each indicator.

Note 1.— Any references to qualitative or quantitative safety indicators, alert levels or target levels of safety performance are provided for illustrative purposes only. It is the responsibility of each State, in conjunction with the operators under its jurisdiction, to develop such criteria in a manner commensurate with the particular needs and complexities of the operations it oversees.

Note 2.— Additional information related to the definition of safety indicators can be found in Doc 9859, Chapters 1 and 4.

Establishing baseline safety performance

5.4.81 In establishing the equivalent safety performance of a specific operational activity, the State and the operator must consider such factors as the level of safety performance provided by current (applicable) regulations as well as the cost/benefits of improvements to the system.

5.4.82 Also within each State, the safety performance for individual operators need not be identical, especially in the matter of desired improvement target setting. In the case of an alert setting, once the safety metrics (Mean + SD) criteria are adopted, they will be based on the individual operator's actual baseline performance. Therefore agreed safety performance should be commensurate with the complexity of an individual operator’s specific operational contexts and the availability of resources to address them.

5.4.83 Establishing baseline performance for the selected indicator (process or activity) involves collecting historical data for the indicators selected over a defined period of time. Then the mean (average performance) and standard deviation (volatility) of the occurrences are calculated which become the recent historical baseline performance. The safety performance outcome of an operator’s process would then be measured against this baseline performance, before and after implementation of performance-based element(s).

Core activity:
Establishing baseline safety performance

Alert levels

5.4.84 After the definition of appropriate safety indicators and the determination of baseline safety performance, the next step is to establish the parameters for tracking the occurrence outcomes or deviations that will ultimately reflect the safety performance of each monitored system or process. This is done to set the performance range for each indicator as well as to differentiate between acceptable and unacceptable occurrence rates. This differentiation is the key to setting the alert levels and targets used to maintain and improve system performance.

5.4.85 Alert levels are typically defined by the operator in conjunction with a monitored operational activity and effectively represent the boundary between the acceptable and unacceptable values for a given safety indicator. Practically speaking, as long as trend data within a given monitoring period indicate that occurrence rates do not exceed the set alert level, the safety performance of an operational activity can be deemed “acceptable” for that period. It is important to note that an alert level, when triggered or exceeded, implies that the occurrence rate around the alert period has reached a significantly abnormal or unacceptable trend, with respect to the SPI's historical or baseline performance.

5.4.86 Alert levels should trigger actions that will restore the safety performance of the applicable operational activity within limits and/or assess the likelihood that limits will be exceeded (if no corrective action is taken).

Target levels

5.4.87 A target improvement level, in contrast to an alert level, serves as the point at which to aim for a desired improvement in safety performance to be achieved upon completion of a defined monitoring period. The fundamental purpose of such targets is to drive down the incident rate of undesirable outcomes. With this objective in mind, an operator in conjunction with the Authority could identify safety performance target values, which are long-term, measurable objectives reflecting safety performance. Safety performance targets can then be linked to the (short-term) safety performance indicators as defined by the operator.

5.4.88 Returning to the example from 5.4.76, baseline performance values are typically based on the operator’s own historical performance data (unless the operator is new). It is from an operator’s own actual performance level that subsequent (short-term) alert and target values will be set. Industry performance values may be viable as a long-term target or benchmark provided the operator’s baseline performance is not already better than the industry average (e.g. the occurrence rate for instances where contingency fuel plus discretionary fuel is fully used should be on the order of 10^{-4} or less or ≤ one instance per 10 000 operations).

Note.— This value is provided for illustrative purposes only and does not reflect the results of an actual quantitative analysis.

5.4.89 In this case the operator could define the following safety performance target value, in relation to its baseline performance and in accordance with the requirements of the State’s civil aviation oversight authority:

- Within a specified period, improve by 5 per cent the baseline (average) mean value between the new monitoring and previous monitoring period of instances of contingency fuel occurrences per 10 000 operations (1×10^{-4}).

5.4.90 Safety performance target values indicate the desired state of a system and can be used by the State to determine if improvement levels of safety performance are being achieved. With predefined alert and target settings, it also becomes readily apparent to the operator that a qualitative/quantitative performance outcome can be derived at the end of any given monitoring period. They also provide an operator with the criteria necessary to develop action plans as the means to achieve the required targets. Such action plans typically include additional operational procedures, technologies, systems and programmes to which measures of reliability, availability, performance and/or accuracy can be specified.

5.4.91 Subsequently, the operator's progress towards target levels of safety performance provides objective evidence for the State to measure the effectiveness and efficiency that the operator's safety risk controls and/or its mitigation measures should achieve in operations. The target level achievements thus can be a reference against which the State can measure whether the operational variation results in an equivalent or improved level of compliance with the regulatory requirements.

5.5 SAFETY OVERSIGHT BY STATE

5.5.1 States and operators have different roles in tactical SRM but share a common goal: the basic objective being to ensure, to the extent possible, the safety of flight operations.

5.5.2 The State through periodic safety reviews and audits monitors the effectiveness of an operator's safety risk controls and mitigation measures related to a specific operational activity. In the case of performance-based requirements it may not be as simple as a fail/pass criterion. For each requirement there may be varying degrees of compliance depending on the complexity of the process being audited. There may be a challenge reaching agreement between the State and the operator on the proposed alert levels and/or selecting the most appropriate performance indicators. However early involvement, regular oversight, regular interaction and routine monitoring would facilitate the audit process.

5.5.3 The CAA's periodic oversight audits would include assessment of the FPFM processes and activities, primarily the FPFM SPIs. This would follow a thorough evaluation of the operator's alert level breaches and/or the target performances achieved.

5.5.4 Another way to facilitate the audit process is that when the operator develops FPFM process specific risk mitigation matrices, it could do so in conjunction with the regulator. As an example, Figure 5-10 relates specific operator actions to the safety risk index derived from an operator's tactical SRM component. Such associations between the State and the operator with predefined actions ensure effective management of responsibilities related to risk management. This also ensures that the operator's mitigation strategies perform to an acceptable standard.

5.5.5 In summary, the regulatory oversight processes of the State's Authority should have sufficient fidelity and sophistication to qualitatively and, when practicable, quantitatively assess the design and performance of the operator's alternate aerodrome selection and fuel planning systems and related processes. The Authority should also have sufficient access to the expertise and knowledge necessary to assess appropriately the overall safety performance of the operator as well as the operator's ability to avoid breach of alert levels and meet improved safety performance targets.

EXAMPLE ONLY	
Risk level	*Operator action*
Unacceptable	Requires immediate action to eliminate, reduce, mitigate or transfer the risk.
Tolerable	Requires action to control and mitigate the risk.
Acceptable with Review	May be acceptable — after review of the operation; may be acceptable with review by appropriate Authority; requires tracking and probable action.
Acceptable	Continue data collection, trending, and continuous improvement.

Figure 5-10.

5.6 SUMMARY

5.6.1 This chapter described the core criteria for capable operators and illustrated how such operators can use performance-based safety data to support an application (safety case) for consideration to vary from an existing or basic prescriptive regulatory standard or requirement. States should, however, carefully assess the operational capability of each operator and the fidelity of their own oversight processes when approving variations. Additionally, prescriptive regulations should continue to be used as the baseline for new operations until operators gain sufficient operational experience to provide the necessary data-based safety performance indicators to support any variation considerations. Figure 5-11 summarizes the process of developing and implementing performance-based variations.

5.6.2 The appendices to this chapter contain examples of the additional specific criteria, processes and safety risk controls used by States and operators in support of performance-based regulations or operational variations from existing regulations. The examples are excerpted from regulations that are already in use around the world and offer insights to States and operators who wish to develop comparable operational variations. Together with the reference material illustrated in Figure 5-12, the examples should provide sufficient basis for States and operators to determine whether or not they are positioned to implement operational variations that require demonstrable capabilities as well as a demonstration of safety performance relative to equivalent standards of performance.

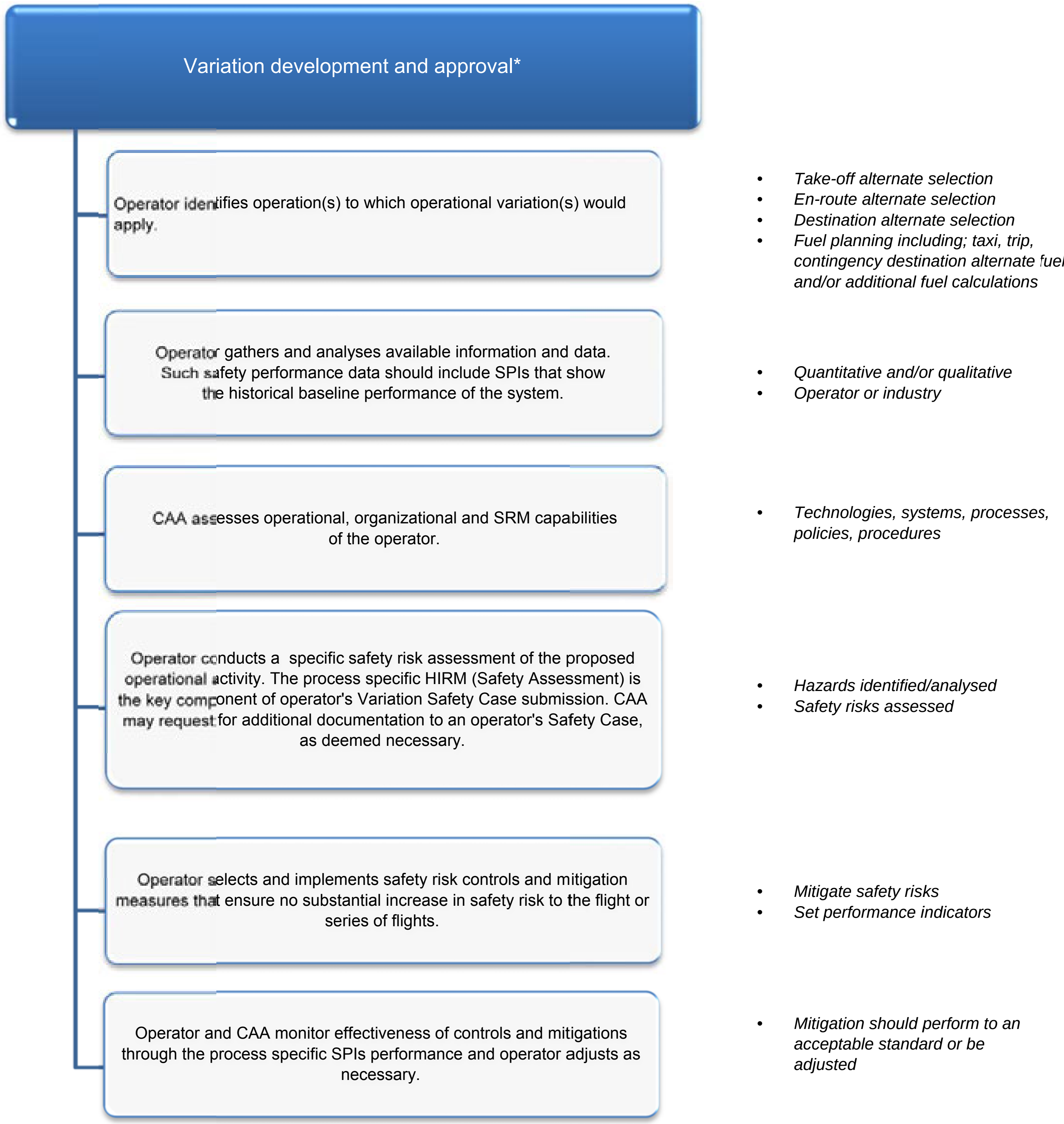


Figure 5-11.

**Note.— Appendix 7 to this chapter contains a performance-based planning job-aid for use by an approving CAA. It summarizes the criteria that should be considered during the implementation of performance-based regulations or variations from existing prescriptive regulations.*

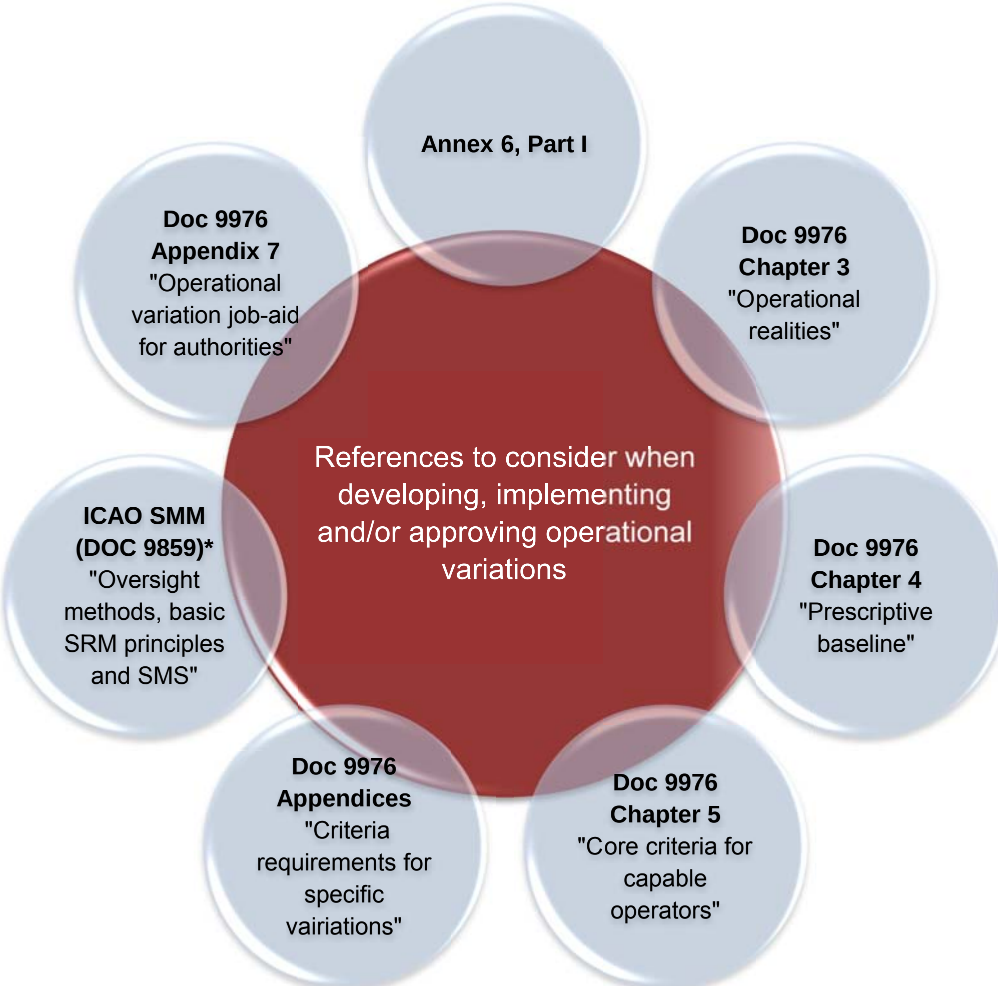


Figure 5-12. Source references to consider during development or approval of performance-based variations

**Note.— Doc 9859 is an invaluable resource for guidance related to the design and application of the SRM principles intrinsic in performance-based system design. As such, it should be used as a source reference by States and operators alike during the development and implementation of performance-based variations to the prescriptive alternate aerodrome selection and fuel planning SARPs of Annex 6, Part I.*

— — — — — — — —

Appendix 1 to Chapter 5

EXAMPLE OF REQUIREMENTS FOR AN OPERATIONAL VARIATION FROM ANNEX 6, PART I, 4.3.4.1.2 — TAKE-OFF ALTERNATE AERODROMES

1. INTENT OF PRESCRIPTIVE CRITERIA AND EXPECTED OUTCOMES OF A VARIATION

The overall intent of Annex 6, Part I, 4.3.4.1.2, is to minimize the exposure time to an aeroplane operating with one engine inoperative by nominating a take-off alternate aerodrome within a prescribed flight time from the aerodrome of departure. Operational variations may be necessary as many civil aviation authorities derive maximum take-off alternate aerodrome diversion distances using a fixed speed schedule based on the maximum certificated gross mass of the aeroplane.

Annex 6, Part I, 4.3.4.4, describes the means by which capable operators can vary from Standard 4.3.4.1.2 using performance-based methods and a performance-based approach to regulatory compliance. This appendix addresses the additional criteria requirements, processes, mitigation measures, safety risk controls and/or other demonstrable capabilities specific to the application of a variation. They should be considered within the context of the core capabilities and safety risk assessment activities described in Annex 6, Part I, 4.3.4.4, and Chapter 5 of this manual.

2. GENERAL

Overall, Annex 6, Part I, 4.3.4.1.2, specifies that, when required, take-off alternate aerodromes shall be located within prescribed flight times considering the actual take-off mass of the aeroplane regardless of the type of operation. Provisions 4.3.4.1.2 a) and b) further specify that a take-off alternate aerodrome shall be located at a distance equivalent to the relevant flight time based on a speed determined from the aeroplane operations manual (AOM), calculated in ISA and still-air conditions using the actual take-off mass of the aeroplane, the distance to be calculated being dependent on the number of engines fitted to the aeroplane.

Lastly, 4.3.4.1.2 c) takes into account the operator's extended diversion time operations (EDTO) that are unable to provide a take-off alternate aerodrome within the distances prescribed in 4.3.4.1.2 a) or b) due to the physical remoteness of the departure aerodrome from an available alternate. In such situations operators may seek to nominate a take-off alternate aerodrome at a greater distance in order to allow for a planned EDTO.

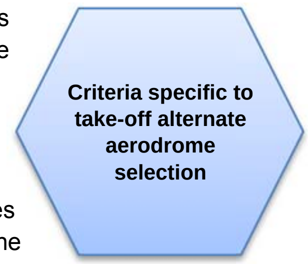
In short, Annex 6, Part I, 4.3.4.1.2 a), b) and c) flight times and associated diversion distances are all based on a speed calculated using actual take-off mass of the aeroplane. The AOM, however, may specify large variations in the economical cruising speed dependent upon the mass of the aeroplane. For this reason an operator may determine that an aerodrome suitable for use as a take-off alternate when the aeroplane is operating at maximum gross mass may fall outside of the distance specified in the Standards when the aeroplane is operating at lower masses.

States having the knowledge and expertise to monitor and approve operator performance should consider allowing competent operators to nominate a take-off alternate aerodrome for all operations (including EDTO) at a distance based on a cruise speed obtained from the AOM using the aeroplane's maximum gross mass provided the operator can demonstrate that the time of flight to the alternate aerodrome shall not exceed that specified in Annex 6, Part I, 4.3.4.1.2.

As the intent of the Standard is to minimize the exposure time to an aeroplane operating with one engine inoperative, the operator would need to demonstrate that operating at a fixed speed schedule would not adversely affect the operation of the aeroplane with one engine inoperative.

In all cases the application of a variation should be based on a safety case presented by the operator to the Authority that would, at a minimum, include the results of a specific safety risk assessment addressing the criteria of Annex 6, Part I, 4.3.4.4 a) through f). Additionally, where the application of an operational variation is contingent on the use of other processes or methods, the inter-relationships between methods or systems should be addressed in operator policy and procedure. This is especially important as the mitigation measures necessary to address a particular variation may be imbedded in other approved processes or methods (e.g. EDTO).

3. SPECIFIC CRITERIA, MITIGATION MEASURES AND/OR SAFETY RISK CONTROLS FOR OPERATIONAL VARIATIONS FROM TAKE-OFF ALTERNATE AERODROME SELECTION REGULATIONS



States having the knowledge and expertise to monitor and measure an operator's performance should consider allowing capable operators to nominate a take-off alternate aerodrome based on the use of a fixed speed schedule. Such approval should be subject to the presence of core criteria for performance-based variations described in Chapter 5 of this manual and the following additional criteria:

- The available information for the take-off alternate aerodrome indicates that, at the estimated time of use, the conditions will be at or above the adequate minima as prescribed by the State of the Operator and in accordance with Annex 6, Part I, 4.3.4.1.3.

- The operator has an engine trend monitoring system in place. The allowable in-flight shut down (IFSD) rate should not be less than that specified for EDTO.

- The operator is able to maintain direct two-way communications with the aeroplane.

- The operator should demonstrate that a failure of one engine will not result in a total loss of redundancy for other airworthiness critical systems.

- The maximum distance to the take-off alternate aerodrome does not exceed that prescribed by the State of the Operator.

4. TAKE-OFF ALTERNATE AERODROME SELECTION PROCESSES

States that consider allowing operational variations from take-off alternate aerodrome regulations should base such approvals on the presence of specific operator processes designed to mitigate the potential safety risks that could affect a flight or series of flights. In all cases the aim of the operator's internal processes and controls should be to ensure that there is, to the greatest extent practically possible, no increase in safety risk to an aeroplane departing without a take-off alternate aerodrome within the exact distance prescribed in Annex 6, Part I, 4.3.4.1.2.

An operator should not be required to consider multiple independent failures when assessing the risks associated with such operations. Where, however, the failure of an engine will increase the likelihood of a subsequent failure that could affect the airworthiness of the aeroplane, the operator should not operate unless the take-off alternate aerodrome is within the limits prescribed by the Standards. Such determinations are practically accomplished in operations through the application of the aeroplane Minimum Equipment List (MEL) or Configuration Deviation List (CDL).

Operators who wish to vary from the prescriptive requirements of the Standards related to the nomination of a take-off alternate aerodrome or nominate a take-off based on the use of a fixed speed schedule should demonstrate the following specific processes in addition to those specified in Chapter 5 of this manual:

- ***Suitable alternates:*** A process to classify aerodromes that are suitable for use as take-off alternate aerodromes. The operator should seek to nominate take-off alternate aerodromes that are as close to the point of departure as reasonably possible.

— — — — — — — —

Appendix 2 to Chapter 5

EXAMPLE OF REQUIREMENTS FOR OPERATIONAL VARIATIONS FROM ANNEX 6, PART I, 4.3.4.3 — DESTINATION ALTERNATE AERODROMES

1. INTENT OF PRESCRIPTIVE CRITERIA AND EXPECTED OUTCOMES OF A VARIATION

The overall intent of Annex 6, Part I, 4.3.4.3, is to ensure to the greatest practical extent that a usable runway will be available to an aeroplane when needed. This is accomplished using the prescriptive approach to regulatory compliance by stipulating the conditions that trigger the nomination of one or more alternate aerodromes or the carriage of fuel to wait for conditions to improve at an isolated aerodrome. The prescriptive approach, however, does not take into account limitations of infrastructure, operational capabilities or other factors that may preclude the nomination of destination alternate aerodrome(s) exactly as specified. Additionally, it does not recognize the multi-layered defenses deployed by modern-day operators to ensure, to the greatest practical extent, that a usable runway will be available to an aeroplane when needed even if a destination alternate aerodrome or combination of destination alternates cannot be nominated in accordance with prescriptive criteria.

Annex 6, Part I, 4.3.4.4, describes the means by which capable operators can vary from Annex 6, Part I, 4.3.4.3, using a performance-based approach to regulatory compliance. This appendix addresses the additional criteria, processes, mitigation measures, safety risk controls and/or other demonstrable abilities specific to the application of a variation. They should be considered within the context of the safety risk assessment activities and capability assessments described in Annex 6, Part I, 4.3.4.4, and Chapter 5 of this manual.

2. GENERAL

Annex 6, Part I, 4.3.4.3, specifies when a destination alternate aerodrome should be nominated on the operational and Air Traffic Services (ATS) flight plan. The State of the Operator may, however, in accordance with 4.3.4.4, vary from the prescribed requirements of 4.3.4.3. The following guidance material should be used as an example by States when considering operational variations from destination alternate aerodrome criteria and does not encompass every potential variation that may be implemented by a State's Authority or sought by an operator.

In all cases the application of an operational variation should be based on a safety case presented to the Authority by the operator that would at a minimum include the results of a specific safety risk assessment addressing the criteria of 4.3.4.4 a) through f). Additionally, where the application of an operational variation is contingent on the use of other processes or methods, the inter-relationships between methods or systems should be addressed in operator policy and procedure. This is especially important as the mitigation measures necessary to address a particular variation may be embedded in other approved processes or methods (e.g. single runway at destination associated with DP planning).

3. SPECIFIC CRITERIA, MITIGATION MEASURES AND/OR SAFETY RISK CONTROLS FOR OPERATIONAL VARIATIONS FROM DESTINATION ALTERNATE AERODROME SELECTION REGULATIONS

States having the knowledge and expertise to monitor and measure operator performance should consider allowing competent operators to nominate a destination alternate aerodrome under conditions that vary from the prescribed requirements of Annex 6, Part I. Such approval should be subject to the presence of core requirements for performance-based variations described in Chapter 5 of this manual and the following additional criteria for:

Criteria specific to no-destination alternate operations

- ***No-destination alternate operations to aerodromes without two separate runways or without a nominated instrument approach procedure:*** Annex 6, Part I, 4.3.4.3.1 a) requires the nomination of an alternate aerodrome where the planned destination does not have two or more runways configured such that if one runway is closed, operations to the other runway(s) will not be affected. Additionally, it prescribes that although VMC conditions may be forecast, at least one runway must have an operable instrument approach procedure. It does not, however, take into account limitations of infrastructure or the capabilities of the operator to assess the likelihood that a usable runway will be available and/or a landing can be accomplished under VMC at the estimated time of use.

  Accordingly, an operator may seek to vary from 4.3.4.3.1 b) to the extent necessary to complete a planned operation as long as there is no appreciable increase in safety risk to the flight. With this in mind, a flight that is planned to operate to an aerodrome that has a single runway[1] or without a nominated instrument approach may be deemed by a State's Authority to meet the intent of Annex 6, Part I, 4.3.4.3.1 subject to the application of the following criterion, which is in addition to those for all operational variations described in Chapter 5 of this manual:

  - An aerodrome is considered as having two separate runways if it has intersecting runways and the distance from the threshold to the point of intersection, on one of the runways with a straight-in approach procedure, exceeds the landing distance required, plus any required margin.

  An additional consideration for no-alternate operations to destinations without separate runways is a demonstration, based on the outcome of a specific safety risk assessment, that the operator has mitigated the risk of the runway not being available at the time of intended landing. Possible mitigation strategies typically include, but are not limited to:

  - The required minima are based on the second lowest minima approach navigation aid available and usable by the flight. Where an aerodrome has only a single approach navigation aid the minima are such as to allow the aeroplane to make a visual approach;

  - The prescribed minima take into account meteorological phenomena, other than ceiling and visibility that could impact on the safe landing of the aeroplane. Such phenomena should include the presence of thunderstorms and wind which, taking into account the intended direction of landing, exceeds the aeroplane crosswind and downwind limitations;

  - The runway lighting system has two separate power supplies. Where the runway lighting is activated by the aeroplane in flight, an alternative, ground-based means of activation should be provided. Where the use of the ground-based means of activation would result in a delay, additional holding fuel should be carried by the aeroplane sufficient to cover the period of the delay or an alternate aerodrome should be provided;

1. A single runway, in this example, is a runway that has a straight-in instrument approach at one end only.

- The aerodrome has prescribed letdown procedures available. In the case of an aerodrome that does not have a nominated instrument approach, or has only a single instrument approach, a visual letdown procedure, approved by the State, should be acceptable; and
- The operator provides additional holding fuel to cater for a short-term closure of the available runway.

Criteria specific to destinations forecast below VMC

- ***No-destination alternate operations to destinations forecast to below VMC****:* Annex 6, Part I, 4.3.5.3.1 a) 1) prescribes that a destination alternate aerodrome be nominated if an approach and landing cannot be accomplished at the destination under VMC. An operator may seek to vary from 4.3.5.3.1 a) to the extent necessary to complete planned operations to aerodromes where the meteorological conditions are forecast to be below VMC as long as there is no appreciable increase in safety risk to the flight. With this in mind a flight may be permitted to operate to an aerodrome where the meteorological conditions are forecast to be less than VMC, as prescribed by the State if at least two independent means by which a flight can conduct an approach are available that conform to one or more of the following criteria:
    - Two runways are available each with an operational instrument approach;
    - A categorized ILS should be considered as two independent approaches provided the aeroplane has two ILS receivers available;
    - GNSS approach systems may be considered as two independent means, providing the aeroplane is fitted with approved dual receivers;
    - Where approved by the State, an operator may utilize GNSS capability as a substitute for a ground-based aid providing the aid is in commission at the time of the approach and the approach is coded in the aeroplane's FMS (*Note.— There is no requirement for the aid to be serviceable.*);
    - A GNSS approach with vertical guidance may be considered as being equivalent to a CAT I ILS. In this case the GNSS approach should not be considered as two independent approaches, unless the aeroplane is fitted with approved dual receivers.

Criteria specific to destinations with CAT III or CAT II

- ***Destinations with CAT III or CAT II capability****:* An operator may seek to vary from Annex 6, Part I, 4.3.5.3.1 a) to the extent necessary to complete planned operations to aerodromes serviced by a CAT III or CAT II instrument approach when the meteorological conditions are forecast to be below VMC as long as there is no appreciable increase in safety risk to the flight. With this in mind an operator may not need to nominate a destination alternate aerodrome subject to the presence of the following criteria:
    - The meteorological conditions are forecast to be at or above CAT I minima for the time of intended use;
    - The operator maintains CAT III or CAT II authorization, as applicable, for those fleets and flight crews to which this variation would apply;
    - The intended destination aerodrome has at least one operational CAT III or CAT II approach;
    - The operator has a process to alert the flight of a change in meteorological forecast.

- ***Destination alternate operations associated with FAA OpSpec C355****:* An operator may seek to vary from Annex 6, Part I, 4.3.5.3.1 a) to the extent necessary to complete planned operations to aerodromes serviced by a CAT I or II instrument approach when the meteorological conditions are forecast to be below VMC as long as there is no appreciable increase in safety risk to the flight. With this in mind an operator may not need to nominate a destination alternate aerodrome subject to the presence of the criteria contained in the OpSpec.

> Criteria specific to operations associated with FAA OpSpec 355

Note.— FAA OpSpec C355 is included in total in Appendix 2 to Chapter 3.

- ***No destination alternate operations for operators that use Decision Point (DP) Planning****:* If an operator uses DP planning and the nominated destination has only a single runway or two different runways, a State may permit the planned operation without a requirement to nominate a destination alternate aerodrome provided the operator meets all of the requirements specified for DP planning in Appendix 3 to this chapter and applies the following additional criteria:

> Criteria specific to operators that use DP planning

  - *Destination weather minima:* The operator should ensure that the meteorological forecast for any aerodrome used for DP calculations is such that a reasonable certainty exists that a landing can be successfully completed. In order ensure a reasonable certainty exists it may not be appropriate to rely on a single NAVAID for the determination of operational minima. Where the State of the Operator does not specify operational minima based on the use of two independent NAVAIDs (see Note 1) then the operator should establish operational minima that will account for an unexpected NAVAID failure.

    Where the aerodrome of intended landing has a single runway or two different runways (see Note 2) the meteorological forecast at the time of arrival should not be less than the applicable landing minima adjusted in both ceiling and visibility as prescribed by the State of the Operator. Where the State of the Operator does not prescribe any adjustment, the operator should apply an appropriate adjustment of not less than 120 m (400 ft) to the prescribed ceiling and not less than 1 500 m to the prescribed visibility.

    Note 1.— With respect to the two independent NAVAIDs, satellite-based navigation systems may be used to meet these requirements as approved by the State of the Operator.

    Note 2.— In this example, a single runway is a runway that has a straight-in approach to one end of the runway. Circling to the opposite end of the runway may be available. Two different runways is one runway with a straight-in approach to both ends of the runways.

  - Alternate aerodromes associated with DP planning**:** Where an operator uses DP planning, processes or procedures should be in place to ensure the en-route alternate aerodromes nominated for use prior to the decision are available for the time of intended use. The following operational requirements apply when nominating an en-route alternate aerodrome for use when utilizing DP planning:

    — The fuel on board the aeroplane is sufficient to reach the nominated en-route alternate aerodrome plus any additional holding fuel required for meteorological conditions or ATC traffic holding, plus any additional fuel required for the completion of an approach plus fixed fuel reserve;

    — The nominated alternate aerodrome should be capable of supporting the operation of the aeroplane, including the availability of taxiways, parking areas, facilities to disembark passengers and crew, required ground service equipment and any other facilities required by the operator to facilitate the transit and subsequent departure of the aeroplane.

- ***Single destination alternate operations****:* Annex 6, Part I, 4.3.4.3.2 prescribes the conditions that require two destination alternate aerodromes be nominated on the operational and ATS flight plan. An operator may seek to vary from 4.3.4.3.2 to the extent necessary to complete planned operations to aerodromes when a second destination alternate cannot be nominated as long as there is no appreciable increase in safety risk to the flight. With this in mind, a flight may be permitted to operate to a destination aerodrome without the nomination of a second destination alternate, under the conditions specified in the Standard, subject to the presence of the following additional criteria:

  Criteria specific to single destination alternate operations

  - The operator conducts a route-specific hazard analysis and safety risk assessment to determine the potential hazards that pose additional safety risks to the flight;
  - The operator mitigates any safety risks that result from the route-specific safety risk assessment to a level as low as reasonably practicable;
  - Where mitigation measures are not sufficient to lower the safety risk to acceptable levels, a second alternate aerodrome should be provided.

- ***Two-destination alternate operations associated with FAA Exemption 3585****:* Annex 6, Part I, 4.3.4.3.2 prescribes the conditions that require two destination alternate aerodromes be nominated on the operational and ATS flight plan. The Standard, however, does not address conditional remarks (TEMPO, PROB, or BECMG) contained in meteorological forecasts that are below operating minima thus rendering a destination or alternate aerodrome unusable for dispatch purposes. An operator may seek to vary from 4.3.4.3.2 to the extent necessary to complete planned operations to aerodromes when conditional remarks contained in meteorological forecasts indicate that the aerodrome may be below operating minima as long as there is no appreciable increase in safety risk to the flight.

  Criteria specific to operations associated with FAA Exemption 3585

  With this in mind, a flight may be permitted to operate to a destination aerodrome based on the presence of conditional remarks that are below operating minima in the forecast for the destination and/or first alternate aerodrome subject to the presence of the following additional criteria:

  - Forecast prevailing meteorological conditions are at or above the operator's established operating minima for the operation at the estimated time of use at both the destination and alternate;
  - A second alternate aerodrome is nominated on the operational and ATS flight plans;
  - Conditional phrases in the forecast for the destination aerodrome must be no less than half the weather minimum for the expected approach (e.g. if an ILS approach with an 800 m [*half mile*] visibility minimum is expected to be used, then the conditional remarks in the forecast cannot list anything below 400 m [*quarter mile*]);
  - Conditional phrases for the first alternate aerodrome must be no less than half that required to file as an alternate;
  - For the second alternate, the worst meteorological forecast controls.

4. ALTERNATE AERODROME SELECTION PROCESSES

States that consider allowing operational variations from destination alternate aerodrome regulations should base such approvals on the presence of specific operator processes designed to mitigate the potential safety risks that could affect a flight or series of flights. In all cases the aim of the operator's internal processes and controls should be to ensure that there is, to the greatest practical extent, no increase in safety risk to an aeroplane as the result of an operational variation. Additionally, an operator should not be required to consider multiple independent failures when assessing the risk associated with the operation.

Operators who wish to vary from the prescriptive requirements of the Standard related to the nomination of a destination alternate aerodrome should demonstrate the following specific process in addition to those specified in Chapter 5 of this manual:

- ***Suitable alternate aerodromes:*** A process to classify aerodromes that are suitable for use as destination alternate aerodromes.

— — — — — — — —

Appendix 3 to Chapter 5

EXAMPLES OF REQUIREMENTS FOR FLIGHT PLANNING PROCESSES THAT DEPEND ON THE ADVANCED USE OF ALTERNATE AERODROMES IN ACCORDANCE WITH ANNEX 6, PART I, 4.3.6

1. INTENT OF PRESCRIPTIVE CRITERIA AND EXPECTED OUTCOMES OF A VARIATION

The overall intent of Annex 6, Part I, 4.3.6, is to ensure to the greatest practical extent that sufficient fuel is carried to complete a flight safely, allowing for planned deviations from the route in accordance with the balance of the criteria contained in the SARPs. This is accomplished using the prescriptive approach to regulatory compliance by strict adherence to regulations based on the ensuing SARPs that allocate and define the quantities of fuel to be carried.

The prescriptive approach, however, does not take into account limitations of infrastructure, operational capabilities or other factors that shaped the development of existing national fuel regulations. These factors may preclude the determination of total fuel required exactly as specified in the applicable provisions of 4.3.6. Additionally, the prescriptive approach does not recognize the multi-layered defenses deployed by modern-day operators to ensure, to the greatest practical extent, that sufficient fuel will be uplifted even if it is not allocated in strict accordance with the prescriptive criteria of the SARPs.

Annex 6, Part I, 4.3.6.6, describes the means by which such operators can vary from the applicable SARPs of Annex 6, Part I, 4.3.6 using performance-based methods and a performance-based approach to regulatory compliance. This appendix addresses the additional criteria requirements, processes, mitigation measures, safety risk controls and/or other demonstrable abilities specific to the application of an operational variation associated with the specific flight planning methods described herein. They should be considered within the context of the safety risk assessment activities and capability assessments described in Annex 6, Part I, 4.3.6.6, and Chapter 5 of this manual.

2. INTRODUCTION

Decision Point (DP), Pre-Determined Point (PDP) and 3% ERA planning methods are discussed in this appendix as they are representative of flight planning methods already approved by CAAs and used by operators to address the minimum fuel requirements of Annex 6, Part I, 4.3.6. These methods were independently developed by States and operators to address many of the operational realities intrinsic to the determination of a national fuel policy. They illustrate a need for operational flexibility and efficiency in flight planning that may prompt States to implement operational variations from regulations based on the Annex 6, Part I, SARPs. With this concept in mind, the descriptions in this appendix provide the operational context for the operational variations typically implemented in conjunction with such planning methods.

The descriptions that follow also illustrate the level of sophistication necessary during data collection and analysis to support to DP, PDP and 3% ERA planning. The data collection requirements and quantitative data analysis methods can also be used by operators to provide the foundation for operational SRM activities while providing States with confidence in the ability of the operator to maintain safety performance in relation to specified targets or levels.

The following descriptions of flight planning methods are provided for guidance purposes only since exact specifications may vary and should be developed by operators in conformance with the requirements of the State. Additionally, the following examples do not encompass every potential method that may be approved by a State’s Authority or implemented by an operator.

3. DECISION POINT (DP) PLANNING

Aeroplanes that operate across routes approaching the limits of their range may utilize DP planning to maximize payload uplift while maintaining acceptable levels of safety performance. DP planning is a system of flight planning used by operators whereby an aeroplane is planned and filed to a destination via one or more decision points. Prior to crossing each decision point the PIC assesses the aeroplane serviceability, the meteorological conditions, and any other known factors that may affect the flight before deciding whether to continue to the aerodrome of intended landing or divert to the nominated en-route alternate aerodrome. The system is applicable to both airways and free flight navigation (Figure 5-A3-1).

Prior to the final decision point the aeroplane is always in range of at least one aerodrome that has been approved and is suitable for use by the operator. Once past the final DP, however, the aeroplane may not have the operational capability to divert to an alternate aerodrome. As such the aeroplane serviceability, meteorological and aerodrome conditions should ensure a reasonable certainty exists that a successful landing will be completed at the destination or nominated destination alternate aerodrome prior to crossing the final decision point.

With routine operations over long-range sectors, the accuracy of the destination meteorological forecast at the time of departure is a significant factor in the planning process. DP planning can mitigate the effects of forecasting inaccuracies as the aeroplane will receive updated meteorological information prior to crossing each decision point. The flight will then continue to the destination on the basis of this updated information, which will have a higher degree of accuracy than the reports originally received during flight planning.

To maximize the benefits of DP planning the calculation of contingency fuel is normally based on ”the advanced use of alternate aerodromes” in accordance with Annex 6, Part I, 4.3.6.6 b) ii). Operator and flight crew policy and procedure ensure that the loaded pre-flight fuel is managed by prescribing that, at all times, the flight after take-off has sufficient fuel to reach a suitable aerodrome (destination or alternate) with required reserves plus the required contingency fuel. If the minimum fuel requirements cannot be maintained, operator policy and procedure typically require the flight crew to divert to the en-route alternate aerodrome.

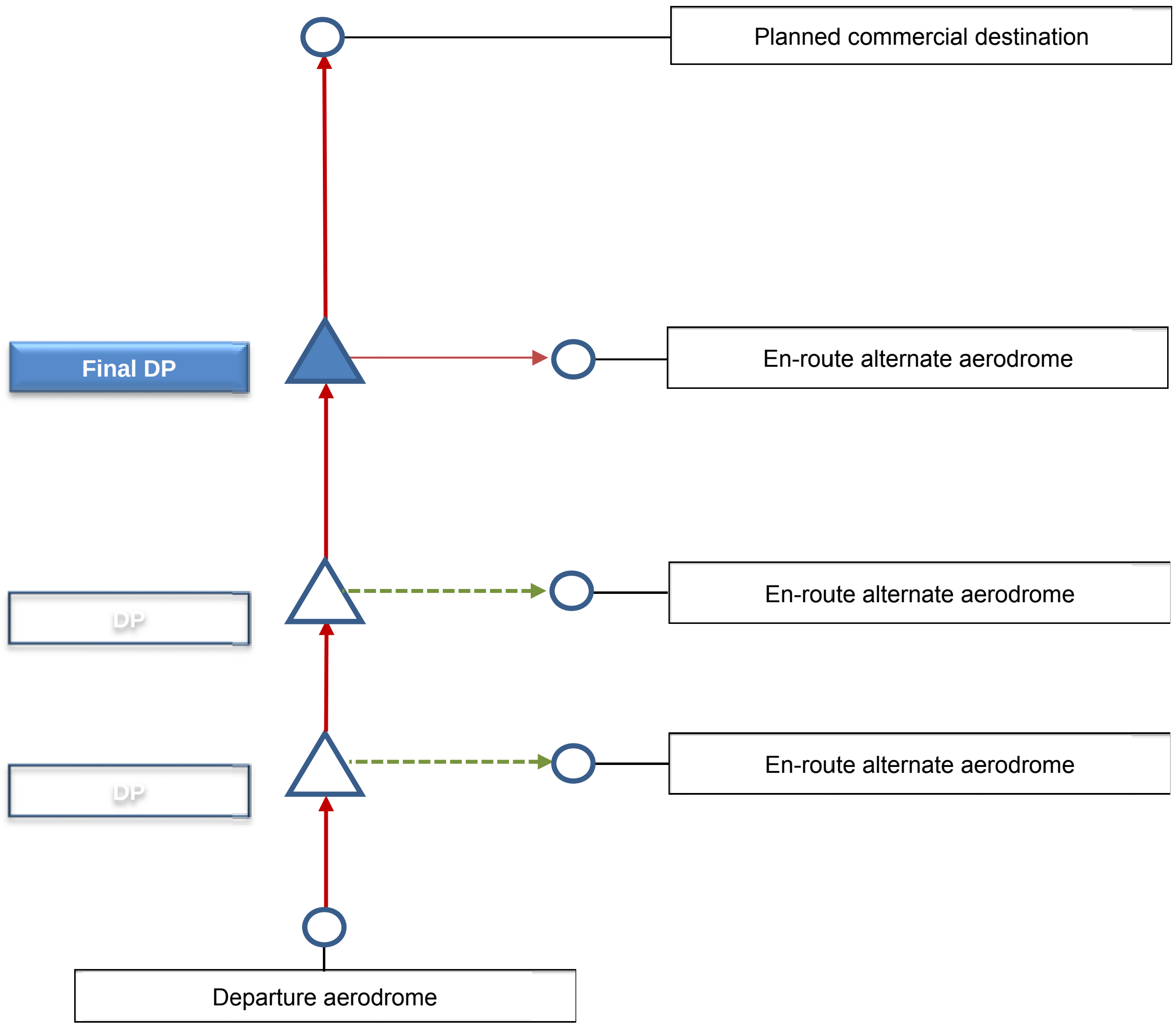


Figure 5-A3-1. Decision Point (DP) planning

The following fuel calculation example illustrates how total fuel is derived to conform to the minimum fuel requirements of Annex 6, Part I, 4.3.6. Total fuel is:

the sum of:

a) taxi fuel;

b) trip fuel (including fuel for foreseen contingencies — Annex 6, Part I, 4.3.6.2 b) from the departure aerodrome to the destination aerodrome in accordance with Annex 6, Part I, 4.3.6.3 b));

c) contingency fuel based on required trip fuel from the final DP to the destination and alternate aerodromes, if applicable. This (contingency) fuel calculation is based on the *"advanced use of alternate aerodromes"* in accordance with Annex 6, Part I, 4.3.6.6 b) ii) and may be capped to a maximum quantity;

d) fixed fuel reserve;

e) alternate fuel (if required);

f) holding fuel (where required by the State to account for known ATC and weather delays);

g) additional fuel if required to conform with Annex 6, Part I, 4.3.6.3 d);

h) discretionary fuel if required by the PIC.

DP planning can be consistent with the nomination of a destination alternate aerodrome; however, over long sectors, or in areas of limited infrastructure, DP planning may also be used as a mitigation strategy to manage the risks associated with the planned operation. Where a destination alternate cannot be planned, DP planning ensures that the decision to proceed past the last point of diversion is based on the latest available information.

The nature of DP planning and the operational context within which it is typically used may require variations from one or more elements of alternate aerodrome selection and fuel planning SARPs contained in Annex 6, Part I. Variations from these SARPs are conditional on the use of DP planning within the context of operational and organizational SRM as well as other incorporated prerequisites (systemic defenses) such as an in-flight fuel policy, an active flight monitoring system, aerodrome surveillance, and dispatch personnel and flight crew training. It is important to note that DP planning requires that at all times in-flight the aeroplane will have sufficient fuel on board to either continue to its planned destination or divert to an alternate aerodrome while conforming to the operator's approved in-flight fuel policy.

The decision point used by the flight crew is a calculated position. That is, it takes into account the planned fuel load on the aeroplane as well as the operational requirements (meteorology and holding) at both the destination and alternate aerodromes. In flight, the crew has the ability to move the decision point based on changes to the planned fuel load and changes in the operational conditions present. In this respect DP planning is a dynamic planning tool that takes into account tactical variations present.

4. SPECIFIC CRITERIA, MITIGATION MEASURES AND/OR SAFETY RISK CONTROLS FOR DP PLANNING

Criteria, mitigations and controls specific to DP planning

States having the knowledge and expertise to monitor and measure operator performance should consider allowing competent operators to conform to Annex 6, Part I, 4.3.6.1, fuel requirements and 4.3.6.3 c) using DP planning methods and associated methodologies for determining contingency fuel subject to the presence of the core requirements for performance-based variations described in Chapter 5 of this manual and the following additional criteria. The operator should:

- employ an FCM programme to monitor the actual fuel consumption rates of the specific aeroplane utilizing DP planning;

- implement an in-flight fuel management policy in accordance with Annex 6, Part I, 4.3.7 that will support the practical management of DP planning. The policy should include procedures that specify the actions to be taken by the PIC prior to the continuation of the flight beyond the decision point. These actions should include, at a minimum:

  - obtain the latest available meteorological forecasts for the aerodrome of intended landing;

  - review the fuel state of the aeroplane to ensure that there is sufficient fuel on board to meet the operational requirements at the aerodrome of intended landing. If the fuel on board is not sufficient to meet these requirements, the PIC should be required to divert to the en-route alternate aerodrome;

  - review the mechanical state of the aeroplane. If any system defect exists that could potentially affect the ability of the aeroplane to conduct a safe landing at the aerodrome of intended landing, the PIC should divert to the en-route alternate aerodrome unless the system deficiency would render a landing at the alternate more hazardous than a landing at the aerodrome of intended landing. If the deficiency would result in the same hazard being present at both the aerodrome of intended landing and the en-route alternate, the decision to continue to the aerodrome of intended landing or to divert should rest with the PIC;

  - review any other information applicable to the aerodrome of intended landing, including current NOTAM information provided by the operator's flight monitoring system or ATC. If the PIC is not satisfied that a safe landing can be completed at the aerodrome of intended landing, the PIC should divert to the en-route alternate aerodrome;

  - ensure that sufficient fuel is carried on board the aeroplane to meet all known holding requirements at the en-route aerodrome or the aerodrome of intended landing. These requirements typically include meteorological conditions, holding and nominated ATC traffic holding. For example, a State's Authority may prescribe that where the forecast meteorological conditions will be below the applicable minima for a TEMPO period, an equivalent of 60 minutes' holding fuel may be carried in lieu of fuel that would be required to divert to a suitable alternate aerodrome. With respect to the aeroplane's arrival, a time buffer should be applied to the meteorological conditions as approved by the State of the Operator;

  - consider, in addition to the forecast height of cloud base and visibility, the presence of meteorological phenomena that could affect the safe landing of the aeroplane (for example, thunderstorms). If such phenomena are forecast for the time of intended landing, the operator should ensure that sufficient fuel is carried to either divert to a suitable alternate aerodrome or hold until the meteorological phenomena are forecast to have abated such that they no longer present a threat to the safe arrival of the aeroplane.

5. DP PLANNING PROCESS AND PROCEDURES

Process and procedure specific to DP planning

Operators who wish to conform to Annex 6, Part I, 4.3.6.1 and 4.3.6.3 c), using DP planning methods and associated methodologies for determining contingency fuel should demonstrate the following processes and procedures in addition to those specified in Chapter 5 of this manual:

- ***Nomination of the Decision Point****:* A decision point, based on the planned fuel load and forecast meteorological conditions, is specified in the OFP. The operator should have processes or procedures to ensure that the route from the nominated decision point to the nominated en-route alternate aerodrome meets all ATC rules. Where User Preferred Route (UPR) procedures are available, the decision point may be at any point along the route. Where UPR procedures are not available, the decision point should be on a nominated airway available for use by the aeroplane. Once in flight the crew may recalculate the position of the decision point based on updated information. In this case the crew must be able to determine the route to be flown from the decision point to the alternate aerodrome.

- ***Actions beyond the Decision Point****:* Once an aeroplane has passed the final decision point and the aeroplane no longer has an approved en-route alternate aerodrome within range, the aeroplane can continue to the aerodrome of intended landing. The operator should have processes or procedures that address the actions to be taken in the event of any unforeseen deterioration of meteorological conditions, reduction in NAVAID availability, aeroplane system failure or any other event that increases the risk of not achieving a safe landing. These actions should be communicated to the PIC. In the event that there is any increase in risk, the PIC should transmit an urgency call (PAN PAN PAN) even though the aeroplane may still land with greater than the minimum fixed fuel reserve.

6. ADDITIONAL DEMONSTRABLE ABILITIES TO REPORT, MEASURE AND ANALYSE ESSENTIAL DATA

Reporting, measuring, and analysing data related to DP planning

An operator that utilizes a DP flight planning system should develop processes to measure and analyse data received from both ground-based sources and in-flight monitoring of aeroplane performance to verify the information used in the planning of flights. These data can then be used to identify deficiencies in the flight planning or meteorological forecasting systems that can then be corrected or mitigated against in the event that correction is not possible. In all cases the aim of any data analysis programme should be to improve overall flight planning accuracy thereby ensuring that the aeroplane will arrive with sufficient fuel on board at the aerodrome of intended landing. In order to achieve these aims, the operator should demonstrate the following capabilities:

- the ability to report, measure and analyse the essential data for the identification, analysis and mitigation of potential safety risks that could affect the outcome of flights in accordance with Chapter 5 of this manual;

- an FCM programme to monitor the actual fuel consumption rates of aeroplanes utilizing DP planning. Where the actual aeroplane fuel burn exceeds the predicted fuel burn, the higher value should be used in the computation of all flight planning data;

- where an operator's aeroplane lands at an aerodrome, and having passed the final decision point has declared an urgency situation exists due to a deterioration of the aerodrome meteorological conditions, NAVAIDs or facilities, the operator should have a process to investigate all aspects of the flight to determine if the planning of the flight was deficient. Where any flight planning deficiencies are found, the deficiencies should be remedied immediately.

7. PRE-DETERMINED POINT (PDP) PLANNING

The Pre-Determined Point (PDP) is another method of flight planning that ensures an aeroplane carries sufficient fuel to complete a planned flight safely in accordance with Annex 6, Part I, 4.3.6. PDP planning does not allow the recalculation of the pre-determined point and may in fact not necessarily aim to optimize the fuel use of the flight. PDP planning is typically used to provide a control gate whereby the operator or crew make a decision to continue or divert prior to passing the nominated point. Unlike DP planning where the decision point is a calculated position that will vary with each flight, PDP planning utilizes a fixed point nominated by the operator. PDP planning is, therefore, a more prescriptive version of DP planning wherein only one scenario allows continuation towards the intended destination when reaching the pre-determined point. The method for the calculation of reserve fuel may also be based on the *"advanced use of alternate aerodromes"* but differs from the methodology used in DP planning.

PDP planning is intended to be used where the distance between the destination aerodrome and the destination alternate aerodrome is so great that carrying alternate fuel as described in the SARPs would not be possible. It may also be used where operational requirements dictate that it is desirable to make a final go/no go decision at a point in time after the aeroplane has departed. PDP brings the decision to divert to the destination alternate aerodrome back from the destination initial approach fix (IAF) to the defined pre-determined point. When continuing beyond this decision point towards the destination, fuel to fly for two hours at cruising altitude over destination may be required to mitigate unforeseen safety risks associated with an inability to complete a successful approach and landing at the time of intended landing at the destination (Figure 5-A3-2).

The following example of required fuel calculation illustrates how total fuel is derived to conform to the minimum fuel requirements of Annex 6, Part I, 4.3.6. If an operator's fuel policy includes planning to a destination alternate aerodrome where the distance between the destination aerodrome and the destination alternate aerodrome is such that a flight can only be routed via a pre-determined point to one of these aerodromes, the amount of usable fuel, on board for departure, should be the greater of 1) or 2) below:

1) the sum of:

a) taxi fuel;
b) trip fuel from the departure aerodrome to the destination aerodrome (including fuel for foreseen contingencies — Annex 6, Part I, 4.3.6.2 b)), via the pre-determined point;
c) contingency fuel calculated in accordance with Annex 6, Part I, 4.3.6.2 c);
d) additional fuel if required, but not less than fuel to fly for two hours at normal cruise consumption above the destination aerodrome. This is not to be less than final reserve fuel; and
e) discretionary fuel if required by the PIC.

or

2) the sum of:

a) taxi fuel;
b) trip fuel from the departure aerodrome to the destination alternate aerodrome (including fuel for foreseen contingencies — Annex 6, Part I, 4.3.6.2 b)), via the pre-determined point;
c) contingency fuel calculated in accordance with Annex 6, Part I, 4.3.6.2 c);
d) discretionary fuel if required by the PIC; and
e) additional fuel if required, but not less than:
   i) for aircraft with reciprocating engines: fuel to fly for 45 minutes; or
   ii) for aircraft with turbine engines: fuel to fly for 30 minutes at holding speed at 1 500 ft (450 m) above the destination alternate aerodrome elevation in standard conditions. This is not to be less than final reserve fuel.

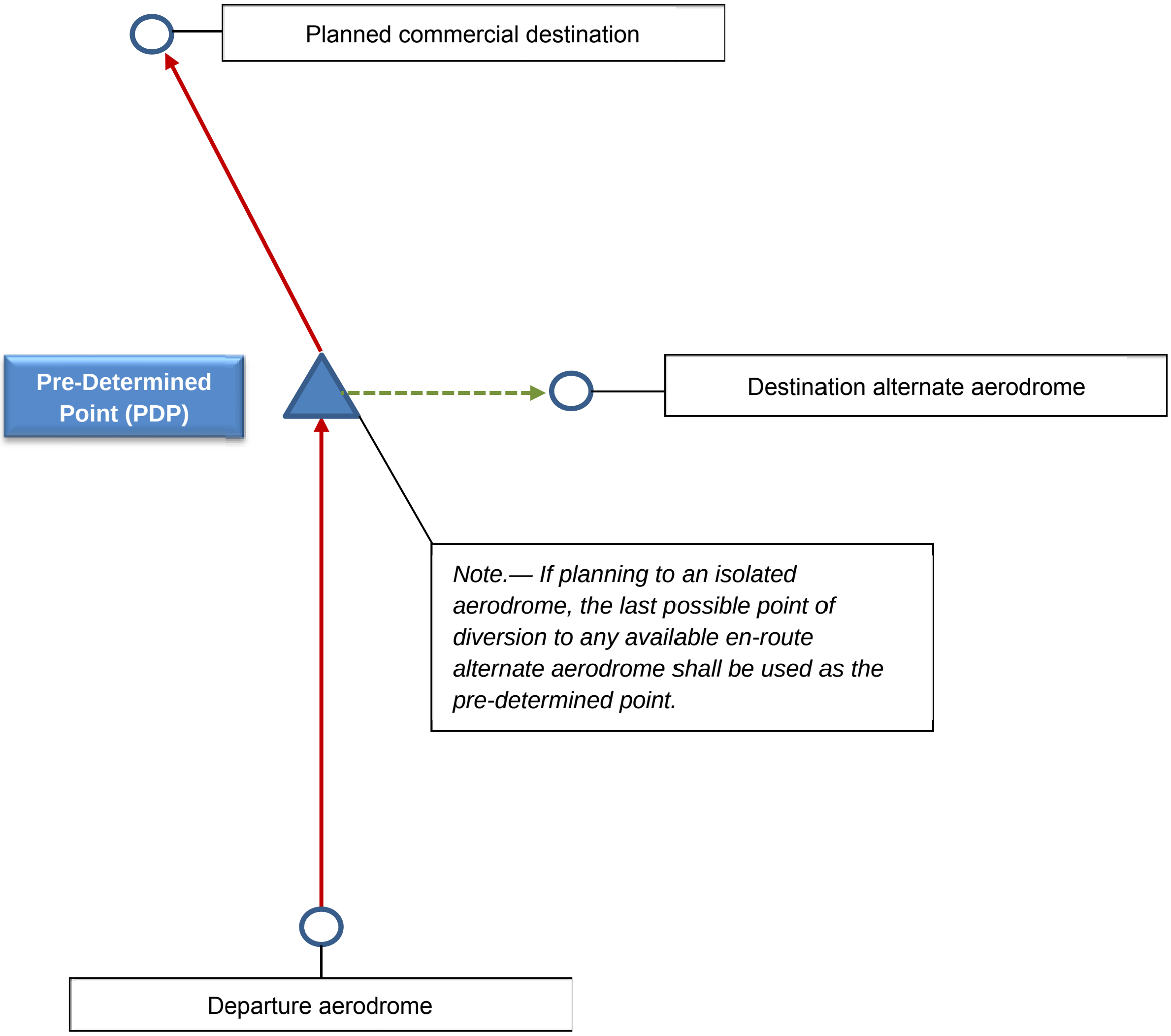


Figure 5-A3-2. Pre-Determined point (PDP) planning

8. SPECIFIC CRITERIA REQUIREMENTS, MITIGATION MEASURES AND/OR SAFETY RISK CONTROLS FOR PDP PLANNING

Criteria, mitigations and controls specific to PDP planning

States having the knowledge and expertise to monitor and measure operator performance should consider allowing competent operators to conform to Annex 6, Part I, 4.3.6, fuel requirements and 4.3.6.3 c) using performance-based PDP flight planning methods and associated methodologies for determining contingency fuel, subject to the presence of the core requirements for performance-based variations described in Chapter 5 of this manual and the following additional criteria. The operator should:

- implement an in-flight fuel management policy in accordance with Annex 6, Part I, 4.3.7, that will support the practical management of PDP planning. The policy should include procedures that specify the actions to be taken by the PIC prior to the continuation of the flight beyond the pre-determined point. If an operator's fuel policy includes planning to an isolated aerodrome, the last possible point of diversion to any available en-route alternate aerodrome should be used as the pre-determined point.

- apply the criteria specified in Sections 3 and 4 of this appendix for DP planning although the State of the Operator may accept some simplification due to the prescriptive nature of PDP planning.

9. PDP PLANNING PROCESS AND PROCEDURES

Process and procedure specific to PDP planning

An operator, when proposing the use of a PDP flight planning system, develops processes and controls whereby the data used during the pre-flight planning and in-flight management of the aeroplane have the required integrity to ensure the safe operation of the aeroplane. Additionally, an operator's PDP planning system demonstrates the following processes and controls in addition to those specified in Chapter 5 of this manual:

- the process and procedures specified in Section 5 of this appendix for DP planning, although the State of the Operator may accept some adaptation and simplification due to the prescriptive nature of PDP planning.

10. DEMONSTRABLE ABILITY TO REPORT, MEASURE AND ANALYSE ESSENTIAL DATA

Reporting, measuring and analysing data related to PDP planning

An operator that utilizes a PDP planning system develops processes to measure and analyse data received from both ground-based sources and in-flight monitoring of aeroplane performance to verify the information used in the planning of flights. These data can then be used to identify deficiencies in the flight planning or meteorological forecasting systems that can then be corrected or mitigated against in the event that correction is not possible. In all cases the aim of any data analysis programme should be to improve overall flight planning accuracy thereby ensuring that the aeroplane will arrive with sufficient fuel on board at the aerodrome of intended landing.

In order to achieve these aims the operator should demonstrate the following:

- the ability to report, measure and analyse the essential data for the identification, analysis and mitigation of potential safety risks that could affect the outcome of flights in accordance with Chapter 5 of this manual.

- the criteria requirements and mitigation measures specified in section 1 of this appendix for DP planning, although the State of the Operator may accept some simplification due to the prescriptive nature of PDP planning.

11. 3% ERA (EN-ROUTE ALTERNATE) CONTINGENCY FUEL PLANNING:

3% ERA is a performance-based means to conform to Annex 6, Part I, 4.3.6.3 c), which permits contingency fuel to be determined based on the *"advanced use of alternate aerodromes*" in accordance with Annex 6, Part I, 4.3.6.6 b) ii). 3% ERA is similar to in-flight re-planning in that it requires the mandatory selection in the OFP of an ERA located along the second part of the trip and before the destination aerodrome. This designation of the ERA is predicated on the qualitative and quantitative assumption that, even if the 3% ERA contingency fuel is used before reaching the planned commercial destination, there would be sufficient fuel on board to land at the ERA with final reserve fuel on board.

3% ERA developed from the quantitative determination that more conservative or prescriptive planning methods result in the carriage of excess fuel on long-haul flights. Such determinations are based on continual monitoring of fuel at destination for all flights to ensure, to the extent reasonably practicable, that future flights carry sufficient fuel, including contingency fuel and final reserve fuel, to complete the planned flight safely.

12. CRITERIA FOR PERFORMANCE-BASED 3% EN-ROUTE ALTERNATE (ERA) CONTINGENCY FUEL PLANNING

States having the knowledge and expertise to monitor and measure operator performance should consider allowing competent operators to conform to Annex 6, Part I, 4.3.6.3 c), using 3% ERA subject to the presence of the core requirements for performance-based variations described in Chapter 5 of this manual and the following additional criteria. The operator should:

- employ a hull-specific FCM programme to monitor the actual fuel consumption rates of the specific aeroplane utilizing 3% ERA contingency fuel;

- implement an in-flight fuel management policy in accordance with Annex 6, Part I, 4.3.7, that will support the practical management of the 3% ERA aerodrome. The policy should give the flight crew specific instructions regarding the best course of action in the case when contingency fuel is totally used before reaching the destination aerodrome;

- select an aerodrome for the purpose 3% ERA contingency fuel only when the appropriate meteorological reports or forecasts, or any combination thereof, indicate that, during a period commencing one hour before and ending one hour after the estimated time of arrival at the 3% ERA aerodrome, the meteorological conditions will be at or above the operator's approved planning minima;

- limit the use of the 3% ERA to meteorological conditions at or above applicable landing minima;

- ensure the 3% ERA aerodrome is located within a circle having a radius equal to 20 per cent of the total flight plan distance, the centre of which lies on the planned route at a distance from the destination aerodrome of 25 per cent of the total flight plan distance, or at least 20 per cent of the total flight plan distance plus 50 nm, whichever is greater, all distances are to be calculated in still-air conditions (see Figure 5-A3-3).

Note.— There is no fuel calculation linked to the location of the ERA. The location of the ERA in the defined circle allows by definition a safe landing at the ERA if diversion happens from cruise level during the second half of the trip.

13. 3% ERA PROCESSES

Operators who wish to conform to Annex 6, Part I, 4.3.6.3 c), using 3% ERA should demonstrate the following processes and controls in addition to those specified in Chapter 5 of this manual:

- process and procedures for determining the period of use and that define a method of calculation of the estimated time of arrival at the 3% ERA aerodrome. During the period commencing one hour before and ending one hour after the time of arrival at the 3% ERA aerodrome, the meteorological conditions will be at or above the operator's approved planning minima. The period of use of the 3% ERA aerodrome should also be specified on the OFP;

- processes or procedures that address complete contingency fuel consumption (plus discretionary, if applicable) before reaching the destination aerodrome including the actions to be taken in the event of such a situation. The PIC should also have clear guidance on when to divert to the 3% ERA or to another suitable aerodrome.

14. DEMONSTRABLE ABILITY TO REPORT, MEASURE AND ANALYSE ESSENTIAL DATA

Operators wishing to conform with Annex 6, Part I, 4.3.6.3 c), using 3% ERA should demonstrate the ability to report, measure and analyse the essential data for the identification, analysis and mitigation of potential safety risks that could affect the outcome of flights in accordance with Chapter 5 of this manual.

- *Data integrity:* Processes to ensure data used during ERA contingency fuel calculations have the required integrity to ensure the safe operation of the aeroplane.

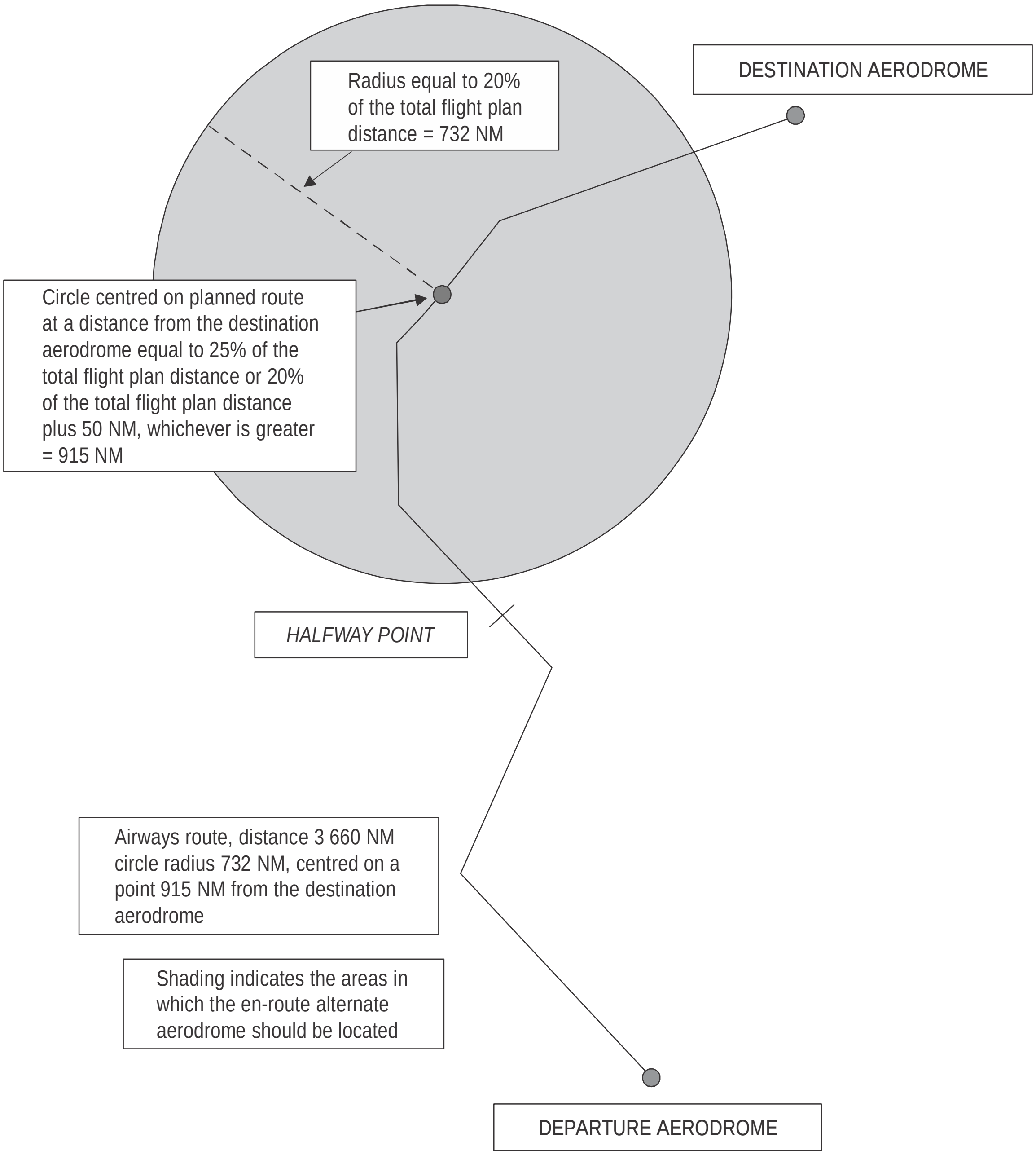


Figure 5-A3-3. Location of the 3% en-route (3% ERA) Aerodrome

— — — — — — — —

Appendix 4 to Chapter 5

EXAMPLES OF METHODOLOGIES FOR CONTINGENCY FUEL CALCULATIONS USED TO CONFORM TO ANNEX 6, PART I, 4.3.6.3 c) AND IN ACCORDANCE WITH ANNEX 6, PART I, 4.3.6.6

1. INTENT OF PRESCRIPTIVE CRITERIA AND EXPECTED OUTCOMES OF A VARIATION

The overall intent of Annex 6, Part I, 4.3.6.3 c), is to ensure to the greatest practical extent that sufficient fuel is carried to compensate for unforeseen factors. Unforeseen factors are those which could have an influence on the fuel consumption to the destination aerodrome, such as deviations of an individual aeroplane from the expected fuel consumption data, deviations from forecast meteorological conditions and deviations from planned routings and/or cruising levels. This is accomplished using the prescriptive approach to regulatory compliance by allocating five per cent of the planned trip fuel or of the fuel required from the point of in-flight re-planning based on the consumption rate used to plan the trip fuel but in any case not lower than the amount required to fly for five minutes at holding speed at 450 m (1 500 ft) above the destination aerodrome in standard conditions.

Annex 6, Part I, 4.3.6.6, describes the means by which capable operators can vary from regulations based on Annex 6, Part I, 4.3.6.3 c), using performance-based methods. This appendix addresses the additional criteria requirements, processes, mitigation measures, safety risk controls and/or other demonstrable abilities specific to the application of a variation. They should be considered within the context of the safety risk assessment activities and capability assessments described in 4.3.6.6.

2. GENERAL

This appendix examines methodologies for the computation of contingency fuel that may require an operational variation in accordance with Annex 6, Part I, 4.3.6.6, in order to conform to the requirements of 4.3.6.3 c). Unlike Appendix 3 to Chapter 5, the methodologies contained in this appendix may or may not be linked to specific flight planning methods. Additionally, it is understood that any method for the computation of contingency fuel that results in an amount of fuel that exceeds what is prescribed in 4.3.6.3 c) is sufficient to fulfil the overall requirements for the carriage of contingency fuel.

3. STATISTICAL CONTINGENCY FUEL (SCF) PLANNING

SCF is a performance-based method for the computation of contingency fuel commonly used to conform to Annex 6, Part I, 4.3.6 c). SCF is based on *"a data-driven method that includes a fuel consumption monitoring programme"* as specified in the Standard (see 4.3.6.6 b) i)). Practically speaking, SCF replaces fixed contingency fuel by an amount sufficient to cover a specified percentage of flights against burning their entire contingency fuel. It does not, by itself, protect against burning all fuel reserves. SCF is also commonly referred to as "Analysed Contingency Fuel" (ACF) and is known worldwide by a host of other acronyms including but not limited to CONT90-99, AEF, and COF90-99. For the purposes of this appendix all such terms are functionally equivalent in that they refer to a performance-based means for the computation of contingency fuel based on statistical analysis.

If an operator's fuel policy includes SCF planning, the amount of contingency fuel on board prior to the commencement of a flight is the greater of 1 or 2:

1. An amount of fuel based on a statistical method approved by the State which ensures an appropriate statistical coverage of the deviation from the planned to the actual trip fuel. This method is used to monitor the fuel consumption on each city-pair/aircraft combination, and the operator uses these data for a statistical analysis to calculate contingency fuel for that city-pair/aircraft combination;

or

2. An amount to fly for five minutes at holding speed at 1 500 ft (450 m), above the destination aerodrome in standard conditions.

4. SPECIFIC CRITERIA, MITIGATION MEASURES AND/OR SAFETY RISK CONTROLS FOR SCF PLANNING

States having the knowledge and expertise to monitor and measure operator performance should consider allowing competent operators to conform to Annex 6, Part I, 4.3.6.3 c) using SCF subject to the presence of the core requirements for performance-based variations described in Chapter 5 of this manual and the following additional criteria requirements. The operator should:

- employ an FCM programme to monitor the actual fuel consumption rates of aeroplanes using SCF.

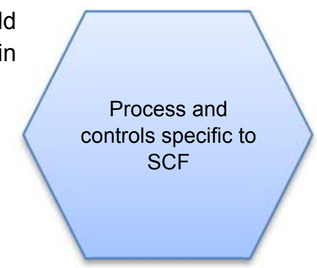
- implement an in-flight fuel management policy in accordance with Annex 6, Part I, 4.3.7, that will support the practical management of SCF. The policy should give the flight crew specific instructions regarding the best course of action in the case when contingency fuel is totally used before reaching the destination aerodrome.

- specify the statistical coverage values to be used. Coverage is the percentage of flights that burn less than their contingency fuel. A coverage value of 95 per cent, for example, means that 95 per cent of flights should arrive with all their alternate fuel (if applicable) and final reserve fuel intact. As the coverage value increases so does the required fuel, albeit disproportionately as the difference between 95 and 99 per cent coverage is not 4 per cent fuel, but an amount that depends on the variability of the fuel consumption on a specific route. One-hundred per cent coverage implies that there is a low probability of consuming all contingency fuel. The choice of coverage values is crucial to the successful implementation of SCF, and the operator should have an approved process to determine which coverage (values ranging from 85 to 99 per cent have been used) should be used depending on the type of flight and the actual conditions such as:

Coverage value considerations
• operations to destinations where diversions would be undesired;
• availability of en-route and/or destination alternate aerodromes;
• adequacy of ATC infrastructure;
• number of usable runways at destination;
• field conditions at destination;
• thunderstorms or other adverse meteorological forecast at destination.

5. SCF PROCESS AND CONTROLS

Operators wishing to conform with Annex 6, Part I, 4.3.6.3 c), using SCF should demonstrate the following processes and controls in addition to those specified in Chapter 5 of this manual:



- ***Data integrity**:* Processes to ensure data used in SCF computations have the required integrity to ensure the safe operation of the aeroplane.

- ***Data use and analysis**:* The operator should have demonstrable processes to analyse the requisite data and perform the calculations necessary to arrive at statistically valid contingency fuel values. Such process typically address:

Statistical fuel method
• historical data collection period required;
• aeroplane-specific trip fuel deviation data in relation to each city-pair and arrival time;
• aeroplane-specific fuel consumption data in accordance with Standard 4.3.6.2;
• trip fuel deviation data corrections for aeroplane take-off mass changes;
• trip fuel deviation data massing to favour more recent data;
• the identification, importance and frequency of experienced trip fuel deviations from the average;
• the identification, importance and frequency of experienced prolonged pre-take-off taxi times;
• distribution of each grouping of trip fuel deviation data and number of standard deviations applied;
• the mean for each grouping of trip fuel deviation data;
• confidence limits of the distribution (e.g. 90 per cent, 95 per cent and 99 per cent);

Statistical fuel method
• detailed instructions for the calculation of trip fuel variation and coverage values for confidence limits;
• criteria for excluding unfavourable data and/or outliers;
• recurrent operational circumstances (frequency or cycles) requiring increased fuel consumption such as seasonal changes;
• procedures to ensure errors do not enter the computation process; and
• the calculation of contingency fuel on the day of use.

- ***Process review:*** It is essential to review the functioning of the system regularly. In particular, the actual coverage value for each type/sector combination should be reviewed regularly to ensure that the designed coverage values are being obtained. The review interval should be short enough to ensure timely intervention, but not too short to be skewed by small sample sizes. A period of one month is typical for daily operations, but a quarter may be more appropriate for lesser frequencies. The process should also contain a method acceptable to the State to normalize the data for variation in planned route length and an acceptable method of massing more recent data versus older.

- ***Process failures:*** Failures to achieve the required coverage levels should be investigated, understood and corrected.

6. ADDITIONAL DEMONSTRABLE ABILITIES TO REPORT, MEASURE AND ANALYSE ESSENTIAL DATA

Operators wishing to conform with Annex 6, Part I, 4.3.6.3 c), using SCF should demonstrate the ability to report, measure and analyse the essential data for the identification, analysis and mitigation of potential safety risks that could affect the outcome of flights in accordance with Chapter 5 of this manual. Such processes should be sufficiently sophisticated to collect the large volumes of safety and operational data necessary to support effective SRM, SCF calculations and other applicable operational processes. The operator should also demonstrate the following capabilities prior to the commencement of operations that use SCF:

- for a given city-pair/aeroplane combination, data should be collected over a significant period of time or number of flights (e.g. one or two years or 60 to 100 flights) approved or accepted by the State that will permit statistically valid conclusions to be drawn. The data to be collected should be representative of seasonal conditions and other known recurrent changes likely to affect operations and typically include in relation to each city-pair:

Data in relation to each city-pair	*Aeroplane specific data*
• route	• planned zero fuel mass;
• en-route time (speeds)	• actual fuel uplift;
• time spent holding;	• actual departure fuel;

Data in relation to each city-pair	*Aeroplane specific data*
• actual versus planned SID/STAR ground track flown (including portion of Point Merge STAR actually flown, if applicable); • destination meteorological below forecast conditions; • missed approaches; • additional approaches; • proceeding to alternate; • MEL/CDL factors.	• planned trip fuel; • trip fuel used; • planned reserve/contingency fuel; • reserve/contingency fuel used; • planned flight distance; • planned flight time; • actual arrival fuel corrected for taxi-in time; • fuel remaining at the alternate aerodrome arrival gate; • fuel consumption history for each specific aeroplane number; • average fuel consumption history by aeroplane type: — same day last week; — same day last month; — same day last year.
Note.— These are recommended data points only. Actual data points may vary based on the availability of data for collection and analysis.	

7. B043 PLANNING — SPECIAL FUEL RESERVES IN INTERNATIONAL OPERATIONS

B043 planning is a performance-based method used in the United States which conforms to Annex 6, Part I, 4.3.6.3 c) fuel requirements. It is based on a qualitative and quantitative determination that more conservative or prescriptive planning methods result in the carriage of excess fuel on long-haul flights without appreciably increasing safety performance. Such determinations are based on continual monitoring of fuel at destination for all flights to ensure, to the extent reasonably practicable, that future flights carry sufficient fuel, including contingency fuel and final reserve fuel, to complete the planned flight safely and allow for planned deviations from the route.

B043 planning requires each aeroplane used by an operator to have enough fuel on board, considering wind and other meteorological conditions forecast, anticipated traffic delays, one instrument approach and possible missed approach at destination, and any other conditions that may delay landing of the aeroplane to accomplish all of the following:

1. fly to and land at the aerodrome to which it is dispatched or released;

2. additionally, to fly for a period of ten per cent of that portion of the en-route time (between the departure aerodrome and the aerodrome to which it was released) where the aeroplane's position cannot be “reliably fixed” at least once each hour;

3. additionally, to fly to and land at the most distant alternate aerodrome specified in the dispatch or flight release, as applicable, (if an alternate is required);

4. additionally, to fly for 45 minutes at normal cruising fuel consumption.

8. SPECIFIC CRITERIA, MITIGATION MEASURES AND/OR SAFETY RISK CONTROLS FOR B043 PLANNING

Criteria, mitigations and controls specific B043 planning

States having the knowledge and expertise to monitor and measure operator performance may consider allowing competent operators to conform to Annex 6, Part I, 4.3.6.3 c), using a process similar to B043 planning subject to the presence of the following criteria requirements in addition to those specified in Chapter 5 of this manual. The operator should:

- employ an FCM programme to monitor the actual fuel consumption rates of the specific aeroplane utilizing B043 contingency fuel;

- implement an in-flight fuel management policy in accordance with Annex 6, Part I, 4.3.7, that gives the flight crew specific instructions regarding the best course of action in the case when contingency fuel is totally used before reaching the destination aerodrome;

- require flight crews to report immediately to the flight operations officer (or flight follower, as applicable) any time the estimated time of arrival at the destination exceeds fifteen minutes beyond the flight plan ETA, the cruise altitude varies by 1 200 m (4 000 ft) or more from the flight plan, or the aeroplane deviates more than 100 nm from the flight-planned route.

The operator is required to report to the State any declarations of emergency fuel (*MAYDAY MAYDAY MAYDAY FUEL).* Additionally, the operator will report any occurrence of a low fuel state (*MINIMUM FUEL* declaration) which results in actions being taken by ATC and/or dispatch, even if no emergency is declared.

Note.— This phraseology reflects the new, fuel-related, ICAO phraseology. See Chapter 6 for guidance on minimum fuel and emergency fuel declarations.

9. B043 PLANNING PROCESS AND CONTROLS

United States operators wishing to conform with Annex 6, Part I, 4.3.6.3 c), using B043 planning need to demonstrate processes and controls similar to those specified in Chapter 5 of this manual.

10. DEMONSTRABLE ABILITY TO REPORT, MEASURE, AND ANALYSE ESSENTIAL DATA

United States operators wishing to conform with Annex 6, Part I, 4.3.6.3 c), using B043 planning would demonstrate the ability to report, measure and analyse the essential data for the identification, analysis and mitigation of potential safety risks that could affect the outcome of flights in accordance with Chapter 5 of this manual.

11. B343 PLANNING — FUEL RESERVES FOR FLAG AND SUPPLEMENTAL OPERATIONS

B343 planning is a performance-based method used in the United States in accordance with Annex 6, Part I, 4.3.6.6, that is used to conform to Annex 6, Part I, 4.3.6.3 c) fuel requirements. B343 planning is based on a qualitative and quantitative determination that more conservative or prescriptive planning methods result in the carriage of excess fuel on long-haul flights without appreciably increasing safety performance. Such determinations are based on continual monitoring of fuel at destination for all flights to ensure, to the extent reasonably practicable, that future flights carry sufficient fuel, including contingency fuel and final reserve fuel, to complete the planned flight safely and allow for planned deviations from the route.

B343 planning requires each aeroplane used by an operator to have enough fuel on board, considering wind and other meteorological conditions forecast, anticipated traffic delays, one instrument approach and possible missed approach at destination, and any other conditions that may delay landing of the aeroplane to accomplish all of the following:

1. fly to and land at the aerodrome to which it is dispatched or released;

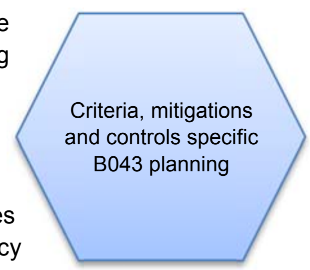
2. additionally, to fly for a period of five per cent of that portion of the en-route time (between the departure aerodrome and the aerodrome to which it was released) where the aeroplane's position cannot be “reliably fixed” at least once each hour;

3. additionally, to fly to and land at the most distant alternate aerodrome specified in the dispatch or flight release, as applicable (if an alternate is required);

4. additionally, to fly for 30 minutes at normal cruising fuel consumption.

12. CRITERIA FOR B343 PLANNING

States having the knowledge and expertise to monitor and measure operator performance may consider allowing competent operators to conform to Annex 6, Part I, 4.3.6.3 c) using a process similar to B343 planning subject to the presence of the following criteria requirements in addition to those specified in Chapter 5 of this manual and the following additional criteria. The operator should:



- employ an FCM programme to monitor the actual fuel consumption rates of the specific aeroplane utilizing Special Flag Fuel Reserve contingency fuel;

- implement an in-flight fuel management policy in accordance with Annex 6, Part I, 4.3.7, that gives the flight crew specific instructions regarding the best course of action in the case when contingency fuel is totally used before reaching the destination aerodrome;

- have approved procedures to maintain a flight monitoring and recording system that requires the flight crew and flight operations officer or flight follower, as applicable, to verify, at least once each hour, the aeroplane’s position, route, altitude and fuel on board compared to flight-planned fuel on board at that point;

- ensure all fuel indicating and monitoring systems are operational at dispatch or release, as applicable. Any en-route failure of these systems should be immediately reported to dispatch or flight-following, as applicable;

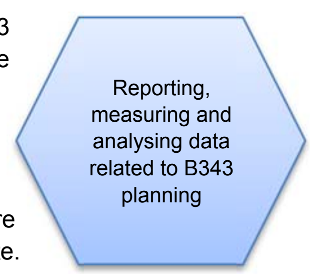
- require flights using B343 to:
  - — if the flight is scheduled for more than six hours, list in the dispatch or flight release at least one designated alternate aerodrome for the destination aerodrome;
  - — ensure appropriate meteorological reports or forecasts or any combination thereof indicate that the meteorological conditions will be at or above the authorized IFR approach and landing minima at the estimated time of arrival at any aerodrome to which the flight is dispatched or released;
  - — ensure appropriate meteorological reports or forecasts or any combination thereof indicate that the meteorological conditions will be at or above the authorized alternate aerodrome IFR weather minima at the estimated time of arrival at any required alternate aerodrome;
- require flight crews to report immediately to the flight operations officer (or flight follower, as applicable) any time the estimated time of arrival at the destination exceeds fifteen minutes beyond the flight plan ETA, the cruise altitude varies by 1 200 m (4 000 ft) or more from the flight plan, or the aeroplane deviates more than 100 nm from the flight-planned route.
- if any of the required reports indicate that en-route reserve fuel will be consumed, communicate this immediately to the flight crew and to the flight operations officer or flight follower, as applicable, and agree to continuation of the flight or deviation. Both flight crews and the flight operations officer or flight follower, as applicable, should record all required reports until completion of the flight.
- if any portion of the en-route reserve fuel is consumed, record this, retain the information and notify the applicable Authority of the occurrence. Both a primary and secondary method of communicating any required reports should be available for the entire route of flight.
- prohibit the use of B343 when flights are re-planned or re-dispatched in accordance with Appendix 4 of this manual.

13. B343 PLANNING PROCESS AND CONTROLS

United States operators wishing to conform to Annex 6, Part I, 4.3.6.3 c), using B0343 reserve fuel would demonstrate the processes and controls similar to those specified in Chapter 5 of this manual.

14. DEMONSTRABLE ABILITY TO REPORT, MEASURE AND ANALYSE ESSENTIAL DATA

United States operators wishing to conform with Annex 6, Part I, 4.3.6.3 c), using B343 should demonstrate the ability to report, measure and analyse the essential data for the identification, analysis and mitigation of potential safety risks that could affect the outcome of flights in accordance with Chapter 5 of this manual and;



- use accurate meteorological data including destination and alternate aerodrome forecasts, and upper wind information equal to or more accurate than 1.25 grid data should be used for the entire flight plan route.

— — — — — — — —

Appendix 5 to Chapter 5

EXAMPLE OF A FUEL CONSUMPTION MONITORING (FCM) PROGRAMME USED TO CONFORM TO ANNEX 6, PART I, 4.3.6.2 a) AND/OR ANNEX 6, PART I, 4.3.6.6 b)

1. GENERAL

The application of scientific methods to actual aeroplane performance brings a higher degree of accuracy to expected aeroplane performance. This appendix contains guidance for the establishment of a hull-specific FCM programme. Such programmes are used extensively to ensure actual fuel use approximates planned fuel use within an acceptable margin of error. The assumption is that operators with the means and resources to measure and analyse sufficient historical data to arrive at valid statistical projections are better equipped to make fact-based determinations during fuel planning.

The data collection and analysis tools used in FCM take into account the many variables and data points used to determine aeroplane specific fuel burn. This process of quantitative analysis can also be used to complement the many qualitative tools used in safety analysis to arrive at statistically valid conclusions. As a result, States with performance-based approaches to regulatory compliance and the ability to oversee such complex activities may be more confident in an operator that uses such advanced techniques to continually achieve target levels of safety performance.

The following programme description is provided for guidance purposes only. Exact specifications may vary and are typically developed by individual operators in conformance with the requirements of the State. If designed and implemented properly, these programmes and other statistically-based fuel use programmes represent systemic defenses against operational safety risks associated with alternate aerodrome selection and fuel planning.

The following example also illustrates the level of sophistication required of data collection and analysis processes. Such sophistication is not only necessary to support FCM implementation but is also desirable when incorporating such programmes into an operator's SMS, if applicable. It is important to note that the data collection requirements and quantitative data analysis methods used in FCM are one of the hallmarks of an operator that has the resources to form the foundation for the development of an SMS.

2. FUEL CONSUMPTION MONITORING (FCM)

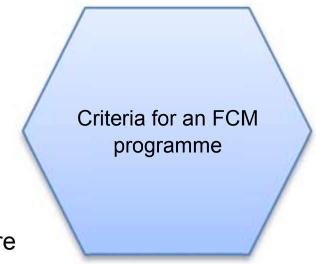
FCM, also commonly referred to as hull-specific fuel bias, refers to the processes of comparing an aeroplane's achieved in-flight performance to that of the aeroplane's predicted performance. Variations between the achieved performance and the predicted performance will result in a variation of the rate of fuel consumption which should be accounted for by the operator during flight planning and in flight.

Poor airframe condition results in an increase in overall drag. Poorly fitting hatches, surface imperfections such as dents and scratches and deterioration of fairings and other airflow control devices can all contribute to the increase in drag. Additionally engine wear, including fan blade erosion and damage, fan rub-strip wear and accumulation of dirt can increase an engine's specific fuel consumption (SFC).

All of these factors typically contribute to a decrease in an aeroplane's Specific Air Range (SAR). Conversely, in-service aeroplane and engine modifications can improve an aeroplane's SAR. A hull-specific FCM programme accounts for all such variations from baseline performance. An operator may elect to use FCM in accordance with the following criteria requirements and as part of the larger systemic defenses or risk mitigation strategies used when seeking variations to the SARPs.

3. CRITERIA FOR AN FCM PROGRAMME

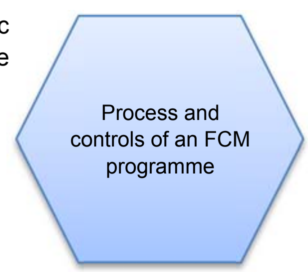
An operator's FCM programme demonstrates the following criteria:



- FCM refers to the determination of an individual aeroplane's performance from the predicted performance. In no cases should data collected from one aeroplane be used as a basis for varying another aeroplane's performance figures away from the predicted value;
- data used in the determination of the aeroplane's actual performance are collected in a manner acceptable to the State;
- data used in the determination of the aeroplane's predicted performance are derived from a source acceptable to the State;
- data used in the determination of the aeroplane's actual performance are collected continuously during routine line operations of the aeroplane;
- data used in the determination of the aeroplane's actual performance should be based on Aeroplane Stable Frame (ASF) readings. If ASF readings are not available then the data may be based on a comparison of planned burn versus actual burn achieved over individual sectors;
- if ASF readings are not used, the operator should exclude all sectors where in-flight environmental conditions may result in the collection of erroneous data. The operator should be able to demonstrate to the State how such sectors are excluded from the data collection;
- data used in the determination of the aeroplane's actual performance should be the average of the data collected over a minimum number of data points that will statistically ensure the integrity of the data used (a minimum of 50 data points or the equivalent of a calendar month of line operations is the recommended minimum). In the event that insufficient data are available, the previous month's performance level can be used in the interim. Irrespective of the number of data points used, or the time frame over which they are collected, the operator should have a process to ensure data which reflects a statistical anomaly, or is erroneous, is filtered to ensure the integrity of the fuel bias programme.

4. PROCESS AND CONTROLS FOR AN FCM PROGRAMME

An operator, when proposing the use of an FCM programme as part of overall systemic defenses or larger mitigation strategies, should develop processes and controls to ensure that the aims of the programme, namely the ability to account for variations in individual aeroplane performance, are met. Additionally, the operator should ensure that the data used during the pre-flight planning and in-flight operation of the aeroplane have the required integrity to ensure the safe operation of the aeroplane. Additionally, such a programme should demonstrate the following processes and controls:



- The operator should demonstrate that the data collected during in-service operation of the aeroplane are accurate. Where possible the data should be collected automatically; however, the manual recording of data does not preclude an operator from participating in an FCM programme.

- The performance data collected during in-service operation of the aeroplane should be compared to the predicted performance to determine the variation between the two.

- The performance data collected during in-service operation should be reviewed and incorporated into the flight planning system and FMS on a regular basis at intervals not exceeding one month.

- The operator should demonstrate how data collected are used by the flight planning system and FMS.

- The operator should demonstrate the controls used to minimize the risk of human error when inputting data to the flight planning system or FMS.

- Where an aeroplane's actual performance is found to have deteriorated resulting in an increase in the fuel burn rate, the whole of the increased burn rate should be used by the operator when preparing future flight plans. The whole of the increase should also be incorporated into the aeroplane's FMS.

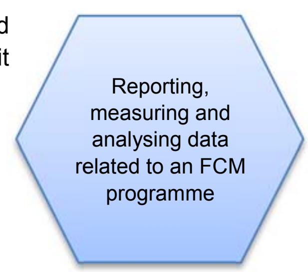
- Where an aeroplane's actual performance is found to have improved resulting in a decrease in the fuel burn rate, the operator should reduce the fuel burn rate over a period of time when preparing future flight plans. The maximum allowable improvement in aeroplane performance that is reflected in the flight planning system should not exceed 0.3 per cent in any one seven-day period, or 1.2 per cent in any one calendar month. Where a single improvement greater than 0.3 per cent is to be made to the flight planning system, the operator should have a process to ensure that the improvement is not the result of statistical anomaly or spurious data.

- The difference between the aeroplane's actual performance and the predicted performance is normally expressed as a percentage deviation from the predicted value with a positive deviation representing degraded aeroplane performance from that predicted and a negative value representing performance better than predicted.

- An operator may elect to use different methodologies than that described but in all cases should demonstrate that the methodology used is compatible with all of the systems used in the flight planning and operation of the operator's aeroplane.

5. DEMONSTRABLE ABILITY TO REPORT, MEASURE AND ANALYSE ESSENTIAL DATA

An operator using FCM as a mitigation strategy should develop processes to measure and analyse data received from the in-flight monitoring of aeroplane performance for the explicit purpose of adjustment and continuous improvement. These data can then be used to identify long-term trends with respect to aeroplane fuel burn or short-term spikes that may be indicative of individual aeroplane defects. In all cases the aim of any data analysis programme should be to improve overall fleet performances which will result in decreased fuel consumption with an associated decrease in CO_2 emissions.



When analysing variations in aeroplane fuel burn, the operator should take into account the operational environment in which the aeroplane has been operating to determine if this has been a factor that has led to the identified variation. Similarly the operator should compare aeroplane maintenance data with the achieved fuel burn to help in the measurement of the efficacy of the maintenance programme. Fuel trend monitoring can also be used as a tool to propose preventative maintenance that can assist in the reduction of fuel burn. For example, an identified increase in an individual aeroplane's fuel burn may be indicative of a control surface rigging problem, engine deterioration or deterioration of the aeroplane's surface. In order to achieve these benefits, the operator should demonstrate the following capabilities:

- a process to record all in-flight data used in the determination of the performance variation of individual aeroplane;

- a process to record all variations made to the flight planning and FMS systems to reflect an aeroplane's actual in-flight performance;

- a process to identify and monitor trends in fuel burn affecting individual aeroplanes and the operator's fleet in general;

- a process for identifying possible causation effects that explain variations in aeroplane fuel burn and should demonstrate a system of mitigation for such effects;

- statistical and trend analysis methods during the analysis of aeroplane performance data. However, it is recognized that there are occasions where nominative comparisons, simulation or expert advice may be required to fully understand the data;

- where the operator uses a cost-benefit analysis to determine if further investigation or remediation of an identified deterioration in aeroplane performance is required, the operator should take into account the environmental cost of CO_2 emissions associated with the increased fuel burn rates.

— — — — — — — —

Appendix 6 to Chapter 5

EXAMPLE OF A STATISTICAL TAXI FUEL PROGRAMME USED TO CONFORM TO ANNEX 6, PART I, 4.3.6.3 a) AND IN ACCORDANCE WITH ANNEX 6, PART I, 4.3.6.6

1. GENERAL

This appendix examines a methodology for the computation of taxi-out fuel that may require an operational variation in accordance with Annex 6, Part I, 4.3.6.6 in order to conform to the requirements of 4.3.6.3 a).

2. STATISTICAL TAXI FUEL

Statistical taxi fuel is a performance-based methodology for the computation of taxi-out fuel based on *"a data-driven method that includes a fuel consumption monitoring programme*" as specified in 4.3.6.6. A statistical taxi fuel programme typically relies on the development of statistical taxi times for all origin and destination airports in an operator's fleet in order to determine the correct amount of taxi fuel to be built into the flight plan based on statistical analysis. The underlying goal of this method is to prevent regular occurrences of flights burning through all of their taxi fuel, and therefore potentially into a portion of the contingency fuel and/or fuel for the CFS.

3. SPECIFIC CRITERIA, MITIGATION MEASURES AND/OR SAFETY RISK CONTROLS FOR A STATISTICAL TAXI FUEL PROGRAMME

States having the knowledge and expertise to monitor and measure operator performance should consider allowing competent operators to conform to Annex 6, Part I, 4.3.6.3 a) using a statistical taxi fuel programme subject to the presence of the core requirements for performance-based variations described in Chapter 5 of this manual and the following additional criteria requirements. The operator should:

- have a method or mechanism for the collection of aeroplane-specific taxi time data;
- monitor the actual fuel consumption rates of aeroplanes using statistical taxi fuel;
- implement a fuel policy in accordance with Annex 6, Part I, 4.3.7, that will support the practical management of a statistical taxi fuel programme. The policy should give the flight crew specific instructions regarding the best course of action in cases when taxi fuel is completely consumed prior to the completion of the taxi-out resulting in the consumption of other fuels (e.g. contingency fuel) before take-off.

4. STATISTICAL TAXI FUEL PROCESS AND CONTROLS

Process and controls specific to statistical taxi-out fuel

Operators wishing to conform with Annex 6, Part I, 4.3.6.3 a) using statistical taxi fuel should demonstrate the following processes and controls in addition to those specified in Chapter 5 of this manual:

- ***Data integrity*:** Processes to ensure data used in statistical taxi fuel computations have the required integrity to ensure the safe operation of the aeroplane.

- ***Data use and analysis*:** The operator should have demonstrable processes to analyse the requisite data and perform the calculations necessary to arrive at statistically valid fuel values. Such processes typically address:

Statistical taxi-out fuel method
• historical data collection period required;
• aeroplane-specific taxi fuel consumption data;
• aeroplane-specific APU fuel consumption data;
• aeroplane-specific additional fuel consumption due to utilization of engine anti-ice;
• aeroplane-specific taxi time data in relation to each departure city, departure time and season;
• taxi fuel deviation data corrections for aeroplane take-off mass changes;
• identification, importance and frequency of experienced prolonged pre-take-off taxi times;
• criteria for excluding unfavourable data and/or outliers;
• recurrent operational circumstances (frequency or cycles) requiring increased fuel consumption such as seasonal changes;
• recurrent circumstances that permit taxi-out with fewer than all engines operating;
• procedures to ensure errors do not enter the computation process;
• calculation of taxi fuel on the day of use;
• default taxi fuel figures to be utilized when statistical data is not available.

- ***Process review*:** Regular review of the functioning of the system is essential. In particular, the actual coverage value for each type/departure airport combination should be reviewed regularly to ensure that the designed coverage values are being obtained. The review interval should be short enough to ensure timely intervention, but not too short to be skewed by small sample sizes (e.g. fewer than 30 flights/data points).

- ***Process failures*:** Failures to achieve the required coverage levels should be investigated, understood and corrected.

5. ADDITIONAL DEMONSTRABLE ABILITIES TO REPORT, MEASURE AND ANALYSE ESSENTIAL DATA

Operators wishing to conform with Annex 6, Part I, 4.3.6.3 a) using a statistical taxi fuel programme should demonstrate the ability to report, measure and analyse the essential data for the identification, analysis and mitigation of potential safety risks that could affect the outcome of flights and in accordance with Chapter 5 of this manual. Such processes should be sufficiently sophisticated to collect the large volumes of safety and operational data necessary to support effective SRM, taxi fuel calculations and other applicable operational processes. The operator should also demonstrate the following capabilities prior to the commencement of operations that use statistical taxi fuel:

- for a given departure city/aeroplane combination, data should be collected over a significant period of time or number of flights approved or accepted by the State that permits statistically valid conclusions to be drawn from available data. The data to be collected should be representative of seasonal conditions and other known recurrent changes likely to affect operations and typically includes in relation to each city pair:

Data in relation to each departure aerodrome	*Aeroplane-specific data*
• taxi route; • departure gate; • departure runway; • initial departure fix; • taxi time; • time spent stopped or idle; • local time of departure; • day of week; • number of engines used for taxi; • departure aerodrome meteorological conditions.	• planned and actual zero fuel mass; • actual fuel uplift; • actual departure fuel; • planned taxi fuel; • taxi fuel used; • planned taxi time; • fuel consumption history for each specific aeroplane number.
Note.— These are recommended data points only. Actual data points may vary based on the availability of data for collection and analysis.	

6. EXAMPLE METHODOLOGY IN ESTABLISHING STATISTICAL TAXI-OUT FUELS

The following is a basic example of how an operator could establish statistical taxi-out fuels for flights departing from its home base aerodrome:

- operator performs an analysis for each departure from the aerodrome, based on the time elapsed from push back until take-off (OUT-OFF event);

- analysis of the data indicates that during certain peak departure times (high traffic volumes), the median taxi-out time increases by +10 minutes, from the normal baseline value of 10 minutes;

- the carrier then establishes a policy applicable during peak departure banks requiring flights to be planned with an additional 10 minutes of taxi-out fuel, above the normal allotted amounts, e.g. 200 kg normal baseline allotment plus 150 kg additional, for total of 350 kg taxi fuel during peak times;

- periodically (every quarter) the carrier performs a re-analysis to determine the additional fuel allotment and validate if the departure peaks have remained constant.

Note.— For aerodromes undergoing major taxiway/runway construction, this re-analysis should occur on a much shorter cycle, e.g. once each week.

— — — — — — — —

Appendix 7 to Chapter 5

A PERFORMANCE-BASED APPROACH JOB-AID FOR AN APPROVING AUTHORITY

This job-aid is provided to assist an approving Authority when reviewing established processes/activities supporting performance-based compliance to FPFM regulations. It summarizes the criteria that should be considered during the implementation of performance-based regulations or variations from existing prescriptive regulations. When reviewing an application submitted by an operator for the approval of performance-based methods and/or performance-based compliance with alternate aerodrome selection and fuel planning regulations, the State of the Operator should review the application in consideration of the elements summarized in this Appendix as well as those espoused in the body of the manual.

The processes and activities that support the implementation of a performance-based approach to FPFM include but are not limited to:

a) the operator's organizational processes are established for FPFM training of staff, monitoring of organizational and FPFM operational processes, hiring qualified personnel, etc., ensuring that the operator's commitment and responsibilities are reflected within the FPFM policy and procedures;

b) the operator's FPFM specific operational capabilities are established as those described in Chapter 5, section 5.4;

c) the operator establishes safety risk management processes for FPFM, i.e. data collection, hazard identification, safety risk assessment and implementation of relevant risk mitigation measures to ensure that the safety risks encountered during the flight planning and fuel management activities are effectively managed;

d) safety performance monitoring by the operator includes selecting FPFM safety performance indicators in agreement with the Authority, collecting historical data for the associated SPIs, defining baseline performance, setting alert and target levels of safety performance;

e) continuous improvement of the FPFM processes and activities to validate that the systems maintain an equivalent level of safety performance through the established SPIs;

f) safety oversight provided by the Authority through various mechanisms such as safety reviews, and audits including early involvement with an operator during their performance monitoring and measurement processes such as those listed above.

A performance-based method can be tailored to the size and complexity of an organization.

Civil aviation authorities having the knowledge and expertise to approve, monitor and measure operator performance should consider allowing capable operators to maximize the technological capabilities of their aeroplanes, flight planning systems, flight following capabilities, relevant ground infrastructure and SRM methods. Such performance-based efficiencies allow for optimal fuel quantities to be carried. Authorities, however, must ensure a level of safety performance that is acceptable to the State of the Operator.

An operator needs to establish a planning process to ensure there is sufficient fuel, including final reserve fuel, to complete a planned flight safely.

Reporting, measurement, analysis and follow-up should be a continuing process and justification for continuance of a variation.

Performance-based methods should not be discouraged by States as long as the operator can demonstrate with a detailed safety case that the operation would provide a level of safety performance that is acceptable to the State of the Operator.

The systems and process established by the operator to support performance-based methods and performance-based compliance with regulation should be approved by the State of the Operator before implementation.

Aeroplane performance monitoring.

a) The operator should maintain a database of valid fuel consumption data used to calculate its required fuel planning figures of the preceding one to five years. This historical data should be flight-, aeroplane type-, and route-specific and could be used by both the regulator and the operator to monitor fuel planning trends and performance.

b) Specific aeroplane data acquisition and processing procedures that result in a detailed analysis of each aeroplane’s individual fuel burn performance (fuel bias).

c) The operator should provide a comparative analysis of actual en-route fuel consumption versus flight planned consumption.

Data verification

The Authority may review the analysis provided by the operator and verify the fuel consumption data computation process and procedures.

Air operator communications capabilities

a) The air operator should have communication capabilities to exchange timely information with aeroplanes in flight. Such communications could, for example, use VHF, HF, and SATCOM capability (Voice / Data), ACARS/AFIS.

b) Redundancy built in for communication interruptions. When the communication systems are outsourced to a third party, the operator should have contingency plans for any scheduled or non-scheduled service interruptions.

Flight planning system

a) Reviewing the flight planning system used by the operator, the Authority should pay particular attention to any computerized system used. The description, functionality and authenticity of software should be considered.

b) The Authority may review or audit the aeroplane performance and navigation databases (e.g. FMS for integrity reliability).

c) The Authority may review the destination route selection criteria, alternate aerodrome selection criteria, and, when appropriate, track selection processes.

Extended Diversion Time Operations — EDTO. In the case of EDTO, the Authority should specifically consider critical fuel consumption calculation processes and factors, if applicable.

Aeroplane navigational accuracy. The Authority should review the following:

a) flight crew navigation and fuel management procedures;

b) SPIs such as the reported Gross Navigational Errors incurred over a certain monitoring period; and

c) FMS installations and capabilities (e.g. approved level of RNP).

Maintenance reliability of fleet. In the case of an operator conducting EDTO, the State of the Operator should, in addition to the fuel quantity and computing systems and indicators used by the operator, also review the operator's reliability programme for engines, APU and EDTO Significant Systems. This reliability programme typically includes:

a) a continuous assessment of engines' reliability, including monitoring of engine in-flight shut down rates (IFSD Rates);

b) as applicable, monitoring of the APU in-flight start reliability;

c) an oil consumption monitoring programme for the engines and the APU;

d) an engine condition monitoring programme;

e) a verification programme.

Alternate and diversion aerodromes. The Authority should evaluate the operational history of the operator and carefully review the following:

a) rate of actual en-route diversions due to mechanical problems per specified number of operations;

b) operational personnel responsible for monitoring availability of en-route alternate or diversion aerodromes;

c) monitoring of continued suitability of diversion or alternate aerodromes with respect to fuel, regulation, navigational and aerodrome facilities;

d) number of air operator on-site audits recommended;

e) confirmation that direct routings between the destination and the alternate aerodrome(s) are not used in fuel planning unless such routings are routinely assigned by ATC.

Flight monitoring, flight following capability. The operator's flight following and monitoring capability could be a determining factor to be considered by the Authority in approving performance-based methods or approaches to regulatory compliance. Therefore, the Authority should review the following:

a) specific dispatcher, flight operations officer, or other operational control personnel flight monitoring or flight following responsibilities;

b) specific dispatcher, flight operations officer, or other operational control personnel flight following coordination requirements with the pilot-in-command that ensure compliance with the operator's fuel-management, and flight diversion procedures;

c) real-time re-analysis capabilities.

Special operational considerations

a) The Authority should consider the application in relation to the air operator specific area of operation as authorized in the relevant operational specifications;

b) In relation to the area of operation, the Authority should ensure that the operator uses appropriate meteorological data including upper wind information with an appropriate level of accuracy.

Additional notes for the approving Authority:

a) The performance-based method, process or system should include mandatory reporting of hull-specific performance monitoring that continuously monitors, analyses, compares and biases the fuel performance calculations to the actual performance for each individual aeroplane being used under the authorization granted.

b) A new aeroplane of the same make and model currently operated under this authorization by the air operator should use the average bias of all aeroplanes of that same make, model and engine combination until its particular bias is established in accordance with the operator's approved programme.

c) A used aeroplane of the same make, model and engine combination being added to the fleet of an operator should be ineligible for a reduction of contingency fuel until its baseline and bias are established.

d) However, if the used aeroplane referred to in c) above has historical fuel bias developed by using the monitoring and analysis programme required, immediately preceding the introduction into service by another operator, the State of the Operator may approve the use of the previous operator's existing bias, provided the aeroplane airframe/engine combination has not changed.

e) Data submitted by the operator should be reviewed by an Aeroplane Evaluations Group, or equivalent, for that type aeroplane.

f) Data for analysis should be presented in the following format:

   Flight #/Date/Origin/Destination/Equipment/Scheduled Time/Actual Time/Planned Burn/Actual Burn/Arrival Fuel/Diversions/Reason/Fuel Emergencies/Low Fuel.

g) Fuel planning data collection spreadsheet.

   i) The Authority should specify the details to be included in the data and the format to be used by the operator submitting data.

   ii) Operators should always submit data accompanied by a summary of their fuel policy.

   iii) The Authority should always request complete data sets and should not filter out any flight data provided. Instead, reviewers having specific reasons to question the data accuracy should identify flight data (with an "X" in the last column) and provide comments in the second-to-last column.

Conclusion. Performance-based alternate aerodrome selection and fuel management is intended to provide flexibility allowing the operators to use SRM principles to optimize the FPFM process (the amount of fuel carried on any given flight) while achieving a target level of safety performance. The mass savings will translate directly to reduced fuel burn. Reduced fuel burn equates directly to lower operating costs and fewer emissions.

Chapter 6

IN-FLIGHT FUEL MANAGEMENT

6.1 INTRODUCTION

6.1.1 Annex 6, Part I, Standards 4.3.7.1 and 4.3.7.2 state:

> 4.3.7 In-flight fuel management
>
> 4.3.7.1 An operator shall establish policies and procedures, approved by the State of the Operator, to ensure that in-flight fuel checks and fuel management are performed.
>
> 4.3.7.2 The pilot-in-command shall continually ensure that the amount of usable fuel remaining on board is not less than the fuel required to proceed to an aerodrome where a safe landing can be made with the planned final reserve fuel remaining upon landing.

6.1.2 Conformance with these Standards requires an operator to establish policies and procedures applicable to both flight crew and operational control personnel for the purposes of ensuring the usable fuel remaining is monitored and appropriately managed in flight (see Figure 6-1). This is important for many reasons but particularly to foster an operational culture that ensures:

a) the continual validation or invalidation of assumptions made during the planning stage (pre-flight and/ or in-flight re-planning);

b) flight management, re-analysis and adjustment occur, when necessary;

c) the protection of final reserve fuel and safe flight completion.

6.1.3 While the previous chapters focused almost entirely on the various planning criteria designed to ensure the safe completion of flights, this chapter outlines the actions to be taken by flight crew and operational control personnel after a flight has departed. Such actions are the culmination of an operator's fuel policy and ultimately ensure, to the extent reasonably practicable, that fuel is used as allocated during pre-flight planning, in-flight re-planning or as necessary to ensure the safe completion of a flight.

6.1.4 It is important to note that in-fight fuel management policies are not intended to replace pre-flight planning or in-flight re-planning activities but to act as controls to ensure planning assumptions are continually validated. Such validation is necessary to initiate, when necessary, the re-analysis and adjustment activities that will ultimately ensure the safe completion of each flight.

6.1.5 Finally, this chapter concludes the manual with an expansion of the in-flight fuel management SARPs related to the protection of final reserve fuel including scenarios that illustrate the circumstances that could lead to a declaration of *MINIMUM FUEL* or a fuel emergency (*MAYDAY MAYDAY MAYDAY FUEL)*. Such declarations should represent the last lines of defense in a multilayered strategy designed to ensure the protection of final reserve fuel and safe flight completion.

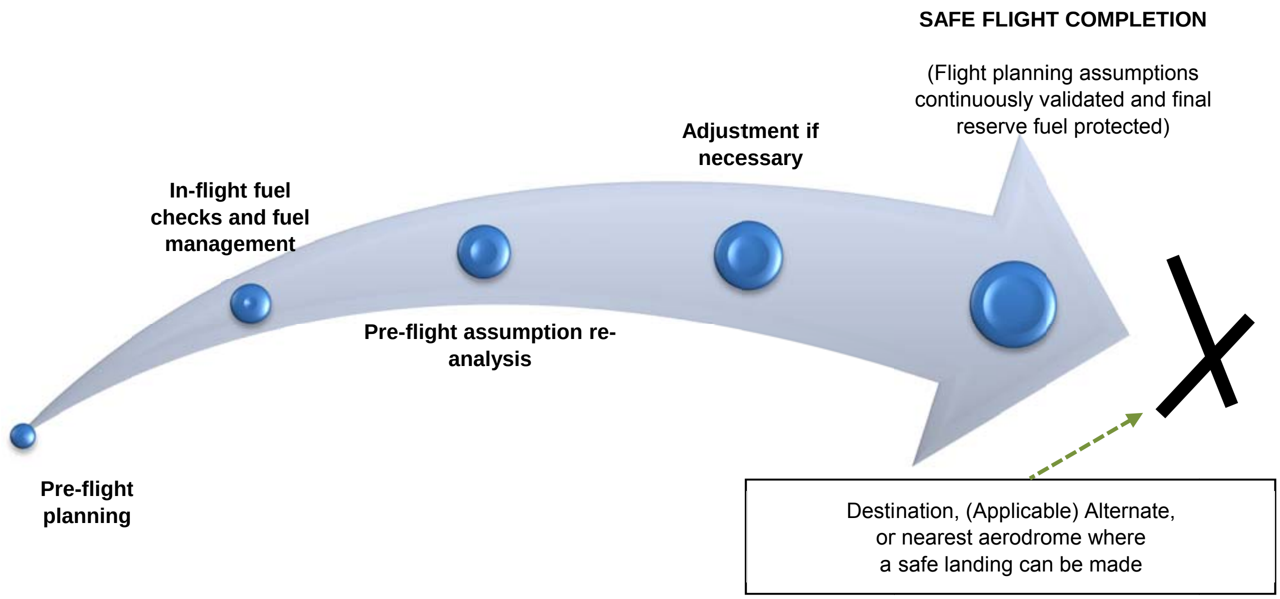


Figure 6-1. Fostering a culture that ensures safe flight completion

6.2 OPERATOR FUEL POLICY AND FOSTERING THE APPROPRIATE OPERATIONAL CULTURE

6.2.1 Conformance with Annex 6 fuel planning SARPs is intended, inter alia, to ensure the safe completion of each planned flight and to allow for deviations from the planned operation. This is accomplished using a balanced approach to the implementation of operator fuel policy that is dependent, to the greatest practical extent, on the use of accurate pre-flight planning, proactive fuel management and actions to protect final reserve fuel (Figure 6-2).

6.2.2 To achieve this balance it is first necessary to understand the relationship between the SARPs which, practically speaking, define the starting and ending points of an operator's fuel policy:

a) Annex 6, Part I, 4.3.6.1 which requires an aeroplane to carry sufficient fuel to complete the planned flight safely; and

b) Annex 6, Part I, 4.3.7.2 which requires the PIC to continually ensure the usable fuel remaining on board is not less than the fuel required to proceed to an aerodrome where a safe landing can be made with the planned final reserve fuel remaining upon landing.

6.2.3 These SARPs, when considered together and in the appropriate context, provide the basis for flight crews to pro-actively manage fuel immediately after flight commencement in order to protect the planned operation or to adjust the plan. They also provide the basis for flight crews to take the pre-emptive actions necessary to protect final reserve fuel. It is important to note, however, that neither SARP considered individually or out of context can provide the basis for a balanced approach to operator fuel policy nor should they be used to continue an improperly planned or invalidated operation.

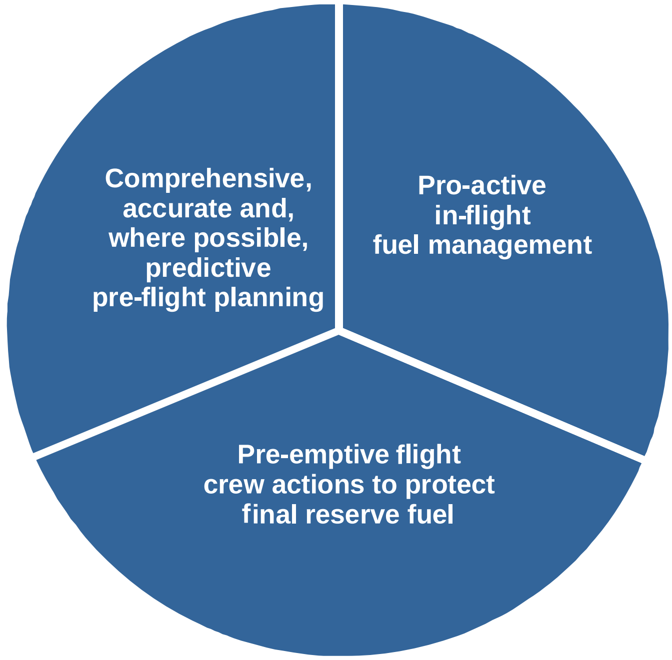


Figure 6-2. A balanced approach to operator fuel policy

6.2.4 The next step in the implementation of fuel policy is the allocation of resources necessary to ensure accurate fuel calculations as well as to support the operational culture of "continuous fuel state awareness and proactive fuel management" necessary to sustain safe flight operations. Such a culture presumes that the continuous validation (by the flight crew and flight operations officer/flight dispatcher, if applicable) of pre-flight planning assumptions is necessary to ensure safe flight completion. It also presumes that when the operation does not unfold as planned, the flight crew will intervene to re-analyse and adjust the plan as necessary. This continuous reconciliation of "planned" versus "actual" performance is a fundamental fuel management activity.

6.2.5 To support this fundamental activity, it is essential that operators create opportunities for the flight crew or operational control personnel to intervene when the criteria used to plan the flight have the potential to be, or have been, invalidated. These opportunities should be imbedded in operator fuel policy, not only to ensure fuel is appropriately allocated, but also to continually ensure sufficient fuel remains available to complete each planned flight safely.

6.2.6 Finally, an operator's fuel policy should culminate in a mandate to protect final reserve fuel remaining in the tanks upon landing at any aerodrome. This mandate should also identify the proactive measures necessary to achieve this aim and is intended to ensure a safe landing when unforeseen circumstances may preclude completion of the flight as originally planned. It is important to note that the ability to protect final reserve fuel, in and of itself, should not be used as a substitute for in-flight re-planning or as justification to continue an improperly planned operation.

6.3 SCOPE OF FLIGHT CREW AND FLIGHT OPERATIONS OFFICER POLICIES AND PROCEDURES

6.3.1 Effective prescriptive and/or performance-based compliance with alternate aerodrome selection and fuel planning regulations is dependent upon many assumptions made during pre-flight planning. These assumptions can be quickly invalidated, however, by inconsistent flight crew actions or unforeseen circumstances. Given this potential, it is essential for all relevant personnel to understand their roles and responsibilities related to the operator's fuel policy. This is especially important in scenarios where fuel carriage is optimized for the route and continual re-analysis/adjustment is crucial to ensuring the completion of the flight as planned. With all of this in mind, operator in-flight fuel checks and fuel management policies and procedures used to conform to Annex 6, Part I, 4.3.7.1, should address, inter alia:

a) the variables used in the calculation of the usable fuel required to take off or to continue beyond the point of in-flight re-planning;

b) the alternate aerodrome selection and fuel planning methods used in flight planning;

c) flight crew responsibilities and actions related to pre-flight fuel planning and fuel load determination;

d) flight crew responsibilities and actions related to flight planning methods that require specific in-flight re-analysis, re-planning or re-dispatch procedures (e.g. RCF, PNR. DP, PDP);

e) the OFP and instructions for its use;

f) deviations from the OFP or other actions that could invalidate flight planning assumptions (e.g. acceptance of direct routings, altitude changes, speed changes);

g) actions related to the acquisition of timely and accurate information that may affect in-flight fuel management (e.g. meteorology, NOTAM, aerodrome condition);

h) the practical means for the in-flight validation (or invalidation) of assumptions made during alternate aerodrome selection or fuel planning including instructions for recording and evaluating remaining usable fuel at regular intervals;

i) the factors to be considered and actions to be taken by the PIC if flight planning assumptions are invalidated (re-analysis and adjustment) including guidance on the addition of discretionary fuel at the flight planning stage if necessary to ensure adequate safety margins are maintained throughout the flight;

j) actions to be taken by the PIC to protect final reserve fuel including instructions for requesting delay information from ATC;

k) instructions for the declaration of *MINIMUM FUEL*;

l) instructions for the declaration of a fuel emergency (*MAYDAY MAYDAY MAYDAY FUEL)*.

6.3.2 Much of the information that can be used as the basis for operational policy and procedure required to conform to Annex 6, Part I, 4.3.7.1, was discussed in the preceding chapters and appendices. The balance of this chapter, however, is devoted to providing an operational perspective on those Standards that form the foundation of an operator's in-flight fuel management policy.

6.4 COMPLETING THE PLANNED FLIGHT SAFELY

6.4.1 Annex 6, Part I, 4.3.6.1, specifies that "An aeroplane shall carry a sufficient amount of usable fuel to complete the planned flight safely and to allow for deviations from the planned operation". Annex 6, Part I, 4.3.6.7 requires that the use of fuel after flight commencement for purposes other than originally intended during pre-flight planning shall require a re-analysis and, if applicable, adjustment of the planned operation. These SARPs, taken together, reinforce the notion that the safe conclusion of any flight depends on the accuracy and completeness of initial planning as well as the intelligent use of on-board resources including usable fuel supply. The best fuel planning in the world cannot ensure a safe outcome if the execution of the plan is faulty or if invalidated planning assumptions go undetected. As such, flight planning activities must be complemented by practical in-flight fuel management policies and procedures.

6.4.2 The preparation of an OFP typically includes anticipated fuel consumption and fuel quantity expected to be remaining over each point of a route. Modern aeroplane technology also offers the capability to closely monitor fuel consumption during operations. Taken together these elements form the basis for reliable and accurate methods to monitor and manage en-route fuel burn. Such methods should be clearly defined by the operator in the form of policies and procedure for use by the flight crew as well as relevant operational control personnel.

Considerations before take-off when a flight does not unfold as planned

6.4.3 At any stage in a flight it may become apparent to the flight crew through an in-flight fuel check or simple inspection that pre-flight assumptions regarding fuel consumption are not being realized. One potential outcome is under-consumption (under-burn), which can arise as the result of one or more of the parameters used in flight planning being more favourable in practice than as planned.

6.4.4 Under-burns are unlikely to cause significant operational difficulty unless a flight was planned near a maximum take-off or landing weight limit. In such cases, under-burn implies that the take-off or arrival landing weight may exceed such limits. In either case, under-burns can be managed easily and do not typically pose a threat to safe flight completion. On the contrary, from purely an operational perspective, being under or on burn typically results in having fuel available for use later in the flight (to deviate, hold, divert, etc.).

6.4.5 Over consumption (over-burn), on the other hand, arises when the conditions encountered in actual practice are less favourable than the conditions or parameters set during pre-flight planning, such as:

a) higher than planned ZFW;

b) longer than expected taxi times;

c) longer than planned routings;

d) cruise altitude less favourable than planned;

e) cruise speed less efficient than planned;

f) worse than forecast wind components.

6.4.6 In contrast to under-burn, unmitigated over-burn can easily limit the PIC’s ability to complete the planned operation. It is therefore essential for flight crews and operational control personnel alike to understand the parameters used to plan the trip as well as the circumstances when over-burn poses a threat to safe flight completion. This is especially important when making decisions that require a clear understanding and accurate assessment of the current fuel state and whether or not margins exist in remaining fuel quantities that can be repurposed in the event of shortfalls.

Considerations prior to take-off (analysis and adjustment)

6.4.7 Flight crews and operational control personnel should be pro-active when it comes to managing a consumable and finite resource such as fuel. To achieve this end, the best place to start is with an accurate plan that accounts for all foreseeable, and to the greatest practical extent, unforeseeable occurrences. The next challenge is to ensure the plan is continuously monitored and reconciled against actual performance. Finally, flight crews must be given the opportunity to intervene as necessary to adjust the plan based on the latest information available.

6.4.8 The greatest challenge during the pre-flight allocation of fuel is deciding how much fuel will be necessary to cope with unforeseen occurrences that have the potential to invalidate the plan as well as when in the flight such fuel may be needed. *Contingency fuel* is allocated for this purpose and is intended to compensate for unforeseen occurrences on the ground and in flight. It is important to note, however, that *contingency fuel*, while available for use during taxi-out, may need to be preserved to account for other unforeseeable occurrences later in the flight.

6.4.9 Arguably the best opportunity to preclude taking fuel shortages into the air occurs on the ground prior to take-off. With this concept in mind, the operator should establish a hierarchy within its fuel policy to practically ensure sufficient fuel is uplifted (and ultimately used) to compensate for foreseeable occurrences on the ground while preserving *contingency fuel*, to the greatest practical extent, to compensate for unforeseeable occurrences in flight (see Figure 6-3).

6.4.10 In order to maintain the integrity of the aforementioned hierarchy and to ensure fuel is appropriately allocated for foreseeable occurrences on the ground, the "qualified use" of contingency fuel to compensate for unforeseen occurrences on the ground could be identified as a "trigger event" within an operator's fuel policy as follows:

a) contingency fuel, while available for use during taxi-out, may need to be preserved to account for other occurrences later in the flight (e.g. to meet EDTO requirements);

b) there may be times when the consumption of contingency fuel on the ground cannot be avoided. In such cases the partial or complete consumption of contingency fuel (presumes taxi and discretionary fuel have already been consumed) requires re-analysis and adjustment as necessary and as determined by the PIC, or the PIC and FOO in a shared system of operational control;

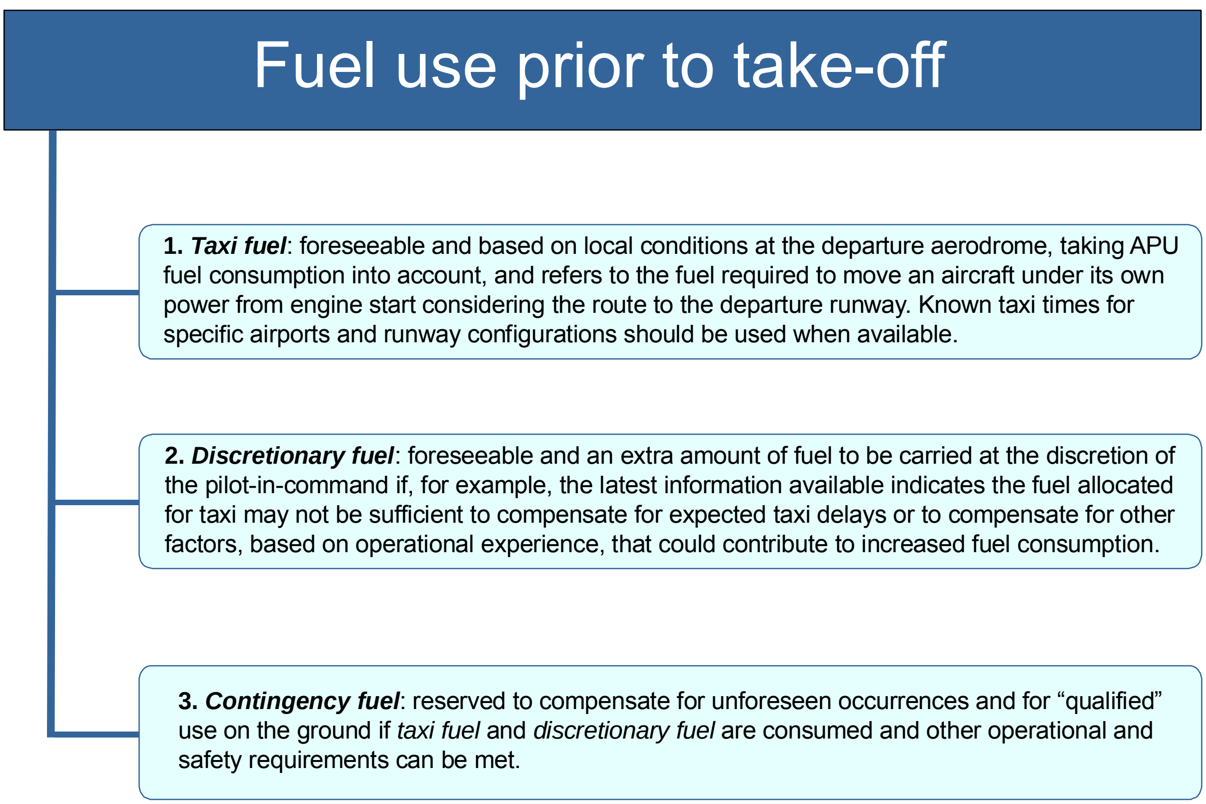


Figure 6-3. Fuel use prior to take-off

c) any re-analysis will include a determination if margins exist in remaining fuel quantities allowing fuel to be re-allocated to ensure safe completion of the planned operation (e.g. reconciliation of plan versus actual trip fuel considering such factors as actual ZFW, planned cruise speed, cruise level);

d) the plan will be adjusted as necessary to restore appropriate safety margins by, as applicable:

1) re-planning using the actual ZFW;

2) flying at a more economical speed than planned;

3) seeking a more economical cruise level;

4) seeking more efficient routing from ATC;

5) re-routing to reduce the length of the critical diversion;

6) selecting a different destination alternate or, if feasible, removing an alternate;

7) revising the flight plan to include planned re-release/re-dispatch;

e) if, in the opinion of the PIC (or PIC and FOO, as applicable), the planned operation cannot be safely completed or adjusted, the PIC should return to refuel in order to preclude taking a known and potentially consequential fuel shortage into the air.

Relationship between contingency fuel and the Critical Fuel Scenario (CFS)

6.4.11 As previously stated, one circumstance when over-burn may pose a threat to safe flight completion is the partial or complete consumption of contingency fuel before take-off. It is important to note, given the accurate computation of taxi fuel and the prudent use of discretionary fuel, that such a circumstance should be a fairly rare event. Additionally and in order for such a circumstance to pose a threat to safe flight completion, there would have to be little or no margin between the planned and actual trip fuel. Nevertheless it is precisely these sorts of assumptions that must be considered by the PIC any time a flight begins to burn into contingency fuel prior to take-off.

6.4.12 In some cases modest over-consumption, implicit in the carriage of contingency fuel, may not in and of itself be a cause for concern. Flight crews must realize, however, that any early consumption of contingency fuel means that fuel may not be available to compensate for occurrences later in the flight. This is an important point as, depending on the nature of the flight, it may restrict the PIC's options precisely when the need for contingency fuel would be greatest.

6.4.13 The concern for the protection of contingency fuel arises when a flight contains a sector which gives rise to a critical fuel scenario, typically an EDTO flight, but conceivably a non-EDTO flight where the depressurization case is limiting. In either case, the fuel allocated to be on board at the critical point is based on the presumption that the fuel consumption en route to the critical point is as planned, so that some of the contingency fuel loaded at departure is still on board. To alleviate this concern, operators may plan a flight to arrive at the critical point with some margin of fuel above the minimum (protected contingency fuel). Over-burn early in the flight, however, can quickly erode this margin to zero requiring flight crew intervention as early as possible to ensure its preservation.

6.4.14 The critical fuel scenario therefore must be considered carefully, as over-burn or improper planning can reduce planned safety margins. Annex 6, Part I, 4.3.6.3 f) defines *contingency fuel* as one of the variables in the additional fuel equation. *Additional fuel* is defined as the fuel required to protect against the very unlikely event of an engine failure or de-pressurization at the most critical point in the flight and/or the manifestation of the EDTO critical fuel scenario as defined by the State of the Operator. The protection of some contingency fuel is therefore intrinsic in the protection of additional fuel. Put another way, it means that any fuel uplifted to comply with the additional fuel requirements of 4.3.6.3 f) typically assumes that some amount of contingency fuel will be dedicated to protecting the critical fuel scenario.

6.4.15 Another point to consider is that because some of the contingency fuel may be included in the additional fuel equation it may not available for other contingencies if the critical fuel scenario manifests itself. Conversely, if contingency fuel is consumed prior to the critical point, there may be insufficient fuel remaining to protect the critical fuel scenario. It is important to note that the entire amount of additional fuel (which may include some of the planned contingency fuel) is allocated during pre-flight planning to ensure the aeroplane, at the most critical point along the route, can descend as necessary, proceed to an alternate aerodrome, fly for 15 minutes at holding speed at 450 m (1 500 ft) above aerodrome elevation in standard conditions and make an approach and landing.

6.4.16 As a practical matter, and to manage the process of protecting contingency fuel (if desired by the operator or required by the authority), and calculating additional fuel for EDTO, flight planning systems typically offer at least three options as outlined in Table 6-1. Note that “protecting” contingency fuel in this context simply means taking the additional steps to ensure it is likely to be available at certain points in the flight but not necessarily requiring that it be available.

6.4.17 It is important that flight crews and operational control personnel alike understand the basis for the computation of additional fuel in order to make prudent decisions regarding the early consumption of contingency fuel. If, as illustrated in the previous paragraph and Table 6-1, for example, flight planning software does not account for the consumption of contingency fuel prior to the most critical point, then it is likely there will be little or no margin for increased fuel consumption up to that point. Conversely, if some amount of contingency fuel consumption en route to the critical point is considered as part of pre-flight planning, then the margin between additional fuel required and additional fuel available is likely to be greater. These distinctions are important as they may impact the PIC’s decision to take off or return to the stand for refuelling after the partial or complete use of contingency fuel on the ground.

Note.— Refer to Chapter 4, 4.24 Pre-flight fuel planning — additional fuel of this manual for practical instructions regarding the computation of additional fuel.

Considerations at the point of in-flight re-planning and/or decision point

6.4.18 Flights that are planned with an in-flight re-planning or decision point share common considerations regardless of the flight re-planning method used (e.g. PDP, DP, 3 per cent ERA, re-dispatch). In each case, a combination of conditions must be satisfied to proceed beyond the re-planning or decision point and continue to the destination. The flight crew therefore spends the time during the en-route phase judiciously monitoring and evaluating a host of factors to determine whether or not a flight may continue beyond a decision point to the destination or must divert to an en-route alternate. All such considerations are typically explained in great detail within an operator’s fuel policy.

6.4.19 One scenario, however, that may be overlooked is the notion of an “un-planned” re-release or re-dispatch. In the case of simple A-to-B flights, for example, there is no planned re-release point although many of the considerations for in-flight re-planning are applicable. It is important to note, however, that regardless of the flight planning method used, flight crews must always be able to recognize when the conditions under which a flight was originally planned (or released) have changed. To accomplish this aim, flight crews must become attuned to the conditions of their release (i.e. flight plan) as well as have access to the most current information available related to its execution.

Table 6-1. Protecting contingency fuel and calculating additional fuel

Option	*Explanation*	*Implications*
1. *Contingency fuel* "unprotected" to the (EDTO) Critical Point[2].	*Contingency fuel* is calculated as a straight percentage of trip fuel in accordance with Annex 6, Part I, 4.3.6.3 c) and no accommodation is made to ensure its availability after flight commencement, for the case of a diversion from the (EDTO) Critical Point[2] to the EDTO en-route alternate aerodrome in the critical fuel scenario	As a consequence, if more than the planned taxi fuel is used on the ground before take-off, "EDTO critical scenario fuel (to account for icing, errors in wind forecasting, APU use, etc.)" and to allow for 15 minutes of holding over the EDTO en-route alternate aerodrome will begin to be consumed. *In the absence of any other mitigating actions[1] the burning of fuel on the ground beyond these quantities means that the EDTO en-route alternate aerodrome cannot be reached in the critical scenario case even if everything else unfolds as planned.*
2. *Contingency fuel* "partially protected" to the (EDTO) Critical Point[2].	One operator best practice is to protect some of the *contingency fuel* en route to the critical point. The logic here is to include a portion of the *contingency fuel* for the DEP to the (EDTO) Critical Point[2] in the additional fuel calculation. This "protected" amount of *contingency fuel* creates a margin that should allow reaching the (EDTO) Critical Point[2] with enough fuel to fulfil the critical fuel scenario to the EDTO en-route alternate aerodrome even in the case of over burn due to unexpected occurrences.	*In the absence of other mitigating actions[1], if the taxi fuel and protected portion of contingency fuel are consumed on the ground due to extended taxi time, the EDTO en-route alternate aerodrome cannot be reached in the critical fuel scenario case for the same reasons attributed to option 1*
3. *Contingency fuel* "completely protected" to the (EDTO) Critical Point[2].	Another operator practice is to protect the entire amount of *contingency fuel* for the DEP to the (EDTO) Critical Point[2]. This option presumes that all of the "required" *contingency fuel* would still be available at the critical point and is practically accomplished at the planning stage by adding the required contingency to the *additional fuel* calculation a second time.	*In the absence of other mitigating actions[1], if the taxi fuel and protected portion of contingency fuel are consumed on the ground due to extended taxi time, the EDTO en-route alternate aerodrome cannot be reached in the critical fuel scenario case for the same reasons attributed to option 1.* By protecting *contingency fuel* in this manner, however, it is assumed that the flight would reach the critical DP with enough fuel to fulfil the critical scenario even if *taxi fuel* and the "required" *contingency fuel* for DEP to DEST were consumed before take-off.

Note 1.— The implications related to each option assume no other mitigating actions taken by the flight crew to preclude a fuel shortage when airborne (e.g. re-analysis and adjustment or the uplift of discretionary fuel*).*

Note 2. — The (EDTO) Critical Point relates to the point along the route with the most limiting Critical Fuel and typically coincides with the last Equal Time Point (ETP) within the EDTO segment of the flight.

6.4.20 Information that would be useful in determining whether or not a landing can be made at the destination or any available en-route alternate is typically related to:

a) meteorological conditions, both en route and at the destination, to include hazardous phenomena such as thunderstorms, turbulence, icing and restrictions to visibility;

b) field conditions, such as runway condition and availability and status of navigation aids;

c) en-route navigation systems and facilities status, where possible failures could affect the safe continuation or completion of the flight;

d) en-route fuel supply, including actual en-route consumption compared to planned consumption, as well as the impact of any changes of alternate airport or additional en-route delays;

e) airborne equipment that becomes inoperative, which results in an increased fuel consumption or a performance or operational decrement that could affect the flight crew's ability to make a safe landing at an approved airport;

f) air traffic management concerns, such as re-routes, altitude or speed restrictions and facilities or system failures or delays; or

g) security concerns that could affect the routing of the flight or its airport of intended landing.

6.4.21 Access to such information is crucial to ensuring flights do not proceed beyond the last possible point of diversion to an en-route alternate airport and continue to the destination when, in the opinion of either the PIC or, in a shared system of operational control, the PIC and FOO/Dispatcher, it is unsafe to do so.

Understanding the Critical Fuel Scenario (CFS)

6.4.22 Although the manifestation of the CFS is an extremely rare event, a fuel shortfall approaching the critical point should be carefully considered. Some of the central issues for the PIC to consider when a fuel shortfall occurs include but are not limited to:

a) What is the size of the shortfall? The size of any fuel shortfall should be translated into minutes of holding over the diversion aerodrome (15 minutes is required) and an analysis undertaken to incrementally refine flight planning assumptions.

b) Is there any conservatism or "pad" left in the flight plan? A reduction in ZFW from plan would result in the flight being lighter than the weight used as the basis for the CFS calculation, resulting in a lower fuel burn to the diversion aerodrome.

c) What were the flight planning assumptions used for the CFS? The CFS is based on an engine failure or depressurization at the most critical point in accordance with Annex 6, Part I, 4.3.6.3 f) 1) although in the case of Annex 6, Part I, 4.3.6.3 f) 2) an engine failure and depressurization must typically be considered. In either case, in addition to fuel for the diversion and 15 minutes holding, CFS fuel includes an allotment of fuel to account for APU use, anti-icing use, errors in wind forecasting and deterioration in cruise fuel burn performance. With this in mind, the operator's dispatch organization, for example, could be enlisted to determine if the allowance for additional fuel for airframe anti-icing and additional drag due to icing on unprotected surfaces is unnecessary or excessive and recalculate the CFS accordingly.

The CFS calculation example in Table 6-2 contains the potential critical fuel scenarios and provides some insight into the variables to be re-analysed by an operator's dispatch organization in the event of a fuel shortfall:

Table 6-2. CFS calculation example

EDTO ENTRY AIRPORT KSFO/SFO
EDTO EXIT AIRPORT PHTO/ITO

EARLIEST/LATEST ARRIVAL TIME FOR EDTO ENR ALTN APTS BASED ON ETD
KSFO/SFO SUITABLE 1826Z/2349Z
PHTO/ITO SUITABLE 2055Z/2345Z

CP-1 N2858.8 W13839.4
FUEL REMAINING 56000 FUEL REQD 54858
2 ENG OR 1 ENG TIME FROM CP TO ALTN AT 320KIAS/FL100 IS 157 MINS
1 ENG TIME FROM CP TO ALTN AT 320KIAS/OPT IS 135 MINS

	CP-KSFO/SFO			CP-PHTO/ITO		
SCENARIO	1 E/O OPT	1 E/O FL100	ALL ENG. FL100	1 E/O OPT	1 E/O FL100	ALL ENG. FL100
Dist	967	967	967	1054	1054	1054
Avg Wind Comp	M23	M10	M10	P20	P12	P12
Avg Oat	M01	P01	P01	M03	P03	P03
Fuel Descent/Crz /Approach	46 359	50 558	48 094	46 359	50 558	48 094
15min Hold 1500ft AFE	3 000	3 000	3 000	3 000	3 000	3 000
Apu Burn	850	850	0	850	850	850
Ice Drag	0	0	0	0	0	0
Engine Anti-Ice	200	200	200	200	200	200
Wing Anti-Ice	0	0	0	0	0	0
Wind Error	260	240	240	270	250	250
TOTAL FUEL REQUIRED	50 669	54 848	51 534	50 679	54 858	52 394

d) Is there additional "conservatism" built into CFS planning? Beyond the previously stated critical fuel allowances, it is important to remember that an engine failure and/or depressurization is an extremely rare event. Rarer still would a failure coincident with the most critical point along the route. Even so, if a failure did occur, would the diversion to the EDTO alternate aerodrome be more or less efficient than planned?

The CFS worst-case scenario involving a depressurization, for example, would require a descent to a low and inefficient altitude. Other diversions (e.g. engine failure without other complications) may well be flown safely at a higher altitude with a consequent reduction in fuel consumption compared to the CFS.

Another point to consider is the proximity to the critical point when a failure occurs as well as any fuel savings to be derived from an expeditious and efficient diversion to the EDTO en-route alternate aerodrome. For example, the use of an idle power descent and allowing the FMC to optimize the speed could result in significant fuel savings en route to the alternate aerodrome. For example, a three-hour planned diversion flown at FL 200 instead of FL100 may result in approximately an extra 30 minutes of holding time available.

e) Are there sufficient fuel margins to protect fuel at the destination and/or destination alternate? Considering that the manifestation of the CFS is an extremely unlikely event, a more operationally realistic measure of the fuel state of the flight may be the forecast fuel remaining at the destination and/or destination alternate. The presumption here is that, from an operational perspective, a low fuel state may not truly exist until there is a reasonable certainty that final reserve fuel can no longer be protected at the destination and destination alternate aerodrome.

One best practice would be to define such a fuel state in the operator's fuel policy to coincide with requests for delay information from ATC. Such requests, intended to preclude minimum and emergency fuel states, are triggered in accordance with Annex 6, Part I, 4.3.7.2.1, when unanticipated circumstances may result in landing at the destination aerodrome with less than the final reserve fuel plus any fuel required to proceed to an alternate aerodrome.

f) Is there an immediate risk to the aircraft or to the safe completion of the flight to the en-route alternate, destination or any other given aerodrome? Remember that the additional fuel calculation is a planning exercise designed to protect against the unlikely manifestation of the CFS. Equally important to remember is that Annex 6, Part I, Attachment D, 3.2.2.3, allows the following factors to be considered if a landing at any given aerodrome would be the more appropriate course of action:

1) aeroplane configuration, mass, systems status and fuel remaining;

2) wind and weather conditions en route at the diversion altitude, minimum altitudes en route and fuel consumption to the en-route alternate aerodrome;

3) runways available, runway surface condition and weather, wind and terrain in the proximity of the en-route alternate aerodrome;

4) instrument approaches and approach/runway lighting available and rescue and firefighting services (RFFS) at the en-route alternate aerodrome;

5) the pilot's familiarity with that aerodrome and information about that aerodrome provided to the pilot by the operator; and

6) facilities for passenger and crew disembarkation and accommodation.

6.4.23 Finally whatever course of action is undertaken, appropriate fuel management is likely to be vital, regardless of when the fuel shortfall occurs. Additionally, steps should be taken by the operator to preclude future shortfalls and ensure to the greatest practical extent that for future flights, if applicable, fuel for the CFS is on board at the (EDTO) Critical Point.

Considerations in the terminal area

6.4.24 Modern systems and methods make it relatively easy to continuously monitor fuel consumption and fuel on board on arrival, although such information may be of little use to a flight crew that does not exercise appropriate judgment as a flight unfolds. With this in mind, it is important to note that all flights no matter the duration always arrive with far fewer options than were available when they departed. For example, a flight typically arrives in the vicinity of its destination aerodrome with the following fuel on board regardless of the length of the flight from the point of departure (see Figure 6-4).

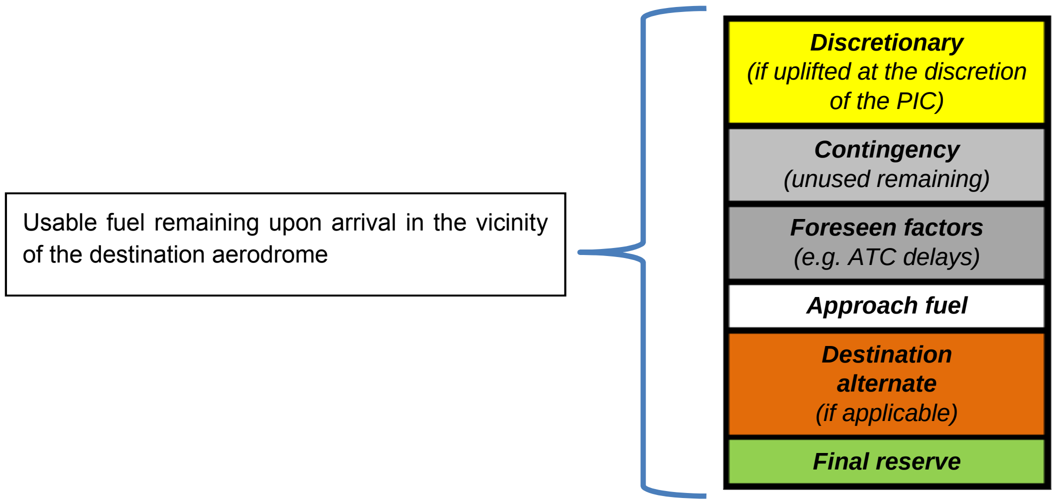


Figure 6-4. Usable fuel remaining

6.4.25 At this point in the flight, the PIC must decide in association with operational control personnel, if available, how best to use the remaining and scarce resource. In many cases, the best decision may be an early diversion in order to avoid making a more difficult choice among fewer options later in the flight. Additionally, if a destination is close to weather minimums or suffering from extended delays, the more information available to increase the PIC's situational awareness, the better the basis for a sound decision.

Diversions

6.4.26 Making informed decisions based on the best information available is essential when weighing options in the terminal area. For example, if alternate fuel is available, it should allow for a diversion from decision height; but is initiating an approach the best decision under the circumstances? The decision to divert may be better made before burning any approach fuel, and even before all contingency fuel is consumed. This mind-set preserves fuel for later in the flight when options may be more limited.

6.4.27 One procedural means to manage fuel at this critical point in the flight, in accordance with the requirements of the State's Authority, permits the PIC to use the alternate fuel to continue to proceed to, or hold at, the destination aerodrome. Such a procedure is commonly known as "Diverting or Committing" to destination.

6.4.28 It is typically used when the PIC decides a safe landing, with not less than final reserve fuel remaining, can be accomplished at the destination aerodrome. The PIC makes this decision after taking into account the traffic and the operational conditions prevailing at the destination and destination alternate aerodromes. Practically speaking this in-flight re-analysis and adjustment option simply allows the PIC to convert fuel originally allocated for a diversion to an alternate aerodrome into fuel to proceed or "divert to" the destination. The additional circumstances in which "Diverting or Committing" is permitted typically include:

a) an assured landing in the prevailing and immediate forecast conditions (including likely single equipment failures); or

b) an allocated Expected Approach Time or confirmation from ATC of maximum likely delay.

6.4.29 This is just one example of an in-flight fuel management policy or procedure that recognizes when a flight crew's assessment of the traffic and meteorological conditions may be more accurate for the destination than for any alternate aerodrome. It is important to note that most diversion decisions whether to divert to the destination or an alternate imply landing without a further alternate aerodrome available making the decision to "divert to destination" nothing unique. Whatever policies and procedures are developed by an operator, however, should be crafted to ensure that the amount of usable fuel remaining in flight is not less than the fuel required to proceed, with the planned final reserve remaining, to a suitable aerodrome where a safe landing can be made.

6.5 PROTECTING FINAL RESERVE FUEL

6.5.1 Annex 6, Part I, SARPs provide the framework for the protection of final reserve fuel beginning with actions to be taken during the planning stage and culminating when a flight lands safely. Three SARPs in particular provide the foundation for this framework by assigning responsibilities, defining terms and recommending actions designed to foster an operational culture that requires the continual evaluation of usable fuel remaining. Taken together these SARPs can also form the foundation of an operator's in-flight fuel management policy:

a) Annex 6, Part I, 4.3.7.2, clearly assigns the responsibility for the in-flight management of fuel to the PIC by stating that the pilot-in-command shall continually ensure that the amount of usable fuel remaining on board is not less than the fuel required to proceed to an aerodrome where a safe landing can be made with the planned final reserve fuel remaining upon landing; and

b) Annex 6, Part I, 4.3.6.3, defines final reserve fuel as the amount of fuel calculated using the estimated mass on arrival at the destination alternate aerodrome or the destination aerodrome, when no destination alternate aerodrome is required:

— for a reciprocating engine aeroplane, the amount of fuel required to fly for 45 minutes, under speed and altitude conditions specified by the State of the Operator; or

— for a turbine-engined aeroplane, the amount of fuel required to fly for 30 minutes at holding speed at 450 m (1 500 ft) above aerodrome elevation in standard conditions, and;

c) Annex 6, Part I, 4.3.6.4, recommends that operators should determine one final reserve fuel value for each aeroplane type and variant in their fleet rounded up to an easily recalled figure.

6.5.2 The values determined in accordance with Annex 6, Part I, 4.3.6.4, are not intended as substitutes for the exact values calculated in accordance with 4.3.6.3, but rather as a quick reference for flight crews to consider during fuel planning and in-flight fuel management activities. Tables 6-3 and 6-4 are simple representations of a Final Reserve Fuel Table provided for illustrative purposes only. Actual charts should represent fuel in the unit of measure appropriate for the operation and be based on data derived from the aeroplane flight manuals (AFM) for all types used in operations. In any case, the conditions upon which the table is predicated should be clearly stipulated in the table notes or accompanying description.

Table 6-3. Example of a basic final reserve fuel table

EXAMPLE ONLY	
Aeroplane Type	*Final Reserve Fuel in kilograms (pounds)*
DC-9	1 400 (3 000)
MD-88/90	1 400 (3 000)
B-737	1 400 (3 000)
B-757	1 600 (3 500)
B-767	2 500 (5 300)
B-777	3 700 (8 000)
B-747-400	5 000 (11 000)
A-319/320	1 400 (3 000)
A330	2 800 (6 000)

Notes.—

- *Chart values are provided for information purposes only. Flight crews should calculate the expected landing fuel remaining and final reserve fuel in accordance with in-flight fuel check policy and procedure.*
- *Final reserve fuel is the amount of fuel required to fly for 30 minutes at holding speed at 450 m (1 500 ft) above aerodrome elevation in standard conditions.*
- *Chart values are rounded up to the nearest 100, include tank gauge tolerance and are based on maximum landing mass.*

6.5.3 While Table 6-3 represents a basic example of a table containing final reserve fuel approximations by aeroplane type, a slightly more sophisticated table may be appropriate as part of an overall procedural strategy to protect final reserve fuel by providing approximate fuel consumption data. Such a table, for example, could address the fuel required to conduct an approach and further aids the PIC in determining an impending low fuel state. Table 6-4 incorporates approximate fuel burn data from the Final Approach Fix in order to better illustrate the point in the flight when a landing below final reserve fuel may be likely.

6.5.4 Whatever guidance is provided to the flight crew it must provide the practical means to protect final reserve fuel in the form of in-flight fuel management policy and procedure in accordance with Annex 6, Part I, 4.3.7.1, including when necessary, instructions for the declaration of MINIMUM FUEL or a fuel emergency in accordance with Annex 6, Part I, 4.3.7.2.2 and 4.3.7.2.3, respectively.

Table 6-4. Example of a Final Reserve Fuel Table that incorporates FAF fuel

EXAMPLE ONLY		
Aeroplane Type	*Final Reserve Fuel In kilograms (pounds)*	*Final Approach Fuel in kilograms (pounds) Approximate fuel required to complete an approach from the FAF*
DC-9	1 400 (3 000)	180 (400)
MD-88/90	1 400 (3 000)	140 (300)
B-737	1 400 (3 000)	180 (400)
B-757	1 600 (3 500)	140 (300)
B-767	2 500 (5 300)	230 (500)
B-777	3 700 (8 000)	450 (1 000)
B-747-400	5 000 (11 000)	950 (2 000)
A-319/320	1 400 (3 000)	180 (400)
A330	2 800 (6 000)	270 (600)

Notes.—

- *Chart values are provided for information purposes only. Flight crews should calculate the expected landing fuel remaining and final reserve fuel in accordance with in-flight fuel check policy and procedure.*
- *Final reserve fuel is the amount of fuel required to fly for 30 minutes at holding speed at 450 m (1 500 ft) above aerodrome elevation in standard conditions.*
- *Chart values are rounded up to the nearest 100, include tank gauge tolerance and are based on maximum landing mass.*

6.6 IN-FLIGHT FUEL CHECKS AND FUEL MANAGEMENT POLICIES AND PROCEDURES

As previously stated, Annex 6, Part I, 4.3.7.1, requires operators to establish policies and procedures to ensure that in-flight fuel checks and fuel management are performed by the flight crew and flight operations officers, as applicable. Practically speaking, and in order for successful fuel management to occur, operator policies and procedures typically require that at regular intervals and/or specified points indicated in the OFP or when otherwise required, the PIC:

a) compares actual versus planned fuel consumption;

b) verifies fuel quantity used against the fuel quantity expected to be used up to that point;

c) verifies fuel quantity remaining against the computed planned remaining quantity at that point;

d) reconciles FMS information with engine fuel flow and fuel quantity indicators;

e) records and forwards fuel use and quantity information to the data collection system. Such data could also be used to support real-time re-analysis and adjustment of aeroplane performance and allow for tactical operational changes as required. Optimum use of data for this purpose may require the use of an advanced operational control system supported by real-time communications capabilities with aeroplanes in flight. Some of the possible tactical changes could include:

   1) the use of Dynamic Airborne Re-route Procedure (DARP);

   2) en-route re-clearance capability;

   3) recalculation of critical decision points;

   4) re-planning in event of system failure;

f) identifies discrepancies between the information provided by the OFP and actual fuel remaining;

g) investigates any discrepancy between the information provided by the OFP and the actual fuel remaining to find the origin and to initiate appropriate action;

h) considers operational factors and potential actions to be taken if flight planning assumptions are invalidated (re-analysis and adjustment). This is of particular importance if, as a result of an in-flight fuel check, the usable fuel remaining is insufficient to complete the flight as originally planned. In such cases the PIC would typically evaluate the traffic and the operational conditions prevailing at the destination aerodrome, at the destination alternate aerodrome (if applicable) and at any other adequate aerodrome before deciding on a new course of action;

i) if operating in accordance with in-flight re-planning, determines if applicable conditions are satisfied to continue beyond the point of in-flight re-planning (re-dispatch/re-release point, DP, etc.) and continue to the planned commercial destination;

j) if operating to an isolated aerodrome, re-calculates the position of the PNR based on actual fuel consumption and fuel remaining and determines if applicable conditions are satisfied for proceeding beyond the PNR to the destination aerodrome;

k) determines if remaining fuel is sufficient to complete the flight safely as planned. This is practically accomplished by calculating the usable fuel remaining upon landing at the destination aerodrome and determining if it will be sufficient to protect the required alternate fuel plus final reserve fuel or final reserve fuel, as applicable;

l) communicates with operational control personnel when necessary to establish appropriate contingency plans, including diversion to another aerodrome, if applicable. This is particularly important in the case of EDTO and in the case of operations to distant aerodromes where no alternate aerodromes are available;

m) communicates with ATC to request delay information in accordance with Annex 6, Part I, 4.3.7.2.1;

n) declares MINIMUM FUEL when required in accordance with Annex 6, Part I, 4.3.7.2.2;

o) declares MAYDAY MAYDAY MAYDAY FUEL to indicate a fuel emergency when required in accordance with Annex 6, Part I, 4.3.7.2.3;

p) takes the appropriate action and proceeds to the nearest aerodrome where a safe landing can be made.

6.7 REQUESTING DELAY INFORMATION FROM ATC

6.7.1 Annex 6, Part I, 4.3.7.2.1 states:

4.3.7 In-flight fuel management

…

4.3.7.2.1 The pilot-in-command shall request delay information from ATC when unanticipated circumstances may result in landing at the destination aerodrome with less than the final reserve fuel plus any fuel required to proceed to an alternate aerodrome or the fuel required to operate to an isolated aerodrome.

6.7.2 Conformance with this Standard requires an operator to define the conditions that require the PIC to request delay information from ATC. Such operator guidance is part of the overall in-flight fuel management strategy to ensure planned reserves are used as intended or required. They should also mark the beginning of a process that will ultimately preclude a landing with less than final reserve fuel on board. It should be noted that the request for delay information, in and of itself, is not a request for assistance or an indication of urgency, but a procedural means for the flight crew to determine an appropriate course of action when confronted with unanticipated delays.

6.7.3 There is no specific phraseology recommended for use with ATC in this case as each situation may be different. The pilot would use the information obtained from this request, however, to determine the best course of action up to and including a determination of when it would be necessary to divert to an alternate aerodrome and/or make additional declarations related to the fuel state of the flight. Example phraseology as well as the appropriate time to use it is contained in section 6.10 of this chapter.

6.8 MINIMUM FUEL DECLARATIONS

6.8.1 Annex 6, Part I, 4.3.7.2.2, complements 4.3.7.2.1 by stating:

4.3.7 In-flight fuel management

…

4.3.7.2.2 The pilot-in-command shall advise ATC of a minimum fuel state by declaring MINIMUM FUEL when, having committed to land at a specific aerodrome, the pilot calculates that any change to the existing clearance to that aerodrome may result in landing with less than planned final reserve fuel.

Note 1.— The declaration of MINIMUM FUEL informs ATC that all planned aerodrome options have been reduced to a specific aerodrome of intended landing and any change to the existing clearance may result in landing with less than planned final reserve fuel. This is not an emergency situation but an indication that an emergency situation is possible should any additional delay occur.

Note 2.— Guidance on declaring minimum fuel is contained in the Flight Planning and Fuel Management Manual *(Doc 9976).*

6.8.2 As previously stated, Annex 6, Part I, 4.3.7.2, specifically assigns the responsibility to the PIC of continually ensuring that the amount of fuel remaining is sufficient to land at a specific aerodrome with final reserve fuel in the tanks. Standard 4.3.7.2.2 further defines this essential responsibility and establishes a common phraseology for use in communicating a potential, impending or imminent low fuel state to ATC.

6.8.3 Annex 6, Part I, 4.3.7.2.2, also complements the MINIMUM FUEL definition in the *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM) (Doc 4444) where provisions to elicit action on the part of air traffic controllers have been expanded, clarifying to pilots when and how to declare a state of MINIMUM FUEL. The expansion of provisions in PANS-ATM is designed to codify the common purpose of protecting final reserve fuel and also addresses inter alia:

a) coordination in respect to the provision of flight information and alerting services whereby circumstances experienced by an aeroplane that has declared MINIMUM FUEL or is experiencing an emergency are reported by the transferring unit to the accepting unit and any other ATS unit that may be concerned with the flight;

b) standard ATC phraseology used by ATC including the provision of delay information after a (pilot) declaration of MINIMUM FUEL; and

c) ATC procedures related to other in-flight contingencies including actions to be taken after pilot declarations of a fuel emergency or MINIMUM FUEL.

6.8.4 Conformance with Annex 6, Part I, 4.3.7.2.2, presumes operator policies and procedures already foster a culture that protects final reserve fuel. Such policies and procedures, at a minimum:

a) require the PIC to continually assess expected landing fuel in accordance with the operator's in-flight fuel management policy and procedure;

b) identify conditions or events that trigger flight crew actions to protect final reserve fuel and, when necessary, expedite a landing at the nearest suitable aerodrome (e.g. unplanned arrival delays, unforecast meteorological conditions, fuel over-burn);

c) enable the PIC to easily identify or calculate the remaining usable fuel as well as determine when any further delay may result in a landing at a specific aerodrome with less than final reserve fuel remaining; and

d) require the PIC to declare MINIMUM FUEL when, having committed to land at a specific aerodrome, any change to the existing clearance to the aerodrome may result in landing with less than planned final reserve fuel.

6.8.5 After a request for delay information, the MINIMUM FUEL declaration likely represents the second in a series of steps to ensure remaining fuel on board an aeroplane is used as planned and final reserve fuel is ultimately protected. Practically speaking, the PIC should declare MINIMUM FUEL when, based on the current ATC clearance, the anticipated amount of fuel remaining upon landing at the aerodrome to which the aeroplane is committed is approaching the planned final reserve fuel quantity. This declaration is intended to convey to the applicable air traffic controller that as long as the current clearance is not modified, the flight should be able to proceed as cleared without compromising the PIC's responsibility to protect final reserve fuel.

Note 1.— Pilots should not expect any form of priority handling as a result of a MINIMUM FUEL declaration. ATC will, however, advise the flight crew of any additional expected delays as well as coordinate when transferring control of the aeroplane to ensure other ATC units are aware of the flight's fuel state.

Note 2.— MINIMUM FUEL declaration scenarios and recommended phraseology for use in communicating with ATC are provided in section 6.10 of this chapter.

6.9 EMERGENCY DECLARATIONS

6.9.1 Annex 6, Part I, 4.3.7.2.3, complements 4.3.7.2.2 by stating:

> 4.3.7 In-flight fuel management
>
> …
>
> 4.3.7.2.3 The pilot-in-command shall declare a situation of fuel emergency by broadcasting MAYDAY MAYDAY MAYDAY FUEL, when the calculated usable fuel predicted to be available upon landing at the nearest aerodrome where a safe landing can be made is less than the planned final reserve fuel.
>
> *Note 1.— The planned final reserve fuel refers to the value calculated in 4.3.6.3 e) 1) or 2) and is the minimum amount of fuel required upon landing at any aerodrome.*
>
> *Note 2.— The words "MAYDAY FUEL" describe the nature of the distress conditions as required in Annex 10, Volume II, 5.3.2.1.1, b) 3.*
>
> *Note 3.— Guidance on procedures for in-flight fuel management are contained in the* Flight Planning and Fuel Management Manual *(Doc 9976).*

6.9.2 The last in a series of procedural steps to ensure the safe completion of a flight is the declaration of an emergency. Conformance with Annex 6, Part I, 4.3.7.2.3, requires the PIC to declare a situation of emergency by broadcasting MAYDAY MAYDAY MAYDAY FUEL when the calculated usable fuel to be available upon landing at the nearest suitable aerodrome where a safe landing can be made will be less than the planned final reserve fuel. This declaration provides the clearest and most urgent expression of an emergency situation brought about by insufficient usable fuel remaining to protect the planned final reserve. It communicates that immediate action must be taken by the PIC and the ATC Authority to ensure that the aeroplane can land as soon as possible.

6.9.3 The MAYDAY declaration is used when all opportunities to protect final reserve fuel have been exploited and, in the judgment of the PIC, the flight will now land with less than final reserve fuel remaining in the tanks. The word fuel is used as part of the declaration simply to convey the nature of the emergency to ATC. It is also important to note an emergency declaration not only opens all options for pilots (available closed runways, military fields, etc.) but it also allows ATC added flexibility in handling an aeroplane.

Note.— MAYDAY (due to fuel) declaration scenarios and recommended phraseology for use in communicating with ATC are provided in section 6.10 of this chapter.

6.10 MINIMUM FUEL AND MAYDAY (DUE TO FUEL) DECLARATION SCENARIOS

6.10.1 Annex 6, Part I and PANS-ATM are aligned in their guidance to ensure that all participants in the international aviation community share a common understanding regarding the definition and intent of the terms *MINIMUM FUEL* and *MAYDAY MAYDAY MAYDAY FUEL*. The following scenarios illustrate how and when to use each term and are also provided as a means to differentiate clearly between such declarations.

6.10.2 It is important to note that a common element in every scenario is that each time *MINIMUM FUEL* is declared, the PIC has already committed to land at a specific aerodrome and is concerned that a landing may occur with less than final reserve fuel in the tanks. It is equally important to note that although the coordinated escalation process (with ATC) related to the protection of final reserve fuel typically occurs in three steps, each situation is different and may be resolved at any stage in the process. The three steps in the escalation process are:

Protecting final reserve fuel in accordance with Annex 6, Part I, 4.3.7	
Step 1	Request delay information when required (in accordance with 4.3.7.2.1).
Step 2	Declare MINUMUM FUEL when committed to land at a specific aerodrome **and** any change in the existing clearance may result in a landing with less than planned final reserve fuel (in accordance with 4.3.7.2.2).
Step 3	Declare a fuel emergency when the calculated fuel on landing at the nearest suitable aerodrome, where a safe landing can be made, will be less than the planned final reserve fuel (in accordance with 4.3.7.2.3).

Scenario 1: *MAYDAY MAYDAY MAYDAY FUEL — An aeroplane is on an IFR flight plan with a destination alternate aerodrome on file.*

Narrative

An aeroplane arrives in the terminal area and is instructed to hold south of its destination (KXYZ). The meteorological conditions are deteriorating rapidly in the vicinity of the destination aerodrome with a front moving in faster than expected. The flight plan fuel uplifted for the flight allotted 60 minutes of fuel for holding upon arrival to compensate for unanticipated meteorological conditions and traffic congestion delays. The flight plan also allotted fuel for the filed alternate (KABC) located 250 miles north of the destination.

Upon initial contact with ATC, the flight is told to hold for 45 minutes. In the holding pattern, the flight crew completes their normal in-flight duties including re-checking the destination meteorological conditions, considering a possible diversion at a pre-determined time as well as determining the point in time and fuel remaining required to depart the holding pattern for the destination aerodrome.

After 40 minutes of holding, ATC directs the flight crew to proceed to a holding fix closer to the destination and clears them to descend to a lower altitude. The Expect Further Clearance (EFC) issued for the new holding fix adds 20 minutes of flight time which will burn the remaining contingency fuel. The flight crew recalculates the expected landing fuel at destination based on the new EFC and is concerned that they will begin burning into required reserves.

The flight crew conveys their current fuel status to ATC and requests additional delay information (in accordance with 4.3.7.2.1). ATC then advises that they will be cleared to the destination (original aerodrome of intended landing) at or before the previously issued EFC time. Five minutes prior to the EFC time, the aeroplane is issued a clearance to the IAF and is informed that no further delays should occur.

Shortly after issuing the clearance to the IAF, ATC informs the flight crew that low-level wind shear warnings were reported by several preceding aeroplanes on final approach to KXYZ. The flight crew elects to continue but unfortunately the meteorological conditions at the destination aerodrome continue to deteriorate, with prevailing winds and visibility that limit arrivals to one runway. The flight crew flies an approach to the only available runway and executes a missed approach due to a wind shear alert on short final approach.

Aware that all contingency fuel has been consumed, the flight crew asks and receives a clearance to their alternate aerodrome (KABC). The PIC simultaneously declares MINIMUM FUEL (in accordance with 4.3.7.2.2) based on fuel remaining calculations, their commitment to the alternate aerodrome and the possibility that any delays incurred en route to their alternate aerodrome may result in a landing at the alternate with less than final reserve fuel remaining.

ATC advises that no further delays are expected *and clears the flight to the alternate aerodrome. En route, the aeroplane is advised that the runway at the alternate aerodrome is temporarily closed due to an incapacitated aeroplane. The PIC immediately declares MAYDAY MAYDAY MAYDAY FUEL (in accordance with 4.3.7.2.3). ATC informs the aeroplane that aerodrome KJKL, a military field, is available and not much farther than KABC. The flight crew is aware of the suitability of the KJKL and informs ATC that they will go direct to KJKL. The aeroplane is cleared as requested and lands at KJKL with 80 per cent of final reserve fuel in the tanks (due to the proximity of the emergency divert field).*

Explanation

In this scenario, when the flight first held in the vicinity of the original destination (KXYZ), the PIC could still divert to the alternate aerodrome while maintaining the appropriate fuel reserves including final reserve fuel. As such and at that point in the flight, a MINIMUM FUEL declaration would be inappropriate as the flight had yet to commit to an aerodrome, and there was sufficient fuel on board to protect final reserve fuel upon landing at either the destination or alternate.

The second holding clearance, however, threatened to consume all of the flight's fuel allocated for holding thereby reducing the options to a landing at the destination if additional delays were unlikely or a pre-emptive diversion to the alternate aerodrome. The potential to burn into the fuel required to divert to the alternate triggered the query regarding additional delays.

When the flight missed the approach at the planned destination and elected to commit to the alternate, the PIC declared MINIMUM FUEL as final reserve fuel could no longer be protected if any additional delays were encountered. Unfortunately, while en route to the alternate (KABC), additional delays were encountered requiring the PIC to declare an emergency. By broadcasting MAYDAY MAYDAY MAYDAY FUEL, the PIC utilized his/her emergency authority to proceed to and land at a military field (KJKL) that would have been otherwise unavailable.

R/T examples, edited for brevity and are not all-inclusive radio transmissions

Pilot	*Controller*
KXYZ Approach ICAO123 FL 240	*ROGER ICAO123 cleared DIRECT WLCOM and I have holding instructions, advise when ready to copy*
ROGER ICAO123 DIRECT WLCOM ready to copy	
	ICAO123 HOLD as published at WLCOM fix Expect further clearance at 1035
Readback	
	ICAO123 proceed DIRECT GONER DESCEND TO FL 190 and I have further holding instructions, advise when ready to copy
ROGER ICAO123 DIRECT GONER ready to copy	*ICAO123 HOLD as published at GONER fix Expect further clearance at 1120 UTC*
Readback and (free text) Have the EFC times been fairly accurate?	*ICAO123 No further delays expected*

	ICAO123 resume the FASTT arrival and cleared for the ILS RWY 35 approach, be advised low level wind shear has been reported
Readback	
KXYZ Approach ICAO123 on the missed approach requesting clearance to KABC	*ROGER ICAO123 CLEARED to KABC via DIRECT ZZZ VOR and J-63, CLIMB TO FLIGHT LEVEL TWO FOUR ZERO*
ROGER ICAO 123 cleared to KABC via DIRECT ZZZ VOR and J-63, leaving ONE ZERO THOUSAND for FLIGHT LEVEL TWO FOUR ZERO *MINIMUM FUEL*	*ROGER MINIMUM FUEL*
	ICAO123 be advised that runway 27/09 is temporarily closed due to an incapacitated aeroplane, it is estimated to open in 30 min.
ROGER ICAO123 MAYDAY MAYDAY MAYDAY FUEL	*ROGER ICAO123 MAYDAY FUEL, KJKL aerodrome has a 4 KM runway and is 30 NM at your 12 o'clock*
Readback	

Outcome

In this scenario, when the aeroplane executed the missed approach at KXYZ and proceeded to the alternate aerodrome KABC, the flight was still operating as planned. That is to say, the flight plan fuel accounted for the possibility of missing an approach at the destination and proceeding to the alternate aerodrome. Due to the subsequent delays at KXYZ and a decision to divert to KABC, however, it became apparent that little if any additional delay could be accepted, thus triggering the declaration of MINIMUM FUEL.

Up to this point the flight could still be considered "routine," until the flight crew was informed that the runway at KABC was temporarily closed. This warranted the MAYDAY MAYDAY MAYDAY FUEL declaration as all apparently available options would have, in the judgment of the PIC, resulted in landing with less than the planned final reserve fuel. Declaring an emergency, however, provided the PIC with additional options. In this case KJKL, a normally unavailable military field, became a viable option for the aeroplane to able to land while protecting as much remaining fuel as possible.

Scenario 2: *MINIMUM FUEL — An aeroplane is on an IFR flight plan with a filed destination alternate aerodrome and diverts after holding near the original destination aerodrome.*

Narrative

An aeroplane arrives in the vicinity of the destination aerodrome (MMAB) at 1500 UTC with flight planned fuel on board. The aeroplane is asked to hold with an EFC time of 1510 UTC due to traffic congestion. This is acceptable to the PIC as sufficient contingency fuel was uplifted for unanticipated delays. Time passes and it becomes apparent that ten minutes of holding will be insufficient to ease the congestion. The PIC requests delay information from ATC (in accordance with 4.3.7.2.1) and is informed to expect an additional 15-minute delay and is subsequently issued a new EFC time of 1525 UTC.

The PIC checks the fuel state and informs ATC that he cannot hold any longer than the original ten minutes and requests a clearance to his alternate aerodrome (MMXZ). The PIC receives a new clearance and proceeds to MMXZ which now becomes the committed aerodrome of intended landing as he has consumed most of his contingency fuel and is concerned that he may begin burning into required reserves.

Meteorological conditions encountered en route require a reroute to the alternate aerodrome which in turn requires more fuel. When the aeroplane is clear of the meteorological conditions and is proceeding to the alternate aerodrome the PIC calculates that, barring any further delays, the flight will be landing with fuel slightly above the planned final reserve fuel quantity. He also notes that any changes to the current clearance to the alternate would likely result in a landing with less than final reserve fuel in the tanks.

The PIC informs ATC of the situation by declaring MINIMUM FUEL (in accordance with 4.3.7.2.2). The controller acknowledges the MINIMUM FUEL call and informs the flight crew that no further delays are expected. The aeroplane proceeds to and lands at the alternate aerodrome as previously cleared and the PIC fulfils his responsibility to protect final reserve fuel.

Explanation

In this scenario the aeroplane was subject to delays that consumed most of the planned contingency fuel and later diverted to the alternate aerodrome (MMXZ). In addition to a small amount of contingency fuel and the planned final reserve fuel, the flight had uplifted the fuel to proceed to an alternate aerodrome. A MINIMUM FUEL state did not exist while proceeding to the original destination aerodrome (MMAB) as the option to divert to the alternate without sacrificing planned reserves was still a viable option.

When the aeroplane, however, encountered WX en route requiring a reroute to MMXZ, the remaining contingency fuel was used. Based on the fuel used and once the aeroplane was back on course to MMXZ, the PIC determined that any further delays en route to the alternate aerodrome to which the flight was committed to land would result in landing with less than final reserve fuel.

The MINIMUM FUEL call was used appropriately in this case as it described the fuel state of the aeroplane to the controller clearly, succinctly and in accordance with Annex 6, Part I, 4.3.7.2.2). In other words, the declaration informed the controller that additional delays could not be accepted and the controller responded by informing the flight crew that no delays were expected. The controller also provided additional relevant information, kept the flight informed of any additional delays and passed along any relevant information when transferring the aeroplane to other ATC units. Both ATC and the flight crew maintained a heightened state of fuel situational awareness and the aeroplane proceeded to the aerodrome as cleared and landed uneventfully.

It is important to note that in this case, the MINIMUM FUEL phraseology was used as intended to convey the fuel status of the aeroplane. It was neither a declaration of urgency nor an emergency declaration, and the aeroplane was *treated as cleared keeping the same approach sequence. However, ATC did take action to keep the flight crew informed of any delays or changes to the previously issued clearance and was required to coordinate with other ATC units to ensure the MINIMUM FUEL state of the flight was passed along.*

R/T examples, edited for brevity and are not all-inclusive radio transmissions

Pilot	*Controller*
MMAB Approach ICAO123 passing ONE TWO THOUSAND for ONE ZERO THOUSAND	*ICAO123 I have holding instructions due to traffic congestion. Advise when ready to copy.*
ICAO123 ready to copy	*ICAO123 HOLD as published at WAITY fix EFC 1510 UTC*
Readback	
	ICAO123 due to continued traffic congestion your new EFC is 1525 UTC, continue holding at WAITY MAINTAIN ONE ZERO THOUSAND
ICAO123 unable to hold any longer and requesting clearance to MMXZ	*ROGER ICAO123 CLEARED TO MMXZ VIA DIRECT XYZ VOR and V-43, CLIMB TO ONE FIVE THOUSAND*
Readback	
ICAO123 requesting deviations to the right for weather ahead.	*ICAO123 you are CLEARED to deviate right of course as requested, advise when able to PROCEED DIRECT MMXZ.*
Readback	
ICAO123 proceeding direct MMXZ and declaring MINIMUM FUEL at this time.	*ROGER ICAO123 understand you are declaring MINIMUM FUEL. Expect no further delays continue as previously cleared, you are number 5 for the approach.*

Outcome

Practically speaking, the events described in this scenario are not out of the ordinary. The MINIMUM FUEL declaration was simply used by the PIC to make ATC aware that circumstances had reached a point where any further change to the current clearance could have resulted in an emergency due to fuel. However, the flight concluded at the alternate aerodrome (MMXZ), having met all fuel requirements including the protection of final reserve fuel.

Scenario 3: *MINIMUM FUEL — The aeroplane is on an IFR flight plan with a filed alternate and is forced to divert to an alternate aerodrome.*

Narrative

ICAO123 is a new large aeroplane (NLA) flying across the Pacific to YSAB. The filed alternate aerodrome, YSXZ, is located 150 miles south and is the only available alternate aerodrome due to a stationary frontal system surrounding YSAB. When ICAO123 is approximately 200 NM from YSAB, ATC advises that the destination aerodrome is closed until further notice due to a security breach. The flight crew accomplish their in-flight planning duties in accordance with operator policy and procedure to include: checking the meteorological conditions, considering diversion options, and completing required fuel calculations.

As a result of these duties, the flight crew decide to proceed to the alternate aerodrome, YSXZ, where they expect to arrive with 100 min or more of fuel. The flight crew requests delay information from ATC (in accordance with 4.3.7.2.1) and informs the controller that while not yet ready to declare MINIMUM FUEL, they are committed to a landing at YSXZ. ATC responds that delays in the YSXZ terminal area are likely given the number of diversions from YSAB and clears ICAO123 to a fix 50 NM from YSXZ with holding instructions and a 25 min EFC time.

As more and more aeroplanes divert to YSXZ and 25 minutes pass in the hold, ATC directs the flight crew of ICAO 123 to proceed to another holding fix closer to YSXZ, clears them to a lower altitude and issues a revised EFC that adds 40 min of flight time. ICAO123 acknowledges the new clearance and informs ATC that if they do not proceed to YSXZ at or before the revised EFC time they will be declaring MINIMUM FUEL (in accordance with 4.3.7.2.2). ATC acknowledges the transmission.

Shortly before the revised EFC time, the flight crew declares MINIMUM FUEL (at this point the aeroplane is estimating to land with 35 min of fuel and, in the judgment of the PIC, any additional delays may result in a landing at YSXZ with less than final reserve fuel in the tanks).

What the flight crew did not know is that prior to the MINIMUM FUEL declaration by the PIC, ATC had already intended to clear ICAO123 for the approach. The controller asks whether an approach clearance at the conclusion of the present circuit in the holding pattern would be acceptable to the flight crew. The flight crew accepts the controller's offer and ATC issues an approach clearance. The flight lands with more than the final reserve fuel in the tanks.

Explanation

The events described in this scenario had the potential to deteriorate rapidly into an emergency. The flight crew and ATC were able to resolve the issue in an orderly and uneventful manner, however, based on a common understanding of the fuel state of the aeroplane. When ATC informed the flight crew that YSAB was closed and they decided to proceed to their alternate aerodrome (YSXZ), the initial calculation indicated that they would arrive with the final reserve fuel (30 min) plus 70 minutes (100 min total fuel). Although the aeroplane was committed to land at YSXZ, as there were no other apparent options, the flight still had some operational flexibility (70 minutes fuel) and was not presently in a MINIMUM FUEL state in accordance with Annex 6, Part I, 4.3.7.2.2.

When ICAO123 was cleared closer to YSXZ and was given an additional holding clearance, the flight crew proactively informed ATC that the EFC time issued was very close to the point where no further delay could be accepted. Finally, with the second EFC time approaching and the flight without an approach clearance, a MINIMUM FUEL state was declared. ATC consulted with the flight crew about the intention of issuing an approach clearance, subsequently cleared the aeroplane for the approach, and the aeroplane landed with more than final reserve fuel.

R/T examples, edited for brevity and are not all-inclusive radio transmissions

Pilot	*Controller*
	ICAO123, be advised YSAB is closed until further notice for security reasons
ROGER, ICAO123 STANBY	
Center, ICAO 123 request CLEARANCE to YSXZ	*ICAO123 CLEARED to YSXZ via DIRECT SUNNY and B850*
ROGER ICAO123 CLEARED to YSXZ via DIRECT SUNNY and B850 be advised YSXZ is our only option and we may need to declare MINIMUM FUEL.	*ROGER ICAO123 are you declaring MINIMUM FUEL*
NEGATIVE not at this time	
Readback	
	ICAO123 HOLD at SOONR fix as published EFC 1030
Readback	
	ICAO123 DIRECT to CLSER fix and HOLD as published EFC 1110
ROGER ICAO123 DIRECT CLSER and HOLD as published EFC 1110. Be advised if we are not cleared for the approach at 1110 we will be declaring MINIMUM FUEL	
Readback	
YSXZ approach ICAO123 MINIMUM FUEL	*ROGER ICAO123, are you able to finish the holding pattern before being cleared for the approach?*
AFFIRMATIVE	*ICAO123 after CLSER CLEARED for the ILS RWY 29 approach*
Readback	

Outcome

This scenario while not necessarily routine benefited from a common understanding of the term MINIMUM FUEL that allowed the flight crew and ATC to manage the situation appropriately. In this case, the closure of YSAB actually posed a bigger problem for ATC as several aeroplanes were now diverting to YSXZ. The flight crew proactively kept ATC informed of their fuel state, and ATC shared their intentions with the flight crew (conclude the present hold before proceeding with the approach clearance). The radiotelephony between the flight crew and ATC was concise and focused on solutions rather than further describing the problem in keeping with the use of the term MINIMUM FUEL as intended in the SARPs.

Scenario 4: *MINIMUM FUEL — The aeroplane is on an IFR flight plan with a filed alternate and is forced to divert to an alternate aerodrome.*

Narrative

ICAO Flight 99 arrives in the terminal area of its planned destination aerodrome, KDEN, with 60 minutes of contingency fuel, alternate fuel to enable the crew to fly to their filed alternate aerodrome (KCOS), and final reserve fuel intact. After holding for some time and burning most of the planned contingency fuel, the crew is advised by ATC of an indefinite delay at the destination aerodrome due to unexpected runway closures. Specifically, ATC advises that the primary runway is closed due to a disabled aeroplane and braking action reported as nil on all other runways. In effect, there is no revised EFC time and KDEN is closed to operations until further notice.

The PIC elects to divert to the planned alternate aerodrome, KCOS. Although the planned contingency fuel was mostly consumed, the planned alternate fuel remains intact and is enough fuel to fly to KCOS. Due to severe meteorological conditions throughout the region, there are no other alternate aerodromes available that would allow the flight crew to conserve fuel. Despite operating in accordance with flight planning assumptions, the PIC declares MINIMUM FUEL (in accordance with 4.3.7.2.2) at this point as the flight is committed to landing at the alternate, KCOS, and any further delays from this point in the flight may result in a landing with less than final reserve fuel in the tanks.

This has not yet developed into an emergency as the flight still has a bit of contingency fuel, the planned alternate fuel to proceed to KCOS plus final reserve fuel remaining. The flight crew, however, is concerned that based on the remaining contingency fuel, very little delay can be accepted. The crew gains additional endurance time en route to KCOS due to better than expected flight conditions, favourable winds and direct routing. They pass this information along to ATC for coordination purposes, and the flight lands uneventfully in KCOS with more than final reserve fuel remaining in the tanks.

Explanation

This scenario is very straightforward and clearly illustrates the appropriate use of the MINIMUM FUEL declaration. In this case, the intent of MINIMUM FUEL is simply to aid the PIC in his/her responsibility to protect final reserve fuel once the flight is committed to a landing at a specific aerodrome. It is apparent that, due to the severity of the meteorological conditions in this example, the crew's alternatives were quite limited. It is important to note, however, that the PIC would be required to declare MAYDAY MAYDAY MAYDAY FUEL had additional delays been encountered en route to the alternate aerodrome and final reserve fuel could no longer be protected. It is equally important to note that had a closer alternate been available, the MINIMUM FUEL declaration would have likely been unnecessary.

In this case, however, the flight was able to successfully divert to its alternate (KCOS) and land without incident. The news that KDEN was closed with no EFC or expected EFC was the primary factor in the PIC's decision to commit to a landing at KCOS, the planned alternate aerodrome (and in this scenario, the only available alternate). The PIC's commitment to land at KCOS, an inability to accept much, if any, delay and the responsibility to protect final reserve fuel are the conditions that justify the MINIMUM FUEL declaration.

R/T examples, edited for brevity and are not all-inclusive radio transmissions

Pilot	*Controller*
	ICAO 99, be advised KDEN is closed until further notice. There is a disabled aircraft on the Runway 34R and all other runways have a reported braking action of "nil". Please advise intentions.

ICAO 99 please STANDBY	
Denver Center, ICAO 99 requests CLEARANCE direct to KCOS	*ICAO 99 CLEARED to KCOS via DIRECT*
ICAO 99 proceeding direct to KCOS and declaring MINIMUM FUEL.	*ROGER, ICAO 99, Denver Center copies that you declaring MINIMUM FUEL. We will pass that information on to the next sector.*
ICAO 99	
	Next Sector:
	ICAO 99, Denver Center, descend TO Flight Level 240, expect no holding at KCOS. You are number one for the arrival. Understand you are MINIMUM FUEL
Readback	
Denver Center, ICAO 99 confirms we are MINIMUM FUEL.	*ICAO 99, Denver Center copies.*

Outcome

This is a straightforward example that illustrates the proper use of the MINIMUM FUEL declaration. Such scenarios are endless and can be rooted in unfavourable meteorological conditions, mechanical problems, traffic, or other unanticipated factors. Once again, the key principles in understanding the use of this term are first: the commitment to an aerodrome with no other alternatives available, and second: protecting final reserve fuel by ensuring to the extent practicable that no additional delays will be encountered.

It is important to note that the PIC always maintains his/her ability to exercise emergency authority at any time. An emergency declaration would include priority handling and afford the PIC the ability to land at the nearest aerodrome available should the conditions warrant such action. The MINIMUM FUEL declaration, however, affords the PIC and ATC the opportunity to work together to protect final reserve fuel and perhaps preclude an emergency from developing.

6.11 FLIGHT CREW OCCURRENCE REPORTING PROCEDURES AND RESPONSIBILITIES

6.11.1 Another important element of an operator’s fuel policy and the foundation of continuous improvement initiatives is the collection and analysis of operational data. Flight crews and flight operations officers, if applicable, are routinely exposed to many challenging situations in the course of flight operations. An operator, through reporting systems and safety data collection tools, should be able to effectively acquire information from these operational personnel about operations and the hazards encountered. Their responsibility to collect operational data and report operational hazards should also be clearly communicated as part of the operator’s fuel and/or safety policies.

6.11.2 Flight crews and other operational personnel are also uniquely positioned to identify systemic hazards that may not have been considered during alternate aerodrome selection and fuel planning for a particular flight. It should be clearly understood by all operational personnel that unreported concerns or unidentified hazards remaining in operations threaten to invalidate the assumptions made during flight planning and may pose a safety risk to future operations. Additionally, the fact that a previously unidentified hazard did not affect a particular flight does not ensure it will not affect future flights. As such, it is important for operational personnel to report all such hazards to ensure systemic defenses and risk controls are appropriately developed.

6.11.3 The development of policy and training relevant to available methods of operational and safety data reporting is essential to ensure operational personnel are aware of, and appropriately use, the different tools available to identify and communicate hazards and safety concerns. Training should also address each of the reporting means available so that hazards or safety concerns may be brought to the attention of the relevant managers. Additionally, operational personnel should be functionally aware of their role in overall safety risk management.

— — — — — — — —

Appendix 1 to Chapter 6

CONSIDERATIONS FOR FLIGHT CREW PROCEDURES TO PRESERVE CONTINGENCY FUEL AND FOR FLIGHT PLAN RE-ANALYSIS AND ADJUSTMENT AFTER THE CONSUMPTION OF CONTINGENCY FUEL PRIOR TO TAKE-OFF

1. General

This appendix contains example Operations Manual (OM) procedures for use by flight crew members to preserve contingency fuel and to ultimately cope with its consumption prior to take-off. Such consumption may require analysis and adjustment of the planned operation in accordance with Annex 6, 4.3.6.7, if *contingency fuel* was uplifted to cope with unforeseen circumstances later in the flight or used as basis for the computation of *additional fuel.* In any case, flight crews must be continuously aware of their fuel state to ensure the operation can be completed as planned or adjusted as necessary to ensure safe flight completion.

2. Defining ***taxi fuel***

Flight crews should be aware of the methodology used to calculate *taxi fuel* as well as have some notion as to its accuracy. The OM, therefore, should contain clear guidance related to the computation of *taxi fuel* including the limitations of any such computation. If, for example, the operator uses statistical taxi times, the data and criteria used as basis for such computations should be clearly identified in the OM so flight crew may intervene as necessary to adjust the fuel load to compensate for occurrences unaccounted for during initial pre-flight planning.

Note.— Refer to Appendix 6 to Chapter 5 for examples of the data and criteria used in a statistical taxi fuel programme.

3. Flight preparation

The OM should contain procedures for flight crews to reconcile the planned *taxi fuel*, indicated on the OFP, against actual operating conditions. Such procedures should direct the PIC to evaluate all available last-minute information to determine the adequacy of the planned *taxi fuel.* If extended delays are anticipated that were not previously accounted for, the PIC should be directed to update the flight plan fuel load by coordinating with the flight dispatcher, if applicable, or by adding *discretionary fuel*. The overriding intent is to ensure, to the extent reasonably practicable, that the planned *taxi fuel* plus *discretionary fuel* is equal to or exceeds the actual taxi fuel burned.

4. Taxi-out

The OM should contain guidance for flight crews to preserve fuel during taxi-out with the presumption that it will be needed later in the flight as well as to preclude a return to the stand for re-fuelling. Such guidance should be part of the operator’s overall policy for fuel management that typically includes coordination with operational control personnel when applicable. In all cases, a strategy for the preservation of fuel begins with guidance for the number of engines to be used for taxi-out (e.g. smart starts) as well as instructions for shutting down an engine(s) when unanticipated and exceptionally long taxi delays are announced by ATC. In defining the length of a taxi delay that should prompt a shutdown, consideration should be given to the fuel required to start the APU and ultimately re-start the engines.

It is important to note that pre-flight planning ends and in-flight fuel management begins at flight commencement. As such, the OM should contain guidance for the pilot monitoring (PM) to begin fuel checks during taxi-out. It is also especially important for all flight crew members to be aware of if or when the flight may begin burning into *contingency fuel* as well as the minimum fuel for take-off that would avoid taking known shortages into the air. Finally, the OM should address when burning into other fuels is allowed. Any such guidance should be based on the assumption that the PIC, and flight dispatcher if applicable, must determine prior to take-off that the remaining fuel is sufficient for the flight conditions to the destination including conditions foreseeable due to weather, ATC and any others that could delay the landing of the aircraft.

With all of this in mind, the OM should contain guidance for the calculation (or recalculation) of the minimum fuel for take-off as soon as the risk of a delayed departure is apparent. Such guidance should require the PIC to use all available resources inside and outside the flight deck to re-analyse and adapt the plan as necessary to ensure safe flight completion. A multi-layered strategy should be employed that includes but is not limited to:

- evaluating the basis for the planned operation to determine if any conservatism is already "built in" to the flight plan (e.g. lower than planned ZFW);
- using *discretionary fuel* (if loaded) to allow for extended taxi delays;
- adjusting the plan as applicable (and feasible) to reduce other required elements in the planned fuel calculation by:
    - — using a slower cruising speed or cost index to reduce the required trip fuel and contingency fuel;
    - — seeking a more economical cruise level or route;
    - — amending the ATC flight plan to one using the reduced contingency fuel (RCF) procedure;
    - — amending the flight plan to RCF with no Dest Alternate if conditions permit;
    - — amending the ATC flight plan to one using re-dispatch or DP planning;
- verifying the critical scenario and the need for *additional fuel*; and
- considering going back to the gate to re-fuel and to avoid taking a known fuel shortage into the air.

———————————

REFERENCES

Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

European Union Commission Regulation (EC) No. 859/2008, 20 August 2008.

International Air Transport Association, *Fatigue Risk Management Systems (FRMS) Implementation Guide*, 1st Edition Draft, October 2010.

International Air Transport Association, *Fuel Efficiency Program Implementation Guidance Material*, 1st Edition, 2011.

International Air Transport Association, *International Operational Safety Audit (IOSA) Standards and Recommended Practices Manual (ISM)*, Third Edition, effective October 2010.

International Civil Aviation Organization, *Manual of Procedures for Operations Inspection, Certification and Continued Surveillance*, Doc 8335-AN/879, Advance fifth edition.

International Civil Aviation Organization, *Operational Opportunities to Minimize Fuel Use and Reduce Emissions,* Cir 303, 2004.

International Civil Aviation Organization, *Outlook for Air Transport to the Year 2025*, Cir 313, 2007.

International Civil Aviation Organization, *Safety Management Manual (SMM)*, Doc 9859, 2nd Edition, 2009.

United States Department of Transportation, Federal Aviation Administration Code of Federal Regulations Title 14.

United States Department of Transportation, Federal Aviation Administration, Information for Operators: "Flight Risk Assessment Tool" InFO 07015, 2007.

United States Department of Transportation, Federal Aviation Administration, Advisory Circular AC No: 120-42b; "Extended Operations (ETOPS and Polar Operations)", 2008.

United States Department of Transportation, Federal Aviation Administration, Advisory Circular AC No: 120-92; "Introduction to Safety Management Systems for Air Operators" 2006 (cancelled 2010).

United States Department of Transportation, Federal Aviation Administration, Advisory Circular AC No:120-92A; "Safety Management System (SMS) for Aviation Service Providers" 2010 (cancelled 2015).

United States Department of Transportation, Federal Aviation Administration, Risk Management Handbook FAA-H-8083-2; 2009 Edition.

United States Department of Transportation, Federal Aviation Administration, Code of Federal Regulations Title 14 ,Operations Specifications (B043), (B044), (B0343), (C355) and (C055).

United States Department of Transportation, Federal Aviation Administration, Code of Federal Regulations Title 14, Exemption 3585.

— END —

ISBN 978-92-9249-838-2