Advisory Circular

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AERODROME COMPATIBILITY STUDY

1.0 PURPOSE

The purpose of this Advisory Circular is to provide guidance to aerodrome operators and aircraft operators on the methodology and procedures to be used when assessing aerodrome compatibility between aircraft operations and aerodrome infrastructure when aircraft exceed the design characteristics of an aerodrome.

2.0 REFERENCES

2.1 Civil Aviation (Aerodrome) Regulations

2.2 Civil Aviation (Operation of Aircraft – Commercial Air Transport) Regulations

2.3 Civil Aviation (Radio Navigation Aids) Regulations

2.4 Civil Aviation (Aircraft Accident and Incident Investigation) Regulations

2.5 Civil Aviation (Aeronautical Information Services) Regulations

2.6 Civil Aviation (Safety Management) Regulations

2.7 ICAO Doc 9137 - Airport Services Manual Part 1, 2, 6 and 8

2.8 ICAO Doc 9157 - Airport Design Manual Part 2 and 3

2.9 ICAO Doc 9184 - Airport Planning Manual

2.10 ICAO Doc 9476 - Manual of Surface Movement Guidance and Control Systems (SMGCS)

2.11 ICAO Doc 9774 - Manual on Certification of Aerodromes

2.12 ICAO Doc 9859 - Safety Management Manual (SMM)

2.13 ICAO Doc 9870 - Manual on the Prevention of Runway Incursions

2.14 ICAO Circular 301 - New Larger Aeroplanes — Infringement of the Obstacle Free Zone: Operational Measures and Aeronautical Study

2.15 ICAO Circular 305 - Operation of New Larger Aeroplanes at Existing Aerodromes

3.0 INTRODUCTION

3.1 The Civil Aviation (Aerodromes) Regulations prescribe the physical characteristics, obstacle limitation surfaces, requirements applicable to aerodromes as well as certain facilities and technical services to be provided for at aerodromes.

3.2 To a great extent, the specifications for individual facilities have been interrelated by a reference code system as described in the regulations, in accordance with the characteristics of the aeroplane for which an aerodrome is intended.

3.3 It is not intended that the aerodrome reference code limit or regulate the operation of aircraft, rather they provide an aircraft operator with an awareness of the operating limitations of each aerodrome facility.

3.4 While aerodrome reference code number relates to runways only, all applicable elements are to be considered and promulgated concurrently for each aerodrome facility, to ensure that obstacle clearances are maintained and that there is adequate ground surface to enable the safe operation of the aircraft.

3.5 When planning a new aerodrome, or upgrading or replacing an existing aerodrome facility, it is important the aerodrome operator carefully considers the aircraft type that they intend to accommodate at their aerodrome. Not only will this enable the appropriate design of each facility, it will potentially avoid future operational limitations.

3.6 It is important for an aerodrome and aircraft operator to understand where an aerodrome does not meet the design characteristics for a particular aircraft type, the aircraft operator may still be able to operate at the aerodrome subject to confirmation that they can do so safely. This will require the completion of a compatibility assessment by the aerodrome operator.

3.7 A Compatibility study shall be undertaken by an aerodrome operator to assess the compatibility between aeroplane operations and aerodrome infrastructure and operations when an aerodrome accommodates or plans to accommodate an aeroplane that exceeds the certificated characteristics of the aerodrome.

3.8 A compatibility assessment may not be required if evidence is provided that an aircraft can operate to a lesser aerodrome reference code for runway width in accordance with an aircraft's flight documentation e.g. aircraft certification, aircraft flight manual or supplement or original equipment manufacturer approved documentation.

4.0 PROCESS TO UNDERTAKE AERODROME COMPATIBILITY STUDY

4.1 A compatibility study or assessment must be performed collaboratively between affected stakeholders who may include; the aerodrome operator, the aeroplane operator, ground handling agencies, the air navigation service provider, refuellers and Aerodrome Rescue and Fire Fighting Service (ARFFS).

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

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

b) the aerodrome operator identifies possible means of accommodating the aeroplane type or 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 or subtype can be accommodated and, if permitted, under what conditions.

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

a) identify the aeroplane's physical and operational characteristics

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;

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.

4.4 A compatibility study may require a review of the obstacle limitation surfaces at an aerodrome.

4.5 For aerodrome operations in low visibility conditions, additional procedures may be implemented in order to safeguard the operation of aeroplanes.

4.6 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.

5.0 APPLICABILITY OF INFORMATION FROM THE AERODROME COMPATIBILITY STUDY

5.1 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 Authority (Director Safety Security and Economic Regulation, Uganda Civil Aviation Authority) with the information which is necessary for safety oversight and the continued monitoring of the conditions specified in the aerodrome certificate.

5.2 Each compatibility study is specific to a particular operational context and to a particular type of aeroplane.

5.3 Information resulting from the compatibility study that is considered to be of operational significance is published in accordance with Civil Aviation (Aerodromes) Regulations and Civil Aviation (Aeronautical Information Services) Regulations.

6.0 IMPACT OF AEROPLANE CHARACTERISTICS ON THE AERODROME INFRASTRUCTURE

6.1 Consideration of the aeroplane's physical characteristics

The aeroplane's physical characteristics may influence the aerodrome dimensions, facilities and services in the movement area. This following aeroplane characteristics that may have an impact on the relevant aerodrome characteristics, facilities and services in the movement area.

6.1.1 Fuselage length

The fuselage length may have an impact on:

a) the dimensions of the movement area; taxiway, holding bays and aprons, passenger gates and terminal areas;

b) the aerodrome category for RFF;

c) ground movement and control e.g. reduced clearance behind a longer aeroplane holding at an apron or a runway or intermediate holding position to permit the passing of another aeroplane; and

d) clearances at the aircraft stand.

6.1.2 Fuselage width

The fuselage width is used to determine the aerodrome category for RFF.

6.1.3 Door sill height

The door sill height may have an impact on:

a) the operational limits of the air bridges;

b) mobile steps;

c) catering trucks;

d) persons with reduced mobility; and

e) dimensions of the apron.

6.1.4 Aeroplane nose characteristics

The aeroplane nose characteristics may have an impact on the location of the runway-holding position of the aeroplane which should not infringe the OFZ.

6.1.5 Tail height

The tail height may have an impact on:

a) the location of the runway-holding position;

b) ILS critical and sensitive areas: In addition to the tail height of the critical aeroplane, tail composition, tail position, fuselage height and length can have an effect on ILS critical and sensitive areas;

c) the dimensions of aeroplane maintenance services;

d) aeroplane parking position in relation to aerodrome OLS;

e) runway and parallel taxiway separation distances; and

f) the clearance of any aerodrome infrastructure or facilities built over stationary or moving aeroplanes.

6.1.6 Wingspan

The wingspan may have an impact on:

a) Taxiway and taxilane separation distances, including runway and taxiway separation distances;

b) the dimensions of the OFZ;

c) the location of the runway-holding position, due to the impact of the wingspan on OFZ dimensions;

d) the dimensions of aprons and holding bays;

e) wake turbulence;

f) gate selection;

g) aerodrome maintenance services around the aeroplane; and

h) equipment for disabled aeroplane removal;

In the case of an aeroplane equipped with folding wing tips, its reference code letter may change as a result of the folding or extending of the wing tips. Consideration should be given to the wingspan configuration and resultant operations of the aeroplane at an aerodrome.

6.1.7 Wing tip vertical clearance

The wing tip vertical clearance may have an impact on:

a) taxiway separation distances with height-limited objects;

b) apron and holding bay clearances with height-limited objects;

c) aerodrome maintenance services;

d) airfield signage clearances; and

e) service road locations.

6.1.8 Cockpit view

The relevant geometric parameters to assess the cockpit view are cockpit height, cockpit cut-off angle and the corresponding obscured segment. The cockpit view may have an impact on:

a) runway visual references like the aiming point;

b) runway sight distance;

c) taxiing operations on straight and curved sections;

d) markings and signs on runways, turn pads, taxiways, aprons and holding bays;

e) lights: in low visibility conditions, the number and spacing of visible lights when taxiing may depend on the cockpit view; and

f) calibration of PAPI/VASIS, for pilot eye height above wheel height on approach.

6.1.9 Distance from the pilot's eye position to the nose landing gear

The design of taxiway curves is based on the cockpit-over-centre-line concept. The distance from the pilot's eye position to the nose landing gear is relevant for:

a) taxiway fillets that is wheel track;

b) the dimensions of aprons and holding bays; and

c) the dimensions of turn pads.

6.1.10 Landing gear design

The aeroplane landing gear design is such that the overall mass of the aeroplane is distributed so that the stresses transferred to the soil through a well-designed pavement are within the bearing capacity of the soil. The landing gear layout also has an effect on the manoeuvrability of the aeroplane and the aerodrome pavement system.

6.1.11 Outer main gear wheel span

The outer main gear wheel span may have an impact on:

a) runway width;

b) the dimensions of turn pads;

c) taxiway width;

d) taxiway fillets;

e) the dimensions of aprons and holding bays; and

f) the dimension of the OFZ.

6.1.12 Wheelbase

The wheelbase may have an impact on:

a) the dimensions of turn pads;

b) taxiway fillets;

c) the dimensions of aprons and holding bays; and

d) terminal areas and aeroplane stands.

6.1.13 Gear steering system

The gear steering system may have an impact on the dimensions of turn pads and the dimensions of aprons and holding bays.

6.1.14 Maximum aeroplane mass

The maximum mass may have an impact on:

a) the mass limitation on existing bridges, tunnels, culverts and other structures under runways and taxiways;

b) disabled aeroplane removal;

c) wake turbulence; and

d) arresting systems when provided as an element of kinetic energy.

6.1.15 Landing gear geometry, tire pressure and Aircraft Classification Number (ACN) values

Landing gear geometry, tire pressure and ACN values may have an impact on the airfield pavement and associated shoulders.

6.1.16 Engine characteristics

a) The engine characteristics include engine geometry and engine airflow characteristics, which may affect aerodrome infrastructure as well as ground handling of the aeroplane and operations in adjacent areas which are likely to become affected by jet blast.

b) The engine geometry aspects are:

   i) the number of engines;

   ii) the location of engines, span and length;

   iii) the vertical clearance of engines; and

   iv) the vertical and horizontal extent of possible jet blast or propeller wash.

c) The engine airflow characteristics are:

   i) idle, breakaway and take-off thrust exhaust velocities;

   ii) thrust reverser fitment and flow patterns; and

   iii) inlet suction effects at ground level.

d) The engine characteristics may be relevant for the following aerodrome infrastructure and operational aspects:

   i) runway shoulder width and composition, jet blast and ingestion issues during take-off and landing;

   ii) shoulder width and composition of runway turn pads;

   iii) taxiway shoulder width and composition, jet blast and ingestion issues during taxiing;

   iv) bridge width, jet blast under the bridge;

   v) the dimensions and location of blast protection fences;

   vi) the location and structural strength of signs;

   vii) the characteristics of runway and taxiway edge lights;

   viii) the separation between aeroplanes and adjacent ground service personnel, vehicles or passengers;

   ix) the design of engine run-up areas and holding bays;

   x) the design and use of functional areas adjacent to the manoeuvring area;

   xi) the design of air bridges; and

   xii) the location of refuelling pits on the aircraft stand.

6.1.17 Maximum passenger- and fuel-carrying capacity

Maximum passenger- and fuel-carrying capacity may have an impact on:

a) terminal facilities;

b) fuel storage and distribution;

c) aerodrome emergency planning;

d) aerodrome rescue and fire fighting; and

e) air bridge loading configuration.

6.1.18 Flight performance

Flight performance may have an impact on:

a) runway width;

b) runway length;

c) the OFZ;

d) runway/taxiway separation;

e) wake turbulence;

f) noise; and

g) aiming point marking.

6.2 Consideration of the aeroplane's operational characteristics

6.2.1 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.

6.2.2 The following list of aeroplane ground servicing characteristics and requirements may affect the available aerodrome infrastructure. This list is not exhaustive; additional items may be identified by the stakeholders involved in the compatibility assessment process:

a) ground power;

b) passengers embarking and disembarking;

c) cargo loading and unloading;

d) fuelling;

e) pushback and towing;

f) taxiing and marshalling;

g) aeroplane maintenance;

h) RFF;

i) equipment areas;

j) stand allocation; and

k) disabled aircraft removal.

7.0 PHYSICAL CHARACTERISTICS OF AERODROMES

In order to adequately assess the aeroplane's compatibility, the following aerodrome physical characteristics must be included in the evaluation process.

7.1 RUNWAYS

a. Runway length

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 the appendix to this Advisory circular.

Longitudinal slopes can have an effect on aeroplane performance.

b. Runway width

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.

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.

The main causes and accident factors are:

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

- aeroplane; asymmetric spin-up and/or reverse thrust, malfunctioning of control surfaces, hydraulic system, tyres, brakes, nose-gear steering, centre of gravity and powerplant (engine failure, foreign object ingestion);
- temporary surface conditions; standing water, rubber, FOD, damage to the pavement and runway friction coefficient;
- permanent surface conditions - horizontal and vertical slopes and runway friction characteristic;
- meteorological conditions e.g. heavy rain, crosswind, strong/gusty winds, reduced visibility; and
- Human Factors; crew, maintenance, balance and payload security;

ii) for landing:

- aeroplane; malfunction of the landing gear, control surfaces, hydraulic system, brakes, tires, nose- gear steering and powerplant (reverse and thrust lever linkage);
- temporary surface conditions; standing water, rubber, FOD, damage to the pavement and applying runway friction coefficient;
- permanent surface conditions; horizontal and vertical slopes and runway friction characteristics;
- prevailing meteorological conditions; heavy rain, crosswind, strong/gusty winds, thunderstorms/wind shear, reduced visibility;

- Human Factors i.e. hard landings, crew, maintenance;
- ILS localizer signal quality or interference, where auto land procedures are used;
- any other localizer signal quality or interference of approach aid equipment;
- lack of approach path guidance such as VASIS or PAPI; and
- approach type and speed.

An analysis of lateral runway excursion reports shows that the causal factor in aeroplane accidents or incidents is not the same for take-off and landing.

Mechanical failure is 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 contaminated runway surfaces have also been a factor in a significant number of veer-offs during landing.

Potential solutions

The lateral runway excursion is linked to specific aeroplane characteristics, performance or handling qualities, or controllability in response to such events as aeroplane mechanical failures, pavement contamination 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 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.

Potential solutions can be developed by applying the following measures, alone or in combination with other measures:

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 or 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.

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.

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.

Aerodromes which use embedded or 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;

b) earlier execution of snow removal operations, as the inset lights are likely to be affected by snow more quickly; and

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

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.

c. Runway shoulders

The runway shoulders 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.

Runway shoulders have three main functions:

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

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

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

Potential issues associated with runway shoulder characteristics; width, soil type and bearing strength are:

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

ii) 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

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

Factors to be considered are:

i) runway centre line deviations;

ii) powerplant characteristics; engine height, location and power; and

iii) soil type and bearing strength; aeroplane mass, tire pressure and gear design.

Potential solutions

Possible solutions can be developed by applying the following measures, alone or in combination with other measures:

i) Excursion onto the runway shoulder; provide the suitable shoulder;

ii) 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;

iii) Rescue Fire Fighting 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

iv) Additional surface inspections; it may be necessary to adapt the inspection programme for FOD detection.

d. Runway turn pads

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.

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.

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

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

ii) adverse surface conditions like standing water and friction coefficient;

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

iv) Human Factors, including incorrect application of the 180-degree procedure that is; nose-wheel steering, asymmetric thrust and differential breaking.

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.

For a specific aeroplane, it may be permissible to operate on a runway turn pad not provided in accordance with Civil Aviation (Aerodromes) Regulations, specifications, considering:

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

ii) the provision for adequate clearances;

iii) the provision for appropriate marking and lighting;

iv) the provision of shoulders;

v) the protection from jet blast; and

vi) if relevant, protection of the ILS.

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

7.2 RUNWAY STRIPS

a. Runway strip dimensions

A runway strip is an area enclosing a runway and any associated stopway and its purpose is to:

i) 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

ii) 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.

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 and 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.

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:

i) runway excursion history;

ii) friction and drainage characteristics of the runway;

iii) runway width, length and transverse slopes;

iv) navigation and visual aids available;

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

vi) scope for procedural mitigation measures; and

vii) accident report.

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

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.

The lateral runway excursion hazard is clearly linked to specific aeroplane characteristics, performance and 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 or 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

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:

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

ii) 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;

iii) 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;

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

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

b. Obstacles on runway strips

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.

An obstacle on the runway strip may represent either:

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

ii) a source of interference to navigation aids.

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.

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:

i) 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;

ii) 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;

iii) 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

iv) 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.

7.3 RUNWAY END SAFETY AREA (RESA)

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.

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.

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

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

ii) the topography and obstruction environment beyond the RESA;

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

iv) overrun and undershoot causal factors;

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

vi) navigation and visual aids available;

vii) type of approach;

viii) 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;

ix) the location of the taxiways and runways;

x) aerodrome climatology, including predominant wind speed and direction and likelihood of wind shear; and

xi) aerodrome overrun/undershoot and veer-off history.

Potential solutions

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:

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

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

iii) 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;

iv) 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;

v) improving runway surfaces in a timely manner and 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;

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

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

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

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

x) installing suitably positioned and designed arresting systems as a supplement or as an alternative to standard RESA dimensions when necessary;

xi) increasing the length of a RESA and minimizing the potential obstruction in the area beyond the RESA; and

xii) publishing provisions, including the provision of an arresting system, in the AIP.

In addition to the AIP entry, information and instructions should be disseminated to local runway safety team and others to promote awareness.

7.4 TAXIWAYS

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

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

Particular care should be taken while manoeuvring on taxiways having a width less than that specified in Civil Aviation (Aerodromes) Regulations, 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.

Causes and accident factors can include:

i) mechanical failure that is hydraulic system, brakes, nose-gear steering;

ii) adverse surface conditions including; standing water and friction coefficient;

iii) loss of the taxiway centre line visual guidance markings and lights inadequately maintained;

iv) Human Factors including directional control, orientation error, pre-departure workload; and

v) aeroplane taxi speed.

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.

Compatibility studies related to taxiway width and potential deviations may include:

i) 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;

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

iii) the aeroplane outer main gear wheel span.

Potential solutions

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:

i) the provision of taxiway centre line lights;

ii) conspicuous centre line marking;

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

iv) reduced taxi speed;

v) the provision of taxi side-stripe markings;

vi) inset or elevated taxiway edge lights;

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

viii) the use of alternative taxi routes; and

ix) the use of marshaller services - follow-me guidance.

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

7.5 TAXIWAY CURVES

Civil Aviation (Aerodromes) Regulations, contain provisions on taxiway curves. Any hazard will be the result of a lateral taxiway excursion on a curved section.

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.

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

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.

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

Potential solutions

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:

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

ii) reduced taxi speed;

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

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

v) pilot judgemental oversteering; and

vi) publication of provisions in the appropriate aeronautical documentation.

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

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

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.

7.6 RUNWAY AND TAXIWAY MINIMUM SEPARATION DISTANCES

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.

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.

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

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

ii) the possible collision between an aeroplane leaving the runway and an object whether 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

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

Causes and accident factors can include:

i) Human Factors by crew and ATS;

ii) hazardous meteorological conditions such as thunderstorms and wind shear;

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

iv) surface conditions, that is; standing water and friction coefficient;

v) lateral veer-off distance;

vi) aeroplane position relative to navigation aids, especially ILS; and

vii) aeroplane size and characteristics, especially wingspan.

The causes and accident factors specific to the local environment and identified above for runway separation issues are mainly supported by local aerodrome experience.

Potential solutions

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:

i) 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;

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

iii) change taxiway routing so that the required runway airspace is free of taxiing aeroplanes; and

iv) employ tactical control of aerodrome movements.

7.7 TAXIWAY AND TAXILANE MINIMUM SEPARATION DISTANCES

a) Taxiway to object separation

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

The separation distances during taxiing are intended to minimize the risk of a collision between an aeroplane and an object; that is taxiway-object separation, taxilane-object separation.

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

The causes and accident factors can include:

i) mechanical failure including; hydraulic system, brakes and nose-gear steering;

ii) surface conditions including standing water and friction coefficient;

iii) loss of the visual taxiway guidance system; and

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

Potential solutions

Potential solutions can be developed by applying the following measures, alone or in combination with other measures;

i) the use of reduced taxiing speed;

ii) the provision of taxiway centre line lights;

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

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

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

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

vii) the use of “follow-me” guidance;

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

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

b) Parallel taxiway separation

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

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.

The potential issues associated with parallel taxiway separation distances are:

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

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

Causes and accident factors can include:

i) Human Factors by crew and ATS;

ii) hazardous meteorological conditions such as reduced visibility;

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

iv) surface conditions like standing water and friction coefficient;

v) lateral veer-off distance; and

vi) aeroplane size and characteristics, especially wingspan.

Potential solutions

Potential solutions can be developed by providing the following facilities, alone or in combination with other measures;

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

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

iii) change taxiway routing;

iv) employ tactical control of aerodrome movements;

v) use of reduced taxiing speed;

vi) provision of taxiway centre line lights;

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

viii) use of “follow-me” guidance;

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

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

7.8 TAXIWAYS ON BRIDGES

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.

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.

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

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

i) landing gear leaving the load-bearing surface;

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

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

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

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

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

The causes and accident factors can include:

i) mechanical failure including; hydraulic system, brakes and nose-gear steering;

ii) surface conditions including; standing water and friction coefficient;

iii) loss of the visual taxiway guidance system;

iv) Human Factors; i.e directional control, disorientation and pilot’s workload;

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

vi) undercarriage design.

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

i) powerplant characteristics including; engine height, location and power;

ii) bridge blast protection width; and

iii) taxiway centre line deviation factors.

In addition to 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

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:

i) where feasible, strengthen existing bridges;

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

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

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

v) use the vertical clearance provided by high wings.

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.

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

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.

7.9 TAXIWAY SHOULDERS

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.

The taxiway shoulder dimensions are based on current information regarding the width of the inner 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.

The factors leading to reported issues are:

i) powerplant characteristics including engine height, location and power;

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

iii) 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

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:

i) *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.

ii) *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.

iii) *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.

7.10 CLEARANCE DISTANCE ON AIRCRAFT STANDS

Civil Aviation (Aerodromes) Regulations provide the minimum distance between an aeroplane using the stand and an obstacle.

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

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

ii) surface conditions e.g. standing water, friction coefficient;

iii) loss of the visual taxi guidance system; and

iv) Human Factors like directional control and orientation error.

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

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:

i) appropriate condition of marking and signage;

ii) apron stand lead-in lights;

iii) azimuth guidance as a visual docking system;

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

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

vi) temporarily downgraded adjacent aircraft stands;

vii) towing the aeroplane on or from the stand;

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

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

x) advanced visual guidance system;

xi) marshaller guidance;

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

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

7.11 PAVEMENT DESIGN

To facilitate flight planning, various aerodrome data are required to be published, such as data concerning the strength of pavements, which is one of the factors required to assess whether the aerodrome can be used by an aeroplane of a specific all-up mass.

The increased mass and/or gear load of the aeroplanes may require additional pavement support. Existing pavements and their maintenance will be evaluated for adequacy due to differences in wheel loading, tire pressure, and undercarriage design. Bridge, tunnel and culvert load-bearing capacities are a limiting factor, requiring some operational procedures.

Potential solutions

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) restrictions on aeroplanes with higher ACN on specific taxiways, runway bridges or aprons; or

b) adoption of adequate pavement maintenance programmes.

8.0 CONTACTS

Further guidance and inquiries may be directed to:

Director Safety Security and Economic Regulation,
Uganda Civil Aviation Authority,
P. O. Box 5536, Kampala, Uganda
TEL: +256 312 352101
Email: dat@caa.co.ug

UGANDA CIVIL AVIATION AUTHORITY
DIRECTOR
SAFETY, SECURITY AND ECONOMIC REGULATION

Director Safety Security and Economic Regulation

Appendix

SELECTED AEROPLANE CHARACTERISTICS

Data are provided for convenience, and are subject to change. Should be used only as a guide. Accurate data may 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 must 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)	Aerodrome Reference 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	
An-24	21 000	3C	1 350	29.2	7.9	7.9	7.6	23.8	23.8	8.6	119	

Aircraft model	Take- off weight (kg)	Aerodrome Reference 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-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
737-400	68 039	4C	2 550	28.9	6.4	12.4	15.9	35.2	36.4	11.2	139	7.0

Aircraft model	Take- off weight (kg)	Aerodrome Reference 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)
737-500	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
777-300ER	351 534	4E	3 060	64.8	12.9	31.2	32.3	73.1	73.9	18.8	149	12.6
777-9#	351 534	4E/4F	****	64.8/	12.8	32.3	36.0	75.2	76.7	19.7	****	12.6

Aircraft model	Take- off weight (kg)	Aerodrome Reference 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)
				71.8								
787-8	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)	Aerodrome Reference 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 winglets.

***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.

Aircraft with folding wing tips (FWT)

MAXIMUM LENGTH OF EVACUATION SLIDES

Model	Deployed length (metres)
B737-600/-700/-800/-900	7.0
B747-100/-200 (upper deck)	11.8
B747-100/-200 (lower deck)	11.5
B747-300/-400 (upper deck)	14.3
B747-300/-400 (lower deck)	11.5
B757-200/-300	9.3
B767-200/-300	8.7
B767-400	9.7
B777-200/-200ER/-B200LR/-200F	12.0
B777-300/-300ER	12.6
A300-600	9.0
A310	6.9
A318	7.2
A319	7.2
A320	7.5
A321	6.2
A330-200/-300	11.5
A340-200/-300	11
A340-500	10.9
A340-600	10.5
A380	15.2