

# Aircraft Classifications



**Dr. Antonio Trani and Julio Roa**  
**Department of Civil and Environmental Engineering.**

**Fall 2025**

# Material Presented

- The aircraft and the airport
- Aircraft classifications
- Aircraft characteristics and their relation to airport planning
- Large capacity aircraft impacts

# Relevance of Aircraft Characteristics

- Aircraft classifications are useful in airport engineering work (including terminal gate sizing, apron and taxiway planning, etc.) and in air traffic analyses
- Most of the airport design standards are related to aircraft size (i.e., wingspan, aircraft length, aircraft wheelbase, aircraft seating capacity, etc.)
- Airport fleet compositions vary over time and thus is imperative that we learn how to forecast expected vehicle sizes over long periods of time



# Relevance of Aircraft Classifications in FAA Advisory Circulars



U.S. Department  
of Transportation  
Federal Aviation  
Administration

## Advisory Circular

**Subject:** Critical Aircraft and Regular Use  
Determination

**Date:** 6/20/2017

**AC No:** 150/5000-17

**Initiated By:** APP-400

### FAA AC 150/5000-17

- *“Defines the Critical Aircraft”*
- *“Provides guidance on the use of Critical Aircraft in facility planning and design studies”*



U.S. Department  
of Transportation  
Federal Aviation  
Administration

## Advisory Circular

**Subject:** Airport Design

**Date:** August 16, 2024

**AC No:** 150/5300-13B

**Initiated By:** AAS-100

**Change:** 1

### FAA AC 150/5300-13B

- *“Contains the Federal Aviation Administration’s (FAA) standards and recommendations for airport design”*

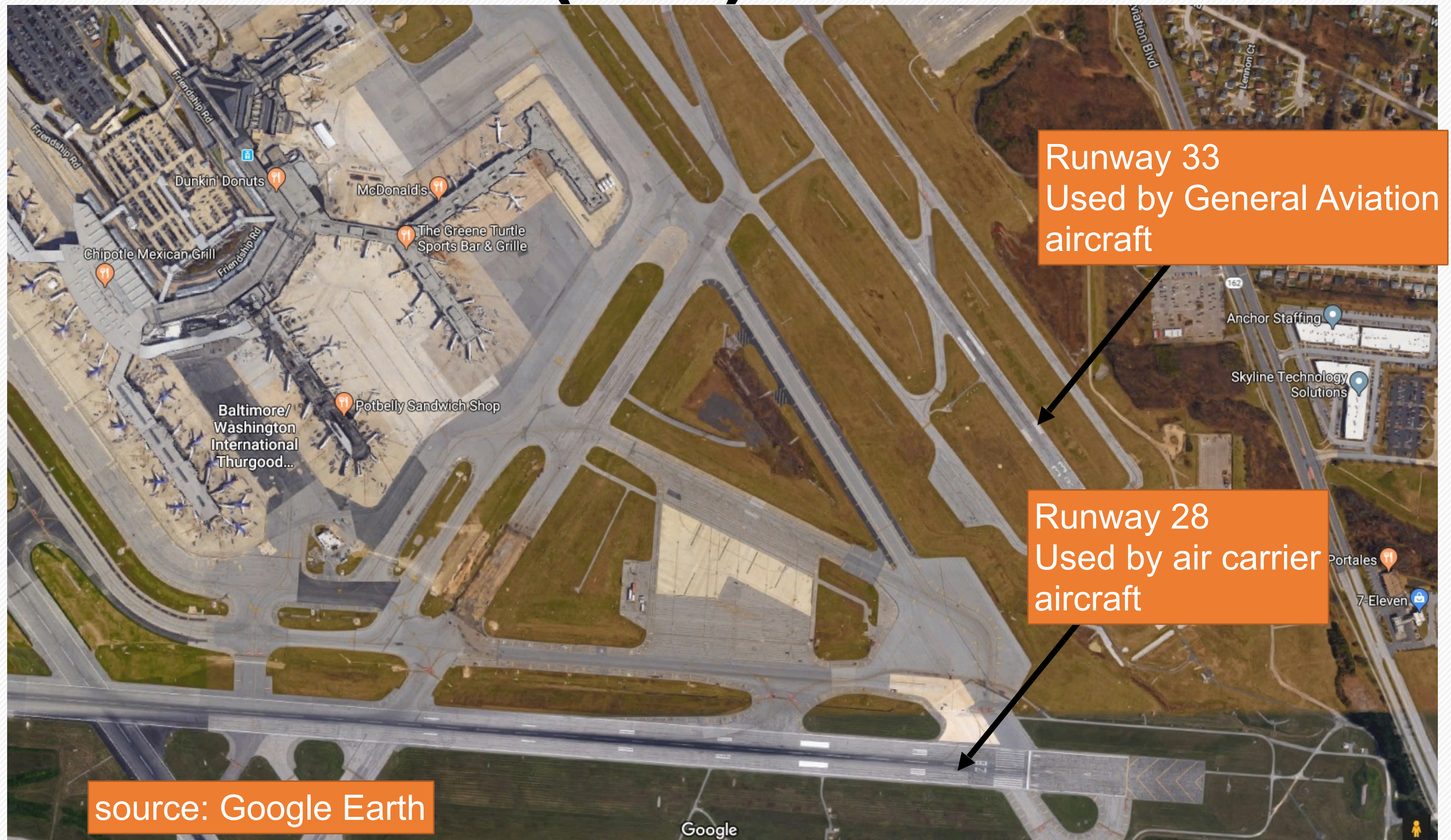


# Different Aircraft can Represent the Critical Aircraft for Separate Elements used in Airport Design

- According to **FAA AC 150/5700-17**:
  - *“Effective planning of an airport may need to consider different and multiple Critical Aircraft”*
  - *Critical Aircraft or grouping of aircraft in the most demanding **Aircraft Approach Category (approach speed)***
  - *Critical Aircraft or grouping of aircraft in the most demanding **Airplane Design Group (ADG)** [wingspan and tail height]*
  - *Critical Aircraft **Runway Design Code (RDC)** – the combination of the most demanding AAC and ADG*
  - *Critical Aircraft or grouping of aircraft for **runway length**.*
  - *Critical Aircraft or grouping of aircraft in the most demanding **Taxiway Design Group (TDG)***
  - *Critical Aircraft for **Engineered Material Arresting Systems (EMAS)**.*



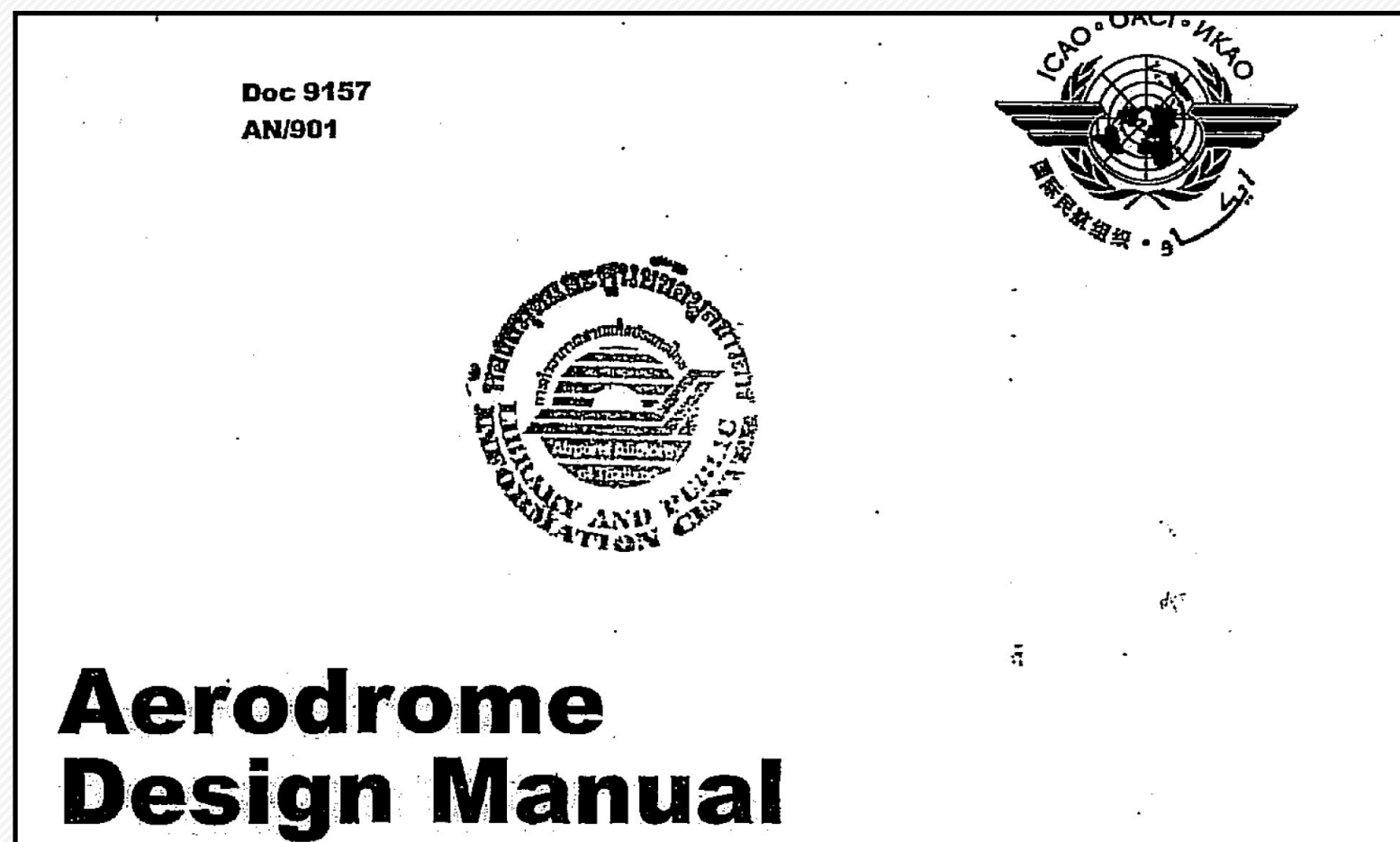
# Example: Baltimore-Washington International (BWI)



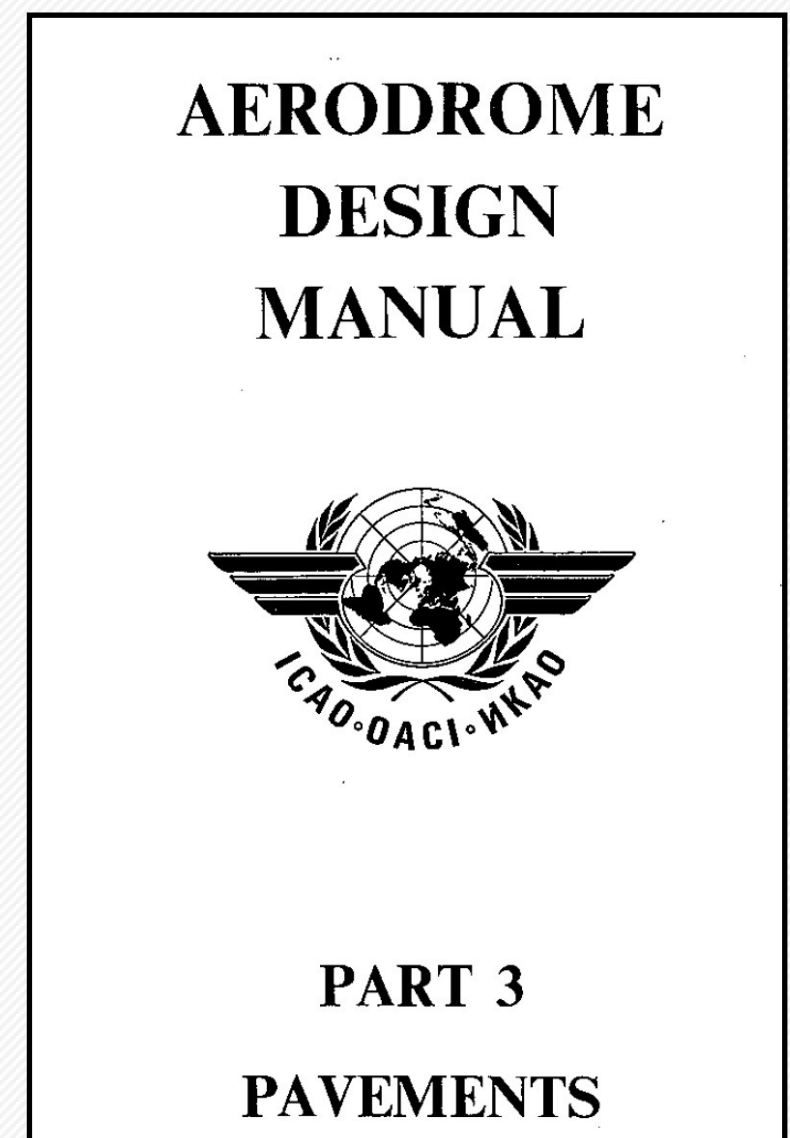


# ICAO - International Civil Aviation Organization

- Provides guidance about airport design in all countries of the World
- FAA design standards and ICAO standards are trending to the same values with time



ICAO Documents 9157 - Aerodrome Design Manual





# ICAO Aerodrome Reference Code

## Code Element 1

ICAO Aerodrome Reference Code used in Airport Design

| Code Number | Aeroplane Reference Field Length<br>(meters) |
|-------------|----------------------------------------------|
| 1           | Less than 800                                |
| 2           | 800 but less than 1200                       |
| 3           | 1200 but less than 1800                      |
| 4           | More than 1800                               |

# ICAO Aerodrome Reference Code

## Code Element 2

ICAO Aerodrome Reference Code used in Airport Geometric Design

| <i>Design Group</i> | <i>Wingspan (m)</i>  | <i>Outer Main Landing Gear Width (m)</i> | <i>Example Aircraft</i>                                                                  |
|---------------------|----------------------|------------------------------------------|------------------------------------------------------------------------------------------|
| <i>A</i>            | <i>&lt; 15</i>       | <i>&lt; 4.5</i>                          | <i>Cessna 172, Cessna 421, Piper PA28, Cessna 510</i>                                    |
| <i>B</i>            | <i>15 to &lt; 24</i> | <i>4.5 to &lt; 6</i>                     | <i>Commuter aircraft, large business jets<br/>(EMB - 120, Saab 2000, Saab 340, etc.)</i> |
| <i>C</i>            | <i>24 to &lt; 36</i> | <i>6 to &lt; 9</i>                       | <i>Boeing 737-700, Boeing 737-800, Boeing 737-8Max, Airbus A320, Airbus A320neo</i>      |
| <i>D</i>            | <i>36 to &lt; 52</i> | <i>9 to &lt; 14</i>                      | <i>Boeing 757-200, Boeing 767-300, Airbus A300-600</i>                                   |
| <i>E</i>            | <i>52 to &lt; 65</i> | <i>9 to &lt; 14</i>                      | <i>Boeing 787-8, Boeing 777-200, Airbus A330-300, Airbus A350-900</i>                    |
| <i>F</i>            | <i>65 to &lt; 80</i> | <i>&gt; 14</i>                           | <i>Airbus A380, Boeing 747-8, Antonov 124, and <b>Antonov 225*</b></i>                   |

\* The only Antonov 225 was destroyed in 2022 near Kyiv



# Federal Aviation Administration Runway Design Code (RDC)

- Combines **three classification criteria** to define the design specifications of each runway of the airport:
  - Aircraft Approach Code (AAC)
  - Aircraft Design Group (ADG)
  - Approach visibility minimums
- **A fourth classification** - called Taxiway Design Group (TDG) is also used in airport design
- The following slides provide some insight about each classification scheme

Note: An airport may have different RDC standards for different runways  
For example, a runway used for air carrier operations may use a higher RDC standard than a runway used for General Aviation Operations

# Federal Aviation Administration Aircraft Design Group (ADG)

| Group # | Tail Height                           | Wingspan                              |
|---------|---------------------------------------|---------------------------------------|
| I       | < 20 ft (< 6.1 m)                     | < 49 ft (< 14.9 m)                    |
| II      | 20 ft to < 30 ft (6.1 m to < 9.1 m)   | 49 ft to < 79 ft (14.9 m to < 24.1 m) |
| III     | 30 ft to < 45 ft (9.1 m to < 13.7 m)  | 79 ft to < 118 ft (24.1 m to < 36 m)  |
| IV      | 45 ft to < 60 ft (13.7 m to < 18.3 m) | 118 ft to < 171 ft (36 m to < 52 m)   |
| V       | 60 ft to < 66 ft (18.3 m to < 20.1 m) | 171 ft to < 214 ft (52 m to < 65 m)   |
| VI      | 66 ft to < 80 ft (20.1 m to < 24.4 m) | 214 ft to < 262 ft (65 m to < 80 m)   |

source: Table 1-2 of FAA AC 150/5300-13B

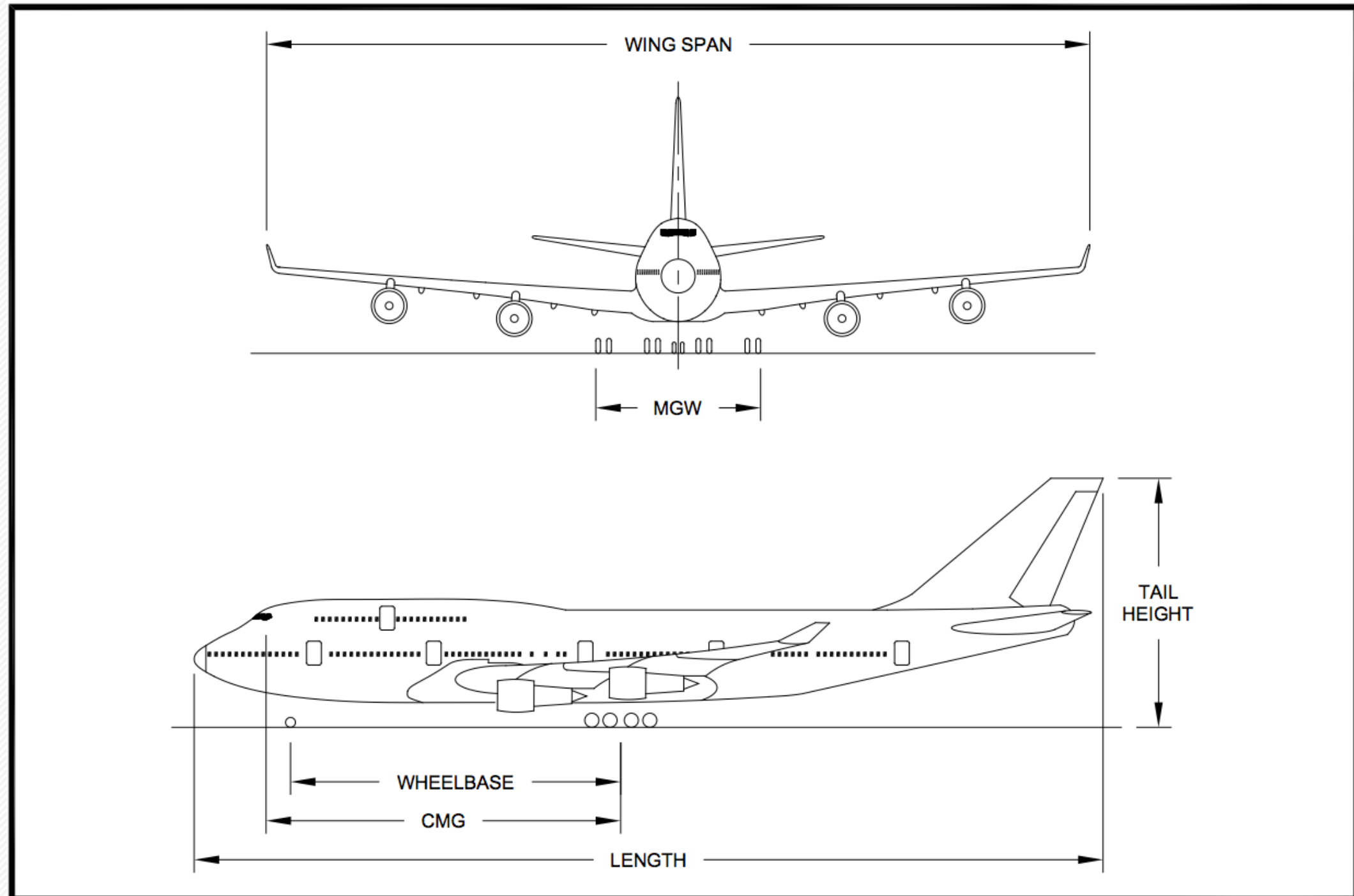
**Note: Use the most critical of the two dimensions to define the ADG group**



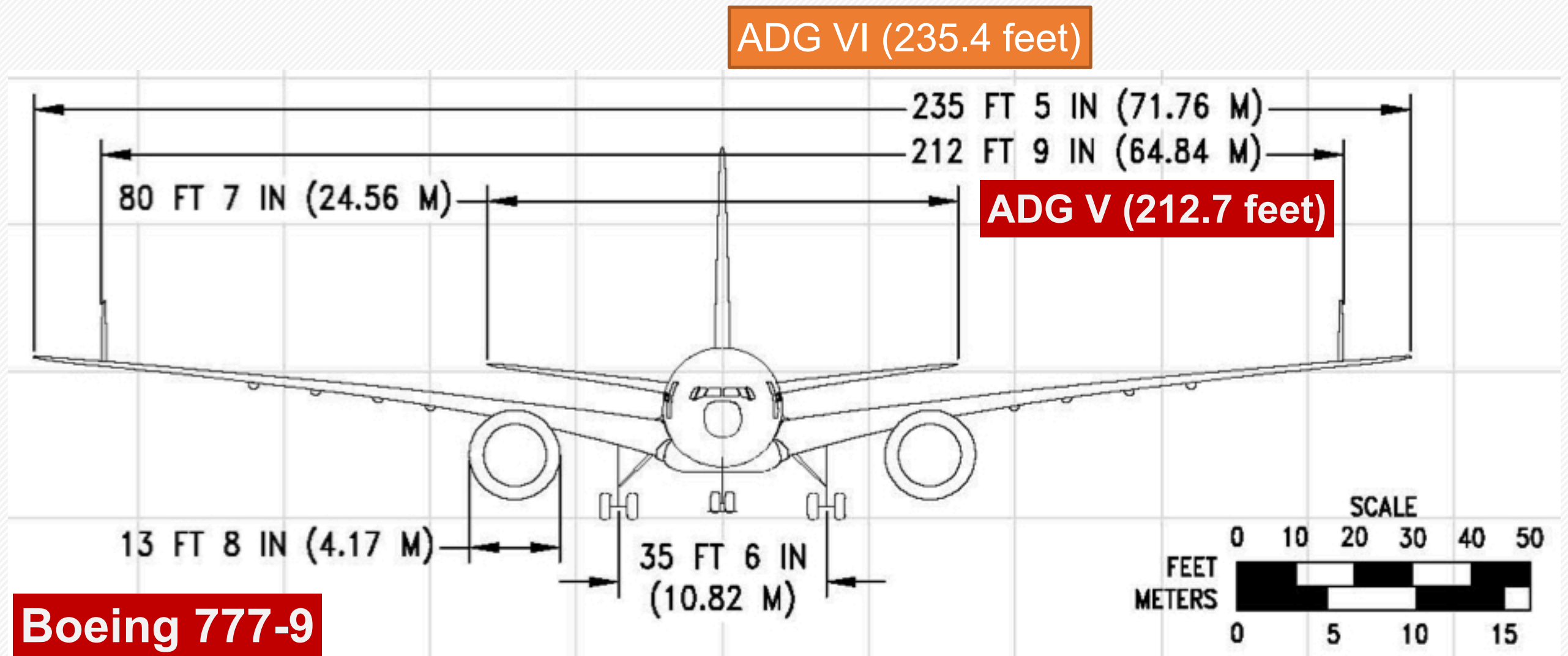
# Federal Aviation Administration Aircraft Design Group (ADG)

| Design Group | Tail Height (feet) | Wingspan (feet) | Representative Aircraft Types                      |
|--------------|--------------------|-----------------|----------------------------------------------------|
| I            | < 20               | < 49            | Cessna 172, Beech 36, Cessna 421, Learjet 35       |
| II           | 20 to < 30         | 49 to < 79      | Beech B300, Cessna 550, Falcon 50, Challenger 605  |
| III          | 30 to < 45         | 79 to < 118     | Boeing 737, Airbus A320, CRJ-900, EMB-190          |
| IV           | 45 to < 60         | 118 to < 171    | Boeing 767, Boeing 757, Airbus A300, Douglas DC-10 |
| V            | 60 to < 66         | 171 to < 214    | Boeing 747, Airbus A340, Boeing 777                |
| VI           | 66 to < 80         | 214 to < 262    | Airbus A380, Boeing 747-8                          |

# Federal Aviation Administration Aircraft Design Group (ADG)



# Aircraft with Folding Wings Fit into two Aircraft Design Groups (ADG)



Aircraft can use existing ADG V gates (ICAO Design Group E)

Source: Boeing Airplane Characteristics for Airport Design  
([https://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/777X\\_RevD.pdf](https://www.boeing.com/resources/boeingdotcom/commercial/airports/acaps/777X_RevD.pdf))



# If an Aircraft Belongs to two ADG Groups, Select the Most Demanding for Design (Except for Aircraft with Folding Wings)

Note: Always use the most critical dimension of the two criteria shown in Table 1-2

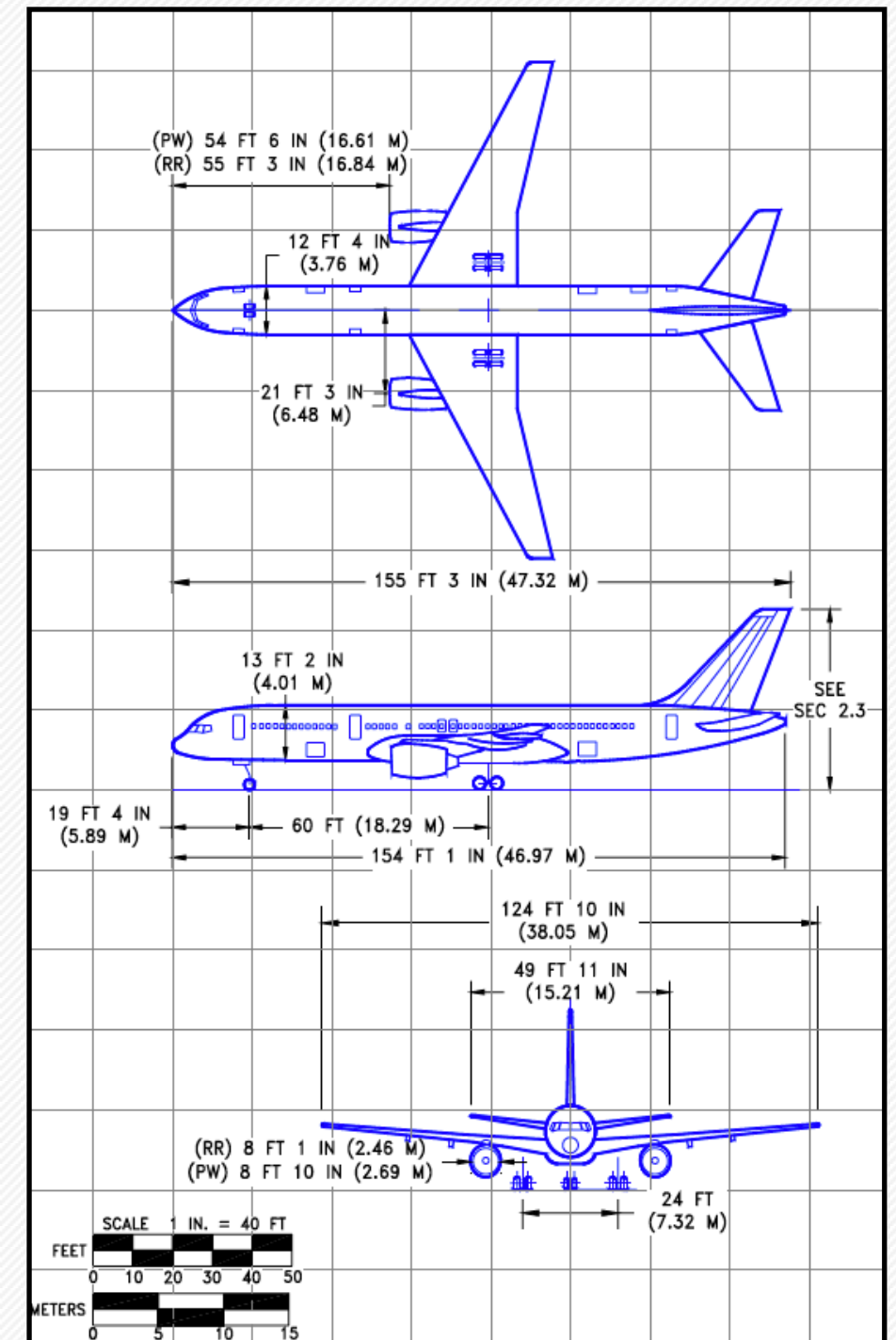
**Example: Boeing 757-200**

Tail height (maximum) = 45.08 feet → ADG IV

Wingspan = 124.83 feet → ADG IV

| Group # | Tail Height                           | Wingspan                                |
|---------|---------------------------------------|-----------------------------------------|
| I       | < 20 ft (< 6.1 m)                     | < 49 ft (< 14.9 m)                      |
| II      | 20 ft to < 30 ft (6.1 m to < 9.1 m)   | 49 ft to < 79 ft (14.9 m to < 24.1 m)   |
| III     | 30 ft to < 45 ft (9.1 m to < 13.7 m)  | 79 ft to < 118 ft (24.1 m to < 36.0 m)  |
| IV      | 45 ft to < 60 ft (13.7 m to < 18.3 m) | 118 ft to < 171 ft (36.0 m to < 52.1 m) |
| V       | 60 ft to < 66 ft (18.3 m to < 20.1 m) | 171 ft to < 214 ft (52.1 m to < 65.2 m) |
| VI      | 66 ft to < 80 ft (20.1 m to < 24.4 m) | 214 ft to < 262 ft (65.2 m to < 79.9 m) |

source: Table 1-2 of FAA AC 150/5300-13B



source: Boeing

# FAA Aircraft Approach Speed Classification (AAC)

source: Table 1-1 of FAA AC 150/5300-13B

| AAC | $V_{REF}$ /Approach Speed                                |
|-----|----------------------------------------------------------|
| A   | Approach speed less than 91 knots                        |
| B   | Approach speed 91 knots or more but less than 121 knots  |
| C   | Approach speed 121 knots or more but less than 141 knots |
| D   | Approach speed 141 knots or more but less than 166 knots |
| E   | Approach speed 166 knots or more                         |

- Approach speeds at maximum landing weight
- See the FAA Aircraft Characteristics Database for a complete listing of aircraft approach speeds

Knot is the unit of speed used in aviation

1 knot = 1.15 miles per hour (statute miles per hour)

**Example:** A Boeing 737-800 has an approach speed of 142 knots or equivalent to 163 miles per hour

# FAA Aircraft Approach Speed Classification (AAC)

| AAC | $V_{REF}$ /Approach Speed                                |
|-----|----------------------------------------------------------|
| A   | Approach speed less than 91 knots                        |
| B   | Approach speed 91 knots or more but less than 121 knots  |
| C   | Approach speed 121 knots or more but less than 141 knots |
| D   | Approach speed 141 knots or more but less than 166 knots |
| E   | Approach speed 166 knots or more                         |

source: Table 1-1 of FAA AC 150/5300-13B

- Aircraft approach speeds are taken at **maximum allowable landing weight**
- For the same aircraft, **approach speeds vary with landing weight**
- For typical commercial aircraft, approach speeds can vary as much as 15-35 knots between maximum landing weight and operating empty weight



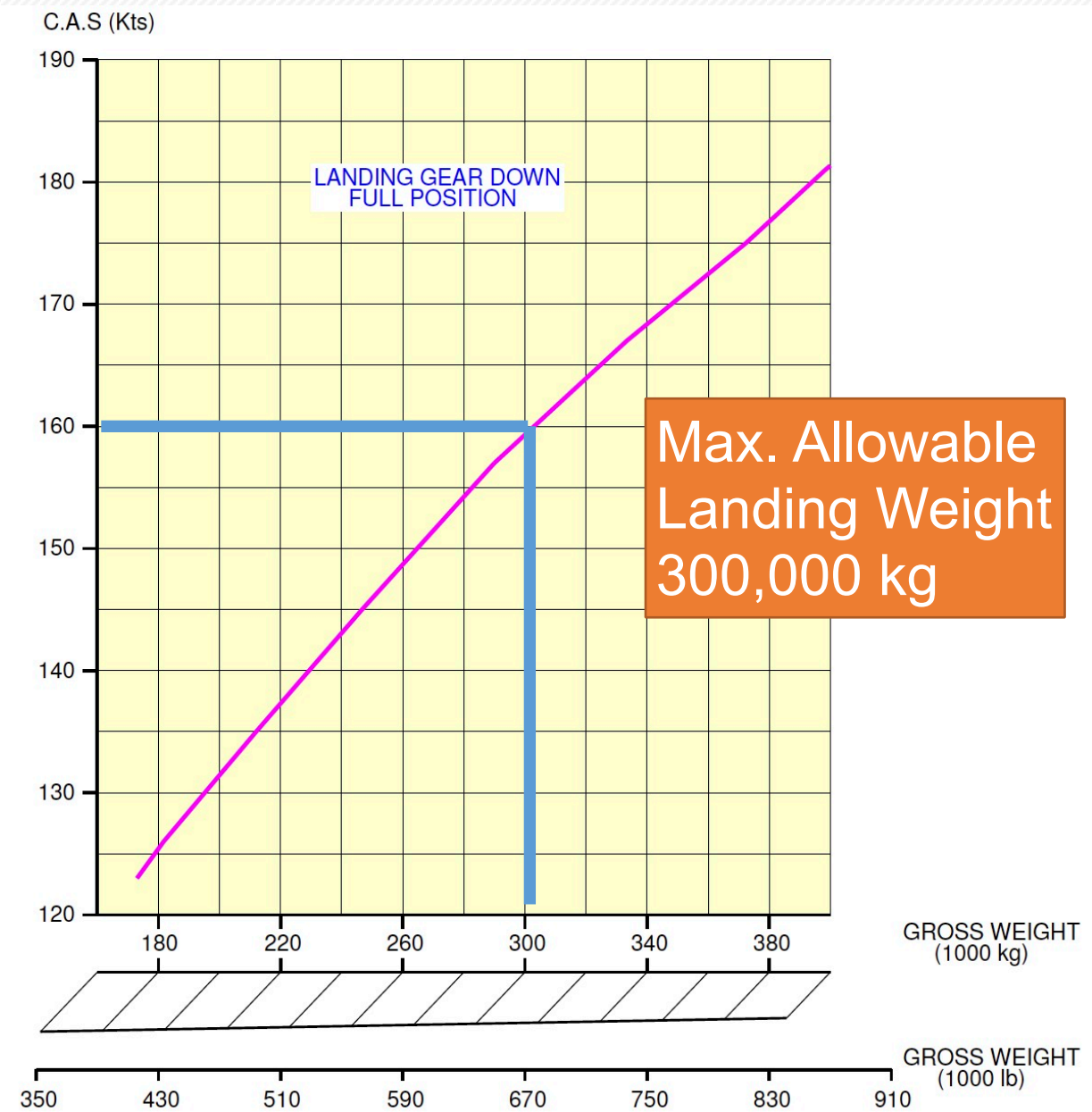
# Example of Aircraft Approach Speed Variations

- Consider the Airbus A340-500 - a long-range aircraft



- Approach speed at 180,000 kg landing weight ~ 125 knots
- Approach speed at 300,000 kg landing weight (maximum allowable landing mass) ~ 160 knots

Approach Speed (knots)



source: Airbus A340-500 Airplane Characteristics for Airport Planning

# Aircraft Characteristics Database

Aircraft characteristics database - sorted by aircraft manufacturer model

| Manufacturer | Aircraft            | AAC | ADG | TDG | Wing-span | Tail Height | Length  | CMG     | Wheel-base | MGW<br>Outer to<br>Outer | MTOW     | V <sub>REF</sub> /<br>Approach<br>Speed |
|--------------|---------------------|-----|-----|-----|-----------|-------------|---------|---------|------------|--------------------------|----------|-----------------------------------------|
|              |                     |     |     |     | ft (m)    | ft (m)      | ft (m)  | ft (m)  | ft (m)     | ft (m)                   | lbs (kg) | kts                                     |
| Airbus       | A-300               | C   | IV  | 5   | 147.1     | 55          | 175.9   | 75      | 61         | 36.1                     | 363,763  | 137                                     |
|              |                     |     |     |     | (44.83)   | (16.72)     | (53.61) | (22.86) | (18.6)     | (11)                     | (165000) |                                         |
| Airbus       | A-300-600           | C   | IV  | 5   | 147.1     | 55          | 177     | 75      | 61         | 36                       | 375,888  | 137                                     |
|              |                     |     |     |     | (44.84)   | (16.7)      | (54.1)  | (22.87) | (18.6)     | (10.96)                  | (170500) |                                         |
| Airbus       | A-310               | C   | IV  | 5   | 144       | 52.1        | 153.1   | 63.9    | 49.9       | 36                       | 361,558  | 139                                     |
|              |                     |     |     |     | (43.9)    | (15.87)     | (46.66) | (19.49) | (15.22)    | (10.96)                  | (164000) |                                         |
| Airbus       | A-318               | C   | III | 3   | 111.9     | 42.3        | 103.2   | 42.4    | 33.6       | 29.4                     | 149,914  | 121                                     |
|              |                     |     |     |     | (34.1)    | (12.89)     | (31.45) | (12.91) | (10.25)    | (8.95)                   | (68000)  |                                         |
| Airbus       | A-318<br>Sharklet * | C   | III | 3   | 117.5     | 42.3        | 103.2   | 42.4    | 33.6       | 29.4                     | 149,914  | 121                                     |
|              |                     |     |     |     | (35.8)    | (12.89)     | (31.45) | (12.91) | (10.25)    | (8.95)                   | (68000)  |                                         |

**Aircraft  
Approach Class**

**Aircraft Design  
Group**

**Taxiway Design  
Group**



# Approach Visibility Minimums

Defined by a parameter called Runway Visual Range (RVR)

“RVR is the range over which the Pilot of an aircraft on the centre line of a runway can see the runway surface markings or the lights delineating the runway or identifying its centre line.” (ICAO)



Forward Scatter Sensor  
(A.A. Trani)



Source: <https://www.vaisala.com/en/products/weather-environmental-sensors/transmissometer-LT31>

RVR Equipment



# Approach Visibility Minimums

| RVR (ft) *  | Instrument Flight Visibility Category (statute mile)                |
|-------------|---------------------------------------------------------------------|
| <b>5000</b> | Not lower than 1 mile                                               |
| <b>4000</b> | Lower than 1 mile but not lower than $\frac{3}{4}$ mile             |
| <b>2400</b> | Lower than $\frac{3}{4}$ mile but not lower than $\frac{1}{2}$ mile |
| <b>1600</b> | Lower than $\frac{1}{2}$ mile but not lower than $\frac{1}{4}$ mile |
| <b>1200</b> | Lower than $\frac{1}{4}$ mile                                       |

\* RVR values are not exact equivalents.

source: Table 1-3 of FAA AC 150/5300-13A

## Instrument Landing System Categories

| Category | Decision Height (ft) | RVR (ft) |
|----------|----------------------|----------|
| I        | 200                  | 2,400    |
| II       | 100                  | 1,600    |
| IIIa     | 50-100               | 1,200    |
| IIIb     | 0-50                 | 600      |
| IIIc     | 0-50                 | 0        |

source: <http://www.youtube.com/watch?v=mjICabR4r3E>

# Recap: Runway Design Code (RDC)

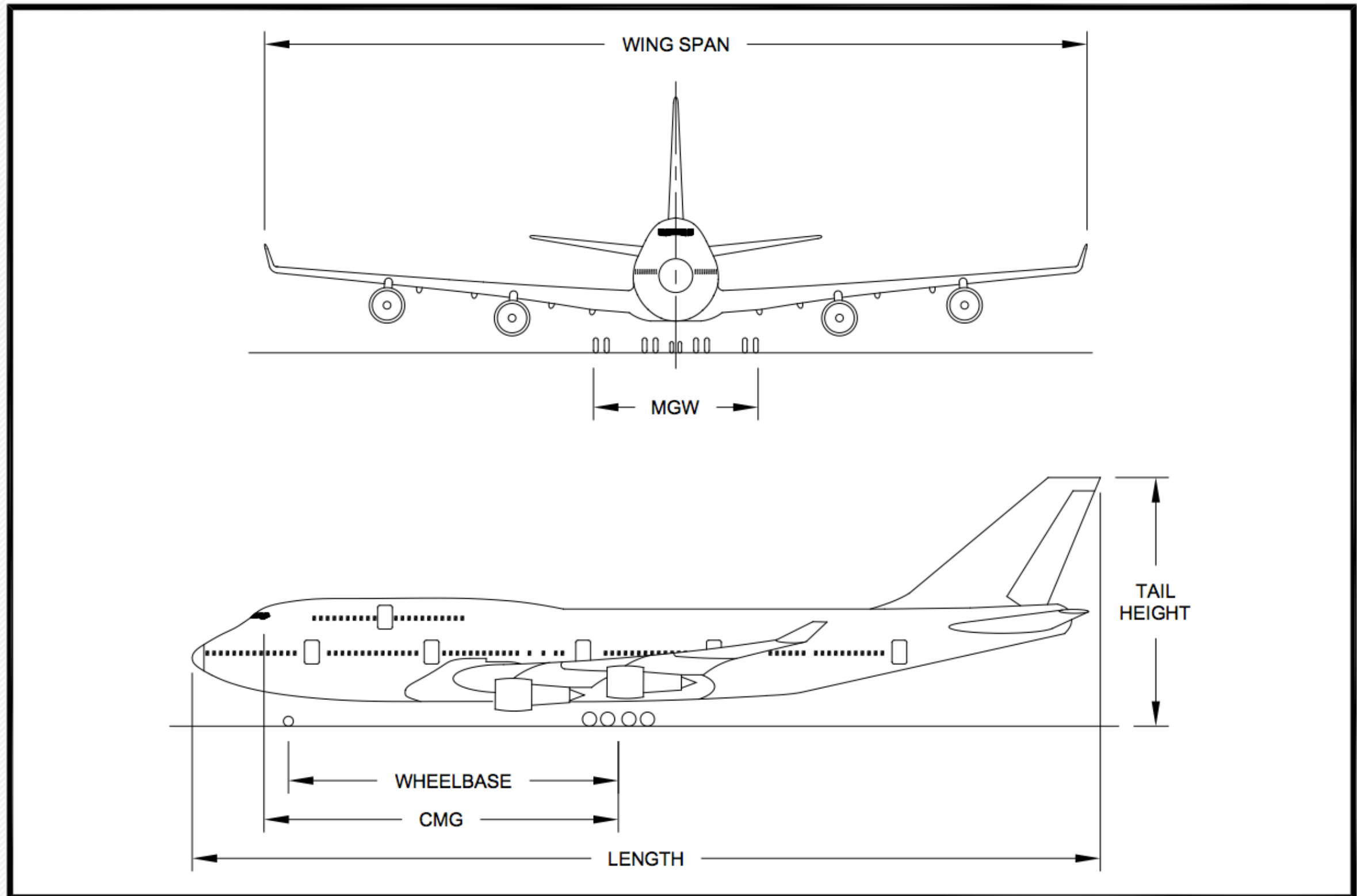
- Three parameters are combined to derive a so-called Runway Design Code (RDC)
  - AAC, ADG and Approach Visibility Minimums
- RDC provides three parameters needed to determine design standards for an airport
- Note: for most airport design projects the TDG parameter is also critical to determine taxiway-to-runway distances

# Taxiway Design Group (TDG)

- Previous FAA guidance considered tail height and wingspan as design factors for geometric design
- New guidance implemented in September 2012 considers:
  - Dimensions of the aircraft undercarriage
  - Main gear width (MGW)
  - Cockpit to main gear dimensions (CMG)



# FAA AC 150/5300-13B (Appendix A)



**CMG is used because pilots normally try following a taxiway centerline**

# FAA AC 150/5300-13B Appendix A

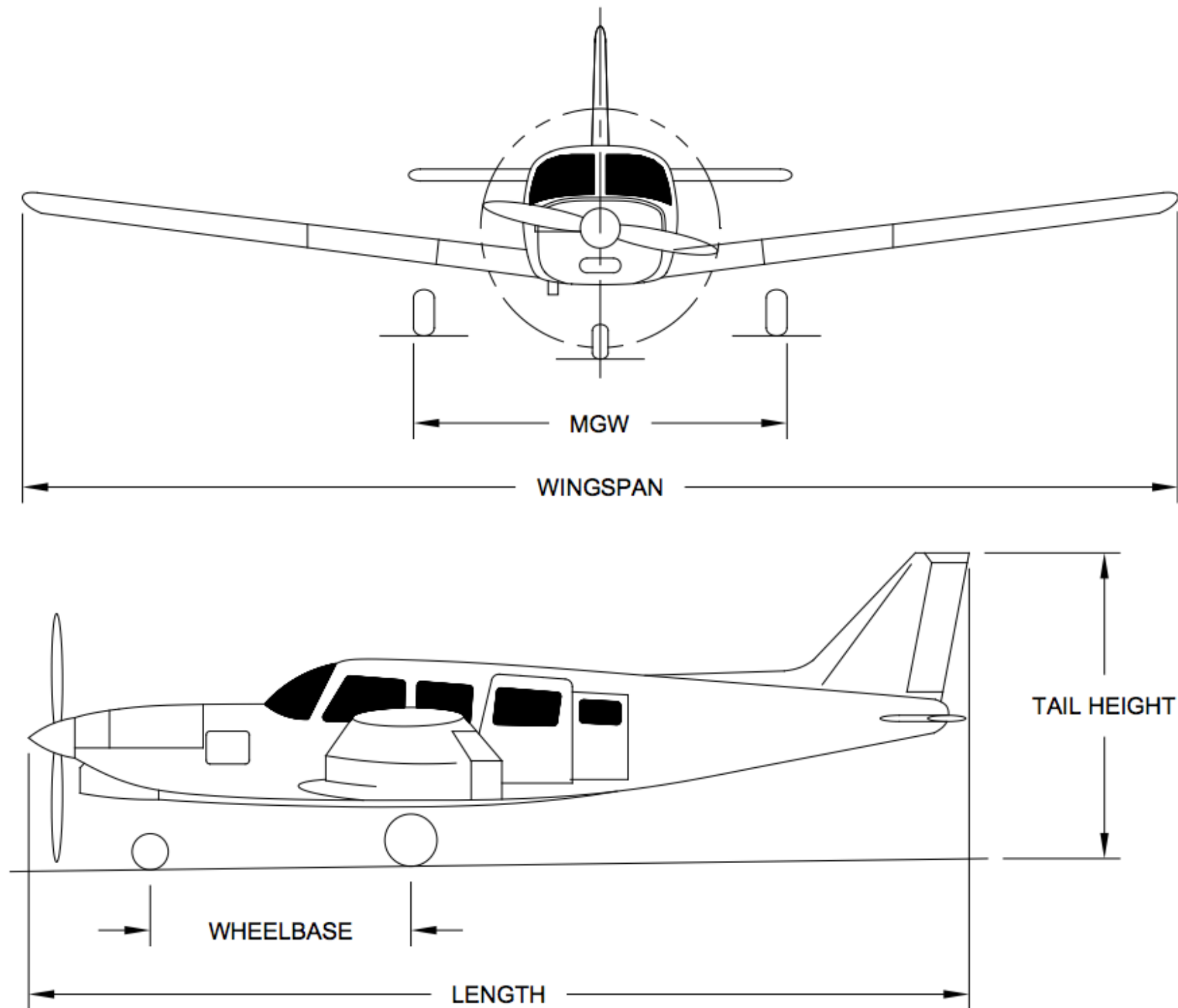


Figure A1-2. Typical dimensions of small aircraft

# CMG Distance vs Wheelbase Distance

FAA specifies:

- Cockpit to Main Gear (CMG) dimension will be used instead of the aircraft wheelbase for aircraft where the cockpit is located forward of the nose gear (typically applies to commercial aircraft)
- For aircraft with the cockpit located aft of the nose gear, use the wheelbase instead of CMG to determine the Taxiway Design Group (TDG)
- See figures in the previous slides



# Examples : Small Aircraft

Many general aviation aircraft (called GA) typically have the nose gear located in front of the cockpit (use the wheelbase distance for design)



Cirrus SR-20  
4-seat single  
engine piston  
power aircraft



Cessna Citation  
Excel 560XL Twin  
turboprop powered  
aircraft



# Examples - Commercial Aircraft

Most commercial aircraft have the cockpit located ahead of the nose gear (use CMG distance)

Airbus A320. Twin-engine turbofan powered, commercial aircraft



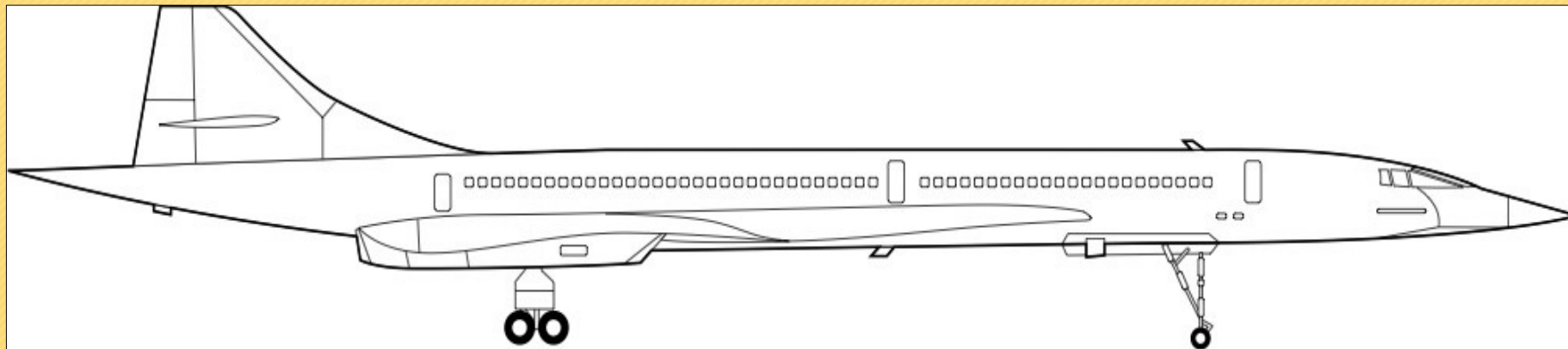
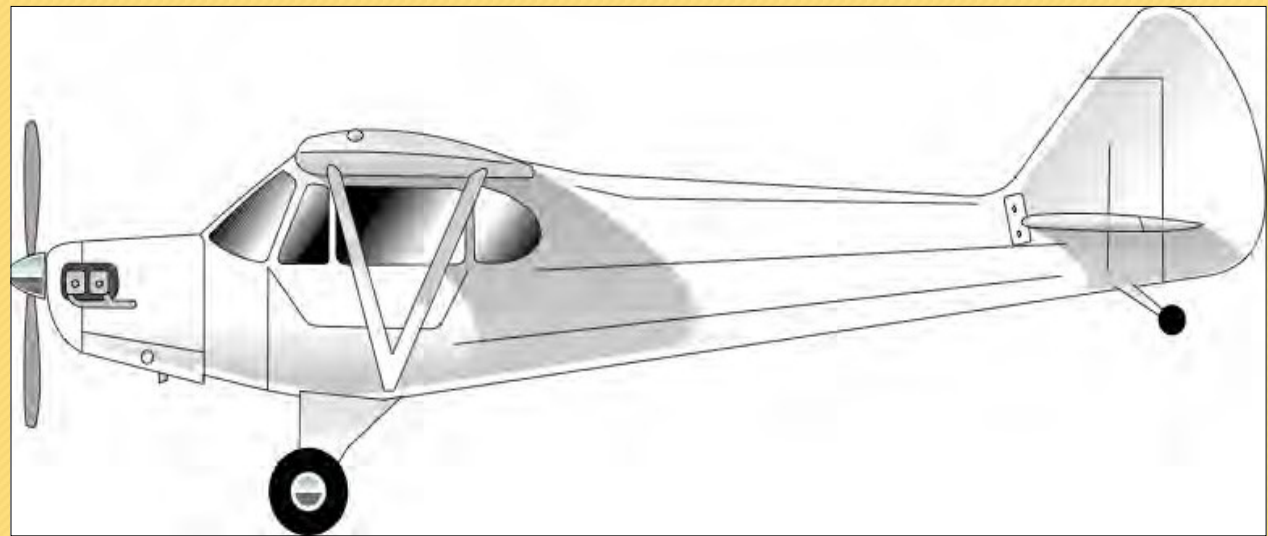
Cockpit to Main Gear  
Distance (CMG)

# Special Landing Gear Configurations

Some aircraft have special landing gear configurations

Piper J-3 Cub  
2-seat single engine  
piston power aircraft

Tail Dragger  
Configuration



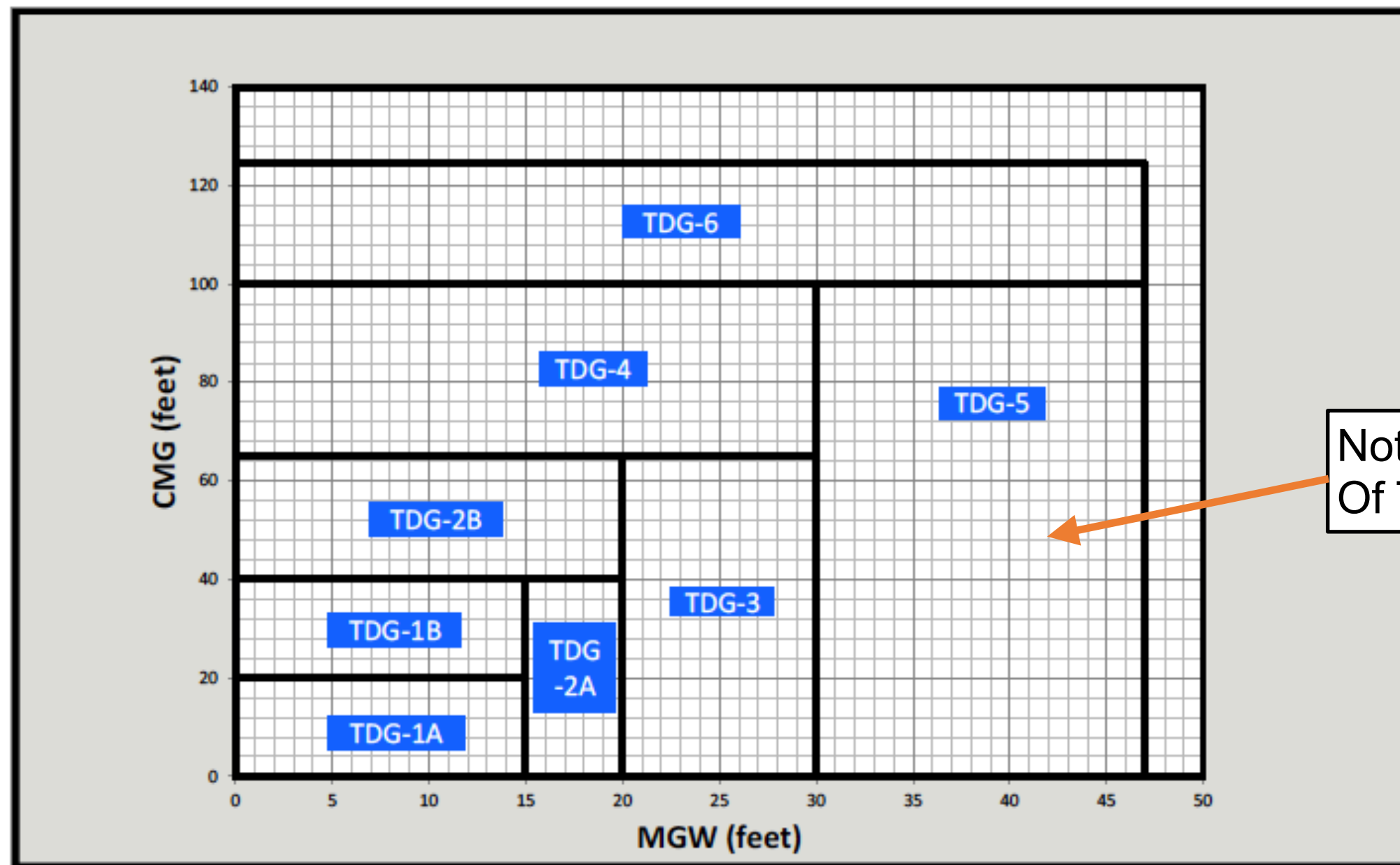
BAC Concorde -  
Supersonic  
Transport (very  
long CMG  
distance)



# Revised Taxiway Design Groups

Figure 1-1. Taxiway Design Groups (TDGs) source: FAA AC 150/5300-13B with Change 1

Figure 1-1. Taxiway Design Groups (TDGs)



Note the expansion  
Of TDG Group 5

**Note:** Values for CMG and MGW in the graph are rounded to the nearest foot. 1 foot = 0.305 meters.

# Excel Database of Aircraft Characteristics

Provides information for thousands of aircraft

Database is not complete (Virginia Tech is helping FAA to complete the database)

 [www.faa.gov/airports/engineering/aircraft\\_char\\_database](http://www.faa.gov/airports/engineering/aircraft_char_database)

| ICAO_Code | FAA_Designator | Manufacturer | Model_FAA                   |
|-----------|----------------|--------------|-----------------------------|
| A20N      | A20N           | AIRBUS       | Airbus A320 Neo             |
| A21N      | A21N           | AIRBUS       | Airbus A321 Neo             |
| A306      | A306           | AIRBUS       | Airbus A300 B4-600          |
| A30B      | A30B           | AIRBUS       | Airbus A300-B2              |
| A310      | A310           | AIRBUS       | Airbus A310                 |
| A318      | A318           | AIRBUS       | Airbus A318                 |
| A319      | A319           | AIRBUS       | Airbus A319                 |
| A320      | A320           | AIRBUS       | Airbus A320                 |
| A321      | A321           | AIRBUS       | Airbus A321                 |
| A332      | A332           | AIRBUS       | Airbus A330-200             |
| A333      | A333           | AIRBUS       | Airbus A330-300             |
| A337      | A337           | AIRBUS       | Airbus A330-700 - Beluga XL |

# Example Problem #1

An airport is to be designed to accommodate the Boeing 757-300 aircraft.  
 Determine the airport reference code and the taxiway design group to be used.

## Solution:

Look at the FAA aircraft characteristics database:

Approach speed is 143 knots

Wingspan is 124.8 feet (134.8 feet with winglets)

Tail height is 44.8 feet

|    | A         | B              | C            | D              | E               | F                     |
|----|-----------|----------------|--------------|----------------|-----------------|-----------------------|
| 1  | ICAO_Code | FAA_Designator | Manufacturer | Model_FAA      | Model_BADA      | Physical_Class_Engine |
| 84 | B753      | B753           | BOEING       | Boeing 757-300 | Boeing B757-300 | Jet                   |

|    | A         | G           | H   | I           | J           | K   | L   | M                   |
|----|-----------|-------------|-----|-------------|-------------|-----|-----|---------------------|
| 1  | ICAO_Code | Num_Engines | AAC | AAC_minimum | AAC_maximum | ADG | TDG | Approach_Speed_knot |
| 84 | B753      | 2           | D   |             |             | IV  | 4   | 143                 |

|    | A         | P                                      | Q                                   | R         | S                     | T            | U                       |
|----|-----------|----------------------------------------|-------------------------------------|-----------|-----------------------|--------------|-------------------------|
| 1  | ICAO_Code | Wingspan_ft_without_winglets_sharklets | Wingspan_ft_with_winglets_sharklets | Length_ft | Tail_Height_at_OEW_ft | Wheelbase_ft | Cockpit_to_Main_Gear_ft |
| 84 | B753      | 124.8                                  | 134.8                               | 178.6     | 44.8                  | 73.3         | 85.3                    |



# Picture the Aircraft in Question (Sanity Check)

Boeing 757-300 with winglets landing at Atlanta Hartsfield-Jackson International Airport (A.Trani)



Aircraft pictures are available at: <http://www.airliners.net>

# Example Problem #1

Boeing 757-300 :Approach speed is 143 knots (AAC = D) and Wingspan is 124.8 feet and tail height 44.5 feet. **Hence the aircraft belongs to ADG group IV.**

Boeing 757-300  
Belongs to Group  
IV

Reason: tail height  
falls into III group,  
wingspan belongs  
to group IV  
Use the most  
critical

| Group # | Tail Height                           | Wingspan                                |
|---------|---------------------------------------|-----------------------------------------|
| I       | < 20 ft (< 6.1 m)                     | < 49 ft (< 14.9 m)                      |
| II      | 20 ft to < 30 ft (6.1 m to < 9.1 m)   | 49 ft to < 79 ft (14.9 m to < 24.1 m)   |
| III     | 30 ft to < 45 ft (9.1 m to < 13.7 m)  | 79 ft to < 118 ft (24.1 m to < 36.0 m)  |
| IV      | 45 ft to < 60 ft (13.7 m to < 18.3 m) | 118 ft to < 171 ft (36.0 m to < 52.1 m) |
| V       | 60 ft to < 66 ft (18.3 m to < 20.1 m) | 171 ft to < 214 ft (52.1 m to < 65.2 m) |
| VI      | 66 ft to < 80 ft (20.1 m to < 24.4 m) | 214 ft to < 262 ft (65.2 m to < 79.9 m) |

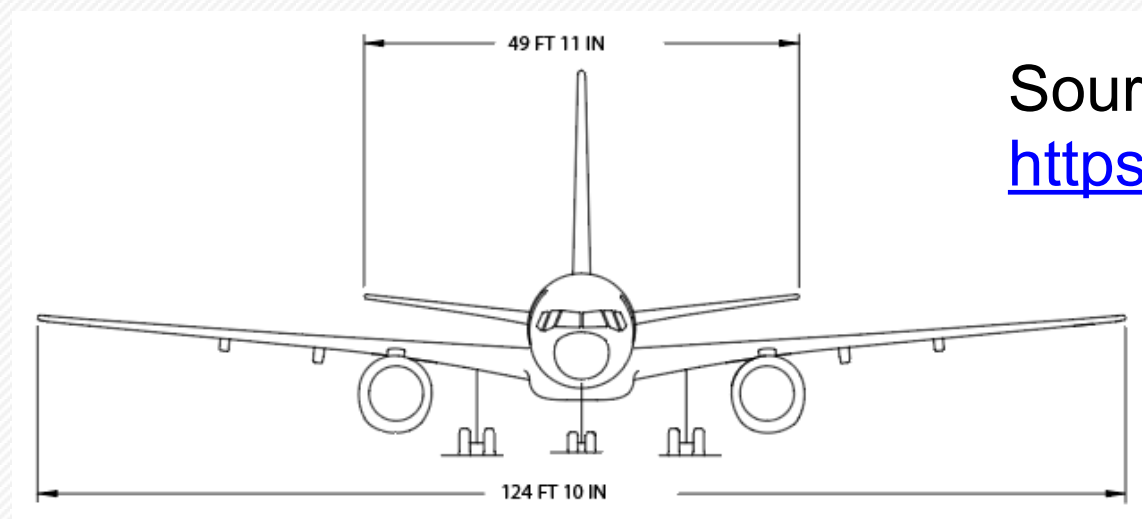
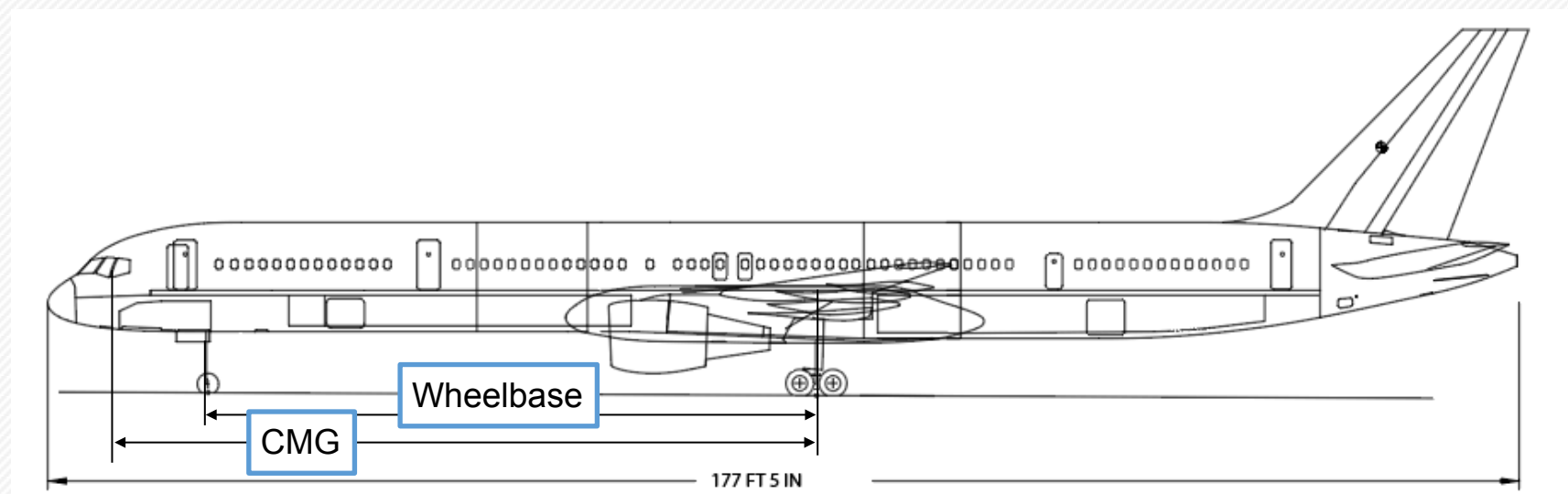
Note: The most critical element for this aircraft is the wingspan ADG Group IV. The tail height belongs to ADG Group III.



# Example Problem #1

Boeing 757-300 has a wheelbase of 73.3 feet, a Main Gear Width of 28.0 feet (8.5 meters) and a Cockpit to Main Gear distance of 85.3 feet (26 m)

| 1  | ICAO_Code | Length_ft | Tail_Height_at_OEW_ft | Wheelbase_ft | Cockpit_to_Main_Gear_ft | Main_Gear_Width_ft | MTOW_lb | MALW_lb |
|----|-----------|-----------|-----------------------|--------------|-------------------------|--------------------|---------|---------|
| 84 | B753      | 178.6     | 44.8                  | 73.3         | 85.3                    | 28.0               | 270,000 | 224,000 |



Source of drawing: Boeing

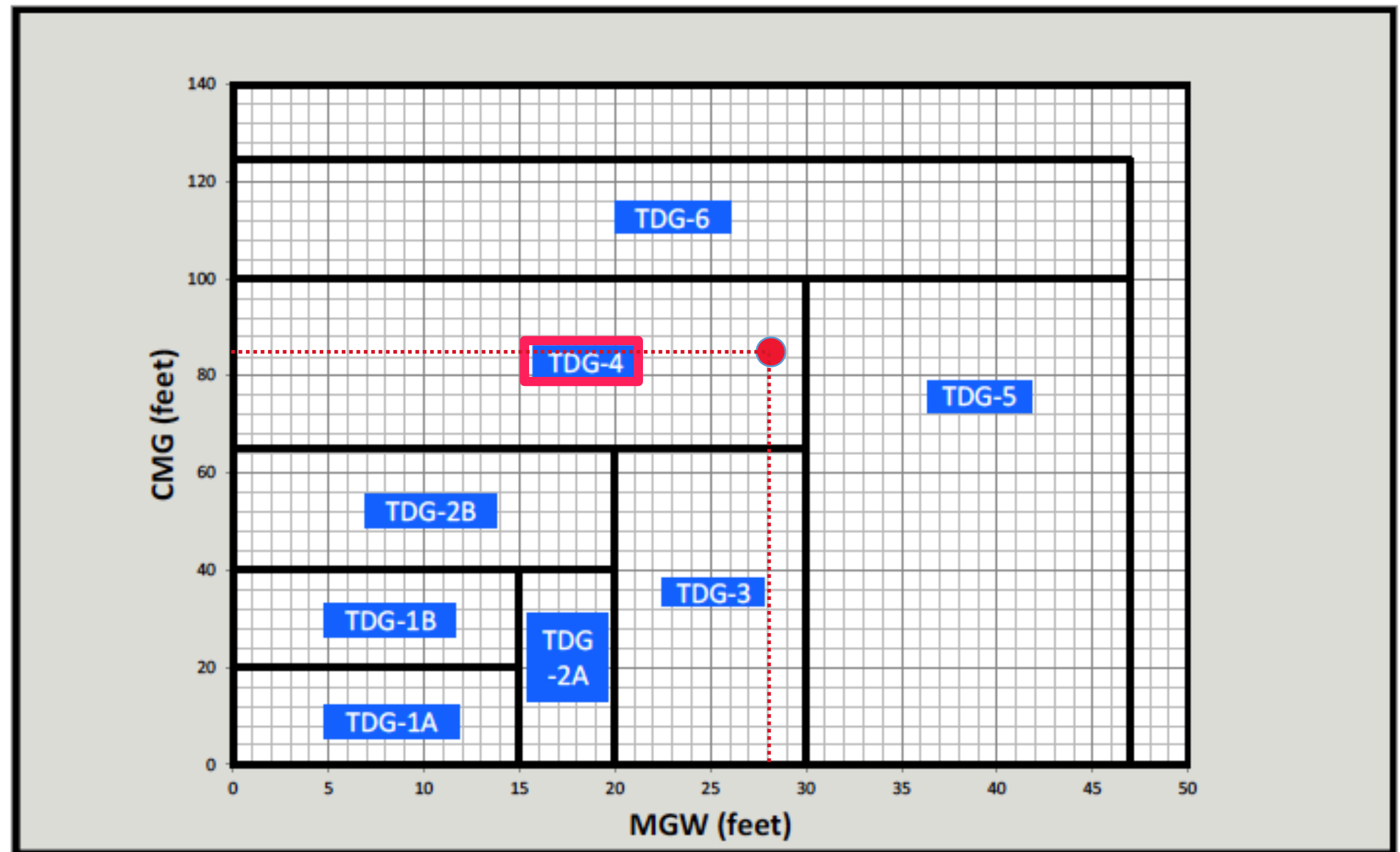
<https://www.boeing.com/commercial/airports/3-view>



# Example Problem #1

Boeing 757-300 has a CMG distance of 85.3 feet, a Main Gear Width of 28.0 feet (8.5 meters)

Figure 1-1. Taxiway Design Groups (TDGs)



**Note:** Values for CMG and MGW in the graph are rounded to the nearest foot. 1 foot = 0.305 meters.

Boeing 757-300  
Belongs to  
Taxiway Design  
Group (TDG) 4

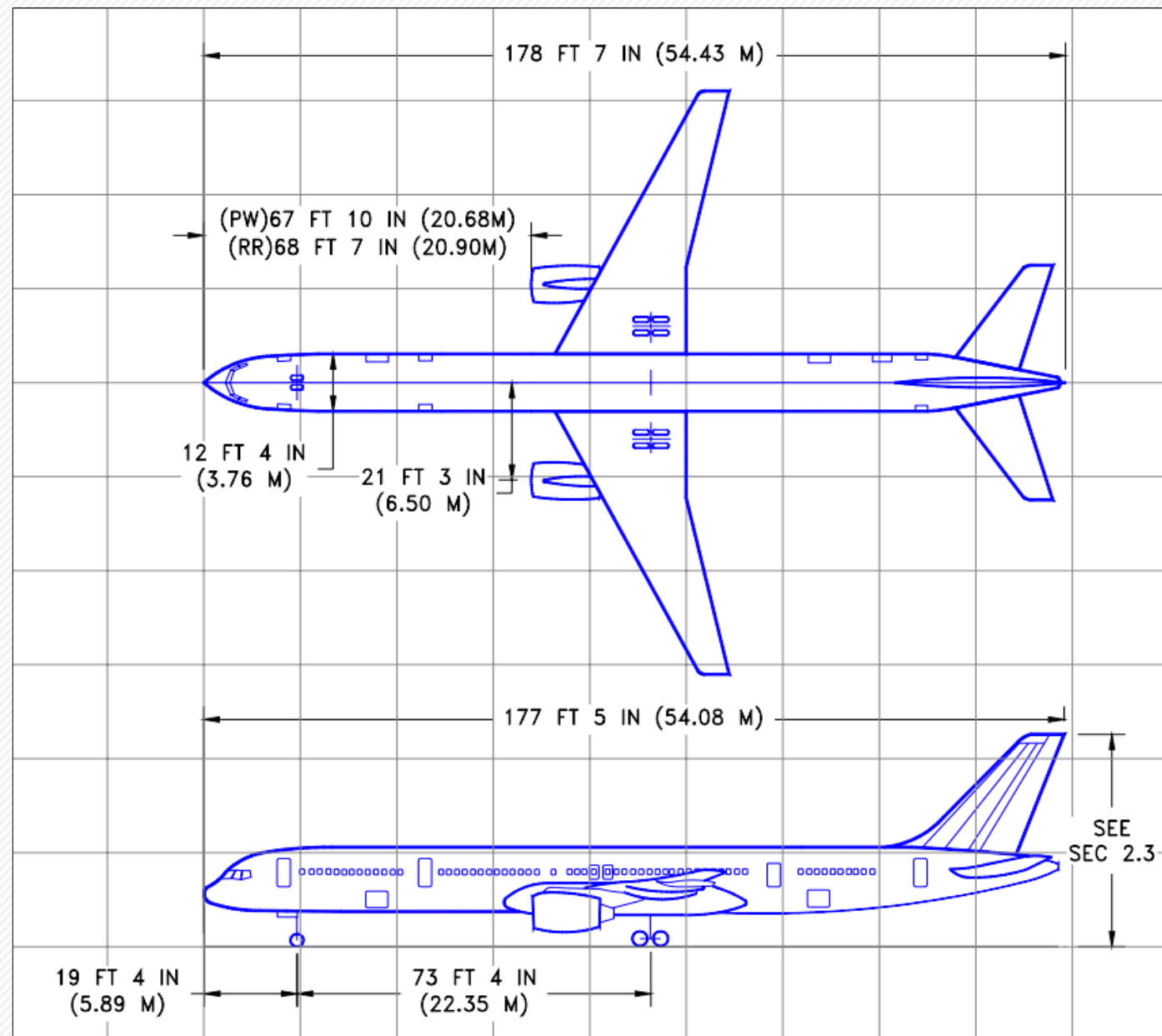
# Boeing 757-200/300 Document for Airport Design

Aircraft Manufacturer documents provide another source of aircraft data



**757-200/300**

## Airplane Characteristics for Airport Planning

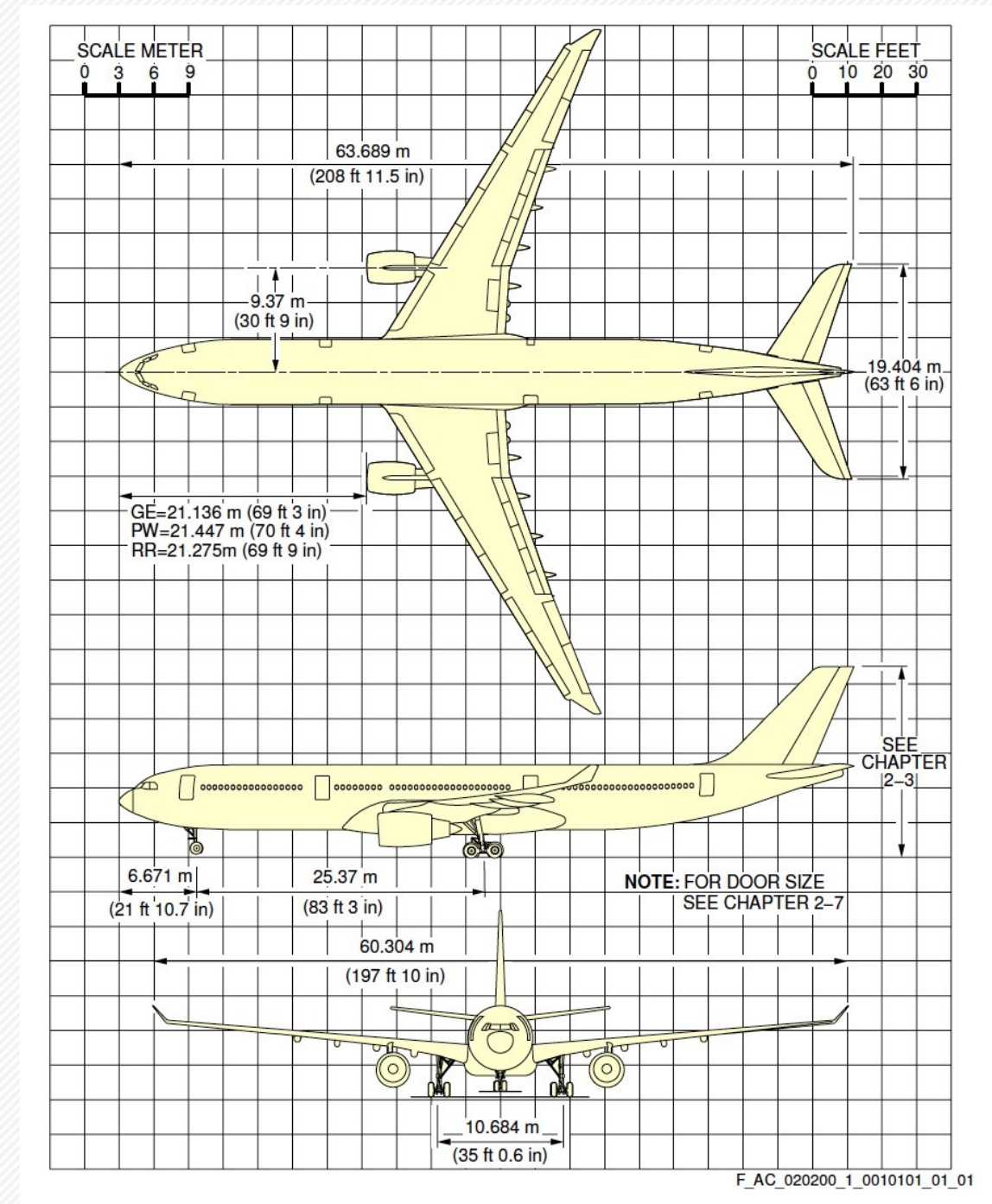
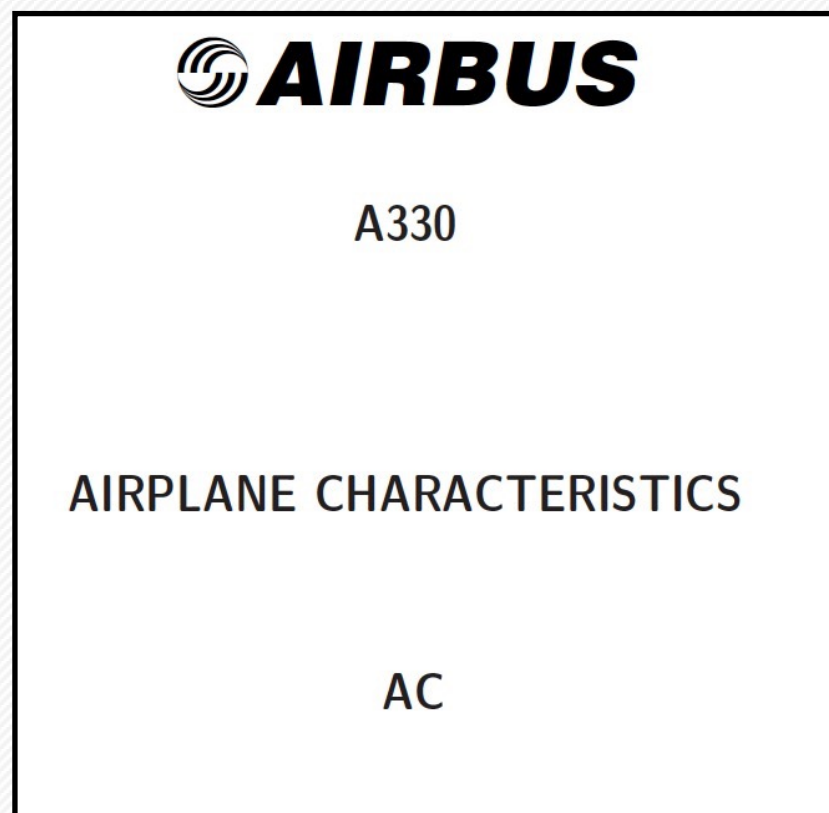
[illegible]

# Example Problem #2

An airport is to be designed to accommodate the Airbus A330-300 aircraft. Determine the ICAO airport reference code element 2 to be used in design.

## Solution:

Look at the aircraft characteristics provided by Airbus





# Example Problem #2

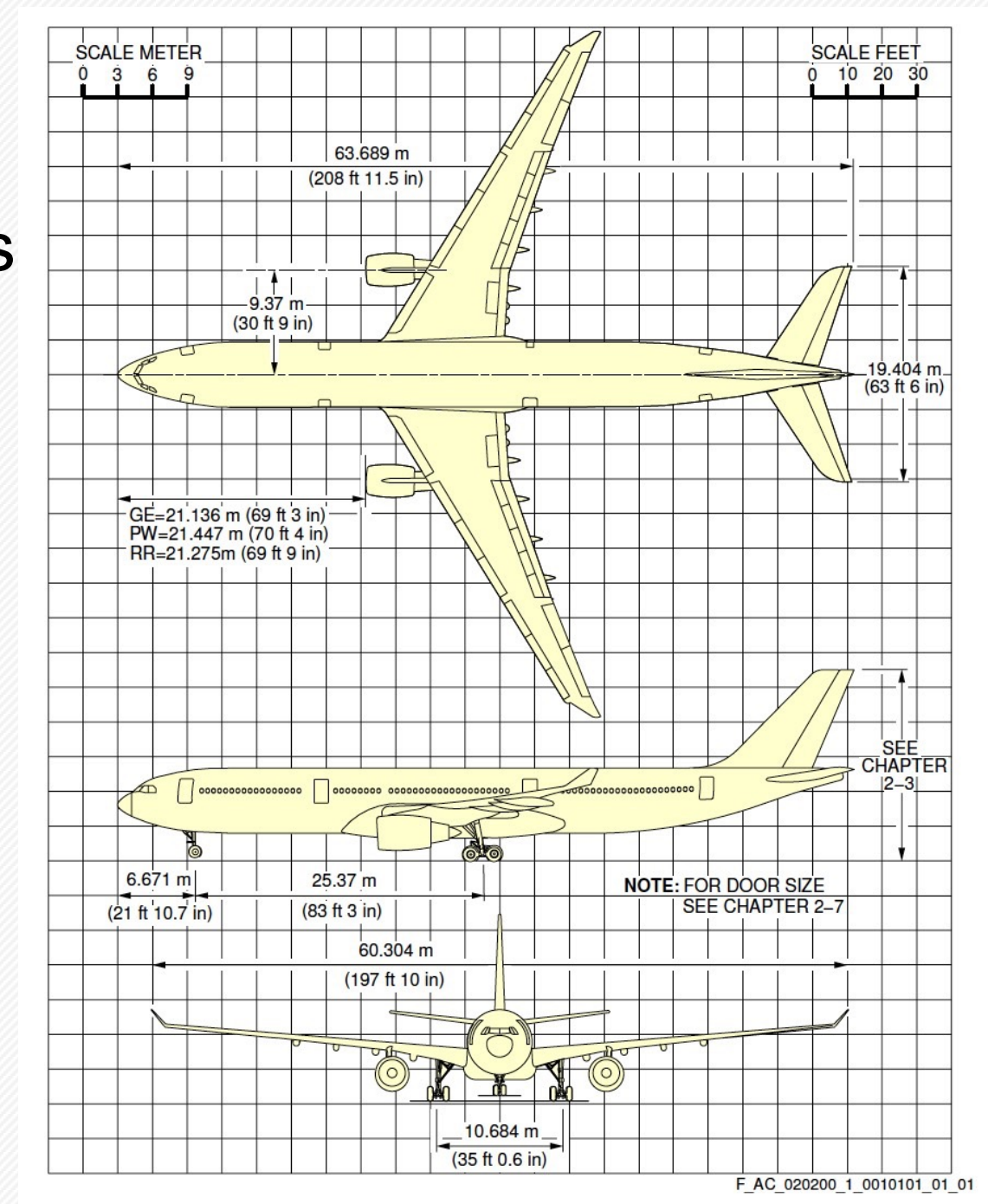
## Solution:

The aircraft wingspan is listed

at 60.3 meters

Outer main gear width is 11.3 meters

Aircraft belongs to **ICAO Code E**



# Picture the Aircraft in Question (Sanity Check)

Airbus A330-300 landing at Charlotte Douglas International Airport (A.Trani)



Aircraft pictures are available at: <http://www.airliners.net>



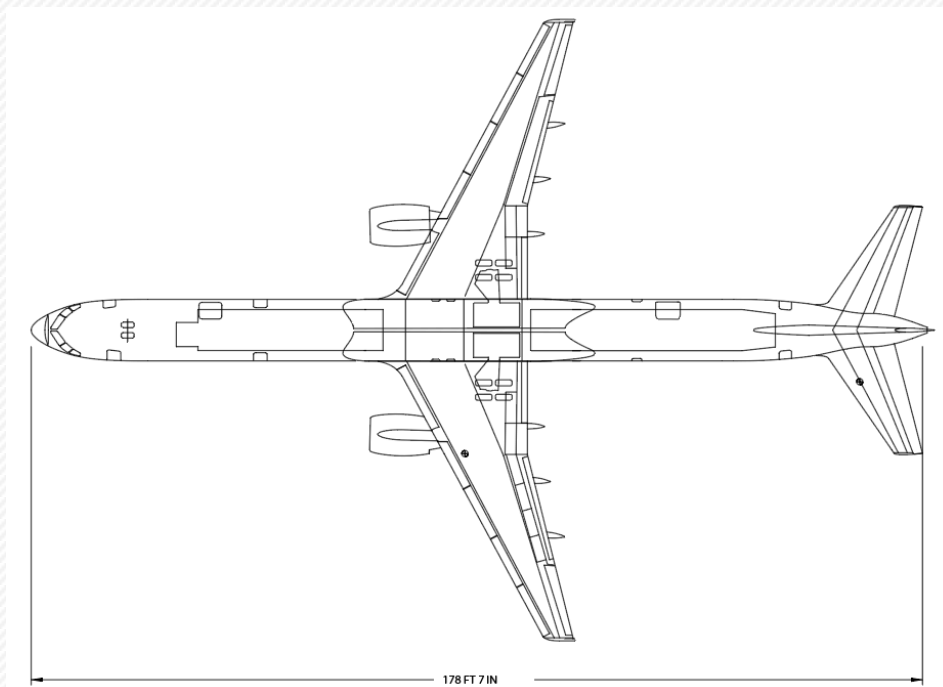
# Obtaining 3-D View Drawings of Aircraft

Boeing Aircraft:

<https://www.boeing.com/commercial/airports/3-view>

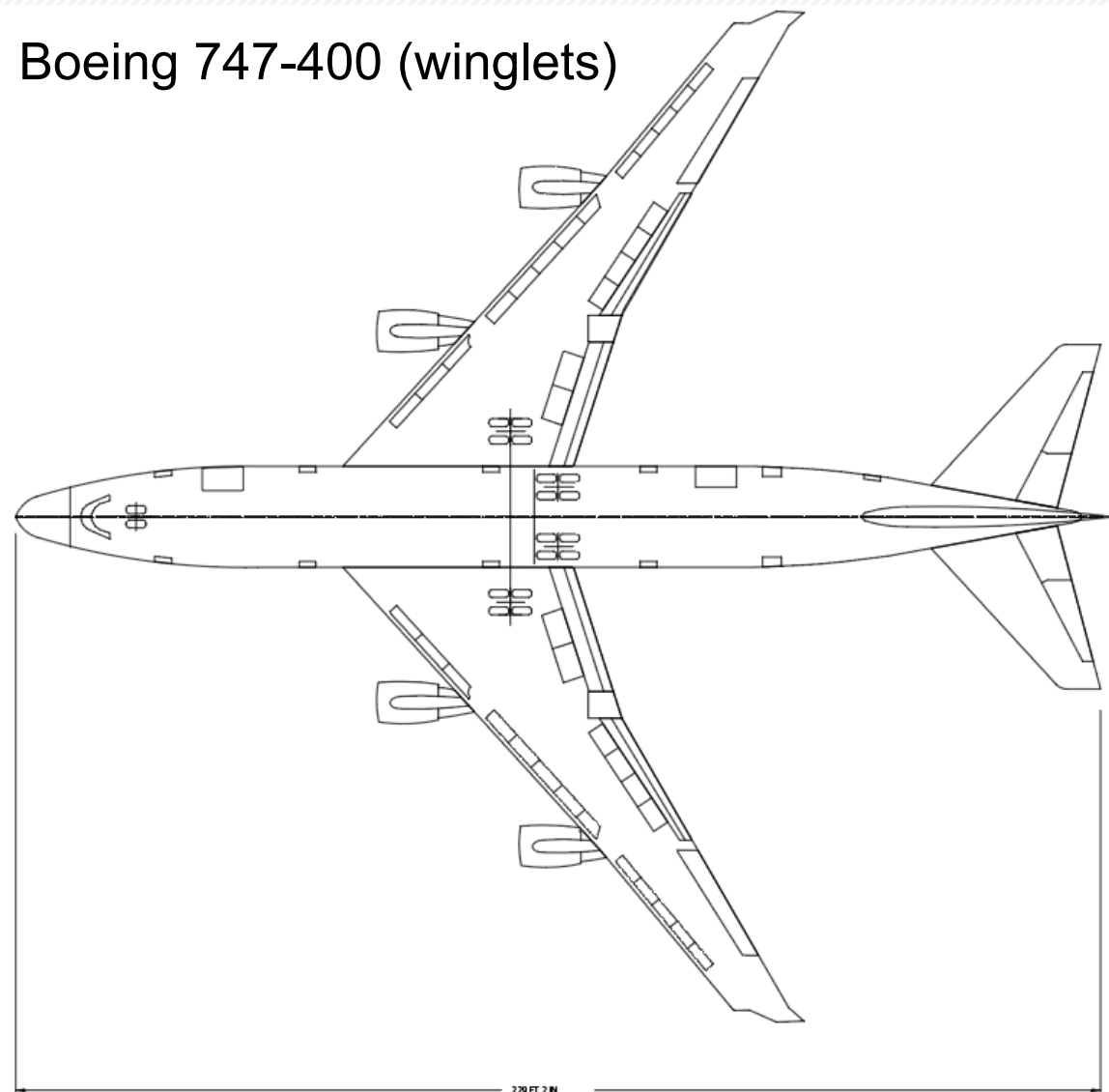
Airbus Aircraft:

<https://aircraft.airbus.com/en/customer-care/fleet-wide-care/airport-operations-and-aircraft-characteristics/autocad-3-view-aircraft-drawings>



Boeing 757-300 (no winglets)

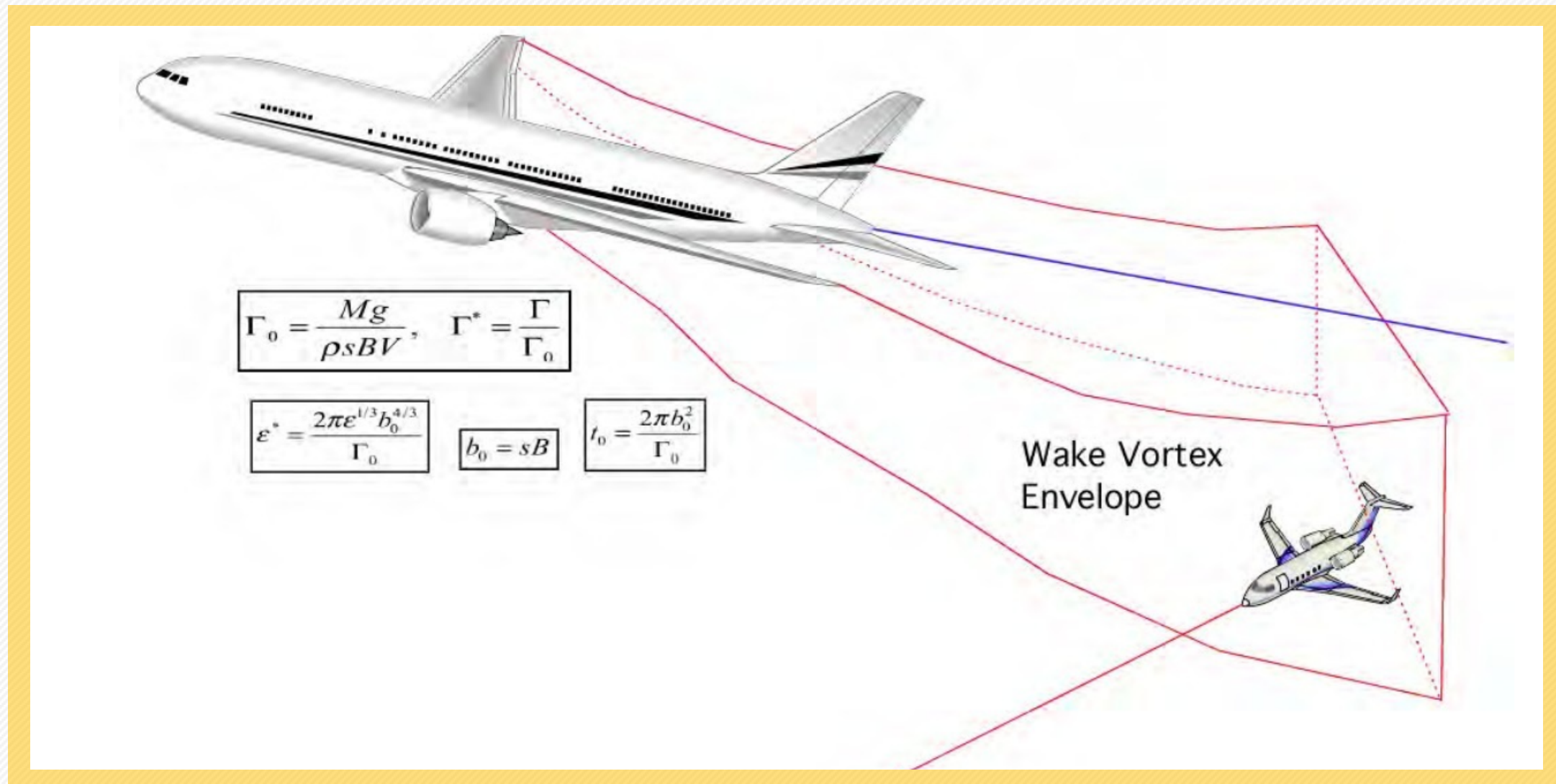
Boeing 747-400 (winglets)





# Wake Vortex Classes

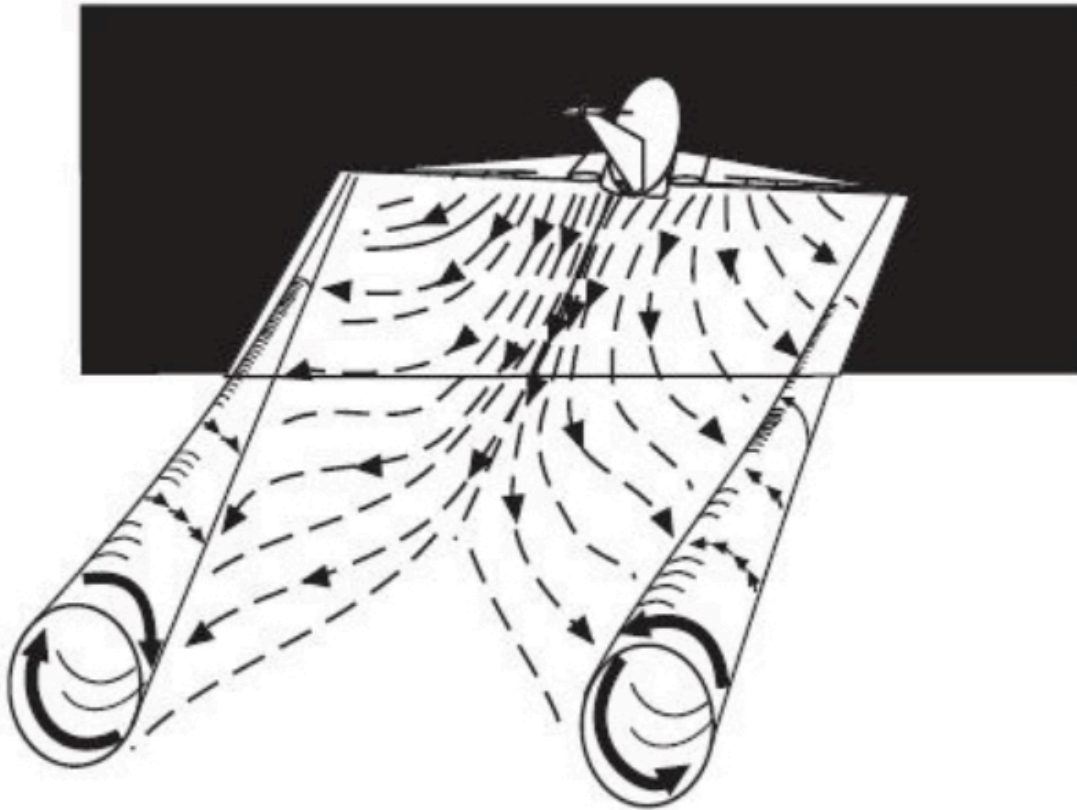
Every aircraft generates wakes behind the wing due to the strong circulation required to generate lift



Circular  
Strenght  
Boundary

Wake vortices depend on  
aircraft mass, wingspan and  
atmospheric conditions

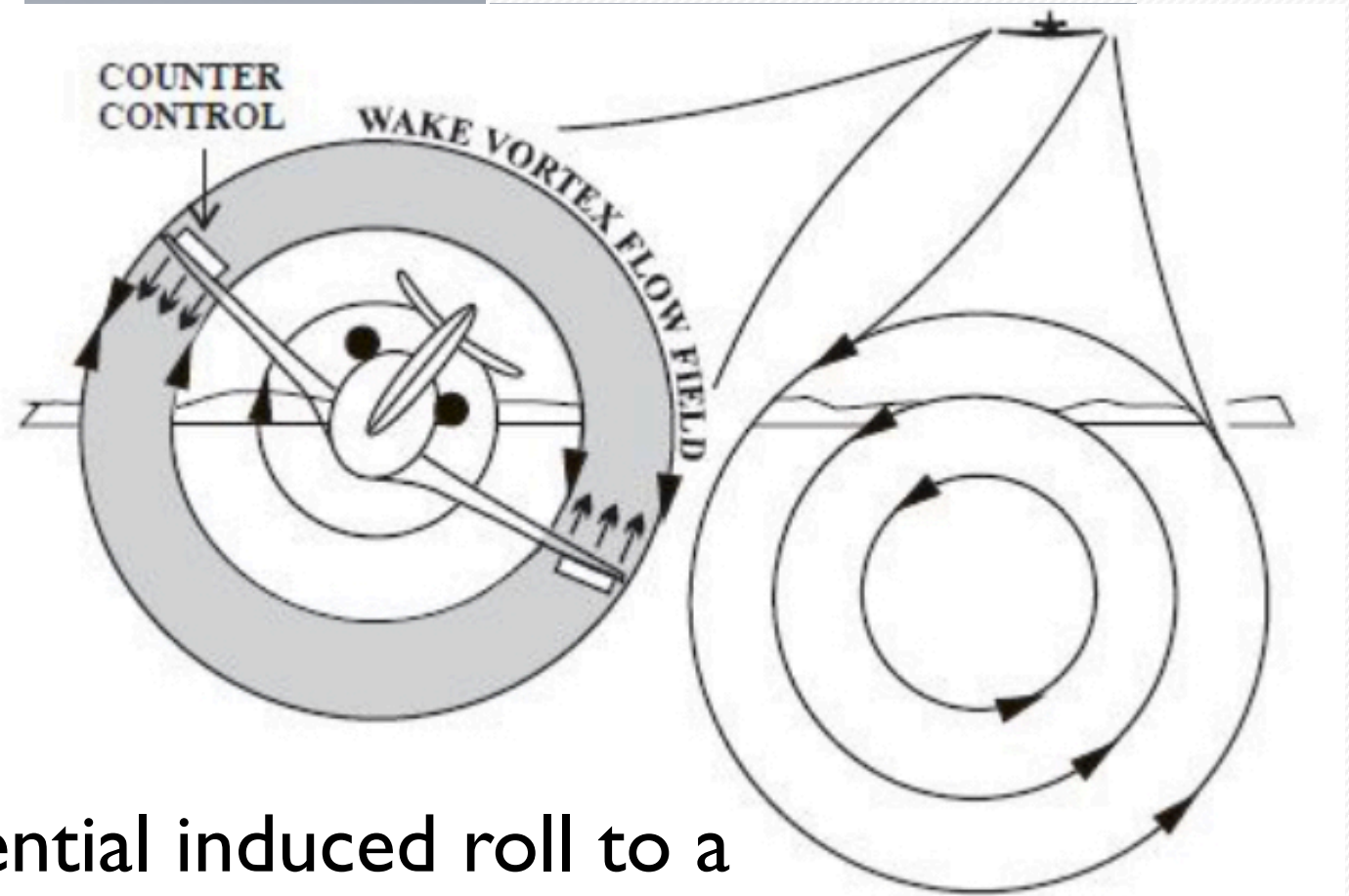
# Wake Vortex



Greatest danger is when aircraft are heavy, clean (no flap configuration and flying slow)

Source: [https://www.faa.gov/air\\_traffic/publications/atpubs/aim\\_html/chap7\\_section\\_4.html](https://www.faa.gov/air_traffic/publications/atpubs/aim_html/chap7_section_4.html)

For heavy aircraft, wakes may last 60-90 seconds behind the generating aircraft

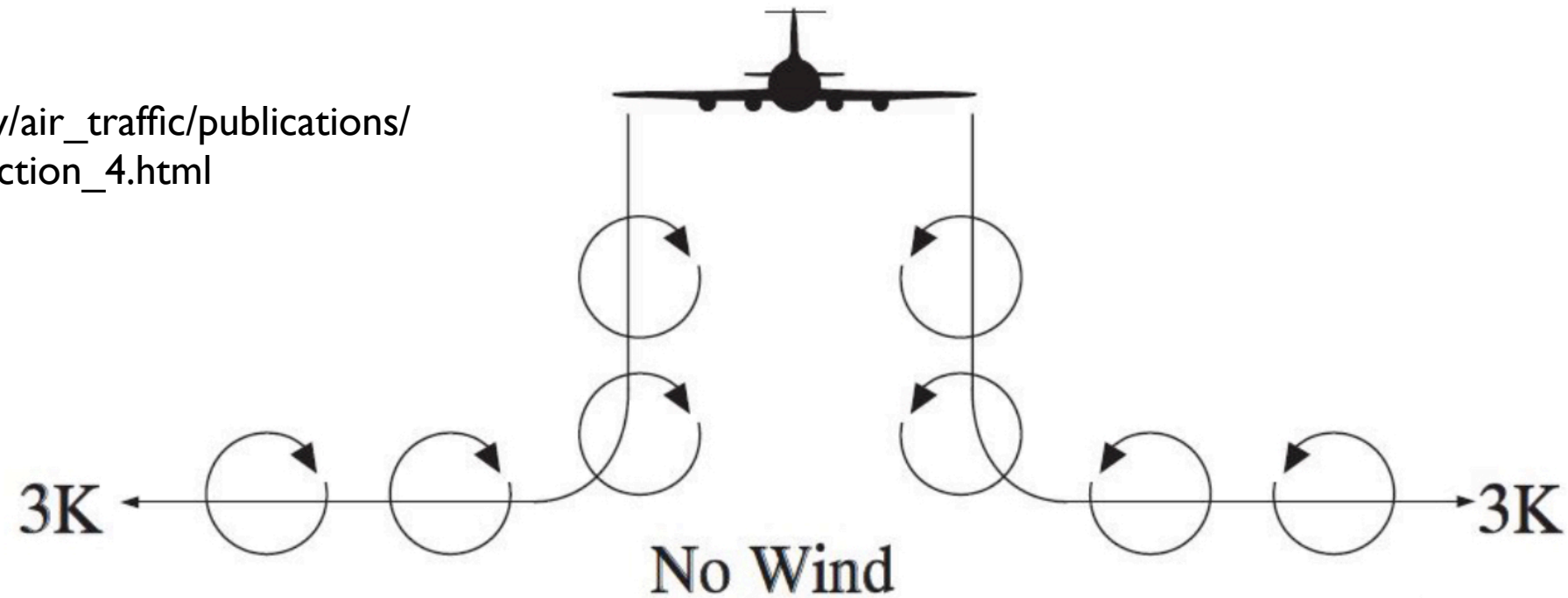


Potential induced roll to a following aircraft

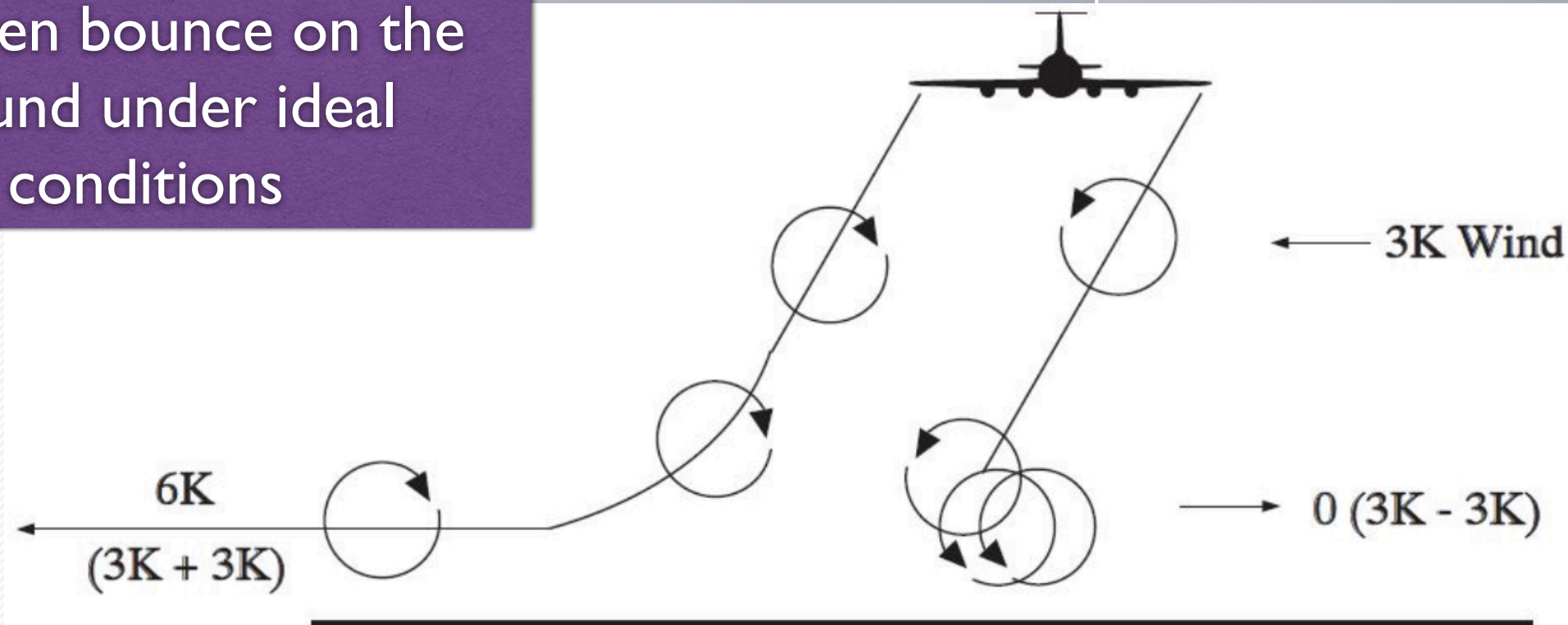


# Wake Vortex Issues

Source: [https://www.faa.gov/air\\_traffic/publications/atpubs/aim\\_html/chap7\\_section\\_4.html](https://www.faa.gov/air_traffic/publications/atpubs/aim_html/chap7_section_4.html)



Wakes can travel laterally and even bounce on the ground under ideal conditions





# Wake Vortex Issues

Wake vortex visualization behind a small regional jet (VFW 614)



# Wake Vortex Separation Standards

- 1970s - FAA develops a legacy wake vortex classification (small, large, heavy - Superheavy added in 2007)
- 1993 - FAA adds Boeing 757-200 to the legacy classification as a group (at the time ATC handles the Boeing 757-200 like a heavy)

FAA Orders 757 Turbulence Alert : Aviation: After crash of private jet in Santa Ana, air controllers are told to alert small planes to wake hazard posed by Boeing craft. Past incidents are cited.

Source: Los Angeles Times (December/23/1993)

- 2012 - FAA implements RECAT (re-categorization Phase I) with **6 wake groups (A-F)**
- 2019 - FAA develops a Consolidated Wake Turbulence Classification (CWT) with **9 groups (A-I)**

# Legacy Wake Vortex Classification

## Final Approach Aircraft Wake Vortex Classification

| Group             | Takeoff Gross Weight (lb) | Example Aircraft                                                                                           |
|-------------------|---------------------------|------------------------------------------------------------------------------------------------------------|
| Small             | < 41,000                  | All single engine aircraft, light twins, most business jets and commuter aircraft                          |
| Large             | 41,000-255,000            | Large turboprop commuters, short and medium range transport aircraft (MD-80, B737, B727, A320, F100, etc.) |
| Heavy             | > 255,000                 | Boeing 757 <sup>a</sup> , Boeing 747, Douglas DC-10, MD-11, Airbus A-300, A-340,                           |
| <b>Superheavy</b> | 1,234,000                 | Airbus A380                                                                                                |

- a. For purposes of terminal airspace separation procedures, the Boeing 757 is classified by FAA in a category by itself. However, when considering the Boeing 757 separation criteria (close to the Heavy category) and considering the percent of Boeing 757 in the U.S. fleet, the four categories does provide very similar results for most airport capacity analyses.



# Consolidated Wake Turbulence Recategorization Classification (CWT)

- FAA Introduced a **consolidated wake re-categorization in 2019**
- [FAA Order JO 7110.126B](#)



## U.S. DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION

### Air Traffic Organization Policy

**ORDER**  
**JO 7110.126B**

**Effective Date:**  
November 9, 2021

**SUBJ:** Consolidated Wake Turbulence (CWT)

---

**1. Purpose of This Order.** This order provides procedural guidance to FAA Order JO 7110.65, Air Traffic Control, related to the use of Consolidated Wake Turbulence procedures and separation minima.

# Consolidated Wake Turbulence Recategorization Classification (CWT)

**Defines nine wake classes including pairwise classes**

## Appendix A Aircraft Wake Categories

Category A – A388 and A225.

Category B – Pairwise Upper Heavy aircraft.

Category C – Pairwise Lower Heavy aircraft

Category D – Non-Pairwise Heavy aircraft.

Category E – B757 aircraft.

Category F – Upper Large aircraft excluding B757 aircraft.

Category G – Lower Large aircraft.

Category H – Upper Small aircraft with a maximum takeoff weight of more than 15,400 pounds up to 41,000 pounds.

Category I – Lower Small aircraft with a maximum takeoff weight of 15,400 pounds or less.

Source: FAA Order JO 7110.126B

# Consolidated Wake Turbulence Recategorization Classification (CWT)

**Defines nine wake classes including pairwise classes**

| Category | Description                                                                                       |
|----------|---------------------------------------------------------------------------------------------------|
| <b>A</b> | A388                                                                                              |
| <b>B</b> | Pairwise Upper Heavy aircraft                                                                     |
| <b>C</b> | Pairwise Lower Heavy aircraft                                                                     |
| <b>D</b> | Non-Pairwise Heavy aircraft                                                                       |
| <b>E</b> | B757 aircraft                                                                                     |
| <b>F</b> | Upper Large aircraft excluding B757 aircraft                                                      |
| <b>G</b> | Lower Large aircraft                                                                              |
| <b>H</b> | Upper Small aircraft with a maximum takeoff weight of more than 15,400 pounds up to 41,000 pounds |
| <b>I</b> | Lower Small aircraft with a maximum takeoff weight of 15,400 pounds or less                       |

Source: FAA Order JO 7110.126B



# Consolidated Wake Turbulence Recategorization Classification (CWT)

| Aircraft Types Categorized |                                |                                |                                       |      |                         |                                |      |                                |      |                                |                                |
|----------------------------|--------------------------------|--------------------------------|---------------------------------------|------|-------------------------|--------------------------------|------|--------------------------------|------|--------------------------------|--------------------------------|
| <b>A</b><br><b>Super</b>   | <b>B</b><br><b>Upper Heavy</b> | <b>C</b><br><b>Lower Heavy</b> | <b>D</b><br><b>Non-Pairwise Heavy</b> |      | <b>E</b><br><b>B757</b> | <b>F</b><br><b>Upper Large</b> |      | <b>G</b><br><b>Lower Large</b> |      | <b>H</b><br><b>Upper Small</b> | <b>I</b><br><b>Lower Small</b> |
| A388                       | A332                           | A306                           | A124                                  | DC85 | B752                    | A318                           | C130 | AT43                           | E170 | ASTR                           | BE10                           |
| A225                       | A333                           | A30B                           | A339                                  | DC86 | B753                    | A319                           | C30J | AT72                           | E45X | B190                           | BE20                           |
|                            | A343                           | A310                           | A342                                  | DC87 |                         | A320                           | CVLT | CL60                           | E75L | BE40                           | BE58                           |
|                            | A345                           | B762                           | A3ST                                  | E3CF |                         | A321                           | DC93 | CRJ1                           | E75S | B350                           | BE99                           |
|                            | A346                           | B763                           | A400                                  | E3TF |                         | B712                           | DC95 | CRJ2                           | F16  | C560                           | C208                           |
|                            | A359                           | B764                           | A50                                   | E6   |                         | B721                           | DH8D | CRJ7                           | F18H | C56X                           | C210                           |
|                            | B742                           | C17                            | AN22                                  | E767 |                         | B722                           | E190 | CRJ9                           | F18S | C680                           | C25A                           |
|                            | B744                           | DC10                           | B1                                    | IL62 |                         | B732                           | GL5T | CRJX                           | F900 | C750                           | C25B                           |
|                            | B748                           | K35R                           | B2                                    | IL76 |                         | B733                           | GLEX | DC91                           | FA7X | CL30                           | C402                           |
|                            | B772                           | MD11                           | B52                                   | IL86 |                         | B734                           | GLF5 | DH8A                           | GLF2 | E120                           | C441                           |
|                            | B773                           |                                | B703                                  | IL96 |                         | B735                           | GLF6 | DH8B                           | GLF3 | F2TH                           | C525                           |
|                            | B77L                           |                                | B741                                  | K35E |                         | B736                           | MD82 | DH8C                           | GLF4 | FA50                           | C550                           |
|                            | B77W                           |                                | B743                                  | KE3  |                         | B737                           | MD83 | E135                           | SB20 | GALX                           | P180                           |
|                            | B788                           |                                | B74D                                  | L101 |                         | B738                           | MD87 | E145                           | SF34 | H25B                           | PAY2                           |
|                            | B789                           |                                | B74R                                  | MYA4 |                         | B739                           | MD88 |                                |      | LJ31                           | PA31                           |
|                            | C5                             |                                | B74S                                  | R135 |                         |                                | MD90 |                                |      | LJ35                           | PC12                           |
|                            | C5M                            |                                | B78X                                  | T144 |                         |                                |      |                                |      | LJ45                           | SR22                           |

Source: FAA Order JO 7110.126B

# FAA and ICAO Aircraft Types

- Sources to understand the FAA/ ICAO aircraft designators:

| A         | B              | C            | D                  |
|-----------|----------------|--------------|--------------------|
| ICAO_Code | FAA_Designator | Manufacturer | Model_FAA          |
| A20N      | A20N           | AIRBUS       | Airbus A320 Neo    |
| A21N      | A21N           | AIRBUS       | Airbus A321 Neo    |
| A306      | A306           | AIRBUS       | Airbus A300 B4-600 |
| A30B      | A30B           | AIRBUS       | Airbus A300-B2     |
| A310      | A310           | AIRBUS       | Airbus A310        |
| A318      | A318           | AIRBUS       | Airbus A318        |
| A319      | A319           | AIRBUS       | Airbus A319        |

Aircraft characteristics database

[https://www.faa.gov/airports/engineering/aircraft\\_char\\_database](https://www.faa.gov/airports/engineering/aircraft_char_database)

## Aircraft Performance Database



ICAO   
Group   
Name   
  
   
You filtered based on: ICAO Code includes a320.



# A320

A320  
by AIRBUS

Type: L2J    WTC: M    RECAT-EU: Upper Medium    APC: C

|                                                |                                                  |                                                  |                                                                            |                                      |
|------------------------------------------------|--------------------------------------------------|--------------------------------------------------|----------------------------------------------------------------------------|--------------------------------------|
| Initial Climb<br>ROC 2500 ft/min<br>IAS 175 kt | Climb to FL 150<br>ROC 2000 ft/min<br>IAS 290 kt | Climb to FL 240<br>ROC 1400 ft/min<br>IAS 290 kt | Cruise<br>Ceiling FL 390<br>ROC 1000 ft/min<br>TAS 450 kt<br>Mach No. 0.79 | Approach<br>IAS 250 kt<br>MCS 210 kt |
|------------------------------------------------|--------------------------------------------------|--------------------------------------------------|----------------------------------------------------------------------------|--------------------------------------|

Eurocontrol Aircraft performance database

<https://contentzone.eurocontrol.int/aircraftperformance/default.aspx?ICAOFilter=a320>

# In-Trail Separation Rules under CWT Standards

Source: FAA Order JO 7110.126B

## WAKE TURBULENCE APPLICATION

g. Separate aircraft by the minima specified in TBL 5-5-1 in accordance with the following:

1. When operating within 2,500 feet and less than 1,000 feet below the flight path of the leading aircraft over the surface of the earth of a Category A, B, C, or D aircraft.

2. When operating within 2,500 feet and less than 500 feet below the flight path of the leading aircraft over the surface of the earth of a Category E aircraft.

3. When departing parallel runways separated by less than 2,500 feet, the 2,500 feet requirement in subparagraph 2 is not required when a Category I aircraft departs the parallel runway behind a Category E aircraft. Issue a wake turbulence cautionary advisory and instructions that will establish lateral separation in accordance with subparagraph 2. Do not issue instructions that will allow the Category I aircraft to pass behind the Category E aircraft.

|        |   | FOLLOWER |      |      |      |        |        |        |      |      |
|--------|---|----------|------|------|------|--------|--------|--------|------|------|
|        |   | A        | B    | C    | D    | E      | F      | G      | H    | I    |
| LEADER | A |          | 5 NM | 6 NM | 6 NM | 7 NM   | 7 NM   | 7 NM   | 8 NM | 8 NM |
|        | B |          | 3 NM | 4 NM | 4 NM | 5 NM   | 5 NM   | 5 NM   | 5 NM | 5 NM |
|        | C |          |      |      |      | 3.5 NM | 3.5 NM | 3.5 NM | 5 NM | 5 NM |
|        | D |          | 3 NM | 4 NM | 4 NM | 5 NM   | 5 NM   | 5 NM   | 5 NM | 5 NM |
|        | E |          |      |      |      |        |        |        |      | 4 NM |
|        | F |          |      |      |      |        |        |        |      |      |
|        | G |          |      |      |      |        |        |        |      |      |
|        | H |          |      |      |      |        |        |        |      |      |
|        | I |          |      |      |      |        |        |        |      |      |

Empty Cells: Apply Minimum Radar Separation  
 3 nm default  
 2.5 nm for runways that meet a 50 second  
 Runway Occupancy Time criteria



# Implications of Aircraft Wake Classes

- In-trail aircraft separations are determined by wake class groups
- Runway capacity today is usually limited by in-trail separations
- In the future runway occupancy times may also be important

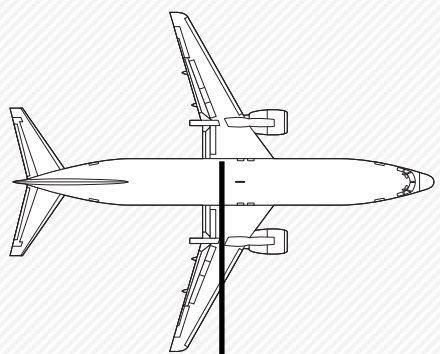


# Example # 3

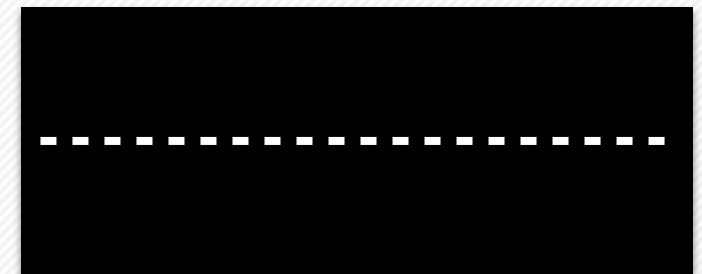
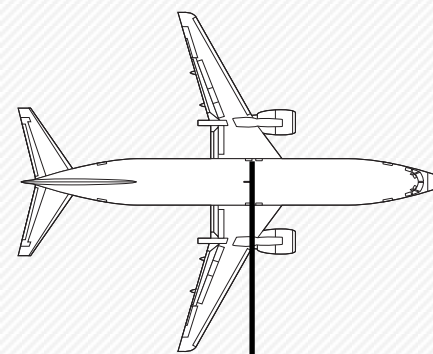
- Estimate the approximate arrival capacity to a single runway at La Guardia airport with 100% of the arrivals belong to the large wake class (Category F under CWT)
- Assume the typical approach speed of arrivals is 140 knots from the final approach fix to the runway



Runway 22 at LGA



2.5 nm + 20 second buffer



Runway 22  
at LGA

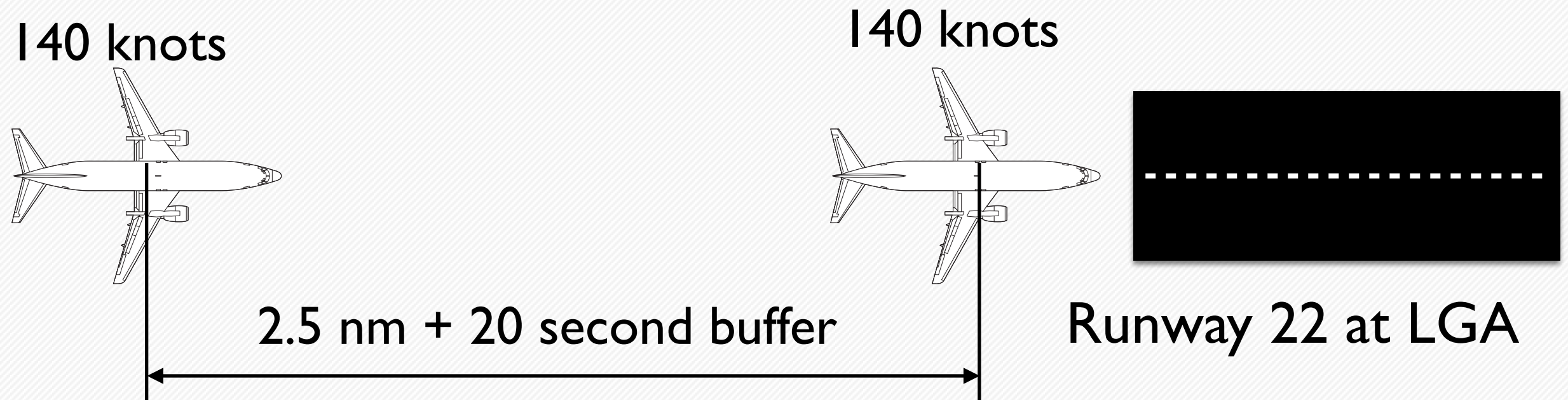
# Example # 3 (cont.)

- A 2.5 nautical miles + 20 second buffer translates into a headway (i.e., time between successive arrivals) of :

$$headway = \left\{ \frac{2.5nm}{140nm/hr} \right\} 3600s/hr + 20s = 84.3s$$

- The arrival capacity is the inverse of headway

$$C_{arrivals} = \frac{3600s/hr}{84.3s} = 42 \text{ arrivals/hr}$$





# International Air Transport Association (IATA) Classification

Used in the forecast of aircraft movements at an airport based on the IATA forecast methodology.

**IATA Aircraft Size Classification Scheme.**

| Category | Number of Seats | Example Aircraft                    |
|----------|-----------------|-------------------------------------|
| 0        | < 50            | Embraer 120, Saab 340               |
| 1        | 50-124          | Fokker 100, Boeing 717              |
| 2        | 125-179         | Boeing B727-200, Airbus A321        |
| 3        | 180-249         | Boeing 767-200, Airbus A300-600     |
| 4        | 250-349         | Airbus A340-300, Boeing 777-200     |
| 5        | 350-499         | Boeing 747-400                      |
| 6        | > 500           | Boeing 747-400 high density seating |

# Other Classifications that You Will Read About in Trade Magazines

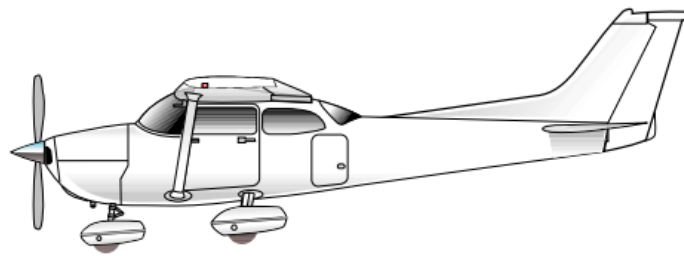
Aircraft classification based on the aircraft use

- General aviation aircraft (GA)
- Corporate aircraft (CA)
- Commuter aircraft (COM)
- Transport aircraft (TA)
- Short-range
- Medium-range
- Long-range

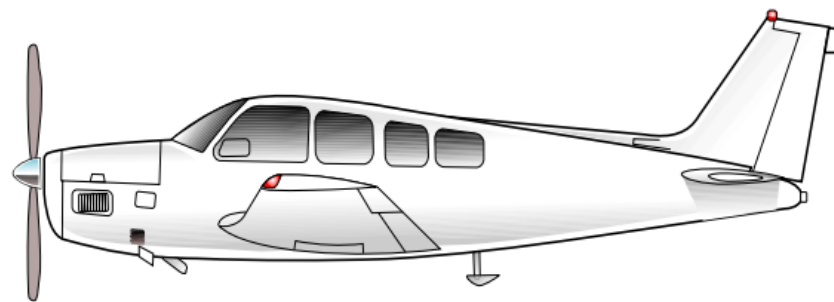
# General Aviation Aircraft

Typically these aircraft can have one (single engine) or two engines (twin engine). Their maximum gross weight is below 14,000 lb.

**Single-Engine GA**

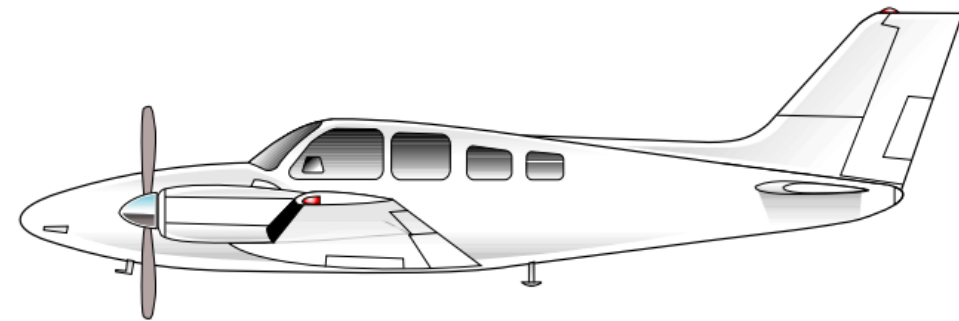


Cessna 172 (Skyhawk)

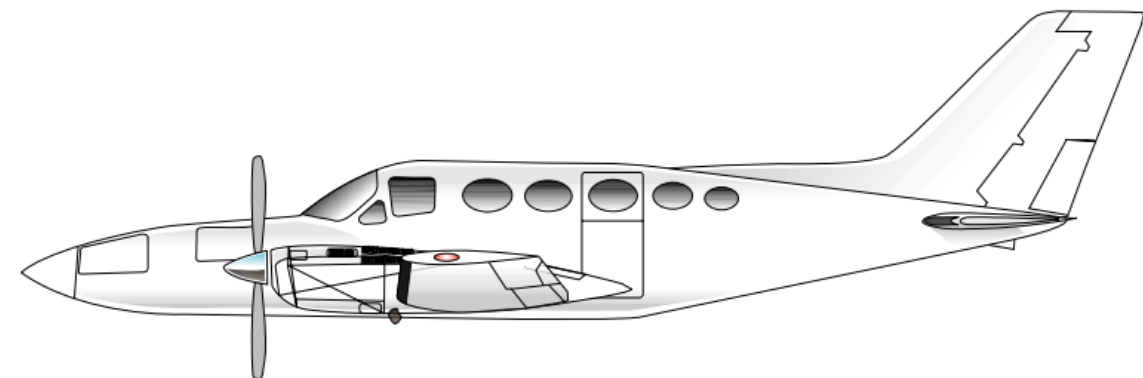


Beechcraft A36 (Bonanza)

**Twin-Engine GA**



Beechcraft 58TC (Baron)



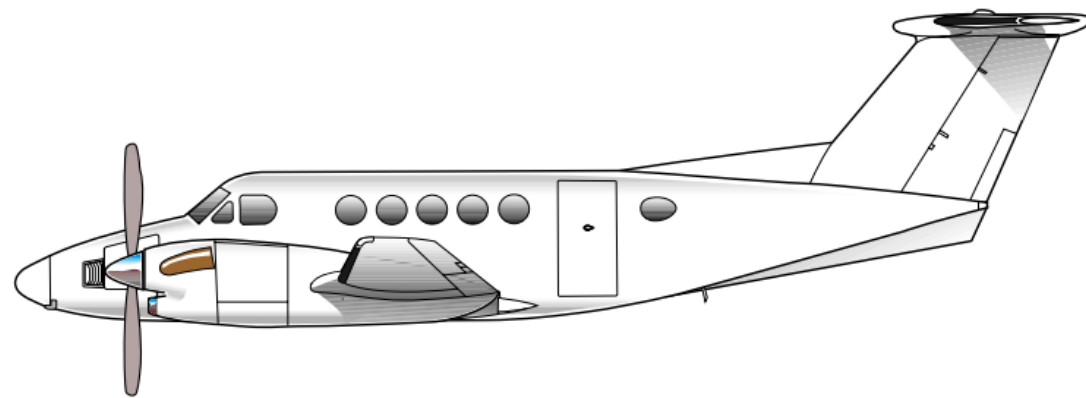
Cessna 421C (Golden Eagle)



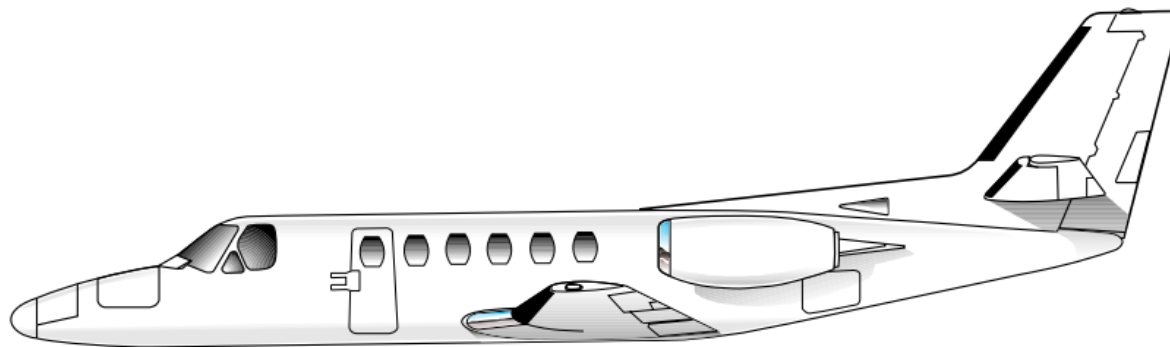
# Corporate Aircraft

Typically these aircraft can have one or two turboprop driven or jet engines (sometimes three). Maximum gross mass is up to 40,910kg (90,000 lb)

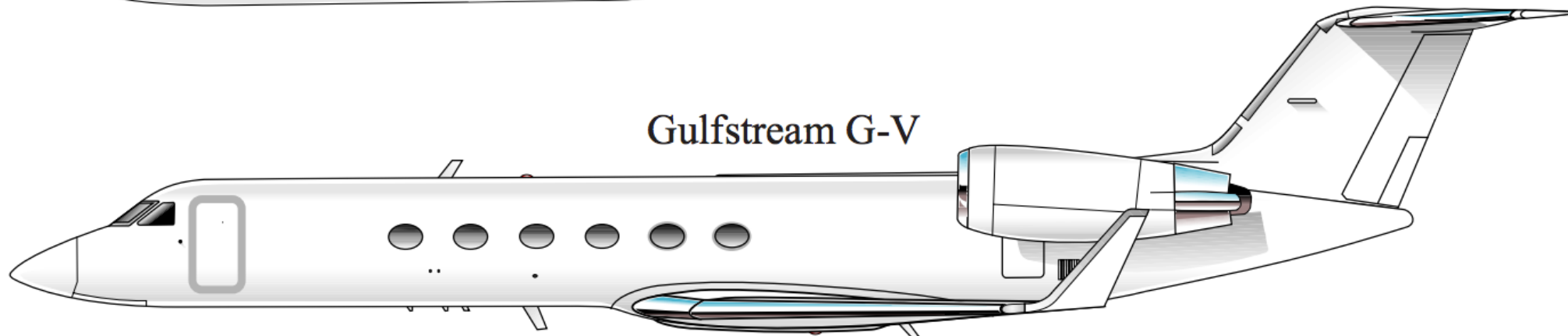
Raytheon-Beechcraft  
King Air B300



Cessna Citation II



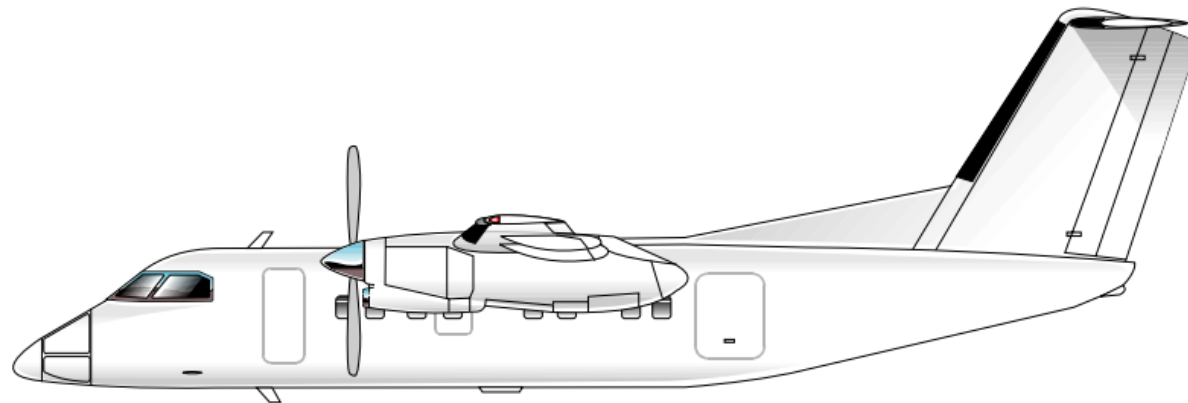
Gulfstream G-V



# Commuter Aircraft

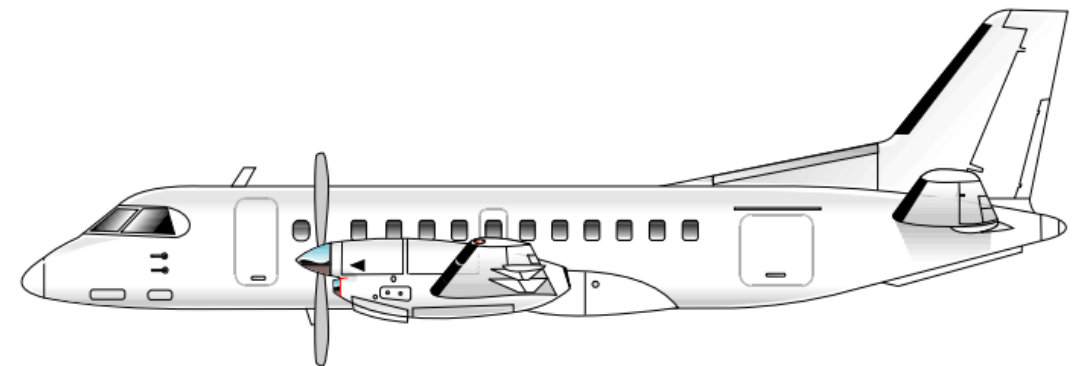
Usually twin engine aircraft with a few exception such as DeHavilland DHC-7 which has four engines. Their maximum gross mass is below 31,818kg (70,000 lb)

Fairchild Swearingen Metro 23

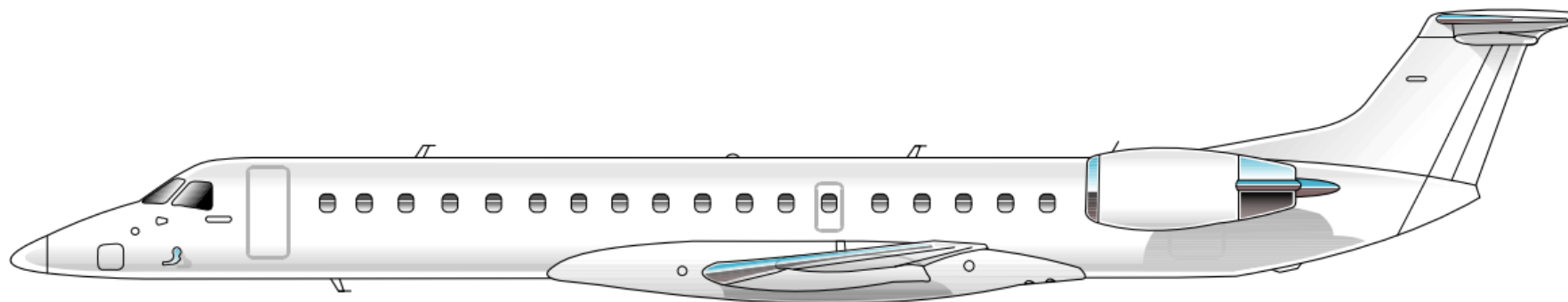


Bombardier DHC-8

Saab 340B

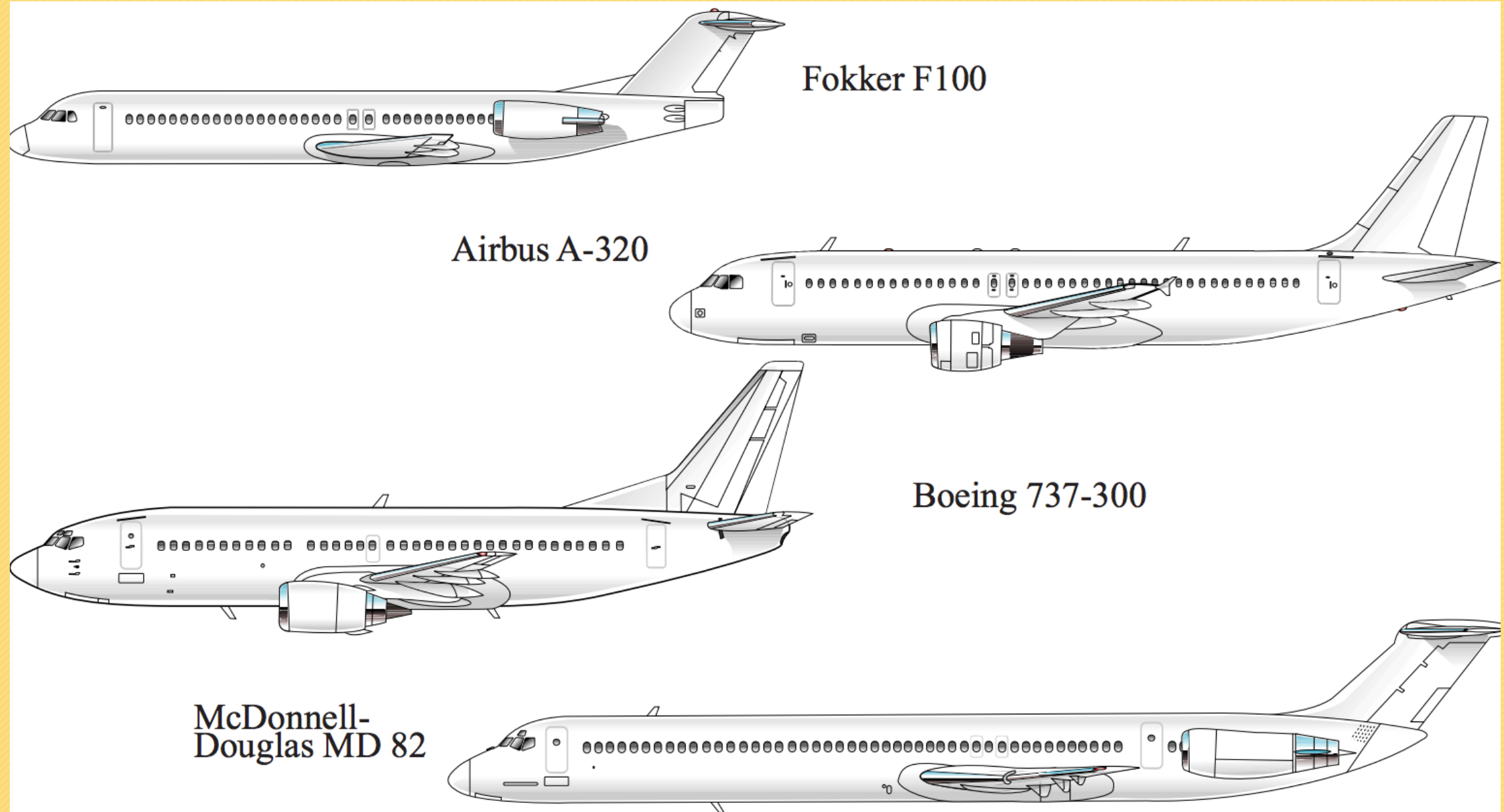


Embraer 145



# Short-Range Transport Aircraft

Certified under FAR/JAR 25. Their maximum gross mass usually is below 68,182kg (150,000 lb.)

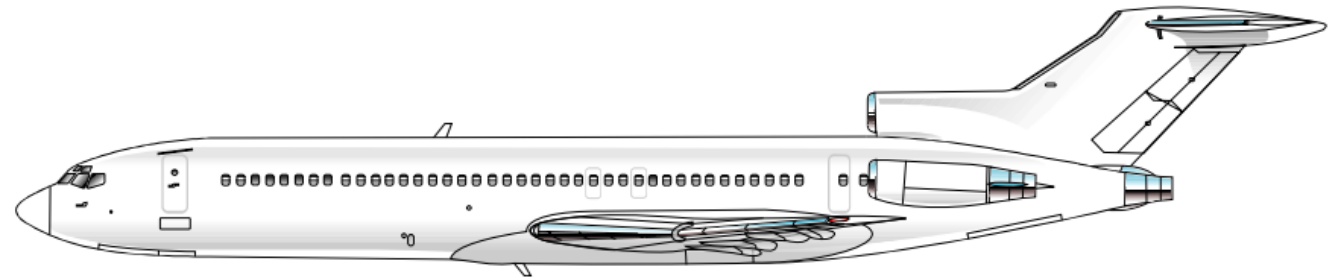




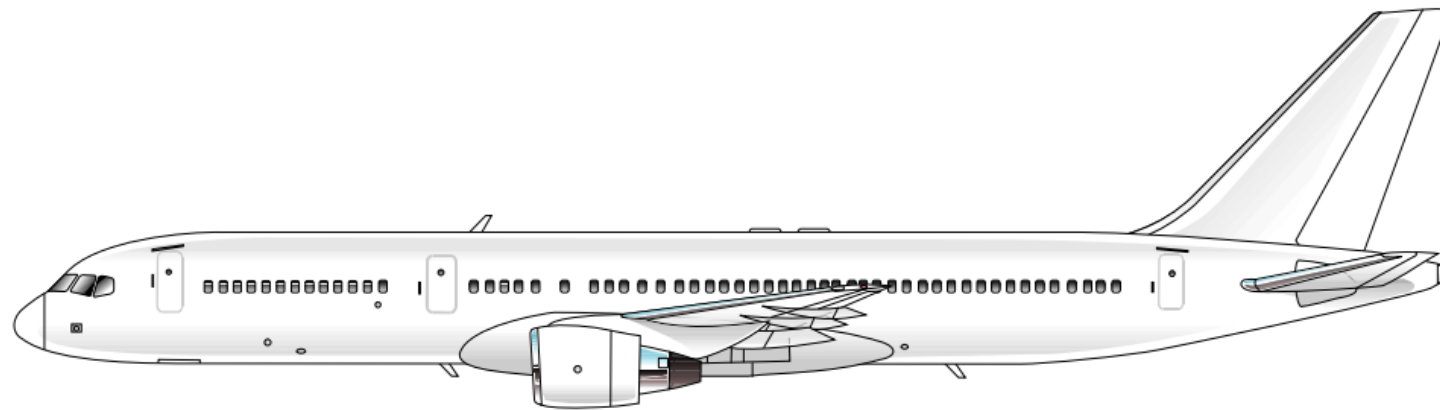
# Medium-Range Transport Aircraft

These are transport aircraft employed to fly routes of less than 3,000 nm (typical). Their maximum gross mass usually is below 159,090kg (350,000 lb.)

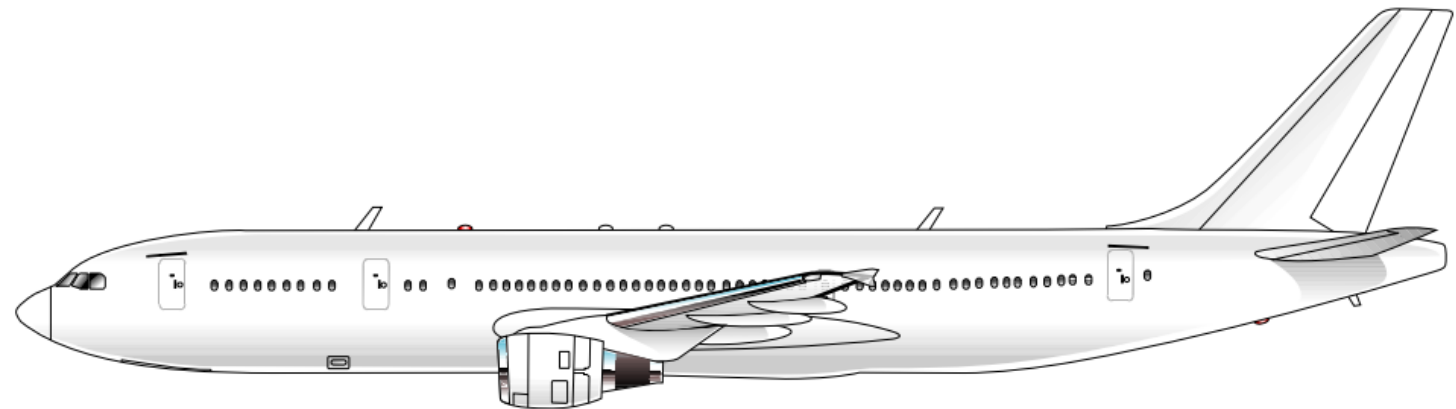
Boeing B727-200



Boeing 757-200



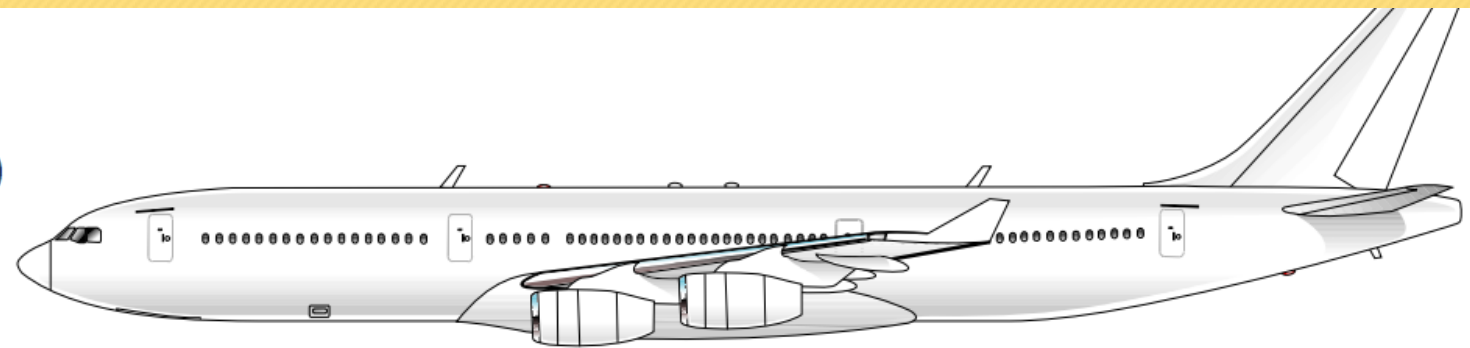
Airbus A300-600R



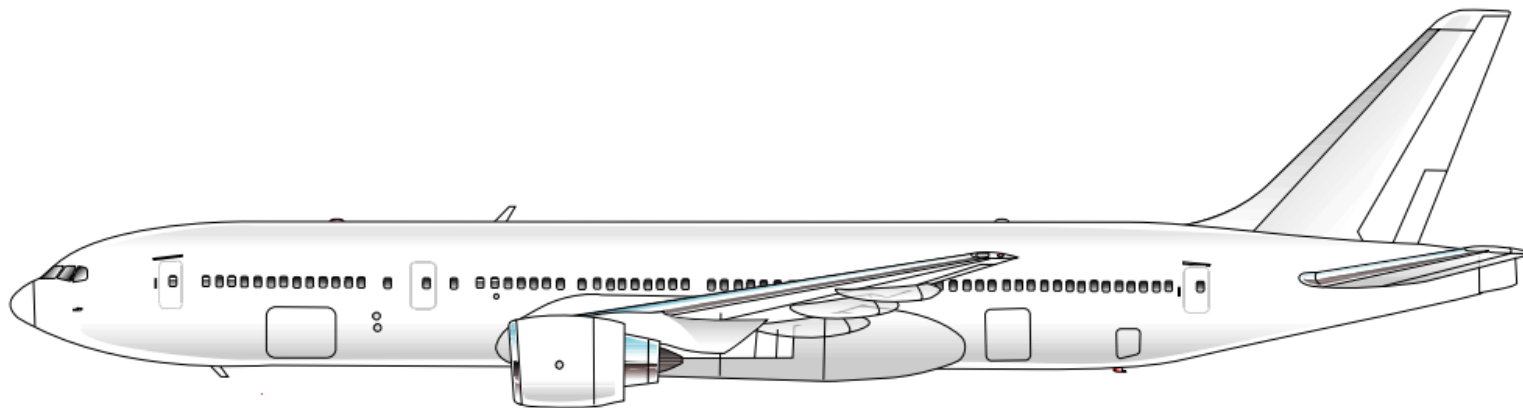
# Long-Range Transport Aircraft

These are transport aircraft employed to fly routes of more than 3,000 nm (typical). Their maximum gross mass usually is above 159,090kg (350,000 lb.)

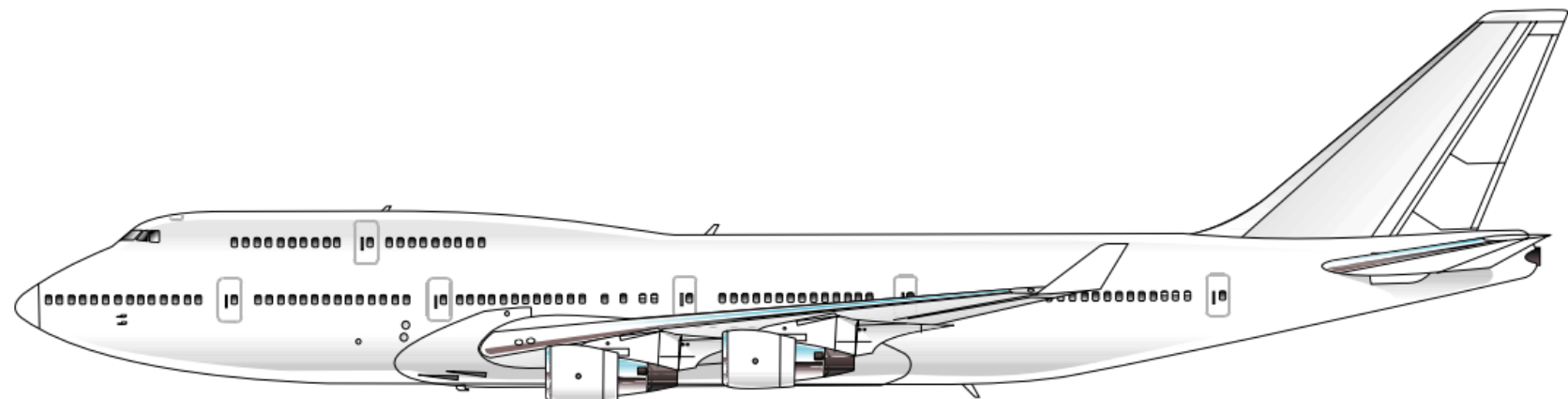
Airbus A340-200



Boeing 777-200



Boeing 747-400



# Aircraft Trends

Very large capacity aircraft

- Airbus A380 and Boeing 747-8

New generation long-range transport

- Boeing 787 and Airbus A350

New generation short range aircraft

- Airbus A220, Comac 919 and Irkut MC-21



# Very Large Capacity Aircraft

- Airbus A380 was introduced into service in 2008
- Boeing 747-8 was introduced in 2012



A380-800 at LAX Airport (A.Trani)

# Tradeoffs in the Design of Aircraft

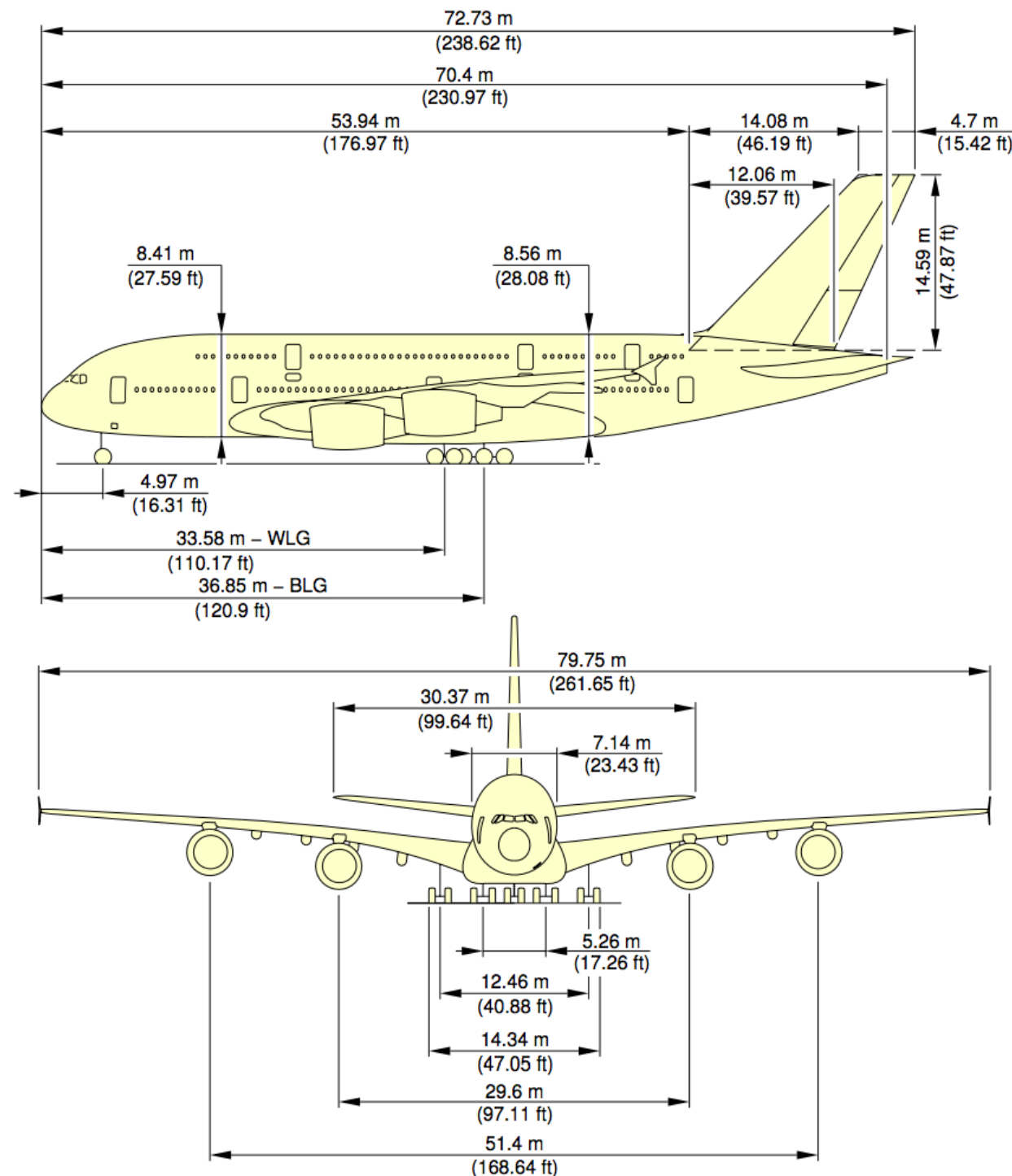
- Aircraft designed purely on aerodynamic principles would be costly to the airport operator yet have low Direct Operating Cost (DOC)
- Aircraft heavily constrained by current airport design standards might not be very efficient to operate
- Adaptations of aircraft to fit airports can be costly  
Some impact on aerodynamic performance
- Weight considerations (i.e., landing gear design)
- Tradeoffs are needed to address all these issues

# Impacts of Very Large Capacity Aircraft

- Large capacity aircraft requirements
- Airside infrastructure impacts (taxiways and runways)
- Runway capacity impacts
- Airport terminal impacts (gates and aprons)
- Pavement design considerations
- Noise considerations

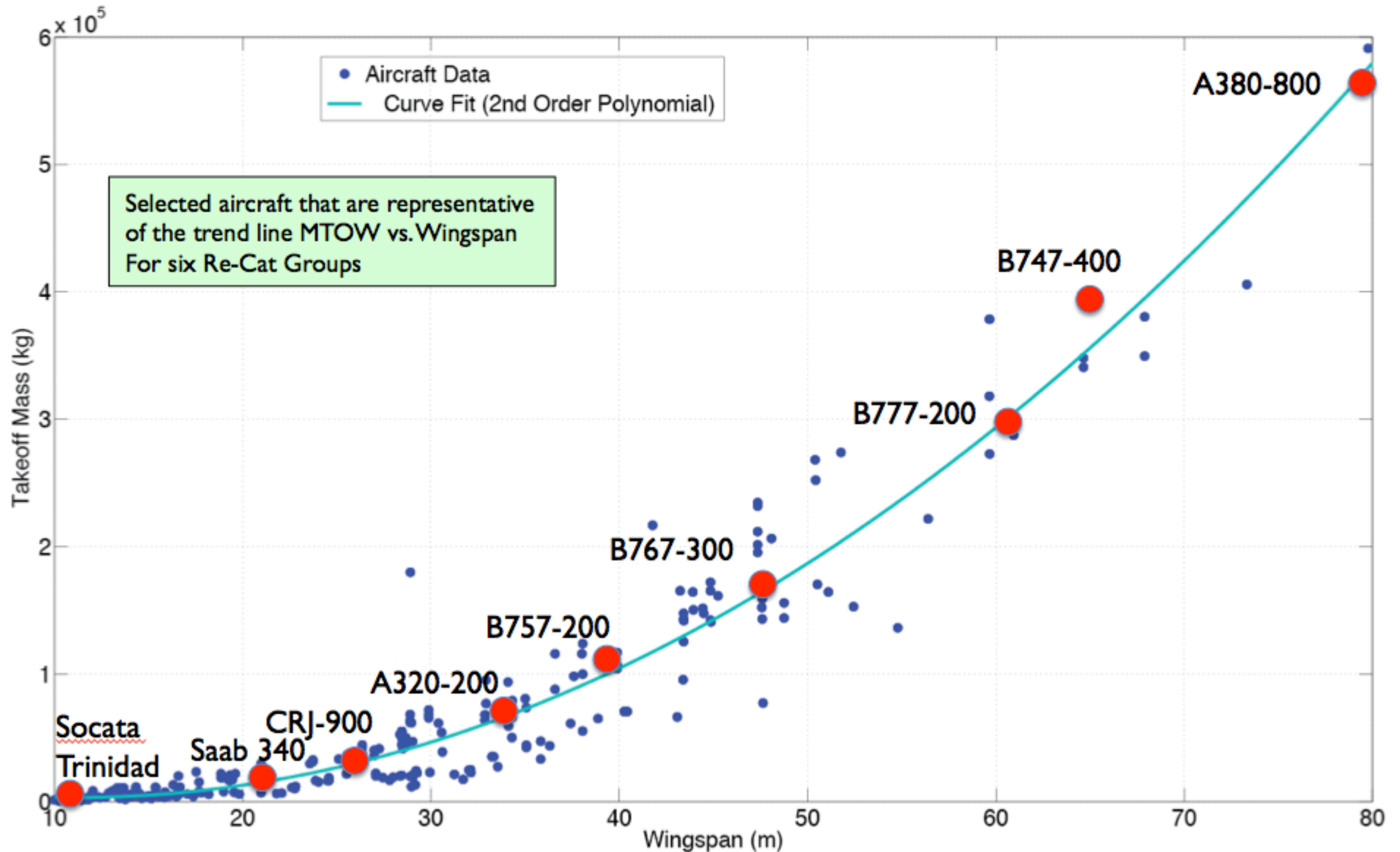


# Very Large Capacity Aircraft: Airbus A380-800

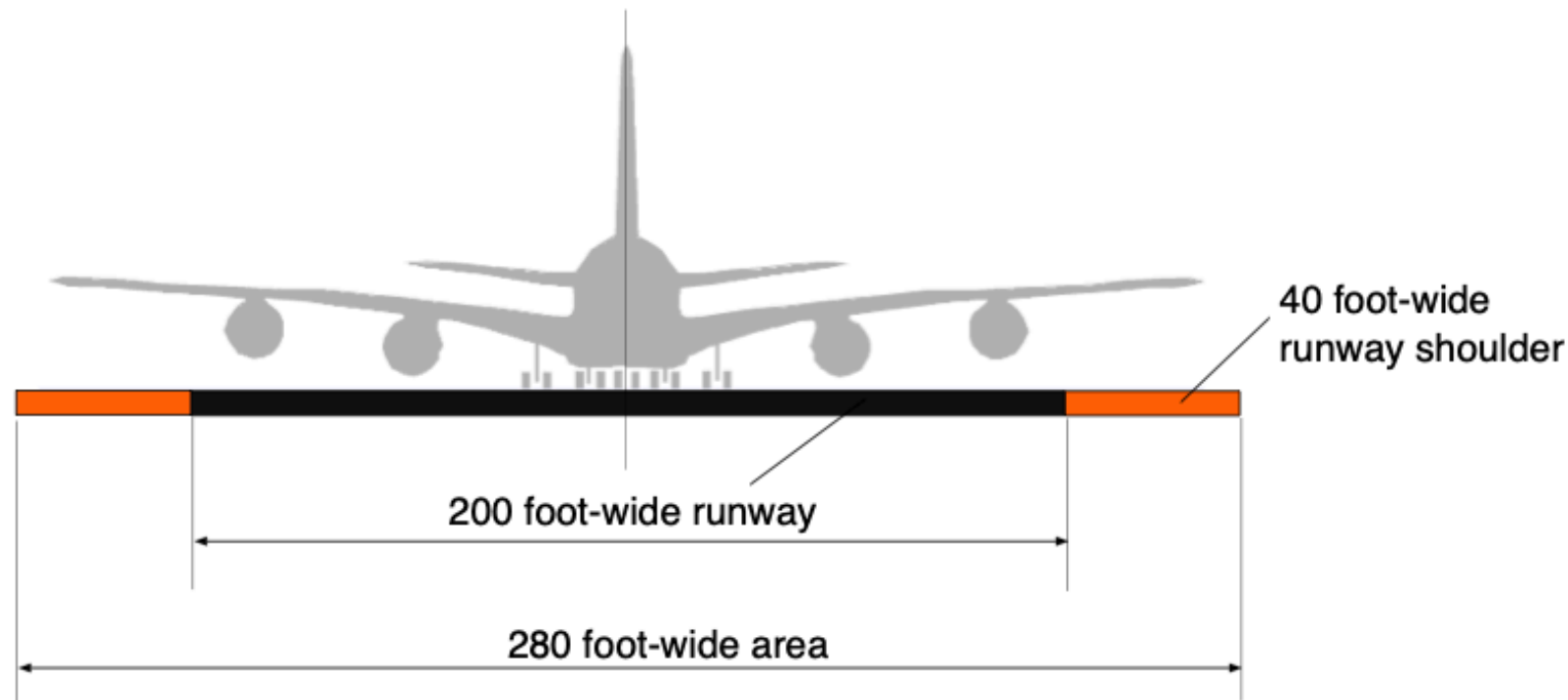


Source: Airbus

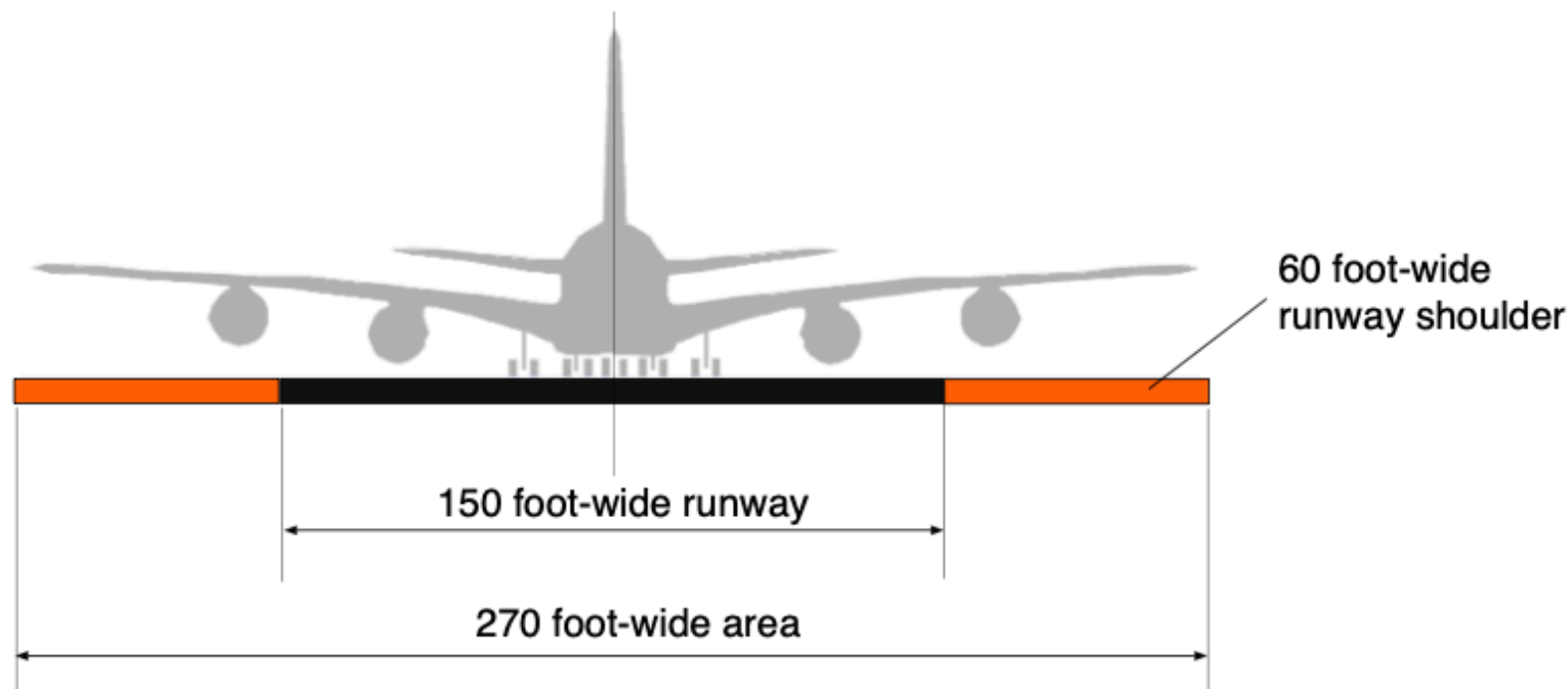
# Evolution of Aircraft Mass and Wingspan



# Very Large Capacity Aircraft Runway and Taxiway Requirements

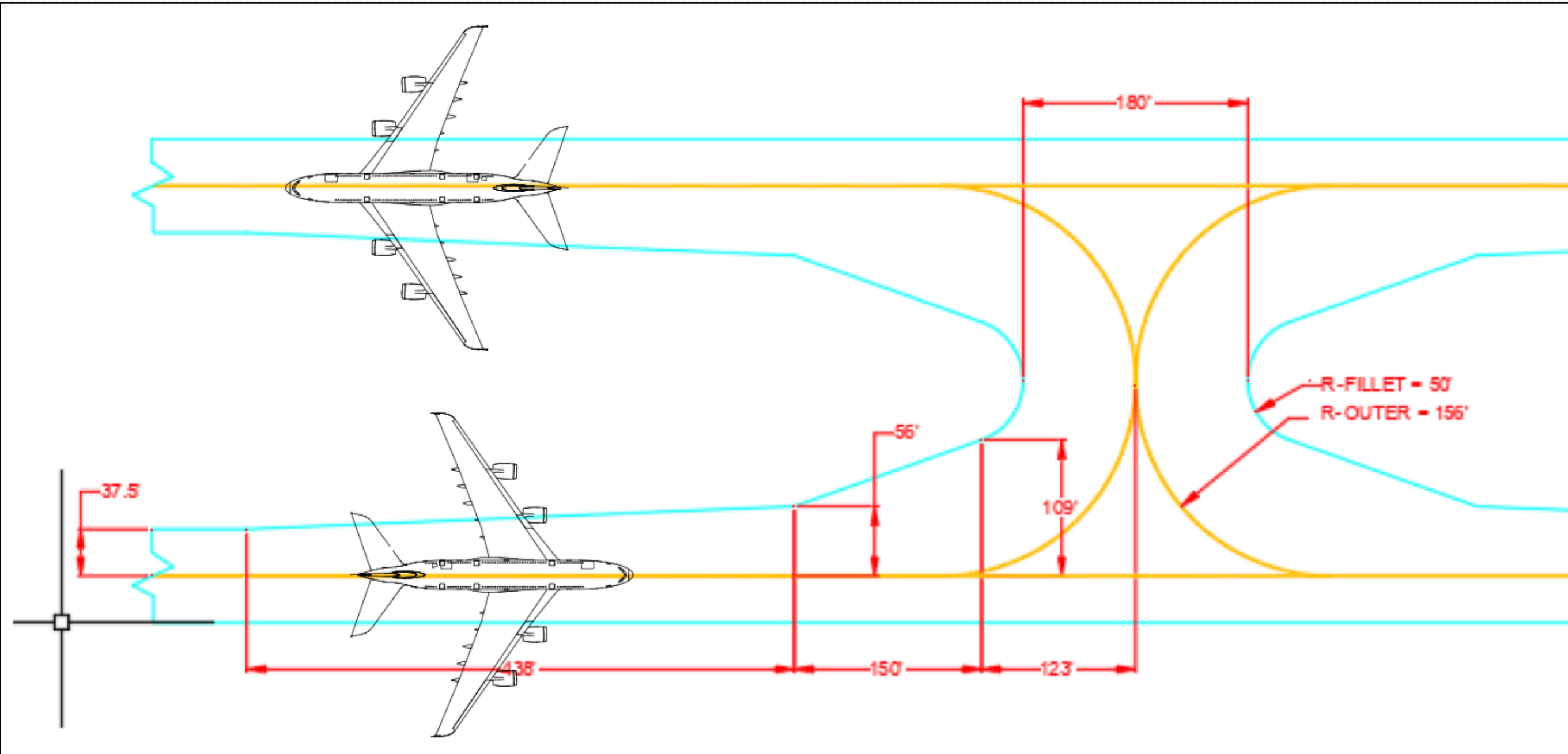


Very large capacity aircraft require wider runways and wider taxiways



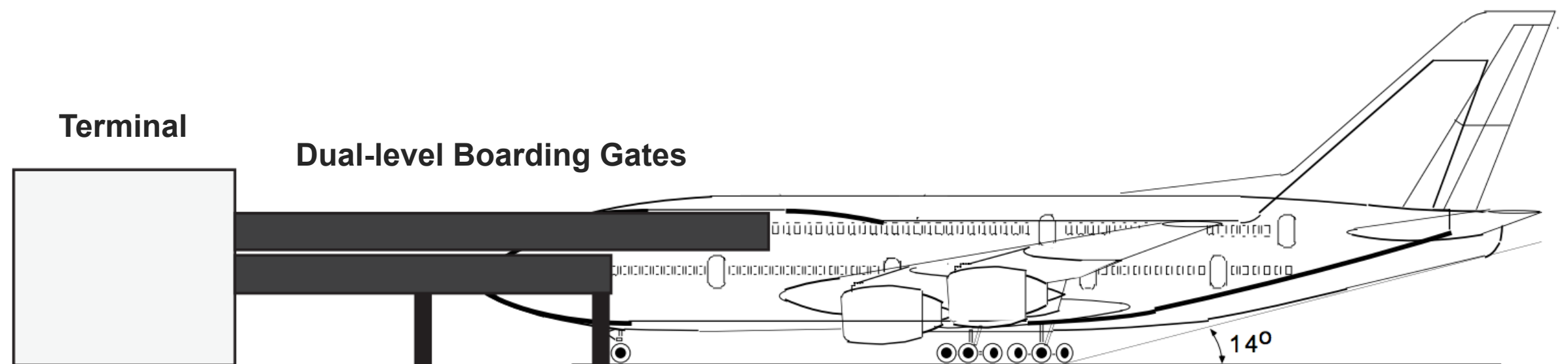


# Large Capacity Aircraft Require Larger Maneuvering Envelopes



# Airport Terminal Impacts

Large capacity aircraft require more complex gate interfaces to expedite the enplaning/ deplaning of passengers



Two-level  
configuration

Upper and lower  
deck doors

