AIRPORTS COUNCIL INTERNATIONAL

BOEING

August 31st, 2018

Subject: Formal Distribution of the Boeing 777-8/9 Airport Compatibility Group documentation

Dear Sir/ Madam:

It is with distinct pleasure that we hereby transmit to you the official release of the Common Agreement Document produced by the Boeing 777-8/9 Airport Compatibility Group 2 (BACG2). The BACG2 group was formed by a number of Civil Aviation Authorities, Airports Council International, the International Air Transport Association, the International Federation of Air Line Pilots' Associations, airport operators, airlines and Boeing. The methodology involved is consistent with the principles outlined in ICAO Doc 9981, "Procedures for Air Navigation Services - Aerodromes", applying the attributes of the Boeing 777-8/9 aircraft to the physical qualities of aerodromes in an effort to establish compatibility.

The final draft of this document was agreed to by representatives of the BACG2 members on April 25th 2018 and has been subsequently endorsed by a number of Civil Aviation Authorities (ref: pages 24-34 of the CAD) resulting in this release.

The entirety of the BACG2 Common Agreement Document and its attachments are found on the flash drive that is included in the binder. We encourage the use of the contents of this document to serve the needs of any airport or civil aviation authority with an interest in accommodating the 777-8/9 at their facilities.

This package is considered to be co-produced by ACI, the endorsing states (currently France, Germany, Italy, Spain, Switzerland, the United Arab Emirates and the United Kingdom) and the Boeing Company. Any questions may be directed to either ACI (e-mail: BACG_enquiries@aci.aero) or Boeing (e-mail: AirportCompatibility@boeing.com.)

Thank you for your interest in this document and thanks to all those whose efforts aided in the creation of its contents.

Very truly yours,

Angela Gittens
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Common Agreement Document

Boeing 777-8/9 Airport Compatibility Group (BACG2)

May 2018

Table of Contents

1 Introduction

1.1 BACG2 Terms of Reference

The BACG2 is an informal group consisting of Aviation Authorities, Airport, and Industry representatives. The group purpose is to agree and promote a common position among the group members, with respect to operation of the 777-8/9 at airports that currently do not meet ICAO Code Letter F specifications.

Recognizing that the ideal for 777-8/9 operations would be to provide a level of aerodrome infrastructure at least equal to the generic ICAO specifications, the BACG2 should

- Agree and promote that any deviation from these ICAO specifications should be supported by appropriate safety assessment studies and relevant risk analysis.

- Report its work and findings to ICAO through the appropriate channels so that the latter may use such data for the development of future provisions.

- Seek to influence the application of the agreed specifications for the operation of the 777-8/9 aircraft within national regulatory frameworks.

- Co-operate with other international organizations and working groups dealing with NLA operations.

- Enable the work of the BACG2 distribution globally.

1.2 Purpose of the Document

The purpose of BACG2 common agreement document is to develop 777-8/9 operational guidance material that include the following:

- Items of aerodrome infrastructure that may be affected by the introduction of the Boeing 777-8/9 aircraft and its folding wingtip concept of operations defined in Attachment G.

- ICAO Recommended Practices relating to those items.

- For any areas of non-compliance, to show appropriate mitigation, if required, proposed by the BACG2 to ensure the safe operation of the 777-8/9 aircraft at aerodromes currently unable to meet ICAO Code Letter F aerodrome Standards and Recommendations.

Operational guidelines developed for the 777-8/9 are recommendations proposed by an informal group. Emphasize that the authority to approve any deviation from ICAO Annex 14 specifications must rest solely with the state having jurisdiction over the aerodrome.

No provision contained herein must be interpreted to have a binding effect on any such authority with respect to the approval of any such deviation.

1.3 Primary Conditions of Application

The operational guidelines discussed and agreed by the BACG2 and listed in this document only apply to the 777-8/9 aircraft as defined in Attachment B. The guidelines were developed in accordance with the principle and methodology outlined in ICAO PANS Aerodromes, Document 9981, Second Edition, 2016, Attachment B to Chapters 3, SAFETY ASSESSMENT METHODOLOGIES FOR AERODROMES and 4 PHYSICAL CHARACTERISTICS OF AERODROMES.

These guidelines intend to permit the 777-8/9 operation at aerodromes without adversely affecting safety or significantly affecting the regularity of operations. However, it is strongly recommended to provide facilities meeting Annex 14 requirements, in full, on all relevant parts of the movement area whenever new construction or major redevelopment is undertaken. When planning such construction or redevelopment, it may be prudent to consider the requirements of aeroplanes larger than the 777-8/9 types or even future aeroplane types needing facilities in excess of Code F.

The BACG2 guidelines have been developed to be generically applicable to airports to perform safety assessment studies for the introduction of 777-8/9 operations at airport facilities. However, it may be permissible to operate with lower separation margins if a safety assessment study taking into account local conditions indicates that such lower margins would not adversely affect the safety or significantly affect the regularity of operations of the 777-8/-9.

The recommendations in this document assume that the 777-8/9 will be the largest aircraft using the airport and all other Code Letter E aircraft. The recommendations may not be applicable for other Code Letter F aircraft in which a separate Safety Assessment Study is required.

Application of the different level of aerodrome infrastructure recommendations for 777-8/9 operations compared to Code Letter F requirements is subject to the following:

- For taxiway separations items (See §3.5), where reduced margins exist compared to Code Letter F recommendations, proper guidance such as centre line lights or equivalent guidance (marshaller for example) to be provided for night, or low visibility operations.

The ICAO Baseline refers to Annex 14, Volume 1 up to and including amendment 14. The ICAO Air Navigation Commission (ANC) Council has adopted the amendment 14 at the sixth meeting of its 213th Session on 9 March 2018. The proposal to amend several aerodrome design and operations parameters were submitted to States and international organizations via State letter AN4/1.2.27 – 18/23. ICAO Council prescribed 16 July 2018 as the date on which it will become effective, and to Contracting States to provide disapproval before that date.

1.4 Abbreviations

Acronym or Term	**Definition**
[RP] A14 P3.8.3	ICAO Recommended Practices Annex 14 Paragraph 3.8.3
[Std]	ICAO Standard
ADM Pt2	Aerodrome Design Manual part 2
ARFF	Aircraft Rescue and Fire Fighting
CON-OPS	Concept of Operations
FOD	Foreign Object Damage
FWT	Folding Wing Tip
IIWG	International Infrastructure Working Group
JAR 25	Joint Aviation Requirements for Large Aeroplane
JAR AWO	Joint Aviation Requirements All Weather Operations
NLA	New Large Aircraft
OCA/H	Obstacle Clearance Altitude/Height
OCP	Obstacle Clearance Panel
OFZ	Obstacle Free Zone
OLS	Obstacle Limitation Surface
OPS	Operations
RESA	Runway End Safety Area
RTO	Rejected Take-Off
RWY	Runway
SARP	Standards and Recommended Practices
TWY	Taxiway
WP	Working Paper

2 Methodology Overview

The methodology used by BACG2 follows the basic scope of risk assessment process described in ICAO Doc 9981, PANS Aerodromes Second Edition, November 2016.

This document provides guidance on conducting safety assessment studies for aerodromes in the following steps:

- Definition of a safety concern and identification of the regulatory compliance.
- Hazard identification and analysis.
- Risk assessment and development of mitigation measures.
- Development of an implementation plan for the mitigation measures and conclusion of the assessment.

This document 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.

This document was used as the primary reference source for safety analysis in accommodating the 777-8/9 as outlined in the Chapter 4, Aerodrome Compatibility, and in developing the Safety Analysis of Airfield Items in Attachment A of this document.

3 Airfield Items Review

3.1 Introduction

The items of aerodrome infrastructure may be affected by the introduction of the Boeing 777-8/9 aircraft have been identified as shown in the tables below as follows:

- Runways (§ 3.2):
  - Runway width.
  - Runway shoulder width.
- Taxiways (§ 3.3):
  - Width of straight taxiway.
  - Width of curved taxiway.
  - Taxiway shoulder width.
- Runway separation (§ 3.4):
  - Runway to parallel Taxiway Separation.
  - Obstacle Free Zone.
  - Runway Holding Positions.
  - Perturbation of ILS signal by a taxing or stopped aircraft.
- Taxiway and Taxilane Separations (§ 3.5):
  - Parallel Taxiway Separation.
  - Taxiway/Apron Taxiway to Object Separation.
  - Aircraft Stand Taxilane to Object Separation.
  - Clearance at the Gate.
- Other Items (§ 3.6):
  - Visual aid implications.
  - Taxiways on bridges.
  - Runway End Safety Area (RESA) width.

- Runway Turn Pad.

- Oversteer Through Fillets.

- Nose and Tail Clearance at Aircraft Parking Position/De-Icing Pad.

Those infrastructure items are presented into tables and reviewed according to four points:

1. *ICAO SARPs and ADM*

   Standards and Recommended Practices contained in Annex 14, Volume 1 (Seventh Edition, July 2016) up to and including Amendment 14, as well as material from the Aerodrome Design Manuals (ADM Part 1, 2006; ADM Part 2, 2005) published by ICAO.

2. *ICAO Rationale*

   Information and formula used to elaborate ICAO SARPs and ADM (applicable to Code Letter E and F aircraft as defined in Annex 14 Chapter 1).

3. *BACG2 Agreement*

   Common position among BACG2 members on the application of ICAO requirements with respect to the 777-8/9 aircraft for infrastructure and operations at airports that currently do not meet the ICAO standard and recommendations.

4. *Justification Material*

   Important information used for the safety analysis found in Attachment A to justify the proposed guidelines for the 777-8/9 operations.

3.2 Runways

Item	Runway width	Width of Runway shoulder
ICAO SARPs and ADM	• The width of a RWY should be not less than 45m where the code letter is E or F, the OMGWS is less than 15m, and the aircraft has two engines. **[RP] A14 P3.1.10** • Strength of RWYs should be capable of withstanding the traffic of aeroplanes the RWY intends to serve. **[RP] A14 P3.1.21**	• The RWY shoulders should extend symmetrically on each side of the RWY so that overall width of RWY and its shoulders is not less than 60m where the code letter is E or F, the OMGWS is less than 15m, and the aircraft has two engines. **[RP] A14 P3.2.3** • Strength of RWY shoulders: - A RWY shoulder should be prepared or constructed to be capable, in the event of an aeroplane running off the RWY, of supporting the aeroplane without inducing structural damage to the aeroplane and of supporting ground vehicles that may operate on the shoulder. **[RP] A14 P3.2.5** - A RWY shoulder should be prepared or constructed to minimize any hazard to an aeroplane running off the RWY. **ADM Pt1 P5.2.3** - In some cases, the bearing strength of the natural ground may be sufficient, without special preparation, to meet the requirements for shoulders. **ADM Pt1 P5.2.4** - When designing shoulders, prevention of the ingestion of stones or other objects by turbine engines should be an important consideration. **ADM Pt1 P5.2.5** - In case of special preparation, visual contrast between RWY and RWY shoulders may be a requirement. **ADM Pt1 P5.2.6**
ICAO Rationale	• Amendment 14 to Annex 14 7th Edition presents the Aerodrome Design and Operations Panel (ADOP) consideration that original runway width recommendations for New Large Aircraft (NLA) were overly conservative.	• Amendment 14 to Annex 14 7th presents the Aerodrome Design and Operations Panel (ADOP) consideration that original runway shoulder width recommendations for New Large Aircraft (NLA) were overly conservative.
BACG Agreement	• A minimum central 45m of pavement of full load bearing strength must be provided.	• Compliance with the minimum 60m ICAO Code Letter E runway + shoulder's width. • Minimum of 2x7.5m wide shoulders on existing 45m wide RWYs. • Depending on local conditions, decision on the composition and thickness of RWY shoulders to be taken by each national authority and airport operator. • If relevant to local conditions, snow removal and ice control as recommended by ICAO (Doc 9137-AN/898).
Justification Material	• No specific justification needed after Annex 14 7th edition amendment 14.	• No specific justification needed after Annex 14 7th edition amendment 14.

3.3 Taxiways

Item	Width of straight taxiway	Width of curved taxiway	Taxiway shoulder width (straight and curved)
ICAO SARPs and ADM	• Unless otherwise indicated, the requirements are applicable to all types of TWYs. **A14 P3.9** • Minimum clearance between outer main wheel and TWY edge: 4.0m for both E and F with OMGWS <15m. **[RP] A14 P 3.9.3** • Width of a straight portion: -23m for code letter E and F with OMGWS <15m. **[RP] A14 P 3.9.5**	• Curves to ensure that when cockpit over TWY centerline, outer main wheel edge maintains 4.0m clearance from TWY edge (with OMGWS<15m). **[RP] A14 P3.9.6** **ADM Pt2 p1.2.9 and ADM Pt2 p1.2.22 + table 1-3**	• Overall width of TWY + shoulders on straight portion: - 38m where code letter is E. - 44m where code letter is F. **[RP] A14 P3.10.1** • The surface should be so prepared as to resist erosion and ingestion of the surface material by aeroplane engines. **[RP] A14 P3.10.2** • Intended to protect an aircraft operating on the TWY and to reduce the risk of damage to an aircraft running off the TWY. **ADM Pt2 p1.6.1** **ADM Pt2 p1.6.2+ Table 1-1**
ICAO Rationale	• TWY width = 2 x clearance distance from wheel to pavement edge + max wheel track Code Letter E: 23m (OMGWS <15m) = 2x4.0m + 15m Code Letter F (OMGWS <15m): 23m = 2x4.0m + 15m. **ADM Pt2 p1.2.7+ table 1-1** • Origin of the 4.0m clearance distance: Amendment 14 to Annex 14 7th edition.	• Origin of the 4.0m clearance distance: Amendment 14 to Annex 14 7th edition.	• No specific justification material available on taxiway shoulder width.
BACG Agreement	• Minimum taxiway width of 23 meters (equal to Code Letter E requirements and Code F based on OMGWS<15m). • Wheel-to-edge minimum clearance of 4.0m for Code Letter E and F aircraft.	• Amendment 14 to Annex 14 7th edition, Wheel-to-edge minimum clearance of 4.0m for Code Letter E and F aircraft. • Where recommended wheel-to-edge minimum clearance 4.0m for Code Letter E and F is not found, aeroplane can oversteer per the manufacturer's oversteer guidance while still maintaining the minimum recommended tire edge clearance of 4.0m.	• On straight portions, Code Letter E compliant: shoulder should be provided for an overall width of 38m, to prevent jet-blast erosion and engine ingestion (paved or natural surface). • Depending on local conditions, decision on the width for curved portions, composition and thickness for straight and curved portions by each national authority and airport operator.

Item	Width of straight taxiway	Width of curved taxiway	Taxiway shoulder width (straight and curved)
Justification Material	• No specific justification needed after Amendment 14 to Annex 14 7th edition.		The 777-8/9 may be completing a portion of its taxi route while in Code F configuration with the wingtips extended, such as when approaching the holding point for takeoff. Per Annex 14 recommendation, wider shoulders should be used for Code F aircraft. However, the position of the wingtips does not affect jet blast and ingestion contours for the 777-8/9, both being the parameters used in determining a suitable shoulder width for the aircraft. This allows a conclusion that a 38m taxiway shoulder width will avoid shoulder erosion and engine ingestion risks for 777-8/9 taxiing with a level of safety equal to current 777 models, regardless of folding wingtip position.

3.4 Runway Separations

Item	RWY to parallel TWY separation	Obstacle Free Zone	Runway holding positions
ICAO SARPs and ADM	• Code F: 180m for instrument RWY or 115m for non-instrument runway (may be reduced and subject to safety assessment study). • Code E: 172.5m for instrument RWY or 107.5m for non-instrument runway (may be reduced and subject to safety assessment study). **[RP] A 14 P3.9.8 + Table 3-1 columns 5 and 9** **ICAO PANS-ADR Doc 9981 Chapter 5 (Runway and Taxiway Minimum Separation Distances, ICAO ADM part 2, section 1.2.31-32)**	• OFZ half width = - 60m for code letter E. - 77.5m for code letter F. - Inner transitional surface slope 1:3. **[Std] A14 P4.1.11 and 4.1.12 + 4.1.17 to 24, Table 4-1, Note e) to Table 4-1** • Where the code letter is F (Column (3) of Table 1-1), the width is increased to 155 m. For information on code letter F aeroplanes equipped with digital avionics that provide steering commands to maintain an established track during the go-around manoeuvre, see Circular 301 "*New Larger Aeroplanes, Infringement of the Obstacle Free Zone: Operational Measures and Aeronautical Study*"	• Take-off RWY, non-instrument and non-precision approach minimum holding position distances - no change compared with Code Letter E (75m). • Precision approaches all CATs: Minimum holding position distances increased to 107.5m for Code Letter F (90m for Code Letter E). [**RP] A14 Table 3-2 footnote 'c'** • Aircraft at precision approach holds not to interfere with the operation of Nav. Aids**.** **[Std] A14 P3.12.6**
ICAO Rationale	• Separation = ½ wing span + ½ strip width: Code Letter E: 172.5m = ½x65m + ½x280m Code Letter F: 180m = ½x80m + ½x280m for instrument RWY. • Origin of 280m RWY strip width: Amendment 14 to Annex 14 7th edition **ADM Pt2 p1.2.19+ Table 1-5**	• Justifications in OCP meetings material and Circular 301, Part II, paragraph 1.3.1: 155m (Code Letter F) and 120m (Code Letter E).	• 107.5m based on Code Letter F OFZ definition and on an aircraft with 24m tail height, 62.2m distance nose-highest tail part, 10m nose height, 45° or more holding.
BACG Agreement	<u>Collision risk</u> • For instrument runways: - Minimum separation is 140m + half wingspan = 140m + 35.9m = 176 m (wings extended). - Lower separation could be envisioned based a safety assessment. • For non-instrument runways: - Minimum separation is 75m + half wingspan. <u>ILS effects</u> • Need of specific runway studies to evaluate ILS interference risks in all the cases.	• Code Number 4 OFZ width of 120m based on ICAO OCP work.	<u>Collision risk</u> • For takeoff and non-precision approach runways, minimum value 75m applied. • For precision approach runways, minimum value of 90m to be applied. <u>ILS effects</u> • Need of specific runway studies to evaluate ILS interference risks in all the cases.

Item	RWY to parallel TWY separation	Obstacle Free Zone	Runway holding positions
Justification Material	Collision risk • Declining trend of Code E runway veeroff frequency over the years. • Code E design separation degraded by 3.45m increase in half-wingspan. • Separation based on OFZ requires only (60 + [3x19.5]) = 118.5m. *Note: Assumes 777-8/9 is largest aircraft using the airport.* ILS effects • Recent studies and ICAO work indicate that vertical tail size is critical, not span, and that the size of the sensitive and critical areas and the operational impact of infringement of CSAs should be reassessed. Therefore the need for specific runway studies.	• ICAO Circular 301 states that when digital autopilot or flight director with track hold guidance is used for the approach, a Code Letter F aeroplane can be contained within the Code Letter E OFZ.	Collision risk • 777-8/9 meets Code Letter E OFZ applicability. • 90m for Code Letter E for precision RWY is applicable based on same nose and tail height as 777-300ER A14 Table 3-2 footnote b note 1. • Lower collision risk than 747SP used in requirement calculation, since the tail is further away from RWY centerline compared to aircraft in A14 Table 3-2 footnote b note 1. ILS effects • Recent studies and ICAO work indicates that vertical tail size is critical, not span, and that the size of the sensitive and critical areas and the operational impact of infringement of CSAs should be reassessed. Therefore the need for specific runway studies.

3.5 Taxiway and Taxilane Separations

Item	Parallel Taxiway Separation	Taxiway and Apron taxiway to Object Separation	Aircraft Stand Taxilane to Object Separation (including service road and height limited object)	Clearance at the gate
ICAO SARPS and ADM	• Code Letter F TWY centerline to TWY centerline separation = 91m. • Code Letter E TWY centerline to TWY centerline separation = 76m. • Possibility to operate with lower separation distances based on a safety assessment study. **[RP] A 14 P3.9.8 + Table 3-1 column 10** • No specific safety buffers for curved portion. **A14 P3.9.8 Note 3**	• Code Letter F TWY centerline to object separation = 51m. • Code Letter E TWY centerline to object separation = 43.5m. • Possibility to operate with lower separation distances based on a safety assessment study. **[RP] A14 P3.9.8 + Table 3-1 column 11** • The taxiway strip should provide an area clear of objects that may endanger aircraft. [RP] **A14 P 3.11.3**	• Code Letter F taxilane centerline to object separation = 47.5m. • Code Letter E taxilane centerline to object separation = 40m. • Possibility to operate with lower separation distances based on a safety assessment study. **[RP] A14 P3.9.8 + Table 3-1 column 12** • The distance shown (above) may need to be increased if jet exhaust likely to be hazardous. **[RP] A14 P3.9.8 note 4**	• Minimum distance between aircraft and obstacle = 7.5m but special circumstances on nose-in stands may permit reduction: - Between terminal (including fixed pax bridge) and aircraft nose - Over any portion of stand provided with azimuth guidance by a visual docking guidance system. **[RP] A14 P3.13.6**
ICAO Rationale	• Separation = wingspan + wingtip clearance: - Code Letter E: 76m = 65m + 11m - Code Letter F: 91m = 80m + 11m **ADM Pt2 p1.2.13 + p.1.2.15 + Tables 1-1 and 1-4 + Figure 1-4**	• Separation TWY to object = ½ wingspan + wingtip clearance: - Code Letter E: 43.5m = ½x65m + 11m - Code Letter F: 51m = ½x80m + 11m **ADM Pt2 p1.2.13 to p1.2.18 + Tables 1-1 and 1-4 + Figure 1-4**	• Separation = ½ wingspan + wingtip clearance: - Code Letter E: 40m = ½x65m + 7.5m - Code Letter F: 47.5m = ½x80m + 7.5m **ADM Pt2 p1.2.13 to p1.2.17 + Tables 1-1 and 1-4 + Figure 1-4**	• Origin of the 7.5m clearance distance unknown – derived from wingtip clearance from apron taxilane to object.

Item	Parallel Taxiway Separation	Taxiway and Apron taxiway to Object Separation	Aircraft Stand Taxilane to Object Separation (including service road and height limited object)	Clearance at the gate
BACG Agreement	• Minimum tip-tip clearance margin of 11m with aircraft positioned center on straight taxiways and positioned cockpit over centerline in curved sections. • For planning purposes, 76m (wingtips folded) or 82.8 m (wingtips extended) should be the minimum. • Lower figures could be accepted and subject to a safety assessment study. • See notes 1 and 2. • In the case of a Rapid Exit Taxiway, a specific safety assessment study should be performed. See Attachment G (FWT CONOPS) for detailed analysis.	• Minimum tip-object clearance margin of 11m with aircraft positioned center on straight taxiways and positioned cockpit over centerline in curved sections. • For planning purposes, Code Letter E taxiway to object separation (43.5m) should be the minimum. • Lower figures could be accepted and subject to a safety assessment study. • See notes 1 and 2.	• Minimum tip-object clearance margin of 7.5m with aircraft positioned center on straight taxiways and positioned cockpit over centerline in curved sections. • For planning purposes, Code Letter E taxilane to object separation (40m) should be the minimum. • Distance may be reduced for height-limited object. All objects to be properly marked or lighted. Depending on local conditions, decision on reduced margins for height limited objects by each authority and airport operator. • See notes 1 and 2.	• ICAO SARPs followed (7.5 m). • Possibility of reduced distance with appropriate measure such as visual docking guidance system, and marshaller(s). • See note 2 and 3. • Distance may be reduced for height-limited object. All objects to be properly marked or lighted. Depending on local conditions, decision on reduced margins for height limited objects by each authority and airport operator.
Justification Material	• Wingtip Clearance + Wingspan = 11 + 71.8 = 82.8m	• No specific justification required.	• No specific justification required.	• No specific justification required.

Note 1: For taxiway separations, where reduced margins exist compared to Code Letter F recommendations, proper guidance such as centerline lights or equivalent guidance, e.g. marshaller, is to be provided for night or low visibility operations.

It may be permissible to operate with lower separation margins than agreed in this document if a safety assessment study taking into account local conditions indicates that such lower margins would not adversely affect the safety or significantly affect the regularity of operations.

Note 2: To ensure that the minimum tip-object margins above are reflected for curved sections of taxiway, it is recommended to use appropriate tools (such as simulation or the analytical method in ICAO ADM).

3.6 Other Items

Item	Visual aids	Taxiways on bridges	RESA (Runway End Safety Area) width
ICAO SARPs and ADM	Elevated Edge Lights • Elevated RWY lights must be frangible + clear of propellers and engine pods. **[Std] A14 P5.3.1.7** • Surface (inset) lights must withstand being run over by aircraft. **[Std] A14 P5.3.1.8** • RWY edge lights will be placed along the edge of the area declared for the use as RWY or outside by less than 3m. **[Std] A14 P5.3.9.4** • Signals must be frangible + clear of propellers and engine pods. **[Std] A14 P.5.4.1.3** PAPI • Where a PAPI or APAPI is installed on RWY without ILS or MLS, they will be sited to ensure guidance for the most demanding aircraft regularly using the RWY. Where a PAPI or APAPI is installed on RWY with ILS or MLS they should be sited to provide guidance for those aircraft regularly using the RWY. **A14 Chap 5 Figure 5-18 P a) and b), A14 Chap 5 Table 5-2 note a.** • The location of PAPI units depends on eye-to-wheel height of the group of aircraft that use the system regularly and by using the most demanding aircraft of the group. **A14 Chap 5 Table 5-2 note a.** • Wheel clearances may be reduced and subject to a safety assessment study but not less than values indicated in Table 5-2 column 3. **A14 Chap 5 Table 5-2 note c**	• The width of the portion of a taxiway bridge capable of supporting aeroplanes, as measure perpendicularly to the taxiway centerline, must not be 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 must not be hazardous for aeroplanes and the intended taxiways. • This width is 38m and 44m for codes E and F respectively. **[Std] A14 P3.9.20 and ADM Pt 2 P1.4.4** • Access should be provided for ARFF vehicles to intervene in both directions. **[RP] A14 P3.9.21** • If aircraft engines overhang the bridge structure, protection of adjacent areas below the bridge from engine blast may be required. **[RP] A14 P3.9.21 Note ADM Pt2 p1.4.4**	• The width of a RESA will be at least twice that of the associated runway. 90m for associated Code Letter F RWY; 90m for Code Letter E RWY. **[Std] A14 P3.5.4** • The width of a RESA should, wherever practicable, be equal to that of the graded portion of the associated runway strip. 150m for Code number 3 and 4. **[RP] A14 P3.5.5**
ICAO Rationale	• Work of ICAO Visual Aids Panel and Working Group.	• No specific justification available for taxiway on bridge.	• Protection beyond the RWY strip to minimize damage when aircraft undershoot or overshoot the RWY during landing or takeoff. **ADM Pt1 P5.4.1**

Item	Visual aid implications	Taxiways on bridges	RESA (Runway End Safety Area) width
BACG Agreement	• For RWY edge lighting position, ICAO SARPs to be followed (placed along the edge of the area declared for the use as RWY or outside by less than 3 m). • Inset RWY edge lights; possibility of elevated runway edge lights according to preliminary engine outputs. Snow clearance to be considered in the choice. • PAPI: No specific 777-8/9 requirement; ICAO compliant.	• Not less than 38m for width of the portion capable of supporting the 777-8/9 and for passenger evacuation. • Possibility of reduced width margins if proven method of lateral restraint is provided. • Not less than 38m for jet blast protection, slide and passenger movement support during evacuation in case full bearing strength width is reduced by proven means of lateral restraint. • Alternative path for ARFF vehicles (whatever the bridge width).	• Minimum 90m based on 45m Code Letter E associated runway width, or twice that of the actual associated runway width. • RESA width equal to the width of the graded portion of the associated runway strip is recommended wherever practical.
Justification Material	• 777-8/9 engine position. • Similar exhaust wake velocity contours as 777-300ER. • Similar glide slope approach attitude.	• 777 outer main gear wheel span. • 777 engine span. • 777-8/9 Jet blast velocity contours at taxiing similar to 777-300ER.	• Amendment to AN14 by State Letter AN 4/1.2.27-18/23 reducing recommended RWY width to 45m for 777-8/9. • History of satisfactory 777 operations on 45m wide RWYs.

Item	Runway Turn Pad	Oversteer Through Fillets	Nose and Tail Clearance at Aircraft Parking Position and De-icing Pads
ICAO SARPs and ADM	• Where the end of a runway is not served by a taxiway or a taxiway turnaround and where the code letter is D, E or F, a runway turn pad will be provided to facilitate a 180-degree turn of aeroplanes. **[RP] A14 P3.3.1.** • The intersection angle of the runway turn pad with the runway should not exceed 30 degrees. **[RP] A14 P3.3.4.** • The nose wheel steering angle to be used in the design of the runway turn pad should not exceed 45 degrees. **[RP] A14 P3.3.5.** • Turn pad geometry recommendation for code E and F are available within the in-design manual. **ADM Pt1 Figure A4-9.**	• Amendment 14 to Annex 14 7th edition proposes to set landing gear edge margin recommendations based on OMGWS as opposed to wingspan. Based on proposed categories, the 777-8/9 would require a 4.0m margin between the landing gear tire edge and the turn pad pavement edge. • The strength of the fillet should be the same as that of the taxiway. **[RP] ADM Pt2, 1.5.1**	• **Taxiway and Apron Taxiway Centerline to object Separation:** minimum 43.5m for Code letter E and 51m for Code letter F. This separation was derived from a minimum 11m wingtip clearance between an aircraft taxiing on a taxiway to an object. Possibility to operate with lower separation distances based on a safety assessment study. **[RP] A14 P3.9.7 + table 3-1 col. 11** • **Aircraft Stand Taxilane Centerline to Object Separation**: minimum 40m for Code letter E and 47.5m for Code letter F. This separation was derived from a minimum 7.5m wingtip clearance between an

Item	Runway Turn Pad	Oversteer Through Fillets	Nose and Tail Clearance at Aircraft Parking Position and De-icing Pads
ICAO SARPs and ADM	• Amendment 14 to Annex 14 7th edition proposes to set landing gear edge margin recommendations based on OMGWS as opposed to wingspan. Based on proposed categories, the 777-8/9 would require a 4.0m margin between the landing gear tire edge and the turn pad pavement edge. • A 6m wheel-to-edge clearance is recommended where severe weather conditions may lower the surface friction characteristics. **[RP] A14 P3.3.7** • The strength of the runway turn pad should be at least equal to the adjoining runway, and should be able to withstand the higher stresses put on the pavement by a slow moving aeroplane making hard turns. **[RP] A14 P3.3.9, [RP] ADM Pt1 A4, 3.3** • The runway turn pad should provide necessary shoulder width to prevent erosion by jet blast and damage by FOD. The minimum shoulder width would need to cover the outer engine of the most demanding aeroplane. **[RP] A14 P3.3.12, [RP] ADM Pt1 A4, 4.1** • The strength of runway turn pad shoulders should be capable of withstanding the occasional passage of the aeroplane it is designed to serve without inducing structural damage to the aeroplane and to the supporting group vehicles. **[RP] A14 P3.3.13, [RP] ADM Pt1 A4, 4.2**		aircraft taxiing on a taxilane to an object. Possibility to operate with lower separation distances based on a safety assessment study. **[RP] A14 P3.9.7 + table 3-1 col. 13** • The separation distance shown above may need to be increased if jet exhaust may cause hazardous conditions for ground servicing. **[RP] A14 P3.9.7 note 4** • **Clearance Distances on Aircraft Stands:** minimum 7.5m for Code letters E or F maneuvering in and out of stands. Special circumstances on nose-in stands may permit clearance reduction between terminal (including fixed passenger bridge) and an aircraft nose, and over any portion of stand provided with azimuth guidance by a visual guidance system. **[RP] A14 P3.13.6** • Clearance on a De-icing/anti-icing pad: Minimum 3.8m clear paved area around the aeroplane should be provided for the movement of de-icing/anti-icing vehicles [RP] A14 3.15.5. Minimum object separation distances specified in ICAO Annex 14 Table 3-1 should also be provided. **[RP] A14 3.15.9 and 3.15.10.** • Further guidance on de-icing pads are contained in ICAO (Doc 9640-AN/940).
ICAO Rationale	• Origin of the 4.0m clearance distance: Amendment 14 to Annex 14 7th edition. • No specific justification material available on taxiway shoulder width.	• No specific justification material available.	• Origin of the 7.5m clearance distance was derived from a minimum 7.5m wingtip clearance between an aircraft taxiing on a taxilane to an object. Possibility to operate with lower separation distances based on a safety assessment study.

Item	Runway Turn Pad	Oversteer Through Fillets	Nose and Tail Clearance at Aircraft Parking Position and De-icing Pads
BACG Agreement	• Minimum turn pad dimensions designed for the 777-300ER based ICAO ADM for Code F aeroplanes are adequate for the 777-8/9. • Depending on local conditions, each national authority and airport operator makes its own decision on the width, composition, and thickness for shoulder portions.	• 777-8/9 requires greater taxiway fillet radii than the 777-300ER. However, the 777-8/9 can safely maneuver a fillet designed for the 777-300ER while maintaining 4.0m MLG clearance to the pavement edge using judgmental oversteer. Oversteering should be considered as a mitigation to deviate from ICAO provision for the 'cockpit over centerline' clearance.	Clearances Maneuvering in/out of Aircraft Stand • ICAO SARPs to be followed for aircraft maneuvering in and out of stand. Possibility of reduced distance with appropriate measure such as visual docking guidance system, and marshaller(s). Clearance Around Parked Aircraft • No guidance from ICAO SARPs on clearances around stationary aircraft. Acceptable clearance to be determined by the aircraft operator and airport authority on a case by case basis. Safety assessment study to be made in case of reduction below these values.
Justification Material	• - 777-8/9 outer main gear wheel span. • - 777-8/9 steering system and cockpit visibility similar to 777-300ER.	• - 777-8/9 outer main gear wheel span. • 777-8/9 steering system and cockpit visibility similar to 777-300ER.	• History of satisfactory operations at airports worldwide with reduced clearances.

4 BACG Participating Members

4.1 Airports

Airport	Name	Position
Heathrow Airport	David Amer	Airfield Planning Manager
Fraport - Frankfurt Airport	Ibrahim Zantout	Dipl.-Ing. Head of Airport Infrastructure
Fraport - Frankfurt Airport	Holger Schwenke	Dipl.-Ing. FTU-F Project Director
ADP Group	Anthony Liot	Airport Planner
ADP Group - CDG Airport	Maryne Floch-Le Goff	Airside Development Manager
Bangalore Intl Airport Limited	SV Arunachalam	Head (Centre of Excellence), Strategy & Development
Sydney Airport	Ken Allcott	Airfield Planning Manager
Brussels Airport Company	Dirk Geukens	Senior Safety Expert
Changi Airport	Chee Kay Hyang	Changi Airport
Narita Airport	Jun Oka	Advisor Safety Management Department of Airports Operations Division

4.2 Authorities

Authority	Name	Position
Australia		
CASA	Darren Angelo	A/Manager Aerodrome Regulation
France		
DGAC	Patrice Desvallees	Programme Director, Strategic and Emerging Projects, Civil Aviation Safety Directorate
DGAC	Nicolas Turcot	Civil Aviation Technical Center (STAC), Aerodrome Safety
DGAC	Aubin Lopez	Civil Aviation Technical Center (STAC), Aerodrome Safety
DGAC	Christine Roure	French Civil Aviation Authority Aerodrome Safety Regulation Office
Germany		
Federal Ministry of Transportation and Digital Infrastructure	Florian Willers	Dipl.-Ing. Department of Airports (LF-15)

Authority	Name	Position
Italy		
ENAC	Costantino Pandolfi	Manager of Airport Department
United Kingdom		
Civil Aviation Authority	Andrew Badham	Policy Lead Aerodromes
UAE		
General Civil Aviation Authority	Mohammad Al Dossari	Director Air Navigation & Aerodromes Department
Singapore		
Singapore Civil Aviation Authority	Tseng Lee Wong	
Switzerland		
FOCA	Michael Muentener	Aerodrome Safety Inspector
Brazil		
ANAC	Rodrigo Flório Moser	Civil Aviation Regulation Expert, Department of Flight Standards
	Marcos Roberto Eurich	Manager, Airport Infrastructure (SIA)
Canada		
Transport Canada	Alyre F. Boudreau	Aerodromes Standards Inspector
China		
Civil Aviation Administration	Xian Cao	
United States		
Federal Aviation Agency	Steve Debban	National Resource Expert for Airport Design
Federal Aviation Agency	George Legarreta (Retired)	Civil Engineer, Airport Engineering
Spain		
AESA	Miguel Sevilla Escudero	Director of Airports and Air Navigation Safety
European Aviation Safety Agency		
EASA	Predrag Sekulic	Aerodromes Expert
International Civil Aviation Organization		
ICAO	Yong Wang	Chief, Airport Operations and Infrastructure Section
ICAO	Joseph Cheong	Technical Officer, Aerodromes

4.3 Airlines

Airline	Name	Position
Emirates	Paolo Guidotti	Senior Manager Flight Operations Performance
Lufthansa German Airlines	Stefan Amtsbuechler	Senior Manager Airport Authorization
ANA	Haruka Hirose	Operation Services, Airport Operations Support
	Tomoyuki Nakagawa	Flight Operations
Cathay Pacific	Lori Shaw	Line Operations Manager
Etihad Airways	David Storey	Manager Ground Safety & Quality – Ground Operations
	Nicolas Zika	Senior Manager Entry Into Service
British Airways	Tony Edwards	Airport Capital Manager

4.4 Industry Organizations

Organization	Name	Position
ACI	David Gamper (Chairman)	Director, Safety and Technical Affairs
Boeing	Evanicio Costa (Secretary)	Lead Engineer, Airport Compatibility Engineering
Boeing	Joseph Hoang	Manager, Airport Compatibility Engineering
Boeing	Dean Abdulaziz	Senior Engineer, Airport Compatibility Engineering
Boeing	Luca Guidoni	Engineer, Airport Compatibility Engineering
Boeing	Karen Dix-Colony (Retired)	Lead Engineer, Airport Compatibility Engineering
Boeing	Yonglian Ding	Senior Engineer, Airport Compatibility Engineering
Boeing	Jennifer Krohn-McKelvey	777X Program Integration Manager
Boeing	Christopher C Lin	777X Program Integration Manager
Boeing	Brian Pakkala	777-8/9 Chief Technical Pilot, Flight Technical Operations
IATA	Ton Van der Veldt	Assistant Director, Safety, Operations & Infrastructure
IFALPA	Heriberto Salazar Eguiluz	IFALPA AGE Committee Chairman
IFALPA	Alexander Dunbar	IFALPA AGE Vice Chairman
IFALPA	Gordon Margison	IFALPA AGE Technical Officer

Annex 1

Endorsement Letters from BACG2 Aviation Authorities

France

Germany

Italy

Spain

Switzerland

United Arab Emirates

United Kingdom

Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

MINISTÈRE DE LA TRANSITION ÉCOLOGIQUE ET SOLIDAIRE

Direction générale de l'Aviation civile

Paris, le 31 JUIL. 2018

Le directeur général

N° 180485 DG

Madame la Directrice Générale,

Par votre lettre du 29 avril 2016, vous avez invité la Direction Générale de l'Aviation Civile française (DGAC) à participer au groupe international non-OACI 'BACG2' (*Boeing 777-8/-9 Airport Compatibility Group*) regroupant un certain nombre d'experts de Boeing, de l'ACI, d'autorités nationales de l'aviation civile, d'exploitants d'aérodromes ou encore de certaines compagnies aériennes. L'objectif de ce groupe informel BACG2 était d'étudier les conditions de l'accueil potentiel des futurs Boeing B777-8/-9 (ou 'B777-X') à saumons d'ailes repliables sur des aérodromes ne respectant pas complètement les spécifications OACI relatives aux aérodromes de code F. En effet, les B777-X seront les premiers avions civils à changer d'envergure et de lettre de code : code F ou code E, suivant que les saumons d'ailes sont ou non dépliés.

Par votre lettre du 14 juin 2018, vous nous avez transmis pour avis le rapport du BACG2 intitulé *« Common Agreement Document »* (CAD), version datée de mai 2018.

Des travaux du BACG2, je retiens, en particulier que, dans la plupart des cas, l'accueil futur des B777-X sur des aérodromes ne respectant pas l'ensemble des spécifications relatives aux aérodromes de code F devra faire l'objet d'études locales de compatibilité et de sécurité, aéroport par aéroport. Ces études de sécurité devront notamment être menées conformément au chapitre 4 (compatibilité aéroportuaire) des PANS-Aérodromes (Procédures pour les services de navigation aérienne aérodromes) de l'OACI.

Pour pallier les cas de défaillances du système de repli ou d'extension des saumons de voilure des B777-X, des procédures spécifiques 'non-normales' devront également être définies en amont, aéroport par aéroport.

Dans ce contexte, et après analyse par mes services, j'ai le plaisir de vous informer que je suis favorable à la diffusion du document CAD du BACG2 comme guide, en soutien aux travaux et études de sécurité que doivent mener les exploitants des aérodromes ne respectant pas l'ensemble des spécifications relatives aux aérodromes de code F.

Madame Angela GITTENS
Directrice Générale
AIRPORTS COUNCIL INTERNATIONAL (ACI-World)
800 rue du Square Victoria
Suite 1810, P.O. Box 302
Montréal, Québec H4Z 1G8, Canada

50, rue Henry Farman
75720 Paris cedex 15

Le document BACG2 peut également être considéré comme une contribution informelle potentiellement utile à d'autres organisations internationales ou groupes de travail qui pourraient avoir à traiter de l'accueil d'avions à saumons d'ailes repliables.

Je vous prie de croire, Madame la Directrice Générale, à l'assurance de mes sentiments les meilleurs.

Patrick GANDIL

COURTESY TRANSLATION

Dear Madam Director-General,

By your letter of April 29, 2016, you invited the French General Directorate of Civil Aviation (DGAC) to participate in the international non-ICAO group 'BACG2' (Boeing 777-8/-9 Airport Compatibility Group) gathering a number of experts from Boeing, ACI, national civil aviation authorities, aerodrome operators, international organizations and from some airlines. The objective of this informal BACG2 group was to study the conditions of the potential future accommodation of the future Boeing B777-8/-9 (or B777-X) equipped with folding wingtips, at aerodromes which do not fully comply with the aerodrome specifications of Code-F. Indeed, the B777-X will be the first civil aeroplanes which will change their wingspan corresponding to code F or E (ICAO Aerodrome Reference code letters), depending on whether wingtips are unfolded or not .

Attached to your letter of June 14, 2018, you forwarded to me, for opinion, the BACG2 report entitled "Common Agreement Document" (or CAD), in its dated version of May 2018.

In particular, what stands out for me in relation to the work accomplished by the BACG2 group is that in most cases, the potential future accommodation of B777-X operations on airports which do not fully comply with the aerodrome specifications of Code-F shall be subject to local safety studies, on a case by case basis, aerodrome by aerodrome. These safety studies shall in particular be done in accordance with the provisions of Chapter 4 (Airport compatibility) of the ICAO PANS-Aerodrome (Procedures for Air Navigation Services Aerodromes).

In order to anticipate and potentially mitigate for future failures of the B777-X folding wingtips mechanisms, specific 'non-normal' procedures will also have to be defined before any operation takes place, on a case by case basis, aerodrome by aerodrome.

In this context, and after an analysis of the document by my services, I am pleased to inform you that I consider that the BACG2 CAD document can be disseminated by ACI, as informal guidance material, to support the work and safety assessment activities to be made by the operators of aerodromes which do not fully comply with the aerodrome specifications of Code-F.

Additionally, we view the BACG2 documentation as an informal contribution which could be potentially helpful to other international organizations and working groups which may deal with the accommodation of aeroplanes with folding wingtips.

Yours faithfully.

Patrick GANDIL

Federal Ministry
of Transport and
Digital Infrastructure

Federal Ministry of Transport and Digital Infrastructure • Postal Address 20 01 00, D-53170 Bonn

Ms. Angela Gittens
Director General
Airports Council International
800 rue du Square Victoria
P O Box 302
Montreal, Quebec H4Z 1G8
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Johann Friedrich Colsman
Director General of Civil Aviation

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AL-LF@bmvi.bund.de
www.bmvi.de

Subject: Boeing 777-X Airport Compatibility Group (BACG2)
Common Agreement Document

Our Ref.: LF15/6111.4/16
Date: Bonn, 01.07 2018
Page 1 of 2

Dear Ms. Gittens, Dear Angela,

The Boeing B777-X Airport Compatibility Group (BACG2) is an informal group consisting of representatives of Civil Aviation Authorities, Airport Operators and Aircraft Operators. It was formed to agree and promote a common position among the group members, with respect to the operation of the 777-8/-9 at airports that currently do not meet ICAO Aerodrome Reference Code Letter F specifications.

The German Federal Ministry of Transport and Digital Infrastructure considers the recommendations and guidance materials contained in the BACG2 Common Agreement Document (May 2018 version) to constitute a planning aid for aeronautical studies to facilitate safe and harmonized operations of the Boeing 777-8/-9 at airports within the State, and for any necessary adaptation of the State's regulations.

We note that the BACG2 documentation will be presented to ICAO, and that a proposal has been presented to the Aerodrome Design and Operations Panel to amend Annex 14, Annex 4 and the PANS-Aerodromes to include language to consider aeroplanes with folding wingtips.

Additionally, we view the BACG2 documentation as a contribution to other international organizations and working groups which may deal with the accommodation of aeroplanes with folding wingtips.

Yours sincerely,
For the Federal Ministry of Transport and Digital Infrastructure

Director General of Civil Aviation

ENAC-DG-16/07/2018-0077954-P

Director General

Ms. Angela Gittens
Director General
Airports Council International
800 rue du Square Victoria
P O Box 302
Montreal, Quebec H4Z 1G8
Canada

Subject: **Boeing 777-X Airport Compatibility Group (BACG2) – CAD**

Dear Ms. Gittens,

The Boeing B777-X Airport Compatibility Group (BACG2) is an informal group consisting of representatives of Civil Aviation Authorities, Airport Operators and Aircraft Operators. It was formed to agree and promote a common position among the group members, with respect to the operation of the 777-8/9 at airports that currently do not meet ICAO Aerodrome Reference Code Letter F specifications.

ENAC (the Italian Civil Aviation Authority) considers the recommendations and guidance materials contained in the BACG2 Common Agreement Document - CAD (May 2018 version) to constitute a planning aid for aeronautical studies to facilitate safe and harmonized operations of the Boeing 777-8/9 at airports within the State, and for any necessary adaptation of the State's regulations.

We note that the BACG2 documentation will be presented to ICAO, and that a proposal has been presented to the Aerodrome Design and Operations Panel to amend Annex 14, Annex 4 and the PANS-Aerodromes to include language to consider airplanes with folding wingtips.

Additionally, we view the BACG2 documentation as a contribution to other international organizations and working groups which may deal with the accommodation of airplanes with folding wingtips. Further than this we consider, as Italian CAA, Eng. Costantino Pandolfi (c.pandolfi@enac.gov.it) and Cpt. Giorgio Vanno Antonelli (g.vannoantonelli@enac.gov.it) as our experts for all the described items on this document.

Respectfully,

Director General

Alessio QUARANTA

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DG

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Ms. Angela Gittens
Director General
Airports Council International
800 rue du Square Victoria
P O Box 302
Montreal, Quebec H4Z 1G8
Canada

Dear Ms. Gittens,

The Boeing B777-X Airport Compatibility Group (BACG2) is an informal group consisting of representatives of Civil Aviation Authorities, Airport Operators and Aircraft Operators. It was formed to agree and promote a common position among the group members, with respect to the operation of the 777-8/9 at airports that currently do not meet ICAO Aerodrome Reference Code Letter F specifications.

The Spanish Aviation Safety and Security Agency (AESA) considers the recommendations and guidance materials contained in the BACG2 Common Agreement Document (May 2018 version) to constitute a planning aid for aeronautical studies to facilitate safe and harmonized operations of the Boeing 777-8/9 at airports within the State, and for any necessary adaptation of the State's regulations.

We note that the BACG2 documentation will be presented to ICAO, and that a proposal has been presented to the Aerodrome Design and Operations Panel to amend Annex 14, Annex 4 and the PANS-Aerodromes to include language to consider aeroplanes with folding wingtips.

Additionally, we view the BACG2 documentation as a contribution to other international organizations and working groups which may deal with the accommodation of aeroplanes with folding wingtips.

Respectfully,

Miguel Sevilla Escudero.
Head of Aerodrome Certification Department.
Spanish Aviation Safety and Security Agency (AESA)

Cc: David Gamper - ACI World
Boeing Commercial Airplanes

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of the Environment, Transport, Energy and Communications DETEC

Federal Office of Civil Aviation FOCA
Safety Division - Infrastructure

CH-3003 Bern, FOCA - SIAP

Airmail
Ms. Angela Gittens
Director General
Airports Council International
800 rue du Square Victoria
P.O. Box 302
Montreal, Quebec H4Z 1G8
Canada

Reference: FOCA waa / 051.1-00006/00008/00004/00001/00007
Your reference: ACI letter dated 15 June 2018
Bern, 10.8.2018

Boeing 777-X Airport Compatibility Group (BACG2) – Common Agreement Document

Dear Director General,

The Boeing B777-X Airport Compatibility Group (BACG2) is an informal group consisting of representatives of Civil Aviation Authorities, Airport Operators and Aircraft Operators. It was formed to develop and promote a common understanding among the group members regarding the future operation of the Boeing 777-8/9 at airports that currently do not meet ICAO Aerodrome Reference Code Letter F specifications.

The Swiss Federal Office of Civil Aviation (FOCA) considers the recommendations and guidance materials contained in the BACG2 Common Agreement Document (May 2018 version) to be in line with the provisions in amendment 14 to ICAO Annex 14, Vol. I, becoming applicable on 8 November 2018. They constitute a useful planning aid for aeronautical studies aiming at the facilitation of safe and harmonized Boeing 777-8/9 operations, in particular at existing airports.

Furthermore, we appreciate that the BACG2 documentation was presented to the ICAO Aerodrome Design and Operations Panel (ADOP) in order to allow the consideration of aeroplanes with folding wingtips in future amendments to ICAO Annex 14, Annex 4 and PANS-Aerodromes.

Yours sincerely,

Federal Office of Civil Aviation

Pascal A. Waldner
Deputy Head of Safety Division Infrastructure
Head of Section Aerodromes and Air Navigation Obstacles

Michael Müntener
Aerodrome Safety Inspector
Section Aerodromes and Air Navigation Obstacles

Federal Office of Civil Aviation FOCA
P.O. Box 41, CH-8058 Zurich Airport
www.foca.admin.ch

COO.2207.111.4.3962041

Reference: FOCA waa / 051.1-00006/00008/00004/00001/00007

Copy by e-mail to:

- ACI, David Gamper, Director, Safety and Technical Affairs, dgamper@aci.aero
- Boeing, Evanicio Costa, Lead Engineer, Airport Compatibility Engineering, evanicio.c.costa@boeing.com

Internally by link to:

- L-SISS, SIAP

2 / 2

COO.2207.111.4.3962041

الهيئة العامة للطيران المدني
GENERAL CIVIL AVIATION AUTHORITY

United Arab Emirates

File: GCAA/ANA/8873/AOP/20180802
Date: 8th August 2018

Ms. Angela Gittens
Director General
Airports Council International
800 rue du Square Victoria
P O Box 302
Montreal, Quebec H4Z 1G8
Canada

Greetings,

Boeing 777-X Airport Compatibility Group (BACG2) – Common Agreement Document

The United Arab Emirates (UAE) General Civil Aviation Authority (GCAA) has reviewed BACG2 Common Agreement Document (May 2018 version) (CAD) and considers the CAD a positive step to facilitate aircraft operations of the Boeing 777-8/9.

The recommendations and guidance materials contained in the CAD will establish a foundation for planning and an aid for Aeronautical Studies, to facilitate safe and harmonized operations of the Boeing 777-8/9 at airports within all States, and for any necessary adaptation of the State's regulations if acceptable to the individual states.

Consequently, the UAE GCAA endorses this document for use as explained above and provided that no provision contained in the CAD is interpreted as having a binding effect on the UAE, with respect to the approval of any such deviation, since this CAD has been developed based on several assumptions that do not preclude the environment at a specific UAE airport.

Respectfully,

Mohammad Al Dossari
Director Air Navigation & Aerodromes Department

Cc:
Mr David Gamper - ACI World
Mr Boeing Commercial Airplanes

Federal Authority | هيئة إتحادية

Tel: +971 2 4447 666 هاتف ص.ب: ٦٥٥٨ أبوظبي، دولة الإمارات العربية المتحدة رؤيتنا: منظومة طيران مدني آمنة ورائدة ومستدامة
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Safety and Airspace Regulation Group
Airspace, Air Traffic Management &
Aerodromes (AAA)

Ms. Angela Gittens
Director General
Airports Council International
800 rue du Square Victoria
P O Box 302
Montreal, Quebec H4Z 1G8
Canada

30 July 2018

Dear Ms Gittens,

The Boeing B777-X Airport Compatibility Group (BACG2) is an informal group consisting of representatives of Civil Aviation Authorities, Airport Operators and Aircraft Operators. It was formed to agree and promote a common position among the group members, with respect to the operation of the 777-8/9 at airports that currently do not meet ICAO Aerodrome Reference Code Letter F specifications.

The United Kingdom Civil Aviation Authority considers the recommendations and guidance materials contained in the BACG2 Common Agreement Document (May 2018 version) to constitute a planning aid for aeronautical studies to facilitate safe and harmonized operations of the Boeing 777-8/9 at airports within the State.

We note that the BACG2 documentation will be presented to ICAO, and that a proposal has been presented to the Aerodrome Design and Operations Panel to amend Annex 14, Annex 4 and the PANS-Aerodromes to include language to consider aeroplanes with folding wingtips.

Additionally, we view the BACG2 documentation as a contribution to other international organizations and working groups which may deal with the accommodation of aeroplanes with folding wingtips.

Yours sincerely

Inez Bartolo
Manager Aerodromes
Airspace, Air Traffic Management &
Aerodromes (AAA)
Safety & Airspace Regulation Group

Andrew Badham
Policy Lead Aerodromes
Airspace, Air Traffic Management &
Aerodromes (AAA)
Safety & Airspace Regulation Group

Cc: David Gamper - ACI World
Boeing Commercial Airplanes

Civil Aviation Authority
1NE, SARG, Aviation House, Gatwick Airport South, Gatwick, West Sussex. RH6 0YR
Telephone: 01293 573271 Email: Inez.bartolo@caa.co.uk Website: www.caa.co.uk

Annex 2

Recommendation Letters from BACG2 Aviation Authorities

United States

U.S. Department
of Transportation
Federal Aviation Administration

Office of Airport Safety and Standards

800 Independence Ave., SW
Washington, DC 20591

JUL 3 0 2018

Ms. Angela Gittens
Director General
Airports Council International
800 rue du Square Victoria
P O Box 302
Montreal, Quebec H4Z 1G8
Canada

Dear Ms. Gittens:

The Boeing B777-X Airport Compatibility Group (BACG2) is an informal group consisting of representatives of Civil Aviation Authorities, Airport Operators and Aircraft Operators. It was formed to agree on, and promote, a common position among the group members, with respect to the operation of the 777-8/9 at airports that currently do not meet ICAO Aerodrome Reference Code Letter F specifications.

While the United States Federal Aviation Administration (FAA) does not explicitly endorse the BACG2 Common Agreement Document (May 2018 version) it does consider it an industry best practices aid for planning and aeronautical studies to facilitate safe and harmonized operations of the Boeing 777-8/9 at airports. FAA Engineering Brief 94 *Accommodating the Boeing 777 Folding Wingtip Airplane onto Airports* is the benchmark for 777-8/9 airport integration within the United States and its territories.

We note that the BACG2 documentation will be presented to ICAO, and that a proposal has been presented to the Aerodrome Design and Operations Panel to amend Annex 14, Annex 4 and the PANS-Aerodromes to include language to consider aeroplanes with folding wingtips.

Additionally, we view the BACG2 documentation as a contribution to other international organizations and working groups which may deal with the accommodation of aeroplanes with folding wingtips.

Sincerely,

John R. Dermody, P.E.
Director of Airport Safety
and Standards

cc: David Gamper – ACI World
Boeing Commercial Airplanes

Attachment A

Safety Analysis of Airfield Items

Table of Contents

List of Figures

List of Tables

1 Introduction

1.1 Methodology

The methodology that the BACG2 proposed for establishing the minimum operational requirements and infrastructure needs for the 777-8/9 aircraft is based on that which is defined in ICAO PANS Aerodromes, Document 9981, First Edition, 2015, Attachment B to Chapters 3, SAFETY ASSESSMENT METHODOLOGIES FOR AERODROMES and 4 PHYSICAL CHARACTERISTICS OF AERODROMES.

A safety analysis in four steps was used for each infrastructure characteristic and critical equipment that may be affected by the introduction of the 777-8/9: runways, taxiways, runway (RWY) separations, taxiway (TWY) separations and other items. The four steps are as follows:

- Baseline identification of the regulatory compliance such as relevant ICAO Standards and Recommended Practices (SARPs).
- Hazard identification and analysis.
- Risk assessment and possible mitigation measures.
- BACG2 Conclusion.

1.2 Risk Assessment

Depending on the nature of the risks, the safety risk assessments and evaluations are based on three different types of rationale, as defined in ICAO Doc 9981 PANS Aerodromes, Second Edition, 2016, Chapter 3:

1.2.1 Type A

Aircraft and system performance – The risk level is dependent upon airplane and system performance (e.g. more accurate navigation capabilities), handling qualities and infrastructure characteristics. Risk assessment can then be based on airplane and system design, validation, certification, simulation results, and an accident or incident analysis.

1.2.2 Type B

Existing aircraft database measurements versus accident analysis – For other hazards, the aircraft behavior is not really linked with specific aircraft performance and handling capabilities, and can be calculated from existing aircraft measurements. Risk assessment should then be based on statistics (e.g. deviations) for existing aircraft or accident analyses, and development of generic quantitative risk models can be well adapted.

1.2.3 Type C

Geometric argument – In this case, a risk assessment study is not needed. A simple geometric argument is sufficient to calculate infrastructure requirements without waiting for certification results or collecting deviation statistics for existing aircraft.

1.3 Basic Principles

The recommendations in this document assume that the 777-8/9 will be the largest aircraft using the airport and all other traffic will be no larger than code E. The recommendations may not be applicable for other Code Letter F aircraft for which a separate safety assessment study will be needed.

When the wing tips are extended and in transition, the 777-8/9 will be an ICAO Aerodrome Reference Code (ARC) letter F aircraft. When the wing tips are folded the 777-8/9 will be an ICAO Code letter E aircraft.

Application of the different level of aerodrome infrastructure recommendations for the 777-8/9 operations compared to Code Letter F requirements is subject to the following: Approval to operate in an ICAO Code Letter E OFZ will be based on Circular 301 and Circular 345[1]

It may be permissible to operate with lower separation margins than agreed in this document if a safety assessment study indicates that such lower margins would not adversely affect the safety or significantly affect the regularity of operations of the 777-8/9 while taking local conditions into account.

The ICAO Baseline refers to the Seventh Edition of Annex 14, volume I up to and including Amendment 14.

The following changes from Amendment 14 include revised recommendations on runway and runway shoulder width; taxiway and taxiway shoulder width; tire edge clearance, and RWY-TWY separation based on strip width:

- Runway Strip width.
    - Runway strip reduced from 300m to 280m for Code Number 3 and 4 runways.
- Runway plus shoulder width.
    - Runway width will be based on OMGWS (Outer Main Gear Wheel Span). For the 777-8/9 (12.75m) the required RWY width will be 45m.
    - Because the 777-9 is a Code Letter F aircraft with wingtips extended while on the runway, and because the 777-8/9 has 2 engines, the required RWY shoulder width will be 7.5m.

[1] ICAO Circular 301: New Larger Airplanes — Infringement of the Obstacle Free Zone: Operational Measures and Aeronautical study, December 2005; ICAO Circular 345: COLLISION RISK MODEL (CRM) OBSTACLE ASSESSMENT SURFACES (OASs) FOR ILS OPERATIONS, expected publication November 2018

- Taxiway plus shoulder width.
    - Taxiway width will be based on OMGWS. The 777-8/9 will require a TWY width of 23m.
    - Because the 777-8/9 is a Code Letter F aircraft with wingtips extended while on the taxiway, the required TWY shoulder width will be 10.5m.
- Tire edge clearance will be based on OMGWS. The 777-8/9 will require a 4.0m tire edge clearance.
- Runway to taxiway separation.
    - Because the 777-8/9 is a Code Letter F aircraft with wingtips extended while on the runway, the required RWY-TWY separation will be 180m.

The changes have been transmitted to States and international organizations for comments via State letter AN4/1.2.27 – 18/23. ICAO Council prescribed 16 July 2018 as the date on which it will become effective, and to Contracting States to provide disapproval before that date.

A summary of 777-8/9 compliance with different Annex 14 baselines can be found in Table 1-1.

Table 1-1. Summary of 777-8/9 Compliance with Different Annex 14 Baselines

FWT Operations	**Infrastructure Design Baselines - ICAO Annex 14 Various Editions 777-8/9 Operations Compatibility**		
	Reference Standard: ICAO Annex 14 7th Edition– Amendment 14th		
Topic	**Code Letter E Infrastructures Design Per ICAO Annex 14, 6th Edition**	**Code Letter E Infrastructures Design Per ICAO Annex 14, 7th Edition**	**Code Letter E Infrastructures Design Per ICAO Annex 14, 7th Edition (Am. 14)**
Runway width	✈ Meets standard.	✈ Meets standard.	✈ Meets standard.
Runway shoulders width	✈ Meets standard.	✈ Meets standard.	✈ Meets standard.
Taxiway width	✈ Meets standard.	✈ Meets standard.	✈ Meets standard.
Taxiway shoulder width	✈ Meets standard.	✈ Meets standard.	✈ Meets standard. ✈ Requires mitigation if the wing tip is not fully folded (i.e. preparation before takeoff and after landing).
Taxiway graded Strip	✈ Meets standard.	✈ Meets standard.	✈ Meets standard.

FWT Operations	Infrastructure Design Baselines - ICAO Annex 14 Various Editions 777-8/9 Operations Compatibility		
	Reference Standard: ICAO Annex 14 7th Edition– Amendment 14th		
Topic	**Code Letter E Infrastructures Design Per ICAO Annex 14, 6th Edition**	**Code Letter E Infrastructures Design Per ICAO Annex 14, 7th Edition**	**Code Letter E Infrastructures Design Per ICAO Annex 14, 7th Edition (Am. 14)**
Runway-taxiway separation	✈ Meets standard.	✈ Meets standard.	✈ Meets Standard if the 777-8/9 with FWT extended on the runway (Code Letter F)/ Code Letter E on parallel Taxiway. ✈ Requires mitigation if the 777-8/9 with FWT extended on the taxiway (Code Letter F)/ Code Letter E on parallel Runway.
Taxiways separation ***(Note: taxiway to object: similar to the case where a Code Letter E is on an adjacent taxiway)***	✈ Meets standard if FWT folded. ✈ Meets standard if one aircraft Code Letter E/one 7778/9 with FWT extended (ex. Dual entrance TWY). ✈ Requires mitigation if two 777-8/9 with FWT extended (ex. Dual entrance TWY)[1].	✈ Meets standard if FWT folded. ✈ Requires mitigation if one aircraft Code Letter E /one 777-8/9 with FWT extended (ex. Dual entrance TWY)[1]. ✈ Requires mitigation if two 777-8/9 with FWT extended (ex. Dual entrance TWY)[1].	✈ Meets standard if FWT folded. ✈ Requires mitigation if one aircraft Code Letter E /one 777-8/9 with FWT extended (ex. Dual entrance TWY). ✈ Requires mitigation if two 777-8/9 with FWT extended (ex. Dual entrance TWY) Note: Specific assessment required for RETs.
Taxiway on bridges	✈ Meets standard.	✈ Meets standard.	✈ Meets standard.
Taxiway to object	✈ Meets standard.	✈ Meets standard if FWT folded. ✈ Requires mitigation if 777-8/9 with FWT extended[1].	✈ Meets standard if FWT folded. ✈ Requires mitigation if 777-8/9 with FWT extended.
Taxilane separation	✈ Meets standard if FWT folded. ✈ Requires mitigation if 777-8/9 with FWT extended[1].	✈ Meets standard if FWT folded. ✈ Requires mitigation if 777-8/9 with FWT extended[1].	✈ Meets standard if FWT folded. ✈ Requires mitigation if 777-8/9 with FWT extended.
Taxilane to object	✈ Meets standard if FWT folded. ✈ Requires mitigation if 777-8/9 with FWT extended[1].	✈ Meets standard if FWT folded. ✈ Requires mitigation if 777-8/9 with FWT extended[1].	✈ Meets standard if FWT folded. ✈ Requires mitigation if 777-8/9 with FWT extended.

Note: Code Letter E considered in the table – full wingspan.

1.4 Abbreviations and Acronyms

Acronym or Term	Definition
[RP] A14 P3.8.3	ICAO Recommended Practices Annex 14 Paragraph 3.8.3
[STD]	ICAO Standard
ARC	Aerodrome Reference Code
ACN	Aircraft classification number
ANC	ICAO Air Navigation Commission
ADM Pt2	ICAO Aerodrome Design Manual Part 2
ATS	Air Traffic Services
CSA	Critical Sensitive Area
FOD	Foreign Object Debris
FWT	Folding Wingtip
GSE	Ground Service Equipment
IIWG	International Infrastructure Working Group
ILS	Instrument Landing System
JAR 25	Joint Aviation Requirements for Large Airplane
JAR AWO	Joint Aviation Requirements All Weather Operations
NLA	New Large Aircraft
OFZ	Obstacle Free Zone
OLS	Obstacle Limitation Surface
OCP	Obstacle Clearance Panel
OCA/H	Obstacle Clearance Altitude/Height
OMGWS	Outer Main Gear Wheel Span
OPS	Operations
PCN	Pavement classification number
RESA	Runway End Safety Area
ARFF, RFF	Aircraft Rescue and Fire Fighting, Rescue and Fire Fighting
RTO	Rejected Take-Off
RWY	Runway
SOPs	Standard Operating Procedures
TWY	Taxiway
Vmcg	Minimum controllable speed on the ground
WP	Working Paper

2 Part A: Runways

2.1 Runway Width

With Amendment 14 to Annex 14 Seventh Edition, recommendations for runway width will be based on OMGWS instead of wingspan. The 777-8/9 will require a 45m wide runway (previously considered a Code Letter E runway) based on the new classification, therefore this section will not be addressed.

2.2 Runway Shoulder Width

With Amendment 14 to Annex 14 Seventh Edition, recommendation on runway shoulder width will be based on OMGWS and number of engines instead of wingspan. The 777-8/9 will require a 7.5m wide runway paved shoulders on both sides (previously considered a Code Letter E runway shoulder) based on the new classification, therefore this section will not be addressed. Different shoulder composition could be envisaged on the basis of an aeronautical safety study. Refer to ICAO Doc 9981 (PANS Aerodromes), Appendix to Chapter 4, for guidelines.

3 Part B: Taxiways

3.1 Taxiway Width

With Amendment 14 to Annex 14 Seventh Edition, recommendation on taxiway width will be based on OMGWS instead of wingspan. The 777-8/9 will operate on a 23m wide taxiway (previously considered a Code Letter E taxiway) based on the new classification, therefore this section will not be addressed. Operation on narrower taxiways could be envisaged on the basis of an aeronautical safety study. Refer to ICAO Doc 9981 (PANS Aerodromes), Appendix to Chapter 4, for guidelines.

3.2 Taxiway Shoulder Width

3.3 Synopsis

ICAO Baseline	• Overall width of TWY + shoulders on straight portion: - 38m where Code Letter is E - 44m where Code Letter is F **[RP] A14 P3.10.1** • The surface should be so prepared as to resist erosion and ingestion of surface material by airplane engines. **[RP] A14 P3.9.2.** • Intended to protect an a/c operating on the TWY and to reduce the risk of damage to an a/c running off the TWY. **ADM Pt2 p1.6.1 and ADM Pt2 p1.6.2 + Table 1-1**.			
Hazard Analysis	**Hazard Identification**		**Risk 1** **Shoulder erosion and engine ingestion at taxiing**	**Risk 2** **Aircraft damage after incursion on taxiway shoulder**
	Main causes and accident factors		• Powerplant (engine position, engine power). • Taxiway shoulder width and cohesion. • Taxiway centerline deviation factors (see taxiway veer-off risk).	• No 777-8/9 specific issue
	Severity	Theoretical	• Minor except if undetected and followed by potentially major engine failure at take-off	
		In-service		
Risk Assessment	**Risk assessment category**		**C** **(geometric argument)**	
	Main technical materials		• 777-8/9 jet blast velocity at idle (most of taxi time is spend at idle thrust). • 777-8/9 jet blast velocity contour at break-away and the transient (temporary) nature of the breakaway thrust application. • Information about lateral deviation from taxiway centreline (see Attachment B).	
BACG2	• On straight portions, Code Letter E compliant: shoulder should be provided for an overall pavement width of 38m, to prevent jet-blast erosion and engine ingestion, regardless of folding wingtip position. • Depending on local conditions, decision on the width for curved portions, composition and thickness for straight and curved portions by each national authority and airport operator. • Different shoulder composition could be envisaged, based on an aeronautical safety study. Refer to ICAO Doc 9981 (PANS Aerodromes), Appendix to Chapter 4, for guidelines.			

3.4 ICAO Baseline

See previous synopsis.

3.5 Hazard Analysis

3.5.1 Hazard Identification

The main purposes of the provision of taxiway shoulders are:

- To prevent jet engines that overhang the edge of a taxiway from ingesting stones or other objects that might damage the engine.
- To prevent erosion of the area adjacent to the taxiway.

In addition and in theory, the risk of damage to an aircraft running off the taxiway should be taken into account for taxiway shoulder design. The shoulder width should not be regarded as an issue for a specific airplane; in theory, taxiway shoulders should be designed to allow pilots to steer the aircraft back onto taxiway in case of minor lateral excursion. This also depends on the aircraft Code Letter.

BACG2 members decided to focus on geometric issues. Decisions on taxiway shoulders composition and thickness will be made by each national authority and airport operator.

Additionally, the current low frequency and low severity of taxiway veer-off case does not justify any further evaluation of this risk (Attachment B: B57)

These are the reasons why only shoulder erosion and engine ingestion are considered.

3.5.2 Causal Analysis

The main causes and accident factors for FOD are

- Powerplant characteristics (engine position, engine power).
- Taxiway shoulder width and cohesion.
- Taxiway centerline deviation factors (see taxiway veer-off risk).

3.5.3 Consequences Analysis

The erosion and ingestion hazard when taxiing could be classified as a minor risk except if it is undetected by crew and followed by a potentially major engine failure at take-off.

3.6 Risk Assessment

A geometric argument is relevant to establish infrastructure requirements relative to jet blast and engine ingestion issues (cf. risk assessment). Shoulder erosion and engine ingestion issues come under "Type C" risk assessment category.

The location of the engine centerline of the 777-8/9 is approximately 1 meter further outboard from the fuselage centerline than the 777-300ER. A comparison of the outer engine height above ground shows that the 777-8/9 nacelle clears the ground by 10cm more than the 777-300ER at the minimum clearance condition (Attachment B, B6, 26).

The width of the 777-8/9 breakaway exhaust velocity contour width at 56km/h is estimated to extend approximately 16m from the fuselage centerline and is similar to that of the 777-300ER. At a total width of 32m, this is easily contained within the 38m total pavement width recommended for Code Letter E aircraft. It should be noted that breakaway thrust is momentary since the pilot will reduce power as soon as the aircraft starts rolling, well before the exhaust velocity contour has reached the stabilized steady-state size shown. (See Attachment B: B23-24).

As for the ingestion risk, the ingestion contour for the 777-8/9 at breakaway thrust extends 7.8m laterally from the nacelle centerline, placing it at a total distance of 18.5m from the fuselage centerline. Despite the slightly larger engine span than the 777-300ER, the 777-8/9 ingestion contour would still be contained within a 38m shoulder width (Attachment B: B27)

The 777-9 may be completing a portion of its taxi route while in Code Letter F configuration with the wingtips extended, such as when approaching the holding point for takeoff. Per Annex 14 recommendation, wider shoulders should be used for Code Letter F aircraft. However, the position of the wingtips does not affect jet blast and ingestion contours for the 777-8/9, both being the parameters used in determining a suitable shoulder width for the aircraft. This allows a conclusion that a 38m taxiway shoulder width will avoid shoulder erosion and engine ingestion risks for 777-8/9 taxiing with a level of safety equal to current 777 models, regardless of folding wingtip position.

3.7 Conclusions

BACG2 members agree:

- On straight portions, Code Letter E compliant: shoulder should be provided for an overall pavement width of 38m, to prevent jet-blast erosion and engine ingestion, regardless of folding wingtip position.
- Depending on local conditions, decision on the width for curved portions, composition and thickness for straight and curved sections is left to each national authority and airport operator.
- Different shoulder composition could be envisaged on the basis of an aeronautical safety study. Refer to ICAO Doc 9981 (PANS Aerodromes), Appendix to Chapter 4, for guidelines.

4 Part C: Runway Separations

4.1 Synopsis

<table>
<tr><td rowspan="1">ICAO Baseline</td><td colspan="5">

- Runway to Parallel Taxiway Separation:
  - Amendment 14 to Annex 14 7th edition reduces runway strip width for Code Number 3 and 4 precision approach runways from 150m each side of the runway centerline to 140m. This allows for a runway to parallel taxiway separation of 180m for Code Letter F and 172.5m for Code Letter E for instrument runways. For non-instrument runways, parallel taxiway separations are 115m for Code Letter F and 107.5m for Code Letter E.
[**RP] A14 P3.9.8 + Table 3-1 columns 5&9, ADM P2 Table 1-1**
- OFZ:
  - OFZ half width = 60m where Code Number is 4 and 77.5m where Code Letter is F, then inner transitional surface slope 1:3.
[Std] A14 P4.1.11 & 4.1.12 + 4.1.17 to 24, Table 4-1
Note e) to Table 4-1: Where the Code Letter is F (Column (3) of Table 1-1); the width is increased to 155 m. For information on Code Letter F airplanes equipped with digital avionics and track hold guidance that provide steering commands to maintain an established track during the go-around manoeuvre, see Circular 301 "*New Larger Airplanes- Infringement of the Obstacle Free Zone: Operational Measures and Aeronautical safety study*".
- Runway Holding Positions:
  - Takeoff RWY, non-instrument & non-precision approach minimum holding position distances - no change compared with Code Letter E (75m).
  - Precision approaches all CATs: Minimum holding position distances increased to 107.5 m for Code Letter F (90m for Code Letter E). **[RP] A14 Table 3-2 footnote 'c'**
  - A/C at precision approach holds - not to interfere with the operation of Nav. Aids. **[Std] A14 P3.12.6**

</td></tr>
<tr><td rowspan="4">Hazard Analysis</td><td colspan="2">Hazard Identification</td><td>Risk 1
Collision between an aircraft in flight and an object (fixed or mobile) on the airport</td><td>Risk 2
Collision between an aircraft veering off the runway and an object (fixed or mobile) on the airport</td><td>Risk 3
Perturbation of ILS signal by a taxiing or stopped aircraft</td></tr>
<tr><td colspan="2">Main causes and accident factors</td><td>• Human factors (crew and ATS).
• Weather conditions (visibility).
• Aircraft: mechanical failure (such as engine, hydraulic system, flight instruments, and control surface), wingspan.
• Airport layout and facilities: location of holding points and parallel taxiway, ground radar system.
• Obstacle density (taxiing aircraft included), marking, lighting and publication.</td><td>• Runway veer-off causes and accident factors. (See runway veer-off risk)
• Lateral veer-off distance.
• Aircraft size.
• Airport layout: location of holding points and parallel taxiway.
• Obstacle density. (taxiing aircraft included).</td><td>• Aircraft position and NAV-aids.
• Aircraft characteristics (such as height, length, and shape, component).
• Obstacle density.</td></tr>
<tr><td rowspan="2">Severity</td><td>Theoretical</td><td>• Catastrophic.</td><td rowspan="2">• Potentially catastrophic.</td><td rowspan="2">• Potentially major.</td></tr>
<tr><td>In-service</td><td>• No known cases reported in-service.</td></tr>
</table>

<table>
<tr><th rowspan="2">Risk Assessment</th><th>Risk assessment category</th><th>A (aircraft performance)
B (generic risk model)
C (geometric argument)</th><th>B
(generic risk model)</th><th>Generic risk assessment not feasible</th></tr>
<tr><td>Main technical materials</td><td>• ICAO Circular 345 states that when digital autopilot or flight director with track hold guidance is used for the approach, a code Letter F airplane can be contained within the code E OFZ.
• The 777-8/9 has digital autopilot/flight director and track hold guidance.
• FAA Regulations (see Attachment F).</td><td>• Declining trend of Code E and F runway veer-off frequency over the years.
• Code Letter E design separation degraded by 3.45m increase in half-wingspan. (See Attachment B: B4)
• Separation based on OFZ requires only (60+[3x19.6]) = 118.8m. (See Attachment B: B17)
• Separation based on taxiing 777-8/9 with wings extended clear of precision RWY graded strip requires (105+35.9) = 140.9m.</td><td>• Recent studies and ICAO work indicates that vertical tail size is critical, not wing span, and that the size of the sensitive and critical areas and the operational impact of infringement of CSAs should be reassessed. Hence the need for specific runway studies.
• The vertical tail height of the 777-8/9 is slightly taller than legacy 777 models, but still <20m, which is used as ICAO design parameter for Code E recommendations.
• 777-8/9 has a carbon fiber tail, shown to have less impact on ILS signals than a metal tail.</td></tr>
<tr><th>BACG2 Conclusions</th><td colspan="4">• Runway to parallel taxiway separation:
- To avoid encroachment on the runway strip, minimum runway to taxiway separation is 140m + half wingspan. For a 777-8/9 with wings extended, this is 176m.
- Lower separation could be envisaged on the basis of an aeronautical safety study. Refer to ICAO Doc 9981 (PANS Aerodromes), Appendix to Chapter 4, for guidelines.
• OFZ:
- Code Number 4 OFZ width of 120m based on ICAO OCP work.
• Runway holding positions:
- For takeoff and non-precision approach runways, minimum value 75m to be applied.
- For precision approach runways, minimum value of 90m to be applied.
- Need of specific runway studies to evaluate ILS interference risks in all cases.</td></tr>
</table>

4.2 ICAO baseline

See previous synopsis.

4.3 Hazard Analysis

4.3.1 Hazard Identification

The hazards linked to runway separation requirements are:

- Collision risk between an aircraft in flight and an object (fixed or mobile) on the airport.
- Collision risk between an aircraft that runs off the runway and an object (fixed or mobile) on the airport.
- Perturbation of ILS signal by a taxiing or stopped aircraft.

4.3.2 Causal Analysis

Main causes and accident factors could be defined as follows:

- Collision between an aircraft in flight and an object (fixed or mobile) on the airport.
    - Human factors (crew, ATS).
    - Weather conditions (visibility).
    - Aircraft: mechanical failure (such as engine, hydraulic system, flight instruments, control surfaces) wingspan.
    - Airport layout and facilities: location of holding points and parallel taxiway, radar system.
    - Obstacle density (taxiing aircraft included), markings, lighting and publication.
- Collision between an aircraft veering off the runway and an object (fixed or mobile) on the airport.
    - Runway veer-off causes and accident factors. (See runway veer-off risk)
    - Lateral veer-off distance.
    - Aircraft size.
    - Airport layout; location of holding points and parallel taxiway.
    - Obstacle density (taxiing aircraft included).

- Perturbation of ILS signal by a taxiing or stopped aircraft.
  - Aircraft position and NAV-aids.
  - Aircraft characteristics (such as height, length, shape, component).
  - Obstacle density.
- The huge variety and the complexity of accident factors for collision risk must be emphasized.

4.3.3 Consequences Analysis

The first two hazards are potentially catastrophic and the third one is potentially major.

4.4 Risk Assessment

4.4.1 Collision Between an Aircraft In Flight and an Object (Fixed or Mobile) on the Airport

Based on aircraft performance (types A and B), risk assessment focus on the ability of the aircraft to follow the runway centerline when doing a balked landing.

4.4.1.1 Balked Landing Simulations

The object of the balked landing simulation study is to determine whether the improvements in avionics and aircraft performance over the last 20 to 30 years have led to a quantifiable decrease in the expected aircraft deviations from the desired track when landing or executing a balked landing. If existent, this decrease might be used to justify reducing Code Letter F requirements for certain type of airspace, particularly the OFZ, for these state of the art aircraft.

The ICAO OCP was in charge of this study for NLA operations, which resulted in the release of ICAO Circular 345 "*New Larger Airplanes-Infringement of the Obstacle Free Zone: Collision Risk Model and Aeronautical Study*".

This ICAO circular states that a Code Letter F aircraft can be contained within the Code Letter E OFZ when digital autopilot or flight director and flight track hold guidance are used for the approach.

The Code Letter E OFZ may be applied as the 777-8/9 is equipped with the following avionics: digital autopilot and flight director, and track hold guidance.

4.4.2 Collision Between an Aircraft Veering Off the Runway and an Object (Fixed or Mobile) on The Airport

Two different lateral runway excursions database analysis resulted in the following conclusions:

- Veer-off distances[2] do not increase in proportion to aircraft size. That means that this collision risk comes under "Type B" (generic risk model) risk assessment category. (i.e. extrapolation of current accident database to future aircraft seems relevant).

- Taxiing deviation effect is relatively of little consequence.

- Lateral runway excursion risk (frequency and veer-off distances) is not lower for non-instrument approach and take-off than for instrument approach. Meaning in theory, to provide a uniform level of safety, requirements to mitigate collision risk in case of aircraft veer-off should be as strict for non-instrument and take-off runways as for instrument runways.

For that reason, the ICAO SARPs formula relative to runway-taxiway separation distances for non-instrument runway (75m + half wingspan) and to runway holding positions for take-off and non-precision approach runway (75m) must be regarded as a strict minimum for operations.

In some complex airport layouts (such as parallel runways, intermediate taxiways used to cross runways, especially if the crossing is at a point where aircraft taking-off are at high speed or are potentially airborne), a specific study may be needed to evaluate runway holding positions when runways are used by 777-8/9 aircraft.

4.4.2.1 Perturbation of ILS Signal by a Taxiing or Stopped Aircraft

A generic risk assessment on this topic seems not feasible. ILS signal distortion risk should be assessed in a case-by-case study base taking into account local conditions like airport layout and traffic density.

These case-by-case studies could take advantage of several generic studies dealing with A380 effects on ILS safety area:

- A preliminary study from Park Air Systems (AACG, Appendix 4 Part M) calculates for Nomarc ILS the difference between A380 and 747 Sensitive Areas. The output indicates that the Sensitive Area for a CAT III approach is approximately 30-40% wider for an A380 than for a 747. However, it must be noted that the A380 was modelled with a metal vertical tail, rather than carbon fiber.

- According to ILS specialists, the carbon fiber that is used for A380 vertical tail could lead to a decrease in ILS signal perturbation versus metal.

[2] The veer-off distance is defined here as the maximum lateral deviation distance reported during a veer-off between the aircraft center of gravity and the runway centerline.

- A study by ADP to assess the impact of carbon fiber versus metal on ILS signal perturbations by making real tests at CDG with A310 fitted with tail material of carbon fiber and metal. (See Attachment C, reference 15)

- A recent study (2006) by a workgroup of ILS experts in Europe indicates that vertical tail size is critical, not the wingspan even with the provision of winglets.

The vertical tail of the 777-8/9 is slightly taller than legacy 777 models (0.89m greater than a 777-300ER, and 0.75m greater than a 777F). It is however still less than 20m, which is the tail height used in determining the ICAO recommendation for ILS holding point location for Code Letter E aircraft based on the 747SP as the critical aircraft. Furthermore, the 777-8/9 has a composite carbon fiber tail, shown in ADP studies to have less impact on ILS signals than a metal tail.

4.5 Conclusions

BACG2 members agreed:

- Runway to parallel taxiway separation:
    - To avoid encroachment on the runway strip, minimum runway to taxiway separation is 140m + half wingspan. For a 777-8/9 with wings extended, this is 176m.
    - Lower separation could be envisaged on the basis of a safety assessment. Refer to ICAO Doc 9981 (PANS Aerodromes), Appendix to Chapter 4, Section 5 for guidelines.
- OFZ:
    - Code Number 4 OFZ width of 120m based on ICAO OCP work.
- Runway holding positions:
    - For takeoff and non-precision approach runways, minimum value 75m to be applied.
    - For precision approach runways, minimum value of 90m to be applied.
    - Need of specific runway studies to evaluate ILS interference risks in all cases.

5 Part D: Taxiway Separations

The normal taxi configuration for the 777-8/9 will be with wingtips in the folded position changing the classification to an ARC E airplane. During the transition prior to takeoff, the aircraft may have wingtips extended on the taxiway environment, depending on the extend location identified on the aerodrome. Refer to Attachment H for the generic operational plan under a non-normal FWT scenario.

The following analysis is presented for a 777-8/9 on one taxiway and a Code Letter E aircraft on the adjacent taxiway at 76m centerline separation. In the case of a multi-entrance taxiway system at the runway end and Rapid Exit taxiway, see Attachment G, for detailed analysis.

5.1 Synopsis

<table>
<tr><td rowspan="1">ICAO Baseline</td><td colspan="3">• Parallel Taxiway Separation:
- Code Letter F taxiway centerline to taxiway centerline separation = 91 m.
- Code Letter E Taxiway centerline to taxiway centerline separation = 76 m.
- (Code Letter E and F aircraft require 11 m wingtip separation)
- Possibility to operate with lower separation distances based on a safety assessment study. [RP} A14 P3.9.7 + Table 3-1 col. 10.
- No specific safety buffers for curved portion. A14 P.3.9.7 Note 3</td></tr>
<tr><td rowspan="4">Hazard Analysis</td><td colspan="2">Hazard Identification</td><td>Risk 1
Collision between two aircraft or between an aircraft and an object (fixed or mobile)</td></tr>
<tr><td colspan="2">Main causes and accident factors</td><td>• Human factors (such as crew, taxi routing error).
• Weather conditions.</td></tr>
<tr><td rowspan="2">Severity</td><td>Theoretical</td><td rowspan="2">• Potentially major.</td></tr>
<tr><td>In-service</td></tr>
<tr><td rowspan="2">Risk</td><td colspan="2">Risk assessment category</td><td>B
(generic risk model)</td></tr>
<tr><td colspan="2">Main technical materials</td><td>• Taxiway deviation statistics analysis (existing and ongoing analyses).
• 777-8/9 cockpit visibility. (See Attachment B: B39).</td></tr>
</table>

BACG2 Conclusions	
BACG2 Conclusions	• Parallel Taxiway separation: - Current Code Letter E parallel taxiway 76m separation: Wingtip clearance margin of 7.6m available with 777-8/9 with wingtips extended on one taxiway and 65m Code Letter E aircraft on adjacent taxiway, both aircraft assumed centered on taxiway centerlines. With wingtips folded, the aircraft will comply with the recommended 11m wingtip separation to a Code E aircraft on the parallel taxiway. - To maintain 11m recommended wingtip clearance between two 777-8/9 with wingtips extended on parallel taxiways, a minimum centerline separation of 82.8m is required. - To maintain 11m recommended wingtip clearance between a 777-8/9 with wingtips extended on one taxiway and a 65m wingspan Code E aircraft on the parallel taxiway, a minimum centerline separation of 79.4m is required. - Lower separation could be envisaged, based on an aeronautical safety study. Refer to ICAO Doc 9981 (PANS Aerodromes), Appendix to Chapter 4, for guidelines. • RET (Rapid Exit Taxiway) - In the case of a Rapid Exit Taxiway, a specific safety assessment study should be performed. See Attachment G (FWT CONOPS) for detailed analysis. - For dual entrance taxiways, where reduced margins exist compared to Code Letter F recommendations, proper guidance such as center line lights or equivalent guidance for example a marshaller is to be provided for night or low visibility operations.

5.2 ICAO Baseline

See previous synopsis.

5.3 Hazard Analysis

5.3.1 Hazard Identification

The separation distance between taxiways is intended to limit the risk of collision between two aircraft.

5.3.2 Causal Analysis

The causes and accident factors identified for taxiway separation could be classified as

- Mechanical failure.
- Surface conditions (aquaplaning, loss of control on ice-covered surface).
- Loss of visual taxiway guidance system (markings and lights covered by snow).
- Pilot precision and attention (such as directional control, orientation error).

5.3.3 Consequences Analysis

Consequences of collision on taxiing are potentially major.

5.4 Risk Assessment

The collision hazard at taxiing does not depend on specific aircraft performance but on human factors. The expected 777-8/9 behavior could therefore be inferred from existing aircraft behavior.

As existing measurements in straight section tend to show that the bigger the aircraft, the smaller the taxiway deviation. The extrapolation of available data on taxiway deviation for the 777-8/9 seems quite conservative. (See Attachment B)

This statement means that taxiway separation distances issue comes under “type B” risk assessment category (generic risk model).

Three kinds of argument could be developed accordingly:

- Use taxiway deviation statistics to assess the collision risk between two aircraft or between an aircraft and an object. Several taxiway deviation studies are available (Amsterdam, London - LHR, New York - JFK, Anchorage, Paris - CDG, Frankfurt, San Francisco, and others).

- Take advantage of the experience of some major airports that applied lower separation distances specified in the ICAO Air Navigation Plan of European Region for 747-400 operations. ICAO European ANP defines specific measures to apply these reduced wingtip margins on existing infrastructures for generic NLA operations based on 747-400 experience [e.g. centerline lighting or equivalent guidance (i.e. marshaller) for night, winter and low visibility operations, objects marking and lighting, good surface friction conditions, publication in AIP]. (See Attachment D and E)

- Take advantage of the recommendations of the AACG for A380 and the BACG for 747-8 operations who proposed reduced tip to tip margins based on extensive analysis of the above mentioned studies and experiences.

As risk collision when taxiing is a “type B” hazard (generic risk model), the reduced separation distances used at some major airports for 747-8 and A380 with no adverse effect on the safety could be extrapolated for 777-8/9 dual entrance taxiway operations.

5.5 Conclusions

BACG2 members agreed:

- Parallel Taxiway separation.

    - On parallel taxiways with 76m Code Letter E separation, minimum wingtip-wingtip clearance margin of 7.6 m between a 777-8/9 with wingtips extended and a Code letter E aircraft. Both aircraft are assumed to be centered on straight taxiways, and positioned cockpit over centerline in curved sections.

    - To maintain 11m recommended wingtip clearance between two 777-8/9 with wingtips extended on parallel taxiways, a minimum centerline separation of 82.8m is required.

    - To maintain 11m recommended wingtip clearance between a 777-8/9 with wingtips extended on one taxiway and a Code Letter E aircraft on the parallel taxiway, a minimum centerline separation of 79.4m is required.

- In the case of a Rapid Exit Taxiway, a specific safety assessment study should be performed. See Attachment G (FWT CONOPS) for detailed analysis.

Where wingtip margins will be less than the ICAO-recommended 11m, it is strongly recommended to

- Request a deviation approval to the National Aviation Authority supported by a local safety study, if this study can demonstrate an acceptable level of safety. Refer to ICAO Doc 9981 (PANS Aerodromes) for guidelines on performing a safety assessment study.

- Use operational procedures as mitigation measures such as taxi speed limitations, follow me, or temporary wingspan restriction on aircraft taxiing on parallel taxiway during 777-8/-9 operations.

6 Part E: Other Items

6.1 Runway Visual Aids

6.1.1 Synopsis

<table>
<tr>
<td>ICAO Baseline</td>
<td colspan="5">

Runway Lights

Elevated lights shall be frangible and clear of propellers and engine pods. [Std] A14 P5.3.1.6
Surface (inset) lights shall withstand being run over by aircraft. [Std] A14 P5.3.1.7
RWY edge lights shall be placed along the edge of the area declared for use as the RWY or outside the edge of the area at a distance of not more than 3m. [Std] A14 P5.3.9.4

Visual Approach Slope Indicator Systems

When the RWY is equipped with an Instrument Landing System (ILS) and /or Microwave Landing System (MLS), the siting and the elevation of light units of a T Visual Approach Slope Indicator System (T-VASIS), Precision Approach Path Indicator (PAPI), or Abbreviated Precision Approach Path Indicator, (APAPI) shall be such that the visual approach slope conforms as closely as possible with the glide path of the ILS or the minimum glide path of the MLS, as appropriate. [Std] A14 P5.3.5.19 & A14 P5.3.5.36.
Where a PAPI or APAPI is installed on a RWY without an ILS or MLS they shall be sited to ensure guidance for the most demanding aircraft regularly using the RWY. Where a PAPI or APAPI is installed on a RWY with ILS or MLS, it should be sited to provide guidance for those aircraft regularly using the RWY. [Std] A14 Chap 5 Figure 5-19 Notes a) & b).
The location of PAPI or APAPI unit depends on eye-to-wheel height of the most demanding aircraft regularly using the RWY or the range of eye-to-antenna heights of the aircraft regularly using the RWY. However, in no case will the wheel clearance over the threshold be lower than that specified in column (3) of Table 5-2. [Std] A14 Chap 5 Figure 5-9, Note b)

Signs shall be frangible. Those located near a runway or taxiway shall be sufficiently low to preserve clearance for propellers and engine pods of jet aircraft. [Std] A14 P5.4.1.3
Markers shall be frangible. Those located near a runway or taxiway shall be sufficiently low to preserve clearance for propellers and engine pods of jet aircraft. [Std] A14 P5.5.1

</td>
</tr>
<tr>
<td rowspan="4">Hazard Analysis</td>
<td colspan="2">Hazard Identification</td>
<td>Risk 1
Elevated lights damaged by jet blast</td>
<td>Risk 2
VASIS, PAPI or APAPI guidance not adapted for an aircraft in approach</td>
<td>Risk 3
Aircraft damage caused by elevated lights after a veer-off</td>
</tr>
<tr>
<td colspan="2">Main causes and accident factors</td>
<td>

Powerplant (engine position and engine power).
Elevated lights strength.
Aircraft (rotation angle at take-off).
Runway centerline deviation factors (runway veer-off risk).

</td>
<td rowspan="5">No specific 777-8/9 issue</td>
<td rowspan="5">No specific 777-8/9 issue</td>
</tr>
<tr>
<td rowspan="2">Severity</td>
<td>Theoretical</td>
<td rowspan="2">Potentially major if undetected before takeoff and followed by engine ingestion and tire bursting risks.</td>
</tr>
<tr>
<td>In-service</td>
</tr>
<tr>
<td rowspan="2">Risk Assessment</td>
<td colspan="2">Risk assessment category</td>
<td>C
(geometric argument)</td>
</tr>
<tr>
<td colspan="2">Main technical materials</td>
<td>

777-8/9 engine position. (Attachment B: B28).
777-8/9 jet blast contours. (Attachment B: B23-25).

</td>
</tr>
</table>

Conclusions	
	• For RWY edge lighting position, ICAO SARPs to be followed (placed along the edge of the area declared for use as a runway or outside the edge of the area at a distance of not more than 3 m). • Inset RWY edge lights; possibility of elevated runway edge lights according to preliminary engine outputs. Snow clearance to be considered in the choice. • T-VASIS, PAPI, APAPI: No specific 777-8/9 requirement; Airport to ensure ICAO compliance for 777-8/9

6.1.2 ICAO Baseline

See previous synopsis.

6.1.3 Hazard Analysis

6.1.3.1 Hazard Identification

Three potential hazards linked to runway visual aids characteristics could be identified as:

1. Elevated lights damaged by aircraft jet blast.

2. T-VASIS, PAPI, or APAPI guidance not adapted for an aircraft on approach.

3. Aircraft damage caused by elevated lights after an aircraft veer-off.

Hazards 1 and 2 could effectively be related to NLA characteristics (engine position, engine thrust, eye-to-wheel height, landing attitude). However, hazard 3 is not a specific NLA issue. The frangibility characteristic of elevated lights is a mitigating measure potentially useful for all kinds of aircraft (and probably more for the smallest aircraft since the bigger the gear wheel, the more the frangibility) in case of runway veer-off.

T-VASIS, PAPI, or APAPI guidance issues are linked to aircraft characteristics but, considering 777-8/9 eye-to-wheel height in approach configuration, Annex 14 requirements should be sufficient to determine A-VASIS, PAPI, APAPI guidance for 777-8/9. This is not a specific 777-8/9 item. (See Attachment B, B59-60)

In addition to these three hazards, it could be relevant to study the risk of centerline lights damage caused by aircraft rolling on surface lights. In this case, the 777-9 is not the most critical aircraft in term of weight per wheel. Hence, only the jet blast effect on runway edge lights has been considered here for the 777-8/9.

6.1.3.2 Causal Analysis

Main causes and accident factors for elevated runway lights damage risk are

- Powerplant characteristics (engine position and engine power).

- Elevated light strength.

- Aircraft rotation angle at take-off.

- Runway centerline deviation factors. (See runway veer-off risk).

6.1.3.3 Consequences analysis

Runway light damage can potentially have major consequences if undetected before takeoff while followed by engine ingestion and tire bursting.

6.1.4 Risk Assessment

6.1.4.1 Runway Lights Damage

Jet blast hazards are typical geometric issues and come under “Type C” geometric argument risk assessment category.

Preliminary 777-8/9 jet blast contours are now available and can be compared to other existing aircraft jet blast contours. (See Attachment B: B23-25)

While the engine positions on the 777-8/9 are ~1m further outboard, they remain significantly laterally inward from the runway edge lights. Additionally, a study of the 777-8/9 take-off thrust velocity contour at 56 km/h indicates that the runway edge lights are already subject to jet blast velocities similar to the expected 777-8/9 jet blast [51 m (168 ft.) wide for the 777-8/9 compared to a calculated width of 58.1 m (190.6 ft.) for the 777-300ER.]

Preliminary simulation results of theoretical study would show that the elevated lights should withstand the 777-8/9 jet blast based on mechanical strength values of elevated runway edge lights requirements.

6.1.5 Conclusions

BACG2 members agreed:

- For runway edge lighting position, ICAO SARPs are to be followed (placement along the edge of the area declared for use as a runway or outside by not more than 3m).

- T-VASIS, PAPI or APAPI: No specific 777-8/9 requirement; ICAO compliant.

6.2 Taxiway on Bridges

6.2.1 Synopsis

<table>
<tr><td rowspan="1">ICAO Baseline</td><td colspan="5">The width of the portion of a taxiway bridge capable of supporting airplanes, as measured perpendicularly to the taxiway centerline, shall not be 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 shall not be hazardous for airplanes for which the taxiway is intended. [Std] A14 P3.9.20 & ADM Pt2 P1.4.4
Access should be provided for RFF vehicles to intervene in both directions. [RP] A14 P3.9.21
If aircraft engines overhang the bridge structure, protection of adjacent areas below the bridge from engine blast may be required. [RP] A14 P3.9.21 Note & ADM Pt2 P1.4.4</td></tr>
<tr><td rowspan="4">Hazard Analysis</td><td colspan="2">Hazard identification</td><td>Risk 1
Evacuation slides falling past the edge</td><td>Risk 2
Difficulties for firefighting intervention</td><td>Risk 3
Blast under the bridge</td></tr>
<tr><td colspan="2">Main causes and accident factors</td><td>Aircraft stop away from taxiway centerline.
Width of the bridge.
Evacuation slides configuration.</td><td>Engine span.</td><td>Engine position, engine power.
Width of jet blast protection on the bridge.
Taxiway deviation factors. (See Taxiway Veer-Off Risk)</td></tr>
<tr><td rowspan="2">Severity</td><td>Theoretical</td><td>Hazardous</td><td rowspan="2">Major to catastrophic.</td><td rowspan="2">Major for other traffic (not for the aircraft).</td></tr>
<tr><td>In-service</td><td>No cases reported</td></tr>
<tr><td rowspan="2">Risk Assessment</td><td colspan="2">Risk assessment category</td><td colspan="3">C
(predominant geometric issues)</td></tr>
<tr><td colspan="2">Main technical materials</td><td>Comparison with margins for a 777-300ER on a code letter E bridge.</td><td>Firemen practices.
777-8/9 wingspan and engine span. (See Attachment B: B4)</td><td>777-8/9 engine span. (See Attachment B: B28)
Taxiing jet blast contours. (See Attachment B: B23-25)</td></tr>
<tr><td>Conclusions</td><td colspan="5">Not less than 38m for jet blast protection, slide and passenger movement support during evacuation in case full bearing strength width is reduced by proven means of lateral restraint.
Alternative path for RFF vehicles (depending on the bridge width).</td></tr>
</table>

6.2.2 ICAO Baseline

See previous synopsis.

6.2.3 Hazard Analysis

6.2.3.1 Hazard Identification

The following hazards have been identified:

- In case of an emergency evacuation, deployment of an escape slide with its end outside the bridge.

- Impossibility for fire emergency vehicles to drive around the aircraft.

- Jet blast on whatever is under the bridge.

6.2.3.2 Causal Analysis

The causes of such an event can be classified as

- Taxiway bridge design issues. (width of taxiway bridge, width of jet blast protection)

- Aircraft design issues. (evacuation slides configuration and engine positions)

6.2.3.3 Consequences Analysis

The hazards, under the regulatory (FAR/EASA) scale, would be classified as “major” to “catastrophic”.

6.2.4 Risk Assessment

For these hazard mechanisms, a “Type C” analysis is adequate (geometric argument), i.e. one in which the geometric characteristics of the aircraft are the predominant factor. Safety levels can be defined through a comparison with Code letter E requirements and 777-8/9 characteristics. (See Attachment B: B4, B28)

The risk of a slide falling outside the bridge is a function of the margin between the location of the outermost part of the slide (when the aircraft is on the taxiway bridge centerline) and the bridge edge. The height of the 777-8/9 above the ground is the same as the 300ER; therefore, the slide length requirements are the same for both aircraft, which makes clearance between the slide and the edge of the bridge adequate for RFF traffic to pass through, and for passengers to exit safely using the slides.

It is necessary to provide fire-fighting vehicles with routes allowing access to both sides of the aircraft for fire intervention, using the best side, depending upon wind direction. An important factor is the distance between the fuselage centerline and the engine centerline, this distance is 10.63m for the 777-8/9. This allows RFF traffic to pass between the engine and the edge of the bridge. For both the 777-300ER and the 777-8/9 the margin between the engine and the taxiway bridge edge is significant. According to firemen practices, the most important consideration is to have another bridge nearby for access to the “other” side of an aircraft (rather than an increased bridge width implying a passage under the wing). This is available when bridges are paired (parallel taxiways) or when there is a service road in the vicinity. Ground surface on the bypass routes should also be stabilized where it is unpaved.

For jet blast protection under the bridge, the distance between fuselage centerline and the engine centerline is of importance. Although the distance between fuselage centerline and engine centerline for the 777-8/9 is approximately one meter greater than the 777-300ER, the jet blast velocity contours of both aircraft are similar. No additional jet blast protection is needed in comparison with Code Letter E requirements.

The 777-8/9 may be completing a portion of its taxi route and require crossing a taxiway bridge while in Code Letter F configuration with the wingtips extended, such as during taxi prior to takeoff. Per Annex 14 recommendation, Code Letter F aircraft require a 44m taxiway graded strip, which increases the bridge width requirement accordingly. However, the position of the wingtips does not affect engine position and jet blast contours for the 777-8/9, both being the primary drivers in determining the taxiway bridge width requirement. Slide deployment geometry and RFF access will remain unchanged after extension of the folding wingtip.

The above mentioned arguments allow the conclusion that for a 777-8/9 the use of a Code Letter E taxiway bridge is as safe as it is for a 777-300ER.

6.2.5 Conclusions

BACG2 members agreed the analysis concludes that the code letter E requirement of 38m bridge width is adequate for the 777-8/9 regardless of folding wingtip position.

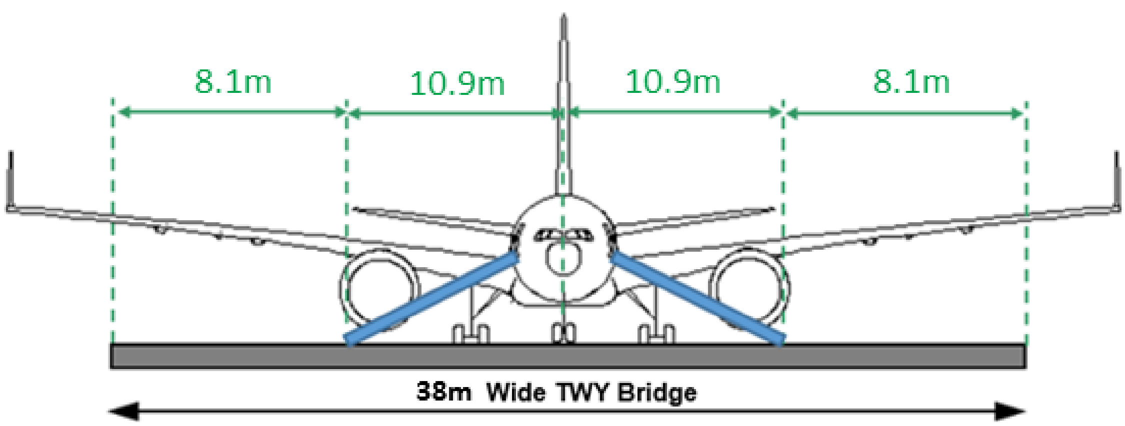


Figure 6-1. 777-8/9 Slide Deployed on a Code Letter E Taxiway Bridge

6.3 Runway End Safety Area (RESA)

6.3.1 Synopsis

ICAO Baseline	• A runway end safety area shall be provided at each end of a runway strip where the code number is 4. **[Std] An 14 P3.5.1.** • The RESA is intended to provide protection beyond the runway strip to minimize damage when aircraft undershoot, overshoot or overrun the runway during landing or take-off. **ADM Pt1 P5.4.1.** • The width of a RESA shall be at least twice that of the associated runway. **[Std] A14 P3.5.5.** Therefore, because an aircraft with an OMGWS 9m up to but not including 15m will require a 45m runway the RESA shall be at least 90 m wide. • The width of a RESA should, wherever practicable, be equal to that of the graded portion of the runway strip at the runway end. **[RP] A14 P3.5.6.** • The RESA shall be at least 90 m long (Code Number 4) **[Std**] A14 P3.5.3. The RESA should be, wherever practicable, 240 m long (Code Number 4**) [RP] A14 P3.5.4** (stated for clarity – this is not a 777-8/9 specific item). • If an arresting system is installed, the above length may be reduced, based on the design specification of the system, subject to acceptance by the State. **[Std] A14 3.5.3.**			
Hazard Analysis	**Hazard identification**		**Risk 1** **Runway overrun excursion at take-off**	**Risk 2** **Runway undershoot or runway overrun excursion at landing**
	Main causes and accident factors		• Human factors (flight crew, maintenance, weight and balance, load shifting). • Powerplant. (engine failure, FOD ingestion). • Surface conditions. (contaminated RWY). • Aircraft (control surfaces, navigation instrument, hydraulic system, brakes/anti-skid, tires). • Weather conditions (wind condition, visibility, inaccurate meteorological information). • Airport navigational aid (including inoperative, distorted signal).	• Human factors (flight crew, air traffic control, maintenance). • Aircraft (landing gear, control surfaces, navigation instrument, hydraulic systems, brakes/anti-skid, tires). • Powerplant failure. • Surface conditions (contaminated RWY). • Weather conditions (wind condition, visibility, inaccurate meteorological information). • Airport navigational aid (including inoperative, distorted signal).
	Severity	Theoretical	• Major to Catastrophic depending on the aircraft speed.	
		In-service	• Usually Minor to Serious depending on the aircraft speed (on a std RESA).	
Risk Assessment	**Risk assessment category**		**A** **(aircraft performance)**	**A** **(aircraft performance)**
	Main technical materials		• Per Amendment 14 to Annex 14, 7th edition, 777-8/9 can operate on 45m wide RWY: critical failure conditions at take-off, V_{MCG} criteria, envelope of environmental conditions covered by aircraft certification. • Design commonalities with the 777-300ER. • Flight deck features similar or better than the 777-300ER that improve situational awareness. (See Attachments B and G).	• Per Amendment 14 to Annex 14, 7th edition, 777-8/9 can operate on 45m wide RWY: critical failure conditions at landing, envelope of environmental conditions covered by aircraft certification and Auto land criteria. • Design commonalities with the 777-300ER. • Flight deck features similar or better than the 777-300ER that improve situational awareness. (See Attachments B and G).

Conclusions	
	• Minimum 90m based on 45m, the runway width required for the 777-8/9, or twice that of the actual associated RWY width. • However a RESA width equal to the width of the graded portion of the associated runway strip is recommended wherever practicable.

6.3.2 ICAO Baseline

See previous synopsis.

6.3.3 Hazard Analysis

6.3.3.1 Hazard Identification

The principal hazards linked to runway end safety areas are runway-undershoot at landing and runway-overrun at take-off or landing. On a standard RESA, the related risks are typically minor to serious damages to the gear, structure and engines.

6.3.3.2 Causal Analysis

There are many factors that may cause a runway-undershoot, an overrun, or a lateral excursion. Most of them are not related to the size of the aircraft. The main causes and accident factors are listed as follows:

- For take-off:
  - Human factor (flight crew, maintenance, weight and balance, required distances and V-speeds, load shifting).
  - Aircraft (control surfaces, navigation instrument, hydraulic systems, brakes and anti-skid, gears and tires).
  - Powerplant (engine failure, fuel system, FOD ingestion).
  - Surface conditions (contaminated RWY).
  - Weather conditions (wind condition, visibility, inaccurate meteorological information).
  - Navigational aid (including inoperative, distorted signal).
- For landing:
  - Human factors (flight crew, air traffic control, maintenance, weight and balance, required distances and V-speeds, payload security).
  - Aircraft (landing gear, navigation instrument, control surfaces, hydraulic systems, brakes/anti-skid, gears and tires).

- Powerplant (thrust reversers).
- Surface conditions (aquaplaning, snow).
- Weather conditions (wind condition, visibility, inaccurate meteorological information).
- Airport navigational aid (including inoperative, distorted signal)

6.3.3.3 Consequences Analysis

The runway-undershoot and runway-overrun hazard can be classified as a major to catastrophic risk depending on the aircraft speed.

Safety analyses (Functional Hazard Assessment, System Safety Assessment, Environmental Conditions Hazard Assessment) on landing and take-off operations will be made during the operational approval process.

Runway undershoot and overrun are risks explicitly taken into account by The Boeing Company in the aircraft design process. (See Attachment B: B19-20, B55-56)

6.3.4 Risk Assessment

This type of risk comes under “Type A” risk assessment category, mainly based on aircraft performance and handling capabilities.

Numerous design changes from the 777-300ER were made to improve flight deck situational awareness of 777-8/9 during take-off and landing. The 777-8/9 design is intended to retain or improve the on the in-flight capability of the 777-300ER. Refer to Part A, Risk Assessment section for those design improvement and commonalities.

It may be expected that the behavior of the 777-8/9 in case of runway excursion as good as or better than that of the 777-300ER due to design improvements and commonalities.

Amendment 14 to Annex 14 7th edition reduces the recommended runway width for the 777-8/9 to 45m. We can therefore conclude that this aircraft type is not more demanding than a 777-300ER or any other Code Letter E aircraft in terms of dimensions of the RESA. A minimum RESA width requirement of 90 m is adequate for the 777-8/9.

6.3.5 Conclusions

BACG2 members agreed:

- The RESA width shall be related to the actual "associated" runway width.
- A minimum RESA width of 90m, based on 45m, the runway width required for the 777-8/9, or twice that of the actual associated runway width, is adequate for 777-8/9.
- A RESA width equal to the width of the graded portion of the associated runway strip is recommended, independent on the size of (large) aircraft using that runway. This RESA should be 240m long as recommended by the ICAO for Code Number 4 when practical.

6.4 Runway Turn Pad

6.4.1 Synopsis

<table>
<tr><td>ICAO Baseline</td><td colspan="4">
• Where the end of a runway is not served by a taxiway or a taxiway turnaround and where the Code Letter is D, E or F, a runway turn pad shall be provided to facilitate a 180-degree turn of airplanes. [RP] A14 P3.3.1.
• The intersection angle of the runway turn pad with the runway should not exceed 30 degrees. [RP] A14 P3.3.4.
• The nose wheel steering angle to be used in the design of the runway turn pad should not exceed 45 degrees. [RP] A14 P3.3.5.
• Turn pad geometry recommendation for Code Letter E/F are available in the in design manual. ADM Pt1 Figure A4-9.
• Amendment 14 to Annex 14 7th edition proposes to set landing gear edge margin recommendations based on OMGWS as opposed to wingspan. Based on proposed categories, the 777-8/9 would require a 4.0m margin between the landing gear tire edge and the turn pad pavement edge.
• 6m wheel-to-edge clearance is recommended where severe weather conditions may lower the surface friction characteristics [RP] A14 P3.3.7
• The strength of the runway turn pad should be at least equal to the adjoining runway, and should be able to withstand the higher stresses put on the pavement by a slow moving airplane making hard turns. . [RP] A14 P3.3.9, [RP] ADM Pt1 A4, 3.3
• The runway turn pad should provide necessary shoulder width to prevent erosion by jet blast and damage by FOD. The minimum shoulder width would need to cover the outer engine of the most demanding airplane. [RP] A14 P3.3.12, [RP] ADM Pt1 A4, 4.1
• The strength of runway turn pad shoulders should be capable of withstanding the occasional passage of the airplane it is designed to serve without inducing structural damage to the airplane and to the supporting group vehicles. [RP] A14 P3.3.13, [RP] ADM Pt1 A4, 4.2
</td></tr>
<tr><td rowspan="4">Hazard Analysis</td><td colspan="2">Hazard identification</td><td>Risk 1
Excursion from the full-strength pavement</td><td>Risk 2
Shoulder erosion and engine FOD ingestion during turning</td></tr>
<tr><td colspan="2">Main causes and accident factors</td><td>• Mechanical failure affecting steering capability (hydraulic system and linkage systems).
• Environmental conditions (reduced friction due to surface contamination, strong crosswind and gust).
• Loss of visual lateral guidance (low visibility, obscured markings and lights due to surface contaminants).
• Human factors (distraction or heads down, and loss of situational awareness).</td><td>• Powerplant (engine position, engine power).
• Runway turn pad shoulder width and cohesion.
• Centerline deviation factor.</td></tr>
<tr><td rowspan="2">Severity</td><td>Theoretical</td><td>• Potentially major.</td><td>• Minor if detected and engine is shutdown; potentially major if undetected prior to next aircraft to use the turn pad and runway, which may ingest the FOD.</td></tr>
<tr><td>In-service</td><td>• Minor.</td><td>• Minor.</td></tr>
</table>

	Risk assessment category	B (generic risk model)	C (geometric argument)	C (geometric argument)
Risk Assessment	Main technical materials	• Runway turn pad excursion statistics analysis. (existing and on-going studies). (See Attachment C)	• 777-8/9 outer main gear span within Code letter E limit and less than the 777-300ER. (See Attachment B) • 777-8/9 steering capability remains similar as the 777-300ER. • Turn pad and maneuvering analysis. (See Attachment B: B41-47)	• 777-8/9 engine position. • 777-8/9 jet blast velocity at idle. • 777-8/9 jet blast velocity contour at break-away and the transient (temporary) nature of the breakaway thrust application. • Runway turn pad excursion statistics. (See Attachment B: B23-25, B56-57)
Conclusions	• Minimum turn pad dimensions designed for the 777-300ER are adequate for the 777-8/9. • Depending on local conditions, each national authority and airport operator makes its own decision on the width, composition, and thickness for shoulder portions.			

6.4.2 ICAO Baseline

In additional to the previous synopsis, the following factors should be taken into consideration for evaluating the 777-8/9's capability to make a 180-degree turn on a turn pad:

- Airplane turns at a low taxi speed.
- Airplane's steering capability exceeds the recommended 45-degree steering angle for a turn pad design. (The actual steering angle could be up to 70 degrees, 64 degrees effective steering angle, in accordance with airplane physical characteristics, which will not subject tires to unacceptable wear.)

6.4.3 Hazard Analysis

6.4.3.1 Hazard Identification

The principle hazards are lateral excursion from a runway turn pad and shoulder erosion and FOD ingestion during turning.

The main purposes of the provision of runway turn pad shoulders are

- To prevent jet engines that overhang the edge of a runway turn pad from ingesting FOD that might damage the engine.
- To prevent erosion of the area adjacent to the runway turn pad.

- To allow for the occasional pass of an airplane and to prevent damage to an aircraft running off the turn pad.

    - The shoulder width should not be considered an NLA issue. The turn pad shoulder should be designed to allow pilots to steer the aircraft back onto the turn pad in case of minor lateral excursion regardless of aircraft Code Letter.

- The shoulder composition and thickness may be a specific airplane issue, but other aircraft than the 777-8/9 may have stronger impact on the turn pad shoulders. For example, both the A340-600 and the A350-900, both Code Letter E aircraft, have higher single wheel loads and higher tire pressure than the 777-8/9. Decisions on shoulder composition and thickness will be made by each national authority and airport operator. BACG2 members decided to focus on geometric issues, so the pavement aspect is not discussed here. (See Attachment B: B35)

    - The current low frequency and low severity of the 777-taxiway veer-off cases do not justify any further evaluation of this risk. Consequently, this hazard damage to an aircraft running off the turn pad is not discussed in this study.

For these reasons, only shoulder erosion and engine FOD ingestion are considered in the Hazard Identification.

6.4.3.2 Causal Analysis

The causes for runway turn pad excursion can be classified as

- Mechanical failure affecting steering capability (hydraulic system and linkage systems).

- Environmental conditions (reduced friction due to surface contamination causing slippage); Strong crosswind and gust causing a veer-off.

- Loss of visual lateral guidance (low visibility, obscured markings and lights due to surface contaminants).

- Human factors (distraction/heads down, loss of situational awareness).

The causes for shoulder erosion and FOD ingestion during turning are related to

- Powerplant (engine position, engine power).

- Runway turn pad shoulder width and cohesion.

Ground maneuvering analyses verified that the 777-8/9 can make a 180-degree turn on a ICAO Code Letter E design runway turn pad. (See Attachment B: B41)

6.4.3.3 Consequences Analysis

In theory, the turn pad excursion consequence is potentially major. As an airplane turns at a low speed, taxiway excursion accident and incident statistics data is applicable to evaluate potential consequence of turn pad excursion. According to the accidents and incidents involving Code Letter E and F airplane lateral taxiway excursion events compiled from various sources by The Boeing Company, only minor injuries in some cases were reported.

777-8/9 ground maneuvering analyses was also performed on a turn pad designed for the 777-300ER per the ICAO standards and recommendation. It is concluded that the 777-8/9 can make a 180-degree turn on such a turn pad using cockpit over centerline maneuvering. (See Attachment B: B46-47)

The shoulder erosion and engine FOD ingestion hazard during turning could be classified as a minor risk except when it is undetected by flight crew and followed by potentially major risk of engine failure at take-off of the next aircraft.

6.4.4 Risk Assessment

For the causes listed above (Hazard Analysis, Section 2 “Causal Analysis”) for runway turn pad excursion, the first three have a low dependency on aircraft type. (i.e. aircraft are equally likely to veer off the runway turn pad regardless of the main landing gear track width).

The fourth one is relevant to the 777-8/9 since it is heavily related to the margin between the main landing gear outer wheel edge and the taxiway pavement edge. This is a Type B case (generic risk model) as well as a Type C case (geometric).

The 777-8/9 outer main gear wheel to pavement edge clearance is greater than that of the 777-300ER. The pilot eye position in the 777-8/9 cockpit is similar to the 777-300ER, thus the 777-8/9 flight deck pilot visibility is expected to be similar to the 777-300ER. The 777-8/9 steering system and landing gear design, including the aft-axle steering system, are similar to those for the previous 777 models and will have the same touch and feel characteristics. The 777-8/9’s behavior can be predicted to be similar to the current 777s in operation based on similarity between the current 777 models. (See Attachment B: B39)

While there are no deviation studies specific to runway turn pads, there are no incident reports of 777 models excursion from a turn pad. Consequently, it is concluded that the probability of the 777-8/9 excursion from a runway turn pad is the same as other 777 models.

As for erosion and FOD ingestion risk, the above-mentioned two causes are geometric arguments. They are relevant to establishing the infrastructure requirements relative to jet blast and engine ingestion issues. Therefore, shoulder erosion and engine FOD ingestion issues come under the “Type C” risk assessment category (geometric argument).

Comparisons of the engine position and jet blast velocity contours for the 777-300ER and the 777-8/9 at both idle and breakaway thrust show that the 777-8/9 is comparable with the 777-300ER. Therefore, a turn pad and shoulder designed to consider the jet blast velocity of the 777-300ER would be adequate to contain the jet blast velocity contour of the 777-8/9.

The geometric argument shows that the wheel to edge clearance of the 777-8/9 on a Code Letter E runway turn pad is greater than that for the 777-300ER.

6.4.5 Conclusions

BACG2 members agreed:

- The 777-8/9 can safely make a 180-degree turn on a turn pad designed to be compliant with the ICAO standards and recommendations for the 777-300ER.

6.5 Oversteer Through Fillets

6.5.1 Synopsis

<table>
<tr><td>ICAO Baseline</td><td colspan="4">• Amendment 14 to Annex 14 7th edition proposes to set landing gear edge margin recommendations based on OMGWS as opposed to wingspan. Based on proposed categories, the 777-8/9 would require a 4.0m margin between the landing gear tire edge and the pavement edge.
• The strength of the fillet should be the same as that of the taxiway [RP] ADM Pt2, 1.5.1</td></tr>
<tr><td rowspan="4">Hazard Analysis</td><td colspan="2">Hazard identification</td><td colspan="2">Risk 1
Excursion from the full-strength pavement</td></tr>
<tr><td colspan="2">Main causes and accident factors</td><td colspan="2">• Mechanical failure affecting steering capability (hydraulic system and mechanical linkages).
• Environmental conditions (reduced friction due to surface contamination, strong or gusty crosswinds).
• Loss of visual lateral guidance (low visibility, obscured markings and lights due to surface contamination).
• Human factors (distraction or heads down, and loss of situational awareness).</td></tr>
<tr><td rowspan="2">Severity</td><td>Theoretical</td><td colspan="2">• Potentially major</td></tr>
<tr><td>In-service</td><td colspan="2">• Minor</td></tr>
<tr><td rowspan="2">Risk Assessment</td><td colspan="2">Risk assessment category</td><td>B
(generic risk model)</td><td>C
(geometric argument)</td></tr>
<tr><td colspan="2">Main technical materials</td><td>• Fillet deviation statistics analysis. (existing and on-going studies). (See Attachment C)</td><td>• 777-8/9 geometric characteristics (wheel span within Code Letter E limits and less than the 777-300ER, similar steering capability as the 777-300ER).
• Fillet maneuvering analysis using oversteer. (See Attachment B: B40-45)</td></tr>
<tr><td>Conclusions</td><td colspan="4">• 777-8 requires similar taxiway fillet radii of the 777-300ER and 777-9 requires greater taxiway fillet radii than the 777-300ER. However, the 777-8/9 can safely maneuver a fillet designed for the 777-300ER while maintaining 4.0m MLG clearance to the pavement edge using judgmental oversteer. Oversteering should be considered as a mitigation to deviate from ICAO provision for the ‘cockpit over centerline’ clearance.</td></tr>
</table>

6.5.2 ICAO Baseline

See previous synopsis.

6.5.3 Hazard Analysis

6.5.3.1 Hazard Identification

The hazard is an excursion from a taxiway fillet.

6.5.3.2 Causal Analysis

The causes of such an event can be classified as

- Mechanical failure affecting steering capability (hydraulic system and mechanical linkages).
- Environmental conditions (reduced friction due to surface contamination, strong or gusty crosswinds).
- Loss of visual lateral guidance (low visibility, obscured markings and lights due to surface contamination).
- Human factors (distraction or heads down, and loss of situational awareness).

6.5.3.3 Consequences Analysis

Consequences are typically minor for the passengers, and mostly minor to medium to the aircraft (damages to the tires). In practice, only minor injuries in some cases were reported according to the accidents and incidents involving a Code letter E or F airplane veering off from a taxiway fillet compiled from various sources by the Boeing Company. (See Attachment B: B57)

6.5.4 Risk Assessment

Of the four causes listed above (Hazard Analysis, Section 2 "Causal Analysis"), the first three have a low dependency on aircraft type. (i.e., aircraft are equally likely to leave the taxiway regardless of the main landing gear track width).

The fourth one is relevant to the 777-8/9 since it is heavily related to the airplane effective wheelbase, the margin between the outer main gear wheel and taxiway edge, and the guidance provided by the manufacturer on oversteer procedures. This is a Type B case (generic risk model) as well as a Type C case (geometric argument).

No event of the 777 excursion from fillets was found.

The 777-8/9 steering system and landing gear design, including the aft-axle steering system, are similar to those for the previous 777 models and will have the same touch and feel characteristics. The pilot eye position in the 777-8/9 cockpit is similar to the 777-300ER, thus the 777-8/9 flight deck pilot visibility is expected to be similar to the 777-300ER. All functioning aircraft respond reliably to pilot directional inputs when taxiing at a normal speed. The 777-8/9's behavior can be predicted as similar to the current 777s in operation based on its similarity to the current 777 models. (See Attachment B: B39)

The outer main gear wheel to pavement edge clearance of the 777-8/9 on a Code Letter E taxiway (23m wide) is greater than that for the 777-300ER, but the effective wheelbase of the 777-9 is greater than the 777-300ER and the 777-8 is similar to the 777-300ER. The overall result is the requirement for a larger fillet for the 777-9.

The 777-8/9 ground maneuvering analysis was conducted on a fillet designed for the 777-300ER. The 777-8/9 can pass through this fillet using judgmental oversteer, and still maintain the minimum 4.0m required tire to pavement edge clearance. (See Attachment B)

6.5.5 Conclusions

BACG2 members agreed:

- The 777-9 requires greater taxiway fillet radii than the 777-300ER. However, the 777-8/9 can safely maneuver a fillet designed for the 777-300ER while maintaining 4.0m MLG clearance to the pavement edge using judgmental oversteer. Oversteering should be considered as a mitigation to deviate from ICAO provision for the ‘cockpit over centerline’ clearance.

6.6 Nose and Tail Clearance at Aircraft Parking Position /De-icing Pads

6.6.1 Synopsis

<table>
<tr><td>ICAO Baseline</td><td colspan="4">
• Taxiway and Apron Taxiway Centerline to object Separation: minimum 43.5m for Code Letter E and 51m for Code Letter F. This separation was derived from a minimum 11m wingtip clearance between an aircraft taxiing on a taxiway to an object. Possibility to operate with lower separation distances based on a safety assessment study. [RP] A14 P3.9.7 + table 3-1 col. 11
• Aircraft Stand Taxilane Centerline to Object Separation: minimum 40m for Code Letter E and 47.5m for Code Letter F. This separation was derived from a minimum 7.5m wingtip clearance between an aircraft taxiing on a taxilane to an object. Possibility to operate with lower separation distances based on a safety assessment study. [RP] A14 P3.9.7 + table 3-1 col. 13
• The separation distance shown above may need to be increased if jet exhaust may cause hazardous conditions for ground servicing. [RP] A14 P3.9.7 note 4
• Clearance Distances on Aircraft Stands: minimum 7.5m for Code Letters E or F. Special circumstances on nose-in stands may permit clearance reduction between terminal (including fixed passenger bridge) and an aircraft nose, and over any portion of stand provided with azimuth guidance by a visual guidance system. [RP] A14 P3.13.6
• Clearance on a De-icing/anti-icing pad: Minimum 3.8m clear paved area around the airplane should be provided for the movement of de-icing and anti-icing vehicles [RP] A14 3.15.5. Minimum object separation distances specified in ICAO Annex 14 Table 3-1 should also be provided. [RP] A14 3.15.9 & 3.15.10. Further guidance on de-icing pads are contained in ICAO Doc 9640-AN/940)
</td></tr>
<tr><td rowspan="4">Hazard Analysis</td><td colspan="2">Hazard Identification</td><td>Risk 1
Collision between a taxiing aircraft and the nose or tail section of parked aircraft.</td><td>Risk 2
Collision between a ground vehicle and the nose or tail section of parked aircraft.</td></tr>
<tr><td colspan="2">Main causes and accident factors</td><td>
• Human factors (flight crew of the taxiing aircraft distraction, loss of situational awareness, deviation from taxiway or taxilane or parking centreline and deviation from parking nose stop markings).
• Environmental factors (reduced visibility, reduced surface friction, high crosswinds and gust, obscured markings and lights due to surface contaminants).
• System malfunction of taxiing aircraft (steering, brakes, and tires).
• System malfunction of visual docking guidance system.
</td><td>
• Human factors. (ground vehicles operator’s distraction and skill level, excessive speed, parked aircraft deviating from parking centerline and nose stop markings).
• Environmental factors (reduced visibility, reduced surface friction, high crosswinds and gust, obscured markings and lights due to surface contaminants).
• Ground vehicle and equipment malfunction (such as steering, brakes, and tires).
• System malfunction visual docking guidance system.
</td></tr>
<tr><td rowspan="2">Severity</td><td>Theoretical</td><td>• Minor to potentially major</td><td>• Minor</td></tr>
<tr><td>In-service</td><td>• TBV</td><td>• Minor</td></tr>
</table>

	Risk assessment category	B (generic risk model)	C (geometric argument)	B (generic risk model)	C (geometric argument)
Risk Assessment	Main technical materials	• Taxiway deviation statistics analysis (existing and on-going studies). (See Attachment C, items 6-9) • Overall length of the 777-8/9 fuselage and geometry of the nose and tail section. (See Attachment B: B9-10)	• Overall length of the 777-8/9 fuselage and geometry of the nose and tail section. (See Attachment B: B9-10)	• In-service ground accident/incident data involving 777 model aircraft. (See Attachment B: B56-57) • Overall length of the 777-8/9 fuselage and geometry of the nose and tail section. (See Attachment B: B9-10)	• Overall length of the 777-8/9 fuselage and geometry of the nose and tail section. (See Attachment B: B9-10)
Conclusions	• Clearances Maneuvering in/out of Aircraft Stand: - ICAO SARPs to be followed. Possibility of reduced distance with appropriate measure including visual docking guidance system, and marshaller(s). Consideration to be given for adequate space for the tow vehicle. • Clearances Around Parked Aircraft: - No guidance from ICAO SARPs on clearances around stationary aircraft. Acceptable clearance to be determined by the aircraft operator and airport authority on a case by case basis. • Safety assessment study to be made in case of reduction below these values. Refer to ICAO Doc 9981 (PANS Aerodromes), Appendix to Chapter 4, for guidelines.				

6.6.2 ICAO Baseline

Other than stating an aircraft stand should provide minimum clearances to the parked aircraft, ICAO does not provide SARPs concerning minimum vertical separation for two objects longitudinally nor SARPs concerning maximum aircraft fuselage length except aerodrome category for RFF.

6.6.3 Hazard Analysis

6.6.3.1 Hazard Identification

- Collision between a taxiing aircraft and the nose or tail section of parked aircraft.
- Collision between a ground vehicle and the nose or tail section of parked aircraft.

The first hazard relates to taxiway and taxilane to object separation which has been discussed in Part D, Taxiway Separation. Refer to Part D for the corresponding analysis and conclusion.

The second hazard is specific to vehicles operating on the ramp including GSE (ground service equipment), airline or airport staff and security vehicles, RFF vehicles. This analysis will focus on the Type C (geometric risk model) since there is little or no data to support Type B (generic risk model).

6.6.3.2 Causal analysis

The main causes of a taxiing aircraft colliding with the 777-8/9 are:

- Human factors.
- Environmental.
- System malfunction of taxiing aircraft.
- System malfunction of visual docking guidance system.

The main causes of a moving airport vehicle colliding with a 777-8/9 are:

- Human factors.
- Environmental factors.
- Ground vehicle and equipment malfunction.

6.6.3.3 Consequences analysis

Consequences of a taxiing aircraft colliding with the 777-8/9 are potentially major. In theory, consequences of a moving service vehicle/equipment colliding with the 777-8/9 are potentially minor.

6.6.4 Risk Assessment

None of causes listed in Section 2, Hazard Analysis, are directly related to the 777-8/9 performance, resulting in the following:

- Collision between a taxiing aircraft and the 777-8/9 is related to centerline deviation studies, therefore a Type B, generic argument risk assessment, was developed.
- The collision hazard of a ground vehicle or equipment colliding with a parked aircraft can be linked to the exterior 3D geometry of the aircraft. Type C, geometric argument risk assessment was developed.
- The collision hazard of a ground vehicle or equipment colliding with a parked aircraft is related to a) the ability of the vehicle to remain within the service road markings and b) the ability of the vehicle to avoid colliding with the underside of any park of a parked airplane. Although no accident or incident database can be used for this risk assessment, analyzing the management of aircraft stands/ramps under the current operating policies in place at worldwide airports could be considered a “generic risk model” assessment.

Attachment B contains the 777-8/9 vertical ground height data and graphic comparison with the 777-300ER. The exterior contour of 777-8/9 fuselage forward of nose landing gear and aft of last main deck door remains the same as the 777-300ER. The horizontal stabilizer of the 777-8/9 will be installed at the same location of the fuselage (relatively to the tail cone) as the 777-300ER, although it will be larger and higher above the ground at the end. The minimum ground height within those two segments of fuselage remains in the similar range between the 777-8/9 and the 777-300ER. The 777-8/9's collision risk with ground vehicle or equipment can be predicted as similar to the 777-300ER based on its similarity to the 777-300ER.

ICAO Annex 14 recommends a minimum of 7.5m clearance for Code Letter E and F aircraft maneuvering into and out of parking stands. ICAO also permits a reduction of such clearance at a nose-in stand served with azimuth guidance by a visual guidance system. ICAO European region in Air Navigation Plan (Doc 7754, Vol. 1) permits a minimum clearance of 5m between an aircraft using a stand equipped with a visual docking guidance system and any adjacent building, aircraft on other stand and other objects. This ANP document allows a further reduction to the clearance distance between an aircraft on a stand provided with azimuth guidance by a visual docking guidance system and an object or edge of a service road, subject to local circumstances provided that the object is not higher than 3m above the aircraft stand ground.

There is no ICAO guidance on minimum clearance to be maintained around stationary parked aircraft. As such, minimum clearances to ensure an adequate level of safety are to be determined by the aircraft operator or the airport authority on a case by case basis.

Airports worldwide have been operating safely for years under various clearance policies for a parked aircraft. The following are examples of stand clearance policies currently in place in worldwide airports:

- Aircraft nose clearance:
    - No clearance between aircraft nose and a service road or ground equipment storage area located in front of the aircraft.
    - 4.5m clearance between aircraft nose and a service road or ground equipment storage area located in front of the aircraft.
- Aircraft tail clearance:
    - Aircraft tail is permitted to overhang the service road located behind it where a height restriction is posed on vehicles operating on the service road.
    - No clearance between a parked aircraft and a service road located either behind or in front of it.
    - 1m clearance (horizontal distance) between a parked aircraft tail and a service road located behind it.
    - 3m clearance (horizontal clearance) between a parked aircraft and a service road located behind it.

6.6.5 Conclusions

BACG2 members agreed:

- 7.5m full body clearance to be maintained while maneuvering in and out of parking stand.

  - The minimum horizontal clearance in front of the 777-8/9 nose to any object (including mobile and fixed objects) could be reduced if a safety assessment study warrants it.

  - If azimuth guidance is provided with a visual docking guidance system, this minimum horizontal clearance could be reduced to any object (including mobile and fixed objects), the overhang distance is approximately 3.0m above the ground right underneath the 777-8/9 nose tip.

- Operators and airports to determine acceptable clearance to stationary parked aircraft.

BACG2 Attachment B

Physical Characteristics and Performance of 777-8/9

Table of Contents

777-8/9
Airplane Configuration

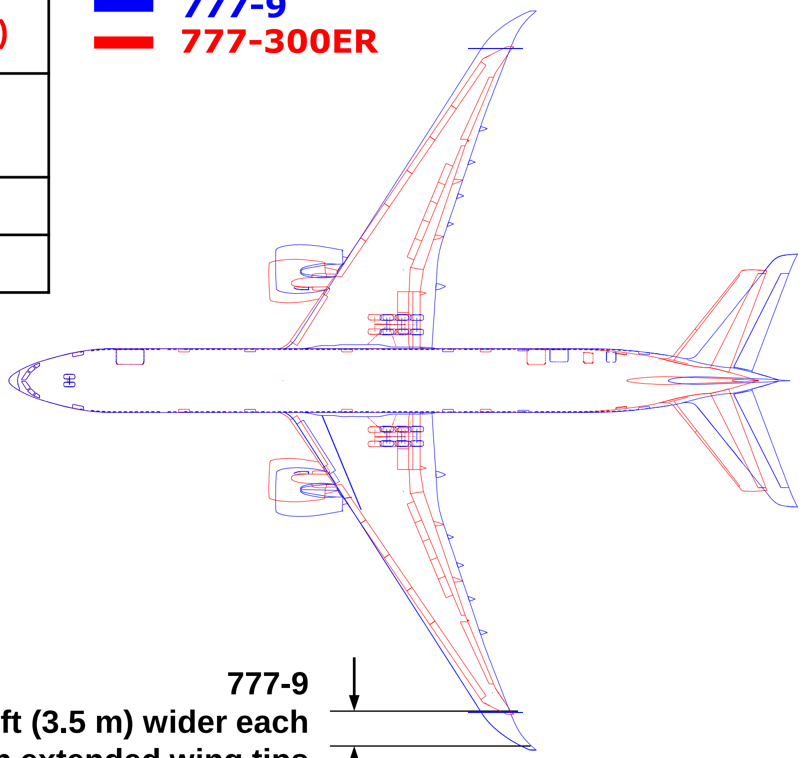
*777-8 data not available. Data will be available at a later date.

777-9 vs. 777-300ER Comparison

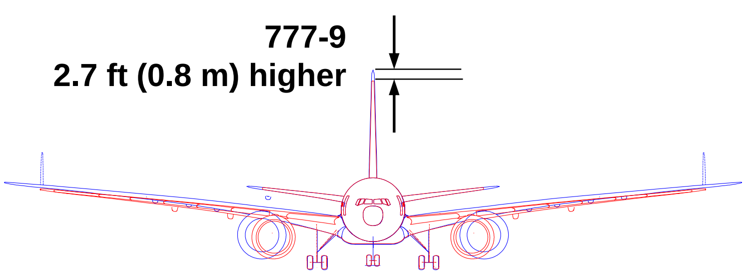
	777-9 (ft/m)	777-300ER (ft/m)
Span	235.4/71.8 (Extended Wings) 212.8/64.8 (Folded Wings)	212.6/64.8
Length	251.8/76.7	242.3/73.9
Height	64.1/19.5	61.4/18.7

*Information referenced in Attachment A – Part A Sec.

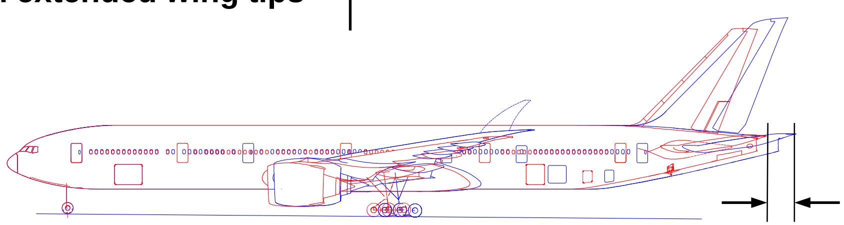
777-9
777-300ER



777-9
11.4 ft (3.5 m) wider each side with extended wing tips



777-9
2.7 ft (0.8 m) higher



777-9 9.5 ft (2.8 m) longer

*777-8 data not available. Data will be available at a later date.

777-9 General Characteristics

Characteristics	Units	777-300ER	777-9
Max design taxi weight	lb	777,000	777,000
	kg	352,442	352,442
Max design takeoff weight	lb	775,000	775,000
	kg	351,535	351,535
Max design landing weight	lb	554,000	587,000
	kg	251,290	266,259
Seating capacity (long range two-class)	seats	396 38 Business Class and 358 Economy Class	414 42 Business Class and 372 Economy Class
Max Cargo		(8) 96 in pallets + (20) LD-3 containers	(8) 96 in pallets + (24) LD-3 containers
Maximum fuel capacity	US gal	47,890	52,180
	L	181,283	197,523

***777-8 data not available. Data will be available at a later date.**

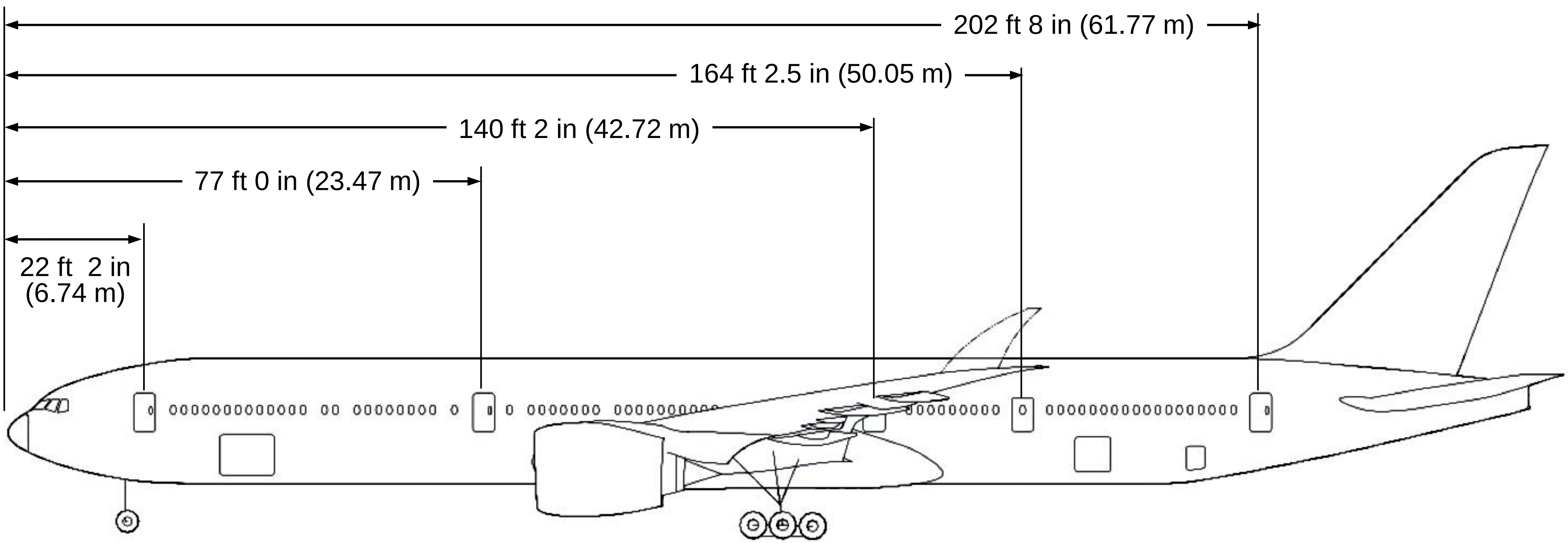
BOEING

777-9 Airport Compatibility
Large Airplane Comparison

Critical model shown in red	777-9	777-300ER	747-400ER	747-8	A340-600	A380-800
Wingspan	235.4ft (71.8 m)	212.6 ft (64.8 m)	213.0 ft (64.9 m)	224.4 ft (68.4 m)	208.0 ft (63.4 m)	261.8 ft (79.8 m)
Length	251.8 ft (76.7 m)	242.4 ft (73.9 m)	231.8 ft (70.7 m)	250.2 ft (76.3 m)	247.4 ft (75.4 m)	238.7 ft (72.7 m)
Tail height (max)	64.1 ft (19.5 m)	61.4 ft (18.7 m)	64.3 ft (19.6 m)	64.0 ft (19.5 m)	58.7 ft (17.9 m)	80.2 ft (24.4 m)
Wheelbase (to turning centroid)	106.0 ft (32.3 m)	100.4 ft (30.6 m)	79.0 ft (24.1 m)	92.3 ft (28.1 m)	107.9 ft (32.9 m)	97.8 ft (29.8 m)
Cockpit-to-main gear	118.0 ft (36.0 m)	112.2 ft (34.2 m)	86.6 ft (26.4 m)	100.0 ft (30.5 m)	121.6 ft (37.1 m)	104.6 ft (31.9 m)
Main gear span (to outer tire edges)	41.8 ft (12.8 m)	42.3 ft (12.9 m)	41.4 ft (12.6 m)	41.7 ft (12.7 n)	41.3 ft (12.6 m)	46.9 ft (14.3 m)
Outer engine span (centerline to centerline)	69.8 ft (21.3 m)	63.0 ft (19.2 m)	138.0 ft (42.1 m)	138.0 ft (42.1 m)	126.3 ft (38.5 m)	168.6 ft (51.4 m)
Wingtip height (min)	27.6 ft (8.4 m)	23.6 ft (7.2 m)	16.8 ft (5.1 m)	18.6 ft (5.7 m)	19.4 ft (5.9 m)	17.1 ft (5.2 m)
Max taxi weight	777,000 lb (352,442 kg)	777,000 lb (352,442 kg)	913,000 lb (414,130 kg)	990,000 lb (449,056 kg)	840,400 lb (381,200 kg)	1,258,000 lb (571,000 kg)

***777-8 data not available. Data will be available at a later date.**

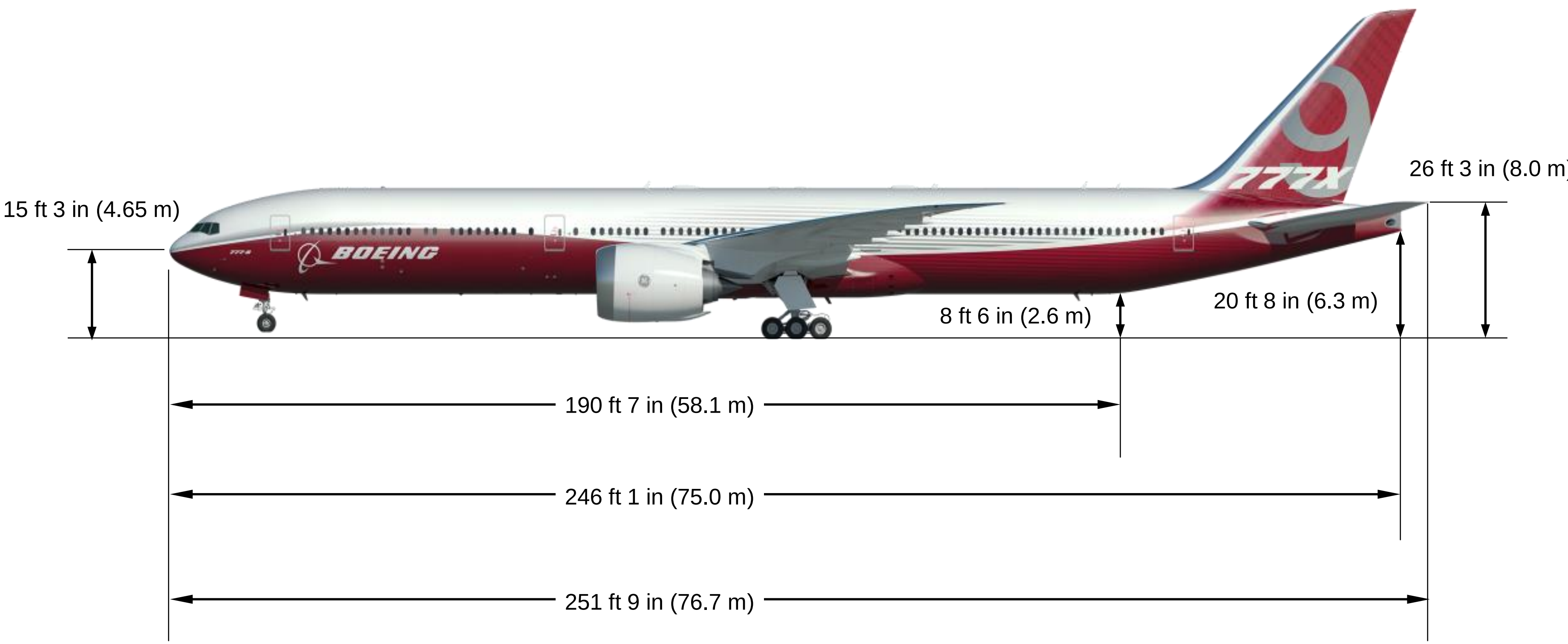
777-9 Door Locations



***777-8 data not available. Data will be available at a later date.**

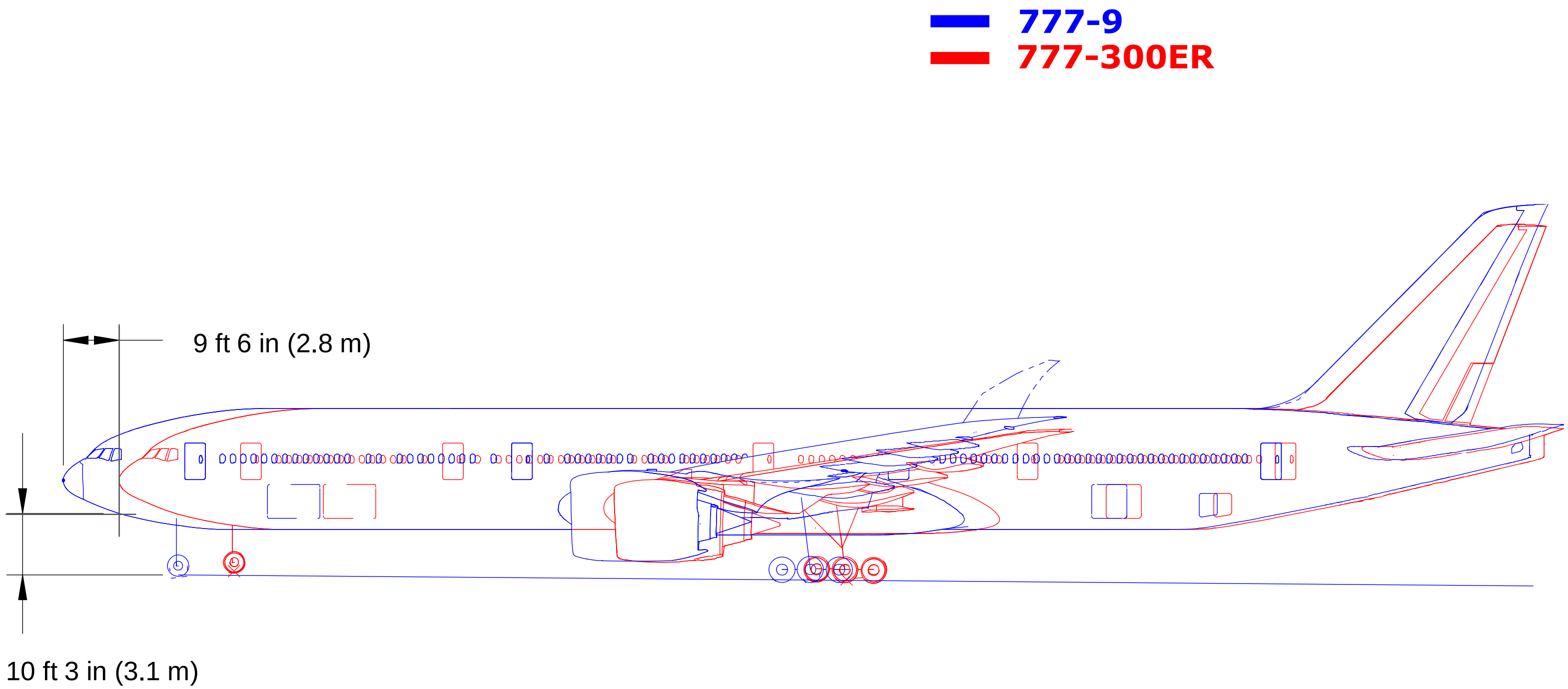
777-9 Ground Clearance

Estimated minimum height under normal loading conditions



***777-8 data not available. Data will be available at a later date.**

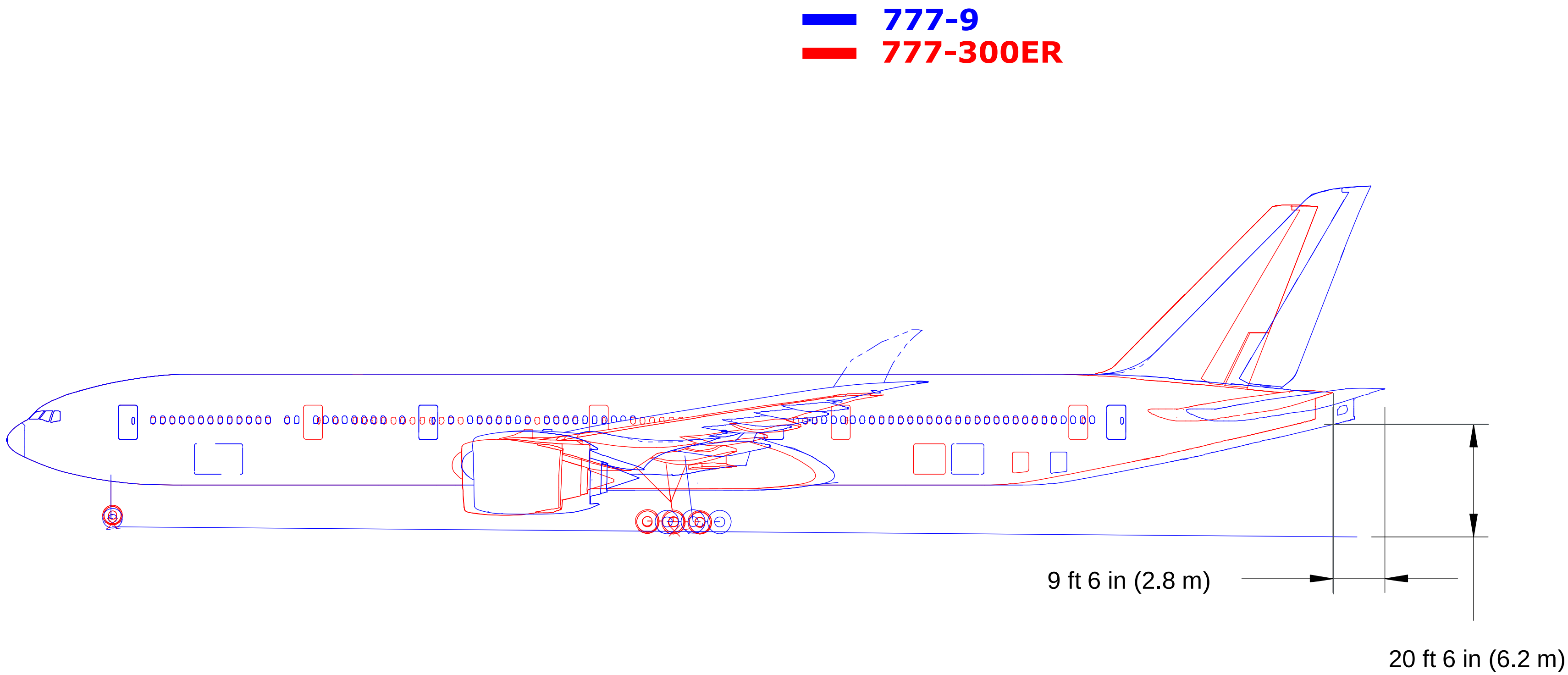
777-9 Ground Clearance
Estimated nominal height



Maximum overhang at nose (aft end of 777-9 aligned with 777-300ER).

***777-8 data not available. Data will be available at a later date.**

777-9 Ground Clearance
Estimated nominal height



Maximum overhang at tail (nose of 777-9 aligned with 777-300ER).

***777-8 data not available. Data will be available at a later date.**

777-8/9 Performance Features and Safety Enhancements

777-8/9 Low Speed Flying Capability is Similar or Better than 777-300ER

- Lateral handling qualities are anticipated to be similar to those of the current 777 models as a result of the following are design changes and new features for the 777-8/9:
  - Directional control.
    - New larger vertical tail to maintain heritage 777 directional control given the larger wing.
    - New single hinged rudder to remove complexity and simplify the design while maintaining 777 directional control.
    - Inertial Thrust Asymmetry Compensation to improve existing control system and to incorporate 787 technology.
    - Spudders for improved directional control on ground, incorporate 747-8 technology.
    - P-Beta for advanced directional control in air, incorporate 787 technology.
  - Lateral Control.
    - Increased number of spoilers to maintain heritage 777 lateral control given the larger wing.
    - P-Beta for advanced lateral control in air, incorporate 787 technology.
- 777-9 and 777-8 retains Code E aircraft maneuverability.

777-8/9 Flight Deck Features to Improve Situational Awareness

- Wingtip view from the Ground Maneuver Camera System.
- Moving map (now forward versus looking off to the side).
- Vertical situation display (VSD) (new) – improves vertical awareness; path prediction relative to the ground; airplane shown in a vertical profile.
- Integrated approach navigation (IAN) (new) – ILS-like deviation alerts, same procedure for all approaches.
- Global navigation satellite landing system (GLS) (new) – less noise (signal interference) than ILS.

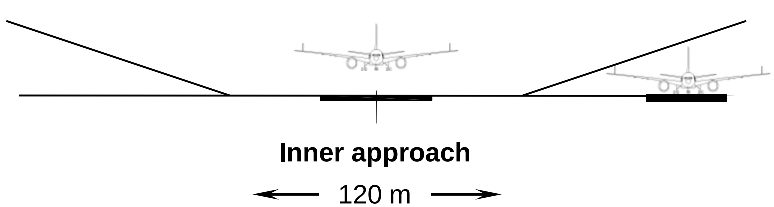
Obstacle Free Zone (OFZ)

777-8/9 is Compatible with ICAO Code E OFZ

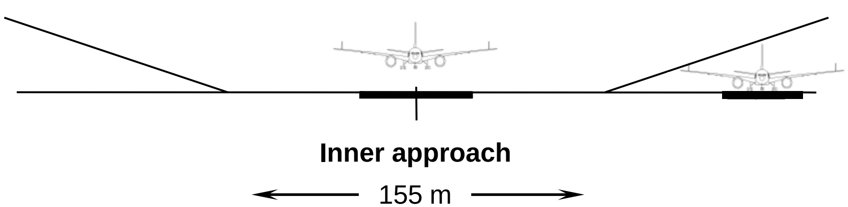
OFZ (Obstacle Free Zone)

- Obstacle free airspace centered along the runway for balked landing protection.
- Studies have found that airplanes equipped with digital auto pilot/avionics and track hold guidance remain on intended ground track more accurately.
  - ICAO has declared that a Code F airplane so equipped (such as 777-8/9) is compatible with Code E OFZ. (Annex 14, Table 4-1 Note e; ICAO Circular 301)
  - ICAO IFPP (Instrument Flight Procedures Panel) CRM (Collision Risk Model): Drafting Circular 345, an update to Circular 301 pertaining to Code F aircraft operating in Code E OFZ (Obstacle Free Zone).
- 777-8/9 on a parallel taxiway is not affected by Code E OFZ (Lower tail height than 747-400ER).

Code E approach



Code F approach



***777-8 data not available. Data will be available at a later date.**

ICAO Documents on Code F OFZ

- ICAO Annex 14 Text on Obstacle Free Zone (OFZ).

  Chapter 4, Table 4-1, Note e: Where the code letter is F (Column (3) of Table 1-1), the width is increased to 155m. For information on code letter F airplanes equipped with digital avionics that provide steering commands to maintain an established track during the go-around maneuver, see Circular 301 — *New Larger Airplanes — Infringement of the Obstacle Free Zone: Operational Measures and Aeronautical Study*.

- ICAO Circular 301-AN/174 text on OFZ findings.

  Part I, Chapter 3:

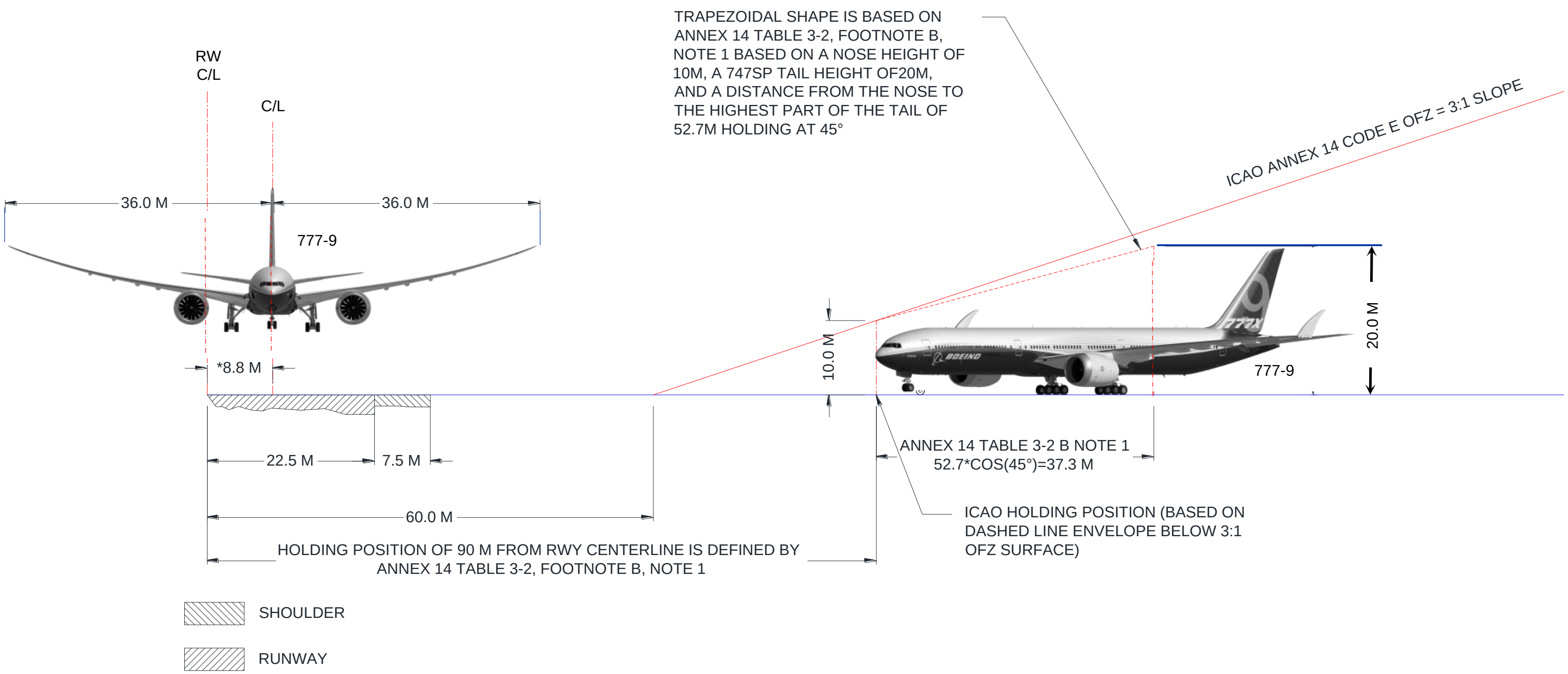
  3.2.2: The balked landing study results found that when a modern digital autopilot or flight director with track hold guidance is used for the approach, a code letter F airplane would be contained within the code letter E OFZ. Consequently, the code letter E balked landing surface could be used to assess obstacles around the runway.

  3.2.3: Both the total width of 120m and the slope of 3:1 for the balked landing surface were found to be adequate.

- ICAO Circular 345 – *New Larger Airplanes – Infringement of the Obstacle Free Zone: Collision Risk Model and Aeronautical Study* further confirmed the suitability of the OFZ defined for Code letter E operations for Code Letter F aircraft.

777-9 is Compatible with ICAO Code E OFZ

OBSTACLE FREE ZONE CODE E
90 M HOLD LINE POSITION



* MAXIMUM OFFSET (ON GROUND, ONE EVENT) FROM 2148 AIRCRAFT CERTIFICATION FLIGHT TESTS (LANDINGS,TAKEOFFS, TOUCH AND GOES) CONDUCTED BY BOEING, FAA, AND EASA PILOTS.

BALKED LANDING STUDY RESULTS SHOW CODE F AIRCRAFT WITH MODERN DIGITAL AUTOPILOT WITH TRACK HOLD GUIDANCE (777-9 IS SO EQUIPPED) USED FOR APPROACH IS CONTAINED WITHIN CODE E OFZ. ICAO CIRCULAR 301 (NEW LARGER AIRPLANES - INFRINGEMENT OF OBSTACLE FREE ZONE: OPERATIONAL MEASURES AND AERONAUTICAL STUDY)

***777-8 data not available. Data will be available at a later date.**

Autoland Requirements/ Performance

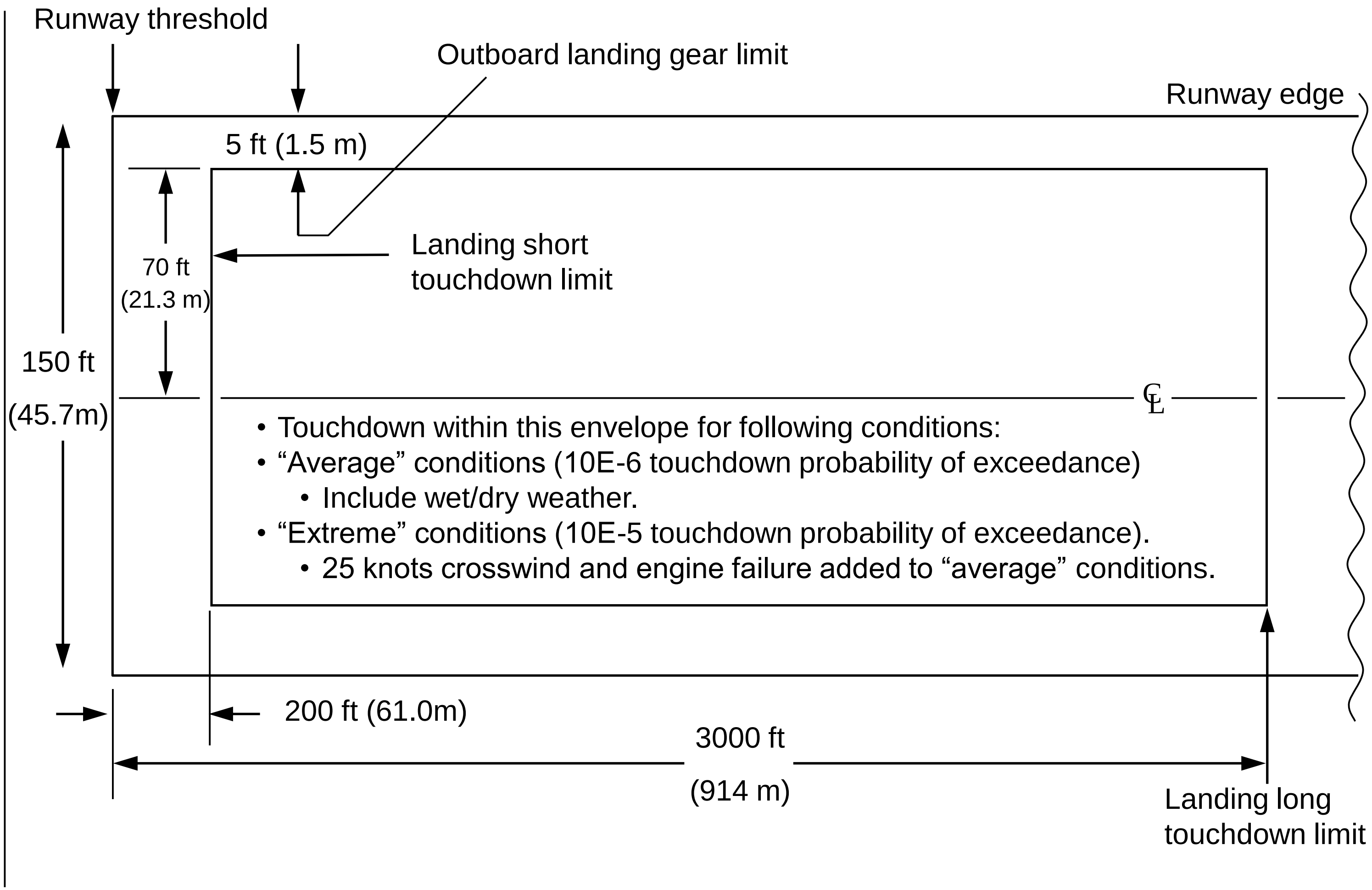
777-9 Autoland Requirement

- Autoland certification requirement:
  - FAA AC 120-28D/JAR-AWO sub-part 1, 2, and 3 “Criteria for approval of category III weather minima for takeoff, landing, and rollout”.

- Based on 777-300ER simulation data for certification, 777-8/9 is expected to be well within the prescribed touchdown zone for all test conditions:
  - Simulation correlated to actual aircraft (777-300ER) performance.
  - Aircraft configuration parameters matched.
    - Similar landing gear geometry.
    - Improved autopilot design.
    - Same autoland control law design.
      (Retuned for aerodynamic differences)

***777-8 data not available. Data will be available at a later date.**

Expected Lateral Performance



- Touchdown within this envelope for following conditions:
- "Average" conditions (10E-6 touchdown probability of exceedance)
  - Include wet/dry weather.
- "Extreme" conditions (10E-5 touchdown probability of exceedance).
  - 25 knots crosswind and engine failure added to "average" conditions.

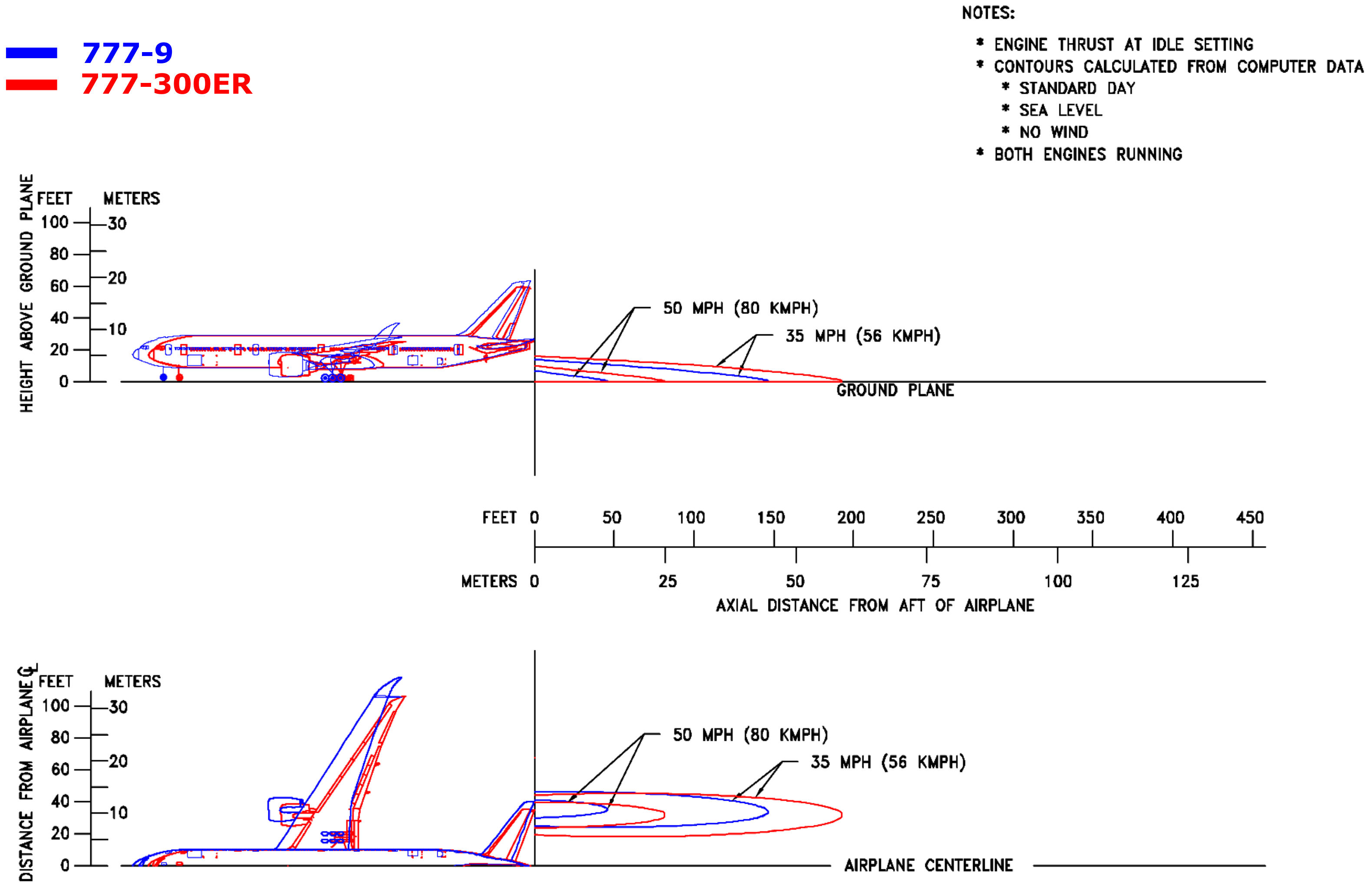
Engine Exhaust Velocities

777-8/9 Engine Exhaust Velocity Contours

- For runway shoulder width design, the preliminary 56 km/h exhaust velocity contour at take-off thrust is used as a reference for the evaluation of jet blast protection.
- ICAO Code E runway and taxiway shoulder widths are adequate for 777-8/9.
  - Breakaway velocity contour width similar to current 777-300ER (applies to TWY shoulders).
  - Takeoff velocity contour width (at 56 km/hr) is estimated at 51m, well within the Code E runway plus shoulder width of 60m.
  - 777-8/9 engine height above ground is higher than 777-300ER providing improved ground and obstacle clearance.
- No additional shoulder width is required for jet-blast protection, engine ingestion protection, and occasional RFF vehicle access.

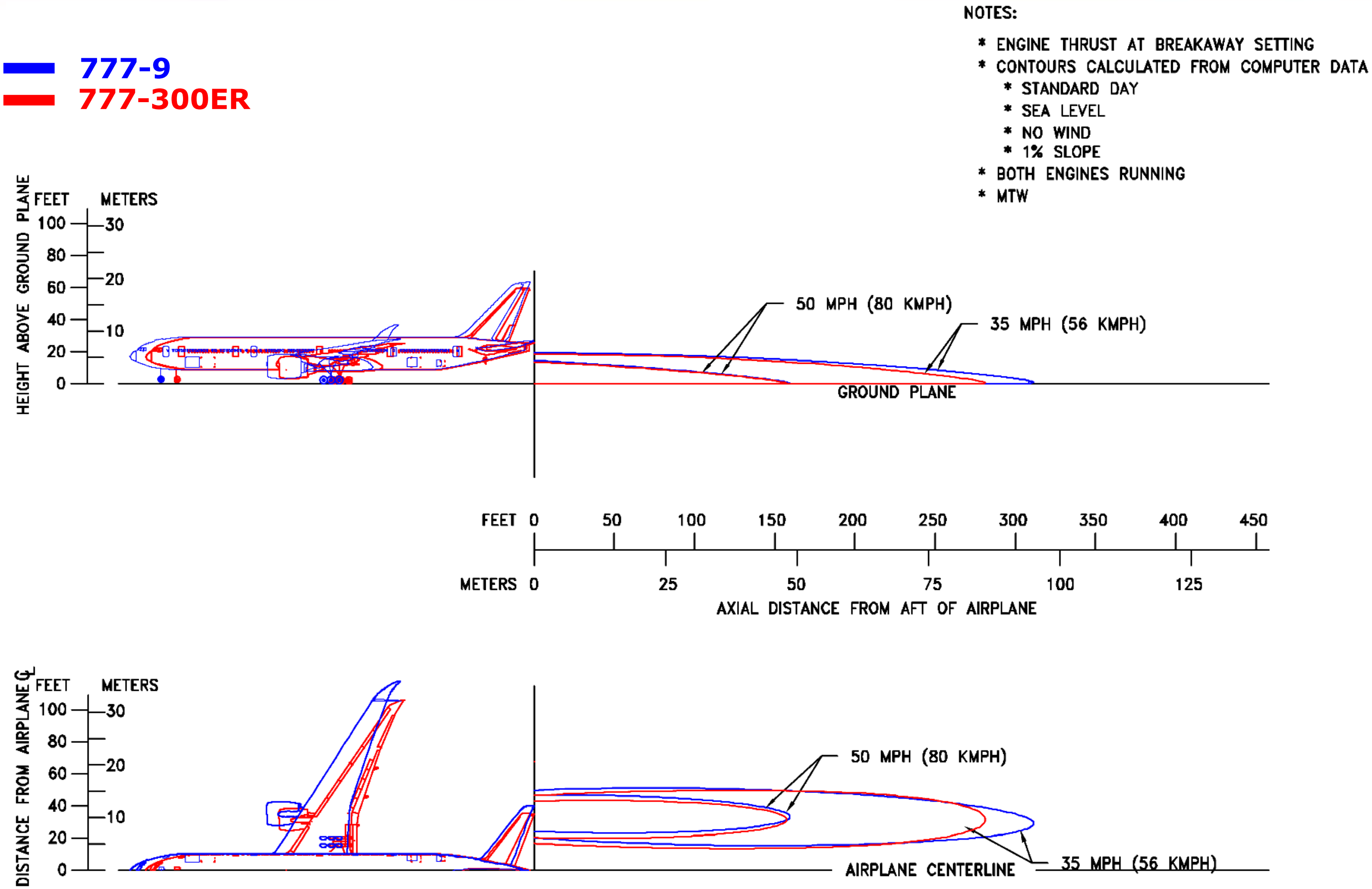
***777-8 data not available. Data will be available at a later date.**

777-9 vs. 777-300ER Engine Exhaust Velocities – Idle Thrust



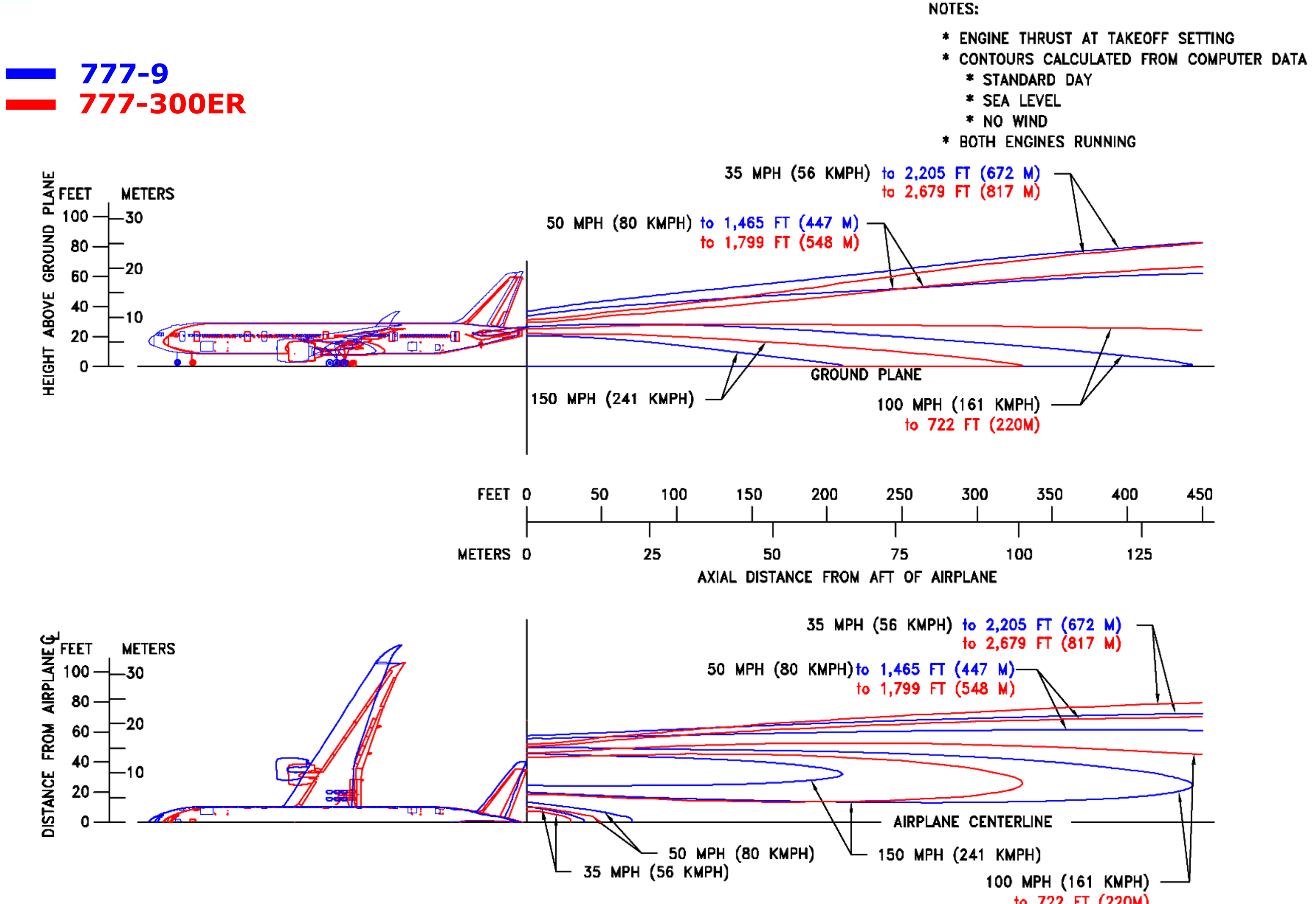
***777-8 data not available. Data will be available at a later date.**

777-9 vs. 777-300ER Engine Exhaust Velocities – Breakaway Thrust



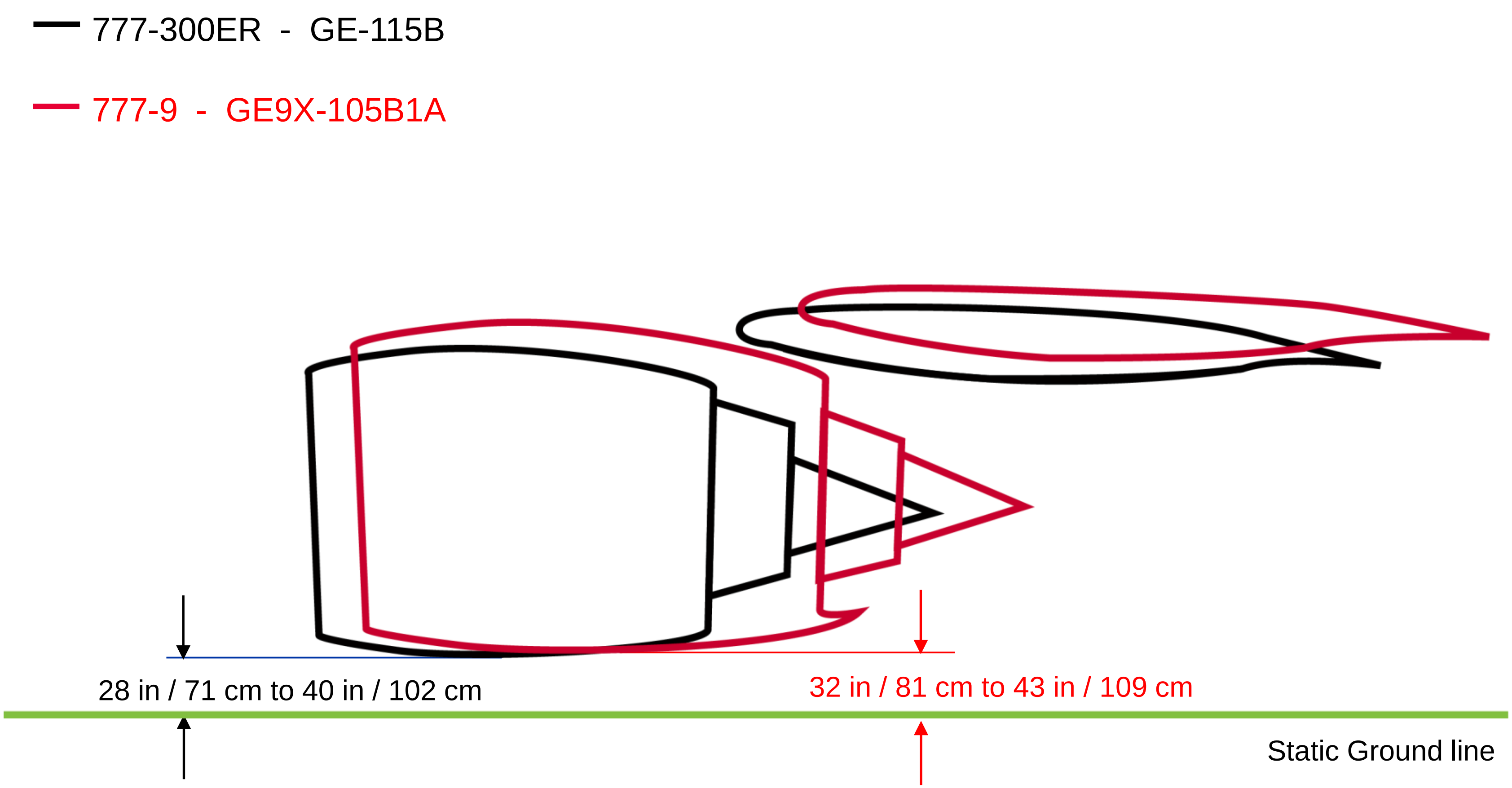
*777-8 data not available. Data will be available at a later date.

777-9 vs. 777-300ER Engine Exhaust Velocities – Takeoff Thrust



***777-8 data not available. Data will be available at a later date.**

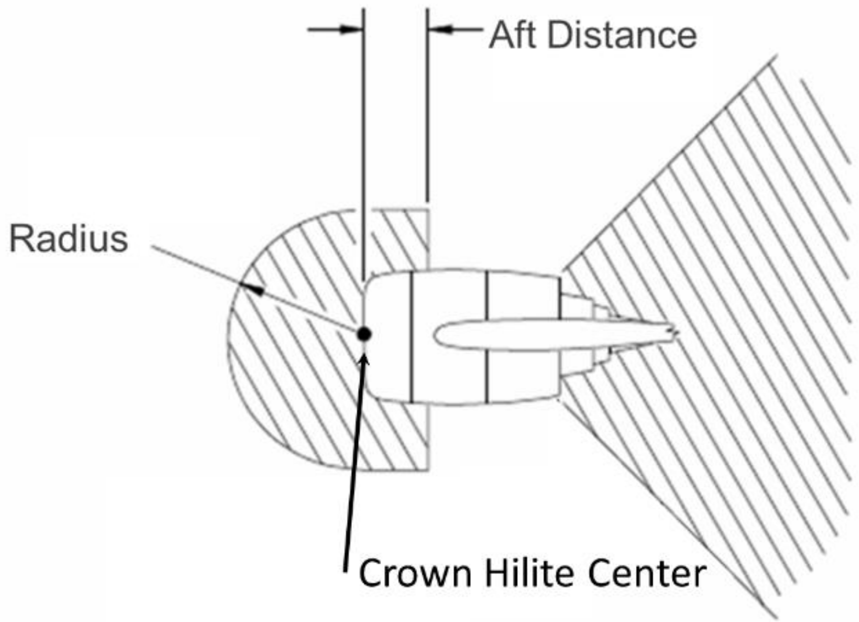
777-9 Engine Height Above Ground



Heights are preliminary until after Flight Test is complete.

***777-8 data not available. Data will be available at a later date.**

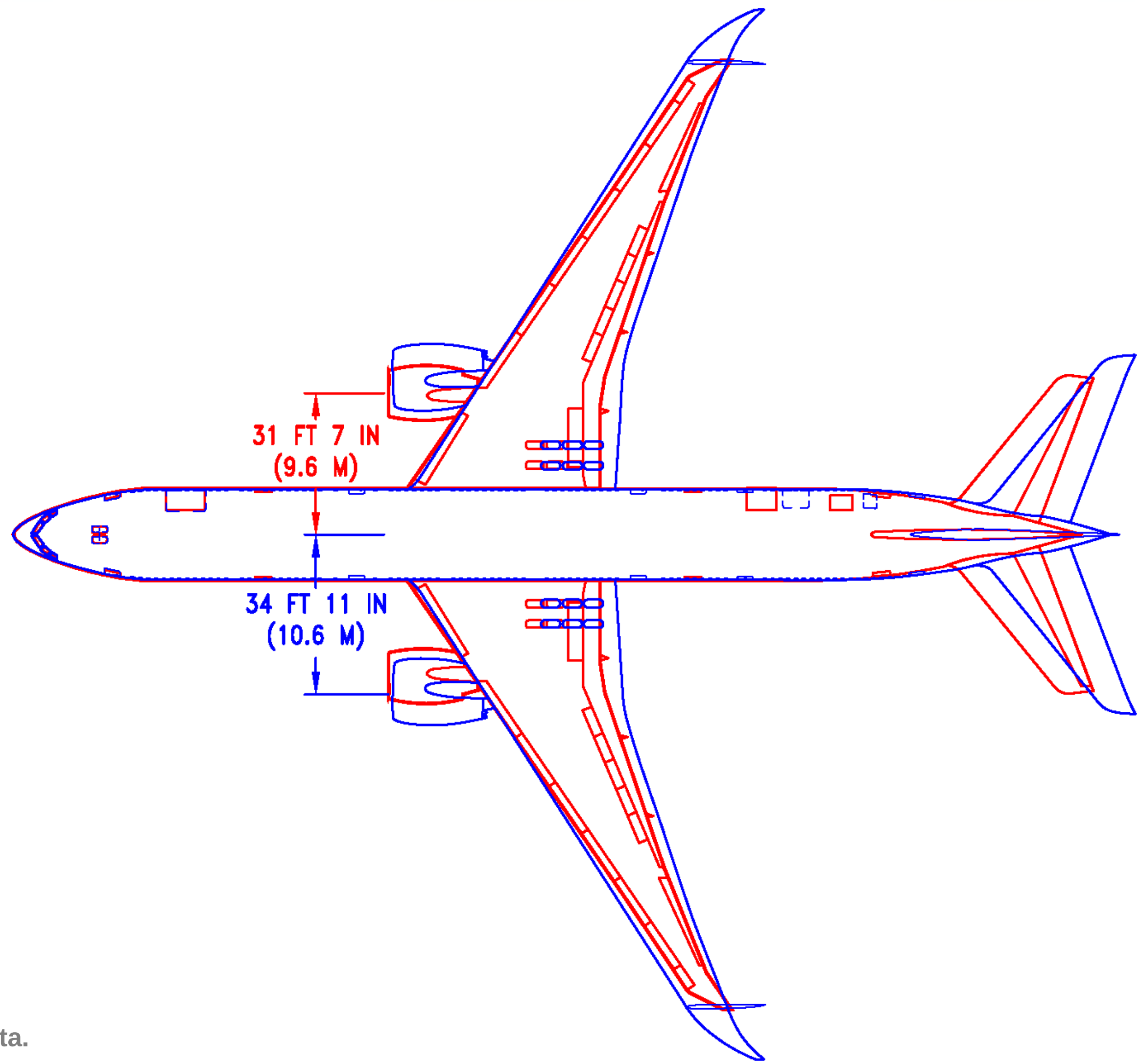
777-8/9 Engine Ingestion



	Radius		Aft Distance	
Idle Thrust	22.1 ft	6.7 m	11.0 ft	3.4 m
Breakaway Thrust	25.5 ft	7.8 m	15.3 ft	4.7 m
Takeoff Thrust	46.8 ft	14.3 m	18.1 ft	5.5 m

***777-8 data not available. Data will be available at a later date.**

777-8/9 Engine Distance from Fuselage Centerline

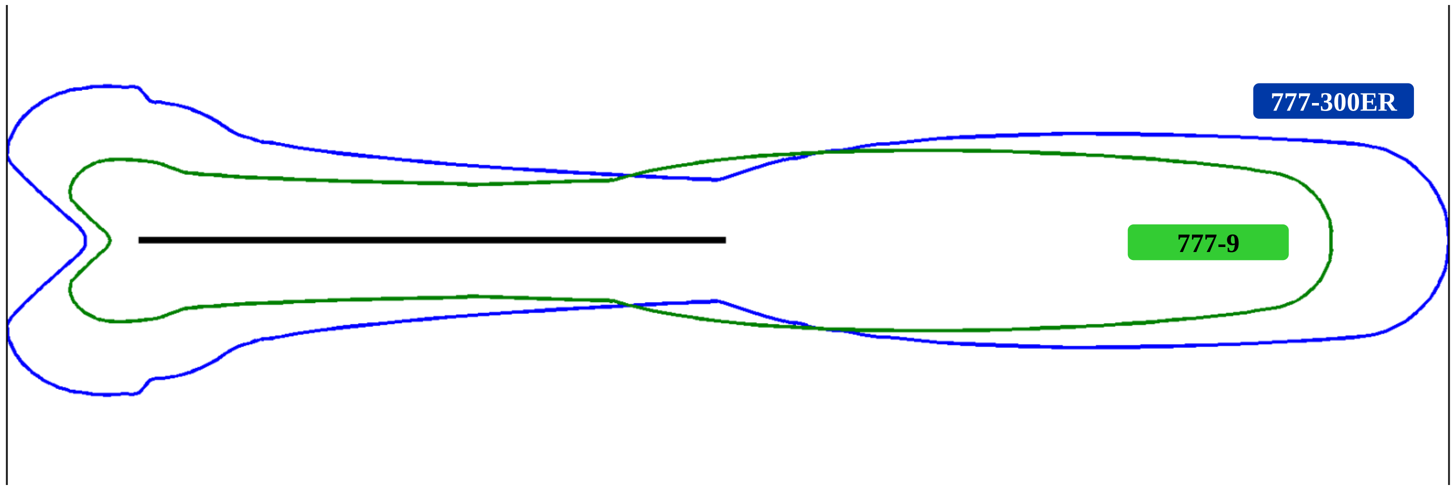


*777-8 Preliminary data.

Noise Contours
Wake Vortex

777-9 Quieter for the community

- 85dBA Takeoff Noise Contours, MTOW mission

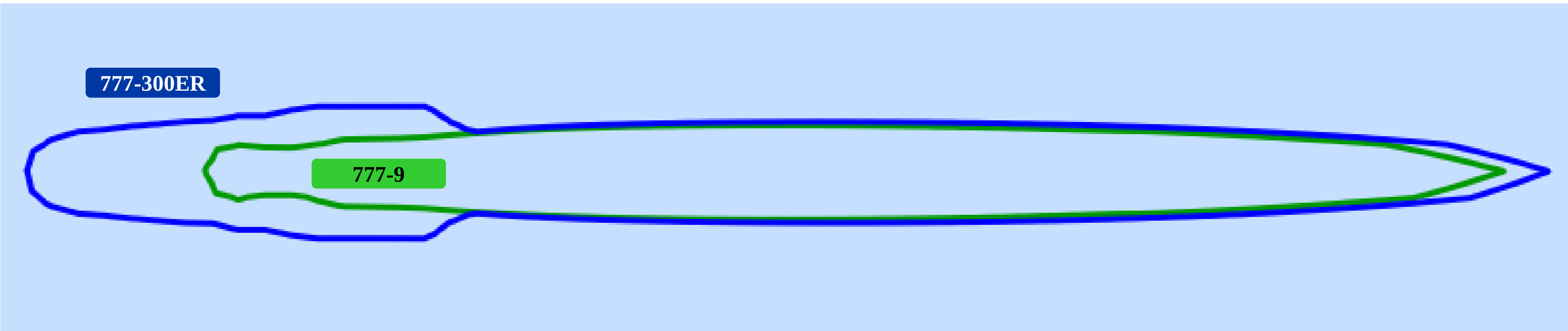


- 777-300ER levels are based on Certified Noise database.
- 777-9 levels are predicted levels based on the noise model.
- Based on a 10,000 ft (3,048 meter) long runway.

***777-8 data not available. Data will be available at a later date.**

777-9 Quieter for the community

- 85dBA Approach Noise Contours at MLW



- 777-300ER levels are based on Certified Noise database.
- 777-9 levels are predicted levels based on the noise model.
- Based on a 10,000 ft (3,048 meter) long runway.

***777-8 data not available. Data will be available at a later date.**

- Current ICAO wake separations are based on airplane weight, but new wake classifications being implemented in the US and elsewhere are based on wake characteristics (e.g. RECAT I and II, RECAT-EU).

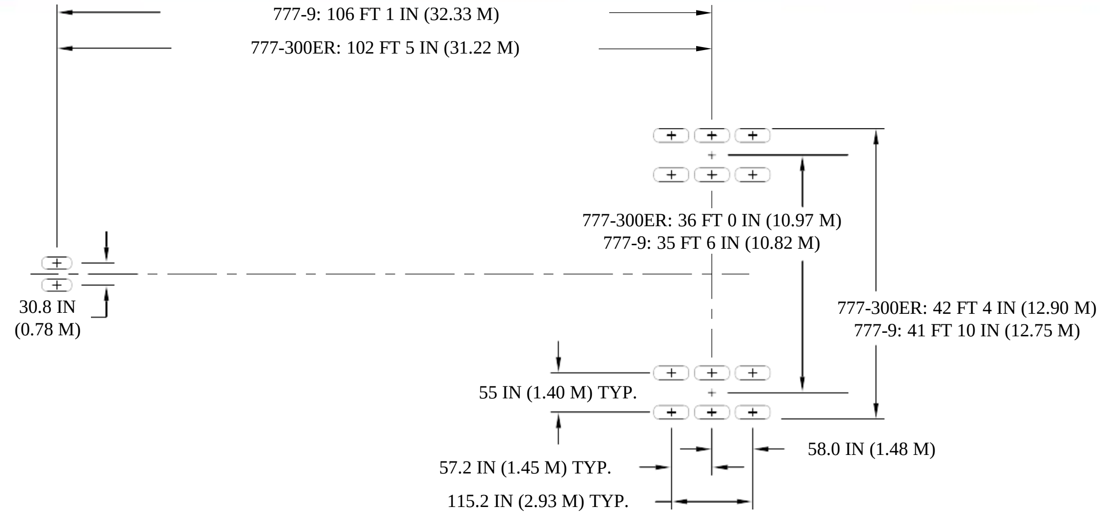
- The 777-8/9 is designed to have wake characteristics similar to today's Heavy aircraft.

- While detailed assessments are now underway, a combination of wind-tunnel data and wake-development simulations suggests that this design objective is being met.

***777-8 data not available. Data will be available at a later date.**

Ground Maneuvering

777-9 Landing Gear Footprint



Characteristics	Units	777-300ER	777-9
Max design taxi weight	lb	777,000	777,000
	kg	352,442	352,442
Nose gear tire size	in	43x17.5R17/32PR	43x17.5R17/32PR
Nose gear tire pressure	psi	218	215/218
		15.3	15.1/15.3
Main gear tire size	in	52x21R22/36PR	52x21R22/38PR
Main gear tire pressure	psi	218	229
		15.3	16.1

***777-8 data not available. Data will be available at a later date.**

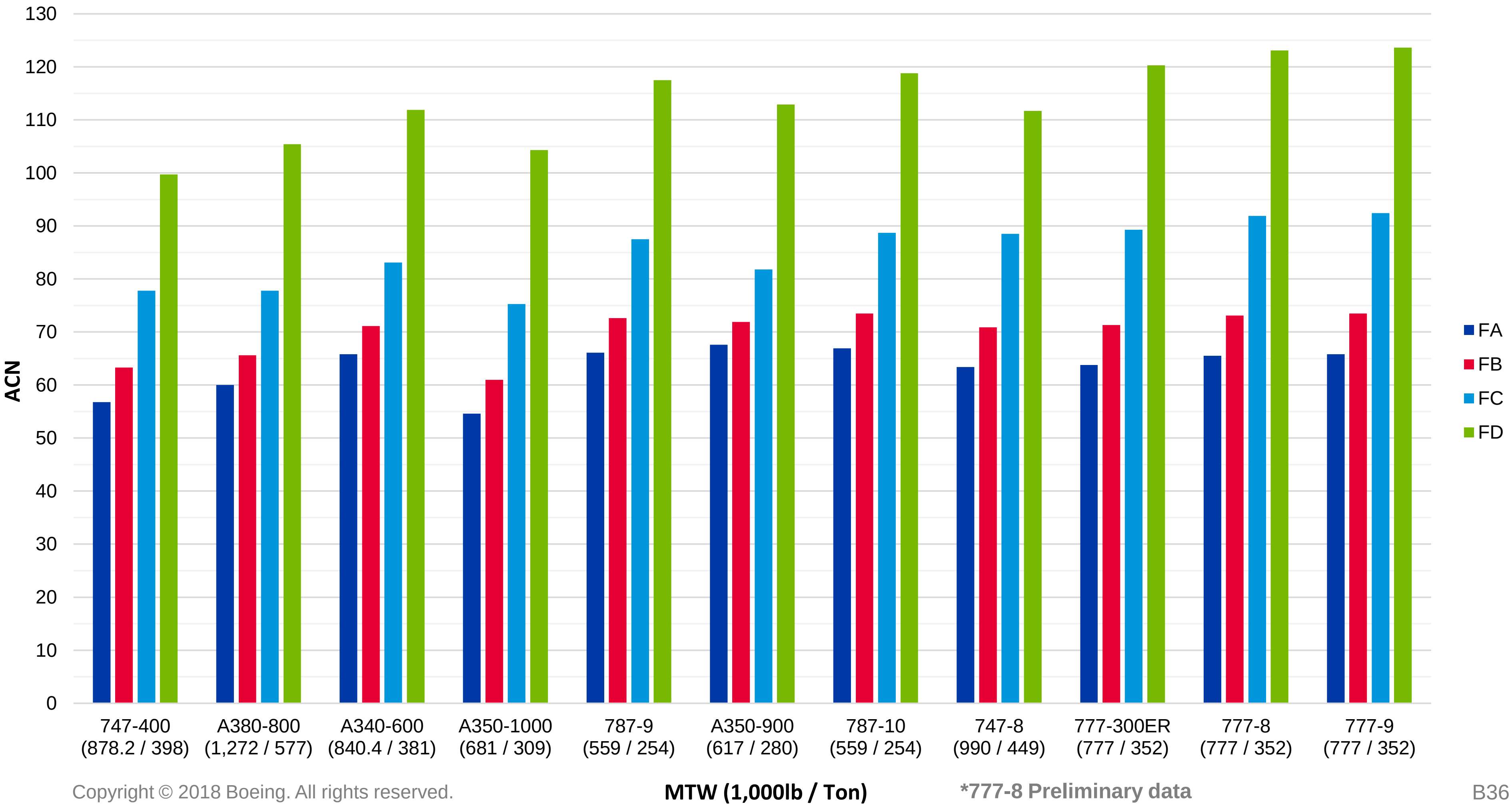
777-8/9 Landing Gear Tire Pressure Comparison

Model	MLG Tire Pressure (psi)	MLG Tire Pressure (MPa)	Single Wheel Load (lb)	Single Wheel Load (kg)
747-400ER	228	1.57	53399	24,221
747-400ERF	228	1.57	53399	24,221
A330-200	206	1.42	60879	27,614
A330-200F	206	1.42	60879	27,614
A330-300	216	1.49	62774	28,474
A340-200	206	1.42	60422	27,407
A340-300	206	1.42	60689	27,528
A340-500	234	1.61	66465	30,148
A340-600	234	1.61	66696	30,253
A350-900	244	1.68	71280	32,332
A380-800	218	1.50	60106 (4 wheel)	27, 264 (4 wheel)
B747-400	200	1.38	51166	23,209
B747-400F	200	1.38	51176	23,213
B747-8	221	1.52	58589	26,576
B747-8F	221	1.52	58379	26,480
B777-200	183	1.26	42707	19,372
B777-200ER	205	1.41	50342	22,835
B777-200LR	218	1.50	58739	26,644
B777-300	215	1.48	52320	23,732
B777-300ER	221	1.52	59868	27,156
B777-8	229	1.58	60865	27,608
B777-9	229	1.58	61059	27,696
B777F	218	1.50	58749	26,648
B787-10	226	1.56	65450	29,688
B787-8	228	1.57	57449	26,058
B787-9	226	1.56	64888	29,433
MD-11F	206	1.42	61354	27,830

***777-8 Preliminary data**

777-9 ACN Comparison (Flexible Pavement)

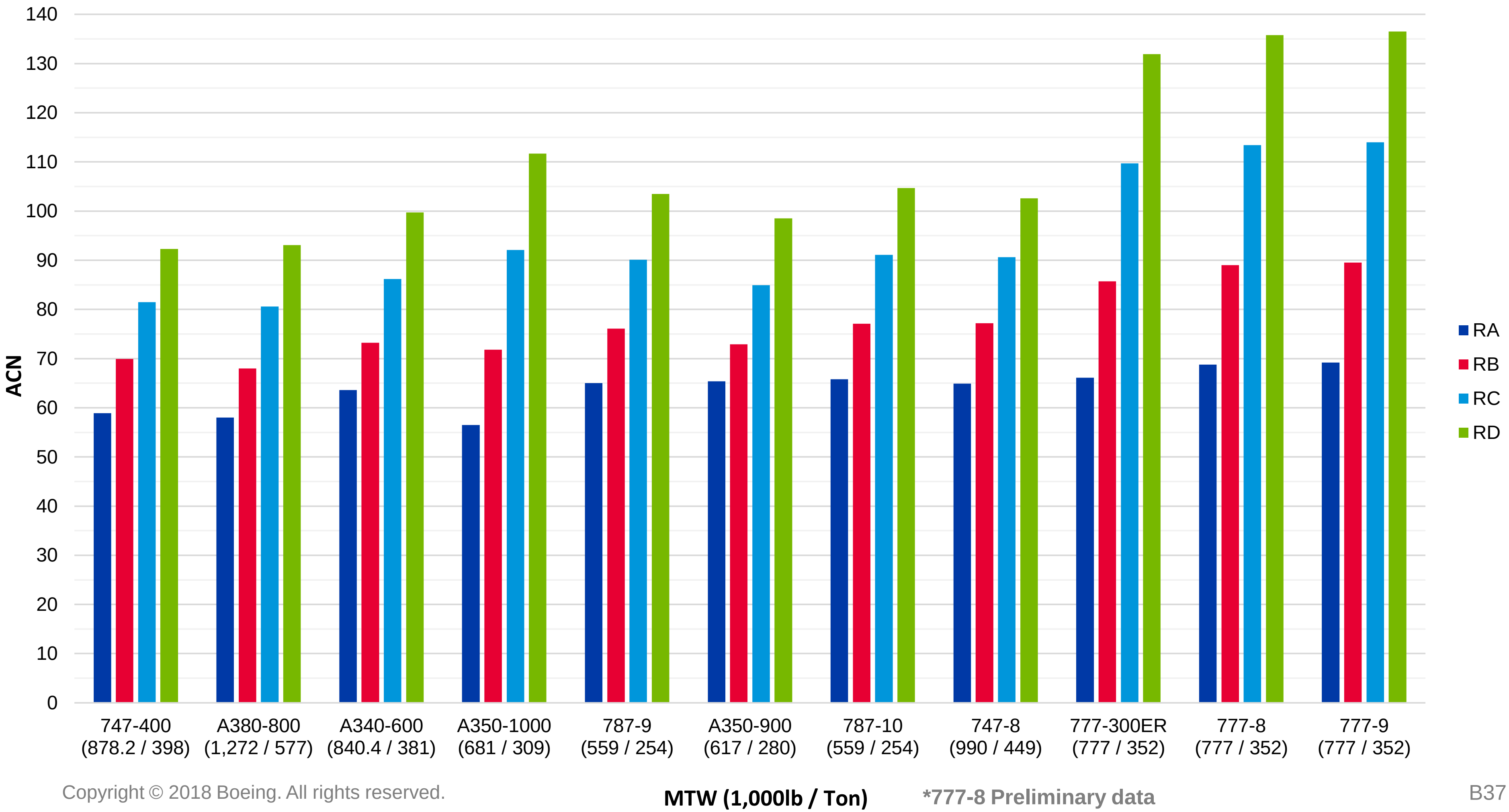
ICAO Aerodromes Manual, Annex 14, provides general guidance for permissible overload operations provided the pavement is in good condition, and as long as the overload traffic does not exceed 5% of total annual aircraft movements at the airport. For flexible pavements, the permissible overload is 10%, such that the aircraft ACN should not exceed 10% above the reported PCN. The airline must confirm the allowance for overload with the airport authority prior to commencing the operation. The ICAO guidance for overload is not binding and may vary depending on country. Further, some counties use a formal pavement concession system for individual operations.



*777-8 Preliminary data

777-9 ACN Comparison (Rigid Pavement)

ICAO Aerodromes Manual, Annex 14, provides general guidance for permissible overload operations provided the pavement is in good condition, and as long as the overload traffic does not exceed 5% of total annual aircraft movements at the airport. For rigid pavements, the permissible overload is 5%, such that the aircraft ACN should not exceed 5% above the reported PCN. The airline must confirm the allowance for overload with the airport authority prior to commencing the operation. The ICAO guidance for overload is not binding and may vary depending on country. Further, some counties use a formal pavement concession system for individual operations.



*777-8 Preliminary data

777-9 ACN
Reduced TOW For Alternate Operations

1 Hour Flight at MZFW, Standard Rules:

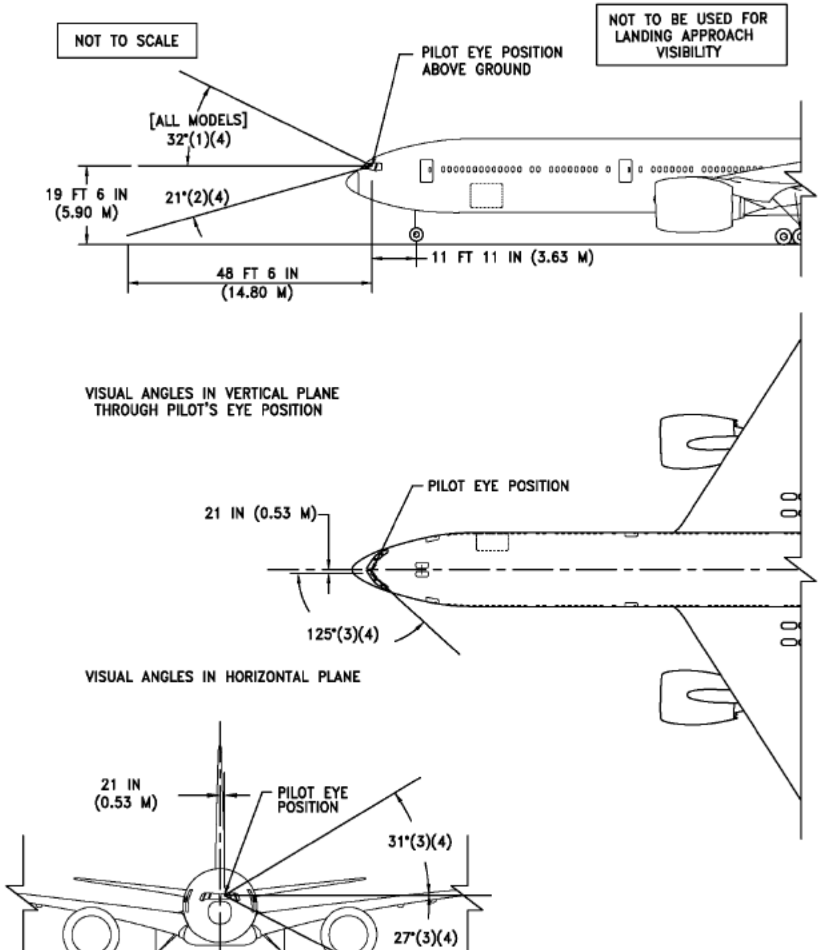
- ZFW: 562,000 lb
- Total Loaded Fuel: 31,931 lb
- Takeoff Weight: 593,400 lb
- C.G. : 33.8% MAC

Pavement Type	Flexible				Rigid			
Subgrade	A	B	C	D	A	B	C	D
ACN	46	50	61	86	47	59	76	92

*777-8 data not available. Data will be available at a later date.

777-9 and 777-300ER Cockpit Visibility

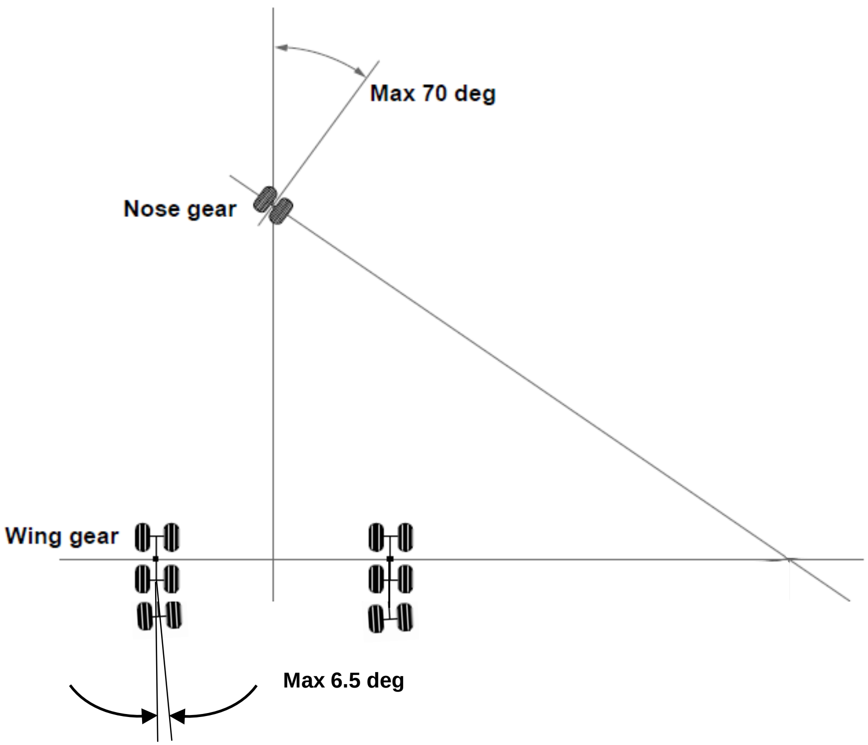
*777-8 data not available. Data will be available at a later date.

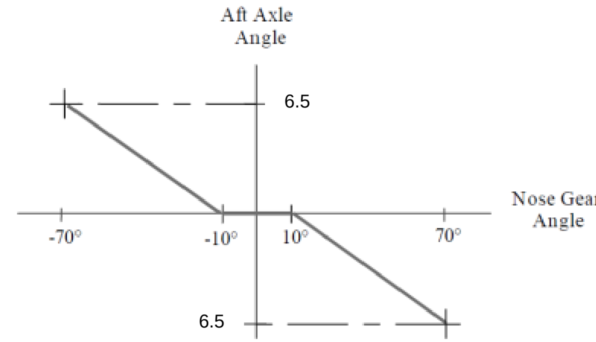


NOTES:
(1) UPWARD THROUGH MAIN WINDOW
(2) DOWNWARD THROUGH MAIN WINDOW
(3) VISION THROUGH SIDE WINDOW
(4) HEAD ROTATED ABOUT POINT 3.3 IN (0.08 M) AFT OF PILOT'S REFERENCE EYE POSITION.

777-9: Same Proven Steering System as Existing 777-300ER

777-8/9 has the same main gear aft axle steering system as today's 777-300ER.

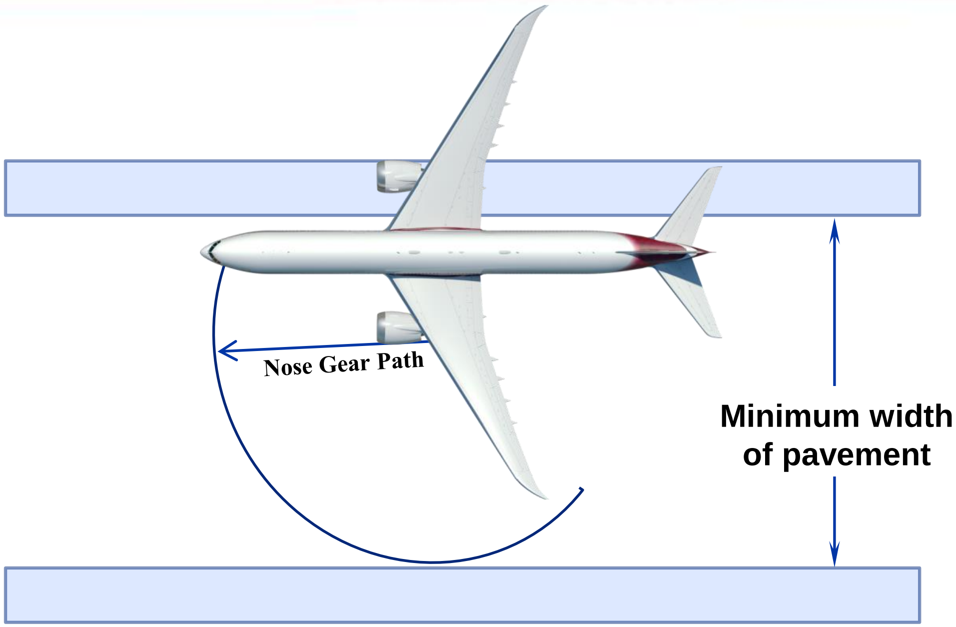




Nose Gear	Main Gear Aft Axle
0 to 10 degrees	0
10 to 70 degrees	0 to 6.5 degrees

***777-8 Preliminary data**

777-9 180° Turn Width Requirement



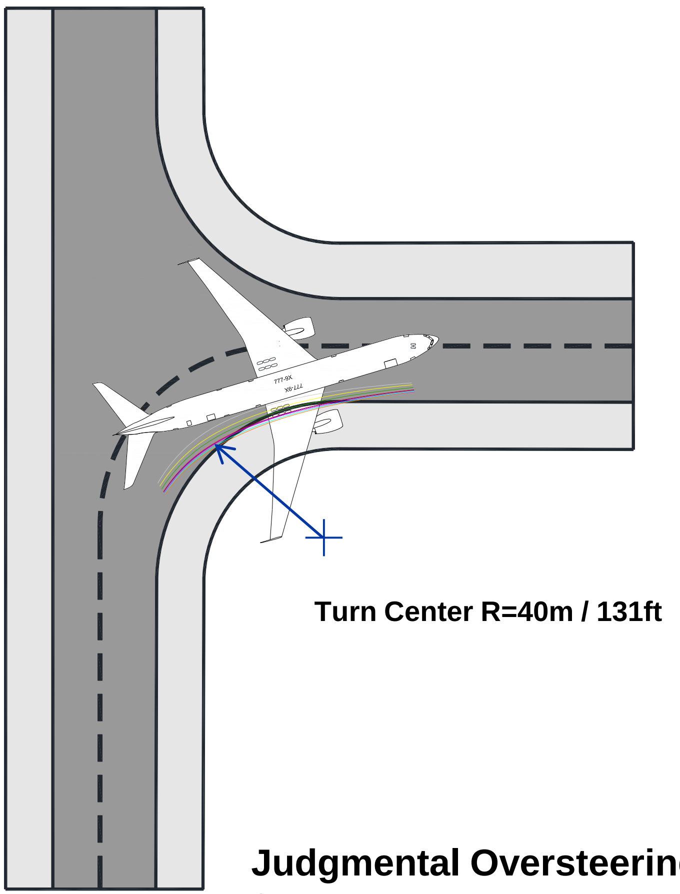
- U-turn width can be reduced by using differential braking or asymmetrical thrust.
- Minimum widths are calculated based on data from available airport planning manuals and not nominal values.

	747-400	787-10 [1]	747-8	777-300ER	777-9 [1]	A340-600	A380-800 [2]
ICAO Airplane Design Code	E	E	F	E	F	E	F
180 turn width (max steering angle, no differential braking)	51m	52m	52 m	57 m	58 m	57 m	57 m

1. PRELIMINARY
2. Boeing calculation using no differential braking, asymmetric thrust – current Airbus A380 planning manual value (50.91) includes differential braking and asymmetric thrust.
3. Minimum widths do not take into account tire-edge clearance of 15 ft (4.5m) at both pavement edges.

*777-8 data not available. Data will be available at a later date.

777-9 Fillet Requirement
90° Turn
Nose Gear over Centerline



Model	ICAO design code	Tire edge to turn center (ft)
A340-600	E	38.4
A350-1000*	E	38.7
A380	F	39.0
777-9*	E**	39.0
777-300ER	E	39.3
747-8	F	39.9
787-10*	E	40.8
747-400	E	41.8

LESS CRITICAL

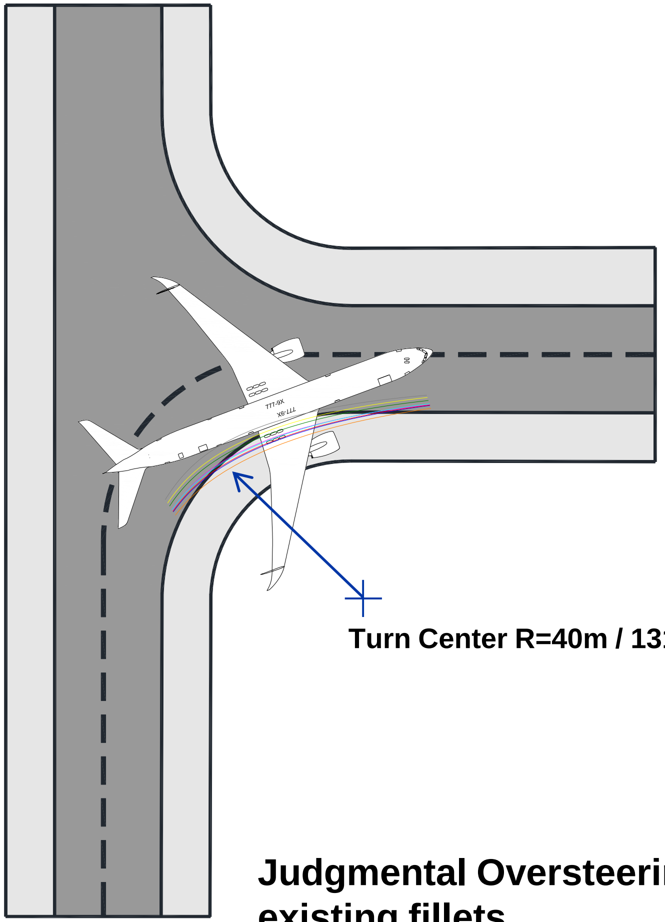
* PRELIMINARY
** E after exiting the taxiway

Judgmental Oversteering permits adequate tire edge clearance on a typical 40m existing fillets.

NOTE: Analysis by AeroTurn software with 777-300ER and 777-9 aft-axle steering in-operative.

***777-8 data not available. Data will be available at a later date.**

777-9 Fillet Requirement
90° Turn
Cockpit over Centerline



Model	ICAO design code	Tire edge to turn center (ft)
A340-600	E	36.1
777-9*	E**	37.1
777-300ER	E	37.3
A350-1000*	E	37.7
A380	F	37.9
747-8	F	38.9
787-10*	E	39.7
747-400	E	40.9

LESS CRITICAL

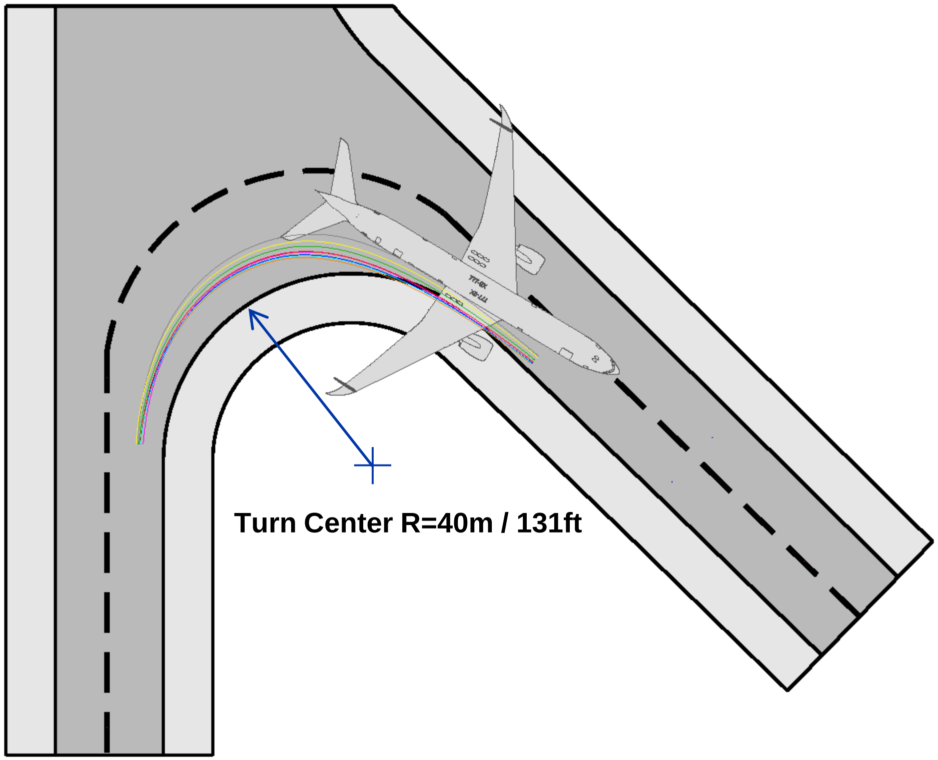
* PRELIMINARY
** E after exiting the taxiway

Judgmental Oversteering permits adequate tire edge clearance on a typical 40m existing fillets.

NOTE: Analysis by AeroTurn software with 777-300ER and 777-9 aft-axle steering in-operative.

*777-8 data not available. Data will be available at a later date.

777-9 Fillet Requirement
45° Turn
Nose Gear over Centerline



Model	ICAO design code	Tire edge to turn center (ft)
A340-600	E	38.8
A350-1000*	E	39.1
777-9*	E**	39.3
A380	F	39.5
777-300ER	E	39.8
747-8	F	40.6
787-10*	E	41.0
747-400	E	42.6

LESS CRITICAL

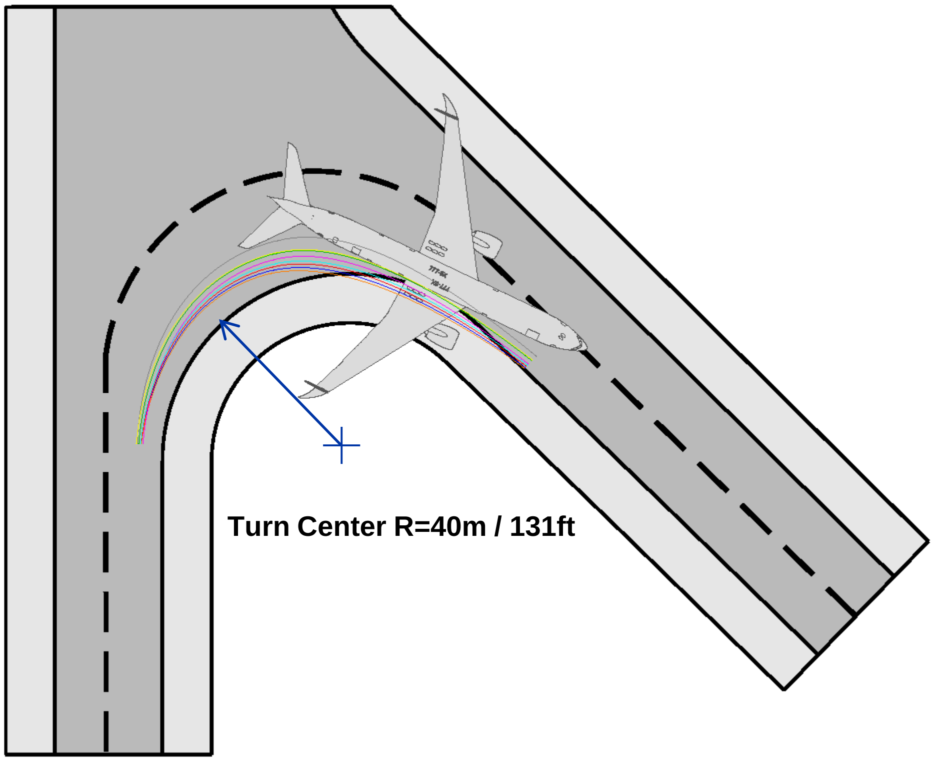
* PRELIMINARY
** E after exiting the taxiway

Judgmental Oversteering permits adequate tire edge clearance on a typical 40m existing fillets.

NOTE: Analysis by AeroTurn software with 777-300ER and 777-9 aft-axle steering in-operative.

*777-8 data not available. Data will be available at a later date.

777-9 Fillet Requirement
45° Turn
Cockpit over Centerline



Model	ICAO design code	Tire edge to turn center (ft)
A340-600	E	31.7
777-9*	E**	32.9
777-300ER	E	33.1
A350-1000*	E	33.6
A380	F	33.9
747-8	F	34.9
787-10*	E	35.7
747-400	E	37.1

LESS CRITICAL

* PRELIMINARY
** E after exiting the taxiway

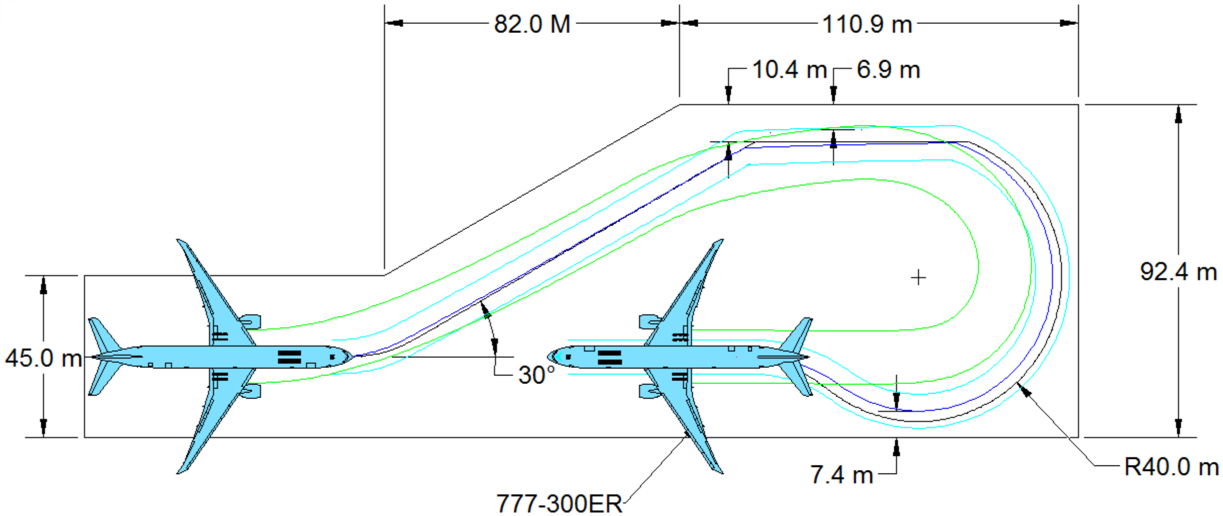
Judgmental Oversteering permits adequate tire edge clearance on a typical 40m existing fillets.

NOTE: Analysis by AeroTurn software with 777-300ER and 777-9 aft-axle steering in-operative.

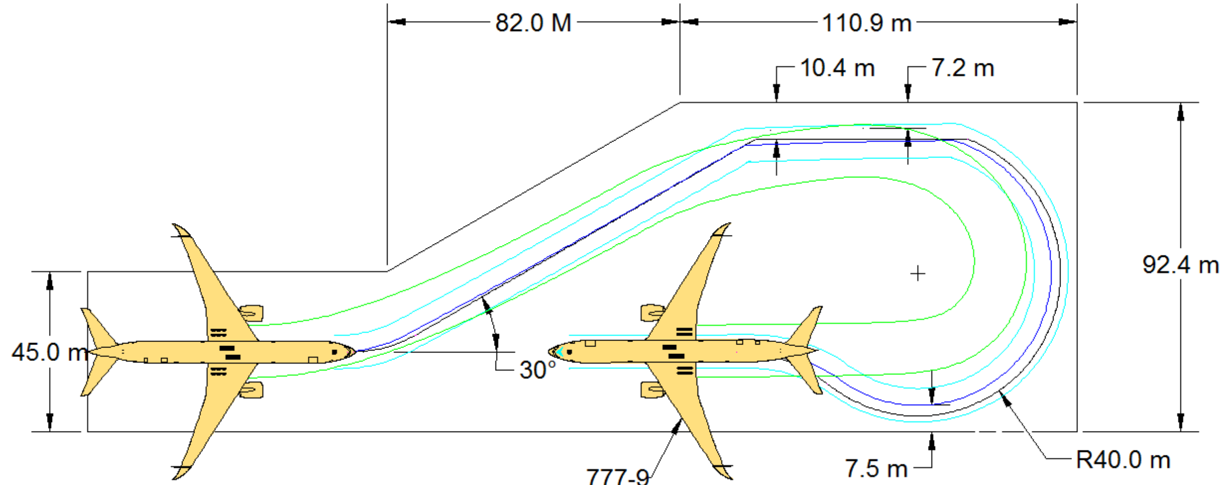
*777-8 data not available. Data will be available at a later date.

777-9 on an ICAO Code E Turnpad *

ICAO CODE LETTER E AIRCRAFT WITH THE WHEELBASE GREATER THAN 25.6 M. (ADM 9157, P1, FIG A4-7)
RUNWAY WIDTH = 45 M, OUTER MAIN GEAR = 12.88 M, AIRCRAFT COCKPIT TO MAIN GEAR DISTANCE = 34.85 M, RADIUS OF CURVATURE = 40 M, C = 4.0 M MIN. CLEARANCE.



- 4.0m Main Gear Tire Clearance
- 4.0m Nose Gear Tire Clearance
- Nose Gear Path
- Cockpit Path

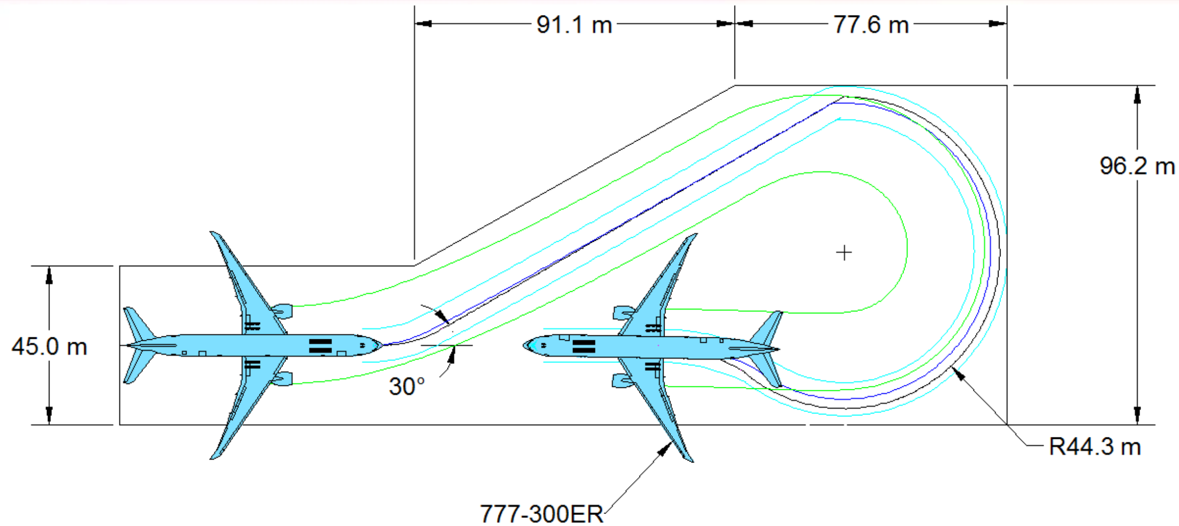


* As illustrated in Appendix 4, Runway turn pads, Figure A4-7
NOTE: Analysis by AeroTurn software with aft-axle steering in-operative.

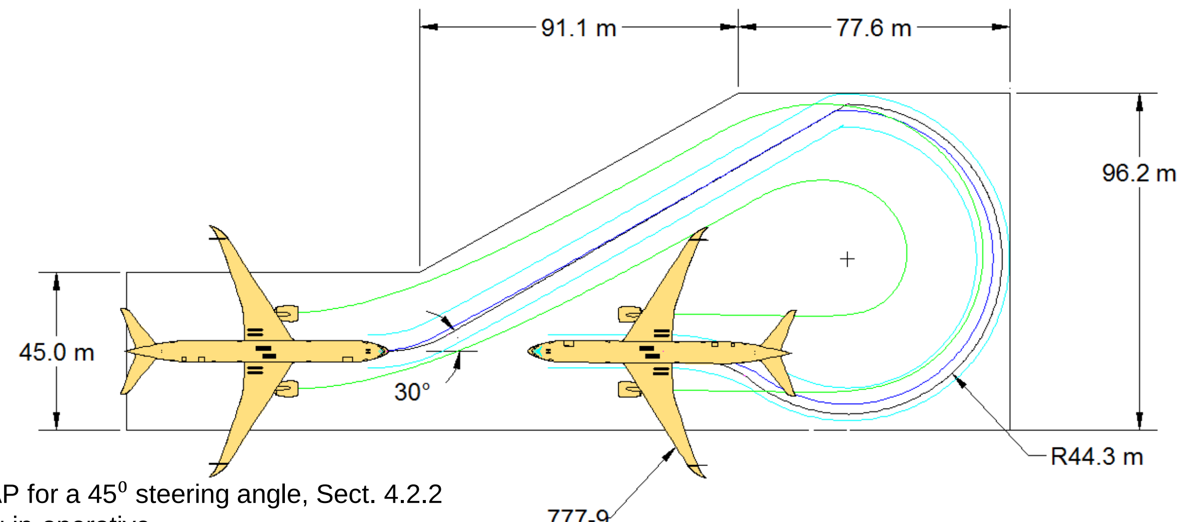
*777-8 data not available. Data will be available at a later date.

777-9 on an ICAO 777-300ER Turnpad *

ICAO CODE LETTER E AIRCRAFT WITH THE WHEELBASE GREATER THAN 25.6 M. (ADM 9157, P1, FIG A4-7)
RUNWAY WIDTH = 45 M, OUTER MAIN GEAR = 12.9 M, AIRCRAFT COCKPIT TO MAIN GEAR DISTANCE = 34.85 M, RADIUS OF CURVATURE (45° steering angle) = 44.3 M, C = 4.0 M MIN. CLEARANCE.



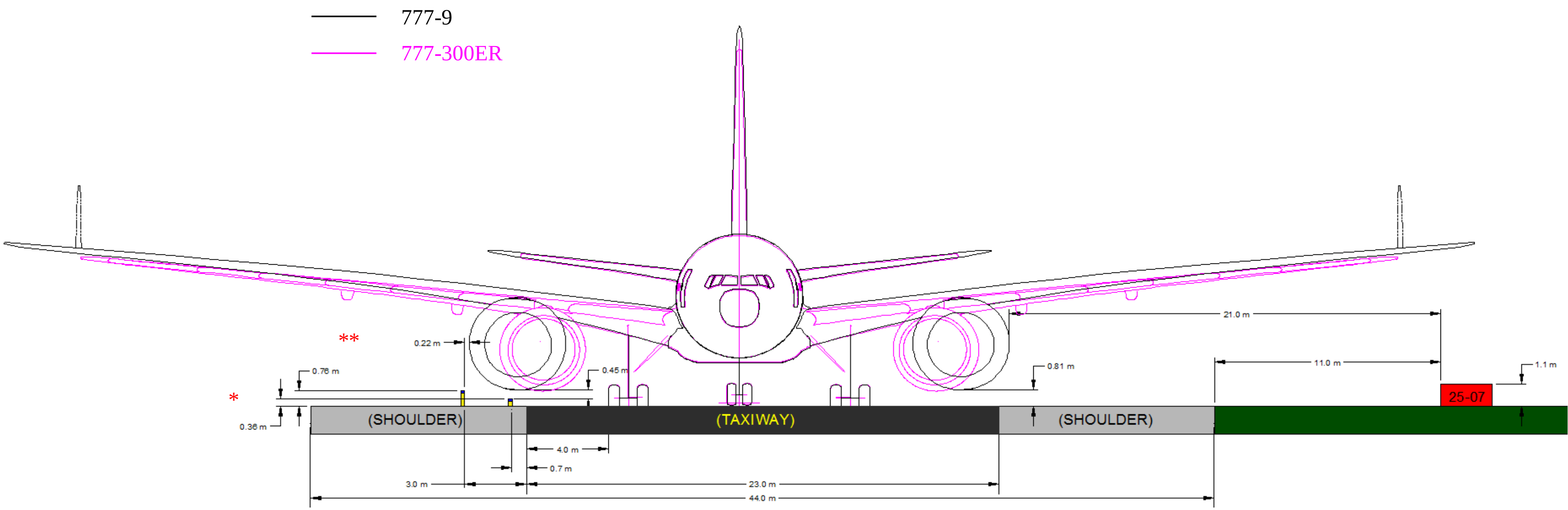
- 4.0m Main Gear Tire Clearance
- 4.0m Nose Gear Tire Clearance
- Nose Gear Path
- Cockpit Path



* Using a radius of curvature defined in the 777-300ER ACAP for a 45° steering angle, Sect. 4.2.2
NOTE: Analysis by AeroTurn software with aft-axle steering in-operative.

*777-8 data not available. Data will be available at a later date.

777-9 Nacelle Clearance

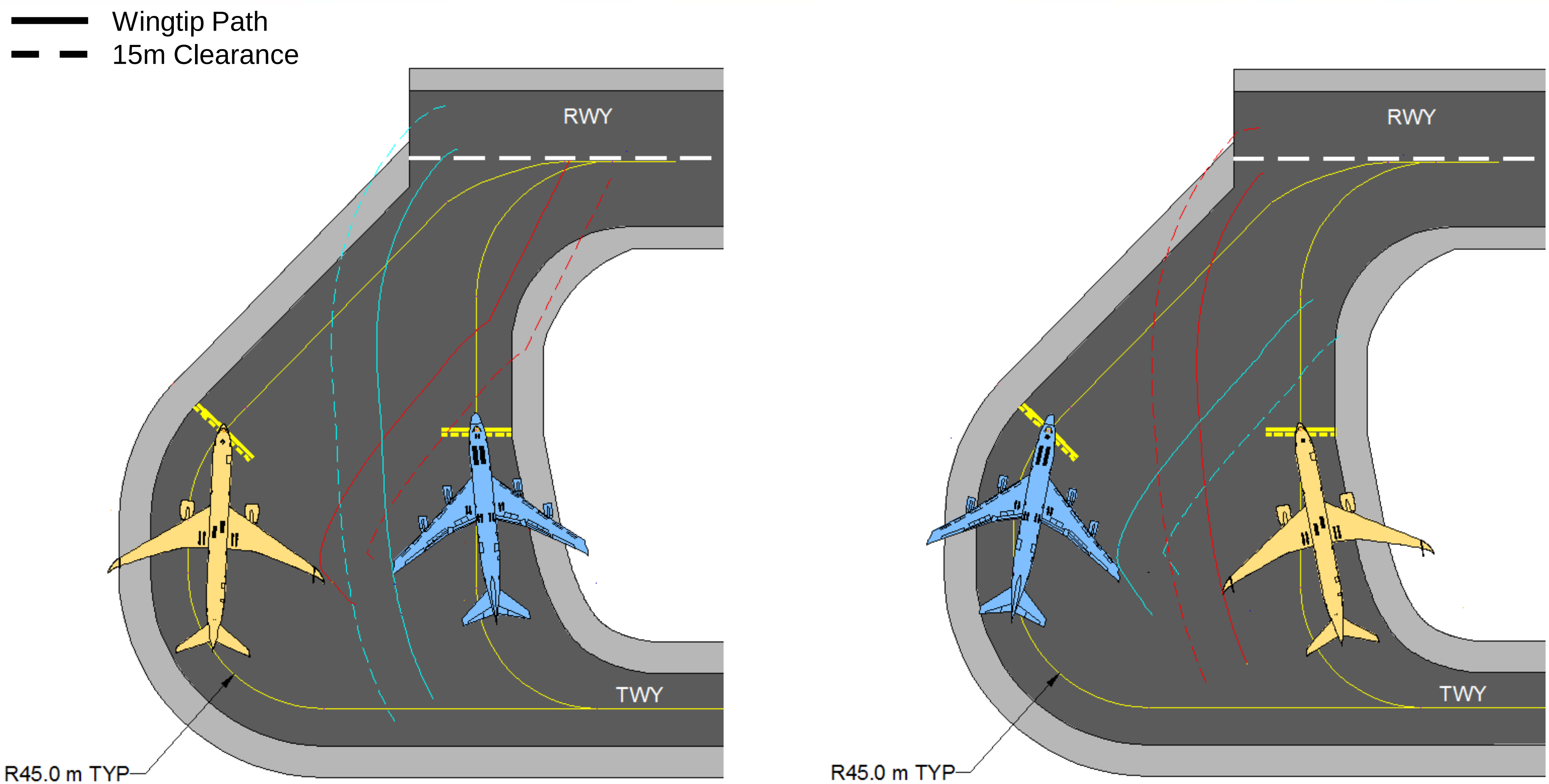


Minimum clearance condition: MLG edge 4.0m from Taxiway edge

Dimensions per ICAO Annex 14 V1 7th Ed Amendment 14 - Code E.
* Max height recommended by ICAO Airport Safety Manual Pt 6. (Doc 9137)
** Allowance per FAA AC 150/5340-30H. See Fig. 108 in document.

*777-8 data not available. Data will be available at a later date.

777-9 on ICAO Code E Holding Bay 747-400 Adjacent

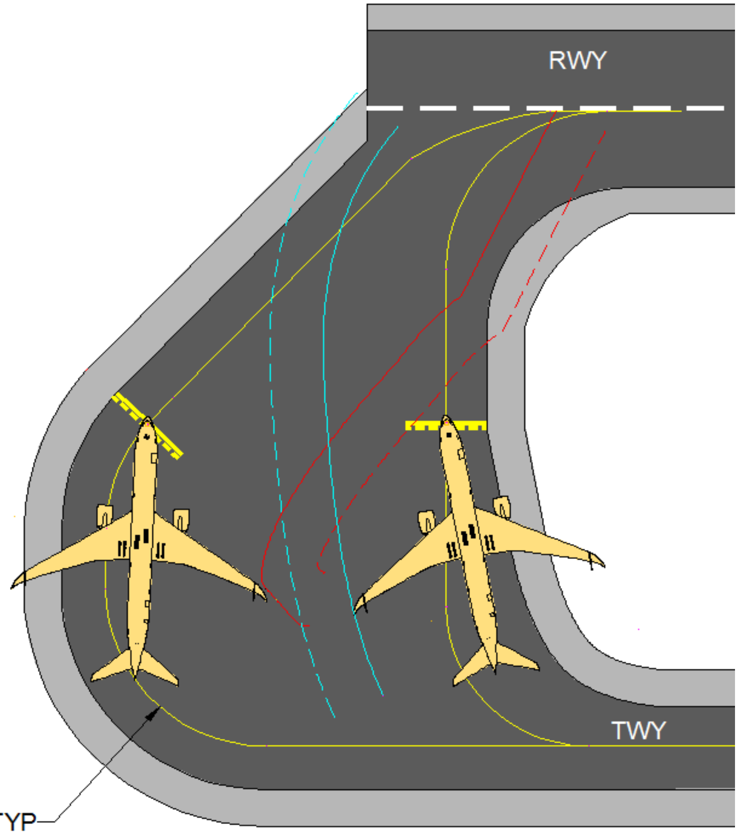


Holding bay layout per ICAO Aerodrome Design Manual (DOC 9157) Part 2 to provide 15m wingtip clearance between two code E aircraft. 747-400 used as limiting code E aircraft.

*777-8 data not available. Data will be available at a later date.

777-9 on ICAO Code E Holding Bay
777-9 Adjacent

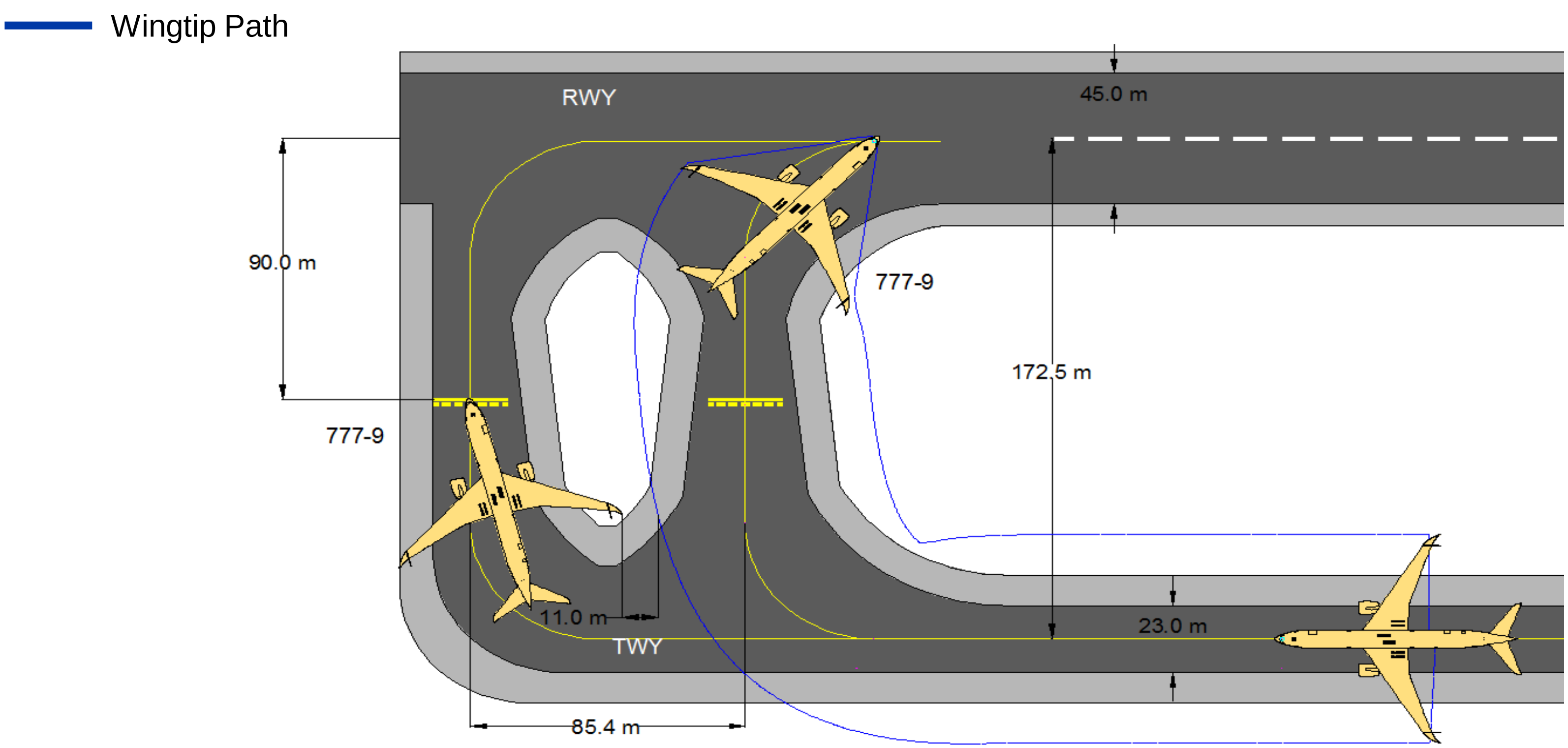
Wingtip Path
15m Clearance



Holding bay layout per ICAO Aerodrome Design Manual (DOC 9157) Part 2 to provide 15m wingtip clearance between two code E aircraft. 747-400 used as limiting code E aircraft.

***777-8 data not available. Data will be available at a later date.**

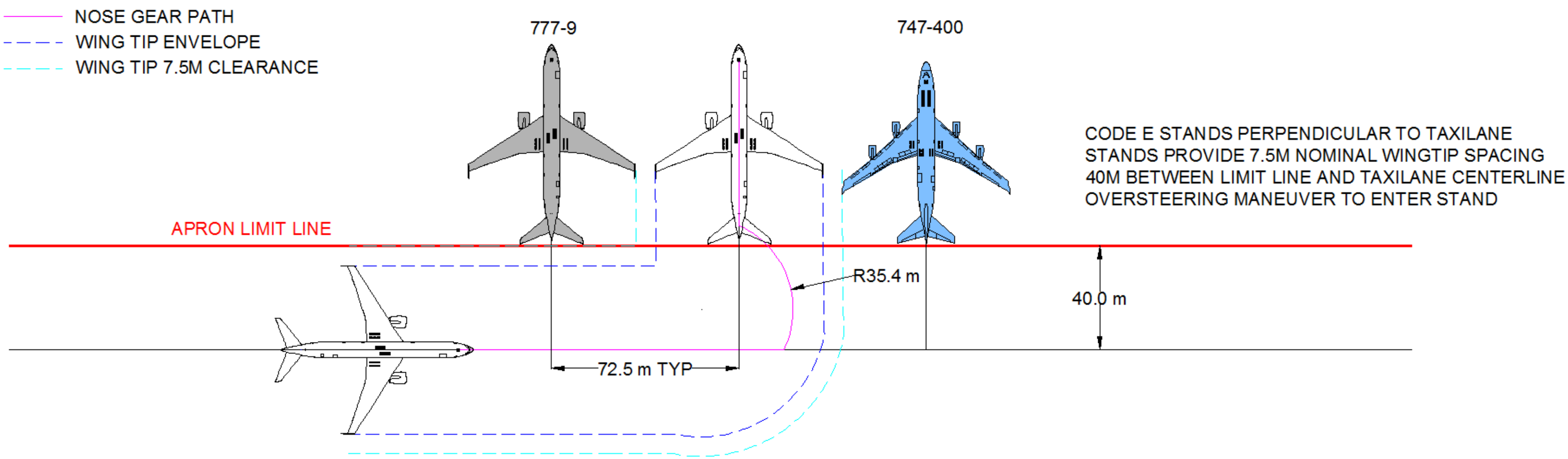
777-9 on Parallel Rwy Holding Points



On airports with Code E RWY-TWY separation specified in ICAO Annex 14 V1 7th Ed, Amendment 14, a minimum of **85.4m** centerline separation is required for parallel holding points to ensure 11m wingtip clearance between tww 777-9 aircraft with wingtips extended.

***777-8 data not available. Data will be available at a later date.**

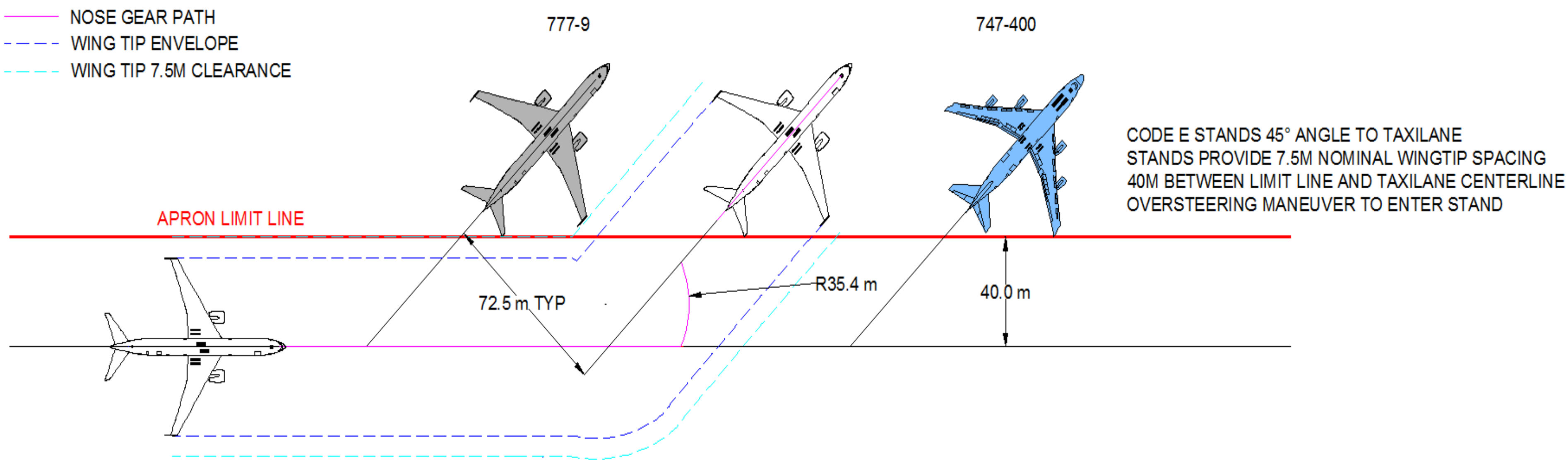
777-9 Parking



Aircraft to follow appropriate lead-in line marking for oversteer into stand.

*777-8 data not available. Data will be available at a later date.

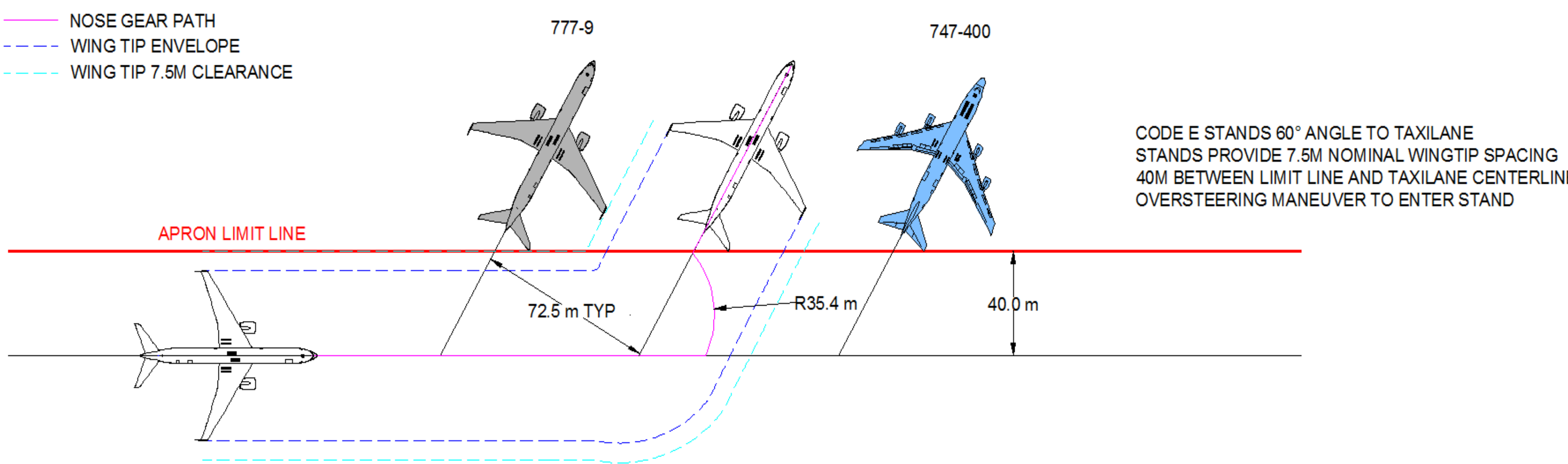
777-9 Parking



Aircraft to follow appropriate lead-in line marking for oversteer into stand.

***777-8 data not available. Data will be available at a later date.**

777-9 Parking

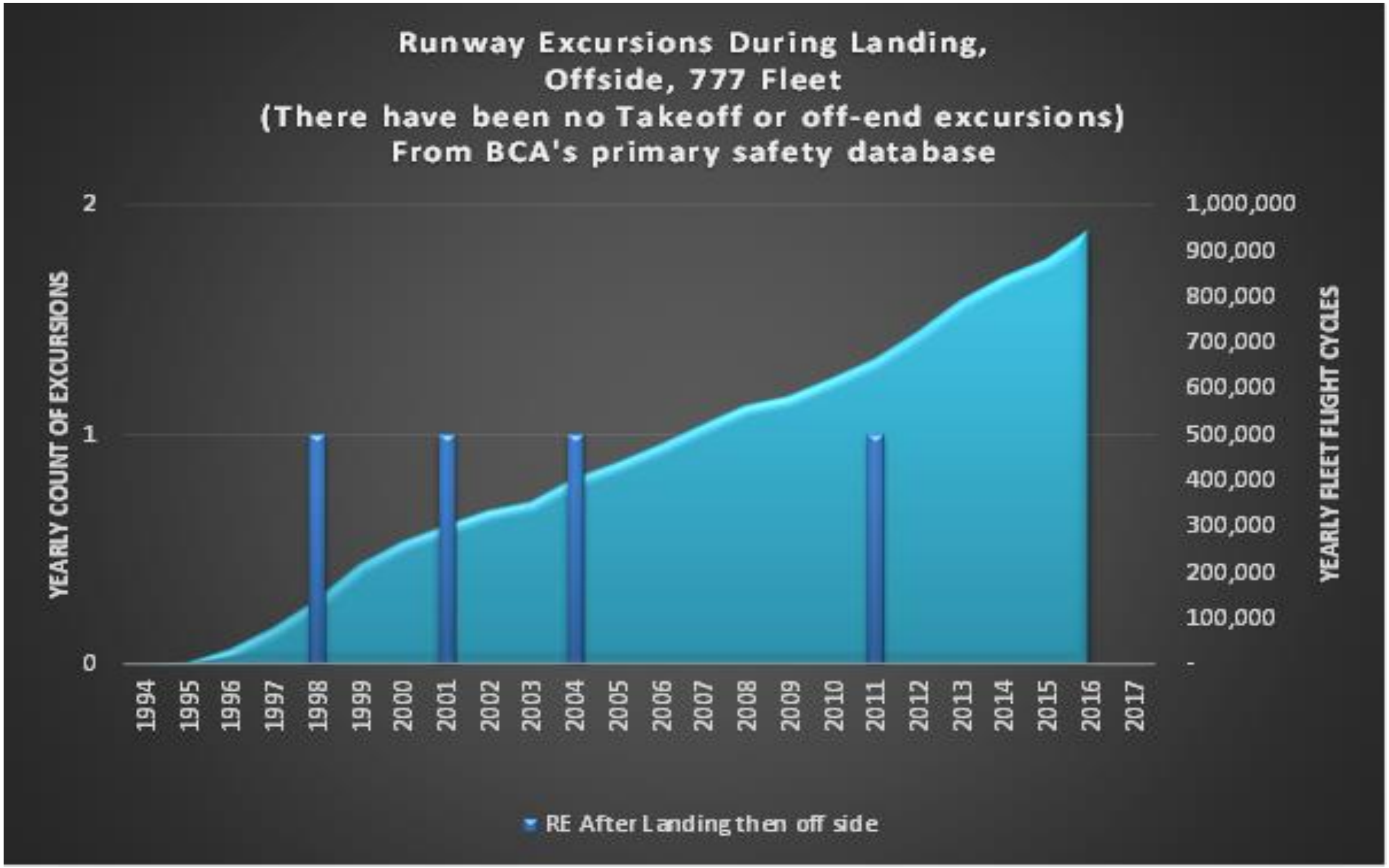


Aircraft to follow appropriate lead-in line marking for oversteer into stand.

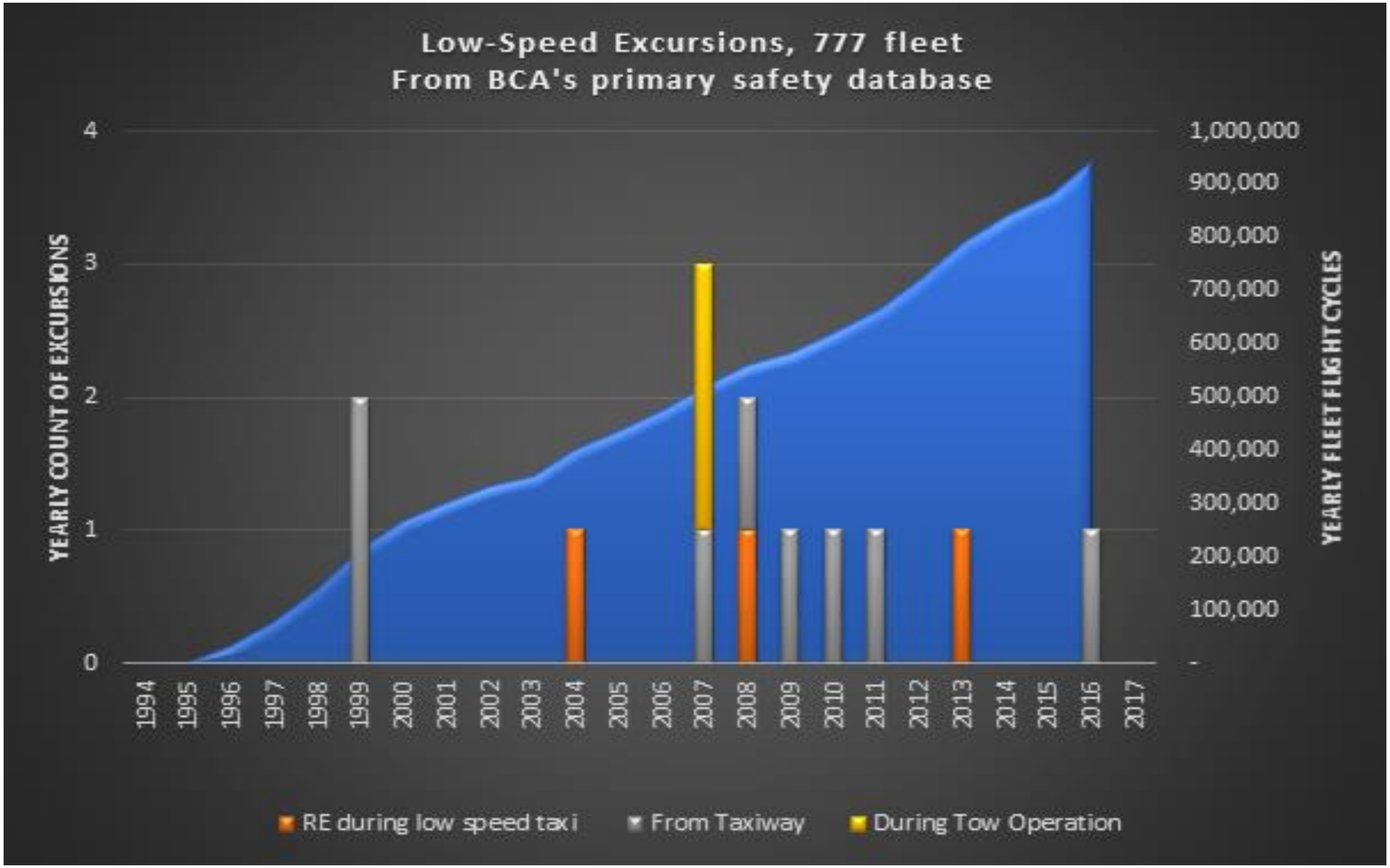
***777-8 data not available. Data will be available at a later date.**

Accident / Incident Analysis

777 Fleet Runway Excursion Occurrence Versus Yearly Fleet Movements

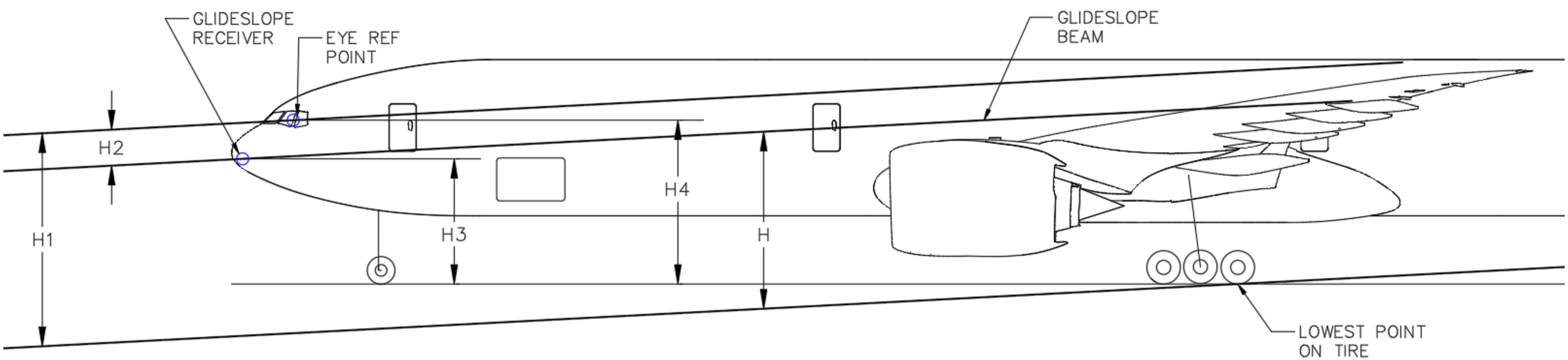


777 Fleet Taxiway Excursion Occurrence Versus Yearly Fleet Movements



Appendix

Reference Points and Distances for Approach Analysis
(all distances are measured vertically)



Drawing for demonstration only and is not to scale

***777-8 data not available. Data will be available at a later date.**

777-9 Visual Landing Aids Data

Table A1-1: Vertical distances between critical points on aircraft at maximum pitch attitude (VREF) (ILS)

	2.5-degree slope						3.0-degree glide slope					
Aircraft model	**Pitch att (deg) Flap setting**	**Eye path to ILS beam (ft) H2**	**ILS beam to wheel path (ft) H**	**Eye path to wheel path (ft) H1**	**ILS antenna above wheels (ft) H3**	**Pilot's eye above wheels (ft) H4**	**Pitch attitude (degrees)**	**Eye path to ILS beam (ft) H2**	**ILS beam to wheel path (ft) H**	**Eye path to wheel path (ft) H1**	**ILS antenna above wheels (ft) H3**	**Pilot's eye above wheels (ft) H4**
777-300	3.6 Flaps 25	12.9	24.1	37.0	19.3	31.9	3.2	12.9	24.3	37.2	18.5	31.0
777-9	2.9 Flaps 25	9.9	24.5	34.4	19.3	29.2	2.4 Flaps 25	9.9	24.5	34.4	18.3	28.2

Table A1-2: Vertical distances between critical points on aircraft at minimum pitch attitude (VREF+5) (ILS)

	2.5-degree slope						3.0-degree glide slope					
Aircraft model	**Pitch att (deg) Flap setting)**	**Eye path to ILS beam (ft) H2**	**ILS beam to wheel path (ft) H**	**Eye path to wheel path (ft) H1**	**ILS antenna above wheels (ft) H3**	**Pilot's eye above wheels (ft) H4**	**Pitch attitude (degrees)**	**Eye path to ILS beam (ft) H2**	**ILS beam to wheel path (ft) H**	**Eye path to wheel path (ft) H1**	**ILS antenna above wheels (ft) H3**	**Pilot's eye above wheels (ft) H4**
777-300	1.9 Flaps 30	12.7	20.8	33.5	15.9	28.4	1.4 Flaps 30	12.7	20.8	33.5	15.0	27.3
777-9	1.5 Flaps 25, 30	9.9	21.6	31.5	16.4	26.3	1.0 Flaps 25, 30	9.9	21.6	31.6	15.3	25.3

***777-8 data not available. Data will be available at a later date.**

Attachment C

Listing of Studies and References Relating to ICAO Annex 14 SARP's

Attachment C

Listing of Studies and References Relating to ICAO Annex 14 SARP's

Nb	Title	Runways	Shoulders	Lights/ Signs	Runway Strip	Runway End Safety Area	OFZ	Holding Points	Width of straight taxiway	Width of curved taxiway	Straight and curved taxiway shoulders	Bridges , Tunnels and Culverts	Taxiway Minimum Separation Distances		Approval
													Rwy-Twy	Twy-Twy	
1	Annex 14 — Aerodromes, Volume I — Aerodrome Design and Operations, 7th edition, July 2016, ICAO	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2	Circular 305 — Operation of New Larger Aeroplanes at Existing Aerodromes, June 2004, ICAO	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3	Aerodrome Design Manual (Doc 9157), Parts 1 to 5, ICAO	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4	Circular 301 — New Larger Aeroplanes – Infringement of the Obstacle Free Zone: Operational Measures and Aeronautical Study, December 2005						X								
5	Notice to Aerodrome License Holders, February 2003, CAA UK [(1) (2)]	X	X	X	X	X			X	X	X	X	X	X	X
6	Statistical Extreme Value Analysis of Taxiway Center Line Deviations for 747 Aircraft at JFK and ANC Airports, August 2003, Boeing [(1)]								X					X	X
		https://www.faa.gov/airports/resources/publications/reports/media/JFK_101703.pdf													
7	Statistical Analysis of Aircraft Deviations from Taxiway Center Line, Taxiway Deviation Study at Amsterdam Airport, Schiphol, 1995, Boeing Company Information and Support Services [(1) (5)]								X	X				X	X
		Report available in Appendix 4 of the AACG CAD (see #10) Available at Boeing (AirportTechnology@boeing.com), ACI or Airbus (Contact: airport.compatibility@airbus.com)													
8	Aircraft Deviation Analysis at Frankfurt Airport, February 2004, Frankfurt Airport [(1) (3) (5)]								X	X				X	
		Preliminary results available in Appendix 4 of the AACG CAD (see #10) Additional deviation analysis in curved portion available Available at Fraport, ACI or Airbus (Contact: airport.compatibility@airbus.com)													
9	Runway Lateral Deviations during Landing, Study with Flight Recorder Systems On-board, CAA-France [(1) (3)]	X													
		Preliminary results available Available at CAA-France or Airbus (Contact: airport.compatibility@airbus.com)													
10	Common Agreement Document (CAD) of the A380 Aerodrome Compatibility Group, December 2002, CAA-France, CAA-UK, CAA-Netherlands, CAA-Germany, ACI, IATA, Airbus [(1) (2) (5)]	X	X	X			X	X	X	X	X	X	X	X	X
		http://www.aci.aero/Media/aci/file/ACI_Priorities/Technical%20Issues/AACG_Common_Agreement_Doc_2003.pdf													
11	Analysis of Runway Lateral Excursions from a common accident/incident database (source: ICAO, FAA, Airbus, Boeing), June 2003, Airbus [(1) (5)]				X			X					X		
		Report available in Appendix 4 of the AACG CAD (see #10) Available at ACI or Airbus (Contact: airport.compatibility@airbus.com)													

Nb	Title	Runways	Shoulders	Lights/ Signs	Runway Strip	Runway End Safety Area	OFZ	Holding Points	Width of straight taxiway	Width of curved taxiway	Straight and curved taxiway shoulders	Bridges , Tunnels and Culverts	Taxiway Minimum Separation Distances		Approval
													Rwy-Twy	Twy-Twy	
12	Test of Load Bearing Capacity of Shoulders, 2003, CAA-France and Airbus [1]		X												
		English version available at Airbus (Contact: airport.compatibility@airbus.com)													
13	A380 Pavement Experimental Project, October 2001, LCPC, Airbus, CAA-France	X													
		http://www.stac.aviation-civile.gouv.fr/publications/documents/rapportPEP.pdf													
14	Reduced Separation Distances for Code F Aircraft at Amsterdam Airport, Schipol, 2001, Amsterdam Airport, Schipol [1] [5]								X	X				X	X
		Report available in Appendix 4 of the AACG CAD (see #10) Available at AMS, ACI or Airbus (Contact: airport.compatibility@airbus.com)													
15	ILS study at Paris Charles-de-Gaulle international airport (CDG), October 2004, ADP [1] [2]				X			X					X		
		https://www.ecac-ceac.org/nla-forum/IMG/pdf/ILS_Study_at_CDG-V5-2.pdf													
16	Study of the accommodation of the Airbus A380 on runways 1 and 2 of Paris-Charles de Gaulle (runway widths and shoulders), April 2005, ADP and CAA-France	X	X	X											
		Available at Group ADP													
17	Air Navigation Plan — ICAO European Region - Reduced Separation Distances, 2001, ICAO Europe [5]								X	X	X	X		X	X
		Relevant extract available in Appendix 4 of the AACG CAD (see #10) and in Attachment E of the BACG (see #37) Available at ICAO Europe or Airbus (Contact: airport.compatibility@airbus.com)													
18	Final Report on the Risk Analysis in Support of Aerodrome Design Rules, 2001, CAA-Norway [2] [5]	X	X		X	X							X		
		http://www.luftfartstilsynet.no/incoming/article2032.ece/BINARY/AEA_Final_Report_Version%201A.pdf													
on 19	Taxiway Deviation Study at LHR, 1987, BAA [4] [5]								X	X				X	X
		Referenced in the ADM – Part 2 – taxiways (see #2)													
20	Certification Document — A380 operations on 45m wide runways, August 2007, Airbus	X													
		Available at Airbus (Contact: airport.compatibility@airbus.com)													
21	Airbus A380 Operations Evaluation Results, July 2007, FAA	X	X												
		Available at FAA (refer to EB#63B and EB#65A) or Airbus (Contact: airport.compatibility@airbus.com)													
22	Engineering Brief No. 65A, Use of 150-Foot-(45-M) Wide Runways for Airbus A380 Operations, December 2007, FAA	X	X	X											
		https://www.faa.gov/airports/engineering/engineering_briefs/media/eb-65a.pdf													
23	Engineering Brief No. 63B, Taxiways for Airbus A380 Taxiing Operations, December 2007, FAA								X	X					
		https://www.faa.gov/airports/engineering/engineering_briefs/media/eb-63b.pdf													
24	Airbus A380 operations at alternate airports, June 2006, CAA-France	X	X	X			X	X	X	X	X	X	X	X	X
25	Taxiway Analysis for A380 operations on 22.5m wide taxiway, 2004, ADP								X	X					
		Available at ADP													
26	Runway to Parallel Taxiway Study, June 2006, Sydney Airport Corporation				X		X	X					X		
		Available at Sydney Airport Corporation													
27	Holding Point Analysis for A380 operations, 2004-2007, ADP							X							
		Available at ADP													
28	AC 150-5300-13A Change 1 Airport Design, September 2012, FAA	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		http://www.faa.gov/documentLibrary/media/Advisory_Circular/150-5300-13A-chg1-interactive-201705.pdf													

Nb	Title	Runways	Shoulders	Lights/ Signs	Runway Strip	Runway End Safety Area	OFZ	Holding Points	Width of straight taxiway	Width of curved taxiway	Straight and curved taxiway shoulders	Bridges , Tunnels and Culverts	Taxiway Minimum Separation Distances		Approval
													Rwy-Twy	Twy-Twy	
29	Resistance of elevated runway edge lights to A380 jet blast, May 2005, CAA France			X											
		https://www.ecac-ceac.org/nla-forum/IMG/pdf/Jet_blast_tests_report_V1R0.pdf													
30	Evaluation of Wind-Loading on Airport Signs, June 2000, FAA			X											
		http://www.airporttech.tc.faa.gov/Download/Airport-Pavement-Papers-Publications/Airport-Pavement-Detail/ArtMID/3684/ArticleID/107/Evaluation-of-Wind-Loading-on-Airport-Signs													
31	FAA Airport Obstructions Standards Committee (AOSC) Decision Document #04, Approved: March 21, 2005, Runway / Parallel Taxiway Separations Standards												X		
		https://www.faa.gov/about/office_org/headquarters_offices/arc/programs/aosc/media/AOSC_DD_04_Summary.pdf													
32	FAA Engineering Brief 73: Use of Non-Standard 75-Foot (23-M) Wide Straight Taxiway Sections for Boeing 747-8 Taxiing Operations, 2007, FAA								X		X				
		https://www.faa.gov/airports/engineering/engineering_briefs/media/EB-73.pdf													
33	FAA Engineering Brief 74A: Use of 150-Foot (45-m) Wide Runways and Blast Pads for Boeing 747-8 Operations	X	X												
		https://www.faa.gov/airports/engineering/engineering_briefs/media/EB-74A.pdf													
34	FAA Order 5300.1F: Modifications to Agency Airport Design, Construction and Equipment Standards, 2000, FAA	x	x	x	x	x	x	x	x	x	x	x	x	x	x
		http://www.faa.gov/airports/resources/publications/orders/media/construction_5300_1f.pdf													
35	Common Agreement Document (CAD) of the B747-8 Airport Compatibility Group, October 2008, CAA (Germany, France, Australia, Italy, Netherlands, Luxembourg), ACI, Boeing	X	X	X	X	X	X	X	X	X	X	X	X	X	X
		http://www.aci.aero/Media/aci/file/ACI_Priorities/Technical_Issues/BACG_Common_Agreement_Document.pdf													
36	Circular 345 – New Larger Aeroplanes – Infringement of the Obstacle Free Zone: Collision Risk Model and Aeronautical Study, Planned to be published November 2018						X								

[1] Referenced in the ICAO Circular on NLA Operations.
[2] Available on ECAC website.
[3] On-going.
[4] Outdated.
[5] Available in the Common Agreement Document (CAD) of the AACG. The CAD shows a practical example of the application of the methodology in the ICAO circular to a specific NLA, the Airbus A380. It develops alternative measures for the A380, which are supported by the CAAs of the sponsoring States.

Attachment D

Taxiway Separations
AOPG (747-400)
Versus
AACG (A380-800)/BACG (747-8) Agreements

Attachment D

Taxiway Separations
AOPG (747-400)
Versus
AACG (A380-800)/BACG (747-8) Agreements

AOPG – Aerodrome Operations Planning Group of ICAO Europe/North Atlantic developed operational requirements for the 747-400 as part of European Air Navigation Plan.

AACG – A380-800 operational requirements developed by the Airbus A380 Airport Compatibility Group.

BACG – 747-8 operational requirements developed by the Boeing 747-8 Airport Compatibility Group.

Separation Distances Between	**Formula**	**ICAO Annex 14 Volume 1 5th Ed. July 2009** **Curved and straight taxiway (TWY)**	**ICAO Annex 14 Volume 1 7th Ed. July 2016** **Curved and Straight TWY**	**EUR ANP Part III-AOP** **Curved TWY 747-400**	**EUR ANP Part III-AOP** **Straight TWY 747-400**	**AACG** **Curved and straight TWY A380-800**	**BACG** **Curved and straight TWY 747-8**
TWY centerline and TWY centerline	*Wing span* *+ max. lateral dev. (x)* *+ increment (z)* *= TOTAL*	65/80 (9*) 4.5/4.5 (6*) 10.5/13 80/97.5	65/80 11° 76/91	65 5** 6 76	65 5** 6 76	80 11 (x + z) 91****	68.4 11 79.4
TWY apron, TWY centerline and object	*½ wing span* *+ max. lateral dev. (x)* *+ increment (z)* *= TOTAL*	32.5/40 4.5/4.5 10.5/13 47.5/57.5	32.5/40 11° 43.5/51	32.5 2.5** 10.5 45.5	32.5 2.5** 6.5*** 41.5	40 9 (x + z) 49	34.2 9 43.2
Aircraft stand taxilane centerline and object	*½ wing span* *+ gear deviation (x)* *+ increment (z)* *= TOTAL*	32.5/40 2.5/2.5 7.5/8 42.5/50.5	32.5/40 7.5°° 40/47.5	32.5 2.5 7.5 42.5	32.5 2.5 5*** ## 40 ##	40 7.5 (x + z) 47.5	34.2 7.5 41.7

Separation Distances Between	Formula	ICAO Annex 14 Volume 1 5th Ed. July 2009 Curved and straight taxiway (TWY)	ICAO Annex 14 Volume 1 7th Ed. July 2016 Curved and Straight TWY	EUR ANP Part III-AOP Curved TWY 747-400	EUR ANP Part III-AOP Straight TWY 747-400	AACG Curved and straight TWY A380-800	BACG Curved and straight TWY 747-8
Aircraft stand taxilane centerline and 3m-height-limited object or edge of service road	*½ wing span* *+ gear deviation (x)* *+ increment (z)* *= TOTAL*	32.5/40 2.5/2.5 7.5/8 42.5/50.5	32.5/40 7.5°° 40/47.5	32.5 2.5 6.5# 41.5	32.5 2.5 2.5*** 37.5	40 7.5 (x + z) 47.5###	Not included in BACG
Aircraft stand taxilane centerline to aircraft stand taxilane Centerline °°°	*Wing span* *+ max. lateral dev. (x)* *+ increment (z)* *= TOTAL*	Not included in Annex 14 5th edition	65/80 7.5°° 72.5/87.5	Not included in EUR ANP Part III-AOP	Not included in EUR ANP Part III-AOP	Not included in AACG	Not included in BACG

* AOPG rationale for TWY-TWY separation was based on the previous ICAO assumption that aircraft on both taxiways veering toward each other by 4.5m. This value was reduced to 2.5m by AOPG.

** Reduced maximum lateral deviation of 2.5m provided that proper taxi guidance is available.

*** Main gear track-in is up to 4m on curved taxiways.

**** On curved parallel taxiways, 11m clearance is maintained but the separation may not be 91m.

\# Safety buffer is reduced due to height limited objects.

\## Wingtip clearance of an aircraft turning from a taxilane into an aircraft stand should not be less than 7.5m as recommended in Annex 14.

\### Depending on local conditions, decision on reduced margins for height limited objects by each authority and airport operator.

° Wingtip Clearance - ICAO Annex 14 7th Edition table 3-1, basis for development of these distances is given in the Aerodrome Design Manual (Doc 9157), Part 2.

°° Wingtip Clearance - ICAO Annex 14 7th Edition table 3-1, basis for development of these distances is given in the Aerodrome Design Manual (Doc 9157), Part 2.

°°° New separation criteria in ICAO Annex 14 7th Edition, table 3-1.

Attachment E

Runway-to-Taxiway Separation
U.S. FAA Standard

Attachment E

Runway-to-Taxiway Separation
U.S. FAA Standard

FAA Advisory Circular AC 150/5300-13A, para 320 (https://www.faa.gov/documentLibrary/media/Advisory_Circular/150-5300-13A-chg1-interactive-201612.pdf#page=[106])

The separation standard in Table 3-5 intends to satisfy the requirement that no part of an airplane on taxiway centerline is within the runway safety area or penetrate the OFZ.

- Table 3-5 runway separation standards apply to aircraft approach categories from A to E.
- Runway safety area (RSA) is similar to ICAO graded portion of strip in intent. RSA for Group V (Code E equiv.) and Group VI (Code F equiv.) is 500 ft. (152.4m) wide.
- U.S. OFZ configurations vary with span, threshold elevation, and ILS category.

Group V	Group VI	Rationale/Remarks
(ICAO E Equivalent)	*(ICAO F Equivalent)*	
400’ (120m)		Applies to Cat I; Increases with airport elevation. (400’ applies to airport at sea level)
500’ (150m)		Applies to Cat II/III; Applies to airport at sea level.
	500’ (150m)	Applies to Cat I; May increase at higher elevation to meet OFZ requirement.
	550’ (168m)	Applies to Cat II/III.

* Revised through Airport Obstruction Standards Committee (AOSC) Decision Document #4, March 21, 2005, which can be found at https://www.faa.gov/about/office_org/headquarters_offices/arc/programs/aosc/media/AOSC_DD_04_Summary.pdf

Attachment F

U.S. FAA
Modification of Standard (MOS) Process

U.S. FAA Modification of Standard (MOS) Process

- MOS means any change to published FAA standard.
  - Applicable if MOS results in lower cost, greater efficiency, or accommodation under unusual local condition.*
  - Acceptable level of safety must be provided.
  - Airplane specific.
  - Airport site specific.
- FAA Order 5300.1G describes MOS (available on FAA website) https://www.faa.gov/documentLibrary/media/Order/order-5300-1G-modifications-to-standards.pdf

*Condition where application of standard is impracticable to meet

Request for MOS

- Destination airport requests MOS by submitting the following:
  - Group VI standard or code F equivalent requirement being modified.
  - Proposed modification to standard.
  - Explain why group VI standard cannot be met.
  - Discuss viable alternatives.
  - State why modification would provide acceptable level of safety.
- MOS is not required for alternate, diversion or ad-hoc (non-primary) airports. Air carriers should contact their principle inspector(s) and individual airport(s).

MOS Processing Procedure

- FAA Airports Regional Office (ARO) or Airports District Office (ADO) receives MOS from airport.
- ARO or ADO initiates coordination of MOS with other regional lines of business (flight standards, air traffic, airway facilities...)
- ARO or ADO forwards completed MOS to FAA headquarters in DC (AAS-100).
- AAS-100 reviews comments and makes determination.
- AAS-100 approves MOS.
- MOS and letter to airport is sent by Regional Office.

MOS Related FAA Activities

- Preliminary Engineering Brief (EB94) for the 777-8/9 contains design and operating guidelines. Based on coordination with FAA Airports division, the EB94 covers the following:
  - Runway Width: 777-8/9 (ADG VI with wings extended) operations on ADG V 150 ft wide runway and shoulders.
  - Runway-taxiway separation: 777-8/9 ADG VI during extend transition operations on taxiway with ADG V RW-TW separation.
  - Taxiway-taxiway separation: To accommodate 777-8/9 with extended wings.
  - Taxiway-fixed removable objects.
- EB94: https://www.faa.gov/airports/engineering/engineering_briefs/media/EB-94-B-777-9-folding-wingtips.pdf
- 777X MOS meetings:
  - ACI-NA, FAA, Boeing, and U.S. airports to discuss 777-8/9 operational issues collectively via 777-8/9 MOS meetings, in progress.

Attachment G

Boeing 777-8/9
Folding Wing Tip Concept of Operations
(FWT CONOPS)

Table of Contents

List of Figures

List of Tables

1 List of Acronyms

Acronym	**Definition**
ACAP	Aircraft Characteristics for Airport Planning
AIP	Aeronautical Information Publication
ANC	ICAO Air Navigation Commission
ARC	Aerodrome Reference Code
ATC	Air Traffic Control
EICAS	Engine Indication and Crew Alerting System
FWT	Folding Wing Tip
ICAO	International Civil Aviation Organization
MEL	Minimum Equipment List
RET	Rapid-Exit Taxiway

2 Introduction

This document outlines the concept of operations for the 777-8/-9 folding wing tip (FWT). Normal operational procedures for the FWT and other considerations for FWT airport operations are included.

The 777-8 and 777-9 are addressed in this document, as they both have the same wingspan in the folded and extended positions. This document does not address other airport considerations during normal 777-8/9 operations such as pavement strength, servicing, etc. For more information on standard 777-8/9 operations please see the 777-8/9 Aircraft Characteristics for Airport Planning (ACAP) document page at www.boeing.com/airports.

The International Civil Aviation Organization (ICAO) [1] determines International Standards and Recommended Practices for airport design. Separation criteria between taxiways, runways, taxi lanes and objects are included in the design, based on the Aerodrome Reference Code (ARC), A through F, of the operating aircraft. The 777-8/9 operations will be a Code E (same as the Boeing 747-400 and 777-300ER) with wings folded (wingspan of 64.8m) and a Code F with the wings extended (71.8m). The intent of FWT feature is to allow the 777-8/9 to operate at airports designed to ICAO Code E standards when on taxiways and at the gate/apron area.

This document outlines FWT procedures and considerations for the 777-8/9. However, recognizing at some airports, unique operational procedures may be required.

[1] International Civil Aviation Organization. *Annex 14 to the Convention on International Civil Aviation* Aerodromes Volume 1, Aerodrome Design and Operations, Seventh Edition July 2016. Montreal, Quebec, Canada

3 Normal FWT Operations: Overview

The FWT operational phases are shown in Figure 3-1, below. During the taxi for departure phase, the 777-8/9 taxis to the departure runway with the FWT folded. Once passing a predetermined location that assures wingtip clearance, the flight crew will initiate the command for the FWT to extend, to be in the takeoff configuration (extended and locked) prior to the hold-short line. The exact location to extend the FWT will be determined by an aerodrome based on its operational plans and physical layout. Due to the unique geometry of each airport, it will not be practical to automate the extension of the FWT and the extension action will be left to the flight deck crew for manual operation when required.

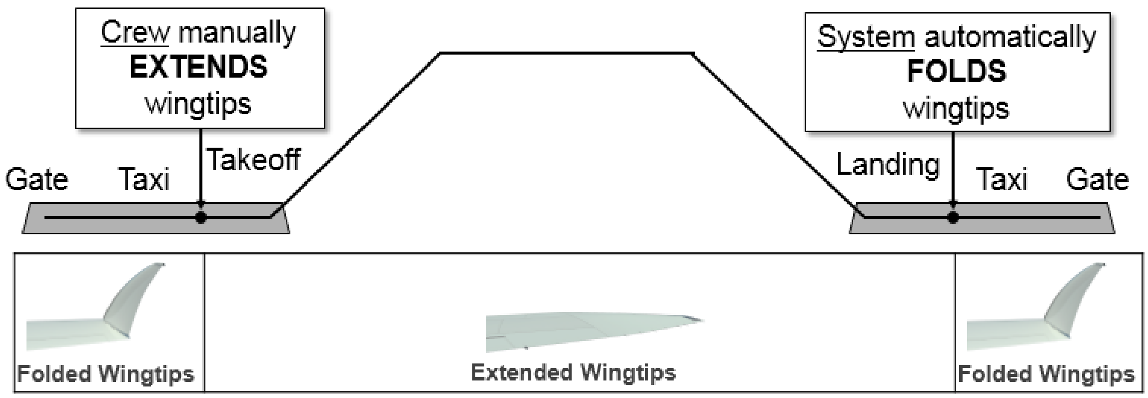


Figure 3-1. FWT Operational Concept

Upon landing, the FWT control logic will automatically fold the FWT after the aircraft has touched down and ground speed is below 50 kts. This ensures the FWT will be folded before entering the parallel taxiway.

In the event of a non-normal FWT condition, an airport-specific Non-Normal FWT Operational Plan will be invoked. The 777-8/-9 Non-Normal Folding Wing Tip operational Plan outlines a generic airport operations plan for 777-8/-9 for ground maneuvering in the event of a non-normal FWT condition, so this scenario is not addressed in this document.

4 FWT Operations Takeoff

The FWT departure procedure shown in Figure 4-1 below.

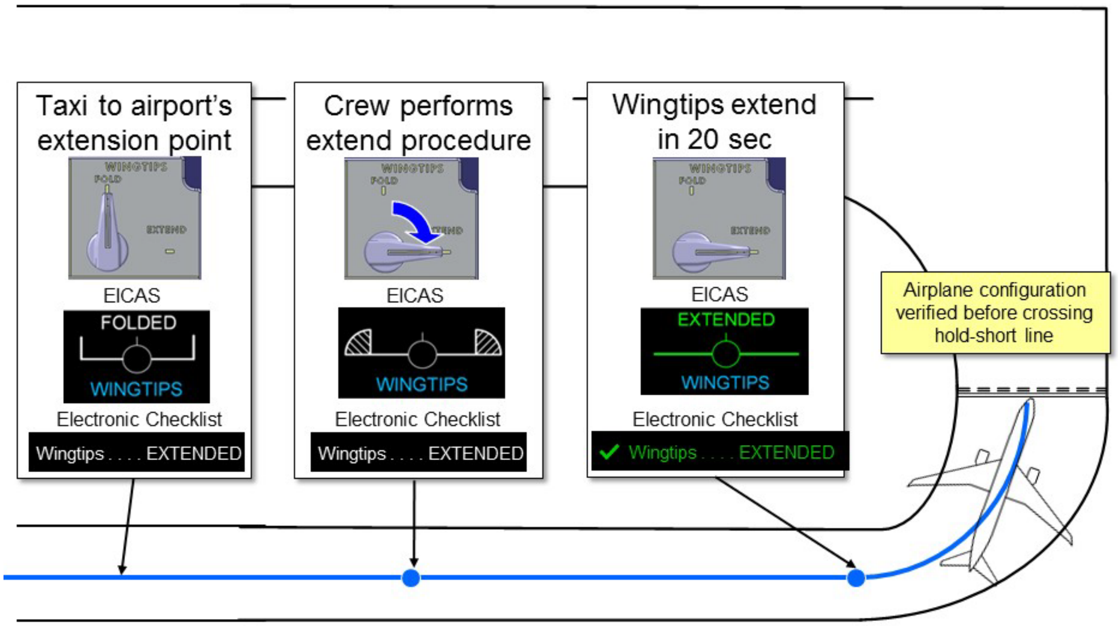


Figure 4-1. FWT Departure Procedure

The FWT will remain folded and prevented from extending while at the gate. If maintenance is needed at the gate, a special function can be used to allow FWT extension that overrides system inhibit logic while the airplane is parked. Any maintenance that requires extending the FWT at a gate may require coordination with the airport operator to ensure there is adequate clearance.

During the taxi for departure phase, the 777-8/9 taxis to the runway with the FWT folded. The flight deck crew will initiate the command for FWT to be in the takeoff configuration (extended and locked) prior to reaching the hold-short line. Extension of the wing tips FWT takes 20 seconds. The exact location to extend the FWT will be determined by an aerodrome based on its operational plans and physical layout; data from Attachment A and Attachment B provide information to support definition of the extend location. Apron procedures should consider moving parallel aircraft. Airline and airport procedures should allow the 777-8/-9 to extend the FWT as early as possible. The location should be included in each airport's aeronautical information publication (AIP) to allow charts and procedures updates as required. The extend location will be part of the pre-flight briefing. The aircraft must enter the runway in the ready-for-takeoff configuration.

Extension of the FWT takes 20 seconds, which envelopes normally encountered conditions.

For an airport where FWT extension is not feasible prior to the hold short line, a supplemental procedure to allow extension of the FWT on the runway is available to the flight deck crew. Delaying wingtip extension until taxiing onto the departure runway may be required when there is limited clearance between runways and taxiways, runways where runway back taxi is required, during taxi route closures, or anytime obstacle clearance with wingtips extended cannot be assured during taxi.

Once the airplane is configured for takeoff, the flight deck crew will request an air traffic control (ATC) takeoff clearance. Wing tip configuration will not be specifically reported to ATC unless a non-normal condition is experienced. In this case, the non-normal condition will be annunciated on the EICAS screen. The flight deck crew will be alerted via EICAS messaging, and the non-normal FWT operation plan will be invoked.

In the event of a high-speed rejected takeoff (RTO) scenario, the automatic fold feature is enabled. If the airplane achieves a rejected takeoff ground speed of 85 kts or above, then the FWT will automatically fold once the airplane has decelerated below 50 kts ground speed. The 85 kts threshold is the same threshold for activating RTO autobrakes and speedbrakes. Rejected takeoffs that occur below 85 kts will not trigger the auto fold function and the flight deck crew will manually fold the FWT.

5 FWT Operations after Landing

The FWT arrival procedure is shown in Figure 3, below.

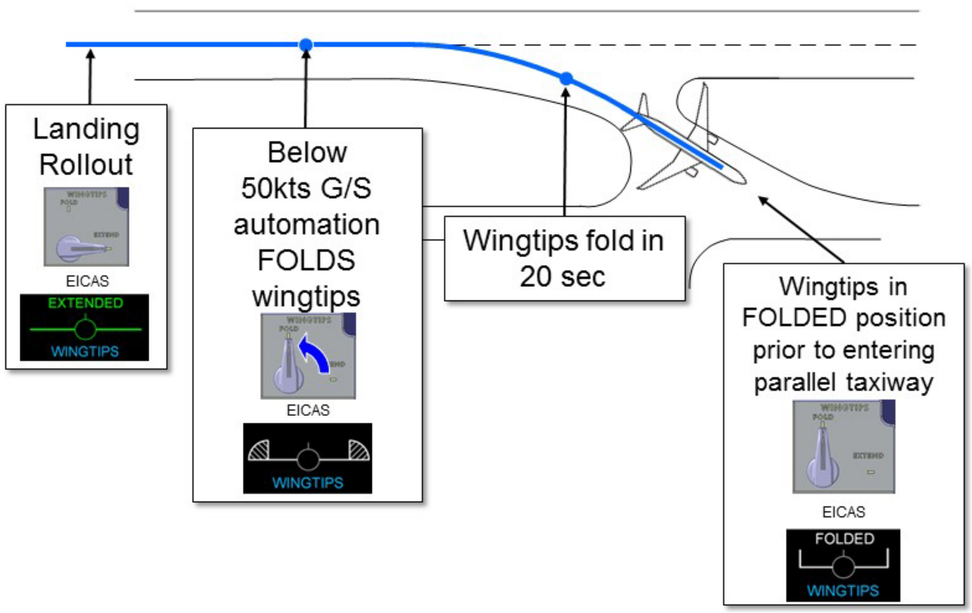


Figure 5-1. FWT Arrival Procedure

Upon landing, the FWT system will automatically fold the wing tips when the aircraft has touched down and ground speed is below 50 kts. Automatic fold of the wing tips prevents adding more tasks for the flight crew to perform during a high-workload phase of operation.

Folding of the wing tips takes 20 seconds, which envelopes normally encountered conditions. Boeing performed studies to confirm that the timing as part of the design will ensure that the FWT will be folded prior to entering the parallel taxiway. These studies considered high-speed exits to rapid-exit taxiways designed to both ICAO and FAA separation standards.

Flight Deck Crews will be alerted via EICAS in the event of a non-normal configuration (failure to fold), and the FWT non-normal procedure will be invoked.

A simulation of a 777-8/9 taking an ICAO rapid-exit taxiway (RET) is shown in Figure 5-2 and Table 5-1. In order to maintain 11m separation to a Code E aircraft on the parallel taxiway, the 777-8/9 must have wing tips folded prior to reaching Point 5 in Figure 5-2. Prior to point 5, the 777-8/9 is still maneuvering through the intersection and not centered on the taxiway centerline, thus maintaining 11m wingtip separation. Point 5 is the point at which the wingtip, if still extended, will encroach on the parallel taxiway strip. All points marked in Figure 5-2 represent cockpit location and assume the aircraft is taxiing with cockpit over centerline. The simulation uses the design parameters recommended

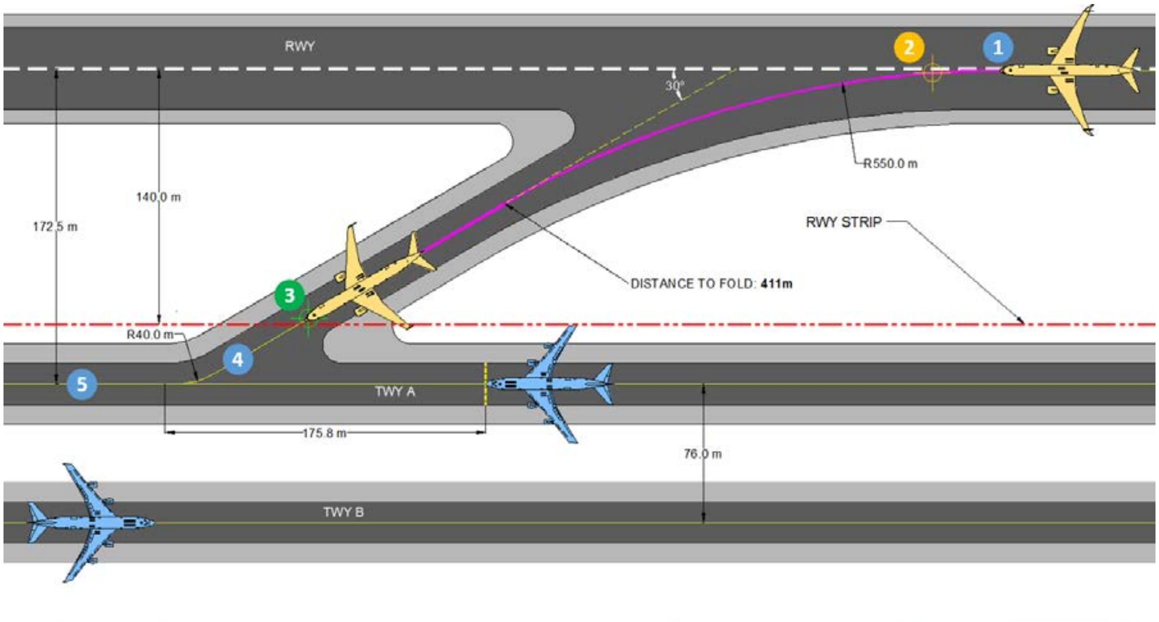


Figure 5-2. Distance to Fold on RET, Simulation (Cockpit Over Centerline)

Table 5-1. Distance to Fold on RET, Simulation (Cockpit Over Centerline)

	FWT State	Time (sec)	Ground speed (kt)	Distance Traveled (m)
1	Extended	-1.5	52.0	0
2	Transition	0	49.9	39.3
3	Folded	20	22.4	411.2
4	Folded	26	14.1	467.5
5	Folded	38	14.1	557.0

in the ICAO Aerodrome Design Manual for a typical RET in terms of geometry and recommended speeds. A constant deceleration of -0.71 m/s^2 is calculated between the tangent points of the two curves to achieve the appropriate design speed for the respective radii. This is less than what the ICAO Aerodrome Design Manual assumes for braking action on a wet taxiway to develop RET geometry recommendations. This case demonstrates a reasonable worst-case scenario and envelopes all 400+ operationally recorded 777-300ER landings that Boeing evaluated. In all recorded cases, the aircraft would have completed wingtip folding prior to entering the taxiway.

1. Initial point where aircraft enters the RET (measured as the tangent point to the taxiway marking offset 0.9m from the runway centerline). Simulation is initiated at 52 kt ground speed. This is the design speed for a 550m radius curve as recommended by the ICAO Aerodrome Design Manual for a 30° RET. From this point, the aircraft begins a constant deceleration to reach Point 4 at 14 kt. This is the design speed for a 40m radius curve as recommended by the ICAO Aerodrome Design Manual.

2. Transition of FWT to fold begins at 50 kt ground speed.

3. FWT are folded prior to entering the parallel taxiway—777-8/9 is Code E.

4. 777-8/9 reaches 14 kt ground speed and maintains it throughout the remainder of the RET.

5. Point by which 777-8/-9 must have completed folding of the FWT to comply with 11m wingtip clearance to a Code E aircraft on TWY B. This corresponds to a path distance of 557m from Point 1.

A 777-8/9 will comply with Code E aircraft on a parallel taxiway using Annex 14, 7th Edition, Amendment 14, when entering the taxiway. This simulation is based on ICAO Annex 14, 7th Edition for code number 3-4 airplanes using a preferred intersection angle of 30° and design speeds per ICAO Aerodrome Design Manual Doc 9157, Part 2 for code number 3-4 airplanes. It must be noted that other RET configurations or specific operational procedures may be encountered, and must be evaluated on a case-by-case basis through a safety assessment study.

6 Other Design Considerations

The FWT is designed to the same standards as other components on Boeing airplanes. The following list identifies some relevant topics that often arise, but is not an exhaustive list of FWT design considerations.

6.1 Threats

The FWT is designed with consideration to the same threats that must be taken into account for other aircraft wing design. For instance, a bird strike to the FWT on takeoff or approach to a landing is not different from a bird strike to other components of the wing structure.

Any realized threat that results in a FWT not being able to fold or extend normally will have an associated EICAS alert, be made evident to the flight crew through EICAS messaging, allowing the FWT non-normal procedure to be invoked.

6.2 De-icing and Anti-icing

The FWT can be de-iced and anti-iced in the folded or extended position. The plan is to treat the FWT no differently than other wing tip devices for de-icing and anti-icing operations (i.e. there will be no reduction in holdover time when the FWT is either de-iced or anti-iced in the folded position). Boeing does not consider the FWT critical for anti-icing. Boeing is seeking regulatory approval for this approach, approval is expected early 2018.

6.3 Wind

There are no limitations due to wind (including crosswinds) on the 777-8/-9 specific to the FWT. The FWT is designed to operate within the wind envelope of the airplane.

When expected wind speeds are 85 kts or higher (Category II hurricane), a maintenance action will be required to extend and lock the FWT or install ground service equipment designed to hold the FWT in place in the folded position under these high wind loads.

6.4 Environment

The FWT is designed for operation in extremes of the in-service environment. Standard design practices are followed for systems and mechanisms directly exposed to harsh environments, similar to the other moveable surfaces on the wing. This includes but is not limited to water, salt spray, de-icing fluid, sand or dust, ice, and vibration.

6.5 Aircraft Rescue and Fire Fighting

The FWT does not drive new or additional requirements for aircraft rescue and firefighting.

6.6 Reliability

The FWT is a highly reliable system with built in redundancy and therefore non-normal operations are expected to be infrequent. Reliability is similar to other systems on existing 777 aircraft such as flaps, main landing gear steering, and thrust reversers.

Attachment H

Boeing 777-8/9
Non-Normal Folding Wing Tip (FWT)
Operations Plan

Table of Contents

List of Figures

1 List of Acronyms

Acronym	Definition
ANC	ICAO Air Navigation Commission
ARC	Aerodrome Reference Code
CON-OPS	Concept of Normal Operation
EIS	Entry In Service
FWT	Folding Wing Tip
ICAO	International Civil Aviation Organization

2 Introduction

This document outlines a generic airport operations plan for 777-8/9 on-ground maneuvering in the event of a non-normal Folding Wing Tip (FWT). All airports are unique and have their own policies, procedures and regulations. Use this document as a generic guide when writing specific operational plans.

This document addresses the 777-8 and 777-9 as they both have the same wingspan in the folded and extended positions. This document does not address other airport considerations during normal 777-8/9 operations such as pavement strength, servicing. For more information on standard 777-8/9 operations please see the 777-8/9 Aircraft Characteristics for Airport Planning (ACAP) document page at www.boeing.com/airports.

The International Civil Aviation Organization (ICAO) [1] determines International Standards and Recommended Practices for airport design. Included in the design are separation criteria between taxiways, runways, taxi lanes and objects based on the Aerodrome Reference Code (ARC) of the operating aircraft, Code A through F. The 777-8/9 operations will be a Code E (same as the Boeing 747-400 and 777-300ER) with wings folded (wingspan of 64.8m) and a Code F with the wings extended (71.8m). The intent of FWT feature is to allow the 777-8/9 to operate at airports designed to ICAO Code E standards when on taxiways and at the gate or apron area. In the event of a non-normal FWT, the wingspan increases up to 3.5m on either side or both sides to a maximum wingspan of 71.8m, becoming a Code F airplane (same as the Boeing 747-8 and the Airbus A380). Therefore, this document will address 777-8/9 operations with a non-normal FWT on aircraft taxi routes designed to less than Code F specifications. Furthermore, it is assumed in this document that the 777-8/-9 will be the largest commercial aircraft operating at the airport, and all other traffic will be at most Code E. Analysis is carried out on airport infrastructure designed per the 7th edition on ICAO Annex 14[2], Amendment 14.

This document recommends procedures that result in an acceptable level of safety when operating a 777-8/9 with a non-normal FWT in a non-Code F environment. However, it is recognized that at some airports, unique operational procedures may be required. In addition, the ICAO PANS – Aerodromes document[2] provides guidance to conduct safety assessment, address airport-airplane compatibility, operational procedures and mitigations. Attachment A and Attachment B provide more information specific to the 777-8/-9 to support development of a safety assessment and airport operational procedures and mitigations.

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[1] International Civil Aviation Organization. *Annex 14 to the Convention on International Civil Aviation* Aerodromes Volume 1, Aerodrome Design and Operations, Seventh Edition July 2016. Montreal, Quebec, Canada

[2] International Civil Aviation Organization. *Annex 14 to the Convention on International Civil Aviation* Aerodromes Volume 1, Aerodrome Design and Operations, Sixth Edition July 2013. Montreal, Quebec, Canada

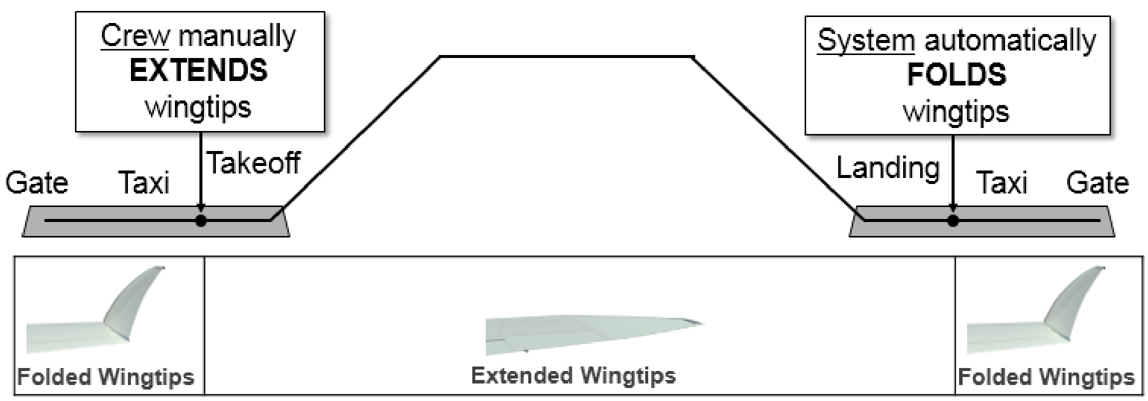
[2] International Civil Aviation Organization. PANS-Aerodromes, Procedures for Air Navigation Services, Doc 9981, Second Edition, 2016

3 Normal FWT Operations: Background, Takeoff and Landing

During the taxi for departure phase, the 777-8/9 taxis to the runway with wings folded (Figure 3-1). The flight crew will initiate the command for the wings to the takeoff configuration (extended and locked) prior to the hold line. Extension of the wing tips takes 20 seconds. The exact location to extend the wing tips will be determined by each aerodrome based on its operational plans and physical layout. The location will be part of the preflight briefing. The flight crew will receive ATC (Air Traffic Control) takeoff clearance upon confirmation that wings are in the takeoff configuration.

When preparing to land a 777-8/9 at a specific airport, part of the approach briefing will include a review of the non-normal FWT alternate taxi routes developed by the airport as part of the "taxi routing to parking" discussion. These routes will specify whether the route is adequate for a single non-normal FWT on a specific side or failure on both sides. This briefing will be conducted to prepare the flight crew for an alternate taxi route in the event of a non-normal FWT.

Upon landing, the FWT system will automatically fold the wing tips when the aircraft has touched down and ground speed is below 50 kts in order to be folded before entering the taxiway environment. Folding of the wing tips takes 20 seconds.



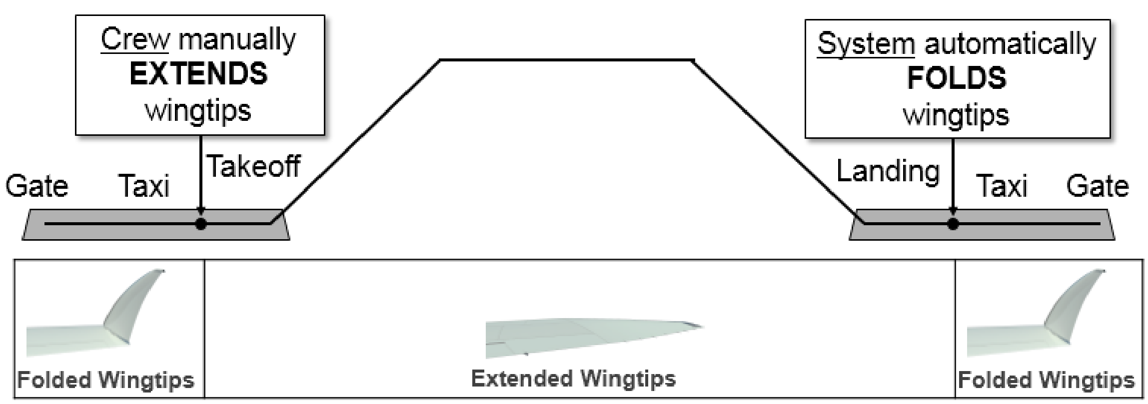


Figure 3-1. FWT Operational Concept

4 FWT Non-Normal Operations Before Takeoff

Two types of non-normal FWT scenarios may occur before takeoff and before departure. Along with the associated procedures, the flight crew will have reviewed the scenarios during the pre-flight briefing.

The first failure mode occurs when the FWT fails to extend when operating the Folding Wing Tip Pilot Control Module lever. In this event, the flight crew will receive the **WINGTIPS DRIVE** message on the EICAS (Engine Indication and Crew Alerting System), as well as a master caution light and aural beeper indicating the malfunction. If both wings fail to extend and the wingspan remains a Code E, the flight crew will inform the tower of the malfunction and their need to return to the gate or to a pre-designated parking stand and wait for instructions. If one or both of the wing tips partially extend or only one wing tip extends, the flight crew can attempt to re-fold the wing tips. If re-folding is unsuccessful, the wingspan will not be Code E. EICAS will indicate which wingtip has failed, and continue to show the sensed position for the non-failed wingtip. The flight crew will then inform the tower of the malfunction and their intentions to follow the non-normal FWT taxi route back to the gate or other designated parking spot. The tower will either approve or offer an alternate to the request. The flight crew will then taxi the aircraft to the designated parking stand or gate via the taxi route agreed upon between the tower and flight crew. After the flight crew coordinates with the airline regarding passenger offload, the wing tips will then be repaired or manually configured for safe flight (see the paragraph below).

The second type of non-normal FWT during departure is when the airplane is dispatched per the minimum equipment list (MEL) with the wing tips manually locked in the extended position as a Code F airplane due to a pre-existing failure of the FWT system. The flight crew will review 777-8/9 non-normal FWT alternate taxi procedure during the pre-flight briefing and inform ground control of their configuration and intended taxi route. Once cleared for pushback, all precautionary and safety measures as defined in the airport's non-normal FWT operational plan are exercised to provide an equivalent level of safety to standard 777-8/9 operations. After pushback, the flight crew will taxi the aircraft along the predetermined non-normal FWT route and takeoff.

5 FWT Non-Normal Operations After Landing

In the event that the FWT system does not automatically issue the fold command (autofold failure), the flight crew will receive a **WINGTIPS POSITION** caution message on the EICAS as well as a master caution light and aural beeper to alert them of the malfunction. The flight crew will action the Folding Wing Tip Pilot Control Module lever manually to command the wing tips to the folded position and assume normal taxi operations to the gate.

In the event of non-normal FWT where one or both of the wing tips fail to move to or reach the Folded position, the flight crew will receive a **WINGTIPS DRIVE** caution message on the EICAS of the malfunction, as well as a master caution light and aural beeper. EICAS will also indicate which wing tip has failed, and continue to show the sensed position of the non-failed wing tip. The flight crew will action the associated non-normal checklist. The flight crew will then inform the tower of the malfunction and their intentions to follow the non-normal FWT taxi route. The tower will either approve or offer an alternate to the request. The flight crew will then taxi the aircraft to the designated parking stand or gate via the taxi route agreed upon between the tower and flight crew. Details of apron operations with one or both wing tips failed in the extend position can be found in Section 7c, “Apron and Stand Operations”.

In some cases, the FWT system can detect specific malfunctions prior to landing that will prevent the wing tips from correctly folding. The indicated failure condition displays a **WINGTIPS SYS** advisory message, and enables the flight crew to execute ATC, tower, and airline operations coordination immediately in advance of landing.

6 Non-Normal FWT Taxiway Operations

6.1 Runway to Taxiway Separations

The ICAO Aerodrome Design Manual for taxiways[3] clarifies that the runway to taxiway separation is based on the principle that the wing tip of an airplane taxiing on a parallel taxiway should not penetrate the runway strip. This relationship is currently quantified by the following equation:

$$\textit{Runway to Taxiway Separation Distance} = \frac{1}{2}\textit{Wingspan taxiing aircraft} + \textit{Runway Strip Width}$$

Proposed revision to ICAO Annex 14 7th edition (per Amendment 14) recommends a runway strip extending 140m each side of the centerline. The recommendation for taxiway to runway centerline separation based on this strip width is 172.5m for Code E operations and 180m for Code F operations. Applying this equation to a 777-8/-9 with Non-Normal FWT results in a minimum Runway to Taxiway separation of 176m. A Code E aircraft on the runway with a 777-8/-9 with Non-Normal FWT on the parallel taxiway with 172.5m separation shown in Figure 6-1.

A 777-8/-9 with non-normal FWT will encroach on the runway strip by 3.4m at the minimum ICAO Code E separation of 172.5. A safety assessment study should be performed or mitigation procedures enacted to ensure safety of operations[4].

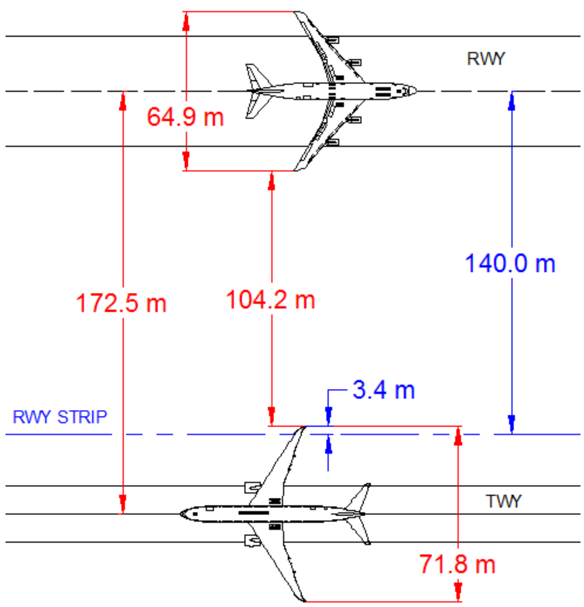


Figure 6-1. Code E Aircraft on Runway With 777-8/-9 With Non-Normal FWT on Parallel Taxiway

[3] *Aerodrome Design Manual* Part 2, Taxiways, Aprons and Holding Bays Fourth Edition, 2005. Montreal, Quebec, Canada. Sect 1.2.46.

[4] International Civil Aviation Organization. *PANS-Aerodromes*, Procedures for Air Navigation Services, Doc 9981, Second Edition, 2016, Chapter 3.

6.2 Taxiway to Taxiway Separations

ICAO Annex 14 7th edition, Amendment 14, recommends a parallel taxiway centerline separation of 76m for Code E operations and 91m for Code F operations, in order to provide a minimum wing tip clearance of 11m for aircraft of the respective codes operating on parallel taxiways. The clearance between a 777-8/-9 with Non-Normal FWT and a Code E aircraft on parallel taxiways, built per this recommendation, is shown in Figure 6-2.

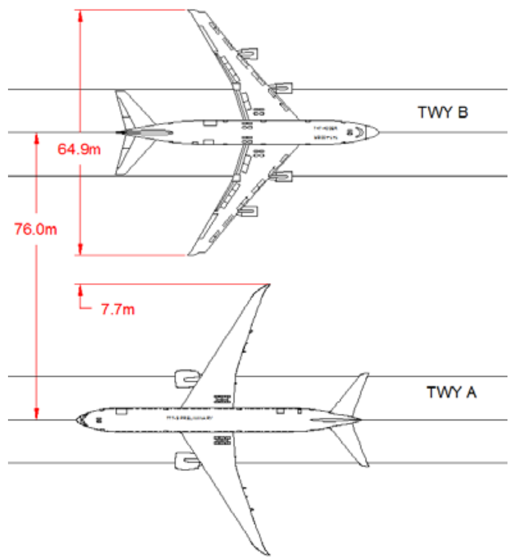


Figure 6-2. Wing Tip Clearances Between a 747-400 (Limiting Code E Aircraft) and a 777-9 With Non-Normal FWT on Parallel Taxiways

During taxiway operations, a 777-8/9 with non-normal FWT will have 7.7m of wing tip clearance to a 747-400 (used as Code E limiting aircraft) on the parallel taxiway, which is less than the recommended 11m. In order for a Code E aircraft to maintain 11m separation to a 777-8/-9 with Non-Normal FWT, a parallel taxiway separation of at least 79.3m is required. As a possible mitigation, aircraft operating on TWY B can be limited to a wingspan of no more than 58.2m in order to maintain the current ICAO recommended wing tip clearance of 11m for Code E.

During taxiway operations with non-normal FWT, it is possible to encounter another 777-8/-9 on a parallel taxiway that has extended FWT in preparation for takeoff, a scenario illustrated in Figure 6-3.

During taxiway operations of 777-8/9 with non-normal FWT will have 4.2m of wing tip clearance, which is less than the recommended 11m.

It may be permissible to operate a 777-8/9 with a non-normal FWT with less than 11m wingtip separation to aircraft on a parallel taxiway if a safety assessment study[4] indicates that such lower separation distances would not adversely affect the safety or significantly affect the regularity of operations of airplanes.

[4] International Civil Aviation Organization. *PANS-Aerodromes*, Procedures for Air Navigation Services, Doc 9981, Second Edition, 2016, Chapter 3.

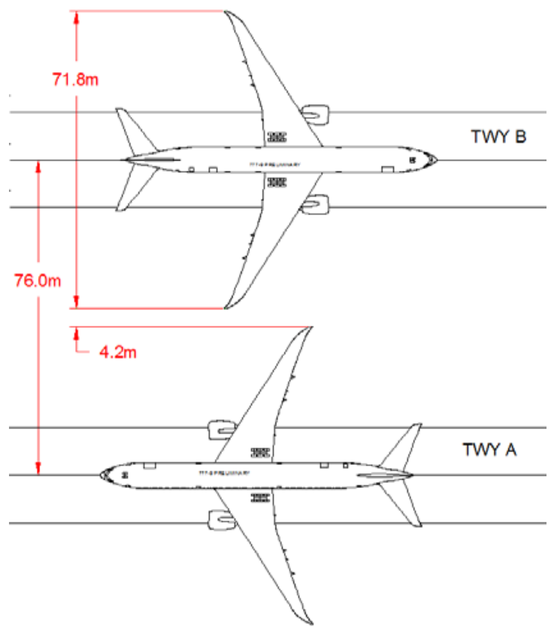


Figure 6-3. Wing Tip Clearances Between a 777-9 With Wings Extended and a 777-9 With Non-Normal FWT on Parallel Code E TWs

6.3 Taxiway to Object Separations

Annex 14 7th edition, Amendment 14, recommends a distance of 43.5m between the centerline of a taxiway and a stationary object, to ensure 11m wing tip clearance. The clearance between a 777-8/-9 with Non-Normal FWT on a taxiway and an object at 43.5m from the taxiway centerline is show in Figure 6-4.

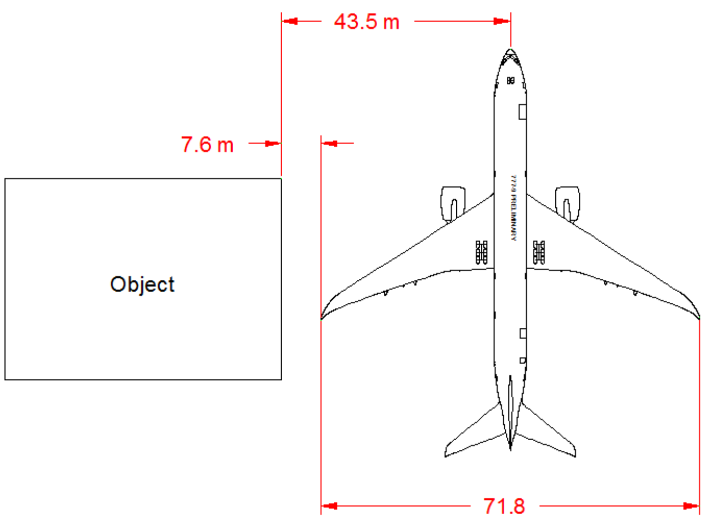


Figure 6-4. Wing Tip Clearances Between a 777-9 With Non-Normal FWT on a Taxiway and a Stationary Object

The resulting clearance is 7.6m, which is less than the recommended 11m. To maintain 11m wing tip separation in the event of a non-normal FWT, the recommended 777-8/9 taxiway centerline to object separation should be at least 46.9m.

It may be permissible to operate a 777-8/9 with a non-normal FWT with less than 11m wingtip separation to an object if a safety assessment study[4] indicates that such lower separation distances would not adversely affect the safety or significantly affect the regularity of operations of airplanes.

6.4 Taxilane and Apron Operations

6.4.1 Taxilane to Taxilane Separations

ICAO Annex 14 7th edition, Amendment 14, recommends a parallel taxilane centerline separation of 72.5m for Code E operations and 87.5m for Code F operations, in order to provide a minimum wing tip clearance of 7.5m. The clearance between a 777-8/-9 with Non-Normal FWT and a Code E aircraft on parallel taxilanes built per this recommendation is shown in Figure 6-5.

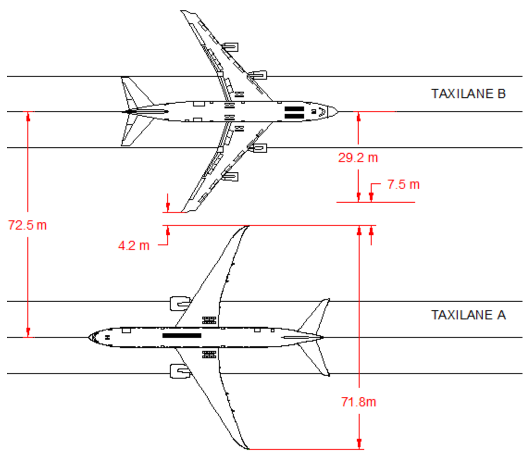


Figure 6-5. Wing Tip Clearances Between a 747-400 (Limiting Code E Aircraft) and a 777-9 With Non-Normal FWT on Parallel Taxilanes

A 777-8/9 with non-normal FWT will have 4.2m of wing tip clearance to a 747-400 (used as Code E limiting aircraft) on the parallel taxilane, which is less than the recommended 7.5m. A minimum parallel taxilane separation of 75.8m is required in order for a Code E aircraft to maintain the recommended 7.5m separation to a 777-8/-9 with Non-Normal FWT. A possible mitigation, aircraft operating on Taxilane B would be limited to a wingspan of no more than 58.4m in order to maintain the current ICAO recommended wing tip clearance of 7.5m for Code E.

It may be permissible to operate a 777-8/-9 with non-normal FWT condition and taxilane-to-taxilane wing tip clearance less than 7.5m, at an existing aerodrome, if a safety assessment study[4] indicates such lower separation distances would not adversely affect the safety or significantly affect the regularity of operations of airplanes.

[4] International Civil Aviation Organization. *PANS-Aerodromes*, Procedures for Air Navigation Services, Doc 9981, Second Edition, 2016, Chapter 3.

6.4.2 Taxilane to Object Separations

Annex 14 7th edition, Amendment 14, recommends Code E and F taxilane centerline to object separations to 40m and 47.5m for Code E and F respectively, allowing for 7.5m of wing tip clearance for both reference codes. The resulting clearance for a 777-8/-9 with Non-Normal FWT is shown in Figure 6-6. The 4.1m clearance available to an object located 40m from the taxilane centerline is less than the recommended 7.5m. In order for the 777-8/9 with Non-Normal FWT to maintain 7.5m wing tip clearance, it would require a taxilane-to-object separation of at least 43.4m.

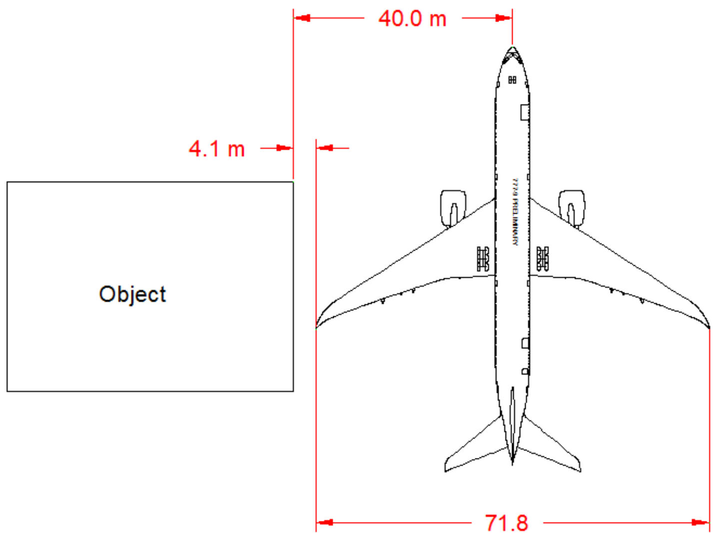


Figure 6-6. Wing Tip Clearances Between a 777-9 With Non-Normal FWT on a Taxilane and a Stationary Object

It may be permissible to operate a 777-8/-9 with non-normal FWT condition and taxilane-to-object wing tip clearance less than 7.5m wing tip clearance, at an existing aerodrome, if a safety assessment study[4] indicates such lower separation distances would not adversely affect the safety or significantly affect the regularity of operations of airplanes.

6.4.3 Apron and Stand Operations

ICAO aerodrome design recommends a minimum aircraft body clearance of 7.5m for Code E and F aircraft parked at an aircraft stand. While the clearance does not change from Code E to Code F operation, it should be noted that any 777-8/9 with a non-normal FWT will be operating with a 3.5m wingspan increase on the side of the non-normal FWT. It is recommended that all 777-8/9 parking operations with a non-normal FWT maintain the 7.5m clearance at all times. Many airports allow less than 7.5m aircraft clearance with wing-walkers; visual docking guidance system and other services that provide an acceptable level of safety (see Figure 6-7).

[4] International Civil Aviation Organization. *PANS-Aerodromes*, Procedures for Air Navigation Services, Doc 9981, Second Edition, 2016, Chapter 3.

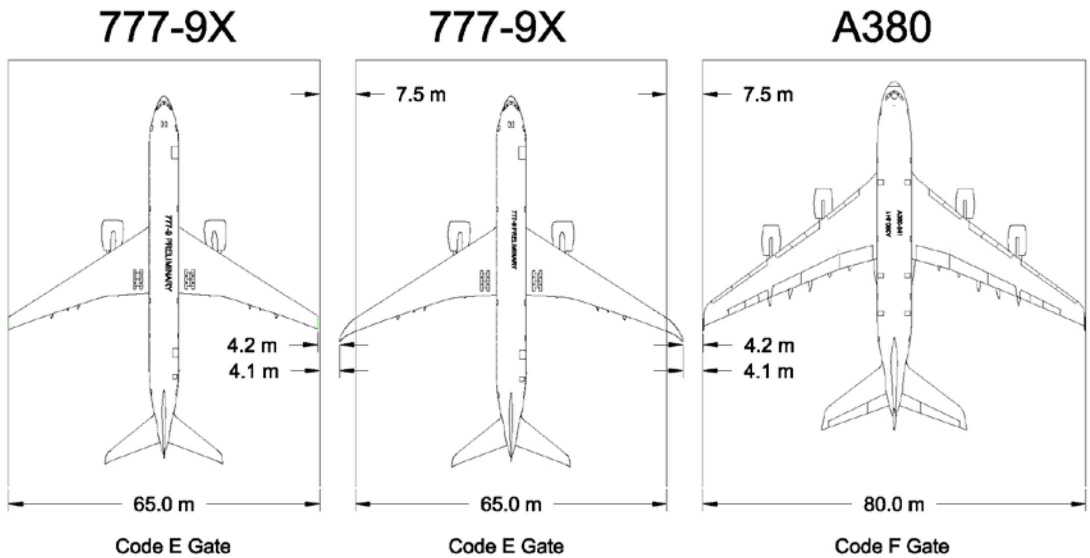


Figure 6-7. 777-9 With Non-Normal FWT Code E and F Clearances

Another option for accommodating a 777-8/9 with a non-normal FWT and still maintaining 7.5m wing tip clearance at the gate is to reduce the size of the aircraft parked at the adjacent gate, as shown in Figure 6-8. By reducing the size of the aircraft parked in the adjacent space a Code E gate can accommodate a 777-9. If a Code F gate is adjacent to the same side as a non-normal FWT, any aircraft with a wingspan under 76.5m (such as the 747-8) will be able to park at that gate and still maintain the 7.5m clearance.

Any aircraft with a wingspan less than 58.2m can park at the gate while maintaining the 7.5 m clearance if the gate adjacent to the non-normal FWT is a Code E gate.

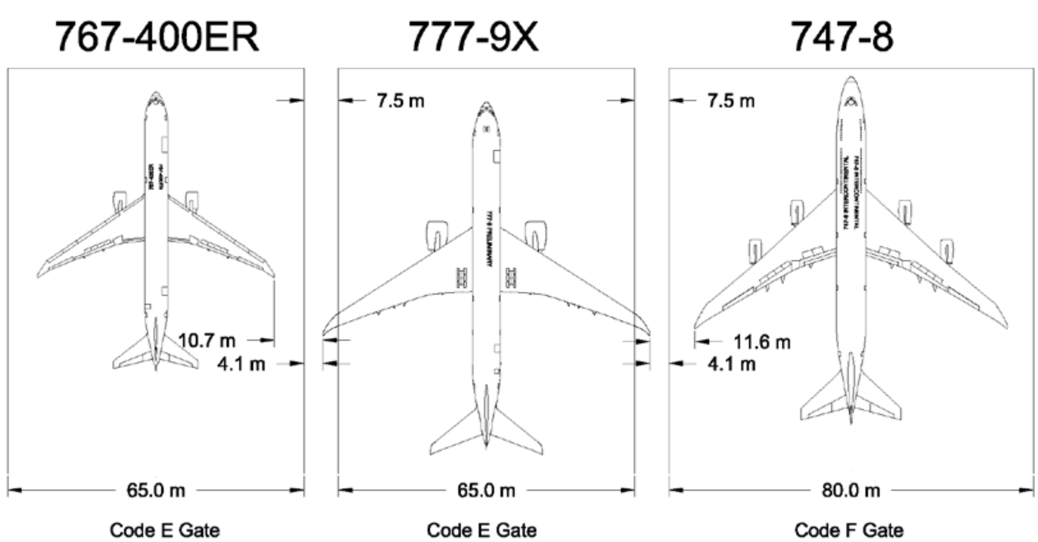


Figure 6-8. 777-9 With Non-Normal FWT Code E and F Clearances