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SIMULTANEOUS OPERATIONS ON PARALLEL OR NEAR-PARALLEL INSTRUMENT RUNWAYS (SOIR)

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Foreword

1. GENERAL

1.1 This circular on simultaneous operations on parallel or near-parallel instrument runways has been prepared by the ICAO Secretariat at the request of the Air Navigation Commission, and with the assistance of a study group made up of members nominated by several Contracting States and international organizations.

1.2 The experts participating in the study group were nominated by Canada, France, United Kingdom, United States, the Airport Associations Coordinating Council (AACC), the International Air Transport Association (IATA) and the International Federation of Air Line Pilots' Associations (IFALPA), and were suitably qualified and experienced in the planning and conduct of all aspects of simultaneous operations on parallel or near-parallel instrument runways.

1.3 The information contained in this circular is a compendium of the experience accumulated by several States, experience that is considered sufficient in nature and scope to be included in an ICAO circular.

2. BACKGROUND INFORMATION

2.1 On 13 March 1980 the Air Navigation Commission reviewed the Secretariat's report and proposals regarding the possibility of developing a Standard or Recommended Practice for minimum distances between instrument runways. When considering this issue, the Commission recognized the difficulty of working out an agreement on the parameters which would have to be taken into account in determining acceptable distances between parallel instrument runways and agreed on the need for ICAO to study the matter further. The Commission decided that States and interested international organizations should be invited to provide information on current practices and related questions with respect to minimum distances between parallel runways for simultaneous use under instrument meteorological conditions.

2.2 The Secretariat, in response to this decision of the Commission, queried ten Contracting States and four international organizations, seeking views on several issues related to minimum distances between parallel runways for simultaneous use under instrument meteorological conditions. The States selected were those considered to have experience in developing criteria for procedures relating to the separation of aircraft conducting instrument approaches to parallel runways.

2.3 The information received indicated that four States have operational experience with simultaneous operations on parallel instrument runways and that these States have conducted studies on the subject. The requirements for the simultaneous use of such runways are considerable, and a number of States and organizations indicated firm views on what these requirements should be. There was also support for ICAO to develop specifications and undertake work on this subject.

2.4 When the Commission completed its review of the Secretariat's report on the views of selected States and international organizations on minimum distances between instrument runways used for simultaneous operations, it noted the complex nature of the subject and the fact that it covered virtually all the disciplines in the air navigation field. It also agreed that guidance material was needed to make clear to States the complexity of the subject. The Commission decided on 29 January 1981 to proceed with the study and established the Simultaneous Operations on Parallel or Near-Parallel Instrument Runways (SOIR) Study Group.

2.5 The study group held its first meeting in Montreal from 27 February to 2 March 1984. At the meeting, the study group discussed in detail the various modes of operation which could be used on parallel or near-parallel instrument runways, and agreed on classifications for four modes of operation. It also examined meteorological conditions in which visual operations could be conducted, and attempted to determine if specific aerodrome operating minima were linked to the use of simultaneous operations. The group noted that there were no minima specific to simultaneous operations and that the operating minima used during these operations were those determined for each runway considered in isolation, except that higher operating minima were sometimes required by States when trials of simultaneous instrument operations were conducted on parallel or near-parallel runways to test new procedures. The study group also discussed the most practical way to develop material and specifications for carrying out simultaneous operations on parallel or near-parallel instrument runways. It agreed that the experience accumulated by several States was sufficient to enable the study group to develop guidance material on the subject.

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Chapter 1

Definitions and Abbreviations

Terms which are defined in the Standards and Recommended Practices (SARPs) and the Procedures for Air Navigation Services (PANS) are used in accordance with the meanings and usages given therein. However, there still remains a number of other terms used in this circular which describe facilities, services, procedures, etc. related to aerodrome operations and air traffic services which as yet are not included in Annexes or PANS documents. These terms, definitions and abbreviations are given below.

1.1 DEFINITIONS

Correction zone. Additional airspace provided for the purpose of resolving conflicts.

Delay time. The time allowed for an air traffic controller to react, co-ordinate and communicate the appropriate command to the pilot, and for the pilot to understand and react and for the beginning of aircraft response.

Dependent approaches. Simultaneous approaches to parallel or near-parallel instrument runways where radar separation minima between aircraft on adjacent extended runway centre lines are prescribed.

Detection zone. Airspace provided for radar controllers to observe, detect, and react to an errant aircraft as it enters a no-transgression zone.

Independent approaches. Simultaneous approaches to parallel or near-parallel instrument runways where radar separation minima between aircraft on adjacent extended runway centre lines are not prescribed.

Independent departures. Simultaneous departures in the same direction from parallel or near-parallel instrument runways.

Lateral track separation. A value chosen to represent the minimum lateral separation achieved when the tracks of both aircraft are parallel after the threatened aircraft has executed the evading manoeuvre in the blunder analysis.

Mixed operations. Simultaneous approaches and departures on parallel or near-parallel instrument runways occurring during the same time period.

Near-parallel runways. Non-intersecting runways whose extended centre lines have an angle of convergence/divergence of 15° or less.

Normal operating zone. Airspace of defined dimensions extending to either side of an ILS localizer centre line. Only the inner half of the normal operating zone is taken into account in independent approaches.

No-transgression zone. A corridor of airspace of defined dimensions located centrally between the two extended runway centre lines where controller intervention is required to manoeuvre the non-blundering aircraft when this airspace is penetrated by an aircraft conducting a simultaneous approach to a parallel or near-parallel instrument runway.

Semi-mixed operations. A condition during simultaneous operations on parallel or near-parallel instrument runways in which one runway is used exclusively for departures while the other runway is used for a mixture of approaches and departures, or one runway is used exclusively for approaches while the other runway is used for a mixture of approaches and departures.

Segregated operations. A condition during simultaneous operations on parallel or near-parallel instrument runways in which one runway is used exclusively for approaches and the other runway is used exclusively for departures.

1.2 ABBREVIATIONS

Abbreviation	*Meaning*
AGL	above ground level
ATC	air traffic control
ATIS	automatic terminal information service
FAA	Federal Aviation Administration
ft	feet
IFR	instrument flight rules
ILS	instrument landing system
IMC	instrument meteorological conditions
km/h	kilometres per hour
kt	knot(s)
m	metre(s)
MLS	microwave landing system
mrad	milliradian(s)
NM	nautical mile(s)
NOZ	normal operating zone
NTZ	no-transgression zone
PGDP	probability-of-good-data point
s	second(s)
SOIR	simultaneous operations on parallel or near-parallel instrument runways
SSR	secondary surveillance radar
VFR	visual flight rules
VMC	visual meteorological conditions

Chapter 2

Operational Concepts and Considerations

2.1 THE NEED FOR SIMULTANEOUS OPERATIONS ON PARALLEL OR NEAR-PARALLEL INSTRUMENT RUNWAYS

2.1.1 The use of parallel runways to maximize efficiency of aerodrome real estate is an old concept. Annex 14, Chapter 3, 3.1.10 recommends that where parallel runways are provided for simultaneous use under visual meteorological conditions only, the minimum distance between their centre lines should be 210 m when the runways are intended for use by medium or large aeroplanes (i.e. code number 3 or 4). These specifications are, however, under review and as a result it is likely that the currently specified minimum separation distance will be increased. For example, in one State simultaneous independent approaches are conducted under visual meteorological conditions (VMC) and visual flight rules (VFR), to runways separated by a minimum of 760 m (2 500 ft). Under instrument meteorological conditions (IMC), however, the safety of a parallel runway operation is affected by several factors, the most obvious being the accuracy of the monitoring air traffic control (ATC) surveillance radar system, the precision with which aircraft can navigate to the runway, and the controller, pilot and aircraft reaction times.

2.1.2 The impetus for considering simultaneous operations on parallel or near-parallel instrument runways in IMC is provided by the need to increase capacity at busy aerodromes. This increase in capacity can be accomplished either by using existing parallel runways more effectively or by building additional runways. The economic and social costs of the latter can be enormous; on the other hand, an aerodrome already having dual instrument landing system (ILS) runways could increase its capacity if these runways could be safely operated simultaneously and independently under IMC. Other factors, such as surface movement guidance and control, environmental considerations, and land-side/air-side infrastructure, may, however, negate the advantages to be gained from simultaneous operations.

2.2 HISTORY OF SIMULTANEOUS OPERATIONS ON PARALLEL OR NEAR-PARALLEL INSTRUMENT RUNWAYS

2.2.1 In the United States, the Federal Aviation Administration (FAA) sponsored several studies in the early 1960s and analysed the requirements for independent parallel instrument flight rules (IFR) approaches. These studies included some field data collection and theoretical analyses as well as a flight test programme at Chicago/O'Hare Airport. This last test was intended to verify the parameters of pilot and controller performance in the event of a blunder by one aircraft towards another aircraft on the approach to an adjacent parallel runway. Independent ILS approaches were approved for use in 1963 using 1 525 m (5 000 ft) spacing between runway centre lines.

2.2.1.1 The FAA concluded that independent approaches could only be conducted when certain requirements were satisfied. The approaches had to be straight-in, with turn-on to the localizer separated vertically by at least 300 m (1 000 ft). Separate parallel approach controllers were required to monitor the approaches once the 300 m (1 000 ft) vertical separation was lost inside the point of glide slope intercept. These controllers ensured that if either aircraft deviated from a designated normal operating zone (NOZ) into the no-transgression zone (NTZ), any threatened aircraft on the other approach course would be vectored away. In the United States, the no-transgression zone was described as an area "at least 610 m (2 000 ft) wide, and equidistant between runway centre lines". For runways with 1 525 m (5 000 ft) spacing, the inner halves of the NOZs were 460 m (1 500 ft) each, and the NTZ was 610 m (2 000 ft).

2.2.2 In Canada, a similar parallel ILS approach study was made in 1974 by Transport Canada. The NTZ was described as being "at least 610 m (2 000 ft) wide, equidistant between extended runway centre lines".

2.2.3 In France, studies were conducted in 1979 to introduce simultaneous independent ILS approaches at

Paris/Charles-de-Gaulle Airport. These studies concluded that each inner half of an NOZ should be 600 m (1 970 ft) from the runway centre line. The NTZ is the space remaining between the inner halves of the two NOZs.

2.2.4 The United Kingdom experience with simultaneous independent approaches on parallel runways has been limited to London/Heathrow Airport. The trials were conducted in conditions which were virtually VMC and little evidence was available during IMC conditions. The simultaneous approach trials were abandoned for a variety of reasons including surface movement guidance and control, environmental considerations and land-side/air-side infrastructure, and London/Heathrow is now operated in a segregated operations mode (landings on one runway and departures on the other).

2.3 METHODOLOGY USED IN DEVELOPING GUIDANCE MATERIAL

2.3.1 After reviewing and discussing the experience gained in the several States conducting simultaneous operations on parallel or near-parallel instrument runways, the SOIR Study Group discussed the means by which it could carry out the task assigned by the Air Navigation Commission, and agreed that four basic approaches were available. These included:

a) a pragmatic approach based on actual experience in various States;

b) a review of previous studies, simulations and flight data collections undertaken by States;

c) simulation studies based on collision risk models; and

d) a combination of the three approaches listed above.

2.3.2 After detailed examination of the various aspects involved, the study group agreed, as a first stage to:

a) take the pragmatic approach and consider that the experience accumulated by several States (in particular the United States) was sufficient to enable it to develop guidance material on the subject. It was emphasized that the group would have to reach a consensus on how to reconcile different separation values and procedures used by various States for each mode of operation and how to adapt the values and procedures for use in different environments on a world-wide basis; and

b) include in the guidance material the main points to be considered for each mode of operation in relation to past studies, simulations and field data collections supporting the concepts and figures presented.

2.3.3 Although the listing of horizontal distances in feet is not in accordance with Annex 5, both metres and feet are included in this document, as many of these values were quoted to ICAO resulting from studies undertaken in the United States. Equivalent values expressed in SI units are given, but cannot be taken in certain cases as being precise conversions of the original values given in feet.

2.3.4 The effort described herein consists of a compendium of experience on simultaneous operations on parallel or near-parallel instrument runways in several States and is based on specified runways, operations, and airspace conditions in these States. By carefully evaluating the effect of aircraft blunders and lateral deviations from the localizer, useful information has been obtained about how closely spaced parallel runway operations may be conducted at a number of aerodromes.

2.4 MODES OF OPERATION

2.4.1 There can be a variety of modes of operation associated with the use of parallel or near-parallel runways.

2.4.1.1 *Simultaneous approaches*

Two basic modes of operation are possible:

— Mode 1, *independent approaches:* approaches which are made to parallel runways where radar separation minima between aircraft using adjacent ILS systems are not prescribed; and

— Mode 2, *dependent approaches:* approaches which are made to parallel runways where radar separation minima between aircraft using adjacent ILS systems are prescribed.

2.4.1.2 *Simultaneous departures*

— Mode 3, *independent departures:* simultaneous departures for aircraft departing in the same direction from parallel runways.

Note.— When the spacing between two parallel runways is lower than the specified value dictated by wake *turbulence considerations, the parallel runways are considered as a single runway with regard to separation between departing aircraft. A simultaneous dependent departure mode of operation is therefore not used.*

2.4.1.3 *Segregated approaches/departures*

— Mode 4, *segregated operations:* one runway is used for approaches, one runway is used for departures.

2.4.1.4 In the case of segregated approaches and departures (Mode 4) there may be semi-mixed operations, i.e. one runway is used exclusively for departures, while the other runway accepts a mixture of approaches and departures; or, one runway is used exclusively for approaches while the other accepts a mixture of approaches and departures. There may also be mixed operations, i.e. simultaneous approaches with departures interspersed on both runways. In all cases, however, semi-mixed or mixed operations may be related to the four basic modes listed in 2.4.1.1 through 2.4.1.3 above as follows:

	Mode
a) *Semi-mixed operations.*	
1) One runway is used exclusively for approaches while:	
— approaches are being made to the other runway, or	1 or 2
— departures are in progress on the other runway.	4
2) One runway is used exclusively for departures while:	
— approaches are being made to the other runway, or	4
— departures are in progress on the other runway.	3
b) *Mixed operations.*	
All modes of operation are possible.	1, 2, 3, 4

2.5 NO-TRANSGRESSION ZONE

2.5.1 The primary purpose for permitting simultaneous operations on parallel or near-parallel instrument runways is to increase runway capacity. The largest increase in arrival capacity is achieved through the use of independent approaches (Mode 1) to parallel or near-parallel runways. Since Mode 1 approaches are made without regard to separation minima between traffic on the adjacent extended runway centre lines, there must be an established means of determining when account must be taken for conditions where an aircraft deviates from the localizer course. This is achieved through the concept of the no-transgression zone (NTZ) (see Figure 2-1).

2.5.2 The NTZ is a corridor of airspace located centrally between the two extended runway centre lines. The length of the NTZ extends from the nearest threshold out to the point where the 300 m (1 000 ft) vertical separation is reduced between aircraft on the two extended runway centre lines. The significance of the NTZ is that controllers must intervene to establish separation between aircraft if any aircraft is observed to penetrate the NTZ. The width of the NTZ depends on the following four factors.

2.5.2.1 *Detection zone.* Some airspace allowance must be made for limitations of the surveillance system and for controller observation/reaction time in the detection of the errant aircraft as it enters the NTZ. The allowance is dependent upon the update rate of the surveillance system, the accuracy of the radar system, and the resolution of the radar scope being used in the monitoring process.

2.5.2.2 *Delay time/reaction time.* Some airspace allowance must be made: firstly, for the time during which the controllers react, determine the appropriate resolution manoeuvre, and communicate the appropriate command to achieve separation; secondly, to allow for the pilot to understand the communication and react to it; and thirdly, for the beginning of aircraft response to the resolution manoeuvre control inputs.

2.5.2.3 *Correction zone.* An additional airspace allowance must be made for the completion of the resolution manoeuvre by the threatened aircraft.

2.5.2.4 *Lateral track separation.* In the blunder analysis, allowance must be made for adequate track separation in the lateral dimension. It must include a lateral separation plus an allowance for the fact that even the normally operating (threatened) aircraft may not be exactly on the extended runway centre line of the adjacent runway.

2.5.3 The determination of airspace allowances for detection zone, delay time/reaction time, correction zone and lateral track separation (2.5.2.1 through 2.5.2.4) depends on several assumptions. One of the most complicated and important tasks of the monitoring controller is the determination of the appropriate resolution manoeuvre

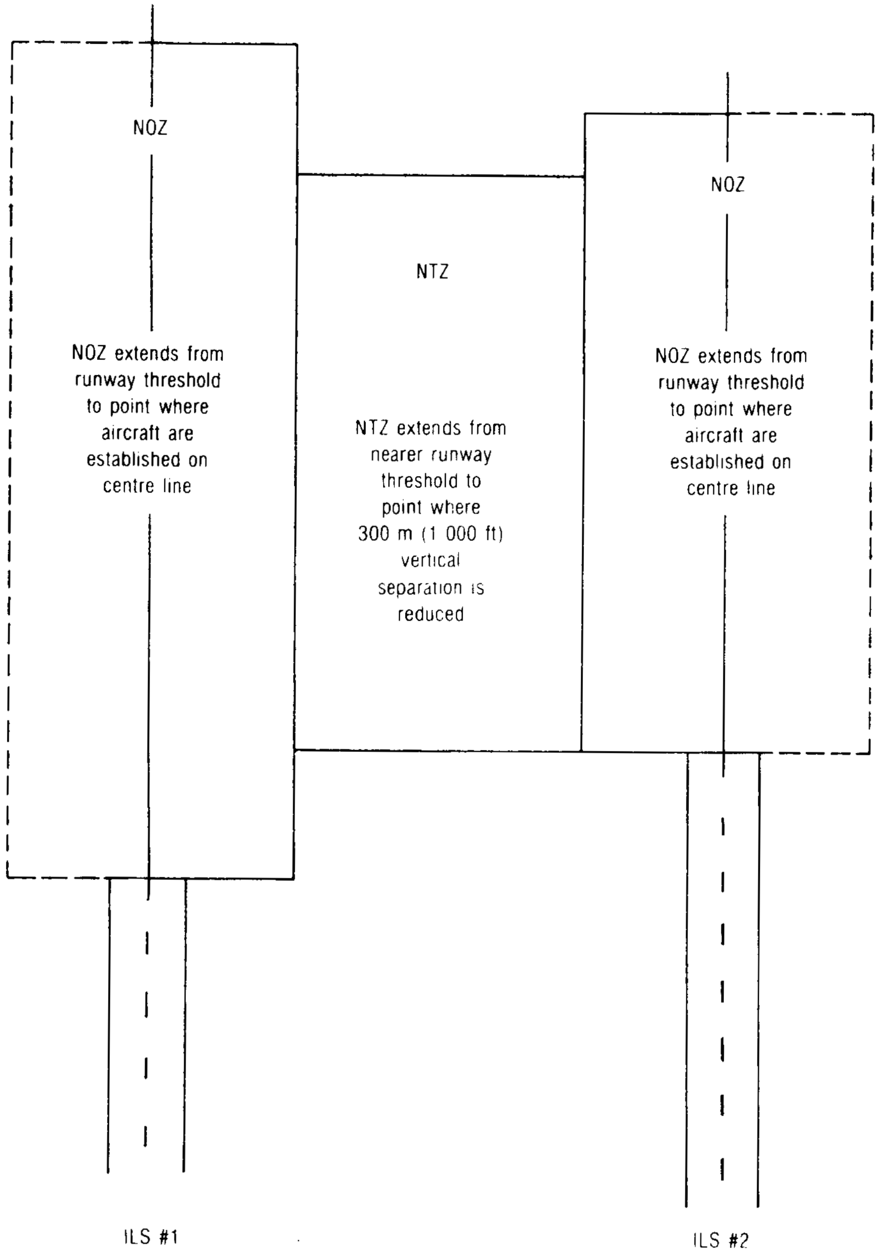

Figure 2-1. Example of normal operating zones (NOZs) and no-transgression zone (NTZ)

for the threatened aircraft following a failure, for whatever reasons, to return the errant aircraft to its appropriate localizer. Turning away from the threat may not always provide the optimum separation for that aircraft. The assumption governing the amount of time required for the controller to determine the proper resolution manoeuvre must therefore be fairly generous.

2.6 NORMAL OPERATING ZONE

2.6.1 If the NTZ is the airspace in which aircraft should not operate, there must be airspace in which the aircraft are expected to operate. This airspace is called the normal operating zone (NOZ) (see Figure 2-1).

2.6.2 In the two-runway example, there is one NOZ associated with each extended runway centre line. The NOZ is centred on the extended runway centre line, and its total width is twice the distance from the extended runway centre line to the nearest edge of the NTZ. Thus, the airspace between the two extended runway centre lines consists of the NTZ and the two inner halves of the NOZs associated with each centre line. Aircraft normally manoeuvre in the NOZ without controller intervention. Furthermore, the aircraft are expected to remain within the NOZs after becoming established on the extended runway centre line.

2.6.3 The length of an NOZ extends from the threshold out to the point where the aircraft joins the extended runway centre line. The width of the NOZ is determined by taking account of the guidance systems involved and the track-keeping accuracy with which the aircraft is flown; the more precise the navigation aids and track-keeping, the narrower the NOZ.

2.6.4 The NOZ should be of such a width that the likelihood of any normally operating aircraft straying outside the NOZ is very small. This maintains a low controller work-load, as well as high pilot confidence that intervention from the controller is not a "nuisance alarm".

2.7 COMBINING NORMAL OPERATING ZONES AND NO-TRANSGRESSION ZONES

2.7.1 The size of NOZs and the NTZ is determined according to the runway situation. An example showing the possible extent of the NOZ and NTZ is presented in Figure 2-1. In the case of existing parallel runways, the width of the NTZ is first determined for the safety considerations described earlier. The remaining airspace can then be allocated to the two NOZs associated with the extended runway centre lines. The results then dictate the level of precision of the approach guidance system that is necessary. If, on the other hand, only one runway exists, and the question is how close can a parallel runway be built, the answer is derived in similar fashion: first the desired NTZ width is determined on account of safety considerations, then the desired widths of the inner halves of the two NOZs are determined. Two full ILS systems may be made available and an operational requirement for coupled approaches may also be established in the future. The lateral separation for the new runway would thus be the sum of the NTZ width plus the width of the two inner halves of the NOZs.

2.7.2 Some typical values for NOZs and NTZs are available from the experiences of two States. In the United States, for example, the minimum lateral centre line separation for independent approaches to parallel runways is 1 310 m (4 300 ft) with a corresponding NTZ width of 610 m (2 000 ft). In Canada the minimum runway centre line spacing is 1 525 m (5 000 ft) for independent approaches, and the minimum NTZ value is taken as 610 m (2 000 ft).

2.7.3 Though other States have studied parallel or near-parallel simultaneous operations, the runway centre line separations and corresponding NTZ widths appearing above are the only ones enjoying regulatory status at the present time.

2.8 APPROACH MINIMA AND SPECIAL PROCEDURES

2.8.1 In the specific case of independent approaches to two parallel or near-parallel runways which each have an instrument approach, there is no need for the simultaneous operation to affect the approach minima of each runway, since it is not necessary for the aircrews or the tower controllers to provide visual separation. Thus, no visual contact need be established for traffic separation purposes, and higher-than-normal approach minima are not necessary.

2.8.2 There are, however, some special procedures which have been promulgated in States using such approaches. Flight crews are alerted that simultaneous parallel approaches are in progress, to make them aware of the importance of executing a precise centre line intercept manoeuvre and staying close to that centre line. This procedure also alerts flight crew to the go-around potential in case of a blunder situation by an aircraft on the adjacent centre line. Controllers use radar vectors so that the centre line is not intercepted at more than a 30° angle. Other conditions may be stipulated to ensure that both aircraft are established on their respective localizers before the 300 m (1 000 ft) vertical separation is reduced.

2.9 FACTORS TO BE REVIEWED IN CONSIDERING THE INTRODUCTION OF SIMULTANEOUS OPERATIONS ON PARALLEL INSTRUMENT RUNWAYS

2.9.1 When it is believed that existing airport capacity should be fully utilized at a particular location having parallel runways or where the provision of an additional parallel runway is envisaged, the use of these runways simultaneously is a means whereby this capacity may be generated.

2.9.2 When making an assessment of the manner in which the runways will be used, i.e. mixed or semi-mixed operations, both of which may include either dependent or independent approaches, theoretical studies generally indicate that the maximum *arrival* capacity may be achieved by operating independent approaches, followed next in order by dependent operations.

2.9.3 These theoretical gains can, however, often be significantly lower in practice because of the practical difficulties associated with achieving independent or dependent approaches. For example, the requirement to have aircraft approaching adjacent localizer courses vertically separated before the radar separation minimum is reduced can, on occasions, result in failure to achieve the required minimum longitudinal spacing between aircraft using the same localizer course.

2.9.4 Further losses to the theoretical capacity may also arise through a lack of familiarity on the part of pilots with the procedures where there is a high proportion of unscheduled flights at the specific location. Lack of familiarity can also result in the selection of incorrect ILS frequencies and routine language difficulties may present other ATC problems.

2.9.5 When there is a need to consider departing aircraft during mixed or semi-mixed operations, gaps have to be created in the landing stream. The effect of this is a reduction in the arrival capacity in order to accommodate departures and hence it is a critical factor in determining the maximum runway capacity during those times of traffic imbalance when there is no clearly defined arrival or departure peak.

2.9.6 It should also be borne in mind that when operating departures on the landing runway there is a greater probability of missed approaches and hence a corresponding reduction in theoretical capacity.

2.9.7 Factors which can affect the maximum capacity or the desirability of operating parallel runways simultaneously are not limited solely to airside considerations. Taxiway layout and the position of passenger terminals relative to the runways in use can generate the need for traffic to cross active runways, a situation which not only leads to delays to arriving or departing traffic, but also to a reduction in the level of safety due to the possibility of inadvertent runway incursions. The total surface movement environment must be carefully assessed when determining how particular parallel runways are to be used.

2.9.8 The decision to implement simultaneous operations at a particular location must take into consideration all of the foregoing factors as well as any other constraints, such as environmental restrictions, on the use of the runways.

Chapter 3

Simultaneous Approaches to Parallel Runways

3.1 BACKGROUND

3.1.1 Procedures exist for independent and dependent approaches to parallel runways in IMC. Extension of these procedures to reduced runway spacings can permit their broader application. This chapter presents the requirements for such reductions in spacing for parallel runway ILS approaches.

3.1.2 The concepts, procedures and dimensions applicable to independent and dependent approaches are based on, and apply to autopilot or hand-flown ILS procedures. Other navigation systems not covered in this document may necessitate changes to the separation requirements of parallel runway operations.

3.2 INDEPENDENT INSTRUMENT APPROACHES (MODE 1)

3.2.1 The concepts for independent approaches to parallel runways date from the 1950s. In the early 1960s, the United States Federal Aviation Administration (FAA) sponsored several studies and analyses of the requirements for independent approaches (see Figure 3-1). These were presumed to be flown with the use of an instrument landing system (ILS) for lateral navigational guidance. These studies included some field data collection, and theoretical analyses, as well as a field flight test programme at Chicago/O'Hare Airport. This latter test was intended to verify the parameters of pilot and controller performance in the event of a blunder by an aircraft on one approach toward an aircraft on the adjacent approach.

3.2.2 Independent parallel ILS approaches were approved for use in the United States at 1 525 m (5 000 ft) spacing between runway centre lines. Separate approach controllers (monitor controllers) were assigned to monitor each of the parallel approaches. These monitor controllers ensured that if either aircraft penetrated the NTZ, the threatened aircraft on the other approach course would be vectored away. For 1 525 m (5 000 ft) runway spacing the inner half of the NOZ was 460 m (1 500 ft), and the NTZ was 610 m (2 000 ft) (see Figure 3-2).

3.2.3 The monitor controllers were required to have override capability for immediate communications with

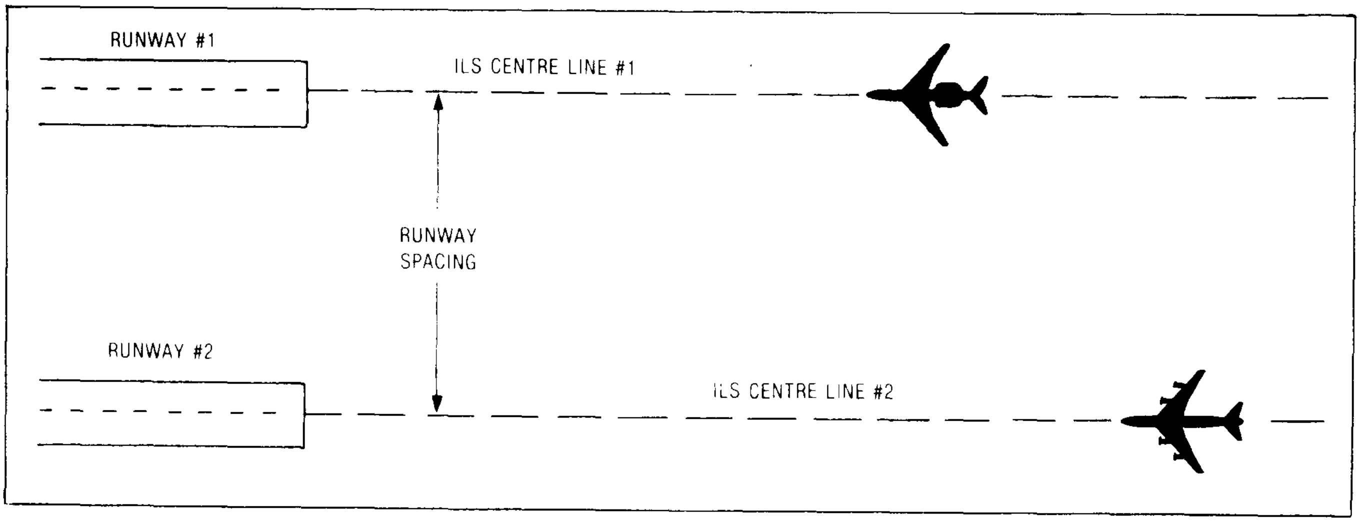

Figure 3-1. Independent approaches

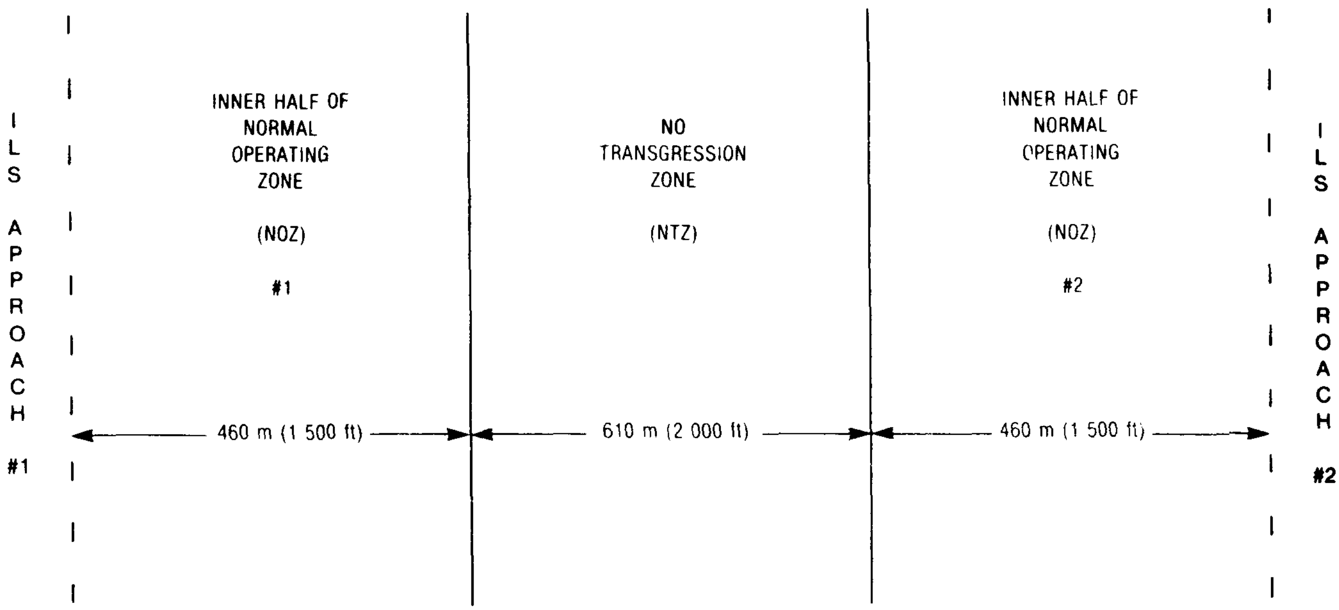

Figure 3-2. Example of NOZs and NTZ in the United States in the 1960s

the pilots conducting independent approaches. Other requirements included two fully operating ILS and airport surveillance radar.

3.2.4 As a result of successful data collection and analysis efforts, the minimum requirement for spacing between parallel runway centre lines was reduced by the FAA in 1974 to 1 310 m (4 300 ft). The data collection showed that the same levels of safety could be achieved, without a significant increase in the false-alarm rate, at the reduced runway separation.

3.3 ANALYSIS OF INDEPENDENT INSTRUMENT APPROACHES

3.3.1 The spacing between parallel runway approaches is divided into two inner halves of NOZs and an NTZ (see Figure 3-2). A monitor controller is provided for each ILS approach. If an aircraft is observed to deviate towards the NTZ boundary, the appropriate monitor controller is required to instruct the aircraft to return to the correct localizer immediately. In the event an aircraft is observed to penetrate the NTZ, the appropriate monitor controller takes positive action to ensure that the aircraft on the adjacent localizer alters its course to avoid the errant aircraft.

3.3.2 The NOZ is sized so that the likelihood of any aircraft being observed operating outside of the NOZ is very small. This maintains a low controller work-load, as well as high pilot confidence that action from the monitor controller is not a routine "nuisance alarm". The remainder of the spacing, i.e. the NTZ, must then suffice for the safe resolution of the potential conflict. Such spacing is based on four factors associated with an assumed blunder scenario and corresponding resolution manoeuvre.

3.3.3 The blunder scenario assumes that the blundering aircraft penetrates the NTZ at a 30° angle and proceeds on this track toward another aircraft on the adjacent approach. The threatened aircraft is vectored away to achieve separation, and the blunder analysis is assumed to end when the threatened aircraft has achieved a 30° track change to parallel the intruder's track. Other initial blunder scenario assumptions appear below:

a) aircraft velocities of 278 km/h (150 kt);

b) recovery turn rate of 3°/s;

c) navigation accuracy of 46 m (150 ft) at 19 km (10 NM) (one sigma); and

d) consideration for navigation of non-blundering aircraft is three sigma of net position-keeping accuracy.

3.3.4 The corresponding values used to ascertain the 1 310 m (4 300 ft) runway spacing are:

a) *detection zone:* 275 m (900 ft) using a surveillance radar with an accuracy of 5 mrad and an update rate of 4 s;

b) *delay time:* 8 s which corresponds to 300 m (1 000 ft) assuming a dedicated monitor with a frequency override broadcast capability;

c) *correction zone:* 180 m (600 ft) with an assumed 3°/s correction rate by the threatened aircraft;

d) *lateral track separation:* 60 m (200 ft) with a 140 m (450 ft) navigation buffer, which means a threatened aircraft is assumed to be not more than 140 m (450 ft) off its centre line at the time of the threat as opposed to being within its own NOZ; and

e) *inner half of NOZ:* A value of 350 m (1 150 ft) is taken as the width of the inner half of the NOZ of the blundering aircraft. It is based on the following factors:

   1) *guidance:* a front-course ILS is being flown manually or coupled; and

   2) *flying precision:* an analysis of an assortment of radar data associated with ILS approaches.

3.4 DEPENDENT INSTRUMENT APPROACHES (MODE 2)

3.4.1 If the spacing between runway centre lines is not adequate for independent approaches, a dependent approach procedure may be used. In the United States prior to 1978, arrivals on different runways were required to be separated by a minimum of 5.6 km (3.0 NM). At less than 760 m (2 500 ft) spacing, the wake turbulence separations were applied as though the aircraft were approaching a single runway.

3.4.2 In 1978, the FAA provided for dependent approaches with a 3.7 km (2.0 NM) radar separation between aircraft on alternating approaches, if the runways were separated by 915 m (3 000 ft) or more. As of 1983, the FAA decided to reduce spacing for dependent approaches to 760 m (2 500 ft). Consecutive aircraft alternated between the two runways (see Figure 3-3). The 3.7 km (2.0 NM) radar separation minimum was applied between aircraft on the two approaches, while the normal in-trail separations applied between arrivals to the same runway. This separation permitted easier handling of blunder situations. Controller monitoring requirements were eased, and runway spacing was reduced, compared to the requirements for independent approaches.

3.4.3 Requirements for parallel runway spacing are summarized in Table 3-1.

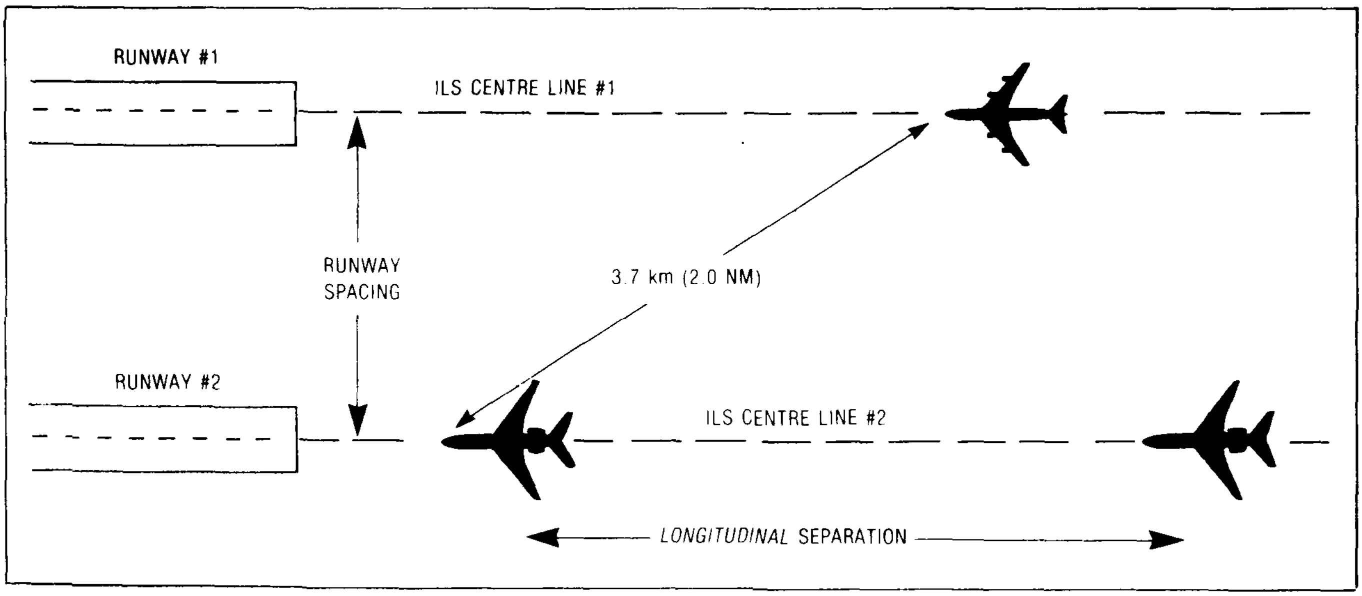

Figure 3-3. Dependent approaches

Table 3-1. IFR approach spacing

Runway spacing	*Type of approach*	*Radar separation* requirements between aircraft on the two approaches*
Less than 760 m (2 500 ft)	essentially single runway	5.6 km (3.0 NM)** 7.4 km (4.0 NM)** 9.3 km (5.0 NM)** 11.1 km (6.0 NM)**
760 m (2 500 ft) to 1 310 m (4 300 ft)	dependent	3.7 km (2.0 NM)
Greater than 1 310 m (4 300 ft)	independent	none

* Separation measured on the diagonal.
** Specific value determined by aircraft pair, and governed by wake turbulence separation minima.

3.5 ANALYSIS OF DEPENDENT INSTRUMENT APPROACHES

3.5.1 Current procedures for dependent instrument approaches include the following major requirements:

a) a minimum radar separation of 3.7 km (2.0 NM) between aircraft on adjacent ILS approaches;

b) a minimum radar separation of 5.6 km (3.0 NM) between aircraft on the same ILS approach course (normal longitudinal separation);

c) ILS runway centre lines spaced at least 760 m (2 500 ft) apart; and

d) a surveillance radar with azimuth accuracy of about 5 mrad and an update rate of 4 s.

3.5.2 No separate monitor controller is required. Instead, the radar approach controller monitors the approaches to prevent violations of required separation.

3.5.3 For dependent approaches, the radar separation between the two aircraft gives a measure of protection which is provided only by the runway spacing for independent approaches; consequently, dependent approaches can be conducted at closer runway spacings than independent approaches.

3.5.4 The minimum separation between aircraft in the event of a blunder is calculated using techniques similar to those used for independent approaches. Current procedures allow dependent approaches to runways as close as 760 m (2 500 ft) apart. It is assumed that independent approaches would be performed if the runways are more than 1 310 m (4 300 ft) apart. Within the range of runway spacings 760 to 1 310 m (2 500 to 4 300 ft), the minimum separation between aircraft in the event of a blunder ranges from 2 135 to 2 360 m (7 000 to 7 750 ft) (see Table 3-2). These values represent large safety margins in the event of a blunder.

Table 3-2. Minimum separation between aircraft in the event of a blunder for dependent approaches

Runway spacing	*Minimum separation*
1 310 m (4 300 ft)	2 135 m (7 000 ft)
915 m (3 000 ft)	2 300 m (7 550 ft)
760 m (2 500 ft)	2 360 m (7 750 ft)
300 m (1 000 ft)*	2 575 m (8 450 ft)

Note.— Airspeeds = 278 km/h (150 kt).

* Reduced runway spacing below 760 m (2 500 ft) may be considered if wake turbulence issues can be resolved.

3.5.5 The minimum separation between aircraft in the event of a blunder at 915 m (3 000 ft) runway spacing was greater than that for 1 310 m (4 300 ft). As Table 3-2 demonstrates, this trend continues even for runway spacing less than 915 m (3 000 ft); as the runway spacing decreases, the minimum separation increases. It therefore appears that, at least for blunder safety, reducing the runway spacing is not only possible but desirable.

3.5.6 This somewhat surprising result is actually quite reasonable. Two factors apply:

a) since the radar separation is applied diagonally, less distance between runways means a greater in-trail distance between the aircraft; and

b) less distance between runways also means that the blundering aircraft crosses the adjacent approach more quickly.

3.5.7 These results would indicate that recovery from a blunder need not be an obstacle to conducting dependent parallel approaches. Before the required runway spacing for dependent approaches can be reduced, however, other potential problems must be addressed.

3.5.8 At present, for wake turbulence reasons, parallel runways less than 760 m (2 500 ft) apart are considered to be a single runway. Alternating arrivals would therefore have to be separated by the single runway standards of 5.6 km (3.0 NM)/7.4 km (4.0 NM)/9.3 km (5.0 NM)/ 11.1 km (6.0 NM).

3.5.9 Another potential problem associated with closer runway spacings is the possibility that an aircraft will line up for the wrong runway. There are at least two ways this situation might occur:

a) the pilot may misinterpret the approach clearance or use the incorrect approach chart and line up on the wrong localizer; or

b) the pilot on an instrument approach may, after breaking out into visual conditions, visually acquire and line up for the wrong runway.

3.5.10 The first situation would be less likely to arise if procedural changes are instituted which require confirmation of the runway assignment, i.e. verbal verification of the localizer frequency. Such procedures would reduce, but not eliminate, the chance of an aircraft approaching the wrong runway.

3.5.11 As the spacing between parallel runways decreases, it becomes more difficult for the approach controller to determine from the radar display whether an aircraft is correctly aligned. Surveillance and navigation errors both contribute to the uncertainty regarding an aircraft's intentions. Improvements in both surveillance and navigation performance may therefore be required to ensure that the number of centre line deviation "false alarms" is kept low.

3.5.12 Such deviations would not necessarily result in blunders, unless the separation also decreased below 3.7 km (2.0 NM). However, they might be significant if the deviating aircraft was thereby exposed to wake turbulence generated by aircraft on the other approach. This factor will need to be considered in the study of operational wake turbulence solutions.

3.5.13 The second situation of runway misidentification involves a correct approach, but visual acquisition of the wrong runway. Such an event might occur too quickly and too close to the threshold to be reliably detected or resolved by the controller. If this situation is determined to be a problem, some means of improving visual runway identification may be required.

3.5.14 In addition to helping with the runway misidentification problem, an improved surveillance system would perhaps have an effect on the resulting lateral track separation in the event of a blunder. Any violation of the required separation would be detected sooner, allowing more time for the controller to act.

3.6 DIFFERENCES BETWEEN INDEPENDENT AND DEPENDENT APPROACH ANALYSES

3.6.1 The differences in the concepts and geometries of independent and dependent approaches have led to differences in the assumptions, and occasionally the methodologies, of the two analyses. For example, different criteria are used for deciding that a blunder has occurred. An independent approach is termed a blunder if it crosses into the NTZ between the two runways. The azimuth accuracy of current surveillance systems is not sufficient to allow the use of such "NTZs" with dependent approaches; instead, the violation of the diagonal separation between aircraft on adjacent approaches is used as a "trigger" for detecting a blunder and starting the avoidance manoeuvre. These differences are summarized in Table 3-3.

Table 3-3. Summary of differences between independent and dependent approach analyses

Situation	*Independent approaches*	*Dependent approaches*
Blunder "trigger"	Violation of NTZ (lateral boundary)	Violation of separation (mainly longitudinal)
Inputs to analysis	Azimuth error (radar and display)	Combined range and azimuth error (mostly display)
	Lateral navigation error	Lateral navigation error not considered
	False alarm rate	False alarm rate not explicitly considered
	PGDP* = 1.0 (implicit) — 2 monitor controllers	PGDP* = 0.5 (input) — no separate monitors
	8 s control delay	12 s control delay
Blunder resolution criteria	Lateral track separation	Minimum separation between aircraft

* Probability-of-good-data point (PGDP) — The probability that a good radar return will be displayed and recognized by the controllers.

3.6.2 Several of the inputs to the blunder analyses differ between the two cases because of the use of the different triggers. Since the lateral deviation from the centre line is the indication of a blunder in the independent approach case, the lateral (azimuth) error of the radar and display is an input. For dependent approaches, the diagonal separation between the aircraft is significant; although there is a lateral component to this separation, it is principally a longitudinal measure. A combination of the radar range error and longitudinal display errors is, therefore, input to the dependent approach analysis.

3.6.3 For independent approaches, the size of the NOZ is determined. The lateral navigation error and the acceptable rate of false alarms (for excursions beyond the inner half of the NOZ) are required for the determination. The dependent approach calculations do not need to consider a lateral NOZ since a longitudinal trigger is used.

3.6.4 Other differences in the inputs reflect the fact that two monitor controllers are required for independent (but not dependent) approaches. With this level of attention to the radar displays, it is assumed that any displayed penetration of the NTZ would be detected immediately. For dependent approaches without a separate monitor, it is recognized explicitly that the radar approach controller's attention would at times be directed elsewhere. For this reason, a value of 0.5 was assigned to the probability-of-good-data point (PGDP).

3.6.5 The absence of a separate monitoring position also leads to a difference in the delay times used in the calculations. It is assumed that it will take 8 s for the monitor controller to react, co-ordinate with the other monitor controller and determine the appropriate resolution manoeuvre, and communicate the appropriate command to achieve separation, and for the pilot and aircraft to respond. For dependent approaches it is assumed that the controller would wait for the next update (4 s later) to verify that a blunder has actually occurred.

Blunder resolution criteria

3.6.6 Only the lateral component of the track separation is considered in the case of independent approaches. It is noted that a longitudinal component may exist as well, but it is not relevant to the calculation. The initial longitudinal position of the aircraft is not fixed. Therefore, an expected value of longitudinal separation could be calculated, although it would require data on the probable relative position at the start of the blunder.

3.6.7 The dependent approach analysis is based on the minimum separation between aircraft in the event of a blunder since both the initial lateral and longitudinal positions of the aircraft are known.

3.7 SUMMARY

Independent approaches

3.7.1 In the United States, independent IFR approaches are currently conducted to runways spaced as close as 1 310 m (4 300 ft) apart. Certain procedural and equipment requirements must be met, including:

a) two fully functioning ILS, surveillance radar and communications;

b) separate parallel approach monitor controllers with override capability; and

c) diverging missed approach procedures.

3.7.2 A no-transgression zone is defined for each pair of runways. An aircraft which deviates towards the NTZ boundary is instructed by the monitoring controller to return to the localizer course; if the NTZ boundary is penetrated, any threatened aircraft on the adjacent approach must be issued appropriate instructions.

3.7.3 The required 1 310 m (4 300 ft) spacing between parallel runways is based upon maintaining separation between the two aircraft in the event of such a blunder, with certain assumptions about aircraft and air traffic control (ATC) performance. This runway spacing requirement can be reduced if improvements are made to surveillance and navigation performance.

Dependent approaches

3.7.4 In the United States, if the spacing between parallel runways is too close to allow independent operations, it may still be possible to conduct dependent IFR approaches using a 3.7 km (2.0 NM) radar separation between adjacent aircraft. Current procedures allow such operations if the runways are spaced at least 760 m (2 500 ft) apart.

3.7.5 Some other requirements are also less restrictive for dependent approaches than for independent approaches. For example, separate monitor controllers are not required and missed approach paths should not conflict with each other.

3.7.6 An NOZ or NTZ is not established for dependent approaches. Instead, the 3.7 km (2.0 NM) radar separation provides the buffer between aircraft on adjacent approaches. Violating the diagonal separation therefore constitutes a blunder, recovery from which must be assured.

3.7.7 The minimum separation between aircraft in the event of a blunder varies with the runway spacing. In general, the minimum separation increases as the spacing between runways is reduced. The reason is primarily because at closer spacings, the blundering aircraft would cross the other approach more quickly, and no longer present a hazard. It appears that, at least for blunder safety, the present runway spacing requirement for dependent operations can be reduced, if wake turbulence is not a determining factor and minimum radar separation is applied.

3.7.8 As parallel runways get closer, it becomes more difficult to ensure that each aircraft is actually lined up for the correct runway. Procedural changes and improved visual and verbal runway identification may reduce the possibility of such an error, but an improved surveillance system would be needed to ensure that the controller could detect such an error if it occurred.

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Appendix to Chapter 3

Example of Requirements and Procedures Used in the United States for Independent and Dependent Instrument Approaches

1. REQUIREMENTS

1.1 *Requirements for independent instrument approaches*

a) Parallel runways are at least 1 310 m (4 300 ft) apart, centre line to centre line.

b) Straight-in landings will be made.

c) All air and ground systems must be fully operational including communication, radar and ILS equipment.

d) Aircraft are informed that independent instrument approaches are in use.

e) Aircraft are informed of the ILS runway number and the localizer frequency.

f) Straight flight of 2 km (1.0 NM) required prior to localizer turn-on.

g) Maximum intercept angle with localizer is 30°.

h) Either 300 m (1 000 ft) vertical or 5.6 km (3.0 NM) radar separation is provided during turn-on to parallel localizer courses.

i) Separate monitor controllers with override capability are provided for each approach.

j) NTZ is depicted on monitor controllers' display.

k) Missed approach paths have diverging courses.

1.2 *Requirements for dependent instrument approaches*

a) Runway centre lines are at least 760 m (2 500 ft) apart.

b) Straight-in landings will be made.

c) Aircraft are informed that approaches are in use to both runways.

d) Either 300 m (1 000 ft) vertical or 5.6 km (3.0 NM) radar separation is provided during turn-on to parallel localizer courses.

e) Approach control must have capability to communicate directly with aerodrome control unless separation responsibility has been delegated to the tower.

f) Missed approaches do not conflict.

2. PROCEDURES

2.1 *Procedures for independent approaches*

2.1.1 When parallel runways are at least 1 310 m (4 300 ft) apart, authorize independent instrument approaches to parallel runways if:

a) straight-in landings will be made; and

b) ILS, radar and appropriate frequencies are operating normally.

2.1.2 Prior to aircraft departing an outer fix, inform aircraft that independent instrument approaches are in use. This information may be provided through the automatic terminal information service (ATIS).

2.1.3 On the initial vector, inform the aircraft of the ILS runway number and the localizer frequency.

Phraseology: ILS RUNWAY (runway number) (left/right) LOCALIZER FREQUENCY IS (frequency).

2.1.4 Clear the aircraft to descend to the appropriate glide slope intercept altitude soon enough to provide a period of level flight to dissipate excess airspeed. Provide at least 2 km (1.0 NM) of straight flight prior to localizer course intercept.

2.1.5 Vector the aircraft to intercept the final approach course at an angle not greater than 30°.

2.1.6 Provide a minimum of 300 m (1 000 ft) vertical or a minimum of 5.6 km (3.0 NM) radar separation between aircraft during turn-on to parallel localizer courses. Provide a minimum of 5.6 km (3.0 NM) radar separation between aircraft on the same localizer course.

Note.— Aircraft established on a localizer course are separated from aircraft established on an adjacent parallel localizer course, provided neither aircraft penetrates the depicted NTZ.

2.1.7 When assigning the final heading to intercept the localizer course, issue the following to the aircraft:

a) position from a fix on the localizer course;

b) an altitude to maintain until established on the localizer course; and

c) clearance for the appropriate ILS runway number approach.

Phraseology: POSITION (number) MILES FROM (fix). TURN (left/right) HEADING (degrees). MAINTAIN (altitude) UNTIL ESTABLISHED ON THE LOCALIZER. CLEARED FOR ILS APPROACH RUNWAY (number) (left/right).

2.1.8 Monitor all approaches regardless of weather. Monitor local control frequency to receive any aircraft transmission. Issue control instructions and information necessary to ensure separation between aircraft and to ensure aircraft do not enter the NTZ.

Note 1.— Separate monitor controllers, each with transmit/receive and override capability on local control frequency, shall ensure aircraft do not penetrate the depicted NTZ. Facility directives shall delineate responsibility for providing a minimum of 5.6 km (3.0 NM) longitudinal separation between aircraft on the same localizer course.

Note 2.— An NTZ at least 610 m (2 000 ft) wide is established equidistant between extended runway centre lines and is depicted on the monitor display. The primary responsibility for navigation on the localizer rests with the pilot. Control instructions and information are therefore issued only to ensure separation between aircraft and to ensure that aircraft do not penetrate the NTZ. Pilots are not expected to acknowledge those transmissions unless specifically requested to do so.

Note 3.— For the purposes of ensuring an aircraft does not penetrate the NTZ, the "aircraft" is considered the centre of its primary radar return. The provisions regarding target separation also apply.

2.1.8.1 When an aircraft is observed to overshoot the turn-on or to continue on a track which will penetrate the NTZ, instruct the aircraft to return to the correct localizer immediately.

Phraseology: YOU HAVE CROSSED THE LOCALIZER COURSE. TURN (left/right) IMMEDIATELY AND RETURN TO LOCALIZER COURSE or TURN (left/right) AND RETURN TO LOCALIZER COURSE.

2.1.8.2 When an aircraft is observed penetrating the NTZ, instruct aircraft on the adjacent localizer to alter course in order to avoid the deviating aircraft.

Phraseology: TURN (left/right) HEADING (degrees) IMMEDIATELY, CLIMB AND MAINTAIN (altitude).

2.1.8.3 Terminate radar monitoring when one of the following occurs:

a) visual separation is applied;

b) the aircraft reports the approach lights or runway in sight; and

c) the aircraft is 2 km (1.0 NM) or less from the runway threshold, if procedurally required and contained in facility directives.

2.1.8.4 Do not inform the aircraft when radar monitoring is terminated.

2.2 *Procedures for dependent approaches*

2.2.1 Provide a minimum of 300 m (1 000 ft) vertical or a minimum of 5.6 km (3.0 NM) radar separation between aircraft during turn-on to parallel localizer courses. Provide a minimum of 5.6 km (3.0 NM) radar separation between aircraft on the same localizer course.

2.2.2 Provide a minimum of 3.7 km (2.0 NM) radar separation between successive aircraft on adjacent localizer courses when the following conditions are met:

a) runway centre lines are at least 760 m (2 500 ft) apart;

b) aircraft are established on the localizers;

c) straight-in landings will be made;

d) missed approach procedures do not conflict;

e) aircraft are informed that approaches to both runways are in use (this information may be provided through the ATIS); and

f) approach control has an override capability to local control at those locations where separation responsibility has not been delegated to the tower.

Note.— The override capability is an integral part of this procedure when approach control has the sole separation responsibility.

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Chapter 4

Independent Instrument Departures from Parallel Runways (Mode 3)

4.1 GENERAL CONCEPT

4.1.1 Parallel runways may be used for independent instrument departures at any time as a result of operating those runways in one of the following ways:

a) one runway is used exclusively for departures while the other runway is used for a mixture of arrivals and departures (semi-mixed operation);

b) both runways are used for mixed arrivals and departures (mixed operation); and

c) both runways are used exclusively for departures.

4.1.2 The three main parameters which govern whether independent instrument departures can be conducted at a specific location are:

a) the spacing between runway centre lines;

b) the course divergence after take-off; and

c) the availability of radar.

4.1.3 Independent instrument departures from parallel runways are practised in at least two States, i.e. the United States and Canada. Both States have similar requirements for the degree of course divergence between departure tracks where radar is available.

4.2 GROUND EQUIPMENT

4.2.1 There is no requirement, other than satisfactory two-way radiocommunications, for any other specialized form of control or navigation aid facility for the conduct of independent instrument departures, except where spacing between parallel runways is less than 1 525 m (5 000 ft) and a course divergence after take-off of 45° or more cannot be achieved. Under these circumstances radar should be provided.

4.2.2 Where radar is a requirement, its technical specifications should be of an order which would enable identification of aircraft within 2 km (1.0 NM) of the departure end of the runways in use. Primary radar data must be available.

4.3 WEATHER MINIMA

The concepts described under 4.1 are applicable in all weather conditions.

4.4 RUNWAY SPACINGS AND ATC PROCEDURES

United States

4.4.1 Simultaneous take-off of aircraft departing in the same direction from parallel runways is authorized where the runway centre lines are spaced by at least 760 m (2 500 ft) and courses diverge by 15° or more immediately after departure (see Figure 4-1).

Spacing between runways	*Course divergence after take-off*	*Radar required*
760 m (2 500 ft) or more	15° or more	Yes

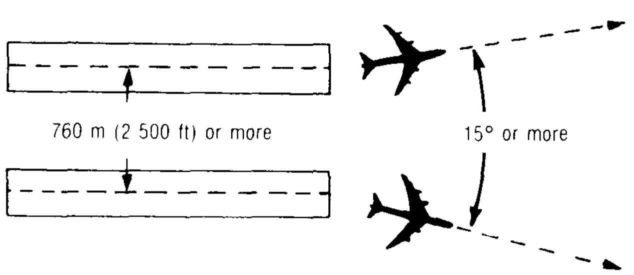

Figure 4-1

Canada

4.4.2 Simultaneous take-off of aircraft departing in the same direction from parallel runways is authorized where the runway centre lines are spaced by at least 1 525 m (5 000 ft) and the course of one aircraft diverges from the other by 15° or more immediately after departure (see Figure 4-2). Turns after take-off must be initiated not later than 150 m (500 ft) above ground level (AGL).

Spacing between runways	*Course divergence after take-off*	*Radar required*
1 525 m (5 000 ft) or more	15° or more	Yes

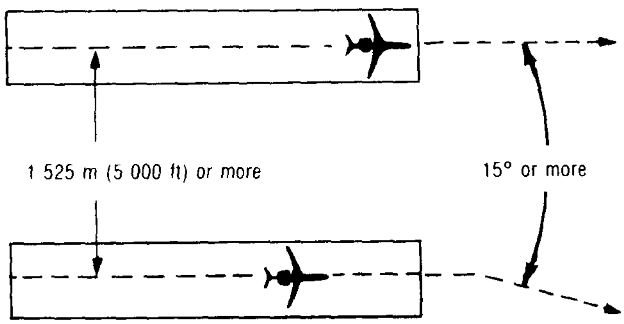

Figure 4-2

4.4.3 Simultaneous take-off of aircraft departing in the same direction from parallel runways is authorized where the runway centre lines are spaced by at least 1 525 m (5 000 ft) and the course of one aircraft diverges from the other by 45° immediately after take-off (see Figure 4-3). Turns after take-off must be initiated not later than 150 m (500 ft) AGL.

Spacing between runways	*Course divergence after take-off*	*Radar required*
1 525 m (5 000 ft) or more	45°	No

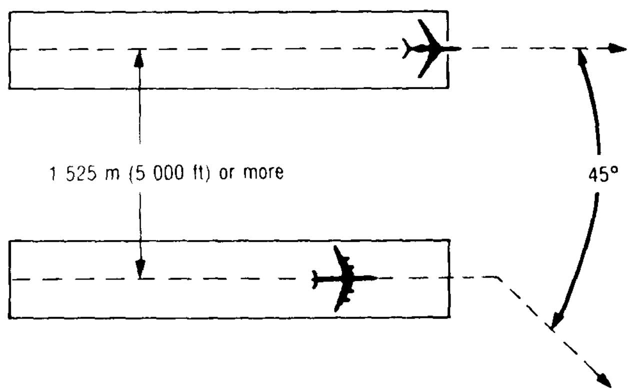

Figure 4-3

Chapter 5

Segregated Operations on Parallel Runways (Mode 4)

5.1 GENERAL CONCEPT

5.1.1 When considering ways in which two parallel runways may be used to best advantage at an aerodrome, the maximizing of aerodrome capacity is usually the prime concern.

5.1.2 Generally speaking, theoretical studies and, in some cases, practical examples indicate that maximum capacities can be achieved by using the parallel runways in a mixed mode of operation. In many cases, however, other factors such as the land-side/air-side infrastructure, the mix of aircraft types, and environmental considerations result in a lower achievable capacity.

5.1.3 Other factors such as non-availability of landing aids on both parallel runways or restricted runway lengths may preclude the conducting of mixed operations at a particular aerodrome.

5.1.4 Because of these constraints, maximum runway capacity may, in some cases, only be achieved by adopting a fully segregated mode of operation, i.e. one runway used exclusively for landings while the other is used exclusively for departures.

5.1.5 The advantages to be gained from a segregated operation as compared to a mixed operation are as follows:

a) separate monitor controllers (for independent approaches) are not required;

b) no interaction between arriving and departing aircraft on the same runway and consequential reduction in the number of potential "go-arounds";

c) an over-all less complex ATC environment for both radar approach controllers and tower controllers; and

d) a reduced possibility of pilot error due to selection of wrong ILS frequency.

5.1.6 There are many examples of aerodromes operating in a segregated mode within the United States, in the United Kingdom at London/Heathrow Airport and in France at Paris/Charles-de-Gaulle. The procedures applicable to the United States, described in 5.4.1 and 5.4.2, provide a model on which to base segregated operations. The procedures described in 5.4.3 and 5.4.4 show how, at London/Heathrow Airport, the model is significantly different, but still considered to be a segregated mode of operation.

5.2 GROUND EQUIPMENT

5.2.1 Segregated operations may be conducted with aircraft carrying out either visual, ILS (CAT I, II or III), surveillance radar or precision radar approaches.

5.2.2 Apart from the general requirement for surveillance radar equipment, the ground facilities should conform to the standards necessary for the type of approaches that will be conducted at the aerodrome.

5.3 WEATHER MINIMA

The procedures described in section 5.4 are applicable in all weather conditions.

5.4 RUNWAY SPACINGS AND ATC PROCEDURES

United States

5.4.1 *Runway thresholds even* (see table below)

Separation between runways when thresholds are even	*Departure course divergence after take-off*	*Radar required*
760 m (2 500 ft) or more	30° or more	Yes

5.4.1.1 When parallel runway thresholds are even and the runway centre lines are at least 760 m (2 500 ft) apart, simultaneous operations between an aircraft departing on one runway and an aircraft on final approach to another parallel runway may be authorized if the departure course diverges immediately after take-off by at least 30° from the missed approach course of the adjacent approach until separation is applied (see Figure 5-1).

5.4.2 *Runway thresholds staggered* (see table below)

Separation between runways when thresholds are staggered	*Departure course divergence after take-off*	*Radar required*
760 m (2 500 ft) or more or less depending on direction of displaced threshold	30° or more	Yes

5.4.2.1 When parallel runway thresholds are staggered, simultaneous operations between an aircraft departing on a runway and an aircraft on final approach to another parallel runway may be authorized if the departure course diverges immediately by at least 30° from the missed approach course until separation is applied and provided that:

a) if the arriving aircraft is approaching the nearer runway, the centre lines are at least 300 m (1 000 ft) apart and the landing thresholds are staggered at least 150 m (500 ft) for each 30 m (100 ft) less than 760 m (2 500 ft) the centre lines are separated (see Figure 5-2); and

Note.— In the event of a missed approach by a heavy jet, wake turbulence separation should be applied or, alternatively, measures taken to ensure that the heavy jet does not overtake an aircraft departing from the adjacent parallel runway.

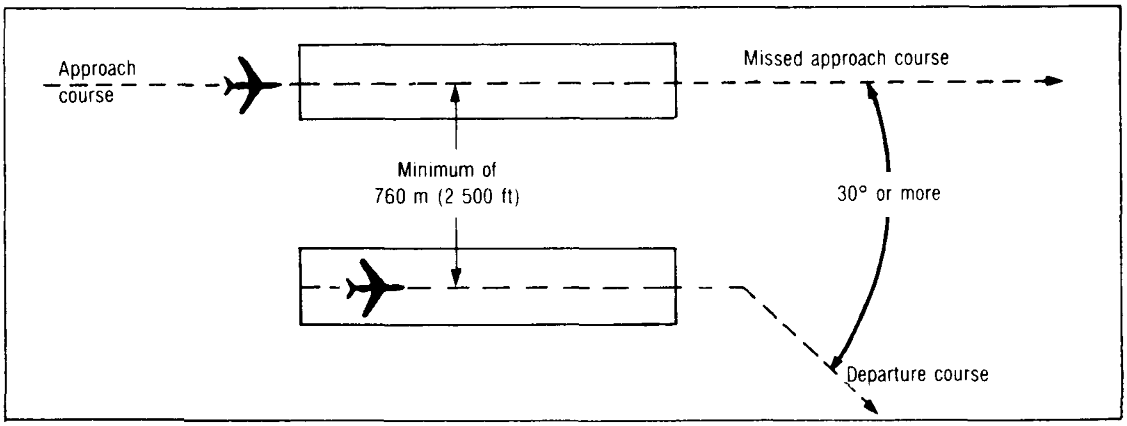

Figure 5-1. Even thresholds

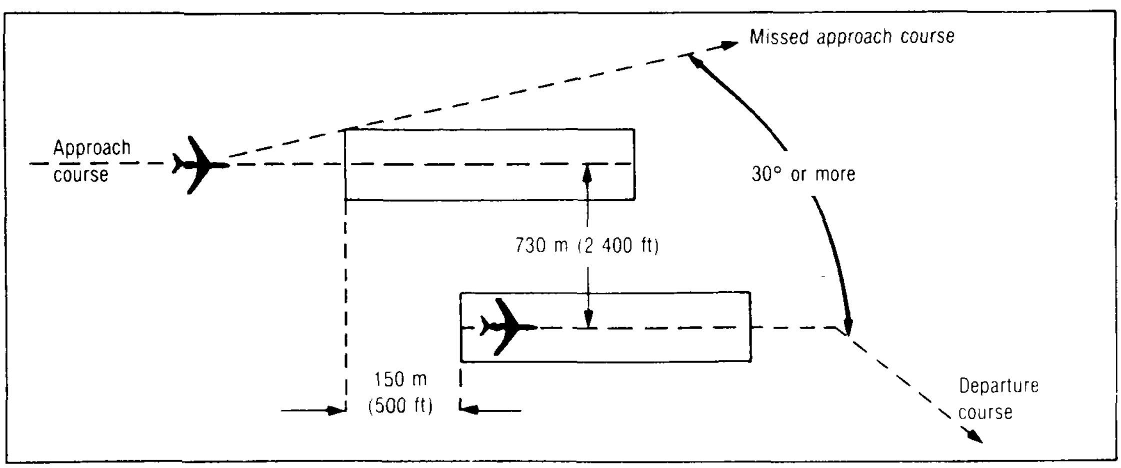

Figure 5-2. Staggered thresholds

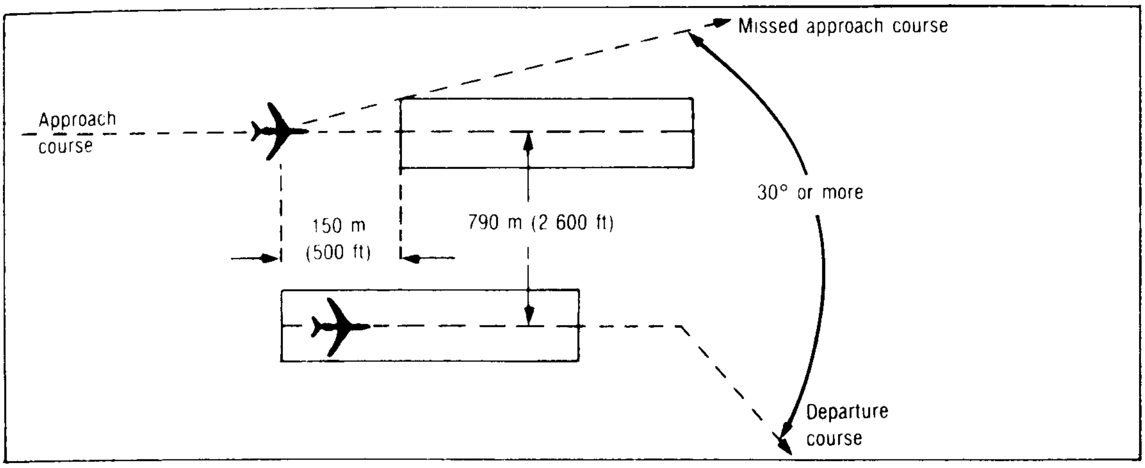

Figure 5-3. Staggered thresholds

b) if the arriving aircraft is approaching the farther runway, the runway centre line separation exceeds 760 m (2 500 ft) by at least 30 m (100 ft) for every 150 m (500 ft) the landing thresholds are staggered (see Figure 5-3).

The United Kingdom

5.4.3 At London/Heathrow Airport, segregated arrivals and departures are conducted with a runway spacing of 1 400 m (4 600 ft) with no requirement for a minimum track divergence between missed approach and departure courses.

5.4.4 In the event of a simultaneous missed approach and departure, controller intervention is required to establish a radar or procedural separation as soon as possible. Experience at London/Heathrow Airport over many years has shown that there have been no difficulties in achieving a safe operation in these circumstances.

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Chapter 6

Near-Parallel Runways

6.1 GENERAL CONCEPT

6.1.1 Near-parallel runways are non-intersecting runways whose extended centre lines have an angle of convergence/divergence of 15° or less.

6.1.2 No special procedures have been developed as yet for simultaneous operations to near-parallel runways. Each situation is considered on a case-by-case basis and is dependent on a number of variable conditions. The present procedures were adopted from existing conditions.

6.1.3 The most important factor to be considered in developing procedures for simultaneous operations to near-parallel runways is the point at which the runway centre lines converge. This point depends on the relative position of the two runways (even or staggered) and the angle of convergence.

6.1.4 It is also important to consider if the two runways are used simultaneously in the converging or the diverging direction.

6.1.5 In the diverging direction of two near-parallel runways, independent approaches are impossible where there are intersecting approach paths. On the other hand, for independent departure or segregated operations the diverging direction leads to a natural lateral separation and is acceptable (see Figure 6-1).

6.1.6 The various modes of operation described in the preceding chapters should also be considered for near-parallel runway operations. A study must be made for each mode of operation for each specific aerodrome before such procedures can be implemented.

6.2 GROUND EQUIPMENT

6.2.1 The ground equipment should conform to the standard necessary for the type of approaches conducted at the aerodrome. A surveillance radar equipment should be required.

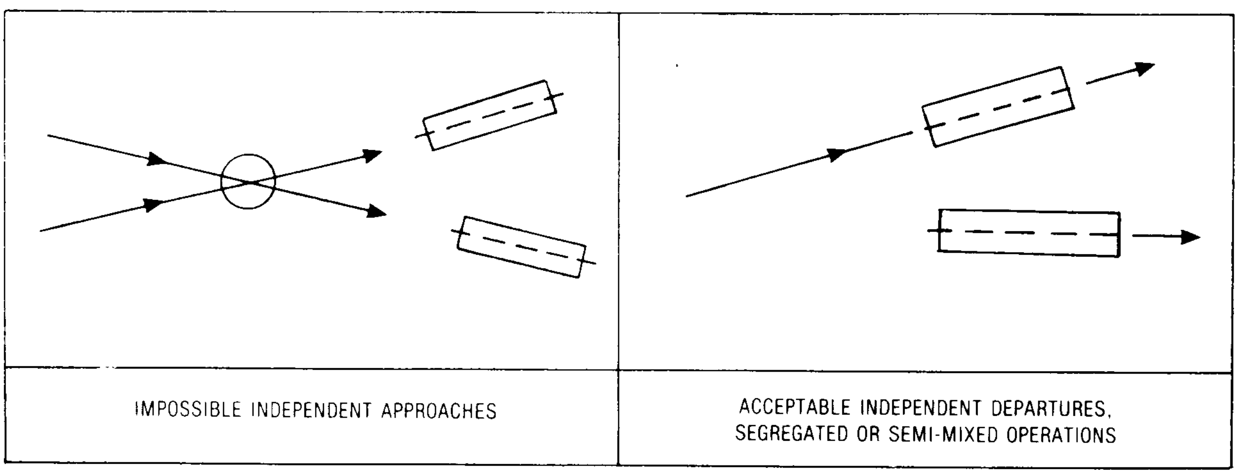

Figure 6-1

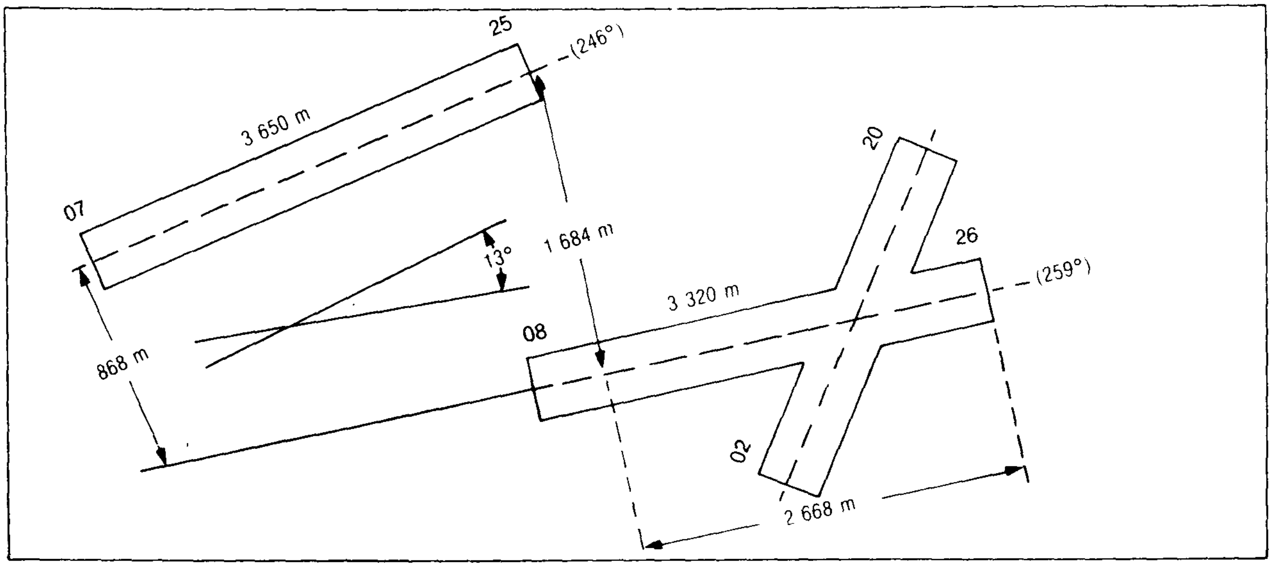

Figure 6-2

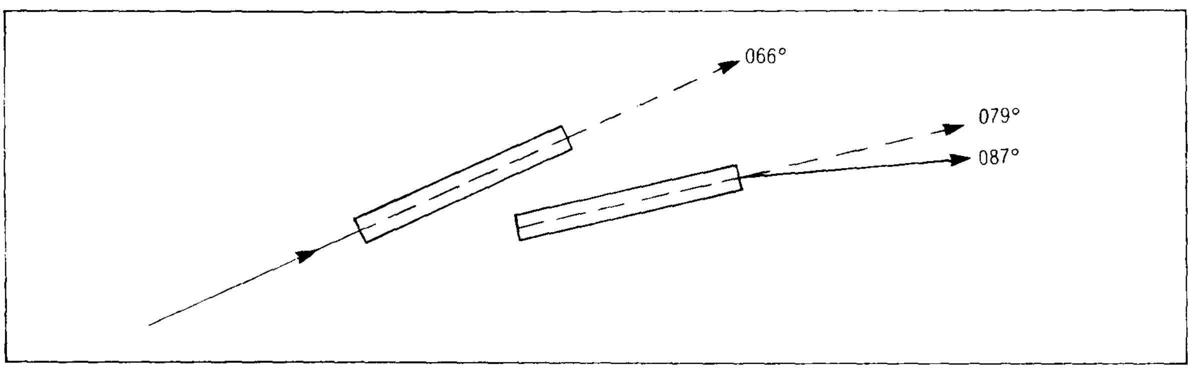

Figure 6-3

Note.— The 8° divergence in one runway's heading is for noise abatement and the need to improve departure separation.

6.3 RUNWAY SPACINGS AND ATC PROCEDURES

6.3.1 Simultaneous operations on near-parallel runways are practised at Paris/Orly Airport in France.

6.3.2 The procedures used at Paris/Orly since 1965 are given below.

6.3.2.1 *Runway orientation* (see Figure 6-2)

6.3.2.2 The two runways 07/25 and 08/26 which have a 13° angle of convergence are used for segregated independent operations:

— easterly: 07 for landing, 08 for take-off;
— westerly: 26 for landing, 25 for take-off.

a) In the easterly direction (07/08) the two runways are treated as independent because the divergence leads to a natural lateral separation (see Figure 6-3).

b) In the westerly direction (25/26) there is some dependence because the runways are converging. Appropriate separation has to be maintained between take-off course on runway 25 and missed approach course on runway 26 (see Figure 6-4). When weather conditions are favourable, the two runways are operated as independent runways because in the initial phase of missed approach,

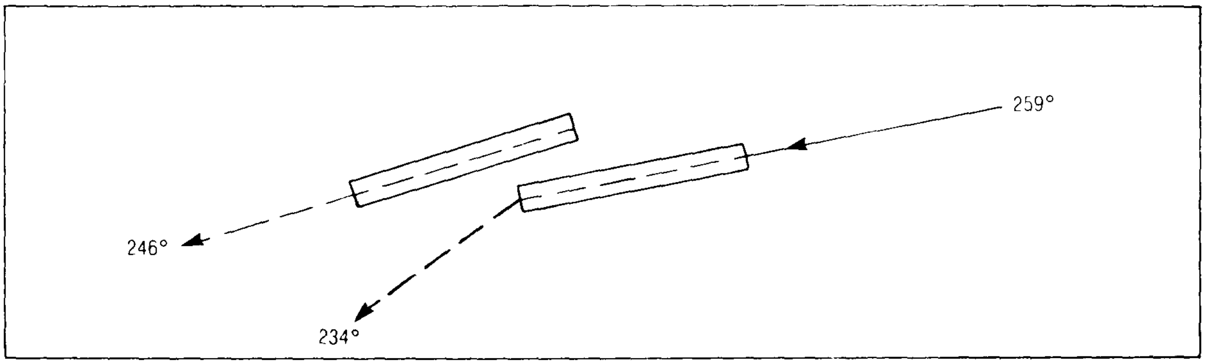

Figure 6-4

visual contact with aircraft taking off on the other runway can be maintained. In adverse weather conditions (visibility below 2 000 m and/or cloud base below 150 m (500 ft)), when an aircraft on final approach is 3.7 km (2.0 NM) from the threshold, no take-off clearance is issued until the controller is sure that a missed approach will not take place.

6.3.2.3 Experiments on simultaneous independent arrivals on runways 25 and 26 were conducted in good weather conditions. Visual contact on traffic landing on the other runway had to be established before the separation between the two approach courses decreased below 5.6 km (3.0 NM). These approach trials were abandoned because of environmental noise.

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Chapter 7

Training of ATS Personnel

7.1 GENERAL

7.1.1 Training of air traffic services (ATS) personnel in the application of these procedures is considered a prerequisite for the introduction of operations on parallel instrument runways. In order to make the following material meaningful to the reader, the training to be described includes that additional training which should normally be given to aerodrome controllers at units where they may be assigned a limited responsibility for separation of instrument flight rules (IFR) aircraft. In the case of approach controllers, only those additional measures which are specific to simultaneous parallel operations are described.

7.1.2 The matter of competency certification should be handled in the following way:

a) when the new procedures are to be introduced at an ATS unit, the certified controllers at that unit should be given the necessary training in the new procedures;

b) when independent approaches are contemplated, the training plan should provide an opportunity in a simulator for controllers to observe, detect and react to errant aircraft situations;

c) required knowledge and skill levels should be satisfactorily demonstrated to the competent authority; and

d) when all controllers at the unit have been so certified, the training should be incorporated into the unit training plan.

7.1.3 Training requirements should be divided into two categories: training for approach controllers and training which is required for aerodrome controllers.

7.2 TRAINING FOR APPROACH CONTROLLERS

7.2.1 Since the approach controllers are already fully qualified for both radar and non-radar procedures at the aerodrome in question, the only additional training required for them should be:

a) an explanation of additions and changes to the procedures and agreements between the approach controllers and the control tower;

b) instruction in the application of high side/low side turn-on procedures, with particular attention to the maintenance of vertical separation until the aircraft are established on the localizers;

c) instruction in the monitoring of aircraft on approaches to ensure containment within the NOZ and avoidance of the NTZ;

d) instruction regarding action to be taken if aircraft stray from the localizer; and

e) instruction in the procedures to follow in the event of a missed approach or successive missed approaches.

7.3 TRAINING FOR AERODROME CONTROLLERS

7.3.1 Aerodrome controllers at control towers where simultaneous parallel approaches/departures are to be used may, in a limited context, be providing separation between IFR aircraft. It will therefore be necessary to train them in some, or all as appropriate, of the following areas:

a) basic theory of radar (primary and secondary surveillance radar (SSR));

b) operation, set-up and alignment of radar equipment in use at the unit;

c) identification of aircraft using primary radar, SSR and radar hand-offs;

d) regulations governing use of transponder codes and codes to be used in the unit;

e) the applicable radar separation minima;

f) application of the radar separation minima;

g) provisions regarding terrain clearance;

h) provision of radar vectors and how position information is provided, including:

1) when vectors may or shall be used;

2) methods of vectoring aircraft; and

3) termination of vectoring;

i) precautions to be taken in the event of radar or communications failure, including:

1) the air-ground communication failure procedures; and

2) the procedures for communications failure during radar vectoring;

j) precautions to be taken and instructions to be issued in the event of a missed approach or successive missed approaches;

k) the terms and application of the procedures and agreements between approach control and the control tower units. In particular they should understand the provisions governing the release of successive IFR departures (where authorized) and the release of independent departures with reference to arriving aircraft (including those carrying out missed approaches); and

l) any special information which may be required to be broadcast on the ATIS if the tower is responsible for recording the ATIS information.

Chapter 8

Implementation and Promulgation

8.1 TRIALS AND FAMILIARIZATION

8.1.1 The decision to implement independent or dependent operations on parallel or near-parallel instrument runways should only be taken after the need has been thoroughly assessed and after a trial and familiarization period during which it has been satisfactorily proven that all the elements such as ground equipment, personnel qualifications and ATC procedures are properly integrated in the over-all system.

8.1.2 The trials should be monitored by a group which includes ATS experts, selected operators' representatives and aerodrome authorities. The trial period should cover a sufficient number of approaches in various conditions, so as to enable the monitoring group to evaluate the level of risk of inadvertent intrusion of the NTZ by an aircraft, and the readiness of ATC to react adequately to such a situation. For example, the trial period should include a number of runs in adverse wind conditions in order to assess the ability of the ATC personnel to cope with blunders. The trial should also determine the ability of the ATC personnel to establish and maintain the required radar separation while monitoring dependent approaches in various weather conditions.

8.1.3 It is advisable during the trial period to specify weather conditions allowed in the first stage so that the "see-and-avoid" principle can be applied by the pilot. These weather conditions should then be cautiously and progressively reduced as the trials progress satisfactorily.

8.2 DECISION TO IMPLEMENT

The decision to implement the procedure for IFR operations on parallel instrument runways in normal operation should only be taken when the analysis of the results of the trial period has demonstrated the safety and the reliability of the procedure.

8.3 PROMULGATION

8.3.1 The promulgation of independent and dependent operations on specified parallel instrument runways of an aerodrome means that:

a) the runways concerned are suitably equipped;

b) the procedures appropriate to such operations have been tested and are determined; and

c) the local ATC units are suitably equipped and personnel are properly trained.

8.3.2 The promulgation should contain the following elements:

a) runways involved with their respective instrument landing system (ILS) characteristics (frequency, identification, category);

b) general description of runway usage, using the classification and the designation(s) given in Chapter 2; separation minima applied, if relevant;

c) periods of availability;

d) special status, e.g. on trial, with related weather limitations, if any;

e) description and purpose of the normal operating zone(s) and the no-transgression zone (independent approaches only);

f) description of the procedure, including the provisions of radar monitor, missed approach, and describing the advisory and corrective ATC actions vis-à-vis one or both aircraft when a target is observed to overshoot the localizer, or to approach the edge of the NOZ, or to penetrate the NTZ; and

Note.— A particular emphasis shall be placed, in case of independent approaches, on the levels of glide slope *interception ("high side" and "low side"), and on the requirement to maintain these levels until the aircraft is established on both the localizer and the glide path.*

g) airborne equipment requirements.

8.3.3 Promulgation and implementation trial should be announced by a Class II NOTAM giving a two-AIRAC cycle notice.

8.3.3.1 There can be a variety of modes of operation associated with the use of parallel and near-parallel instrument runways. The appropriate ATS authority should provide information and guidance for pilots relevant to the selected mode(s) of the simultaneous operation. Information for pilots relevant to these matters is contained in the Appendix to this chapter.

8.3.4 Information on the mode of simultaneous operation selected following the trials should be included in the Aeronautical Information Publication (AIP).

8.3.5 Instrument approach charts for a runway where simultaneous approaches are permitted should contain a note indicating clearly the runways involved.

8.3.6 ATIS broadcast should include the fact that independent approaches or independent departures are in progress, specifying the runways involved.

Appendix to Chapter 8

Information for Pilots

1. INTRODUCTION

1.1 There can be a variety of modes of operation associated with the use of parallel or near-parallel instrument runways.

1.1.1 *Simultaneous approaches*

Two basic modes of operation are possible:

— Mode 1, *independent approaches:* approaches which are made to parallel runways where radar separation minima between aircraft using adjacent ILS systems are not prescribed; and

— Mode 2, *dependent approaches:* approaches which are made to parallel runways where radar separation minima between aircraft using adjacent ILS systems are prescribed.

1.1.2 *Simultaneous departures*

— Mode 3, *independent departures:* simultaneous departures for aircraft departing in the same direction from parallel runways.

Note.— When the spacing between two parallel runways is lower than the specified value dictated by wake turbulence considerations, the parallel runways are considered as a single runway in regard to separation between departing aircraft. A simultaneous dependent departures mode of operation is therefore not used.

1.1.3 *Segregated approaches/departures*

— Mode 4, *segregated operations:* one runway is used for approaches, one runway is used for departures.

1.1.4 In the case of segregated approaches and departures (Mode 4) there may be semi-mixed operations, i.e. one runway is used exclusively for departures, while the other runway accepts a mixture of approaches and departures; or, one runway is used exclusively for approaches while the other accepts a mixture of approaches and departures. There may also be mixed operations, i.e. simultaneous approaches with departures interspersed on both runways. In all cases, however, semi-mixed or mixed operations may be related to the four basic modes listed in 1.1.1 through 1.1.3 above as follows:

	Mode
a) *Semi-mixed operations.*	
1) One runway is used exclusively for approaches while:	
— approaches are being made to the other runway, or	1 or 2
— departures are in progress on the other runway.	4
2) One runway is used exclusively for departures while:	
— approaches are being made to the other runway, or	4
— departures are in progress on the other runway.	3
b) *Mixed operations.*	
All modes of operation are possible.	1, 2, 3, 4

1.2 *Definitions* (see Figure 1)

Normal operating zone (NOZ). Airspace of defined dimensions extending to either side of an ILS localizer centre line. Only the inner half of the normal operating zone is taken into account in independent approaches.

No-transgression zone (NTZ). A corridor of airspace of defined dimensions located centrally between the two

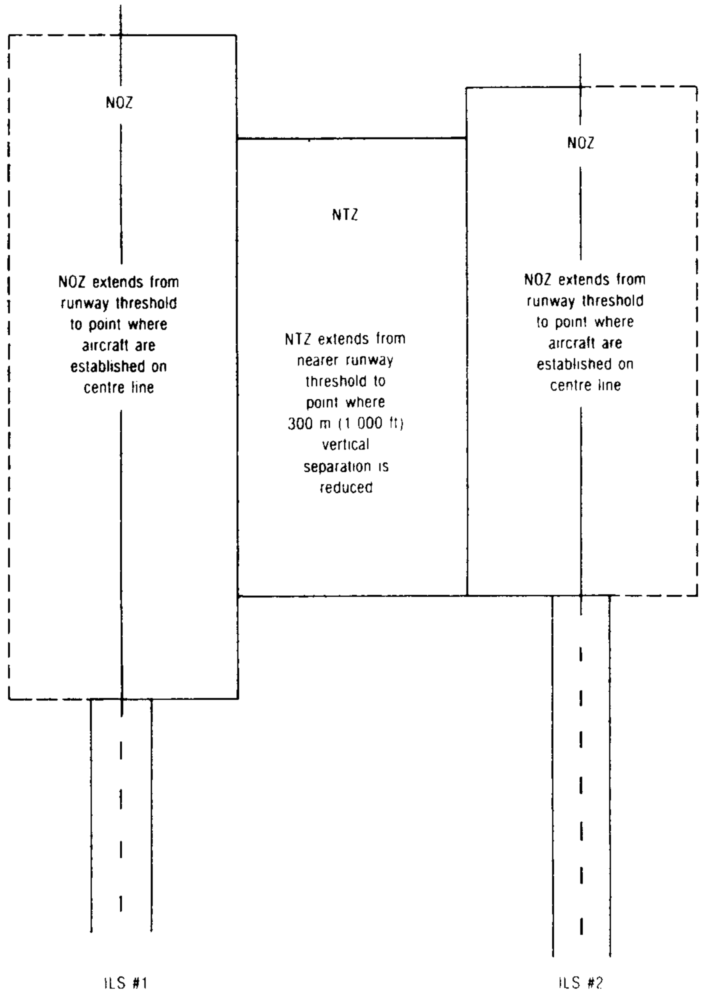

Figure 1. Example of normal operating zones (NOZs) and no-transgression zone (NTZ)

extended runway centre lines where controller intervention is required to manoeuvre the non-blundering aircraft when this airspace is penetrated by an aircraft conducting a simultaneous approach to a parallel or near-parallel instrument runway.

2. EQUIPMENT REQUIREMENTS

Airborne avionics. Normal IFR avionics including full ILS capability are required for conducting parallel approaches. Surveys reveal that pilots flying by hand with a flight director have no trouble remaining in the NOZ.

3. AIRPORT SERVICES AND FACILITIES

The following airport services and facilities are provided in support of independent/dependent approaches:

a) an ILS serving each runway;

b) information that simultaneous operations are in progress;

c) instrument approach charts that contain operational notes regarding the parallel approach procedures;

d) missed approach procedures that provide divergent courses;

e) radar vectoring to the localizer;

f) controllers dedicated to monitoring the track-keeping of aircraft on parallel approaches (independent approaches only); and

g) a VHF override capability for the monitor controllers to use.

4. VECTORING TO THE LOCALIZER

When simultaneous independent approaches are in progress, the following apply:

a) the air traffic control procedure will be to vector arriving aircraft to one or the other of the parallel localizers. When cleared for an ILS approach, a procedure turn is not permitted;

b) each pair of parallel approaches will have a "high side" and a "low side" for vectoring, to provide vertical separation until aircraft are established inbound on their respective parallel localizers. The low side altitude will normally be such that the aircraft will be established on the localizer well before glide path interception. The high side altitude will be 300 m (1 000 ft) above the low side;

c) the main objective is that both aircraft be established on the localizers before the 300 m (1 000 ft) vertical separation is reduced;

d) if an aircraft is observed to overshoot the localizer during turn-to-final, the pilot will be instructed to return to the correct localizer course immediately;

e) once the 300 m (1 000 ft) vertical separation is reduced, the controller monitoring the approach will issue control instructions if the aircraft deviates substantially from the localizer course. If the aircraft fails to take corrective action and penetrates the NTZ, the aircraft on the adjacent localizer will be issued appropriate control instructions; and

f) if considered necessary, appropriate missed approach instructions will be issued.

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Chapter 9

Future Developments

9.1 PROGRAMMES IN THE UNITED STATES

9.1.1 In the United States, a programme to increase airport capacity during instrument meteorological conditions is under way. The project will determine the feasibility and prerequisites for implementing independent operations on parallel runways during instrument meteorological conditions at airports where existing runway spacing is less than the current minimum of 1 310 m (4 300 ft). A goal of 915 m (3 000 ft) runway spacing has been established. Major work elements consist of:

a) real time simulations of an air traffic control, parallel runway environment conducted at the FAA Technical Center; and

b) actual measurement of aircraft/pilot performance on runway approaches using a precision approach radar with automatic data recording capability. This equipment is leased from the Department of Defense and installed at Memphis International Airport, where the parallel runways are 1 050 m (3 450 ft) apart.

9.1.2 The primary ingredient in reduced spacing for independent instrument approaches is an improved surveillance system. Navigational and ATC improvements can, however, assist in this process. These improvements relate to the following:

a) microwave landing system (MLS), for steeper glide path angles and possibly curved approaches, with resultant reduced common path lengths or additional altitude separation between arrivals;

b) offset runway thresholds, to permit greater vertical separation on final approach; and

c) separate short runways, to provide independent streams of traffic for general aviation and commuter aircraft.

9.1.3 The microwave landing system (MLS) may reduce the risks associated with blunders. MLS allows more accurate navigation and provides an expanded capability for automated approaches, reducing the likelihood of a blunder. Additionally, the missed approach guidance available with MLS may make it easier to establish missed approach procedures required for dependent approaches, which do not conflict when these would otherwise present a problem.

9.1.4 The availability of dependent approaches may affect studies on separate short runways. Such studies concern the feasibility and benefits of a separate runway for commuter and general aviation operations at major airports. The maximum benefit from such a runway would be realized if the arrival stream could be completely independent of the air carrier arrivals, but few aerodromes have the land available to locate a new runway 1 310 m (4 300 ft) from existing runways. At closer runway spacings, the feasibility of dependent approaches is important.

9.1.5 Other studies which are currently under way involve triple parallel approaches. These approaches may all be independent approaches, or combinations of independent and dependent approaches. The question of blunders acquires new significance with triple parallel approaches, in which a blunder on one of the outer runways towards the middle may cause as many as three other aircraft to be diverted. Strategies for dealing with blunders on triple parallels are currently being investigated in the United States.

9.2 PROGRAMMES IN OTHER STATES

9.2.1 The congestion at major airports requires a better and more efficient utilization of existing parallel runways, taking into consideration the runway spacing and a possible reduction in the present wake turbulence separation minima. Future work on this subject is required.

9.2.2 Under current IFR procedures, parallel runways with spacing less than 760 m (2 500 ft) are essentially considered to be a single runway for wake turbulence reasons. This situation initiated investigations in different States for various solutions to the wake turbulence problems associated with parallel runways less than 760 m (2 500 ft) apart.

9.3 WAKE TURBULENCE RESEARCH

Activities are under way in the United States and in the Federal Republic of Germany, with research concentrated on movement and rate of decay of wake turbulence. Four field tests were carried out at Frankfurt Airport between 1983 and 1985 and reports have subsequently been published. In addition to the field tests, the wake turbulence generation has been investigated with a B-747 model aircraft in a water tunnel. The test will be conducted in a water towing tank where the vortices can be observed for a longer time. Theoretical work has been undertaken, investigating the application and improvement of mathematical models for the vortices flow field and turbulence movement. It has become evident that additional improved field experiments are necessary. Simultaneous measurements with the equipment of the United States' FAA and of the Federal Republic of Germany (laser Doppler anemometer) would offer the possibility of three-dimensional investigations of the wake flow field and observations of vortices decay.

— END —

ICAO TECHNICAL PUBLICATIONS

The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the Aeronautical Chart Catalogue *or the* Meteorological Tables for International Air Navigation.

International Standards and Recommended Practices are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications contained in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

Procedures for Air Navigation Services (PANS) are approved by the Council for world-wide application. They contain, for the most part, operating procedures regarded as not yet having attained a sufficient degree of maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome.

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