

777X Airport Compatibility

Airport Compatibility Engineering
Boeing Commercial Airplanes

July 2013

ECCN: 9E991

Overview

- 777X Airport Discussions Purpose
- 777-9X Aircraft Characteristics (Preliminary)
 - General Dimensions
 - Folding Wing Tip
 - Overall Length
 - Fuel Connectors
 - Door Locations
 - Turning Capability
- Status of Completed 777X Airport Visits
- 777X Airport Compatibility Plan
- Summary

777-9X Airport Discussions Purposes

- *What do we want to achieve?*

Boeing is striving to balance the improved benefits to the airlines with any potential impacts to the airport infrastructure

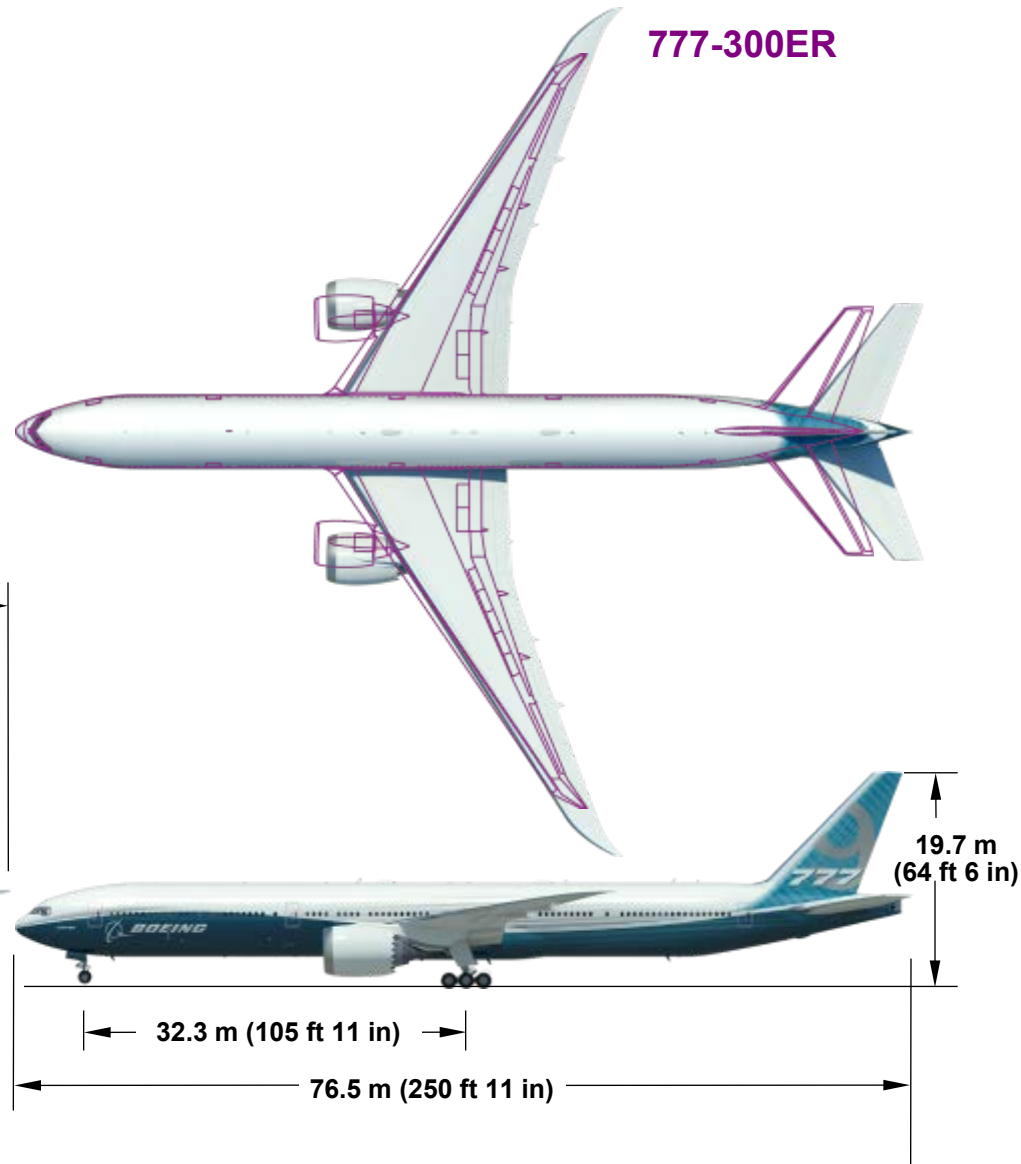
The intent of these discussions is:

- to **share** with the airports and their regulators Boeing's vision for the next derivative 777 fleet and Boeing's plan for minimizing impacts to the airport infrastructure;
- to **encourage** the airports and their regulators to plan for the future;
- to **listen to** any comments and suggestions that the airports and their regulators may have.

777-9X General Dimensions

777-9X Baseline General Arrangement

The folded wing has the same wingspan as the 777-300ER



DIMENSIONS ARE PRELIMINARY AND CAN EXPECT TO CHANGE DURING CONFIGURATION DEVELOPMENT

777-9X Compared to the 777-300ER

- Compared to the 777-300ER, the 777-9X
 - Overall length is 2.62 m (8.6 ft) longer (baseline)
 - Unfolded Wing span is 6.35 m (20.8 ft) wider
 - Horizontal stabilizer is 2.47 m (8.1 ft) wider
 - Wheelbase is 1.07 m (3.5 ft) longer
 - Engine to fuselage centerline is 0.91 m (3 ft) further outboard
 - Vertical tail max. height is < 1 m (< 3 ft) higher
 - Main landing gear width is 0.15 m (6 in) narrower

777-9X Airport Compatibility

– *Items to Consider*

<p>Wingspan</p> <ul style="list-style-type: none"> • Code F • Airfield minimum separations / parking 	<p>Solution – Folding Wing Tip (FWT)</p>
<p>Length/wheelbase</p> <ul style="list-style-type: none"> • Maneuvering/parking • RFF (Rescue fire fighting) <p>Vertical tail height</p>	<p>Solution - Work with key airports worldwide to ensure airports are ready at EIS</p>
<p>45m runway width (Code F aircraft require 60m wide runway)</p>	<p>Solution - Use the 747-8 model to get approval to operate on 45m wide runway</p>
<p>Horizontal tail width</p> <p>Jet blast</p> <p>Ramp servicing</p> <p>Main landing gear footprint/width</p> <p>Pavement loading</p>	<p>Not expected to be an issue – monitor configuration (business as usual)</p>

777X Folding Wing Tip

Introduction: Why Have a Folding Wing Tip?

- Higher wing spans improve aerodynamic efficiency and reduce fuel burn

BUT

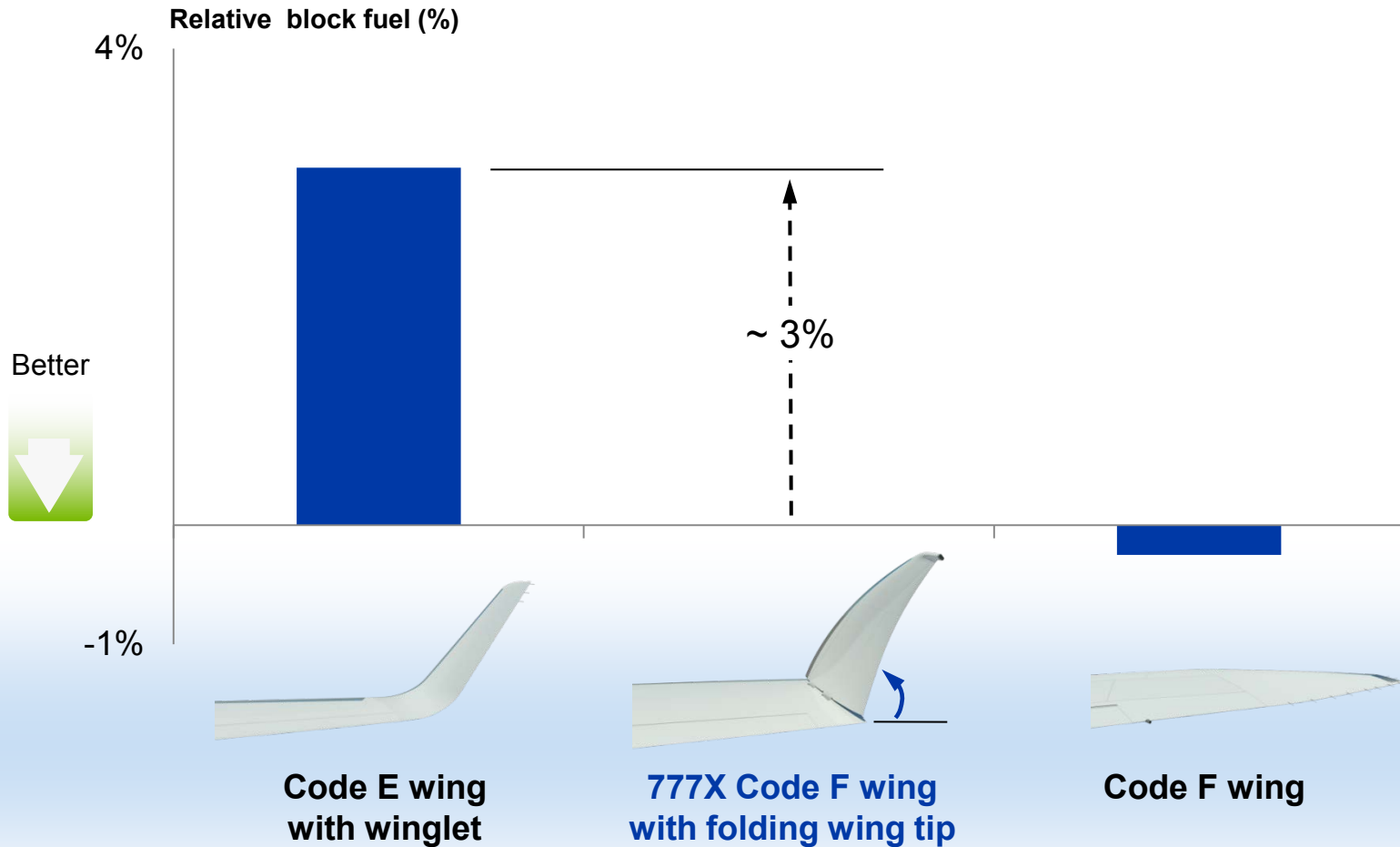
- Higher wing spans create airport compatibility issues

THEREFORE:

- A Folding Wing Tip (FWT) maximizes airport compatibility and retains aerodynamic efficiency and fuel burn reduction

Folding Wing Tip Advantages

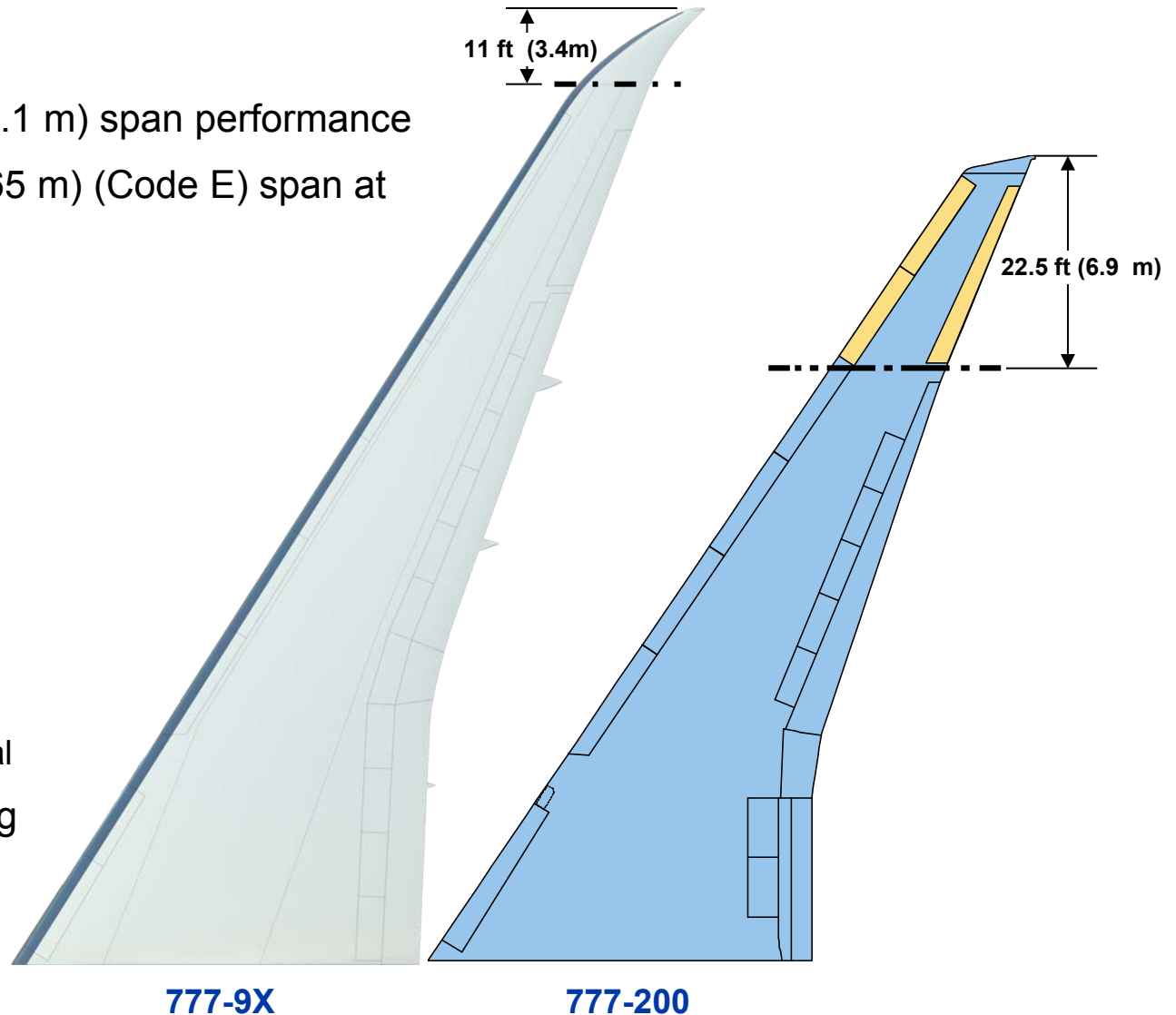
Significant fuel burn savings while compatible with 777-300ER taxiways and gates



Folding wing tip is the optimal choice for the 777X

Folding Wing Tip Comparison to 777-200 “Folding Wing”

- 777X tip fold
 - Enables 233.4 ft (71.1 m) span performance
 - Maintains 213.3 ft (65 m) (Code E) span at taxiways and gates
 - Lighter weight
 - Fewer moving parts
- 777-200 folding wing
 - Larger, heavier
 - More complex
 - Ailerons, slats, hydraulics, electrical
 - Large external fairing



777-9X

777-200

DIMENSIONS ARE PRELIMINARY AND CAN EXPECT TO CHANGE DURING CONFIGURATION DEVELOPMENT

Folding Wing Tip System Safety

- Will be designed to the same requirements for flight critical control surfaces
 - Isolated in flight
 - Redundant load paths, command paths, latch actuators
 - Failure mode is latched and locked

Functional Requirements for Folding Wing Tip

- It shall take less than 20 seconds from pilot command to reaching the commanded position under normal operating conditions for either folding (up) or extending the tips
- With the tips in the folded (up) position, the airplane shall be capable of withstanding Cat 1 hurricane winds* without ground support equipment (GSE) installed or hydraulic power
- It shall be possible to perform pre-flight controls checks and de-icing with the wingtips in any position
- The pilot shall be able to determine wing tip position status without ground crew or tower assistance

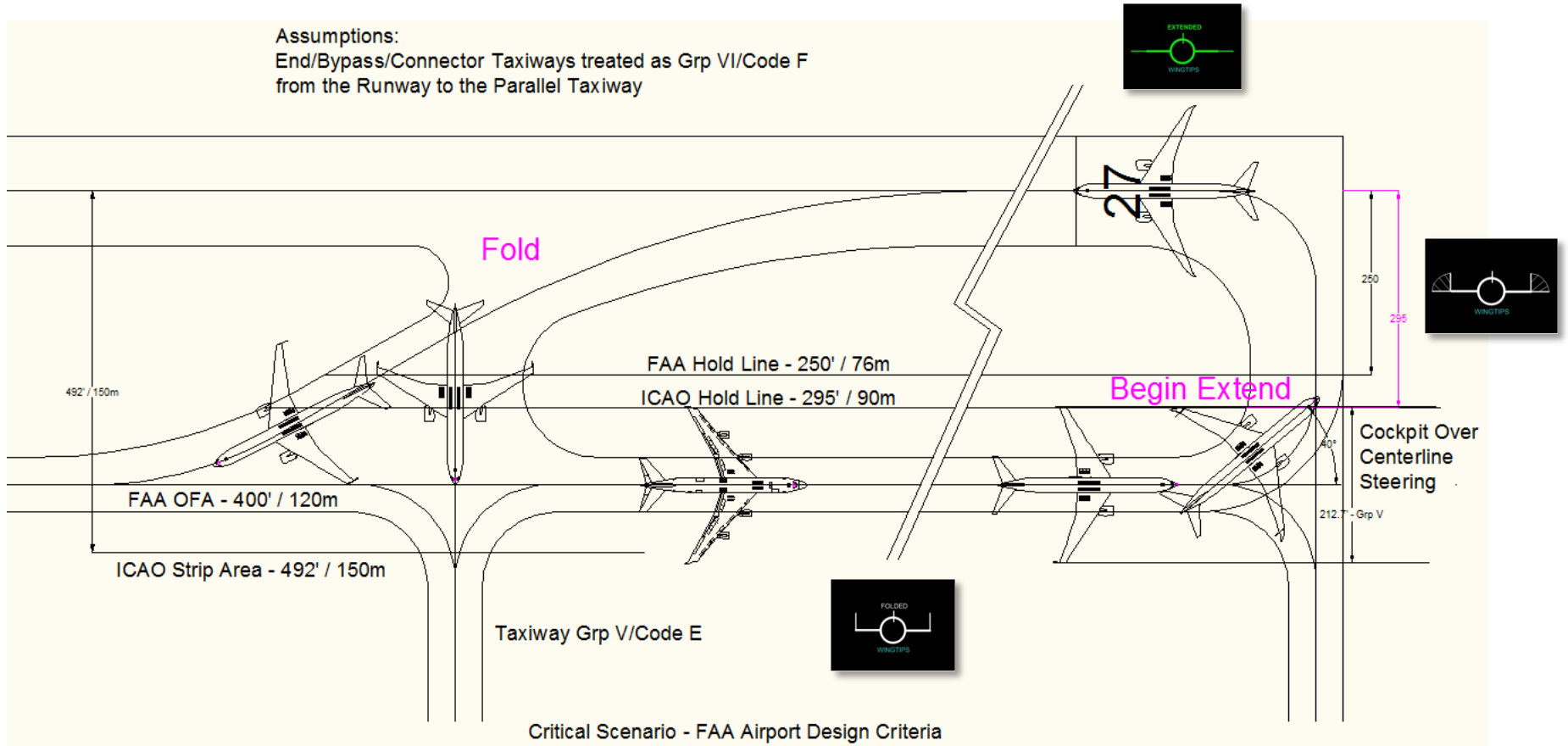
* Average wind speed of Cat 1 hurricane is 74-95 mph.

Flight Deck Features

- Unique flight deck control commands manual tip positioning
- Normal crew procedures require tip fold at every airport
- On the ground, full time EICAS (Engine Indication and Crew Alerting System) will indicate the tip position
- High integrity aircraft position system will alert the crew to command the tip position when approaching / departing the runway
- Takeoff configuration alerting will prevent takeoff with the tips folded
- System inhibits inadvertent operation
- Alerting informs crew of uncommanded tip position

Location on Airfield for Fold / Extend

Assumptions:
End/Bypass/Connector Taxiways treated as Grp VI/Code F
from the Runway to the Parallel Taxiway



- Command initiated when entering and exiting the runway
- Linked to electronic checklist and alerting system
- Alerts prior to takeoff and after landing back up normal crew procedure

Folding Wing Tip Reliability

Reliability similar to other system failures which may affect airport operations

Folding Wing Tip

System failure	Consequence
Tip failure to fold on ground	At non-CODE "F" airports, special handling to adequate parking areas (airport disruption)

Current 777 examples

System failure	Consequence
Nose-wheel steering failure	Towing required (airport disruptions possible)
Braking (jammed/stuck) failure	Runway/taxiway blockage, damage to tires & landing gear (disrupted operations possible)
Main landing gear doors actuator failure	Gear cannot retract, dump fuel, return to land, lost gate, unplanned landing (airport disruption)

Proposed Procedures at Airport for FWT Failure

Proposed procedures at airport if tip fails to fold/extend

One failure per 10,000 landings*

Failure to fold after landing

- Code F airport - Clear runway and taxi to gate via Code F route
- Non-Code F airport - Clear runway and hold for tow to gate / maintenance ramp

One failure per 100,000 dispatches*

Failure to extend prior to takeoff

- If tips return to fold position – aircraft remains Code E – taxi back to the gate
- If one or both tips fail to return to fully extended – aircraft returns to gate / maintenance ramp via tow

Return to gate/maintenance ramp

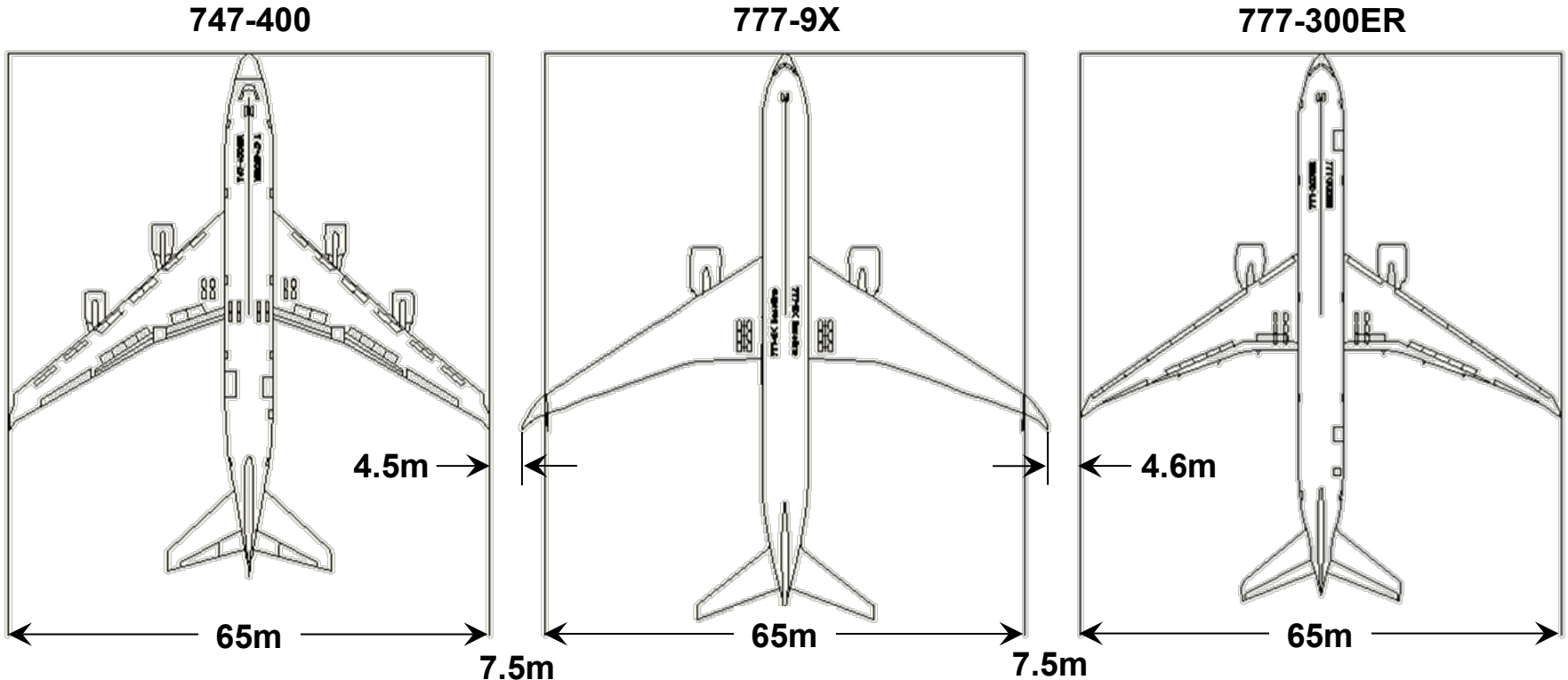
- Boeing to confirm with ICAO/FAA that clearances currently required could be reduced for an aircraft under tow

* Excluding center hydraulic system failures

Code E Gate Parking under FWT Failure

Proposed procedure to return to gate if tip fails to fold

Terminal with Code E Gates



Note: Normal operation of Code E and F aircraft at LAX uses towing with clearances as low as 4.5m;

If 777-9X tips are fully extended and the aircraft is under tow and using wing-walkers, reduced clearances should be acceptable

DIMENSIONS ARE PRELIMINARY AND CAN EXPECT TO CHANGE DURING CONFIGURATION DEVELOPMENT

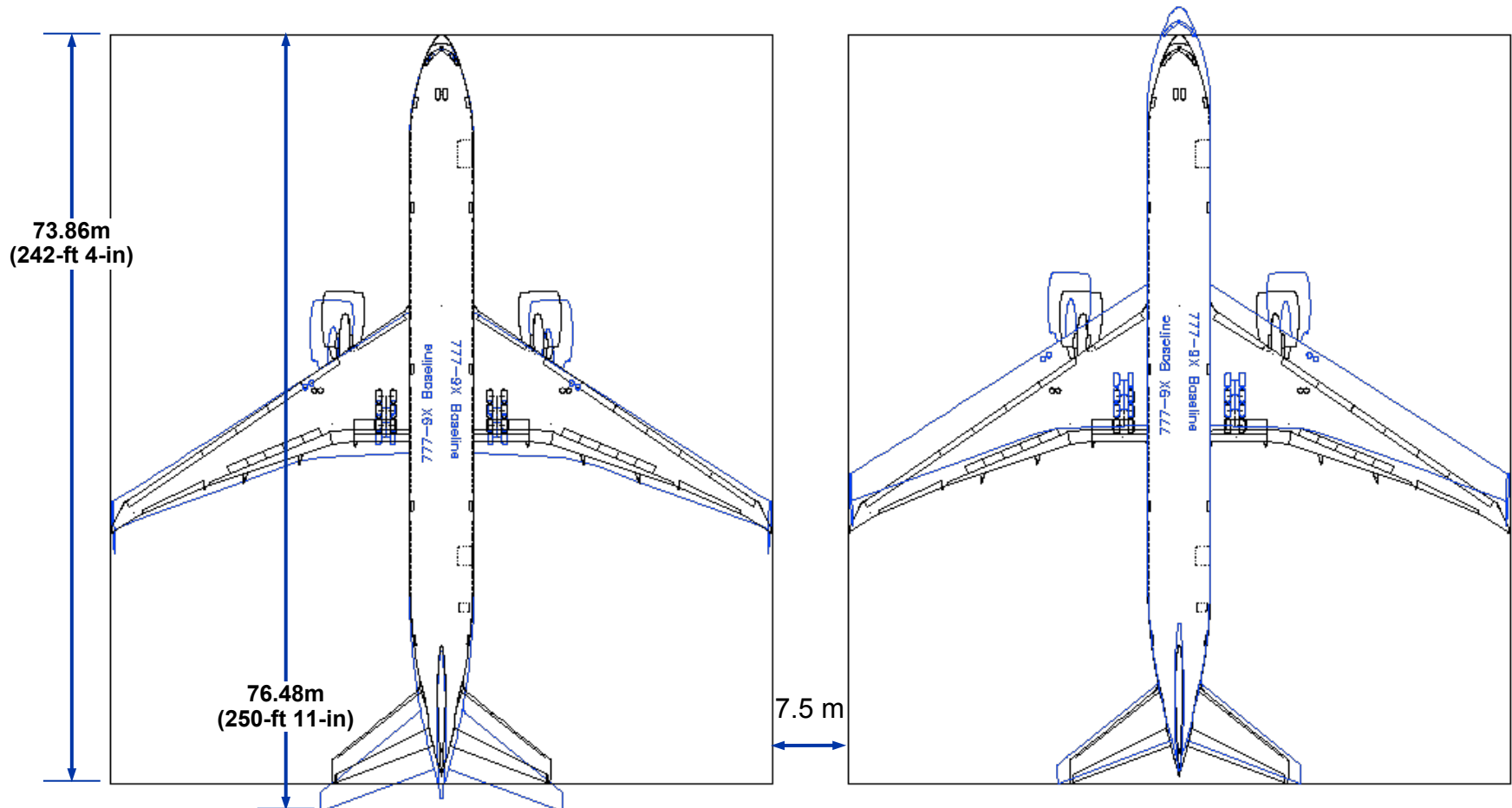
Folding Wing Tip Summary

- A FWT provides the best performance solution while maximizing airport compatibility
- FWT reliability / maintainability is consistent with other major systems
- A special procedure may be required to allow for adequate wingtip clearance (Rwy-Twy, Twy/Taxilane-Twy/Taxilane, Twy/Taxilane-Object clearance) in the unlikely scenario of wingtip failure
- Airlines were overwhelmingly supportive of FWT at recent airline working group meeting
- Boeing seeks inputs from Airports and Regulators in folding wingtip development

777X Overall Length

777-9X Parks at a 777-300ER Gate

- No requirement to down-size adjacent gate
- At many gates increased length of the 777X can be accommodated by moving aircraft forward towards the terminal (additional space available in the front of aircraft nose)

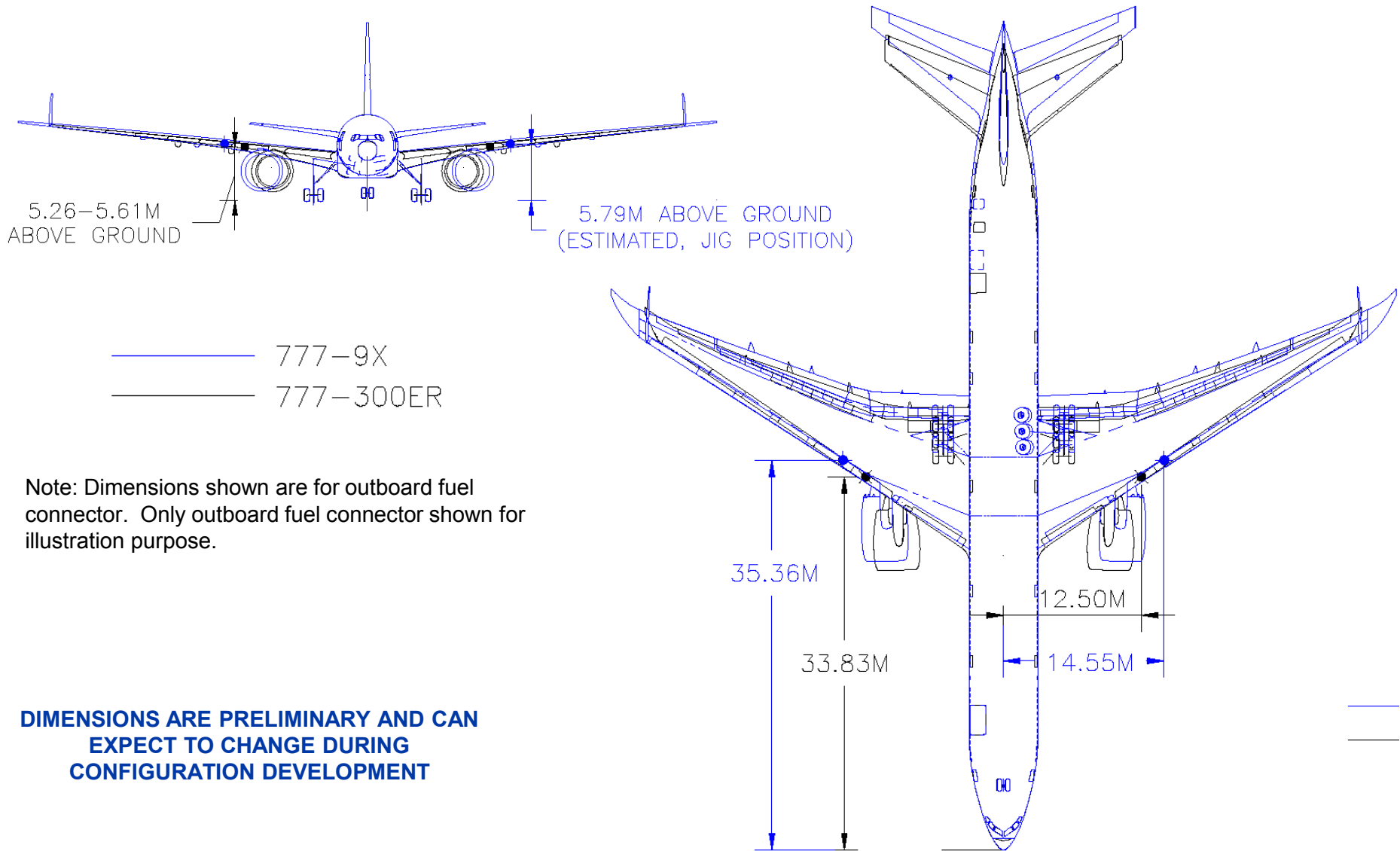


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777X Fuel Connectors

777-9X Fuel Connectors Comparison with 777-300ER

- Compatibility with Existing underground fueling system

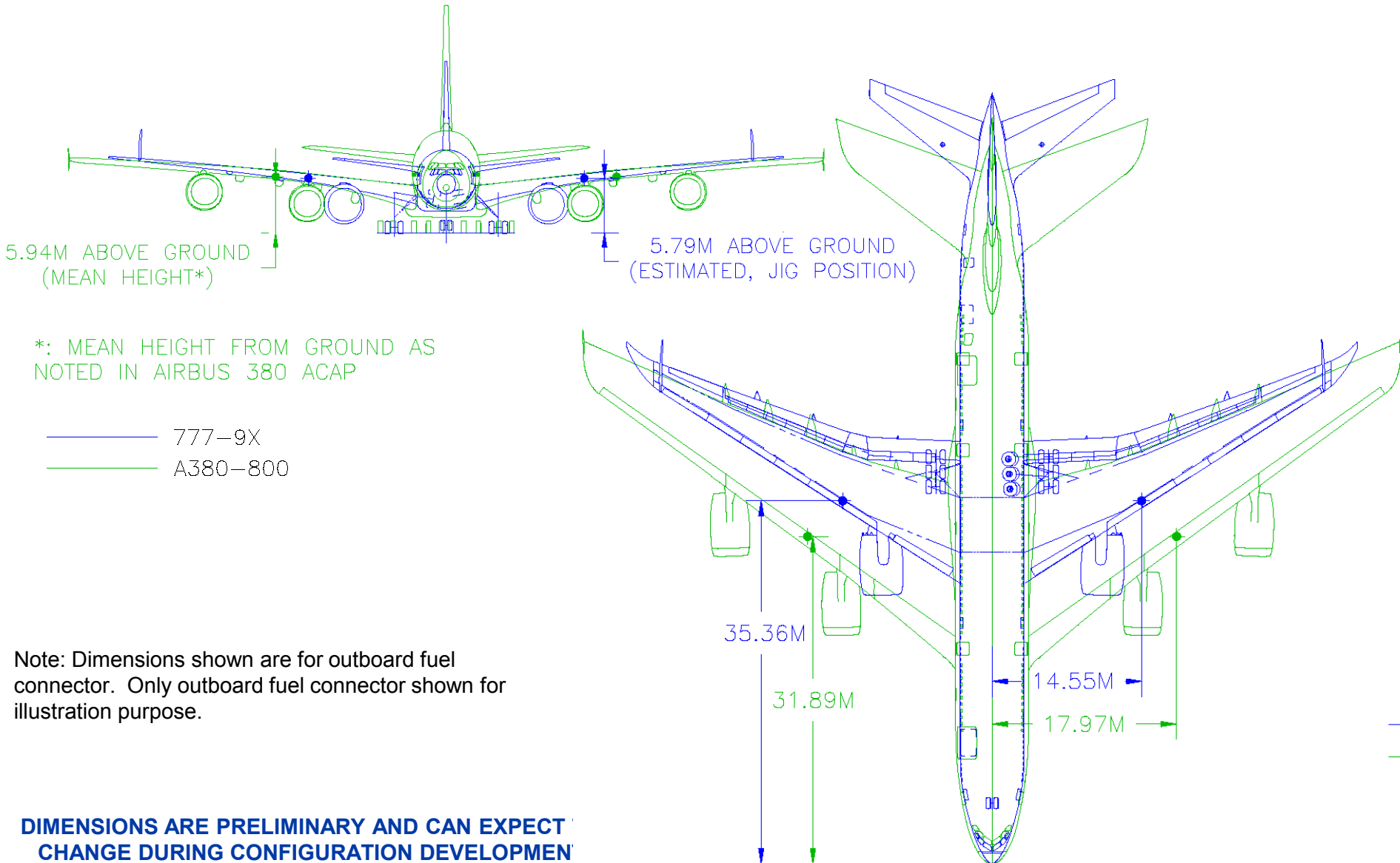


Note: Dimensions shown are for outboard fuel connector. Only outboard fuel connector shown for illustration purpose.

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777-9X Fuel Connectors Comparison with A380-800

- Compatibility with Existing underground fueling system

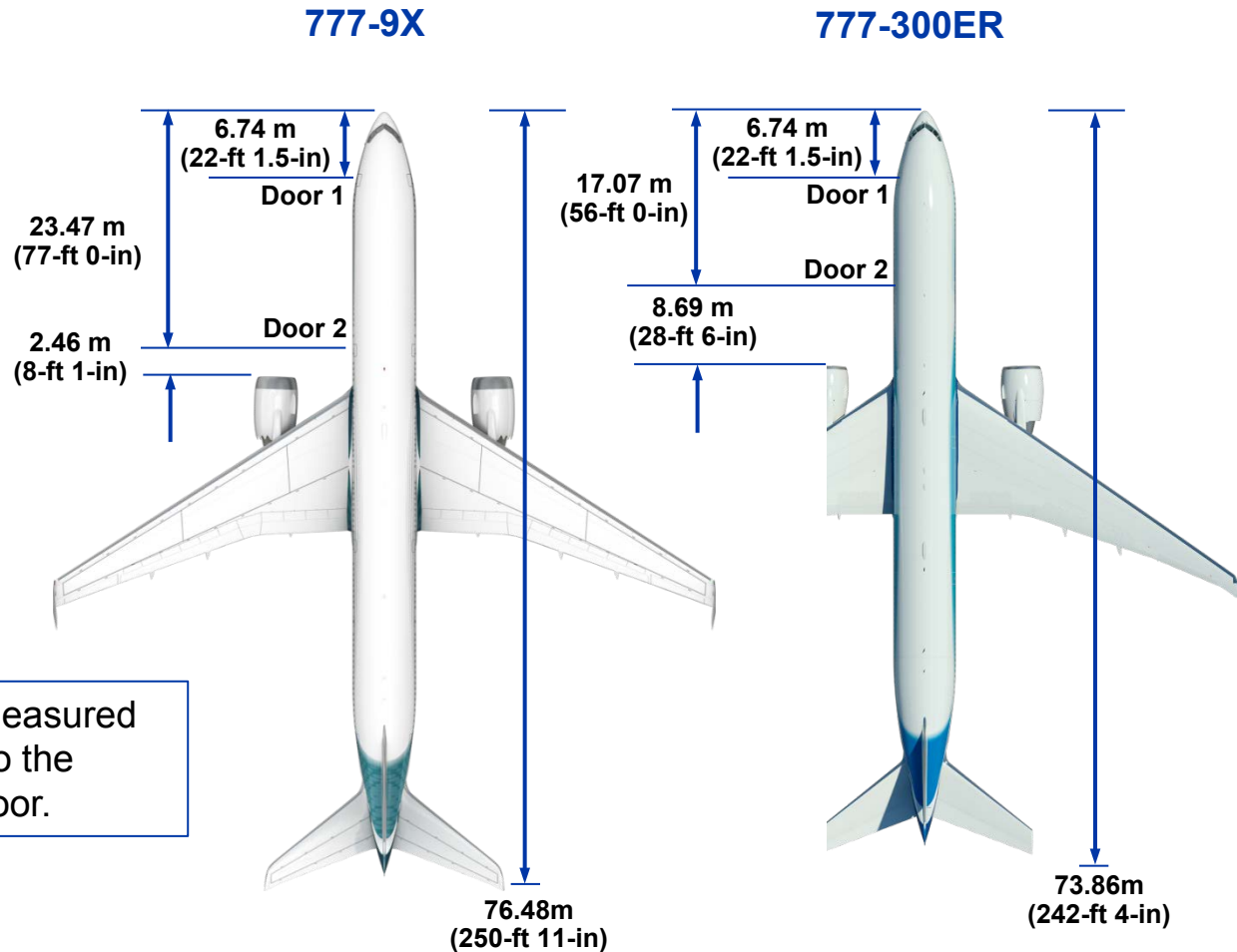


777X Door Locations

777-9X Door Location Comparison with 777-300ER

777-9X Parks at a 777-300ER Gate

Gate access – door 1 and 2



Door distance is measured from the nose tip to the centerline of the door.

A340-600 dimensions:

Nose-door 1: 5.84 m (19-ft 2-in)

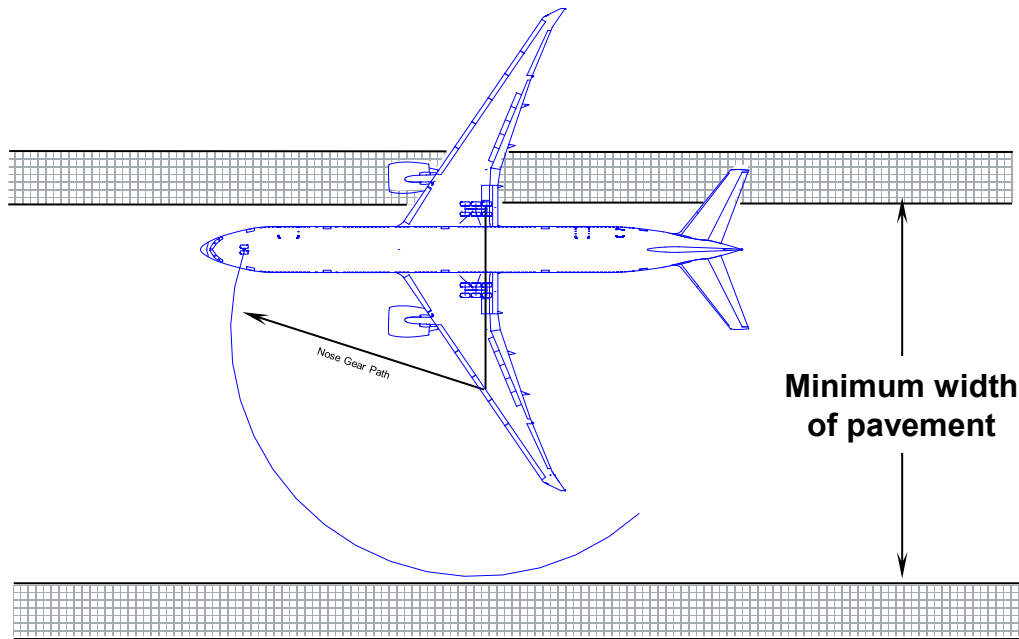
Nose-door 2: 23.90 m (78-ft 5-in)

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DIMENSIONS ARE PRELIMINARY AND CAN EXPECT TO CHANGE DURING CONFIGURATION DEVELOPMENT

777X Turn Capability

777-9X 180° Turn Capability



- U-turn width can be reduced by using differential braking and/or asymmetrical thrust
- Minimum widths do not take into account tire-edge clearance of 15 ft (4.5m) at both pavement edges
- Minimum widths are calculated based on data from available airport planning manuals and not nominal values

	747-400	747-8	777-300ER	777-9X ¹	A340-600	A380-800 ²
ICAO Airplane Design Code	E	F	E	F	E	F
180 turn width (max steering angle, no differential braking)	51m	52 m	57 m	59 m	57 m	66 m

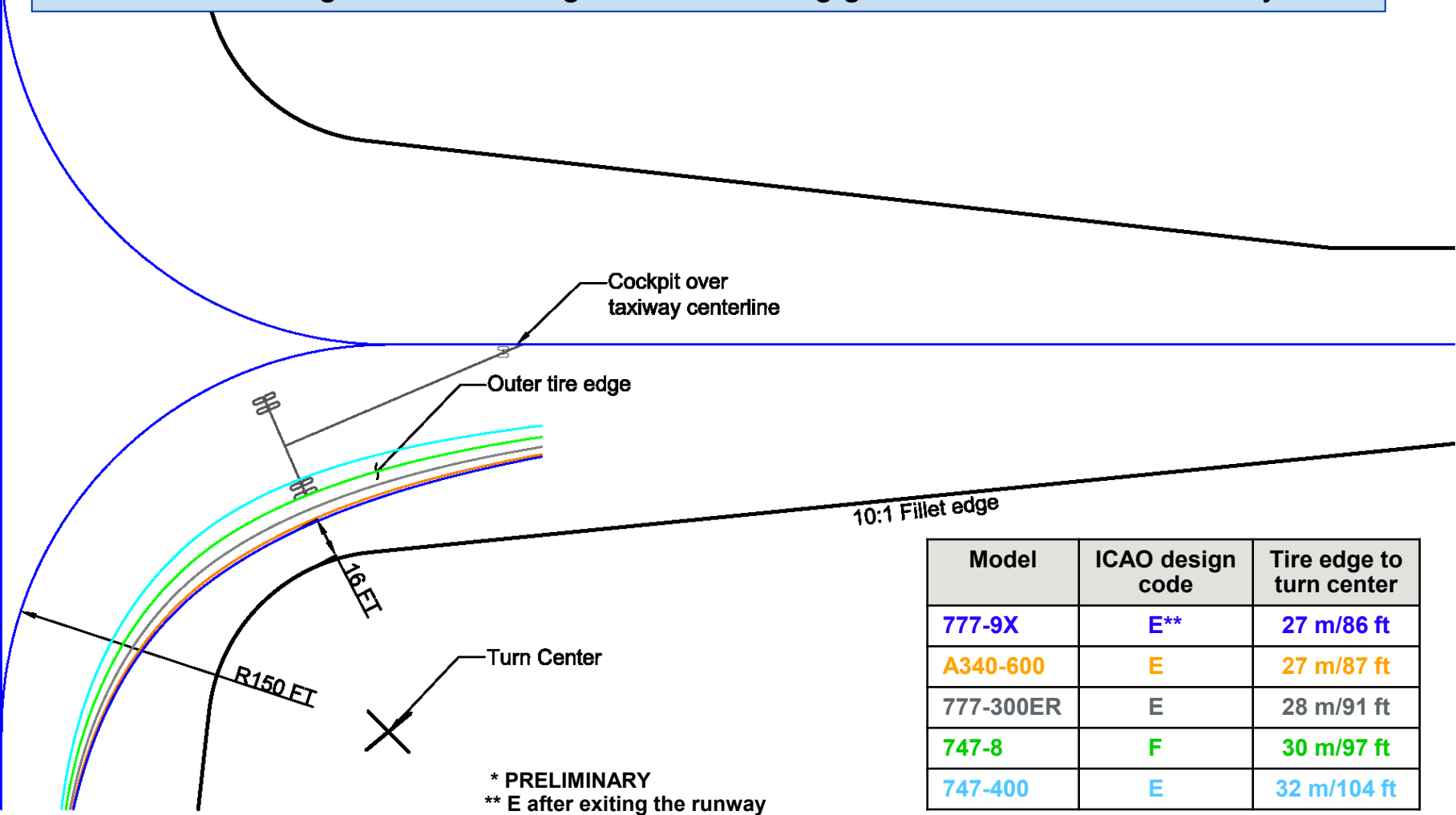
1. 777-9X baseline is PRELIMINARY

2. Original Airbus Calculation – current planning manual value (50.91) includes differential braking and asymmetric thrust

DIMENSIONS ARE PRELIMINARY AND CAN EXPECT TO CHANGE DURING CONFIGURATION DEVELOPMENT

777-9X Fillet Requirement Similar to Today's Large Aircraft

777-9X can maneuver safely on today's fillets using proven over steer techniques included in the flight manual along with the existing ground maneuver camera system



Model	ICAO design code	Tire edge to turn center
777-9X	E**	27 m/86 ft
A340-600	E	27 m/87 ft
777-300ER	E	28 m/91 ft
747-8	F	30 m/97 ft
747-400	E	32 m/104 ft

* PRELIMINARY
 ** E after exiting the runway

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Summary of Completed 777X Airport Visits

777-9X Airports Discussion Status

The list of airports represent those key airports expected to support the first 6-12 months of service



Summary of Completed Airport Visits

- Regarding Folding Wingtip (FWT)

Airports meetings are providing useful feedback



General reaction: Lots of interest and excitement; considered a favorable gate solution

20 second fold/extend time: FWT should not impact capacity

Response: Boeing modeling airport operations with a FWT

Location on airfield to fold/extend:

- Need extend and lock prior to crossing the hold line; some concern over dual runway entrance taxiways

Response: Initial simulator models conclude no impact to runway occupancy when initiating extend at the hold line

- Questioned whether FWT will allow use of today's high-speed exits

Response: Simulator models show no change to operations required

Reliability: more discussion needed on airport procedures for a failure to fold

Response: procedures developed will be similar to those used for similar failures that may cause airport disruption (such as nose gear failure – tow)

Summary of Completed Visits to Airport Regulators

- *Regarding Folding Wingtip (FWT)*

- ICAO and FAA:
 - Agreed that a FWT is a “great idea”
 - Agree that early communication of the FWT concept to airports and their regulators is crucial to supporting EIS
- Next steps:
 - The Boeing Airport Compatibility team will work with ICAO and the FAA to get the FWT included in the relevant design and operational standards documents (ICAO Annex 14 Aerodrome Design and Operations, ICAO Procedures for Air Navigation Services (Pans) – Aerodrome, FAA AC 150/5300-13A, Airport Design)
 - The Boeing Airport Compatibility team will partner with the airlines to engage the airports

Process to Include FWT into Airport Design Documents

- Completed actions:
 - March 2013: verbal conversation with the FAA and ICAO on FWT transition location on the airfield
 - April 2013: Draft DP (Discussion Paper) discussed at the ICAO ADWG (Aerodrome Design Working Group) and AOSWG (Aerodrome Operations and Service Working Group)
- Next steps:
 - Nov 2013: Present formal DP to ADWG and AOSWG
 - 2Q14: ICAO Aerodrome Panel
 - 2Q15: Air Navigation Commission meeting
 - 4Q 16: Update Annex 14 after review by States

777X Airport Compatibility Plan

777X Airport Compatibility Plan

2012				2013				2014				2015				2016				2017				2018				2019			
1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q

Validate FWT Concept
ICAO, FAA, EASA Discussions

Airport/CAA Visits and Analysis
 First 12 Airports
 Second Set of Airports
 Next Set of Airports
 Next Set of Airports
 4 Airport Conc. App
 List of airports and timing TBD

Airport Design Standards
 Initiate request to update Annex 14
 ICAO Aerodrome panel mtg
 Air Navigation Commission mtg
 Review by States
 Update Annex 14

Build Airport Database
 RW-TW, TW-TW, TW-OBJ Separations Database

BACG2
 Gather data, coordinate common agreement document

Airport Compatibility WTG with Airlines
 Develop and prioritize the 777X airport list
 Detailed joint Boeing/Airline/Airport coordination leading to approval to operate 777X

ACAP Airport Planning Manual
 Brochure
 Prelim ACAP
 Final ACAP 6 mo after FT

Summary

777-9X Airport Compatibility Summary

- Airport regulators agree that a FWT is a “great idea”; Airport planners consider the FWT a favorable solution
- The process to get airport design documents updated to reflect a FWT on track
- Discussions with the airports and their regulators are providing useful feedback; infrastructure challenges are being identified early so resolution will be in place by EIS

