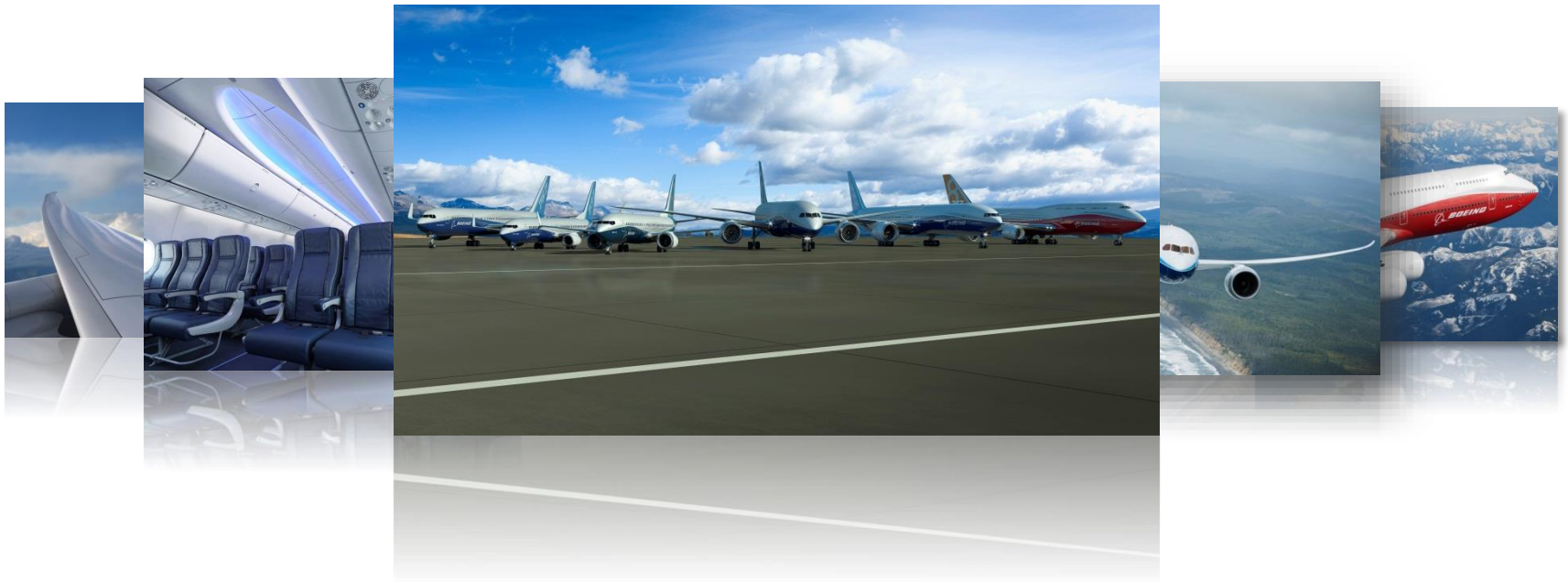


Boeing Airplane Overview

Yonglian Ding, PE

Boeing Airport Compatibility Engineering

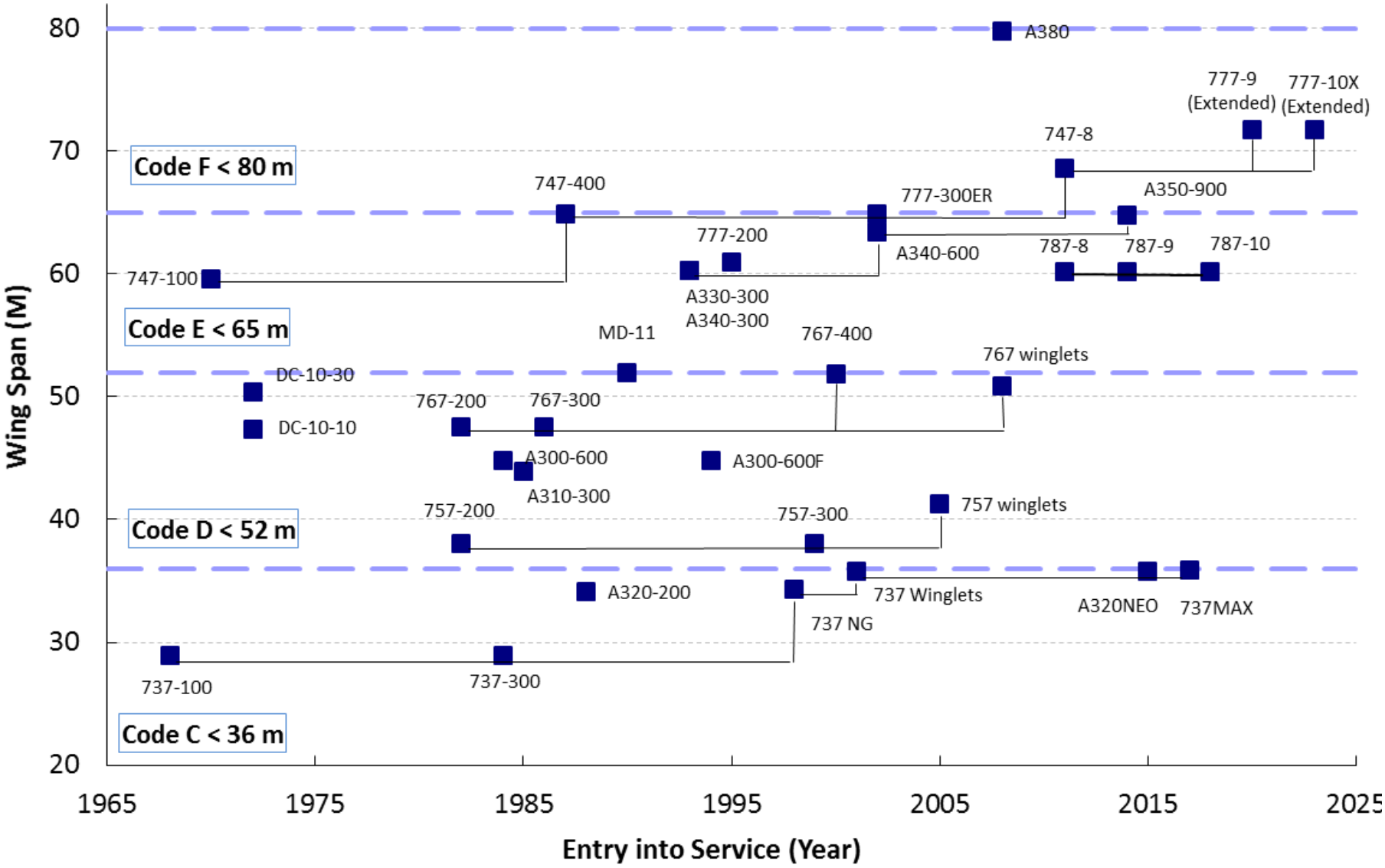
Nov 29, 2016

Agenda

- **Aircraft Growth Trends**
- **Long Term Market - Current Market Outlook (Boeing, 2016-2035)**
- **Boeing Airplane Overview**
  - **B737 MAX**
  - **B787**
  - **B777X**

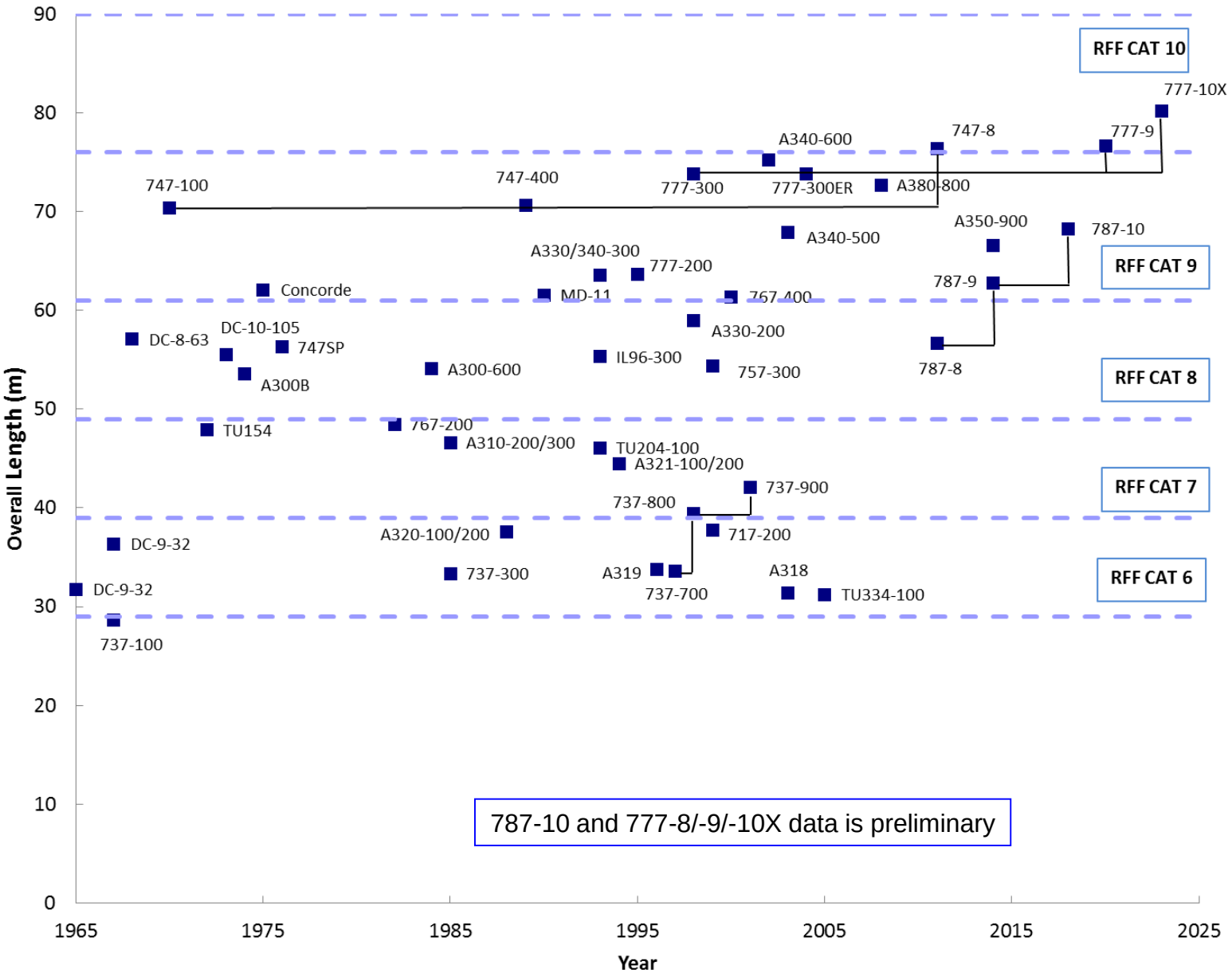
Aircraft Growth Trends

Aircraft Growth Trend
- *Aircraft Wingspan*

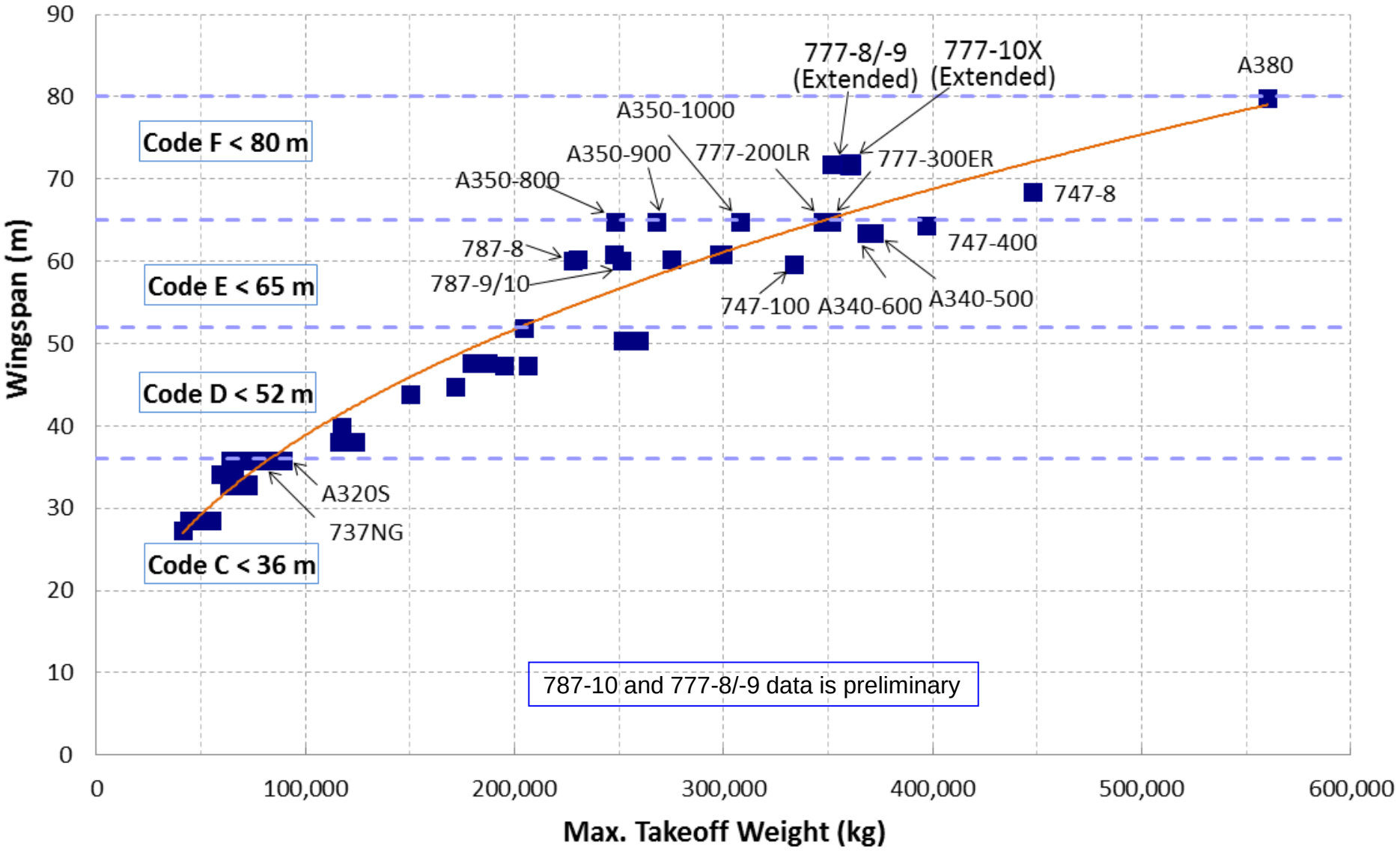


787-10 and 777-8/-9/-10X data is preliminary

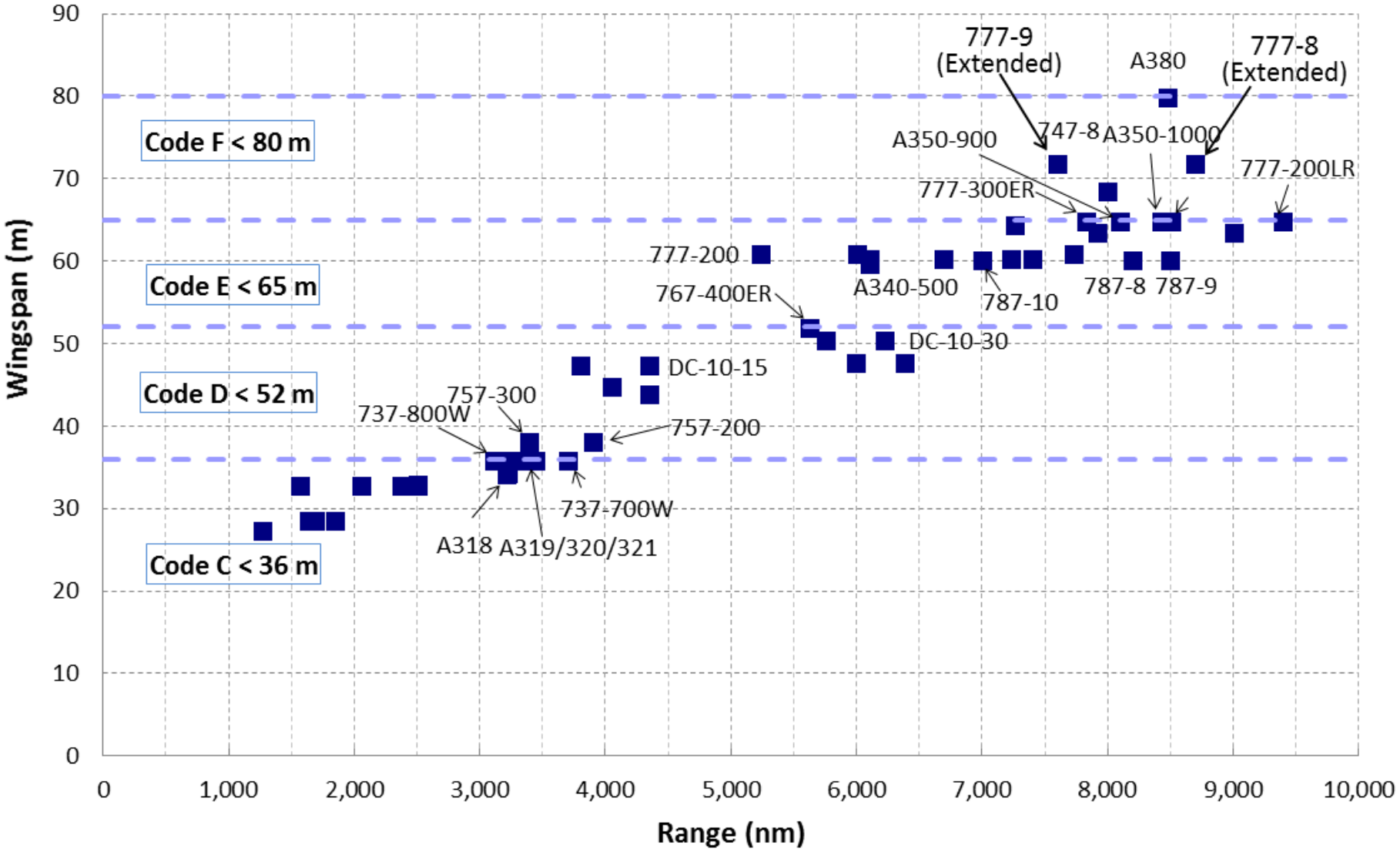
Aircraft Growth Trend
- *Aircraft Overall Length*



Aircraft Growth Trend
- Aircraft Max. Takeoff Weight vs. Wingspan



Aircraft Growth Trend
- Wingspan vs. Range

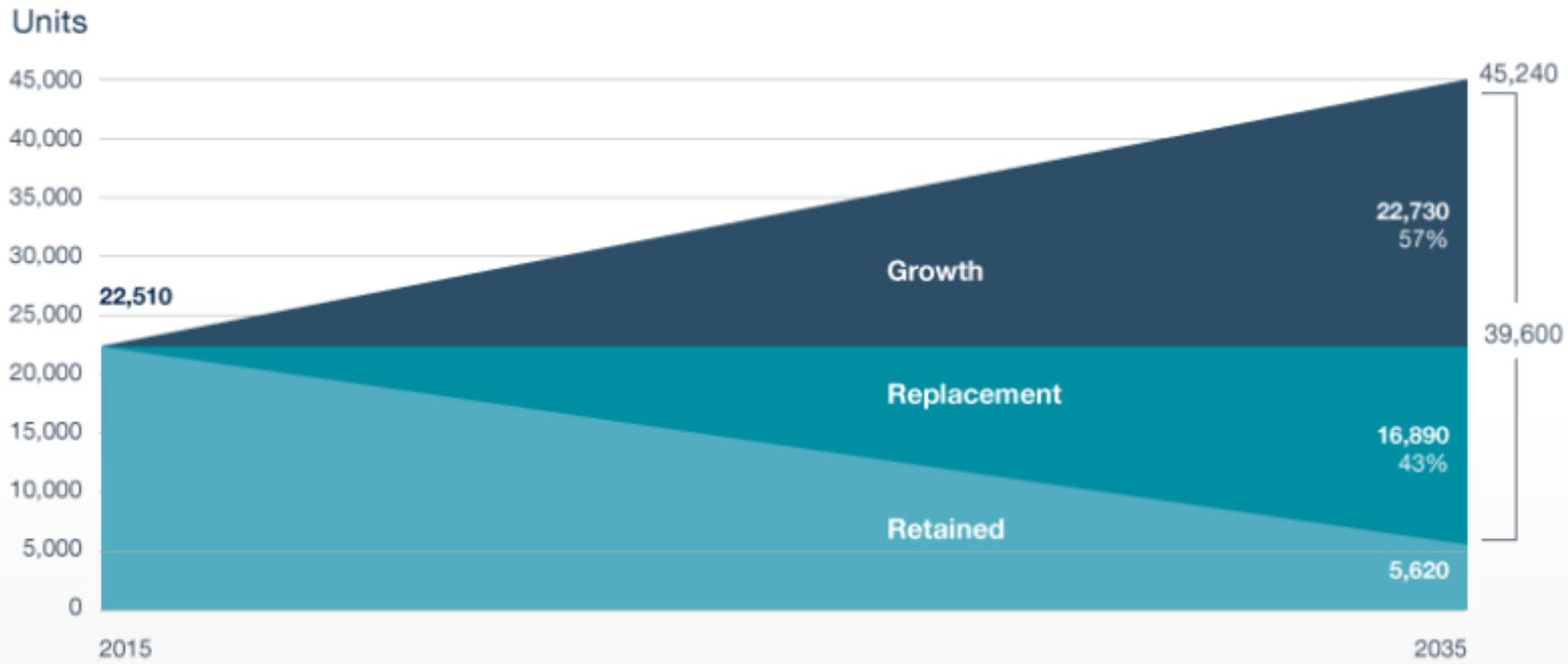


787-10 and 777-8/-9 data is preliminary

Long Term Market
Current Market Outlook
(Boeing, 2016-2035)

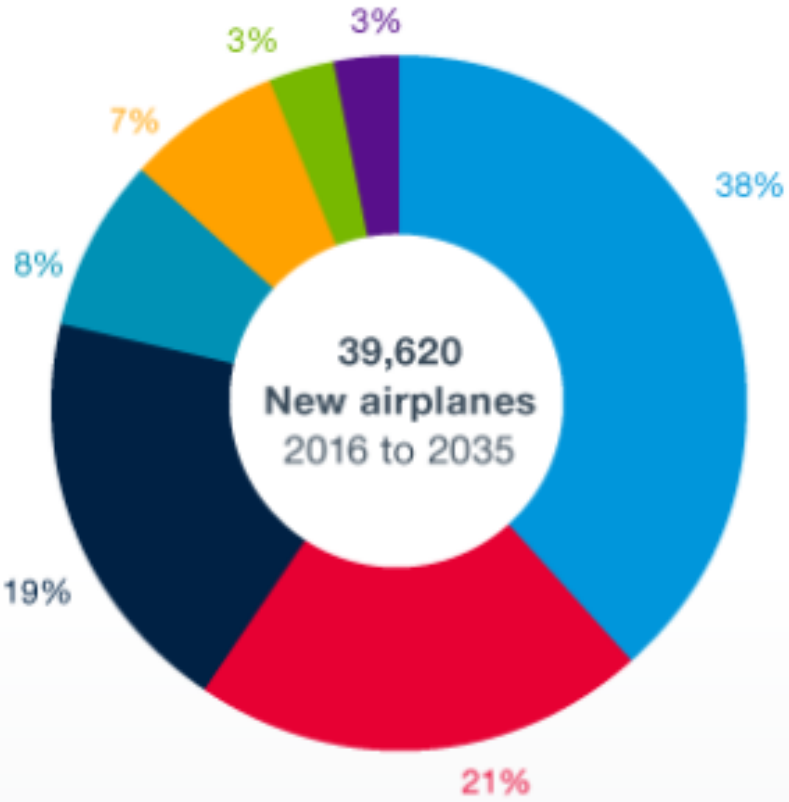
World Fleet

Older, less efficient airplanes will be replaced with more efficient, newer generation airplanes



New Aircraft Deliveries by Region

Delivery demand is diverse



Region	New airplanes
Asia	15,130
North America	8,330
Europe	7,570
Middle East	3,310
Latin America	2,960
Africa	1,150
CIS	1,170
Total	39,620

Latin-America Region

Key indicators and new airplanes

Growth Measures (%)	
Economy (GDP)	2.9
Traffic (RPK)	5.8
Airplane fleet	4.4

	New airplanes	Share by size (%)
Large widebody	--	--
Medium widebody	30	1
Small widebody	260	9
Single aisle	2,530	85
Regional jet	140	5
Total	**2,960**	

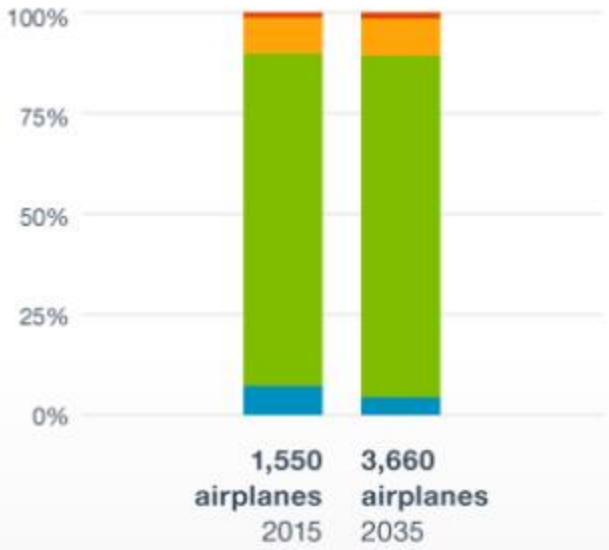
Market size	
Deliveries	2,960
Market value	$350B
Average value	$120M

	2015 fleet	2035 fleet
Large widebody	--	--
Medium widebody	20	40
Small widebody	140	350
Single aisle	1,280	3,110
Regional jet	110	160
Total	**1,550**	**3,660**

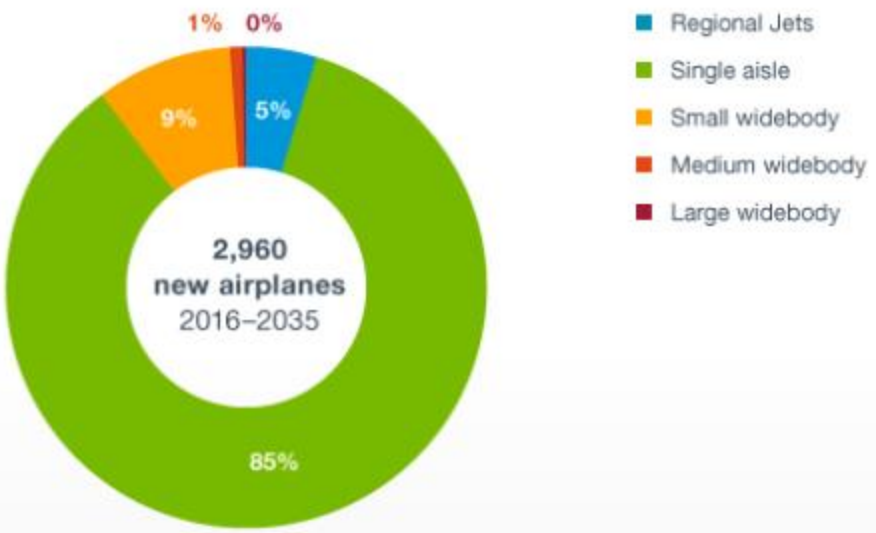
Latin-America Region

Market value: $350 billion

Share of fleet



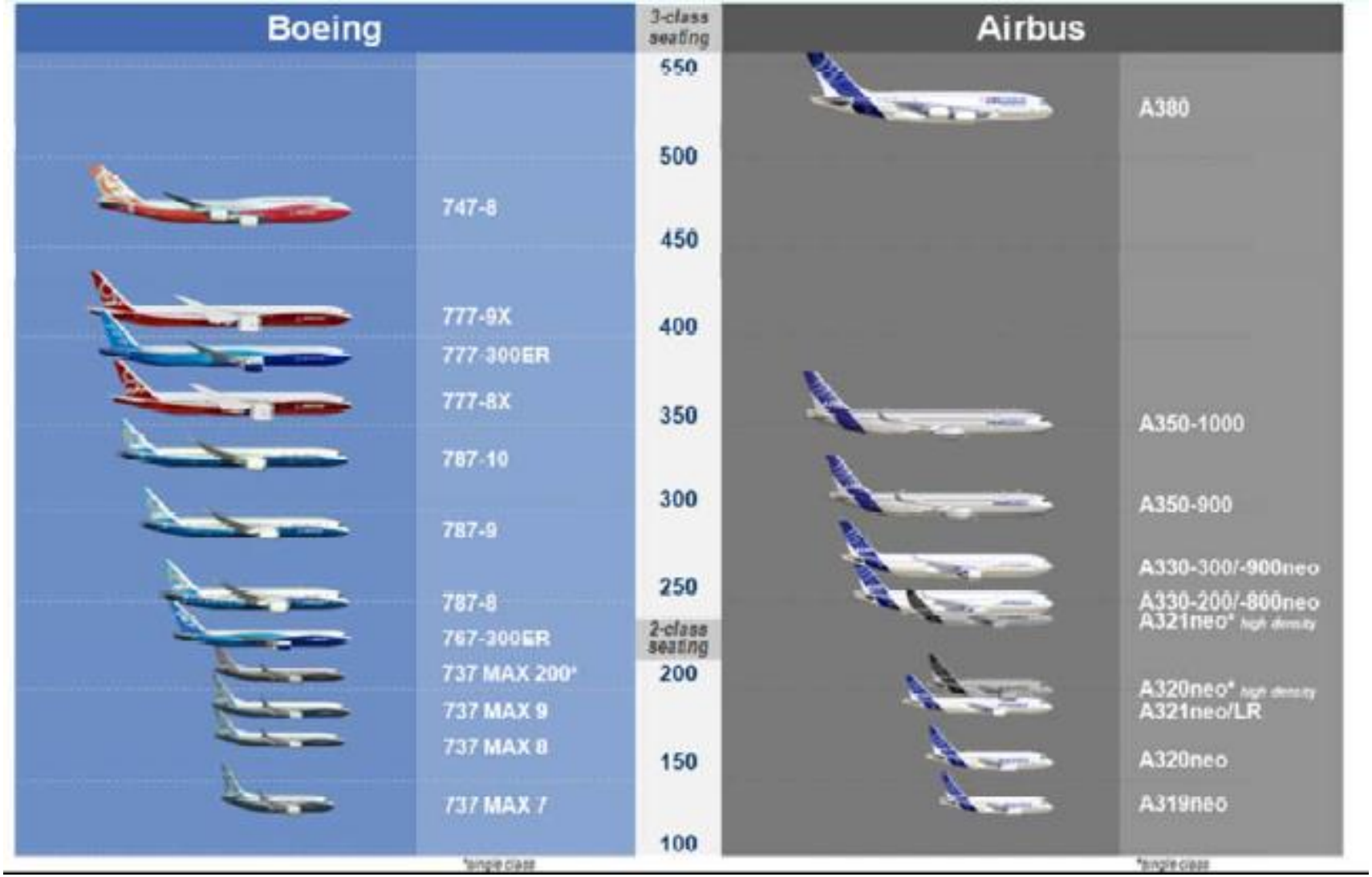
Delivery units



The region's commercial fleet is projected to double between now and 2035, from nearly 1,550 airplanes today to more than 3,600. Latin America will need 2,960 new deliveries over the next 20 years to meet the combined demands of growth and replacement. The majority of these deliveries are expected to be in the single-class segment, reflecting the continued growth of low-cost carriers and further expansion of networks within Latin America and the Caribbean.

- **Boeing Airplane Overview**
  - **B737MAX**
  - **B787**
  - **B777-8/-9/-10X**

Boeing Commercial Product Lineup*



* Ray Conner's presentation slide in Paris Air Show 2015, titled "BCA has most efficient, comprehensive lineup of world-class products"

737 MAX Changes from 737-700/800/900ER

The 737 MAX are derivative aircraft of the 737-700/800/900ER, respectively.

The 737 MAX 8 is scheduled to enter into service in the third quarter of 2017 while 737 MAX 9 and 737 MAX 7 are planned to enter into service in 2018 and 2019, respectively.

Overall Length: **SAME** **(Except MAX 7)**

ICAO RFF Category: **SAME**

Cargo Capacity: **SAME**

Door Locations: **SAME**

ICAO Code Letter: **SAME**

Interior layout: **SAME**

Ground Servicing: **SAME**

Turning (180^{o} turn, fillet): **SAME**

Door Sill Heights: **SIMILAR** (MAX Nose gear is lengthened by 8-in / 20-cm)

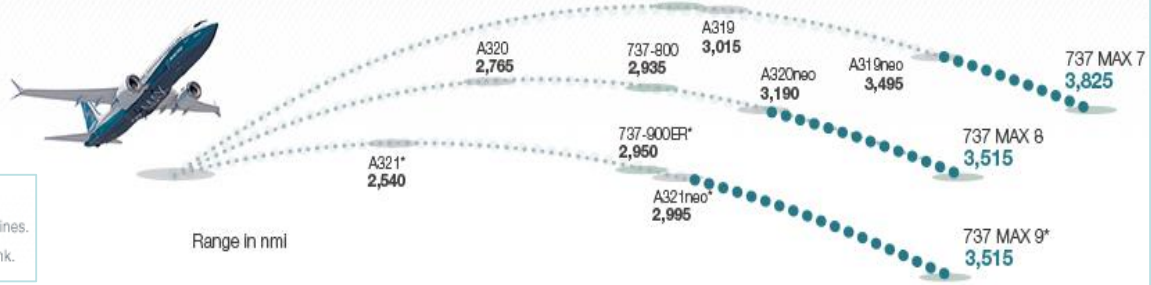
Tires / Tire Pressure: **SIMILAR**

Pavement Loading (ACN): **SIMILAR**

737 MAX Overview

The 737 MAX flies farthest

The Next-Generation 737 has always offered a significant range advantage over the A320. The 737 MAX family continues that advantage over the A320neo family.



Two-class seating
A320 series with CFM engines.
* With one optional aux tank.

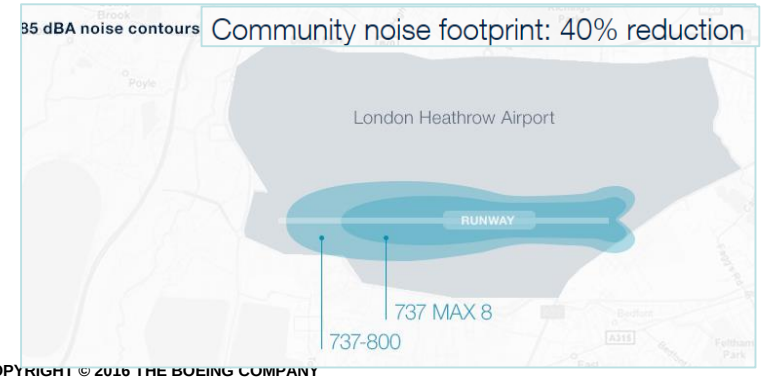
The whole design matters

Less weight

Improved aerodynamics

New LEAP-1B engine

= **8%** LESS FUEL THAN THE COMPETITION



Airlines ask for

An airplane that cuts maintenance expense

Fuel is an airline's biggest operating cost—but not the only one. The 737 MAX is designed to cut maintenance expense. The 737 MAX builds on the continuous improvement of the 737 maintenance cost advantage. The 2015 revision to the Maintenance Planning Document brings airframe cost reductions to all 737s. Compared to 2012 guidelines the MAX will have:

6% lower
airframe maintenance costs

737 MAX General Arrangement

737 MAX 8

35.9 M / 117 ft 10 in
WINGSPAN

39.5 M / 129 ft 8 in
LENGTH

12.3 M / 40 ft 4 in
HEIGHT

184 Passengers
1-Class Configuration

162 Passengers
2-Class Configuration

189 Passengers
Maximum seating

737 MAX 200

35.9 M / 117 ft 10 in
WINGSPAN

39.5 M / 129 ft 8 in
LENGTH

12.3 M / 40 ft 4 in
HEIGHT

200 Passengers
1-Class Configuration

737 MAX 9

35.9 M / 117 ft 10 in
WINGSPAN

42.2 M / 138 ft 4 in
LENGTH

12.3 M / 40 ft 4 in
HEIGHT

204 Passengers
1-Class Configuration

178 Passengers
2-Class Configuration

220 Passengers
Maximum seating

737 MAX 7

HIGH ALTITUDE PACKAGE >

35.9 M / 117 ft 10 in
WINGSPAN

35.6 M / 116 ft 8 in
LENGTH

12.3 M / 40 ft 4 in
HEIGHT

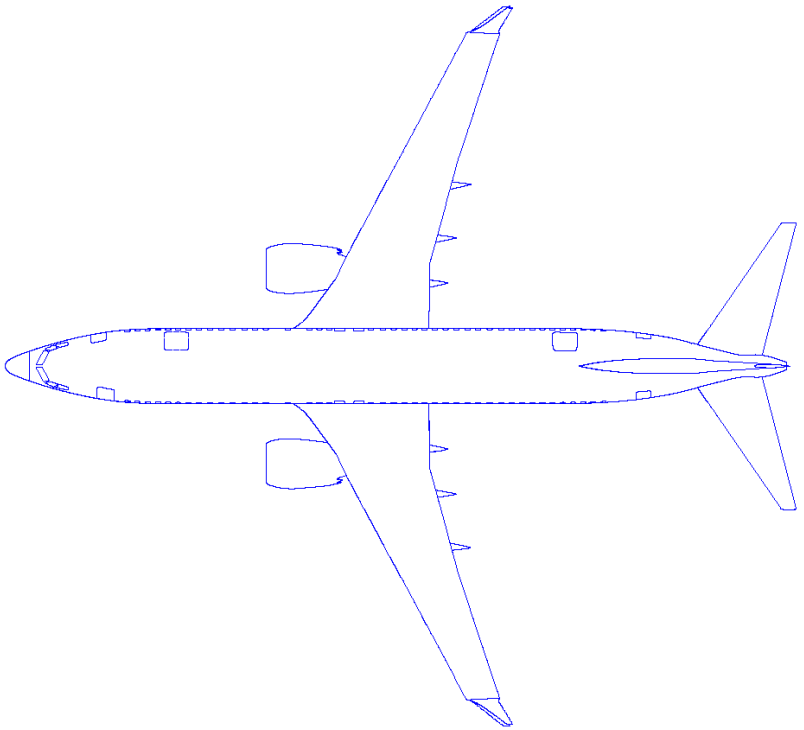
156 Passengers
1-Class Seating

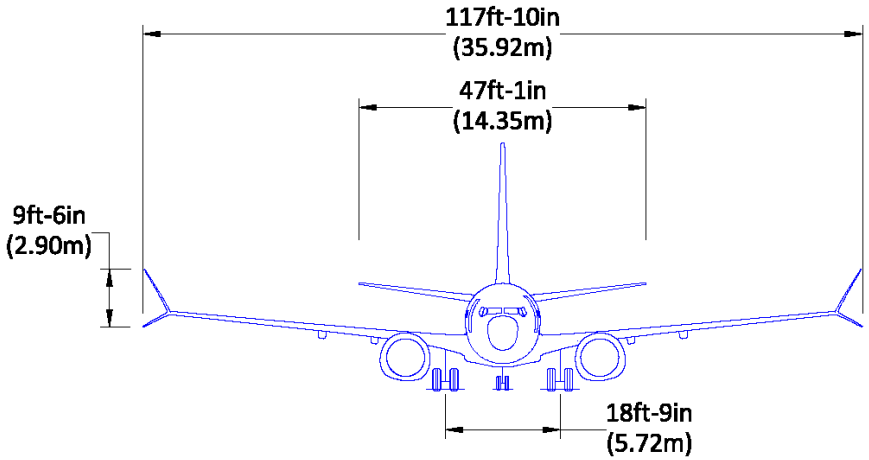
138 Passengers
2-Class Seating

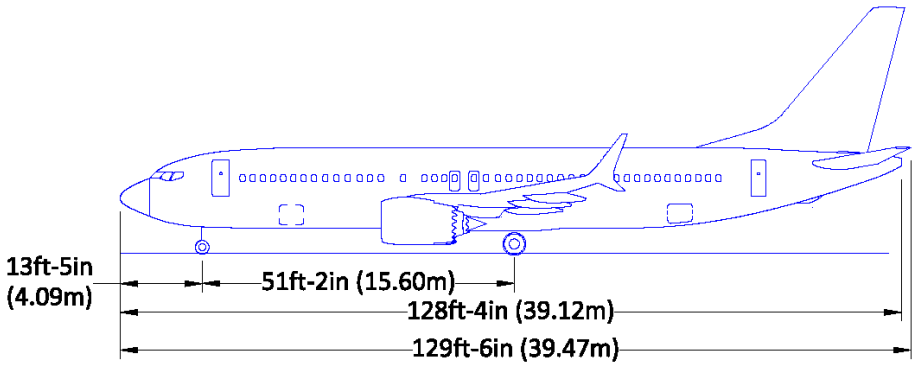
172 Passengers
Maximum Seating

737 MAX 8 General Arrangement

* Static ground line condition, all gears approximately 80% compressed







737 MAX Comparisons with 737NG

	737 MAX 7	737-700 with Winglet	737 MAX 8	737-800 with Winglet	737 MAX 9	737-900ER with Winglet
Wing Span (ft-in/m)	117-10 / 35.9	117-5 / 35.8	117-10 / 35.9	117-5 / 35.8	117-10 / 35.9	117-5 / 35.8
- ICAO Code Letter	C	C	C	C	C	C
- FAA Design Group	III	III	III	III	III	III
Overall Length (ft-in/m)	116-8 / 35.6	110-4 / 33.6	129-6 / 39.5	129-6 / 39.5	138-2 / 42.1	138-2 / 42.1
- ICAO RFF Category	6	6	7	7	7	7
- FAA ARFF Index	B	B	C	C	C	C
Max. Design Taxi Weight (lb/kg)			181,700 / 82,418	174,700 / 79,243	195,200 / 88,541	188,200 / 85,366

- **Boeing Airplane Overview**
  - **B737-7/-8/-9**
  - **B787**
  - **B777-8/-9/-10X**

Broad Market Coverage

1,161 787-8/-9 orders from over 60 customers (142 -8 and 313 -9 deliveries)

- As of September, 2016
- *Leasing operator

787 General Characteristics

The 787-8: A new generation begins

Market Opener. Seasonal & Frequency Right-Sizing. High hot.

Range
7,355 nmi (13,620 km)
Passengers
242 (2-class configuration)
Cargo
4,397 ft3 (124.5 m3)
Length
186 ft (56.69 m)
Height
55 ft 10 in (17 m)

The 787-9: Expanding the family

More seats. More range. Cargo capability.

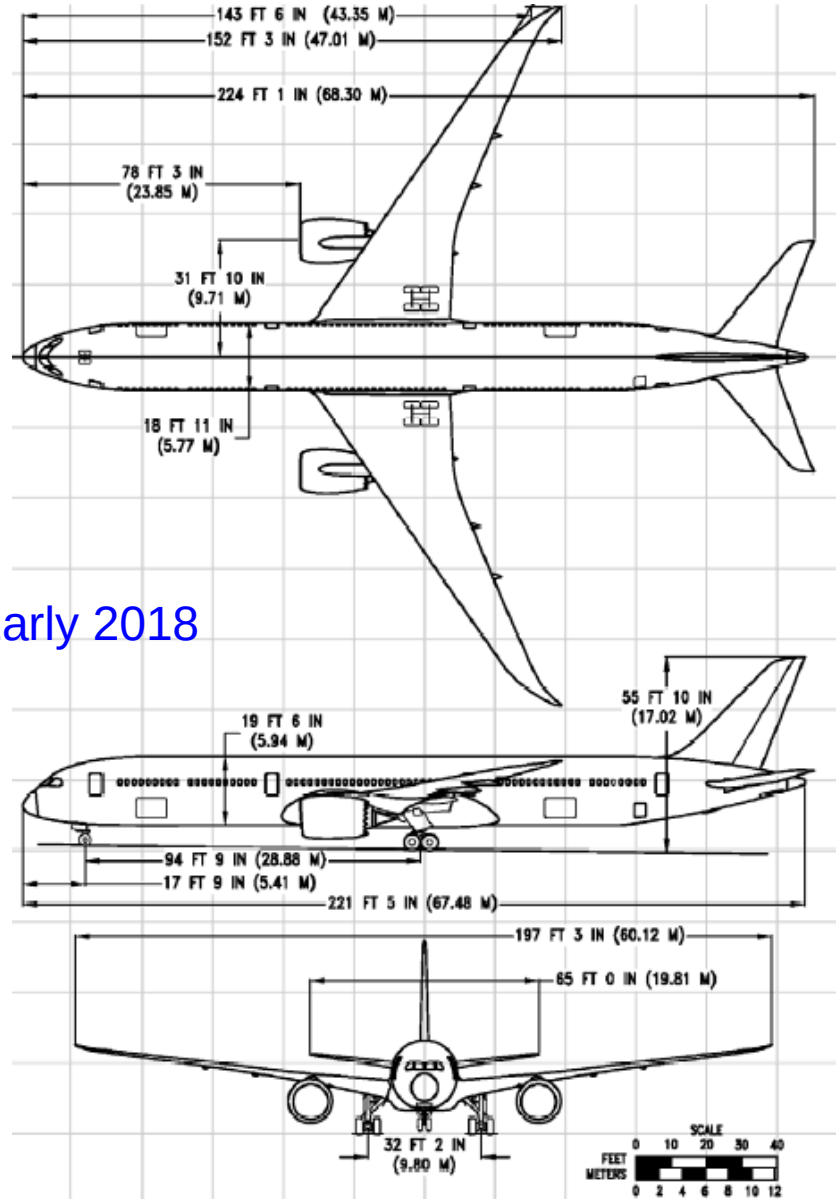
Range
7,635 nmi (14,140 km)
Passengers
290 (2-class configuration)
Cargo
5,452 ft3 (154.4 m3)
Length
206 ft (63 m)
Height
55 ft 10 in (17m)

The 787-10: The efficiency machine

Profitability in core markets. Larger demand markets. Unmatched economics.

Range
6,430 nmi (11,910 km)
Passengers
330 (2-class configuration)
Cargo
6,802 ft3 (192.6 m3)
Length
224 ft (68.27 m)
Height
55 ft 10 in (17 m)

787-10 General Arrangement



Flight Test: Mid 2017
Entry Into Service: Early 2018

787 Airplane Characteristics

CHARACTERISTICS	UNITS	787-8	787-9	787-10
Wing Span	FT/M	197.3 / 60.1	197.3 / 60.1	197.3 / 60.1
ICAO Code Letter		E	E	E
FAA Design Group		V	V	V
Overall Length	FT/M	186.1 / 56.7	206.1 / 62.8	224.1 / 68.3
RFF Category (ICAO)		8	9	9
ARFF Index (FAA)		D	E	E
Max Design Taxi Weight	LB	503,500	561,500	561,500
	KG	228,384	254,692	254,692

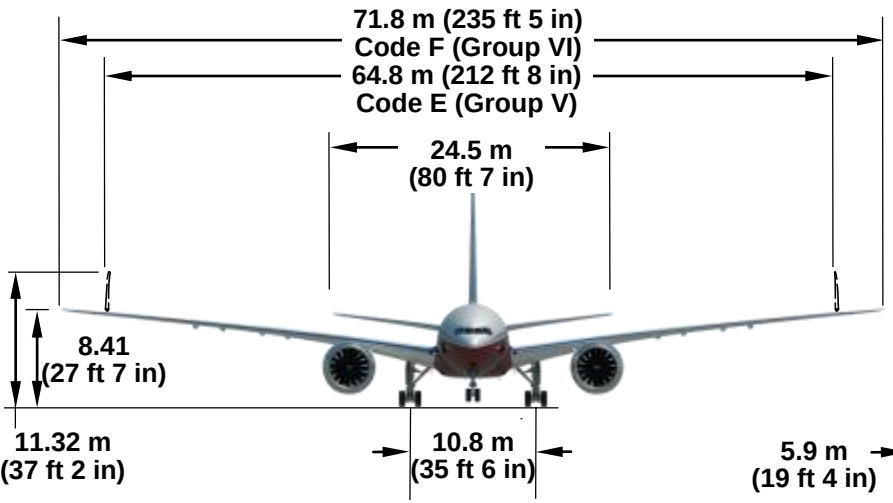
787-10 data is preliminary

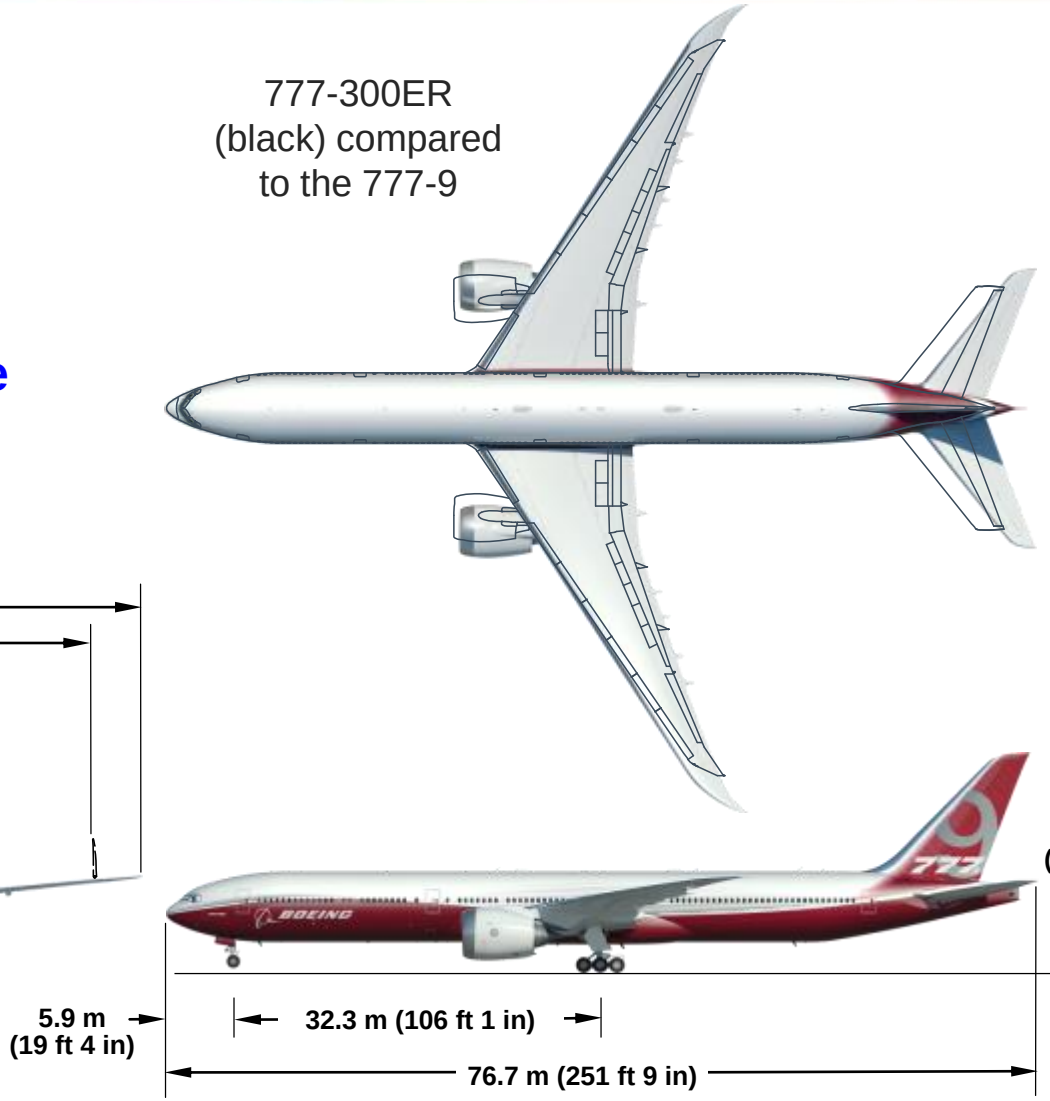
- **Boeing Airplane Overview**
  - **B737MAX**
  - **B787**
  - **B777X**

777-9 general arrangement

777-300ER (black) compared to the 777-9

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





*** Estimate maximum tail height under normal loading conditions**

Dimensions shown are preliminary and may change during configuration development

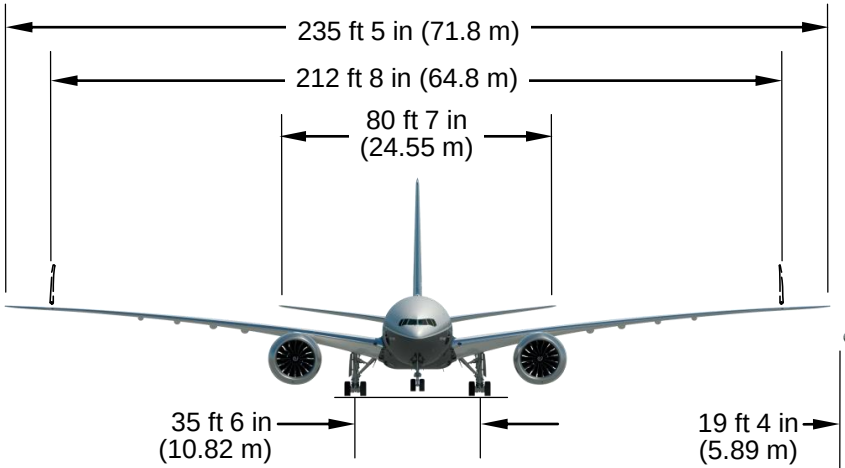
777-9 compared to the 777-300ER

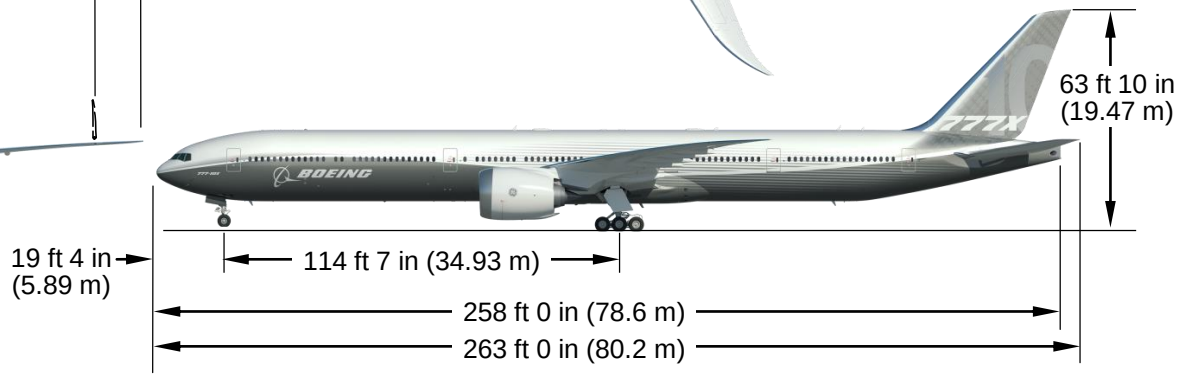
- Compared to the 777-300ER, the 777-9
  - Overall length is 2.9 m (9.4 ft) longer
  - Folded wingspan same, unfolded wingspan is 7 m (22.8 ft) wider
  - Horizontal stabilizer is 3.0 m (9.9 ft) wider
  - Wheelbase is 1.1 m (3.6 ft) longer
  - Distance from the nose to the nose landing gear remains the same
  - Engine to fuselage centerline is 1.0 m (3.3 ft) further outboard
  - Vertical tail max. height is < 1.0 m (< 3.0 ft) higher
  - Main landing gear width is 0.2 m (6 in) narrower

777-10X general arrangement

Product Development Study

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





777-10X compared to the 777-300ER

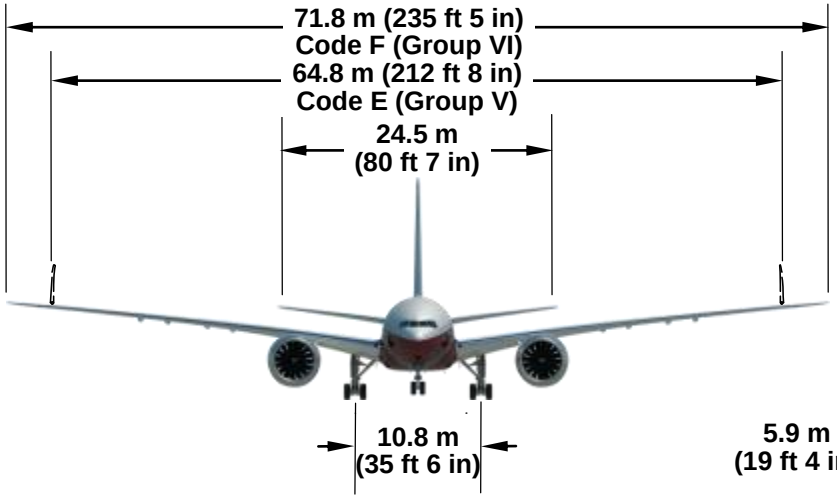
Product Development Study

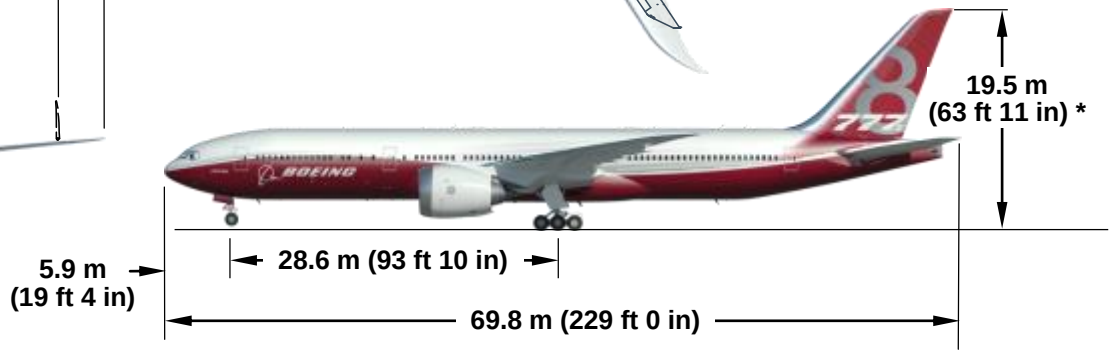
- Compared to the 777-300ER, the 777-10X
  - Overall length is 6.3 m (20.7 ft) longer
  - Folded wingspan same, unfolded wingspan is 7 m (22.8 ft) wider
  - Horizontal stabilizer is 3.0 m (9.9 ft) wider
  - Wheelbase is 3.7 m (12.1 ft) longer
  - Distance from the nose to the nose landing gear remains the same
  - Engine to fuselage centerline is 1.0 m (3.3 ft) further outboard
  - Vertical tail max. height is < 1.0 m (< 3.0 ft) higher
  - Main landing gear width is 0.2 m (6 in) narrower

777-8 general arrangement

777-200LR (black)
compared to the
777-8

The folded wing has the same wingspan as the 777-200LR





*** Static airplane, does not account for changes due to loading**

PDX-CO-0372 R1 1-7-15-CG

777-8/-9/10X at today's airports

Product Development Study

	777-300ER (FT/M)	777-10X (FT/M)	777-9 (FT/M)	777-8 (FT/M)
Wing Span, Wing Tips Extended	N/A	235.4 / 71.8	235.4 / 71.8	235.4 / 71.8
ICAO Code Letter		F	F	F
FAA Design Group		VI	VI	VI
Wing Span, Wing Tips Folded	212.8 / 64.8	212.8 / 64.8	212.8 / 64.8	212.8 / 64.8
ICAO Code Letter	E	E	E	E
FAA Design Group	V	V	V	V
Overall Length	242.5 / 73.9	263 / 80.2	251.8 / 76.7	229.0 / 69.8
RFF Category (ICAO)	9	10	10	9
ARFF Index (FAA)	E	E	E	E

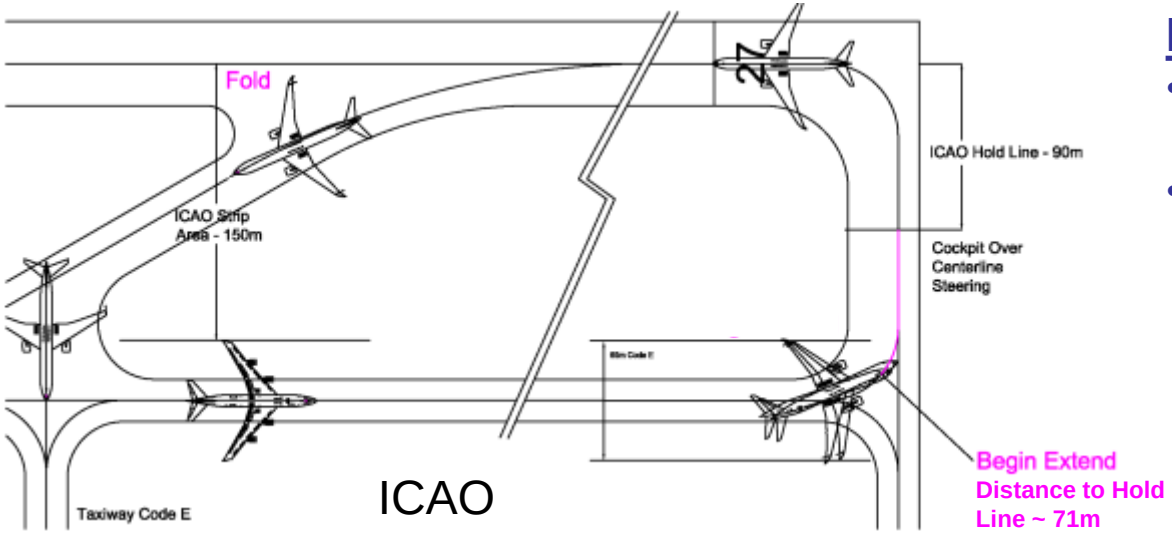
777-8/-9/10X Airport Compatibility

Product Development Study

Key Characteristics

Wingspan • Code F • Airfield minimum separations / parking	**Solution** – Folding Wing Tip (FWT)
Length - Parking	**Solution** – New ICAO wingtip separation standard change (Effective 10 Nov 2016)
Length/wheelbase: • Maneuvering • RFF (Rescue fire fighting) • Runway hold line / obstacle surfaces / NAVIDS critical surfaces (considered together with vertical tail height) Maintenance / De-icing Facilities Pavement loading ETOPS airports	**Solution -** Work with airports worldwide to ensure airports are ready at EIS
45m runway width (Code F aircraft require 60m wide runway)	**Solution –** Seek approval to operate on 45m wide runway (as was done for the 747-8)
FWT Procedures	**Under Development**
Horizontal tail width Jet blast Ramp servicing	**Not expected to be a major issue** – work with airports as needed

Determining where to extend – in work



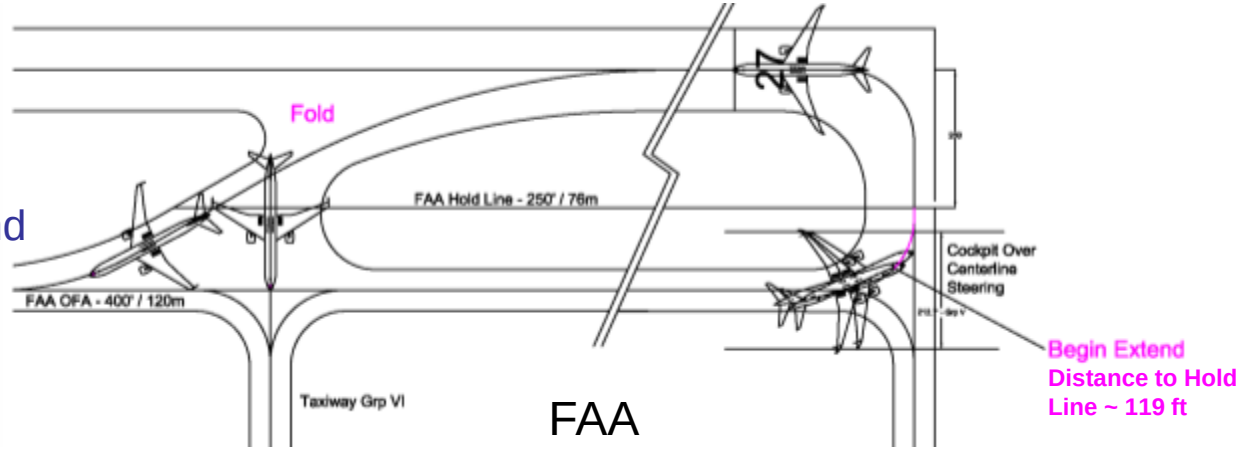
ICAO

Requirements:

- Minimize the potential impacts to airport normal traffic flow
- Minimize impacts to parallel taxiways (Code E vs. Code F)

Next Step:

- Make a case to ICAO / FAA to initiate extend 1000 ft along parallel taxiway prior to RW end

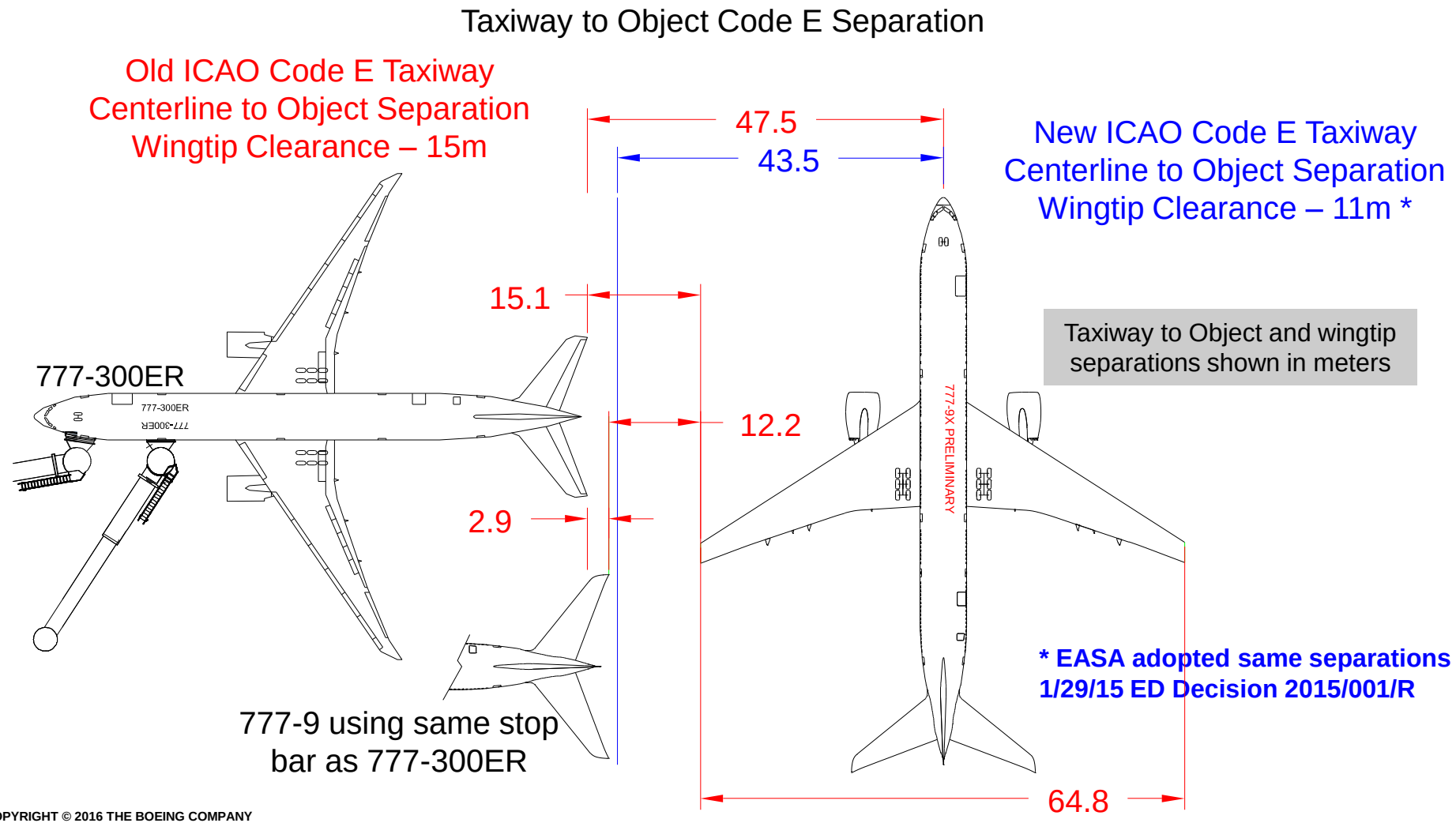


FAA

- Fold/Extend command is linked to electronic checklist and alerting system
- Alerts prior to takeoff and after landing back up normal crew procedure

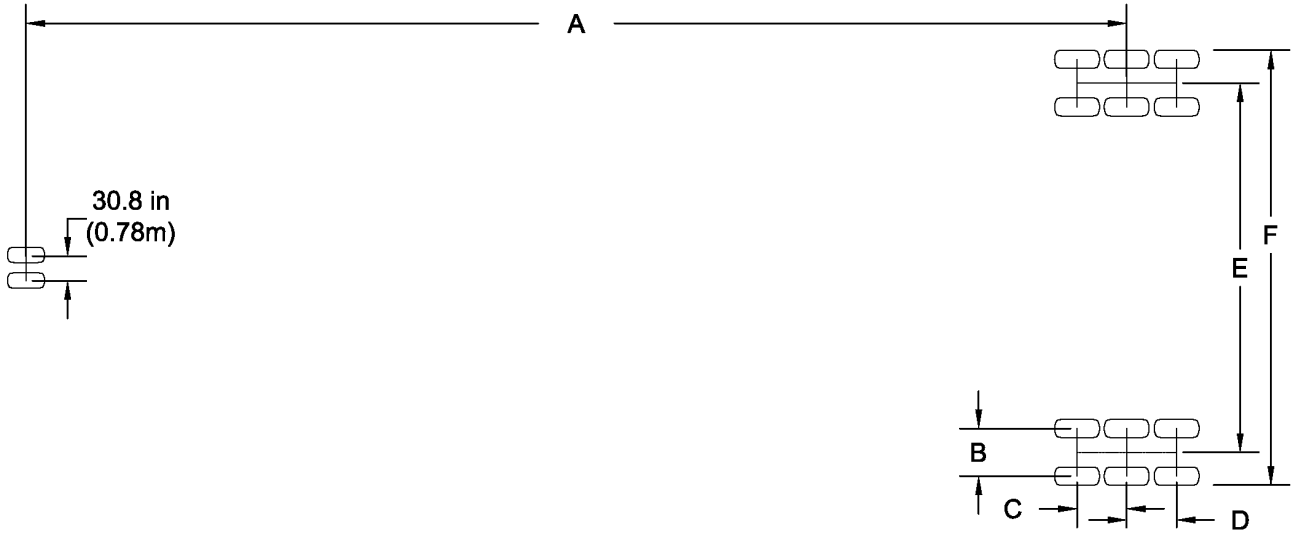
777-9 parking at a 777-300ER gate

- No requirement to down-size adjacent gate with FWT
- ICAO wingtip separation standard change (*effective 10 Nov 2016*) provides relief at gates that do not have service road aft of the parking limit line



777-8/-9/-10X landing gear footprint

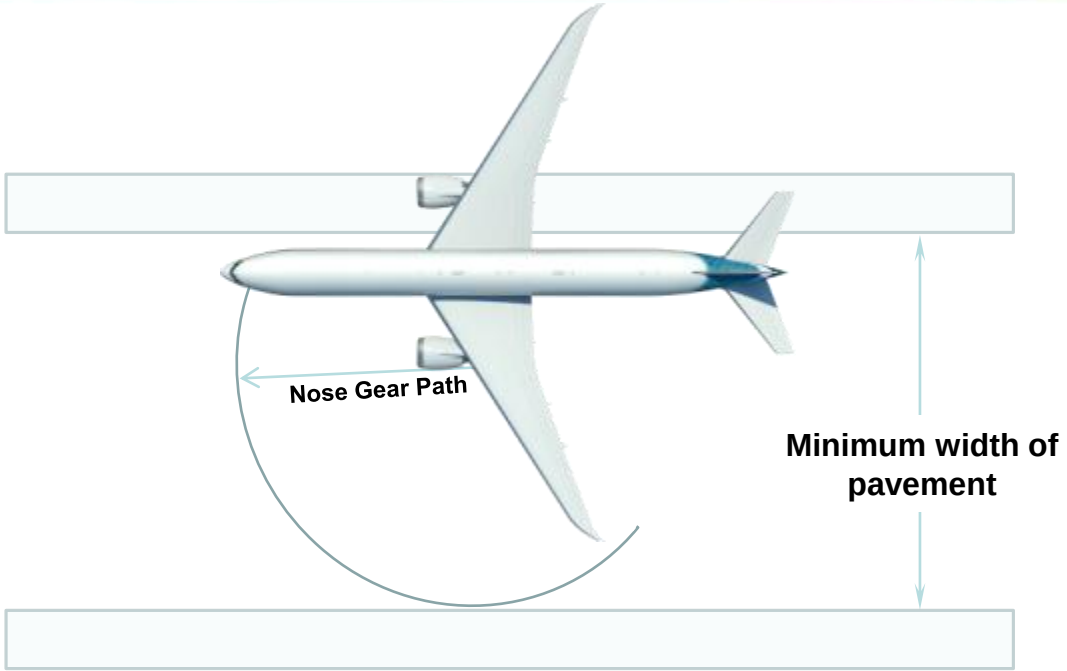
Product Development Study



	UNITS	777-10X	777-9	777-8
Maximum Design Taxi Weight	LB / KG	794,000 / 360,152	777,000 / 352,441	
Nose Gear Tire Size	IN	43 x 17.5 R17 (32PR)		
Nose Gear Tire Pressure	PSI / KG/CM^2	215 / 15.1		
Main Gear Tire Size	IN	52 x 21 R22 (38PR)		
Main Gear Tire Pressure	PSI / KG/CM^2	229 / 16.2		
Wheelbase (A)	FT-IN / M	142-7 / 34.9	106-1 / 32.3	93-10 / 28.6
MLG Truck Width (B)	IN / mm	55 / 140		
MLG Truck Length (C)	IN / mm	57.2 / 145		
MLG Track Length (D)	IN / mm	58.0 / 148		
MLG Maximum Width (E)	FT-IN / M	35-6 / 10.8		
MLG Maximum Tire Edge to Tire Edge width (F)	FT-IN / M	41-10 / 12.8		

777-9/-10X 180º turn capability

Product Development Study



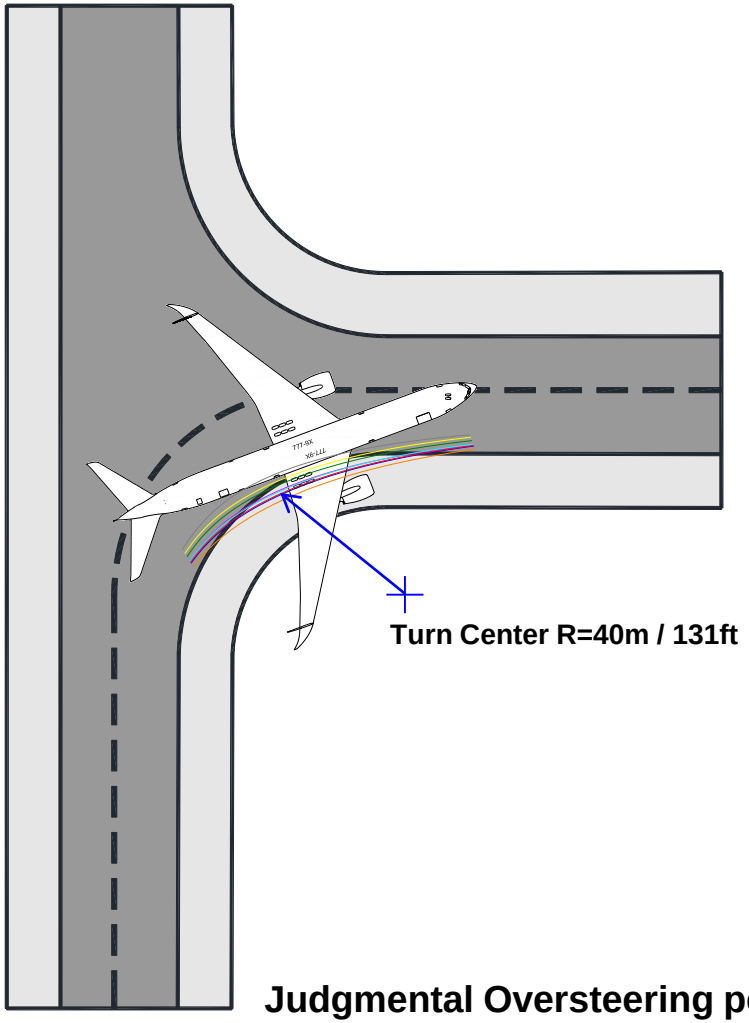
- U-turn width can be reduced by using differential braking and/or asymmetrical thrust
- Minimum widths are calculated based on data from available airport planning manuals – values may vary during operations

	747-400	787-10 [1]	747-8	777-300ER	777-10X [1]	777-9 [1]	A340-600	A380-800 [2]
ICAO Airplane Design Code	E	E	F	E	F/E	F/E	E	F
180º turn width (m) max steering angle [3]	51m	51	52 m	57 m	63 m	59 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, nor differential braking or asymmetrical thrust
4. 777-8 turn width will be less than the 777-300ER

777-9/-10X fillet requirement is similar to 777-300ER

Product Development Study



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

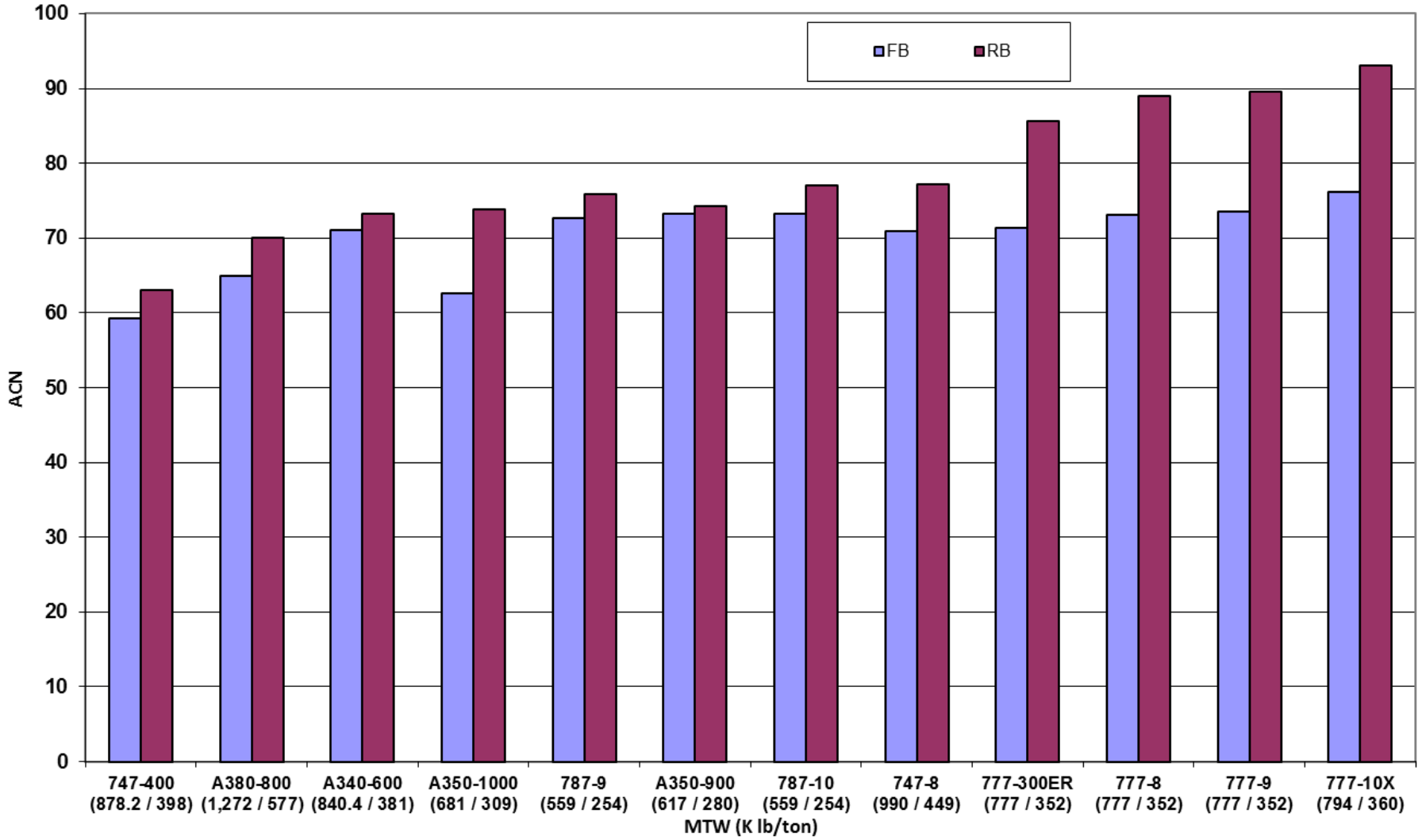
* Preliminary
** Code E after exiting the runway

Judgmental Oversteering permits adequate tire edge clearance on most existing fillets

777-8/-9/-10X Pavement Loading

Product Development Study

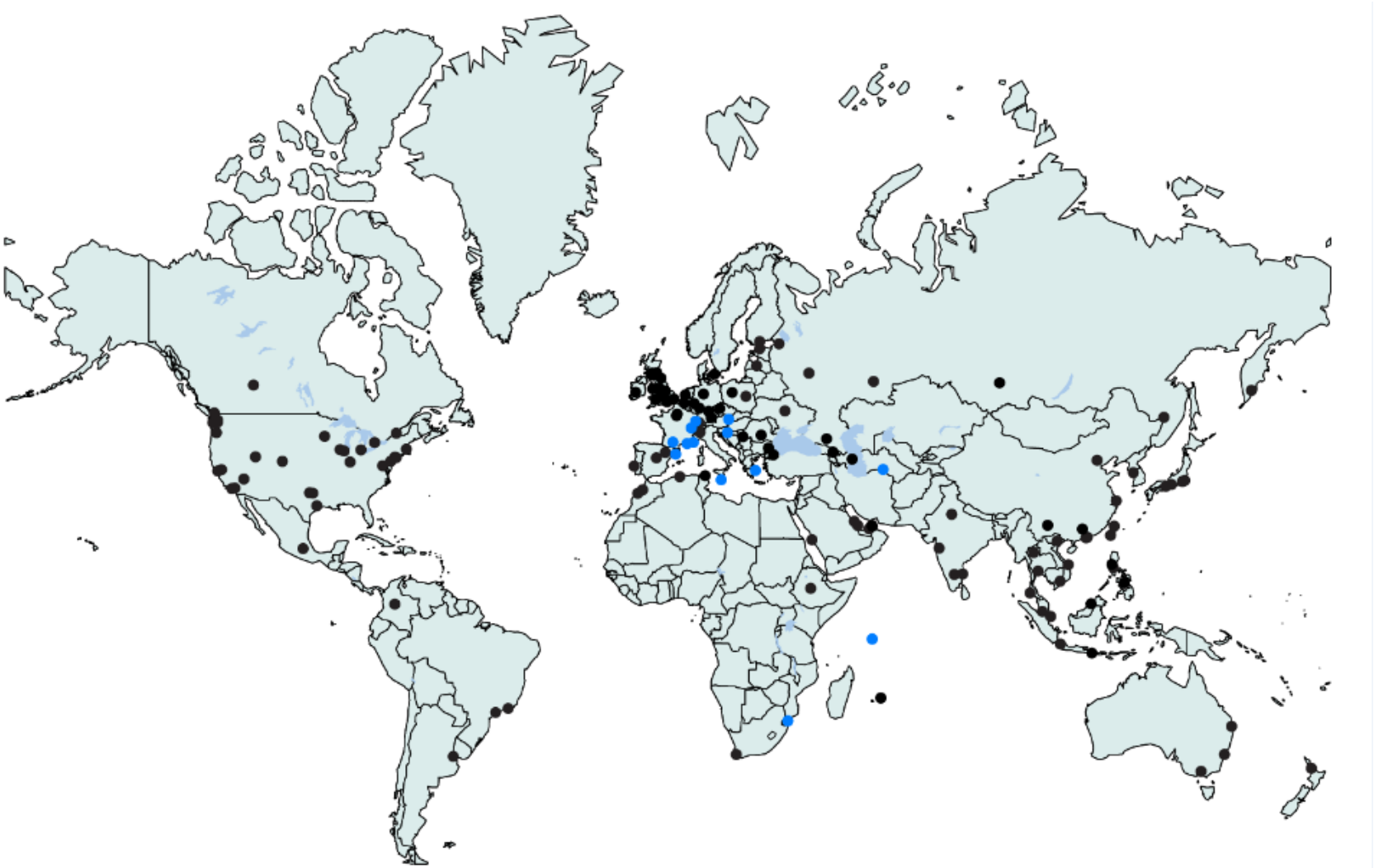
ACN (Aircraft Classification Number) is similar to other wide body aircraft *



* **ACN is preliminary and can be expected to change during design and development**

777-8/-9 airports discussions

150 destination and alternate airports, 32 CAA since 2012



New airports since last report are shown in blue

 777X BPR Map 2016-11-07

BPR 07 November 2016

Summary of 777-8/-9 Airport / CAA Discussions

- **FWT:** Lots of interest and excitement; Code E capability with wings folded is very much appreciated at non-Code F airports
- **Parking:** Folded wing considered a favorable gate solution
- **Maneuvering (fillets, u-turns):** current infrastructure is adequate at many airports
- **Topics requiring further discussion**
  - **FWT:** Fold/extend location and time, dual taxiway runway entrance, reliability and the impact to a process developed for a non-normal configuration FWT
  - **Parking:** Increased length
    Maintainability at a gate to correct a failed wing fold
    Increased Door 2 to Nose distance, and proximity of Door 2 to Engine
    Combination of Jet Bridge Connectivity, Fuel Pit Connectivity
  - **MISC:** ETOPS airports, higher RFF category, de-icing/Anti-icing

777-9/-10X and ICAO RFF (Rescue and Fire Fighting)

Product Development Study

Discussion

- ICAO Annex 14 defines RFF category based on aircraft length and fuselage width
- 777-300ER is RFF Category 9, 777-9 and -10X is Category 10 (same as the 747-8 [length] and the A380 [fuselage diameter])
- ICAO Annex 14 states that in the busiest three consecutive months, when it is expected that the number of Category 10 takeoffs and landings at the airport are less than 700, the airport can adopt RFF Category 9
- ICAO Annex 6 provides the standards and recommended practices (SARPs) for air carrier operations:
  - Remission of two categories for alternates
  - Minimum RFF Cat 4 for ETOPS en-route airports
- Minimum usable amounts of extinguishing agents (volume of water, weight of chemical) higher for Cat 10; no change to required discharge rate or number of vehicles to go from Cat 9 to Cat 10

Airport Design Document Updates

- ICAO ADWG/TF (Aerodrome Design Working Group special task force) is reviewing ANNEX 14 Chapter 3. Items of interest to 777X:
  - The ARC (Aerodrome Reference Code)
  - Runway and runway shoulder width, taxiway and taxiway shoulder width
  - RW strip (which impacts RW-TW separation)
- EASA/TF, similar to the ADWG/TV. In addition to the items above, EASA may review RFF
- ICAO IFPP (Instrument Flight Procedures Panel) CRM (Collision Risk Model): Approved Circular 345, an update to Circular 301 pertaining to Code F aircraft operating in Code E OFZ (Obstacle Free Zone); final English version by end of 2016
- Adding FWT to Annex 14, PANS Aerodromes
- Initiated discussion with the FAA on extending the wingtips while at the end of parallel taxiway, before entering taxiway at runway end

Please visit the Boeing Airport Compatibility Engineering website at:

www.boeing.com/airports

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