GHANA

CIVIL AVIATION AUTHORITY

ADVISORY CIRCULAR
AC 14-007

AERONAUTICAL STUDY AND SAFETY RISK ASSESSMENT

GENERAL
Ghana Civil Aviation Authority (GCAA) Advisory Circulars from Aerodrome Safety and Standards (ASAS) contain information about standards, practices and procedures that the Authority has found to be an Acceptable Means of Compliance (AMC) with the associated Directives.

An AMC is not intended to be the only means of compliance with a Directive, and consideration will be given to other methods of compliance that may be presented to the Authority.

PURPOSE
This Advisory Circular (AC) provides information and guidance to aerodrome operators on the conduct of Aeronautical Study and risk assessment where the aerodrome is unable to meet requirements and need to identify alternative means to achieve an equivalent level of safety.

REFERENCE
GCAD Part 24, – Aerodrome Certification
GCAD Part 25, – Aerodrome Registration
ICAO Annex 14, Volume I; Aerodrome Design and Operations
ICAO Doc 9774 (Manual on the Aerodrome Certification)
ICAO Doc 9859 (Safety Management Manual)
ICAO Doc 9981 (PANS Aerodromes)

STATUS OF THIS AC
This is the first AC to be issued on this subject.

FOREWARD
This document provides guidance to Aerodrome Operators on the processes to petition GCAA for an exemption from any requirement of GCAD Part 24.

APPROVAL

Issue No: 01	Approved by: Director-General	Nov. 2018

GHANA CIVIL AVIATION AUTHORITY
GCAA
DIRECTOR-GENERAL

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CHAPTER 1. AERONAUTICAL STUDIES FOR AERODROME OPERATORS

11.1. INTRODUCTION

11.1.1. The Ghana Civil Aviation Directives (GCADs) Parts 24 and 27 contains basic provisions on the use of aeronautical studies and safety risk assessment as a means to identify alternative means to achieve an equivalent level of safety by means other than full compliance with a specific requirement.

11.1.2. It is acknowledged that there could be some other cases where full compliance with requirements cannot be achieved, and for which a deviation from a regulatory requirement will have to be sought. A safety case based on the same principles as an Aeronautical Study should accompany any application for a deviation.

11.2. AERONAUTICAL SAFETY

11.2.1. An aeronautical study is a tool used to review aerodrome and airspace processes and procedures to ensure that safety criteria in place are appropriate. The study can be undertaken in a variety of ways using various analytical methods appropriate to the aeronautical study requirements.

11.2.2. An aeronautical study should include the use of;

- current state review (baseline position)
- quantifiable data analysis
- stakeholder interviews
- safety/risk matrix

11.2.3. In general an aeronautical study should be viewed as providing an overarching document giving a holistic view of an aerodrome's operational environment. An aeronautical study may contain many elements; however risk assessment, risk mitigation and risk elimination are key components. Additionally there may be aviation system constraints.

11.2.4. The goal of risk management in an aeronautical study is to identify risks, and take appropriate action to minimize risk as much as is reasonably practicable. Decisions made in respect of risks must balance the technical aspects of risk with the social and moral considerations that often accompany such issues.

11.2.5. These decisions may have significant impact on an aerodrome's operation and for an effective outcome there should be a level of consensus as to their acceptability among the key stakeholders.

11.2.6. While this Advisory Circular focuses on the safety outcomes, there may also be non-safety consequences, such as financial loss and operational loss of the aircraft, increased insurance costs and damage to reputation. This Advisory Circular discusses the concept of risk and goes on to describe the trigger factors that may lead to an aeronautical study, the conduct of the study and the types of activities that should be included in the study.

11.2.7. The aeronautical study should be seen as a framework for effective decision- making, rather than as a guaranteed process to come up with the correct outcomes. This framework for conducting aeronautical studies proposes a systematic method, and some tools, for analyzing complex risk issues so as to help the decision-maker to make decisions with confidence and, if necessary, to articulate these decisions.

11.2.8. Aerodrome operators should also undertake aeronautical studies when the aerodrome operating environment changes. These changes are normally precipitated by a trigger event such as a change, or a proposed change in; airspace design, aircraft operations, aerodrome infrastructure or the provision of an air traffic service.

11.2.9. It is the aeronautical study process that determines the site-specific need for services, and identifies and recommends a course of action, or presents options for decision makers to act upon. In all cases the aeronautical study should document and demonstrate the site-specific need and rationale for the level of service, procedure design or operational requirements.

11.3. TRIGGER FACTORS

11.3.1. The aeronautical study is a tool for the aerodrome management to use as part of its operations and strategic planning and is an integral part of the aerodrome’s Quality Assurance and Safety Management Systems.

11.3.2. One of the purposes of the aeronautical study is to determine levels of operational safety, service or procedures that should apply at a particular location. The decision to undertake this type of study may be triggered by any one or more of a wide range of factors.

11.3.3. These may include changes to:

- the number of movements
- the peak traffic periods
- the ratio of IFR to VFR traffic
- the type of operations - scheduled, General Aviation (GA), training, etc
- the types, and variety of types, of aircraft using the aerodrome (jet, turbo-prop, rotary, etc)
- aerodrome layout
- aerodrome management structure
- runway or taxiway and associated manoeuvring areas

- operations of a neighbouring aerodrome or adjacent airspace.

11.3.4. Feedback about any changes should be sought from aviation stakeholders including pilots, individuals and other representative groups as part of the study.

11.3.5. The Director-General (DG) of the Ghana Civil Aviation Authority (GCAA), an aerodrome operator or other interested party, such as an air traffic service provider or air operators, may initiate an aeronautical study.

11.3.6. The DG can assist in identifying whether an aeronautical study is required and the appropriate methodology for the aeronautical study and in reviewing the aeronautical study.

CHAPTER 2. OVERVIEW

2. AERONAUTICAL STUDY

2.1.1. An aeronautical study can be undertaken at any time. It is constructed to consider all relevant factors, including traffic volume, mix and distribution, weather, aerodrome role, aerodrome and airspace configuration, surface activity and the efficiency requirements of operators using the service. The scope of studies can range from minor adjustments to aerodrome configuration, e.g. from the widening of a taxiway to a complete review of aerodrome airspace with the introduction of a new runway.

2.1.2. The scope of an aeronautical study usually reflects one of three situations:

- the existing operation, e.g. the aerodrome, airspace or ATS (or sometimes just a particular part of the operation)
- a change to the existing operation
- a new operation.

2.1.3. Where the aeronautical study is used to consider a change to existing operations or a new operation, it may not initially be possible to provide all the safety assessment and evidence required.

2.1.4. An aeronautical study can identify and evaluate aerodrome service options, including service increases or decreases or the introduction or termination of services (such as the introduction of a rapid exit taxiway or removal of a grass runway). The initial baseline study will be followed by a review of operational issues; this will typically involve an in-depth safety analysis based on quantifiable data and extensive consultation with customers and stakeholders using various interview and data gathering processes. This may identify any changes that are required to ensure the safe, orderly and efficient operation of the aerodrome.

2.1.5. Larger projects may have distinct phases such as requirements definition, design evaluation, introduction to service and routine operation. The aeronautical study can be presented in parts corresponding to these phases as information becomes available; this is illustrated in the flow chart below.

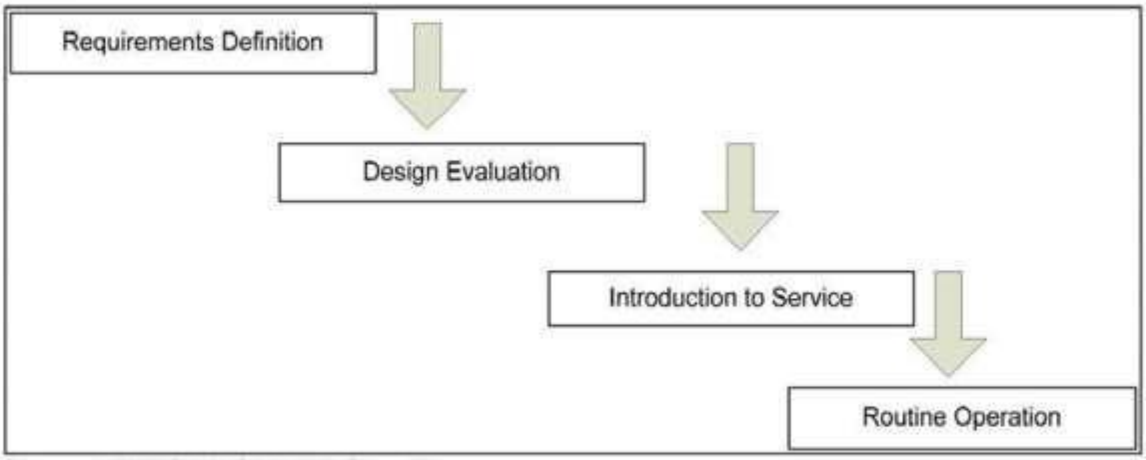

Figure 1: Source UKCAA CAP 728 Chapter 3

2.1.6. An Aeronautical Study Process is provided in Appendix 1. Aerodrome operators should assess the type of process or model to be used as outlined in section 5.0 of this Advisory Circular.

3. CHAPTER 3. THE CONCEPT OF RISK

3.1.1. Risk assessment is a key area in an aeronautical study.

3.1.2. A risk scenario is a sequence of events with an associated frequency of occurrence and consequence. This sequence of events may be summarized as “hazard – threats – controls – key event – mitigations – consequences”. The hazard is what ultimately generates the loss; it may present a number of threats, each of which, without controls, will lead to the “key event”. The key event is the point at which control of the hazard is lost. Once this point has been reached, mitigations may still avoid or reduce undesirable consequences. Controls are proactive defenses, while mitigations may be proactive or reactive.

3.1.3. For example, a rainstorm (the hazard) may result in sheet water on runways (a threat) and reduced braking performance (another threat). The key event in this case is loss of control of the aircraft on the runway; this may result in damage or injury (the consequences). Controls might include tyre design and anti-skid braking systems, while mitigations could include runway end safety areas. The consequences are the damages and injuries that may result.

3.1.4. The risk is the likelihood (or probability) of the damage or injury resulting from the loss of control of the aircraft; it therefore includes the probability of loss of control and the probability of damage or injury. A study scenario example is attached in Appendix 1.

3.2. ACCEPTABLE RISK

3.2.1. “Acceptable risk” is based on the concept that no activity is without some risk, however small. The level of risk that is acceptable varies with the type of activity and according to the consequences; in general, the acceptable level of risk for adventure activities is higher than that for normal day-today activities, and higher for single fatality accidents than for those with multiple fatalities.

3.2.2. If the risk does not meet the pre-determined acceptability criteria, an attempt must always be made to reduce it to a level that is acceptable using appropriate mitigation procedures. If the risk cannot be reduced to or below the acceptable level, it may be regarded as tolerable if:

- the risk is below the pre-determined intolerable level; and
- the risk has been reduced to a level that is as low as reasonably practicable (ALARP); and
- the benefits of the proposed system or changes are sufficient to justify accepting the risk.

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3.2.4. Perceptions of risk can be divided into three broad categories:

- risks that are so high that they are intolerable;
- risks that are low enough to be acceptable; and
- risks between these two categories, these need to be reduced/mitigated to an acceptable level.

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- the risk has been reduced to a level that is as low as reasonably practicable (ALARP); and
- the benefits of the proposed system or changes are sufficient to justify accepting the risk.

3.5. RISK MANAGEMENT PROCESS

3.5.1. Risk mitigation measures may work through reducing the probability of occurrence, or the severity of the consequences, or both. Achieving the desired level of risk reduction may require the implementation of more than one mitigation measure.

3.5.2. The process becomes one of iteration following the steps below,

1. Systematically identify possible hazards.
2. Evaluate the seriousness of the consequences of the key event occurring.

3. Consider the chances of it happening.
4. Determine whether the consequent risk is tolerable and within the organization's acceptable safety performance criteria. If not, take action to reduce the risk to a tolerable level by reducing the severity of the consequences or the probability of them arising.

3.5.3. Risk mitigation strategies can include:

- revision of the system design;
- modification of operational procedures;
- changes to staffing arrangements;
- training of personnel to deal with the hazard;
- development of emergency and/or contingency arrangements and plans;
- ultimately, ceasing operation.

3.6. SUMMARY OF THE SEVEN STEP SYSTEM RISK PROCESS

3.6.1. Risk assessment and mitigation requires a systematic approach. The complete process can be divided into seven steps and may be iterative. These are illustrated in the flow chart below:

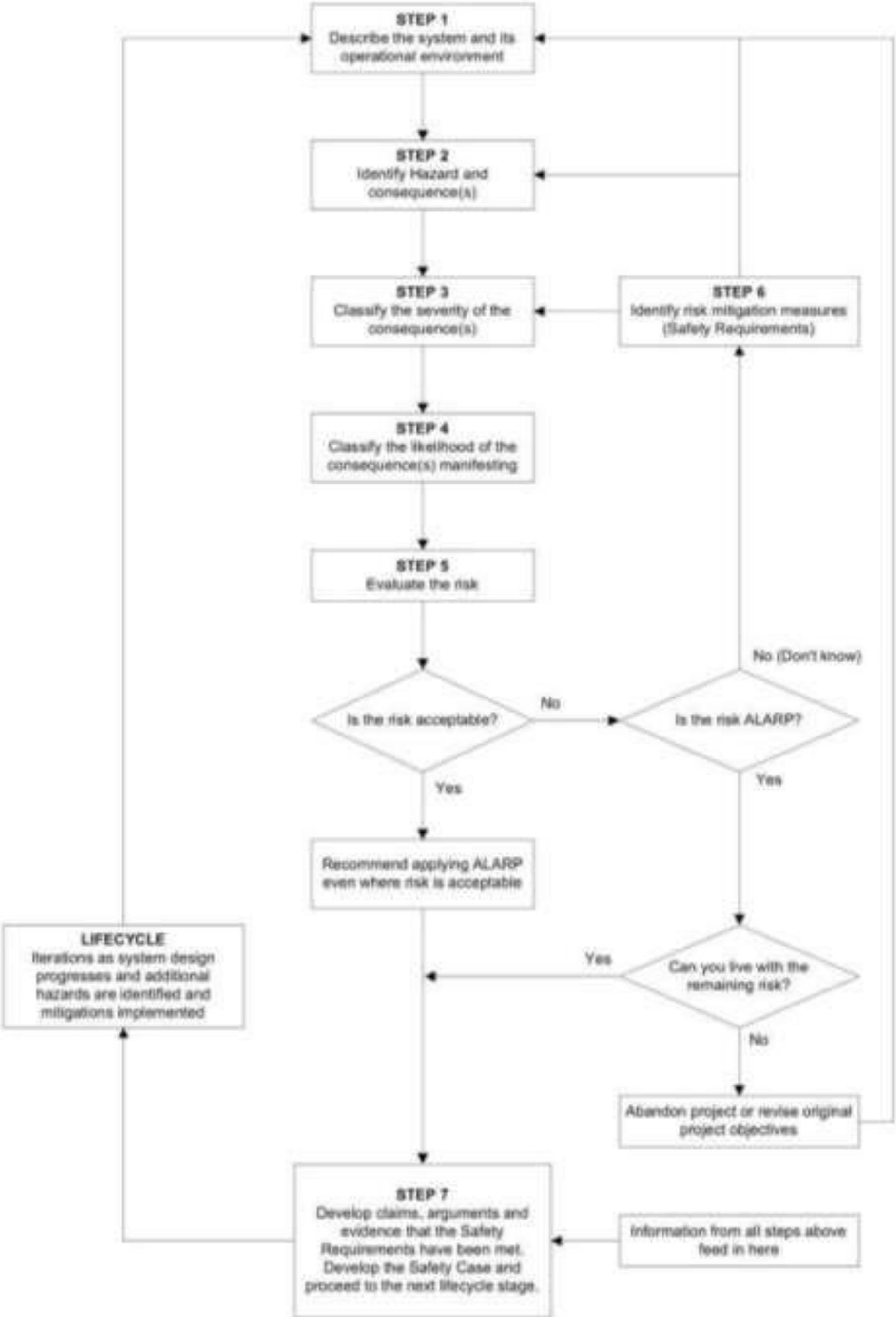

Figure 2: The Seven-Step Approach (CAP 760 Chapter 2)

3.7. AN EXAMPLE OF AN AERONAUTICAL STUDY METHODOLOGY

3.7.1. By way of explanation a generic model of an Aeronautical Study methodology consists of initiation, preliminary analysis, risk estimation, risk evaluation, risk control and action/monitoring and is related to the flow diagram above.

(i) Initiation: Step 1

This step consists of defining the opportunity or problem and the associated risk issues; setting up the risk management team; and beginning to identify potential users who may be affected by any change.

(ii) Preliminary Analysis: Step 2.

The second step consists of defining the basic dimensions of the risk problem and undertaking an initial identification, analysis and evaluation of potential risks. This preliminary evaluation will help determine:

- whether a situation exists that requires immediate action;
- whether the matter requires further study prior to any action being taken; or,
- whether the analysis should be ended as the risk problem is determined not to be an issue.

(iii) Risk Estimation: Steps 3 & 4.

These steps estimate the degree of risk. Step 3 estimates the severity of the consequences and step 4 estimates the probability of their occurrence.

Note: *Safety Risk Probability Table, Safety Risk Severity Table and Safety Risk Index Matrix are given in appendix 2 of procedure for accepting non-compliances at aerodrome.*

(iv) Risk Evaluation: Step 5

The benefits and operational costs of the activity are integrated into the analysis and the risk is evaluated in terms of the safety implications of the activity and of the needs, issues, and concerns of affected users.

(v) Risk Control: Step 6

This step identifies feasible risk controls and mitigations which will act to reduce either the probability of the event or the consequence of the event should it occur.

(vi) Action/Monitoring

(vii) Step 7.

This step entails implementing the chosen risk control options, evaluating the effectiveness of the risk management decision process, and implementing an ongoing monitoring program.

CHAPTER 4

4. PROCESS

4.1. THE STUDY CONTENT

4.1.1. There will be a number of hazards in any aerodrome environment; these must be identified so that the risks that each bears can be determined. It can be very useful to start the process by identifying a number of key events and then deciding what hazards and threats can lead to those events and their possible consequences.

4.1.2. The class of airspace or type of air traffic service required is primarily determined by the level of risk at the aerodrome and in its immediate airspace.

4.1.3. The next stage is to assess the risk levels. The relative risk levels can then be used to identify the threats that have the highest risk, after which it will be possible to determine what, if any, controls can be put in place to reduce the risks.

4.1.4. While this type of study is aimed at determining the appropriate airspace environment at and around an aerodrome, these tools may highlight other risk areas.

4.1.5. There are several tools that can be used in this type of risk assessment; two of them, the Collision Risk Model and the Aerodrome Complexity Model, are discussed later.

4.2. COLLISION RISK MODEL

4.2.1. A widely used tool for this type of study is the collision risk model (CRM). Airspace designers, air navigation service providers or specialist consultants normally use this tool.

4.2.2. The basic output of the CRM is the relative risk of collision between two aircraft (or an aircraft and a parachute) whose intended tracks would bring them into a collision zone. Such pairs are referred to as “conflict pairs”. The relative risk is affected by the environment (type of airspace, service, aircraft) but not by the number of movements. Multiplying the relative risk of collision by the annual number of conflict pairs gives an annual collision risk, which can then be compared to some measure of acceptable risk.

4.2.3. The CRM estimates the risk of collision from failure to take considered action (failure of the control) and failure to take evasive action (failure of the mitigation). As its name suggests, the pilot has some time to initiate a considered action, which is generally the result of information received by radio. A problem close to the collision zone is generally detected visually and requires evasive action. An action initiated within a few seconds of the collision zone is typically too late to alter the flight path sufficiently, so whether a collision takes place or not is a matter of chance.

4.2.4. The model considers the various factors that can lead to the need for considered action and to evasive action, and arranges them in a tree leading to the collision zone. The linking of the branches of the tree is by arithmetical 'AND' and 'OR' operators. Thus to reach the collision zone, both considered action and evasive action must fail. If one aircraft has no radio or is on the wrong frequency, then radio communication fails.

4.2.5. A numerical risk is assigned to each contributory factor, and thus the risk of reaching the collision zone can be calculated. Whether the aircraft will actually collide in the collision zone depends on the collision geometry and a collision geometry factor is applied to allow for this.

4.2.6. For a collision to take place, the two aircraft must initially be on a collision course, at least to the extent that, uncorrected, they will occupy the collision zone at the same time. These pairs are termed "conflict pairs". The total number of pairs that may become conflict pairs can be calculated from traffic data.

4.3. AERODROME COMPLEXITY MODEL

4.3.1. Another tool to estimate risk is an aerodrome complexity model. This type of model assumes that the complexity of operating at, and in the environment of, an aerodrome bears a relationship to pilot workload and hence to the risk of accident. The model therefore identifies a number of complexity factors and scores these according to the relative influence that they are deemed to have. The number of movements and the VFR/IFR mix are then taken into account and an overall complexity score calculated.

4.3.2. Typical complexity factors include the number and disposition of runways and taxiways, the types of operation, the topography and extreme weather conditions that may be expected.

4.3.3. This type of tool allows an aerodrome operator, for example, not only to determine a score that may be compared against some criterion, but also interactively to identify those areas of aerodrome planning where complexity may be reduced.

4.4. Consultation

4.4.1. It is essential that, in conducting the aeronautical study, there is consultation with as wide a range of aerodrome users and other stakeholders as possible. Different users have different views of hazards and the corresponding threats, controls, mitigations and consequences. The following should be included in the consultation:

- Aerodrome operators (including adjacent affected aerodrome operators).
- Aerodrome users.
- Airspace user groups.
- Aircraft operators and operator groups.
- Pilot organisations.
- Air traffic service providers.

4.4.2. Experience has shown that consultation undertaken in open meetings, where ideas can be exchanged and debated, generally results in consensus being achieved. Individual consultation, on the other hand, tends to result in dissatisfaction for those whose proposals or viewpoints are not eventually accommodated

CHAPTER 5. SAFETY ASSESSMENT METHODOLOGIES FOR AERODROMES

Note.— Further guidance on safety risk probability, severity, tolerability and assessment matrix can be found in Doc 9859 — Safety Management Manual (SMM)*.*

1. Depending on the nature of the risk, three methodologies can be used to evaluate whether it is being appropriately managed:

a) *Method type "A".* For certain hazards, the risk assessment strongly depends on specific aeroplane and/or system performance. The risk level is dependent upon aeroplane/system performance (e.g. more accurate navigation capabilities), handling qualities and infrastructure characteristics. Risk assessment, then, can be based on aeroplane/system design and validation, certification, simulation results and accident/incident analysis;

b) *Method type "B".* For other hazards, risk assessment is not really linked with specific aeroplane and/or system performance but can be derived from existing performance measurements. Risk assessment, then, can be based on statistics (e.g. deviations) from existing operations or on accident analysis; development of generic quantitative risk models can be well adapted;

c) *Method type "C".* In this case, a "risk assessment study" is not needed. A simple logical argument may be sufficient to specify the infrastructure, system or procedure requirements, without waiting for additional material, e.g. certification results for newly announced aeroplanes or using statistics from existing aeroplane operations.

Risk assessment method

2. The risk assessment takes into account the probability of occurrence of a hazard and the severity of its consequences; the risk is evaluated by combining the two values for severity and probability of occurrence.

3. Each identified hazard must be classified by probability of occurrence and severity of impact. This process of risk classification will allow the aerodrome to determine the level of risk posed by a particular hazard. The classification of probability and severity refers to potential events.

4. The severity classification includes five classes ranging from "catastrophic" (class A) to "not significant" (class E). The examples in Table 3-Att B-1, adapted from Doc 9859 with aerodrome-specific examples, serve as a guide to better understand the definition.

5. The classification of the severity of an event should be based on a "credible case" but not on a "worst case" scenario. A credible case is expected to be possible under reasonable conditions (probable course of events). A worst case may be expected under extreme conditions and combinations of additional and improbable hazards. If worst cases are to be introduced implicitly, it is necessary to estimate appropriate low frequency.

SAFETY ASSESSMENT FLOW CHART

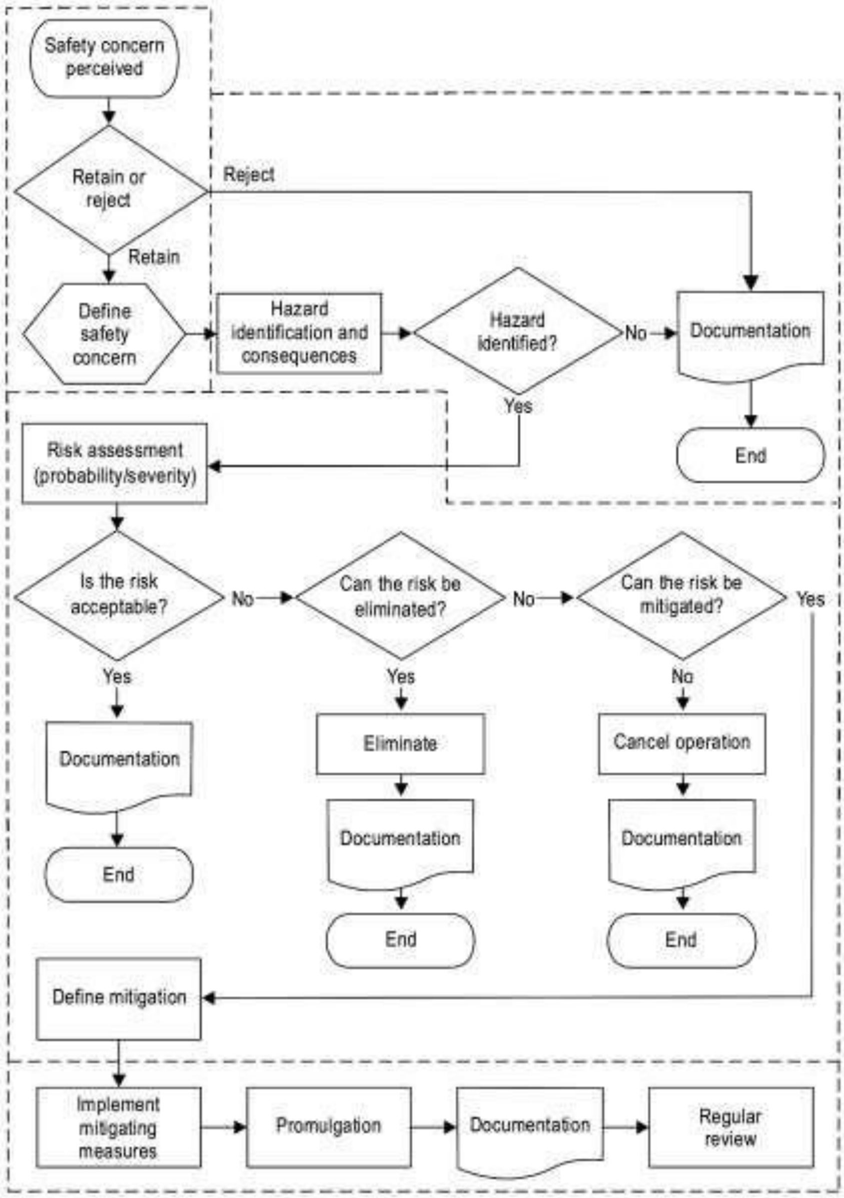

Figure 3: Flow Chart to be used for the conduct of a safety assessment

Table 1. Severity classification scheme with examples

(adapted from Doc 9859 with aerodrome-specific examples)

Severity	*Meaning*	*Value*	*Example*
Catastrophic	– Equipment destroyed – Multiple deaths	A	– collision between aircraft and/or other object during take-off or landing
Hazardous	– A large reduction in safety margins, physical distress or a workload such that the operators cannot be relied upon to perform their tasks accurately or completely – Serious injury – Major equipment damage	B	– runway incursion, significant potential for an accident, extreme action to avoid collision – attempted take-off or landing on a closed or engaged runway – take-off/landing incidents, such as undershooting or overrunning
Major	– A significant reduction in safety margins, a reduction in the ability of the operators to cope with adverse operating conditions as a result of an increase in workload or as a result of conditions impairing their efficiency – Serious incident – Injury to persons	C	– runway incursion, ample time and distance (no potential for a collision) – collision with obstacle on apron/ parking position (hard collision) – person falling down from height – missed approach with ground contact of the wing ends during the touchdown – large fuel puddle near the aircraft while passengers are on-board
Minor	- Nuisance - Operating limitations - Use of emergency procedures - Minor incident	D	- Hard braking during landing or taxiing - Damage due to jet blast (objects) - Expendables are laying around the stands - Collision between maintenance vehicles on service road - Breakage of drawbar during pushback (damage to the aircraft) - Slight excess of maximum take-off weight without safety consequences - Aircraft rolling into passenger bridge with no damage to the aircraft needing immediate repair - Forklift that is tilting - Complex taxiing instructions/ procedures

Severity	*Meaning*	*Value*	*Example*
			– forklift that is tilting – complex taxiing instructions/procedures
Negligible	– Few consequences	E	– slight increase in braking distance – temporary fencing collapsing because of strong winds – cart losing baggage

6. The probability classification includes five classes ranging from “extremely improbable” (class 1) to “frequent” (class 5) as shown in Table 2.

7. The probability classes presented in Table 2 are defined with quantitative limits. It is not the intention to assess frequencies quantitatively; the numerical value serves only to clarify the qualitative description and support a consistent expert judgement.

Table 2. Probability classification scheme

Probability class		*Meaning*
5	Frequent	Likely to occur many times (has occurred
4	Reasonably probable	Likely to occur sometimes (has occurred infrequently)
3	Remote	Unlikely to occur (has occurred rarely)
2	Extremely remote	Very unlikely to occur (not known to have
1	Extremely improbable	Almost inconceivable that the event will

8. The classification refers to the probability of events per a period of time. This is reasoned through the following:

a) many hazards at aerodromes are not directly related to aircraft movements; and

b) the assessment of hazards occurrence probabilities can be based on expert judgement without any calculations.

9. The aim of the matrix is to provide a means of obtaining a safety risk index. The index can be used to determine tolerability of the risk and to enable the prioritization of relevant actions in order to decide about risk acceptance.

10. Given that the prioritization is dependent on both probability and severity of the events, the prioritization criteria will be two-dimensional. Three main classes of hazard mitigation priority are defined in Table 3:

a) hazards with high priority — intolerable;

b) hazards with mean priority — tolerable; and
c) hazards with low priority — acceptable.

11. The risk assessment matrix has no fixed limits for tolerability but points to a floating assessment where risks are given risk priority for their risk contribution to aircraft operations. For this reason, the priority classes are intentionally not edged along the probability and severity classes in order to take into account the imprecise assessment.

Table 3. Risk assessment matrix with prioritization classes

Risk probability		*Risk severity*				
		Catastrophic **A**	Hazardous **B**	Major **C**	Minor **D**	Negligible **E**
Frequent	**5**	**5A**	**5B**	**5C**	**5D**	**5E**
Occasional	**4**	**4A**	**4B**	**4C**	**4D**	**4E**
Remote	**3**	**3A**	**3B**	**3C**	**3D**	**3E**
Improbable	**2**	**2A**	**2B**	**2C**	**2D**	**2E**
Extremely Improbable	**1**	**1A**	**1B**	**1C**	**1D**	**1E**

Table 4: Risk Assessment Matrix (Risk Index)

Risk probability		*Risk severity*				
		Catastrophic **A**	Hazardous **B**	Major **C**	Minor **D**	Negligible **E**
Frequent	**5**	**5A**	**5B**	**5C**	**5D**	**5E**
Occasional	**4**	**4A**	**4B**	**4C**	**4D**	**4E**
Remote	**3**	**3A**	**3B**	**3C**	**3D**	**3E**
Improbable	**2**	**2A**	**2B**	**2C**	**2D**	**2E**
Extremely Improbable	**1**	**1A**	**1B**	**1C**	**1D**	**1E**

Table 5: Risk Acceptability Table

Risk Index	Acceptability/Action Required
5A, 5B, 5C, 4A, 4B, 3A	STOP: Unacceptable under the existing circumstances. Do not permit any operation until sufficient control measures have been implemented to reduce risk to an acceptable level.
5D,5E, 4C, 3B, 3C, 2A, 2B	Management attention and approval of risk control/mitigation actions required.
4D, 4E, 3D, 2C, 1A, 1B	Acceptable after review of the operation
3E, 2D, 2E, 1C, 1D, 1E	Acceptable

CHAPTER 6. AERODROME COMPATIBILITY

6.1 INTRODUCTION

6.1.1 This chapter outlines a methodology and procedure to assess the compatibility between aeroplane operations and aerodrome infrastructure and operations when an aerodrome accommodates an aeroplane that exceeds the certificated characteristics of the aerodrome.

6.1.2 A compatibility study should be performed collaboratively between affected stakeholders which includes the aerodrome operator, the aeroplane operator, ground handling agencies as well as the various air navigation service providers (ANSPs).

6.1.3 The following steps describe the arrangement, to be appropriately documented, between the aeroplane operator and aerodrome operator for the introduction of an aeroplane type/subtype new to the aerodrome:

a) the aeroplane operator submits a request to the aerodrome operator to operate an aeroplane type/subtype new to the aerodrome;

b) the aerodrome operator identifies possible means of accommodating the aeroplane type/subtype including access to movement areas and, if necessary, considers the feasibility and economic viability of upgrading the aerodrome infrastructure; and

c) the aerodrome operator and aircraft operator discuss the aerodrome operator's assessment, and whether operations of the aeroplane type/subtype can be accommodated and, if permitted, under what conditions.

6.1.4 The following procedures should be included in the aerodrome compatibility study:

a) identify the aeroplane's physical and operational characteristics (see Attachments A, B and D);

b) identify the applicable regulatory requirements;

c) establish the adequacy of the aerodrome infrastructure and facilities vis-à-vis the requirements of the new aeroplane (see the appendix to this chapter);

d) identify the changes required to the aerodrome;

e) document the compatibility study; and

f) perform the required safety assessments identified during the compatibility study (see Chapter 3 on safety assessment).

Note 1.— A compatibility study may require a review of the obstacle limitation surfaces at an aerodrome as specified in Chapter 4, Annex 14, Volume I. Further guidance on the function of these surfaces is given in Doc 9137, Part 6 — Control of Obstacles*. Where required, reporting of obstacles is prescribed in Annex 4 —* Aeronautical Charts *and Annex 15 —* Aeronautical Information Services*.*

Note 2.— For aerodrome operations in low visibility conditions, additional procedures may be implemented in order to safeguard the operation of aeroplanes. Further guidance on operations in low visibility conditions are available in Doc 9137 — Airport Services Manual, *Part 8 —* Airport Operational Services*, Doc 9476 —* Manual of Surface Movement Guidance and Control Systems (SMGCS); *and Doc 9830 —* Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual*.*

Note 3.— Additional processes that ensure suitable measures are in place to protect the signal produced by the ground-based radio navigation equipment may be necessary at aerodromes with precision instrument approaches.

6.1.5 The result of the compatibility study should enable decisions to be made and should provide:

a) the aerodrome operator with the necessary information in order to make a decision on allowing the operation of the specific aeroplane at the given aerodrome;

b) the aerodrome operator with the necessary information in order to make a decision on the changes required to the aerodrome infrastructure and facilities to ensure safe operations at the aerodrome with due consideration to the harmonious future development of the aerodrome; and

c) the information which is necessary for its safety oversight and the continued monitoring of the conditions specified in the aerodrome certification.

Note 1.— Each compatibility study is specific to a particular operational context and to a particular type of aeroplane.

Note 2.— See Annex 6 — Operation of Aircraft, *Part I —* International Commercial Air Transport — Aeroplanes*, Chapter 4, regarding the obligation of the aeroplane operator.*

Note 3.— Information resulting from the compatibility study that is considered to be of operational significance is published in accordance with Annex 14, Volume I, 2.13.1, and Annex 15.

CHAPTER 7. IMPACT OF AEROPLANE CHARACTERISTICS ON THE AERODROME INFRASTRUCTURE

7.1 GENERAL

7.1.1 Introducing new types of aeroplanes into existing aerodromes may have an impact on the aerodrome facilities and services, in particular, when the aeroplane characteristics exceed the parameters that were used for planning the aerodrome.

7.1.2 The parameters used in aerodrome planning are defined in Annex 14, Volume I, which specifies the use of the aerodrome reference code determined in accordance with the characteristics of the aeroplane for which an aerodrome facility is intended. The aerodrome reference code provides a starting point for the compatibility study and may not be the sole means used to conduct the analysis and to substantiate the aerodrome operator’s decisions and the State’s safety oversight actions.

Note.— The individual facilities required at an aerodrome are interrelated by the aerodrome reference code. The design of these facilities, including a description of the aerodrome reference code, can be found in Annex 14, Volume I, and are transposed by States into national regulations.

7.2 CONSIDERATION OF THE AEROPLANE’S PHYSICAL CHARACTERISTICS

The aeroplane’s physical characteristics may influence the aerodrome dimensions, facilities and services in the movement area. These characteristics are detailed in Attachment A to this chapter.

7.3 CONSIDERATION OF THE AEROPLANE’S OPERATIONAL CHARACTERISTICS

In order to adequately assess aerodrome compatibility, aeroplane operational characteristics should be included in the evaluation process. The operational characteristics can include the infrastructure requirements of the aeroplane as well as ground servicing requirements. These characteristics are detailed in this guidance.

7.4 PHYSICAL CHARACTERISTICS OF AERODROMES

In order to adequately assess the aeroplane’s compatibility, aerodrome physical characteristics should be included in the evaluation process. These characteristics are detailed in Chapter 8 of this guidance.

CHAPTER 8. PHYSICAL CHARACTERISTICS OF AERODROMES

8.1 INTRODUCTION

Each paragraph within this section is structured as follows:

Introduction

This section provides the rationale, including the basis and objectives for the various elements of the physical infrastructure required in the GCAD Part 14, and references are made, where necessary, to other ICAO documents.

Challenges

This section identifies possible challenges based on experience, operational judgement and analysis of hazards linked to an infrastructure item in relation to ICAO provisions. Each compatibility study should determine the challenges relevant for the accommodation of the planned aeroplane at the existing aerodrome.

Potential solutions

This section presents possible solutions related to the identified problems. Where it is impracticable to adapt the existing aerodrome infrastructure or operations in accordance with the aerodrome Directive, the compatibility study or, where necessary, safety assessment, determines the appropriate solutions or possible risk mitigation measures to be implemented.

Note 1.— Where possible solutions have been developed, these should be reviewed periodically to assess their continued validity. These possible solutions do not substitute or circumvent the provisions contained in the GCAD Part 14.

Note 2.— Procedures on the conduct of a safety assessment can be found in this document.

8.2 RUNWAYS

8.2.1 Runway length

Note 1.— Runway length is a limiting factor on aeroplane operations and should be assessed in collaboration with the aeroplane operator. Information on aeroplane reference field length can be found in Attachment D.

Note 2.— Longitudinal slopes can have an effect on aeroplane performance.

8.2.2 Runway width

Introduction

8.2.2.1 For a given runway width, factors affecting aeroplane operations include the characteristics, handling qualities and performance demonstrated by the aeroplane. It may be advisable to consider other factors of operational significance in order to have a safety margin for factors such as wet or contaminated runway pavement, crosswind conditions, crab angle approaches to landing, aeroplane controllability during aborted take-off, and engine failure procedures.

Note.— Guidance is given in Doc 9157, Part 1 — Runways*.*

Challenges

8.2.2.2 The main issue associated with available runway width is the risk of aeroplane damage and fatalities associated with an aeroplane veering off the runway during take-off, rejected take-off or during the landing.

8.2.2.3 The main causes and accident factors are:

a) for take-off/rejected take-off:

1) aeroplane (asymmetric spin-up and/or reverse thrust, malfunctioning of control surfaces, hydraulic system, tires, brakes, nose-gear steering, centre of gravity and powerplant (engine failure, foreign object ingestion));

2) temporary surface conditions (standing water, dust, residuals (rubber), FOD, damage to the pavement and runway friction coefficient);

3) permanent surface conditions (horizontal and vertical slopes and runway friction characteristics);

4) meteorological conditions (e.g. heavy rain, crosswind, strong/gusty winds, reduced visibility); and

5) Human Factors (crew, maintenance, balance, payload security);

b) for landing:

1) aeroplane/airframe (malfunction of the landing gear, control surfaces, hydraulic system, brakes, tires, nose- gear steering and powerplant (reverse and thrust lever linkage));

2) temporary surface conditions (standing water, dust, residuals (e.g. rubber), FOD, damage to the pavement and applying runway friction coefficient);

3) permanent surface conditions (horizontal and vertical slopes and runway friction characteristics);

4) prevailing meteorological conditions (heavy rain, crosswind, strong/gusty winds, thunderstorms/wind shear, reduced visibility);

5) Human Factors (i.e. hard landings, crew, maintenance);

6) ILS localizer signal quality/interference, where autoland procedures are used;

7) any other localizer signal quality/interference of approach aid equipment;

8) lack of approach path guidance such as VASIS or PAPI; and

9) approach type and speed.

Note.— An analysis of lateral runway excursion reports shows that the causal factor in aeroplane accidents/incidents is not the same for take-off and landing. Mechanical failure is, for instance, a frequent accident factor for runway excursions during take-off, while hazardous meteorological conditions such as thunderstorms are more often associated with landing accidents/incidents. Engine reverse thrust system malfunction and/or contaminated runway surfaces have also been a factor in a significant number of veer-offs during landing (other subjects are relevant to the aeroplane such as brake failures and high crosswinds).

Potential solutions

8.2.2.4 The lateral runway excursion is linked to specific aeroplane characteristics, performance/handling qualities, controllability in response to such events as aeroplane mechanical failures, pavement contamination, winter operations and crosswind conditions. Runway width is not a required specific certification limitation. However, indirectly related is the determination of minimum control speed on the ground (Vmcg) and the maximum demonstrated crosswind. These additional factors should be considered as key factors in order to ensure that this kind of hazard is adequately addressed.

8.2.2.5 For a specific aeroplane, it may be permissible to operate on a runway with a narrower width if approved by the appropriate authorities for such operations.

Note.— The maximum demonstrated crosswind is included in the aircraft flight manual.

8.2.2.6 Potential solutions can be developed by applying the following measures, alone or in combination with other measures. The following list is not in any particular order and is not exhaustive:

a) paved inner shoulders of adequate bearing strength to provide an overall width of the runway and its (inner) shoulders of the recommended runway width according to the reference code;

b) paved/unpaved outer shoulders with adequate bearing strength to provide an overall width of the runway and its shoulder according to the reference code;

c) additional runway centre line guidance and runway edge markings; and

d) increased full runway length FOD inspection, when required or requested.

8.2.2.7 Aerodrome operators should also take into account the possibility that certain aeroplanes are not able to make a 180-degree turn on narrower runways. When there is no proper taxiway at the end of the runway, providing a suitable runway turn pad is recommended.

Note.— Particular care should be given while manoeuvring on runways having a width less than recommended to prevent the wheels of the aeroplane from leaving the pavement, while avoiding the use of large amounts of thrust that could damage runway lights and signs and cause erosion of the runway strip. For affected runways a close inspection, as appropriate, is generally considered to detect the presence of debris that may be deposited during 180-degree turns on the runway after landing.

Note.— Guidance is given in Doc 9137, Part 2 — Pavement Surface Conditions.

8.2.2.8 Aerodromes which use embedded (inset) runway edge lights should take into account additional consequences such as:

a) more frequent cleaning intervals for the embedded lights, as dirt will affect the function more quickly compared to elevated runway edge lights; and

b) in addition, bi-directional inset lights can facilitate dust removal procedures on a wider range.

8.2.2.9 Location and specifications for runway signs should be considered due to the increased size of the aeroplane's wingspan (engine location) as well as the increased thrust rating from the aeroplane's engines.

8.3 RUNWAY SHOULDERS

introduction

8.3.1.1 The shoulders of a runway should be capable of minimizing any damage to an aeroplane veering off the runway. In some cases, the bearing strength of the natural ground may be sufficient without additional preparation to meet the requirements for shoulders. The prevention of ingestion of objects from jet engines should always be taken into account particularly for the design and construction of the shoulders. In case of specific preparation of the shoulders, visual contrast, such as the use of runway side-stripe markings, between runway and runway shoulders, may be required.

Note.— Guidance is given in Doc 9157, Part 1.

Challenges

8.2.3.2 Runway shoulders have three main functions:

a) to minimize any damage to an aeroplane running off the runway ;

b) to provide jet blast protection and to prevent engine FOD ingestion; and

c) to support ground vehicle traffic, RFF vehicles and maintenance vehicles.

Note.— Inadequate width of existing runway bridges is a special topic that needs careful evaluation.

8.2.3.3 Potential issues associated with runway shoulder characteristics (width, soil type, bearing strength) are:

a) aeroplane damage that could occur after excursion onto the runway shoulder due to inadequate bearing capacity;

b) shoulder erosion causing ingestion of foreign objects by jet engines due to unsealed surfaces; consideration should be given to the impact of FOD on aeroplane tires and engines as a potentially major hazard; and

c) difficulties for RFF services to access a damaged aeroplane on the runway due to inadequate bearing strength.

8.2.3.4 Factors to be considered are:

a) runway centre line deviations;

b) powerplant characteristics (engine height, location and power); and

c) soil type and bearing strength (aeroplane mass, tire pressure, gear design).

Potential solutions

8.2.3.5 Possible solutions can be developed by applying the following measures, alone or in combination with other measures. The following list is not in any particular order and is not exhaustive:

a) *Excursion onto the runway shoulder*. Provide the suitable shoulder as detailed in section 2.3;

b) *Jet blast*. Information about outer engine position, jet blast velocity contour and jet blast directions at take-off is needed to calculate the required width of shoulders that has to be enhanced for protection against jet blast. Lateral deviation from the runway centre line should also be taken into account;

Note 1.— Jet blast velocity data may be available from the aircraft manufacturers.

Note 2.— Relevant information is typically available in the aircraft characteristics for airport planning manual of aircraft manufacturers.

c) *RFF vehicles*. Operational experience with aeroplanes currently operated on existing runways suggests that an overall width of the runway and its shoulders which is compliant with the requirements is adequate to permit intervention on aeroplanes by occasional RFF vehicle traffic. However, longer upper-deck escape chutes may reduce the margin between the shoulder edge and the extension of escape slides and reduce the supporting surface available to rescue vehicles; and

d) *Additional surface inspections*. It may be necessary to adapt the inspection programme for FOD detection.

8.4 RUNWAY TURN PADS

Introduction

8.4.1 Turn pads are generally provided when an exit taxiway is not available at the runway end. A turn pad allows an aeroplane to turn back after landing and before take-off and to position itself correctly on the runway.

Note.— Guidance on typical turn pads is given in Doc 9157, Part 1, Appendix 4. In particular, the design of the total width of the turn pad should be such that the nose-wheel steering angle of the aeroplane for which the turn pad is intended will not exceed 45 degrees.

Challenges

8.4.2 For minimizing the risk of a turn pad excursion, the turn pad should be designed sufficiently wide to permit the 180-degree turn of the most demanding aeroplane that will be operated. The design of the turn pad generally assumes a maximum nose landing gear steering angle of 45 degrees, which should be used unless some other condition applies for the particular type of aeroplane, and considers clearances between the gears and the turn pad edge, as for a taxiway.

8.4.3 The main causes and accident factors of the aeroplane veering off the turn pad pavement are:

a) aeroplane characteristics that are not adequate and aeroplane failure (ground manoeuvring capabilities, especially long aeroplanes, malfunctioning of nose-gear steering, engine, brakes);

b) adverse surface conditions (standing water, loss of control on ice-covered surfaces, friction coefficient);

c) loss of the turn pad visual guidance (markings and lights covered by dust or inadequately maintained); and

d) Human Factors, including incorrect application of the 180-degree procedure (nose-wheel steering, asymmetric thrust, differential breaking).

Note.— No turn pad excursions with passenger injuries have so far been reported. Nevertheless, an aeroplane disabled on a turn pad can have an impact on runway closure.

Potential solutions

8.4.4 The ground maneuvering capabilities available from aircraft manufacturers are one of the key factors to be considered in order to determine whether an existing turn pad is suitable for a particular aeroplane. The speed of the manoeuvring aeroplane is also a factor.

Note.— Relevant information is typically available in the aircraft characteristics for airport planning manual of aircraft manufacturers.

2.4.5 For a specific aeroplane, it may be permissible to operate on a runway turn pad not provided in accordance with Annex 14, Volume I, specifications, considering:

a) the specific ground manoeuvring capability of the specific aeroplane (notably the maximum effective steering angle of the nose landing gear);

b) the provision for adequate clearances;

c) the provision for appropriate marking and lighting;

d) the provision of shoulders;

e) the protection from jet blast; and

f) if relevant, protection of the ILS.

In this case, the turn pad can have a different shape. The objective is to enable the aeroplane to align on the runway while losing the least runway length as possible. The aeroplane is supposed to taxi at slow speed.

Note.— Further advisory material on turn pads may be available from the aircraft manufacturers.

8.5 RUNWAY STRIPS

8.5.1 Runway Strip Dimensions

Introduction

8.5.1.1 A runway strip is an area enclosing a runway and any associated stopway. Its purpose is to:

a) reduce the risk of damage to an aeroplane running off the runway by providing a cleared and graded area which meets specific longitudinal and transverse slopes, and bearing strength requirements; and

b) protect an aeroplane flying over it during landing, balked landing or take-off by providing an area which is cleared of obstacles, except for permitted aids to air navigation.

8.5.1.2 Particularly, the graded portion of the runway strip is provided to minimize the damage to an aeroplane in the event of a veer-off during a landing or take-off operation. It is for this reason that objects should be located away from this portion of the runway strip unless they are needed for air navigation purposes and are frangibly mounted.

Note.— The dimensions and characteristics of the runway strip are detailed in Annex 14, Volume I, Chapter 3, 3.4, and Attachment A.

Challenges

8.5.1.3 Where the requirements on runway strips cannot be achieved, the available distances, the nature and location of any hazard beyond the available runway strip, the type of aeroplane and the level of traffic at the aerodrome should be reviewed. Operational restrictions may be applied to the type of approach and low visibility operations that fit the available ground dimensions, while also taking into account:

a) runway excursion history;

b) friction and drainage characteristics of the runway;

c) runway width, length and transverse slopes;

d) navigation and visual aids available;

e) relevance in respect of take-off or aborted take-off and landing;

f) scope for procedural mitigation

measures; and g) accident report.

8.5.1.4 An analysis of lateral runway excursion reports shows that the causal factor in aeroplane accidents/incidents is not the same for take-off and for landing Therefore, take-off and landing events may need to be considered separately.

Note.— Mechanical failure is a frequent accident factor in runway excursions during take-off, while hazardous meteorological conditions such as thunderstorms are more often present with landing accident/incidents. Brake failures or engine reverse thrust system malfunctions have also been factors in a significant number of landing veer- offs.

8.5.1.5 Lateral deviation from the runway centre line during a balked landing with the use of the digital autopilot as well as manual flight with a flight director for guidance have shown that the risk associated with the deviation of specific aeroplanes is contained within the OFZ.

Note.— Provisions on OFZ are given in Annex 14, Volume I, and in Cir 301, New Larger Aeroplanes — Infringement of the Obstacle Free Zone: Operational Measures and Aeronautical Study.

8.5.1.6 The lateral runway excursion hazard is clearly linked to specific aeroplane characteristics, performance/ handling qualities and controllability in response to such events as aeroplane mechanical failures, pavement contamination and crosswind conditions. This type of hazard comes under the category for which risk assessment is mainly based on flight crew/aeroplane performance and handling qualities. Certified limitations of the specific aeroplane is one of the key factors to be considered in order to ensure that this hazard is under control.

Potential solutions

8.5.1.7 Potential solutions can be developed by applying the following measures, alone or in combination with other measures. The following list is not in any particular order and is not exhaustive:

a) improving runway surface conditions and/or the means of recording and indicating rectification action, particularly for contaminated runways, having knowledge of runways and their condition and characteristics in precipitation;

b) ensuring that accurate and up-to-date meteorological information is available and that information on runway conditions and characteristics is passed to flight crews in a timely manner, particularly when flight crews need to make operational adjustments;

c) improving the aerodrome operator's knowledge of recording, prediction and dissemination of wind data, including wind shear, and any other relevant meteorological information, particularly when it is a significant feature of an aerodrome's climatology;

d) upgrading the visual and instrument landing aids to improve the accuracy of aeroplane delivery at the correct landing position on runways; and

e) in consultation with aeroplane operators, formulating any other relevant aerodrome operating procedures or restrictions and promulgating such information appropriately.

8.6 OBSTACLES ON RUNWAY STRIPS

Introduction

8.6.1 An object located on a runway strip which may endanger aeroplanes is regarded as an obstacle, according to the definition of "obstacle" and should be removed, as far as practicable. Obstacles may be either naturally occurring or deliberately provided for the purpose of air navigation.

Challenges

8.6.1.2 An obstacle on the runway strip may represent either:

a) a collision risk for an aeroplane in flight or for an aeroplane on the ground that has veered off the runway; and

b) a source of interference to navigation aids.

Note 1.— Mobile objects that are beyond the OFZ (inner transitional surface) but still within the runway strip, such as vehicles and holding aeroplanes at runway-holding positions, or wing tips of aeroplanes taxiing on a parallel taxiway to the runway, should be considered.

Note 2.— Provisions on OFZ are given in Annex 14, Volume I, and in Circular 301. Potential

solutions

8.6.1.2 Potential solutions can be developed by applying the following measures, alone or in combination with other measures. The following list is not in any particular order and is not exhaustive:

a) a natural obstacle should be removed or reduced in size wherever possible; alternatively, grading of the area allows reduction of the severity of damage to the aeroplane;

b) other fixed obstacles should be removed unless they are necessary for air navigation, in which case they should be frangible and should be so constructed as to minimize the severity of damage to the aeroplane;

c) an aeroplane considered to be a moving obstacle within the runway strip should respect the requirement on the sensitive areas installed to protect the integrity of the ILS and should be subject to a separate safety assessment; and

Note.— Provisions on ILS critical and sensitive areas are given in Annex 10 — Aeronautical Telecommunications*, Volume I* — Radio Navigation Aids*.*

d) visual and instrument landing aids may be upgraded to improve the accuracy of aeroplane delivery at the correct landing position on runways, and in consultation with aeroplane operators, any other relevant aerodrome operating procedures or restrictions may be formulated and such information promulgated appropriately.

8.7 RUNWAY END SAFETY AREA (RESA)

Introduction

8.7.1 A RESA is primarily intended to reduce the risk of damage to an aeroplane undershooting or overrunning the runway. Consequently, a RESA will enable an aeroplane overrunning to decelerate, and an aeroplane undershooting to continue its landing.

Challenges

8.7.2 Identification of specific issues related to runway overruns and undershoots is complex. There are a number of variables that have to be taken into account, such as prevailing meteorological conditions, the type of aeroplane, the load factor, the available landing aids, runway characteristics, the overall environment, as well as Human Factors.

8.7.3 When reviewing the RESA, the following aspects have to be taken into account:

a) the nature and location of any hazard beyond the runway end;

b) the topography and obstruction environment beyond the RESA;

c) the type of aeroplanes and level of traffic at the aerodrome and actual or proposed changes to either;

d) overrun/undershoot causal factors;

e) friction and drainage characteristics of the runway which have an impact on runway susceptibility to surface contamination and aeroplane braking action;

f) navigation and visual aids available;

g) type of approach;

h) runway length and slope, in particular, the general operating length required for take-off and landing versus the runway distances available, including the excess of available length over that required;

i) the location of the taxiways and runways;

j) aerodrome climatology, including predominant wind speed and direction and

likelihood of wind shear; and k) aerodrome overrun/undershoot and veer-off history.

Potential solutions

8.6.3. Potential solutions can be developed by applying the following measures, alone or in combination with other measures. The following list is not in any particular order and is not exhaustive:

a) restricting the operations during adverse hazardous meteorological conditions (such as thunderstorms);

b) defining, in cooperation with aeroplane operators, hazardous meteorological conditions and other factors relevant to aerodrome operating procedures and publishing such information appropriately;

c) improving an aerodrome's database of operational data, detection of wind data, including wind shear and other relevant meteorological information, particularly when it is a significant change from an aerodrome's climatology;

d) ensuring that accurate and up-to-date meteorological information, current runway conditions and other characteristics are detected and notified to flight crews in time, particularly when flight crews need to make operational adjustments;

e) improving runway surfaces in a timely manner and/or the means of recording and indicating necessary action for runway improvement and maintenance (e.g. friction measurement and drainage system), particularly when the runway is contaminated;

f) removing rubber build-up on runways according to a scheduled time frame;

g) repainting faded runway markings and replacing inoperative runway surface lighting identified during daily runway inspections;

h) upgrading visual and instrument landing aids to improve the accuracy of aeroplane delivery at the correct landing position on runways (including the provision of ILSs);

i) reducing declared runway distances in order to provide the necessary RESA;

j) installing suitably positioned and designed arresting systems as a supplement or as an alternative to standard RESA dimensions when necessary (see Note 1);

k) increasing the length of a RESA and/or minimizing the potential obstruction in the area

beyond the RESA; and l) publishing provisions, including the provision of an arresting

system, in the AIP.

Note 1.— Further guidance on arresting systems can be found in Annex 14, Volume I, Attachment A.

Note 2.— In addition to the AIP entry, information/instructions may be disseminated to local runway safety teams and others to promote awareness in the community.

8.7 TAXIWAYS

Introduction

8.7.1 Taxiways are provided to permit the safe and expeditious surface movement of aeroplanes.

8.7.1.2 A sufficiently wide taxiway permits smooth traffic flow while facilitating aeroplane ground steering.

Note 1.— Guidance material is given in Doc 9157, Part 2 — Taxiways, Aprons and Holding Bays*; Section 1.2 and Table 1-1 provide the formula for determining the width of a taxiway.*

Note 2.— Particular care should be taken while manoeuvring on taxiways having a width less than that specified in Annex 14, Volume I, to prevent the wheels of the aeroplane from leaving the pavement, while avoiding the use of large amounts of thrust that could damage taxiway lights and signs and cause erosion of the taxiway strip. Affected taxiways should be closely inspected, as appropriate, for the presence of debris that may be deposited while taxiing into position for take-off.

Challenges

8.7.1.3 The issue arises from a lateral taxiway excursion.

8.7.1.4 Causes and accident factors can include:

a) mechanical failure (hydraulic system, brakes, nose-gear steering);

b) adverse surface conditions (standing water, loss of control on ice-covered surfaces, friction coefficient);

c) loss of the taxiway centre line visual guidance (markings and lights covered by dust or inadequately maintained);

d) Human Factors (including directional control, orientation error, pre departure workload);

and

e) aeroplane taxi speed.

Note.— The consequences of a taxiway excursion are potentially disruptive. However, consideration should be given to the greater potential impact of deviation of a larger aeroplane in terms of blocked taxiways or disabled aeroplane removal.

8.7.1.5 Pilot precision and attention are key issues since they are heavily related to the margin between the outer main gear wheel and the taxiway edge.

8.7.1.6 Compatibility studies related to taxiway width and potential deviations can include:

a) the use of taxiway deviation statistics to calculate the taxiway excursion probability of an aeroplane depending on taxiway width. The impact of taxiway guidance systems and meteorological and surface conditions on taxiway excursion probability should be assessed whenever possible;

b) view of the taxiway from the cockpit, taking into account the visual reference cockpit cut-off angle and pilot eye height; and

c) the aeroplane outer main gear wheel span.

Potential solutions

8.7.1.7 Potential solutions can be developed by applying the following measures, alone or in combination with other measures. The following list is not in any particular order and is not exhaustive:

a) the provision of taxiway centre line lights;

b) conspicuous centre line marking;

c) the provision of on-board taxi camera systems to assist taxi guidance;

d) reduced taxi speed;

e) the provision of taxi side-stripe markings;

f) taxiway edge lights (inset or elevated);

g) reduced wheel-to-edge clearance, using taxiway deviation data;

h) the use of alternative taxi routes; and

i) the use of marshaller services (follow-me guidance).

Note 1.— Taxi cameras are designed to ease the taxi and can assist the flight crew in preventing the wheels of the aeroplane from leaving the full-strength pavement during normal ground manoeuvring.

Note 2.— Taxiways that are not provided with suitable shoulders may be restricted in operation.

8.7.1.8 Special attention should be given to the offset of centre line lights in relation to centre line markings, especially during winter conditions when distinguishing between markings and offset lights can be difficult.

8.7.1.9 Location and specifications for taxiway signs should be considered due to the engine location as well as the increased thrust in the aeroplane engines.

8.8 TAXIWAY CURVES

8.8.1. Introduction

8.8.1.1 Annex 14, Volume I, 3.9.6, contains provisions on taxiway curves. Additional guidance is included in Doc 9157, Part 2.

Challenges

8.8.1.2 Any hazard will be the result of a lateral taxiway excursion on a curved section.

8.8.1.3 The main causes and accident factors are the same as for a taxiway excursion on a straight taxiway section. The use of the cockpit-over-centreline steering technique on a curved taxiway will result in track-in of the main landing gear from the centre line. The amount of track-in depends on the radius of the curved taxiway and the distance from the cockpit to the main landing gear.

8.8.1.4 The consequences are the same as for lateral taxiway excursions on straight sections.

8.8.1.5 The required width of the curved portions of taxiways is related to the clearance between the outer main wheel and the taxiway edge on the inner curve. The hazard is related to the combination of the outer main gear wheel span and the distance between the nose gear/cockpit and the main gear. Consideration should be given to the effect on airfield signs and other objects nearby of jet blast from a turning aeroplane.

8.8.1.6 Certain aeroplanes may require wider fillets on curved sections or taxiway junctions.

Potential solutions

8.8.1.7 Potential solutions can be developed by applying the following measures, alone or in combination with other measures. The following list is not in any particular order and is not exhaustive:

a) the widening of existing fillets or the provision of new fillets;

b) reduced taxi speed;

c) the provision of taxiway centre line lights and taxi side-stripe markings (and inset taxiway edge lights);

d) reduced wheel-to-edge clearance, using taxiway deviation data;

e) pilot judgemental oversteering; and

f) publication of provisions in the appropriate aeronautical documentation.

Note 1.— Taxi cameras are designed to ease the taxi and can assist the flight crew in preventing the wheels of the aeroplane from leaving the full-strength pavement during normal ground manoeuvring.

Note 2.— Operations on taxiway curves that are not provided with suitable taxiway fillets should be restricted.

8.8.1.8 Special attention should be given to the offset of centre line lights in relation to centre line markings.

8.8.1.9 Location and specifications for taxiway signs should be considered due to the increase in the size of aeroplanes as well as the increased thrust in aeroplane engines.

8.9 RUNWAY AND TAXIWAY MINIMUM SEPARATION DISTANCES

8.9.1 Introduction

8.9.1.1 A minimum distance is provided between the centre line of a runway and the centre line of the associated parallel taxiway for instrument runways and non-instrument runways.

Note 1.— Doc 9157, Part 2, section 1.2, and Table 1-5, clarify that the runway/taxiway separation is based on the principle that the wing tip of an aeroplane taxiing on a parallel taxiway should be clear of the runway strip.

Note 2.— It is permissible to operate with lower separation distances at an existing aerodrome if a safety assessment indicates that such lower separation distances would not adversely affect the safety or significantly affect the regularity of operations of aeroplanes. See Note 2 to Table 3-1, and Notes 2, 3 and 4 to 3.9.8 of Annex 14, Volume I.

Note 3.— Doc 9157, Part 2, has related guidance in 1.2.46 to 1.2.49. Furthermore, attention is drawn to the need to provide adequate clearance at an existing aerodrome in order to operate an aeroplane with the minimum possible risk.

Challenges

8.9.1.2 The potential issues associated with runway/parallel taxiway separation distances are:

a) the possible collision between an aeroplane running off a taxiway and an object (fixed or mobile) on the aerodrome;

b) the possible collision between an aeroplane leaving the runway and an object (fixed or mobile) on the aerodrome or the risk of a collision of an aeroplane on the taxiway that infringes on the runway strip; and

c) possible ILS signal interference due to a taxiing or stopped aeroplane.

8.9.1.3 Causes and accident factors can include:

a) Human Factors (crew, ATS);

b) hazardous meteorological conditions (such as thunderstorms and wind shear);

c) aeroplane mechanical failure (such as engine, hydraulic system, flight instruments, control surfaces and autopilot);

d) surface conditions (standing water, loss of control on ice-covered surfaces, friction coefficient);

e) lateral veer-off distance;

f) aeroplane position relative to navigation aids, especially ILS; and g) aeroplane size and

characteristics (especially wingspan).

Note.— Common accident/incident databases deal with lateral runway excursions but do not include accident reports relative to in-flight collisions and ILS signal interference. Therefore, the causes and accident factors specific to the local environment and identified above for runway separation issues are mainly supported by local aerodrome experience. The huge variety and complexity of accident factors for collision risk should be emphasized.

Potential solutions

8.9.1.4 Potential solutions can be developed by applying the following measures, alone or in combination with other measures. The following list is not in any particular order and is not exhaustive:

a) place a restriction on the wingspan of aeroplanes using the parallel taxiway or on the runway, if continued unrestricted taxiway or runway operation is desired;

b) consider the most demanding length of aeroplane that can have an impact on runway/taxiway separation and the location of holding positions (ILS);

c) change taxiway routing so that the required runway airspace is free of

taxiing aeroplanes; and d) employ tactical control of aerodrome movements.

Note.— When A-SMGCS is available, it can be utilized as a supporting means to the proposed solutions especially in low visibility conditions.

8.10 TAXIWAY AND TAXILANE MINIMUM SEPARATION DISTANCES

Introduction

Taxiway to object separation

8.10.1 The taxiway minimum separation distances provide an area clear of objects that may endanger an aeroplane.

Note 1.— See Annex 14, Volume I, 3.9.

Note 2.— Additional guidance material on minimum separation distances is included in Doc 9157, Part 2.

Parallel taxiway separation

8.10.2 The minimum separation distance is equal to the wingspan plus maximum lateral deviation plus increment.

Note 1.— Information is given in Doc 9157, Part 2.

Note 2.— If the minimum required distance between the centre lines of two parallel taxiways is not provided, it is permissible to operate with lower separation distances at an existing aerodrome if a compatibility study, which may include a safety assessment, indicates that such lower separation distances would not adversely affect the safety or significantly affect the regularity of aeroplane operations.

Challenges

Taxiway to object separation

8.10.3 The separation distances during taxiing are intended to minimize the risk of a collision between an aeroplane and an object (taxiway/object separation, taxilane/object separation).

Note.— Taxiway deviation statistics can be used to assess the risk of a collision between two aeroplanes or between an aeroplane and an object.

8.10.4 The causes and accident factors can include:

a) mechanical failure (hydraulic system, brakes, nose-gear steering);

b) conditions (standing water, loss of control on ice-covered surfaces, friction coefficient);

c) loss of the visual taxiway guidance system (markings and lights covered by dust); and

d) Human Factors (directional control, temporary loss of orientation resulting in aeroplanes being incorrectly positioned, etc.).

Parallel taxiway separation

8.10.5 The potential issues associated with parallel taxiway separation distances are:

a) the probable collision between an aeroplane running off a taxiway and an object (aeroplane on parallel taxiway); and

b) an aeroplane running off the taxiway and infringing the opposite taxiway strip.

8.10.6 Causes and accident factors can include:

a) Human Factors (crew, ATS);

b) hazardous meteorological conditions (such as reduced visibility);

c) aeroplane mechanical failure (such as engine, hydraulic system, flight instruments, control surfaces, autopilot);

d) surface conditions (standing water, loss of control on ice-covered surfaces, friction coefficient);

e) lateral veer-off distance; and

f) aeroplane size and characteristics (especially wingspan).

Potential solutions

Taxiway to object separation

8.10.7 Potential solutions can be developed by applying the following measures, alone or in combination with other measures. The following list is not in any particular order and is not exhaustive:

a) the use of reduced taxiing speed;

b) the provision of taxiway centre line lights;

c) the provision of taxi side-stripe markings (and inset taxiway edge lights);

d) the provision of special taxi routing for larger aeroplanes;

e) restrictions on aeroplanes (wingspan) allowed to use parallel taxiways during the operation of a specific aeroplane;

f) restrictions on vehicles using service roads adjacent to a designated aeroplane taxi route;

g) the use of “follow-me” guidance;

h) the provision of reduced spacing between taxiway centre line lights; and

i) the provision of straightforward taxiway naming and ground routings with respect to the hazard of taxiway veer-offs.

Note.— Special attention should be given to the offset of centre line lights in relation to centre line markings. Especially during winter conditions, distinguishing between markings and offset lights can be difficult.

Parallel taxiway separation

8.10.8 Potential solutions can be developed by providing the following facilities, alone or in combination with other measures. The following list is not in any particular order and is not exhaustive:

a) place a restriction on the wingspan of aeroplanes using the parallel taxiway if continued unrestricted taxiway operation is desired;

b) consider the most demanding length of aeroplane that can have an impact on a curved taxiway section;

c) change taxiway routing;

d) employ tactical control of aerodrome movements;

d) use of reduced taxiing speed;

f) provision of taxiway centre line lights;

g) provision of taxi side-stripe markings (and inset taxiway edge lights);

h) use of “follow-me” guidance;

i) provision of reduced spacing between taxiway centre line lights; and

j) provision of straightforward taxiway naming and ground routings with respect to the hazard of taxiway veer- offs.

Note.— When A-SMGCS is available, it can be utilized as a supporting means to the proposed solutions especially in low visibility conditions.

CHAPTER 9

9. TAXIWAYS ON BRIDGES

Introduction

9.1 The width of that portion of a taxiway bridge capable of supporting aeroplanes, as measured perpendicularly to the taxiway centre line, is normally not less than the width of the graded area of the strip provided for that taxiway, unless a proven method of lateral restraint is provided which is not hazardous for aeroplanes for which the taxiway is intended.

Note.— Annex 14, Volume I, section 3.9, and Doc 9157, Part 2, provide information on taxiways on bridges.

9.2 Access is to be provided for RFF vehicles to intervene, in both directions within the specified response time, with the largest aeroplane for which the taxiway is intended.

9.3 If aeroplane engines overhang the bridge structure, it may be necessary to protect the adjacent areas, below the bridge, from engine blast.

Challenges

9.4 The following hazards are related to the width of taxiway bridges:

a) landing gear leaving the load-bearing surface;

b) deployment of an escape slide beyond the bridge, in case of an emergency evacuation;

c) lack of manoeuvring space for RFF vehicles around the aeroplane;

d) jet blast to vehicles, objects or personnel below the bridge;

e) structural damage to the bridge due to the aeroplane mass exceeding the bridge design load; and

f) damage to the aeroplane due to insufficient clearance of engines, wings or fuselage from bridge rails, lights or signs.

9.5 The causes and accident factors can include:

a) mechanical failure (hydraulic system, brakes, nose-gear steering);

b) surface conditions (standing water, loss of control on ice-covered surfaces, friction coefficient);

c) loss of the visual taxiway guidance system (markings and lights covered by dust);

d) Human Factors (directional control, disorientation, pilot's workload);

e) the position of the extremity of the escape slides; and

f) undercarriage design.

9.6 The main causes of and accident factors for jet blast effect below the bridge are:

a) powerplant characteristics (engine height, location and power);

b) bridge blast protection width; and

c) taxiway centre line deviation factors (see taxiway excursion hazard in 4.1.4).

9.7 In addition to the specifications of Chapter 3, Safety Assessments for Aerodromes, hazard prevention mechanisms should be based on the critical dimensions of the aeroplane in relation to the bridge width.

Potential solutions

9.8 Potential solutions can be developed by applying the following measures, alone or in combination with other measures. The following list is not in any particular order and is not exhaustive:

a) where feasible, strengthen existing bridges;

b) provide a proven method of lateral restraint to prevent the aeroplane from veering off the full bearing strength of the taxiway bridge;

c) provide an alternative path/bridge for RFF vehicles or implement emergency procedures to taxi the aeroplane away from such taxi bridges;

d) implement jet blast procedures to reduce the effects of jet blast on the undercroft; and

e) use the vertical clearance provided by high wings.

9.9 The RFF vehicles need to have access to both sides of the aeroplane to fight any fire from the best position, allowing for wind direction as necessary. In case the wingspan of the considered aeroplane exceeds the width of the bridge, another bridge nearby can be used for access to the “other” side of an aeroplane rather than an increased bridge width; in this case the surface of the bypass routes are at least stabilized where it is unpaved.

Note.— The use of another bridge as mentioned in 7.9 is practicable only where bridges are paired (parallel taxiways) or when there is a service road in the surrounding area. In any case, the bridge strength is to be checked, depending on the aeroplane planning to use it.

9.10 The protection from jet blast of vehicular traffic under/near the bridge is to be studied, consistent with the overall width of the taxiway and its shoulders.

9.11 The bridge width should be compatible with the deployment of escape slides. If this is not the case, a safe and quick escape route should be ensured.

Note.— Curved centre lines should be avoided leading up to, on and when leaving the bridge.

CHAPTER 10

10. TAXIWAY SHOULDERS

Introduction

10.1 Taxiway shoulders are intended to protect an aeroplane operating on the taxiway from FOD ingestion and to reduce the risk of damage to an aeroplane running off the taxiway.

10.2 The taxiway shoulder dimensions are based on current information regarding the width of the outer engine exhaust plume for breakaway thrust. Furthermore, the surface of taxiway shoulders is prepared so as to resist erosion and ingestion of the surface material by aeroplane engines.

Note.— Guidance material is contained in Doc 9157, Part 2.

Challenges

10.3 The factors leading to reported issues are:

a) powerplant characteristics (engine height, location and power);

b) taxiway shoulder width, the nature of the surface and its treatment; and

c) taxiway centre line deviation factors, both from the expected minor wander from tracking error and the effect of main gear track-in in the turn area while using the cockpit-over-centre line-steering technique.

Potential solutions

10.4 Potential solutions can be developed by applying the following measures, alone or in combination with other measures. The following list is not in any particular order and is not exhaustive:

a) *Excursion on the taxiway shoulder*. The thickness and composition of shoulder pavements should be such as to withstand the occasional passage of the aeroplane operating at the aerodrome that has the most demanding impact on pavement loading, as well as the full load of the most demanding aerodrome emergency vehicle. The impact of an aeroplane on pavements should be assessed and, if required, existing taxiway shoulders (if allowed to be used by these heavier aeroplanes) may need to be strengthened by providing a suitable overlay.

Note.— Surface materials of an asphalt paved shoulder of 10 to 12.5 cm thick (the higher thickness where widebodied aircraft jet blast exposure is likely) and firmly adhering to the underlying pavement layers (by way of a tack coat or other means that assures a well-bonded interface between the surface layer and the underlying strata) is generally a suitable solution.

b) *Jet blast*. Information on engine position and jet blast velocity contour at breakaway thrust mode is used to assess jet blast protection requirements during taxiing operations. A lateral deviation from the taxiway centre line should be taken into account, particularly in the case of a curved taxiway and the use of the cockpit-over- centre-line steering technique. The effect of jet blast can also be managed by the use of thrust management of the engines (in particular for four-engine aircraft).

Note. — Further information concerning aeroplane characteristics including the margins between the outer engine axis and the edge of the shoulder, and the distance from the outer engine to the ground can be found in the manufacturer's aircraft characteristics for airport planning manual.

c) *RFF vehicles*. Operational experience with current aeroplanes on existing taxiways suggests that a compliant overall width of the taxiway and its shoulders permits the intervention of aeroplanes by occasional RFF vehicle traffic.

Note 1.— For NLA, the longer upper-deck escape chutes may reduce the margin between the shoulder edge and the extremity of these escape slides and reduce the supporting surface available to rescue vehicles.

Note 2.— In some cases, the bearing strength of the natural ground may be sufficient, without special preparation, to meet the requirements for shoulders. (Doc 9157, Part 1, provides further design criteria).

CHAPTER 11

11. CLEARANCE DISTANCE ON AIRCRAFT STANDS

Introduction

11.1 Annex 14, Volume I, 3.13.6, recommends the minimum distance between an aeroplane using the stand and an obstacle.

Note.— Doc 9157, Part 2, provides additional guidance on this subject.

Challenges

11.2 The possible reasons for collision between an aeroplane and an obstacle on the apron or holding bay can be listed as:

a) mechanical failure (e.g. hydraulic system, brakes, nose-gear steering);

b) surface conditions (e.g. standing water, ice-covered surfaces, friction coefficient);

c) loss of the visual taxi guidance system (docking system out

of service); and d) Human Factors (directional control,

orientation error).

11.3 The probability of a collision during taxiing depends more on Human Factors than on aeroplane performance. Unless technical failure occurs, aeroplanes will respond reliably to directional inputs from the pilot when taxiing at the usual ground speed. Nevertheless, caution should be exercised with regard to the impact of aeroplanes with larger wingspans.

Potential solutions

11.4 Potential solutions can be developed by applying the following measures, alone or in combination with other measures. The following list is not in any particular order and is not exhaustive:

a) appropriate condition of marking and signage;

b) apron stand lead-in lights;

c) azimuth guidance as a visual docking system;

d) appropriate training of operating and ground personnel should be ensured by an aerodrome operator;

e) operational restrictions (e.g. adequate clearances before and behind parked or holding aeroplanes due to the increased length of aeroplanes);

f) temporarily downgraded adjacent aircraft stands;

g) towing the aeroplane on/from the stand;

h) use of remote/cargo stands or “roll-through” parking positions for handling the aeroplane;

i) publication of procedures in the appropriate aeronautical documentation (i.e. closing or rerouting of taxilanes behind parked aeroplanes);

j) advanced visual guidance system;

k) marshaller guidance;

l) enhancing apron lighting levels in low visibility conditions; and

m) use of the vertical clearances provided by high wings.

APPENDIX A

1. SUBMISSION OF A TYPICAL AERONAUTICAL STUDY TO GHANA CIVIL AVIATION AUTHORITY.

The aerodrome operator should note the guidance provided in this AC and use the suggested Appendix A and checklist provided in Appendix B to ensure that any aeronautical study submitted to the Authority for consideration of acceptance is thoroughly conducted and documented.

1.1 Parts of an Aeronautical Study

An aeronautical study submitted to the Authority for determination of acceptability should comprise the following parts:

(1) Aim of the Study; (2)

Background;

(3) Safety Assessment; (4)

Recommendations; (5)

Conclusion; and

(6) Monitoring of the deviation.

1.2 Aim of the Study

A. The aim of the study should be explicitly stated. It should:

(1) Address the safety concerns;
(2) Identify safety measures to be put in place to ensure safe aircraft operation at an aerodrome; and

(3) Make reference to the specific Directive in the Ghana Civil Aviation (Aerodrome) Directives which the study is meant to address.

B. An example to illustrate this would be as follows:
"The aim of this aeronautical study is to address the operation of Code 4F aircraft in a code 4E airport (name of airport) and to put in place (list of safety measures) necessary to ensure safe operation of Code 4F aircraft in (name of airport) with reference made to GCADs.

1.3 Background

A. Information on the current situation faced by the aerodrome operator, current procedures that have been put in place and other relevant details should be clearly stated and explained in this subsection. Clear explanation should be provided, particularly on the following:

(1) What is the current situation?

(2) Where are the areas that will be affected by the proposed deviation?

(3) When will the operator be able to comply with the specific standard if it is due to development of the aerodrome?

(4) Why is there a need to review the current processes and procedures?

(5) How will the proposed deviation affect the operation of aircraft at the aerodrome?

B. An example to illustrate this would be as follows:
"Currently, (name of airport) is Code 4E airport with some Code 4F capabilities. These Code 4F capabilities includes (list of the Code 4F capabilities)… (name of airport) is required to handle Code 4F aircraft by (proposed date) and the following (list of affected areas) will be affected. Development of the (affected areas) is proposed to commence on (proposed date) and to be completed by (proposed date). By then, (name of airport) will be upgraded to a Code 4F airport.
Upgrading (name of airport) from Code 4E to Code 4F airport requires the reviewing (name of processes and procedures that need to be reviewed) to ensure safe aircraft operation. In addition, during this development, operation of aircraft at (name of airport) will be affected in the following ways….."

1.4 Safety Assessment

A. Safety assessment is the identification, analysis and elimination, and/or mitigation of risk to an acceptable level of safety. This should be in accordance with the aerodrome Safety Management System (SMS) that is required to be put in place by the operator - a key aerodrome certification requirement. A safety assessment usually consists of the following:

(1). Identification of hazards and consequences; and

(2). Risk management.

B. There is no standard methodology to conduct a safety assessment and it is up to the aerodrome operator to determine the appropriate methodology for each aeronautical study, depending on the size, complexity of the situation and the severity of the safety implications. However, the methodology adopted should be consistent with that established in the aerodrome operator's SMS.

Identification of hazard and consequences.

C. Hazards and its consequences should be identified and recorded in a hazard log. Aerodrome operators have to exercise caution when identifying the hazards and their consequences. Stating a hazard, as its consequence would disguise the nature of the hazard and at the same time; interfere with identifying other important consequences.

D. An example would be “Operation of Code 4F aircraft in a Code 4E airport” and “Wingtip collision in parking bays”. The former is a hazard whereas the latter is one of its consequences. The associated risk and control/mitigation measures should also be recorded in the hazard log when information is available. This log should be constantly updated throughout the aeronautical study life cycle.

E. Appendix B of this AC contains a sample hazard log. The aerodrome operator may use this to formulate its own hazard log to suit the aeronautical study.

Risk management

F. Risk is the assessment, expressed in terms of predicted probability and severity, of the consequence(s) of a hazard taking as reference the worst foreseeable situation. Risk management is the identification, analysis and elimination, and/or mitigation of such risk identified to an acceptable level.

G. The probability and severity of the consequence identified can be qualitative or quantitative. The aerodrome operator is free to use any method appropriate to the aeronautical study, but in accordance with the risk management methodology established in the aerodrome operator’s SMS. Some examples to assess the probability and severity of a consequence occurring are provided in Appendix C to this AC.

H. A risk assessment matrix should be developed. This matrix provides a relationship between the probability and severity of a consequence of a hazard occurring. The risk indexes (combinations of the risk probability values and the risk severity values) should be placed in a risk tolerability table. Appendix C also gives an example of risk assessment matrix and risk tolerability.

(1) Acceptable - The consequence is extremely improbable or not severe enough to be of concern;

(2) Tolerable - Mitigation measures should be taken to reduce the probability or the severity of the consequence. This may often require senior management decision; and

(3) Intolerable -The consequence is unacceptable under the existing circumstances.

Risk control/mitigation measures should be developed to address the potential hazard or to reduce the risk probability or severity of the consequence when the aerodrome operator classifies the risk to be tolerable to a level acceptable. There are three broad categories for risk control/mitigation and they are as follows:

(1) Avoidance - the operation or activity is cancelled as the risks exceed the benefits of continuing the operation or activity;
An example to illustrate this would be as follows: “To prohibit Code 4F aircraft to land or take-off from (name of airport), which is a Code 4E airport with some Code 4F capability.”

(2) Reduction - the frequency of the operation or activity is reduced, action is taken to reduce the magnitude of the consequences of the accepted risk; and
An example to illustrate this would be as follows: “To reduce the number of Code 4F aircraft to land or take-off from (name of airport).”

(3) Segregation of exposure - action is taken to isolate the effects of the consequences of the hazard or build-in redundancy to protect against it.
An example to illustrate this would be as follows:

“To ensure (name of airport) staff liaise with the Aeronautical Information Services (AIS) on the promulgation of aerodrome circulars with the necessary aerodrome information to (names of aircraft operators) and (names of other airports) within (fixed period of time) stated in their new process and/or new procedures.”

1.5 Recommendations

A. To allow the aerodrome operator and the Authority to be convinced and assured that the proposed deviation will not pose a drop in the level of safety, the aerodrome operator should recommend operating procedures/restrictions or other measures that will address any safety concerns. In addition, the aerodrome operator should estimate the effectiveness (through trials, surveys, simulations etc.) of each recommendation listed so as to identify the best means to address the proposed deviation.

B. The aerodrome operator should also ensure that the affected parties are well informed of such changes. The notification procedure including process flow, time frame and different means of notification such as the Aeronautical Information Publication (AIP) and Notice to Airmen (NOTAM) should be included in the study.

C. An example to illustrate this would be as follows:
“The following are some of the operating procedures/restrictions or other measures as well as their measured effectiveness, which could be adopted to ensure safe aircraft operations in (name of airport): (Name of the operating procedures/restrictions or other measures and their corresponding measured effectiveness)

The notification procedure to the affected parties is as follows:
(Description of the notification procedure including process flow, time frame and different means of notification)

1.6 Conclusion

A. The aerodrome operator, after taking into account all the necessary considerations listed above, should be able to summarize and conclude the results of the aeronautical study, and come to a decision on any safety measures that should be adopted. The aerodrome operator should also specify a date to put in place all the necessary safety measures and show they maintain the same level of safety with the recommended safety measures mentioned in the aeronautical study.

B. An example to illustrate this would be as follow:
"The results of this aeronautical study have concluded that (name proposed deviation) will indeed pose a drop in the level of safety. However, by adopting (type of safety measures), this drop in the level of safety can be safely addressed… These safety measures will be put in place on (proposed date) to address the proposed deviation. With these safety measures put in place, (to explain how to maintain the same level of safety)…"

1.7 Monitoring of the Deviation

A. After the completion of the aeronautical study, the aerodrome operator should monitor the status of the deviation and ensure that the implemented recommendations have been effectively carried out, and that the level of safety is not compromised at any time. This assessment is to allow feedback into the safety assessment process, if required.

B. An example would be as follows:
"(Name of the aerodrome operator) will monitor the deviation's status (fixed period of time) and ensure the safety measures has been effectively carried out and the level of safety is not compromised at any time. (Name of the aerodrome operator) will review the safety assessment process, if required…"

C. For temporary deviations, the aerodrome operator should also notify the Authority after the deviation has been corrected.

APPENDIX B - CHECKSHEET FOR AERONAUTICAL STUDY

Note: The purpose of this Appendix B is to provide aerodrome operators with a suggested check sheet for reviewing of an aeronautical study.

Aerodrome operators may use this check sheet as a guide for development of an aeronautical study tailored to his individual situation. The suggested check sheet for reviewing of an aeronautical study is as shown below:

CHECKSHEET FOR AERONAUTICAL STUDY	YES	NO	REMARKS
1. Aim of the study including Address, safety concerns, identify safety measures, and make reference to specific GCAD;	☐	☐	
2. Consultation with stakeholders, senior management team and divisions/departments affected	☐	☐	
3. The study is approved by a senior executive of the organization	☐	☐	
4. Background information on the current situation;	☐	☐	
5. Proposed date for complying with SARPs, if the deviation is due to development of the aerodrome;	☐	☐	
6. Safety assessment including (a) identification of hazards and consequences, and (b) risk management;	☐	☐	
7. The safety assessment used in the study (e.g. hazard log, risk probability and severity, risk assessment matrix, risk tolerability and risk control/mitigation;	☐	☐	
8. Recommendation (including operating procedures/ restrictions or other measures to address safety concerns) of the aeronautical study and how the proposed deviation will not degrade the level of safety;	☐	☐	
9. Estimation of the effectiveness of each recommendation listed in the aeronautical study;	☐	☐	
110. Notification procedure including process flow, time frame and the publication used to promulgate the deviation;	☐	☐	

11. Conclusion of the study;	☐	☐	
12. Monitoring of the deviation; and	☐	☐	
13. Notification to the Authority once the temporary deviation has been corrected.	☐	☐	

APPENDIX C - HAZARD LOG

Note: The purpose of this Appendix B is to provide aerodrome operator with suggested hazard log safety assessment of an aeronautical study. Aerodrome operators may use this log as a guide to formulate his hazard log. This log should be constantly updated throughout the aeronautical study life-cycle.

S/N	Type of Hazard and operation	Hazard & Description	Consequences Identified	Risk Index	Risk Tolerability	Risk Control/ Mitigation	Residual Risk Index	Residual Risk Tolerability	Action, If any to further reduce risk(s) and the resulting risk index and residual risk tolerability
1	Aircraft Operation	Operation of code 4F aircraft in (name of airport) code 4E airport using runway for landing and take-off	- wing tip collision at (parking bay number) - loss of control of aircraft during pushback/towing operations	3c	Tolerable	- Use of wing walkers - Aircraft to taxi at (speed value) -Training of staff for pushback towing operations -Restrictions on other aircraft movements within (parking bay number)	2D	Acceptable	- Conduct trials to study the effectiveness of the implementation -Resulting risk index 2E - Residual risk tolerability: Acceptable

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Attachment D

SELECTED AEROPLANE CHARACTERISTICS

Data are provided for convenience, are subject to change and should be used only as a guide. Accurate data should be obtained from the aircraft manufacturer's documentation. Many aeroplane types have optional weights and different engine models and engine thrusts; therefore pavement aspects and reference field lengths will vary, in some cases enough to change the aeroplane category. Reference field length should not be used for the design of aerodrome runway length, as the required length will vary depending on various factors such as aerodrome elevation, reference temperature and runway slope.

Aircraft model	*Take-off weight (kg)*	*Code*	*Reference field length (m)**	*Wingspan (m)*	*Outer main gear wheel span (m)*	*Nose gear to main gear distance (wheel base) (m)*	*Cockpit to main gear distance (m)*	*Fuselage length (m)*	*Overall (maximum) length (m)*	*Maximum tail height (m)*	*Approach speed (1.3×Vs) (kt)*	*Maximum evacuation slide length (m)******
AIRBUS A318-100	68 000	3C	1 789	34.1	8.9	10.3	15.3	31.5	31.5	12.9	124	7.2
A319-100	75 500	4C	1 800	34.1	8.9	11.4	16.5	33.5	33.5	12.2	128	7.2
A320-200	77 000	4C	2 025	34.1	8.9	12.6	17.7	37.6	37.6	12.2	136	7.5
A321-200	93 500	4C	2 533	34.1	8.9	16.9	22.0	44.5	44.5	12.1	142	6.2
A300B4-200	165 000	4D	2 727	44.8	11.1	18.6	25.3	53.2	54.1	16.7	137	9.0
A300-600R	170 500	4D	2 279	44.8	11.1	18.6	25.3	53.2	54.1	16.7	135	9.0
A310-300	164 000	4D	2 350	43.9	11.0	15.2	21.9	45.9	46.7	16.0	139	6.9
A330-200	233 000	4E	2 479	60.3	12.6	22.2	28.9	57.3	58.4	18.2	136	11.5
A330-300	233 000	4E	2 490	60.3	12.6	25.4	32.0	62.6	63.7	17.2	137	11.5
A340-200	275 000	4E	2 906	60.3	12.6	22.2	28.9	58.3	59.4	17.0	136	11.0
A340-300	276 500	4E	2 993	60.3	12.6	25.4	32.0	62.6	63.7	17.0	139	11.0
A340-500	380 000	4E	3 023	63.4	12.6	28.0	34.5	66.0	67.9	17.5	142	10.9
A340-600	380 000	4E	2 864	63.4	12.6	33.1	39.8	73.5	75.4	17.9	148	10.5
A380-800	560 000	4F	2 779	79.8	14.3	29.7	36.4	70.4	72.7	24.4	138	15.2
ANTONOV An-2	5 500	1B	500	18.2	3.4	8.3	–0.6	12.7	12.4	4.1	62	
An-3	5 800	1B	390	18.2	3.5	8.3	–0.6	14.0	13.9	4.9	65	
An-28	6 500	1B	585	22.1	3.4	4.4	3.1	12.7	13.1	4.9	89	
An-38-100	9 500	2B	965	22.1	3.4	6.2	4.9	15.3	15.7	5.5	108	
An-38-200	9 930	2B	1 125	22.1	3.4	6.2	4.9	15.3	15.7	5.5	119	

Aircraft model	*Take-off weight (kg)*	*Code*	*Reference field length (m)**	*Wingspan (m)*	*Outer main gear wheel span (m)*	*Nose gear to main gear distance (wheel base) (m)*	*Cockpit to main gear distance (m)*	*Fuselage length (m)*	*Overall (maximum) length (m)*	*Maximum tail height (m)*	*Approach speed (1.3×Vs) (kt)*	*Maximum evacuation slide length (m)*******
An-24	21 000	3C	1 350	29.2	7.9	7.9	7.6	23.8	23.8	8.6	119	
An-24PB	22 500	3C	1 600	29.2	7.9	7.9	7.6	23.8	23.8	8.6	119	
An-30	22 100	3C	1 550	29.2	7.9	7.4	7.6	24.3	24.3	8.6	113	
An-32	27 000	3C	1 600	29.2	7.9	7.9	7.6	23.7	23.7	8.8	124	
An-72	31 200	3C	1 250	31.9	4.1	8.0	8.5	28.1	28.1	8.7	108	
An-148-100A	38 950	3C	1 740	28.9	4.6	10.6	10.6	26.1	29.1	8.2	124	
An-70	139 000	3D	1 610	44.1	5.9	14.0	14.9	39.7	40.6	16.4	151	
An-26	24 000	4C	1 850	29.2	7.9	7.7	7.6	23.8	23.8	8.8	124	
An-26B	25 000	4C	2 200	29.2	7.9	7.7	7.6	23.8	23.8	8.8	124	
An-32B-100	28 500	4C	2 080	29.2	7.9	7.9	7.6	23.7	23.7	8.8	127	
An-74	34 800	4C	1 920	31.9	4.1	8.0	8.5	28.1	28.1	8.7	108	
An-74TK-100	36 500	4C	1 920	31.9	4.1	8.0	8.5	28.1	28.1	8.8	108	
An-74T-200	36 500	4C	2 130	31.9	4.1	8.0	8.5	28.1	28.1	8.8	108	
An-74TK-300	37 500	4C	2 200	31.9	4.1	8.0	8.5	28.1	28.1	8.7	116	
An-140	21 000	4C	1 880	24.5	3.7	8.1	7.8	21.6	22.6	8.2	124	
An-140-100	21 500	4C	1 970	25.5	3.7	8.1	7.8	21.6	22.6	8.2	124	
An-148-100B	41 950	4C	2 020	28.9	4.6	10.6	10.6	26.1	29.1	8.2	124	
An-148-100E	43 700	4C	2 060	28.9	4.6	10.6	10.6	26.1	29.1	8.2	124	
An-158***	43 700	4C	2 060	28.6	4.6	11.7	11.8	27.8	30.8	8.2	126	
An-168***	43 700	4C	2 060	28.9	4.6	10.6	10.6	26.1	29.1	8.2	124	
An-12	61 000	4D	1 900	38.0	5.4	9.6	11.1	33.1	33.1	10.5	151	
An-22	225 000	4E	3 120	64.4	7.4	17.3	21.7	57.8	57.8	12.4	153	
An-124-100	392 000	4F	3 000	73.3	9.0	22.8	25.6	69.1	69.1	21.1	154	
An-124-100M-150	402 000	4F	3 200	73.3	9.0	22.8	25.6	69.1	69.1	21.1	160	
An-225	640 000	4F	3 430	88.40	9.01	29.30	16.27	76.62	84.00	18.10	167	
BOEING 707-320C	152 407	4D	3 079	44.4	8.0	18.0	20.9	44.4	46.6	13.0	137	6.6
717-200	54 885	3C	1 670	28.4	5.9	17.6	17.0	34.3	37.8	9.1	139	5.3
727-200	95 254	4C	3 176	32.9	7.1	19.3	21.4	41.5	46.7	10.6	136	6.1
727-200/W	95 254	4C	3 176	33.3**	7.1	19.3	21.4	41.5	46.7	10.6	136	6.1
737-200	58 332	4C	2 295	28.4	6.4	11.4	13.0	29.5	30.5	11.2	133	5.8
737-300	62 823	4C	2 170	28.9	6.4	12.4	14.0	32.2	33.4	11.2	133	7.0
737-300/W	62 823	4C	2 550	31.2**	6.4	12.4	14.0	32.2	33.4	11.2	133	7.0

Aircraft model	*Take-off weight (kg)*	*Code*	*Reference field length (m)**	*Wingspan (m)*	*Outer main gear wheel span (m)*	*Nose gear to main gear distance (wheel base) (m)*	*Cockpit to main gear distance (m)*	*Fuselage length (m)*	*Overall (maximum) length (m)*	*Maximum tail height (m)*	*Approach speed (1.3×Vs) (kt)*	*Maximum evacuation slide length (m)******
737-400	68 039	4C	2 550	28.9	6.4	12.4	15.9	35.2	36.4	11.2	139	7.0
737-500	60 555	4C	2 470	28.9	6.4	11.1	12.7	29.8	31.0	11.2	128	7.0
737-500/W	60 555	4C	2 454	31.1**	6.4	11.1	12.7	29.8	31.0	11.2	128	7.0
737-600	65 091	3C	1 690	34.3	7.0	11.2	12.8	29.8	31.2	12.7	125	7.0
737-600/W	65 544	3C	1 640	35.8**	7.0	11.2	12.9	29.8	31.2	12.7	125	7.0
737-700	70 080	3C	1 600	34.3	7.0	12.6	14.2	32.2	33.6	12.7	130	7.0
737-700/W	70 080	3C	1 610	35.8**	7.0	12.6	14.2	32.2	33.6	12.7	130	7.0
737-800	79 016	4C	2 090	34.3	7.0	15.6	17.2	38.0	39.5	12.6	142	7.0
737-800/W	79 016	4C	2 010	35.8**	7.0	15.6	17.2	38.0	39.5	12.6	142	7.0
737-900	79 016	4C	2 240	34.3	7.0	17.2	18.8	40.7	42.1	12.6	141	7.0
737-900ER/W	84 912	4C	2 470	35.8**	7.0	17.2	18.8	40.7	42.1	12.6	141	7.0
747-SP	318 875	4E	2 710	59.6	12.4	20.5	22.9	53.9	56.3	20.1	140	14.3
747-100	341 555	4E	3 060	59.6	12.4	25.6	28.0	68.6	70.4	19.6	144	11.8
747-200	379 203	4E	3 150	59.6	12.4	25.6	28.0	68.6	70.4	19.6	150	11.8
747-300	379 203	4E	3 292	59.6	12.4	25.6	28.0	68.6	70.4	19.6	152	14.3
747-400ER	414 130	4E	3 094	64.9	12.6	25.6	27.9	68.6	70.7	19.6	157	14.3
747-400	396 893	4E	3 048	64.9	12.6	25.6	27.9	68.6	70.7	19.5	157	14.3
747-8	442 253	4F	3 070	68.4	12.7	29.7	32.0	74.2	78.0	19.2	150***	15.7
747-8F	442 253	4F	3 070	68.4	12.7	29.7	32.0	74.2	78.0	19.2	159***	11.7
757-200	115 666	4D	1 980	38.1	8.6	18.3	22.0	47.0	47.3	13.7	137	9.3
757-200/W	115 666	4D	1 980	41.1**	8.6	18.3	22.0	47.0	47.3	13.7	137	9.3
757-300	122 470	4D	2 400	38.1	8.6	22.3	26.0	54.4	54.4	13.7	143	9.3
767-200	163 747	4D	1 981	47.6	10.8	19.7	24.3	47.2	48.5	16.1	135	8.7
767-200ER	179 623	4D	2 743	47.6	10.8	19.7	24.3	47.2	48.5	16.1	142	8.7
767-300	163 747	4D	1 981	47.6	10.9	22.8	27.4	53.7	54.9	16.0	140	8.7
767-300ER	186 880	4D	2 540	47.6	10.9	22.8	27.4	53.7	54.9	16.0	145	8.7
767-300ER/W	186 880	4D	2 540	50.9**	10.9	22.8	27.4	53.7	54.9	16.0	145	8.7
767-400ER	204 117	4D	3 140	51.9	11.0	26.2	30.7	60.1	61.4	17.0	150	9.7
777-200	247 208	4E	2 380	60.9	12.9	25.9	28.9	62.9	63.7	18.7	136	12.0
777-200ER	297 557	4E	2 890	60.9	12.9	25.9	28.9	62.9	63.7	18.7	139	12.0
777-200LR	347 815	4E	3 390	64.8	12.9	25.9	28.9	62.9	63.7	18.7	140	12.0
777-300	299 371	4E	3 140	60.9	12.9	31.2	32.3	73.1	73.9	18.7	149	12.6

Aircraft model	*Take-off weight (kg)*	*Code*	*Reference field length (m)**	*Wingspan (m)*	*Outer main gear wheel span (m)*	*Nose gear to main gear distance (wheel base) (m)*	*Cockpit to main gear distance (m)*	*Fuselage length (m)*	*Overall (maximum) length (m)*	*Maximum tail height (m)*	*Approach speed (1.3×Vs) (kt)*	*Maximum evacuation slide length (m)******
777-300ER	351 534	4E	3 060	64.8	12.9	31.2	32.3	73.1	73.9	18.8	149	12.6
B787-8	219 539	4E	2 660	60.1	11.6	22.8	25.5	55.9	56.7	16.9	140***	11.1
MD-81	64 410	4C	2 290	32.9	6.2	22.1	21.5	41.6	45.0	9.2	134	5.3
MD-82	67 812	4C	2 280	32.9	6.2	22.1	21.5	41.6	45.0	9.2	134	5.3
MD-83	72 575	4C	2 470	32.9	6.2	22.1	21.5	41.6	45.0	9.2	144	5.3
MD-87	67 812	4C	2 260	32.9	6.2	19.2	21.5	36.3	39.8	9.5	134	5.3
MD-88	72 575	4C	2 470	32.9	6.2	22.1	21.5	41.6	45.0	9.2	144	5.3
MD-90	70 760	3C	1 800	32.9	6.2	23.5	22.9	43.0	46.5	9.5	138	5.3
MD-11	285 990	4D	3 130	51.97	12.6	24.6	31.0	58.6	61.6	17.9	153	9.8
DC8-62	158 757	4D	3 100	45.2	7.6	18.5	20.5	46.6	48.0	13.2	138	6.7
DC9-15	41 504	4C	1 990	27.3	6.0	13.3	12.7	28.1	31.8	8.4	132	5.3
DC9-20	45 813	3C	1 560	28.4	6.0	13.3	12.7	28.1	31.8	8.4	126	5.3
DC9-50	55 338	4C	2 451	28.5	5.9	18.6	18.0	37.0	40.7	8.8	135	5.3
BOMBARDIER CS100****	54 930	3C	1 509	35.1	8.0	12.9	13.7	34.9	34.9	11.5	127	
CS100 ER****	58 151	3C	1 509	35.1	8.0	12.9	13.7	34.9	34.9	11.5	127	
CS300****	59 783	4C	1 902	35.1	8.0	14.5	15.3	38.1	38.1	11.5	133	
CS300 XT****	59 783	3C	1 661	35.1	8.0	14.5	15.3	38.1	38.1	11.5	133	
CS300 ER****	63 321	4C	1 890	35.1	8.0	14.5	15.3	38.1	38.1	11.5	133	
CRJ200ER	23 133	3B	1 680	21.2	4.0	11.4	10.8	24.4	26.8	6.3	140	
CRJ200R	24 040	4B	1 835	21.2	4.0	11.4	10.8	24.4	26.8	6.3	140	
CRJ700	32 999	3B	1 606	23.3	5.0	15.0	14.4	29.7	32.3	7.6	135	
CRJ700ER	34 019	3B	1 724	23.3	5.0	15.0	14.4	29.7	32.3	7.6	135	
CRJ700R****	34 927	4B	1 851	23.3	5.0	15.0	14.4	29.7	32.3	7.6	136	
CRJ900	36 514	3B	1 778	23.3	5.0	17.3	16.8	33.5	36.2	7.4	136	
CRJ900ER	37 421	4C	1 862	24.9	5.0	17.3	16.8	33.5	36.2	7.4	136	
CRJ900R	38 329	4C	1 954	24.9	5.0	17.3	16.8	33.5	36.2	7.4	137	
CRJ1000****	40 823	4C	1 996	26.2	5.1	18.8	18.3	36.2	39.1	7.5	138	
CRJ1000ER****	41 640	4C	2 079	26.2	5.1	18.8	18.3	36.2	39.1	7.5	138	
DHC-8-100	15 650	2C	890	25.9	7.9	8.0	6.1	20.8	22.3	7.5	101	
DHC-8-200	16 465	2C	1 020	25.9	8.5	8.0	6.1	20.8	22.3	7.5	102	
DHC-8-300	18 643	2C	1 063	27.4	8.5	10.0	8.2	24.2	25.7	7.5	107	
DHC-8-400	27 987	3C	1 288	28.4	8.8	14.0	12.2	31.0	32.8	8.3	125	

Aircraft model	*Take-off weight (kg)*	*Code*	*Reference field length (m)**	*Wingspan (m)*	*Outer main gear wheel span (m)*	*Nose gear to main gear distance (wheel base) (m)*	*Cockpit to main gear distance (m)*	*Fuselage length (m)*	*Overall (maximum) length (m)*	*Maximum tail height (m)*	*Approach speed (1.3×Vs) (kt)*	*Maximum evacuation slide length (m)******
EMBRAER ERJ 170-100 STD	35 990	3C	1 439	26.0	6.2	10.6	11.5	29.9	29.9	9.7	124	
ERJ 170-100 LR, SU and SE	37 200	3C	1 532	26.0	6.2	10.6	11.5	29.9	29.9	9.7	124	
ERJ 170-100 + SB 170-00-0016	38 600	3C	1 644	26.0	6.2	10.6	11.5	29.9	29.9	9.7	125	
ERJ 170-200 STD	37 500	3C	1 562	26.0	6.2	11.4	12.3	31.7	31.7	9.7	126	
ER 170-200 LR and SU	38 790	3C	1 667	26.0	6.2	11.4	12.3	31.7	31.7	9.7	126	
ERJ 170-200 + SB 170-00-0016	40 370	4C	2 244	26.0	6.2	11.4	12.3	31.7	31.7	9.7	126	
ERJ 190-100 STD	47 790	3C	1 476	28.7	7.1	13.8	14.8	36.3	36.3	10.6	124	
ERJ 190-100 LR	50 300	3C	1 616	28.7	7.1	13.8	14.8	36.3	36.3	10.6	124	
ERJ 190-100 IGW	51 800	3C	1 704	28.7	7.1	13.8	14.8	36.3	36.3	10.6	125	
ERJ 190-200 STD	48 790	3C	1 597	28.7	7.1	14.6	15.6	38.7	38.7	10.5	126	
ERJ 190-200 LR	50 790	3C	1 721	28.7	7.1	14.6	15.6	38.7	38.7	10.5	126	
ERJ 190-200 IGW	52 290	4C	1 818	28.7	7.1	14.6	15.6	38.7	38.7	10.5	128	

* Reference field length reflects the model/engine combination that provides the shortest field length and the standard conditions (maximum weight, sea level, std day, A/C off, runway dry with no slope).

** Span includes optional wiinglets.

*** Preliminary data.

**** Preliminary data — aircraft not yet certified.

***** Longest deployed slide lengths, including upper deck slides, referenced from aircraft centre line as measured horizontally. Data are based primarily on aircraft rescue fire fighting charts.

MAXIMUM LENGTH[1] OF EVACUATION SLIDES

Model	*Deployed length [2] (metres)*	*Model*	*Deployed length [2] (metres)*
737-600/-700/-800/-900	7.0	A300-600	9.0
747-100/-200 (upper deck)	11.8	A310	6.9
747-100/-200 (lower deck)	11.5	A318	7.2
747-300/-400 (upper deck)	14.3	A319	7.2
747-300/-400 (lower deck)	11.5	A320	7.5
757-200/-300	9.3	A321	6.2
767-200/-300	8.7	A330-200/-300	11.5
767-400	9.7	A340-200/-300	11
777-200/-200ER/-200LR/-200F	12.0	A340-500	10.9
777-300/-300ER	12.6	A340-600	10.5
		A380	15.2

No data available for 787 or 747-8 at this time.

(1) Due to the variety of slides and slide manufacturers only the longest slides and average lengths are indicated here.

(2) Deployed lengths referenced are from the aircraft centre line as measured horizontally. Data are based primarily on aircraft rescue and fire fighting charts.