

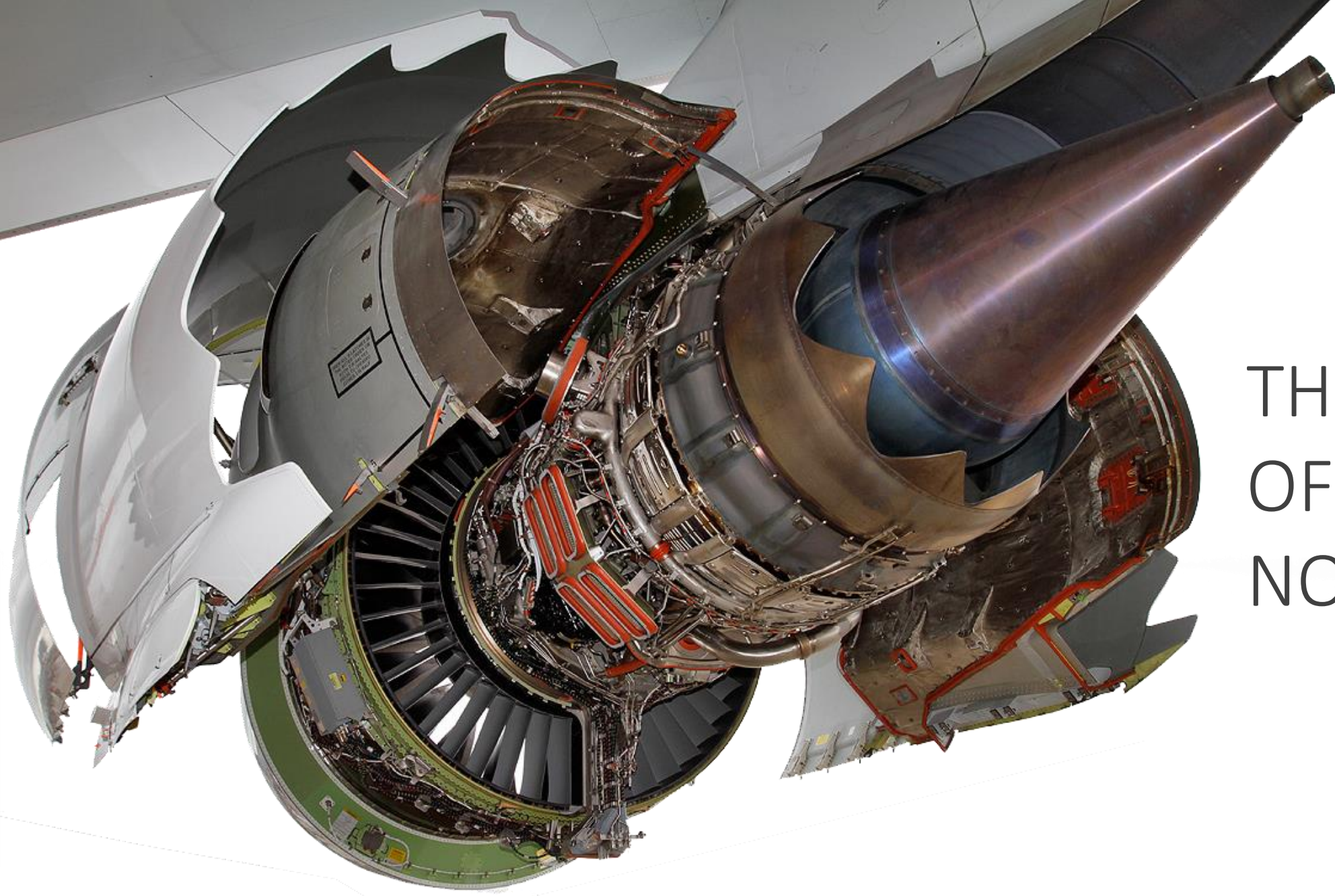


# UC DAVIS AVIATION SYMPOSIUM NOISE 101

March 1, 2020 – San Diego, CA

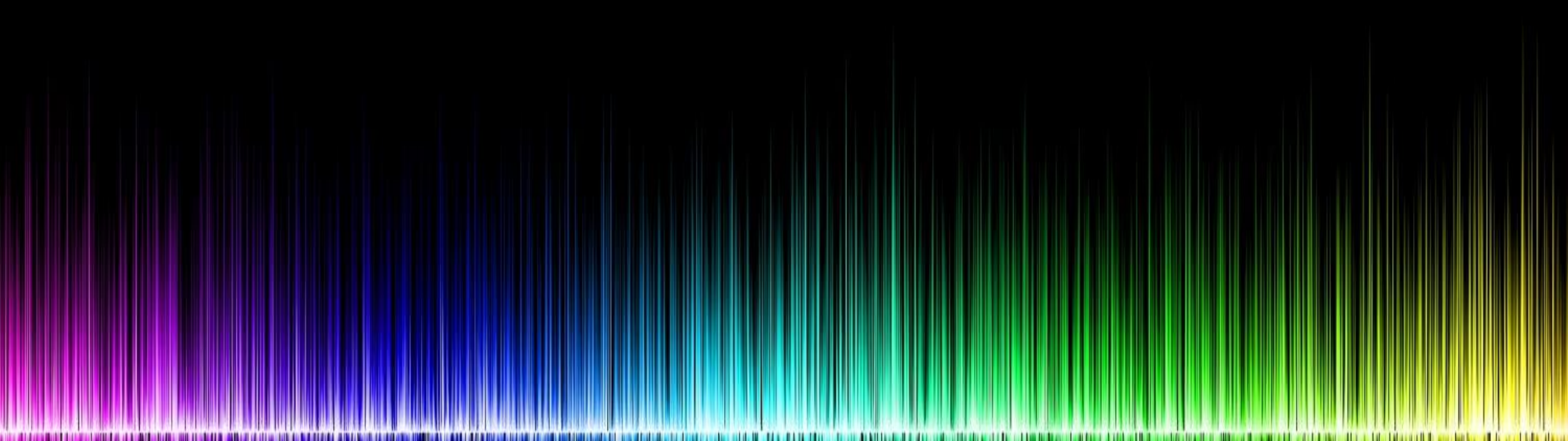
# FLIGHT PLAN

TOPIC	PRESENTER	TIME
Introduction/Ice Breaker	Steve & Greg	12:30
Evolution of Aviation Noise	Steve	12:45
Science of Aviation Noise	Greg	13:15
Quantifying Aviation Noise	Steve	13:45
Break	-----	14:15
Regulating Aviation Noise	Steve	14:30
Aircraft Performance and Noise	Greg	15:00
Mitigating Aviation Noise	Steve	15:30
Questions/Wrap up	Steve & Greg	16:00
Session Ends	-----	16:15



# THE SCIENCE OF AVIATION NOISE





# WHAT IS SOUND?

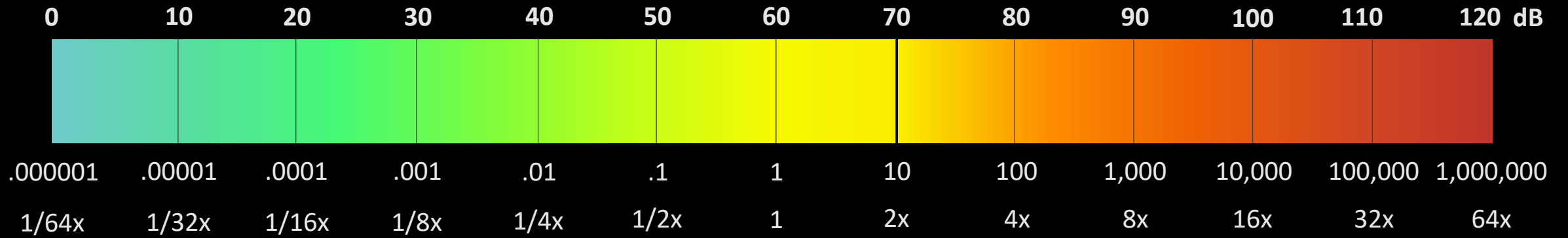
A mechanical wave that results from the vibration of particles

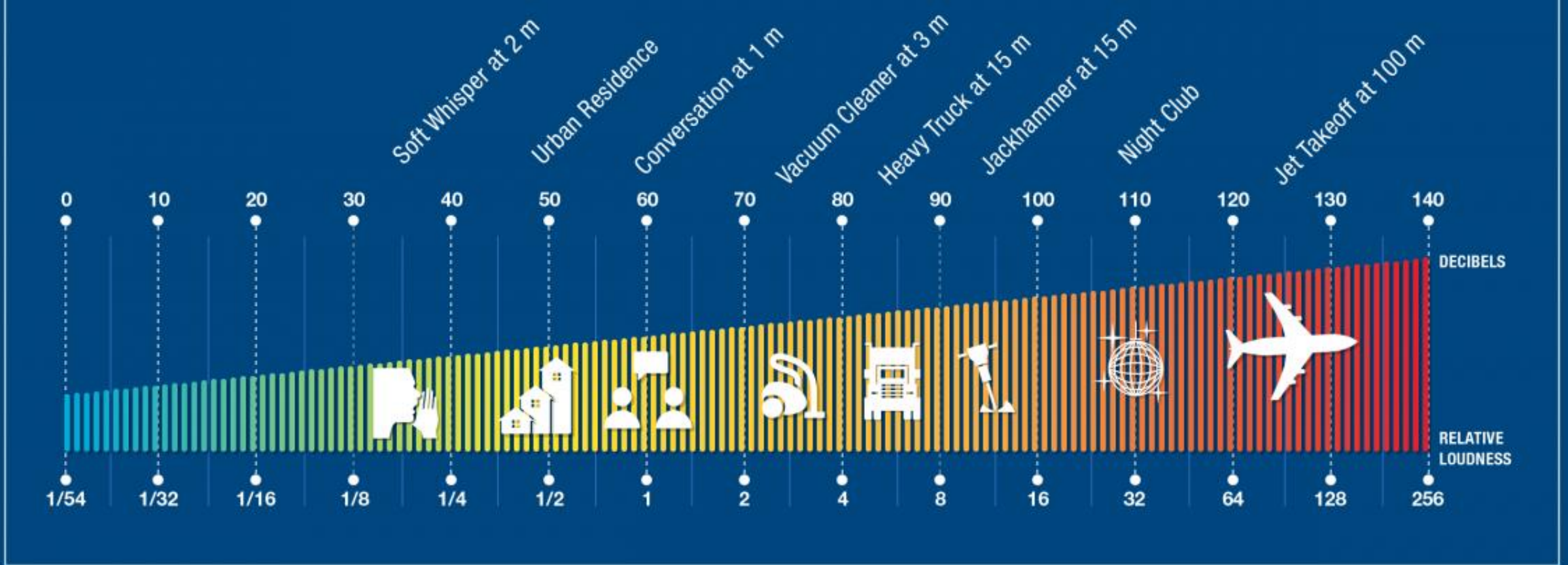


HOW DOES  
SOUND  
TRAVEL?

AIR MOLECULES

# HOW IS SOUND ENERGY MEASURED?





Source: OSHA.gov

# A WEIGHTED SOUND LEVEL (dBA)

A-weighted sound is a sound pressure level, which has been weighted to reduce the influence of the low and high extremes. It has been found to correlate well with the human hearing response and with a person's subjective judgment of the loudness of sounds, and it emphasizes speech frequency bands and de-emphasizes the lower and higher frequencies.

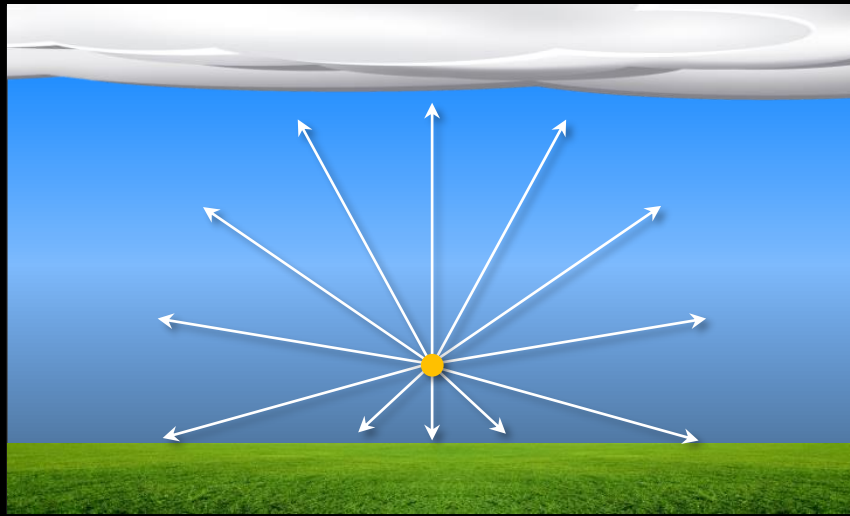
# WHAT DOES A 10 dB INCREASE IN NOISE EQUATE TO?



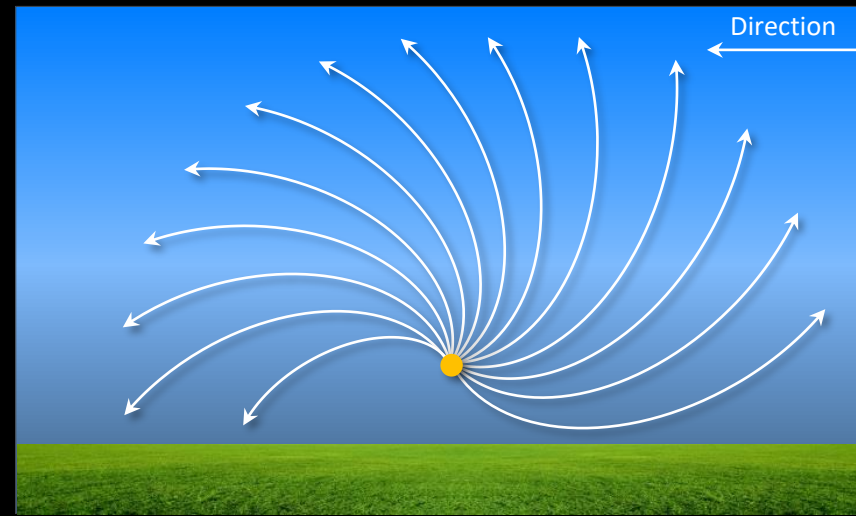
10 dB increase = 10x sound energy but is only perceived to be 2x louder



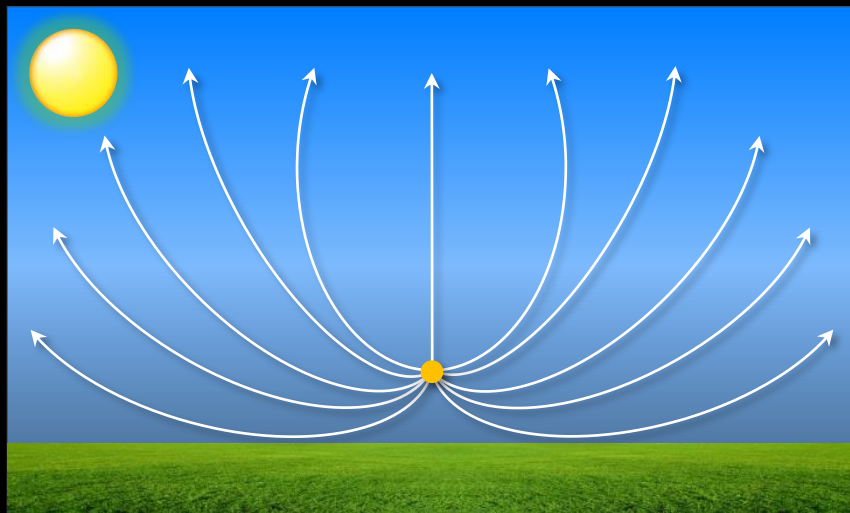
# WEATHER'S EFFECT ON SOUND TRANSMISSION



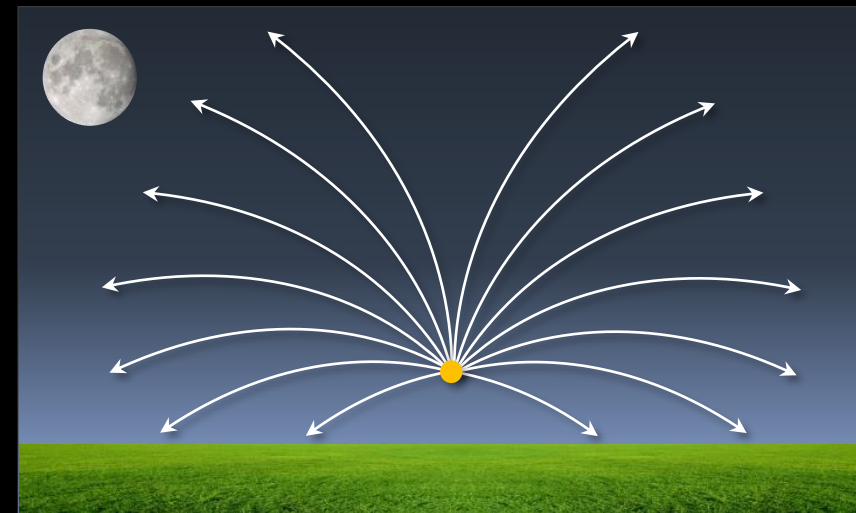
Calm and Cloudy



Windy



Calm and Sunny



Nighttime

# WHAT IS NOISE?

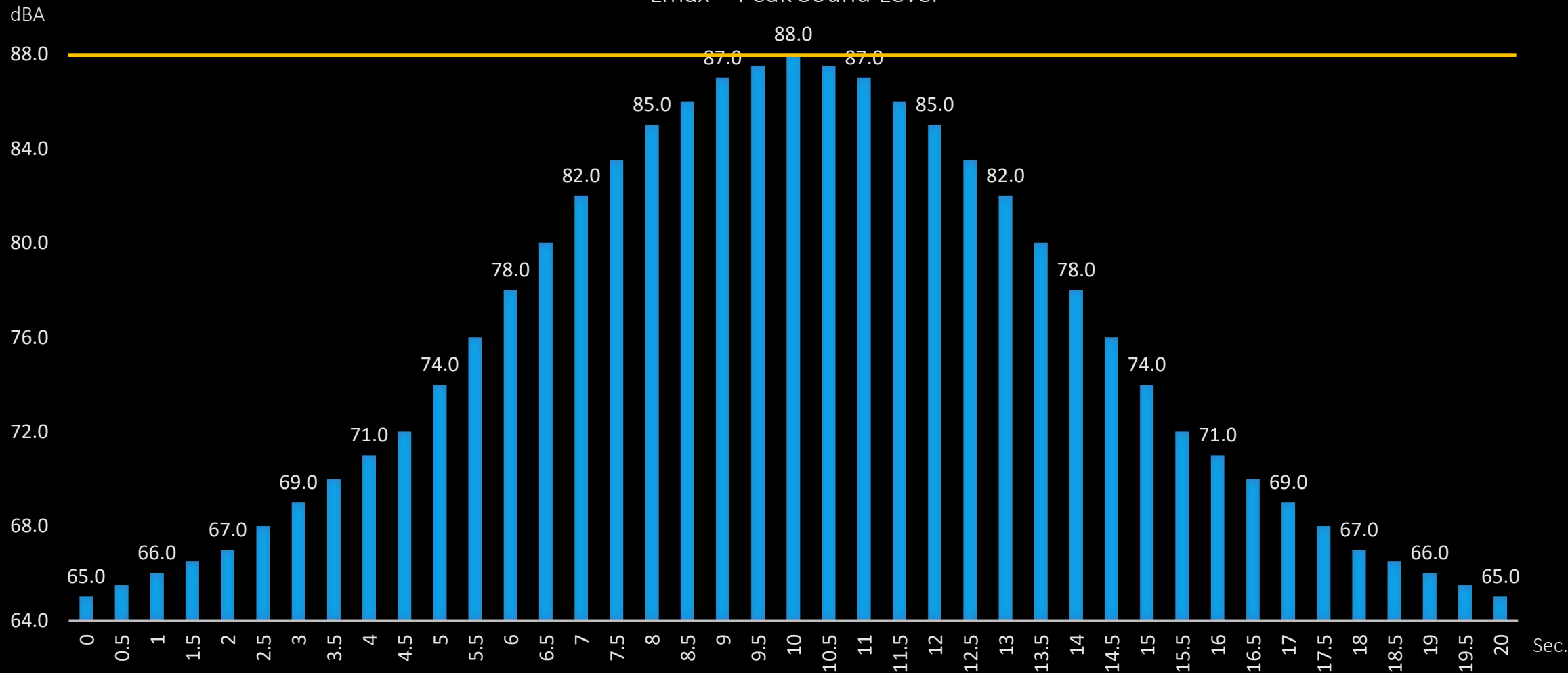


Noise – a sound, especially one that is loud or unpleasant or that causes disturbance. (unwanted sound)

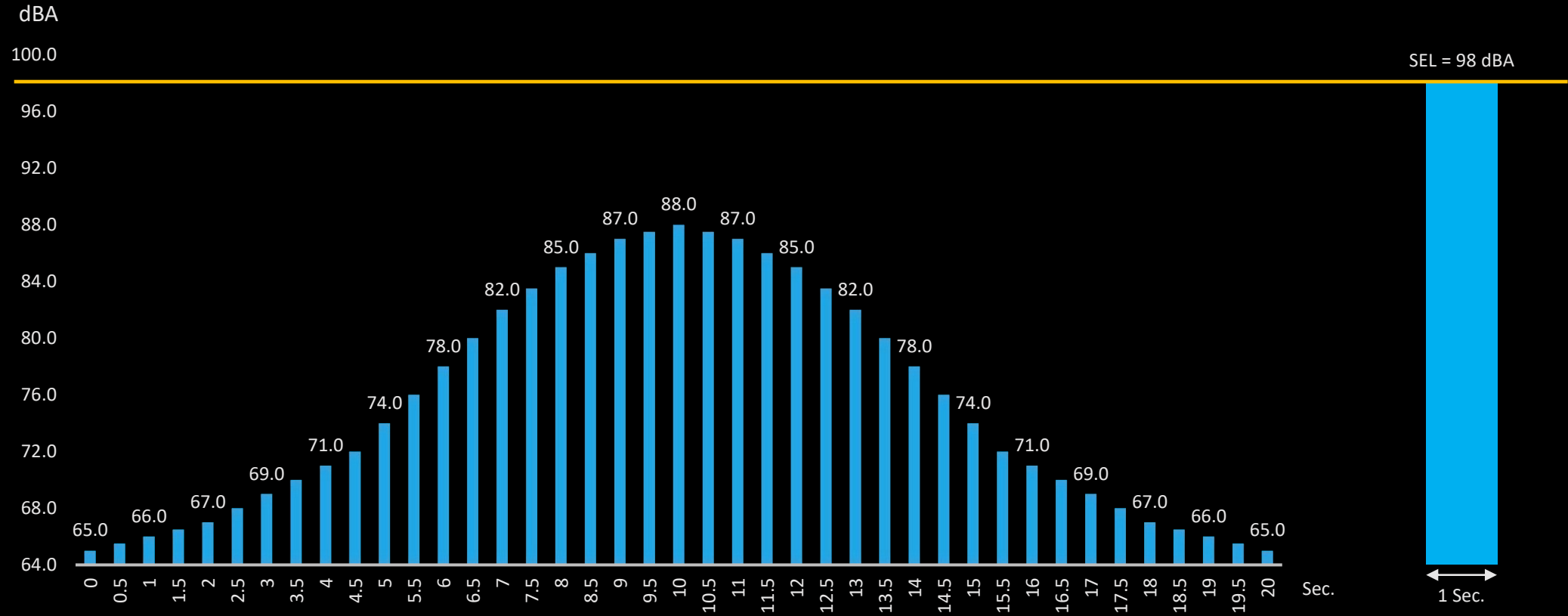


# AIRPLANE NOISE EVENT ACOUSTIC SIGNATURE

Lmax = Peak Sound Level

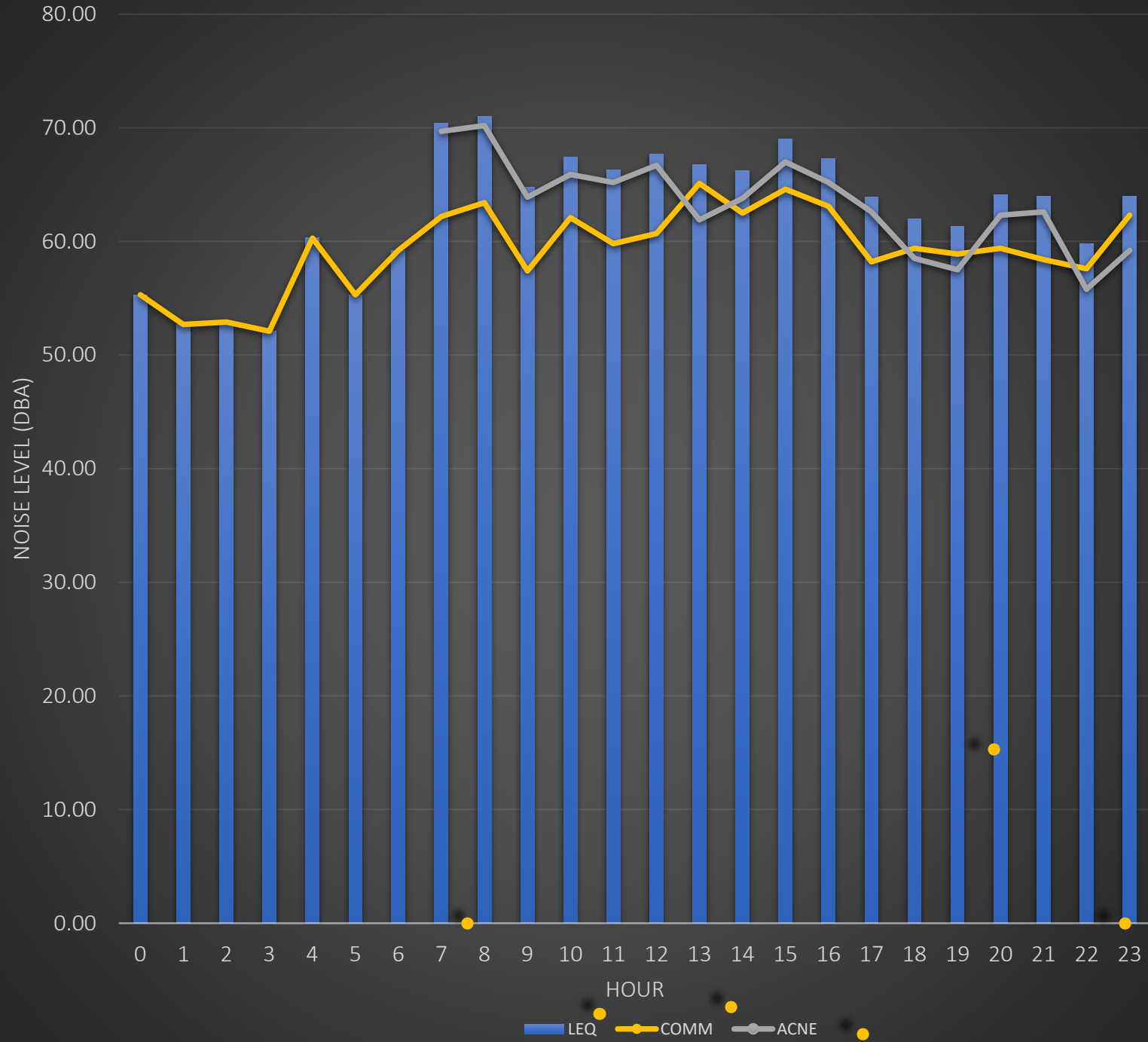


# SOUND EXPOSURE LEVEL



SEL - The sound level that would be experienced if all the sound energy of a single event were compressed into 1 second





## EQUIVELANT SOUND LEVEL (Leq)

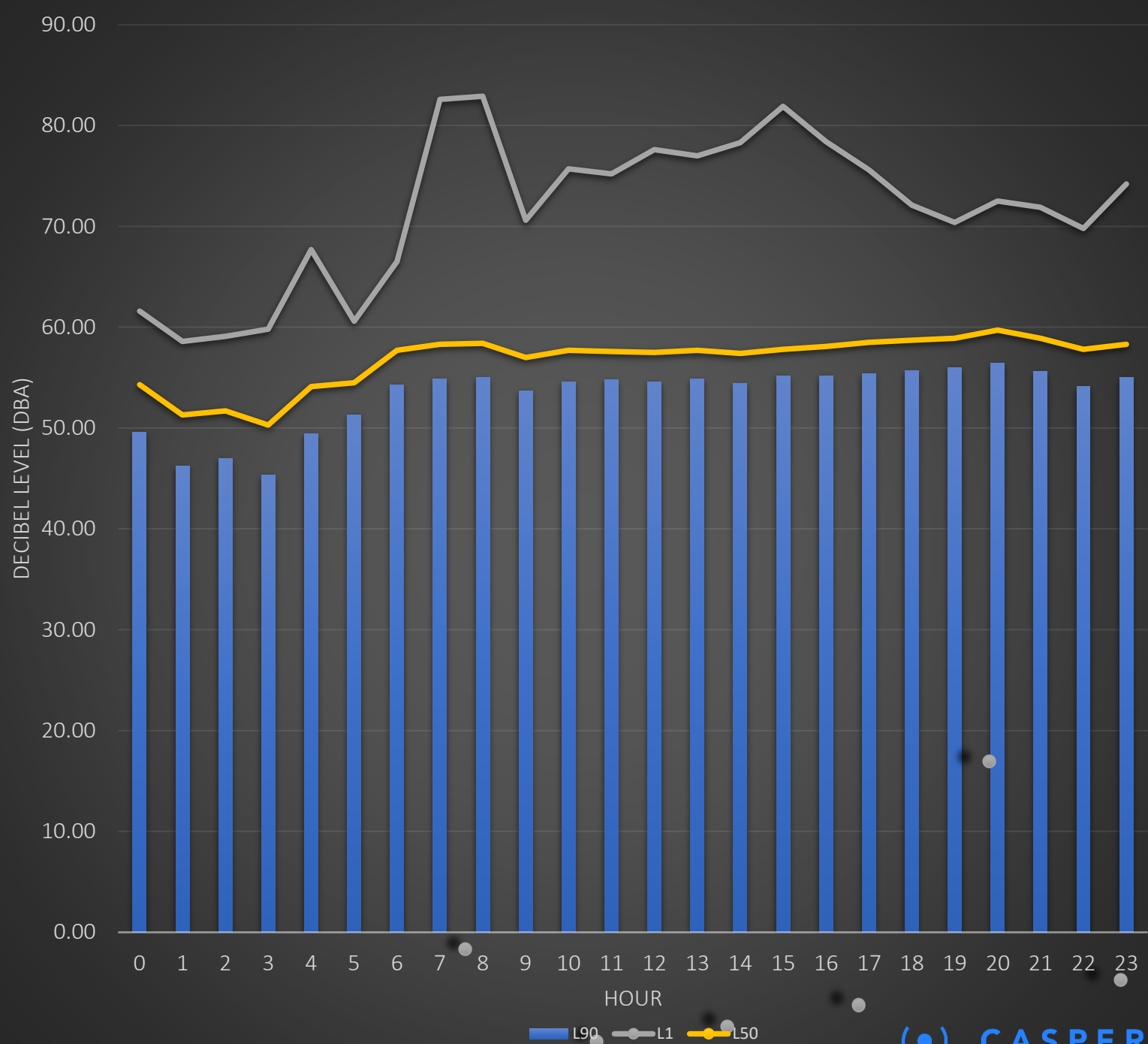
**Leq** – The energy average sound level over a specified period of time usually 1, 8 or 24 hours

Equivalent signifies that the total acoustical energy associated with the fluctuating sound (during the specified time period) is equal to the total acoustical energy associated with the steady sound level of Leq for the same specified period of time.

# STATISTICAL NOISE LEVEL (Ln)

Ln – The statistical percentage of time the noise level exceeds a certain value for a defined period of time.

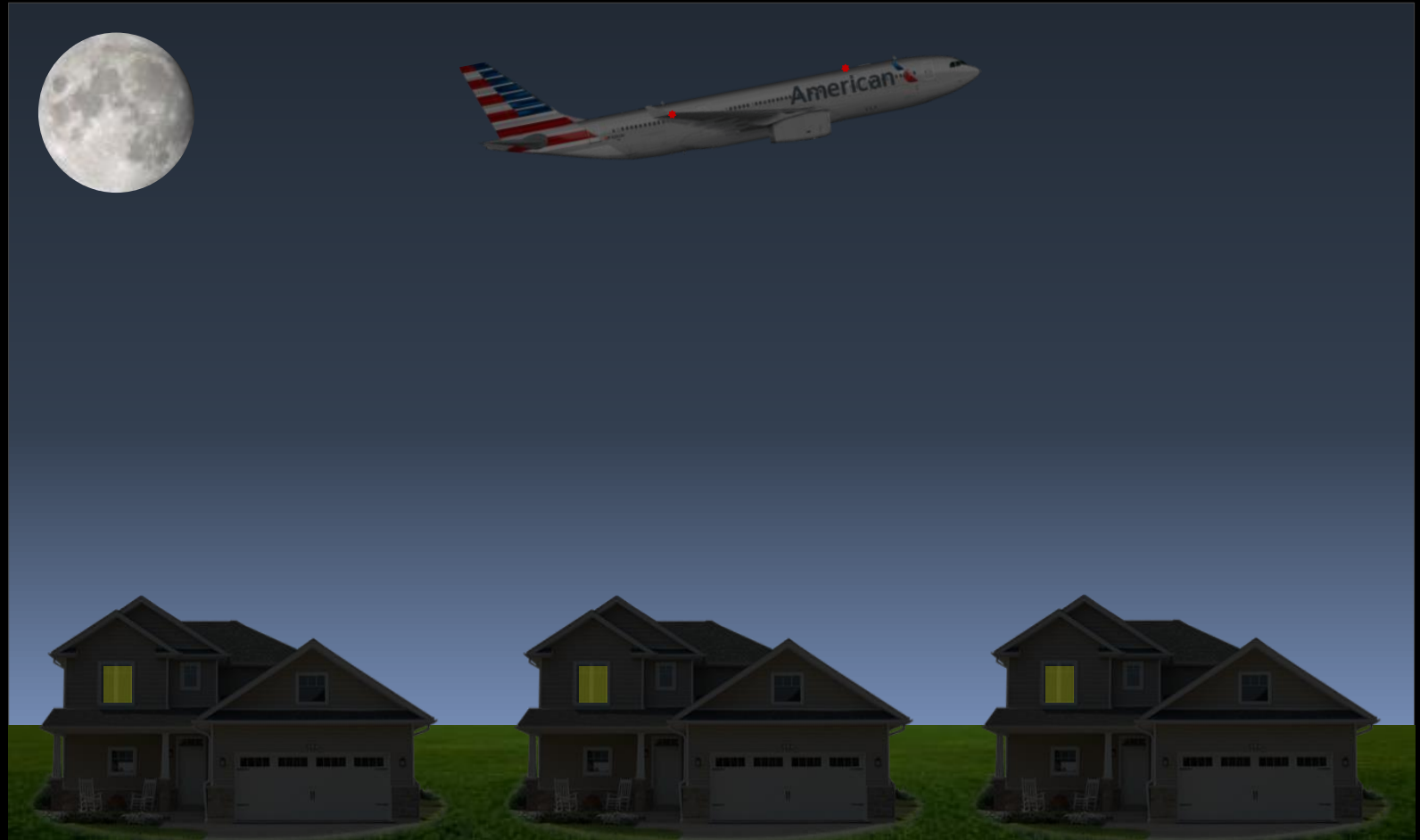
Common values are L10, L50, L90 and L95. For example 70dBA L10 (18 hours)



L90 L1 L50

# DAY NIGHT AVERAGE SOUND LEVEL (DNL)

- DNL was introduced as a simple method for predicting the effects on a population of the average long-term exposure to noise.
- DNL is an enhancement of the Equivalent Sound Level (Leq) metric through the addition of a 10 dB penalty for nighttime (10 p.m. to 7 a.m.) noise intrusions.
- The incorporation of the 10 dB penalty is in recognition of the increased annoyance that is generally associated with noise during the late night and early morning.
- DNL employs the same energy equivalent concept as Leq and uses a 24 hour time integration period.



# DNL NIGHTTIME NOISE PENALTY

DAYTIME AIRCRAFT NOISE



1 Event = 1 Event

NIGHTTIME AIRCRAFT NOISE



1 Event = 10 Events

Aircraft operations between the hours of 10 pm and 7 am have a 10 dB penalty added to them to account for the lower ambient noise levels in communities, which increases the likelihood of these events causing annoyance and sleep disturbance

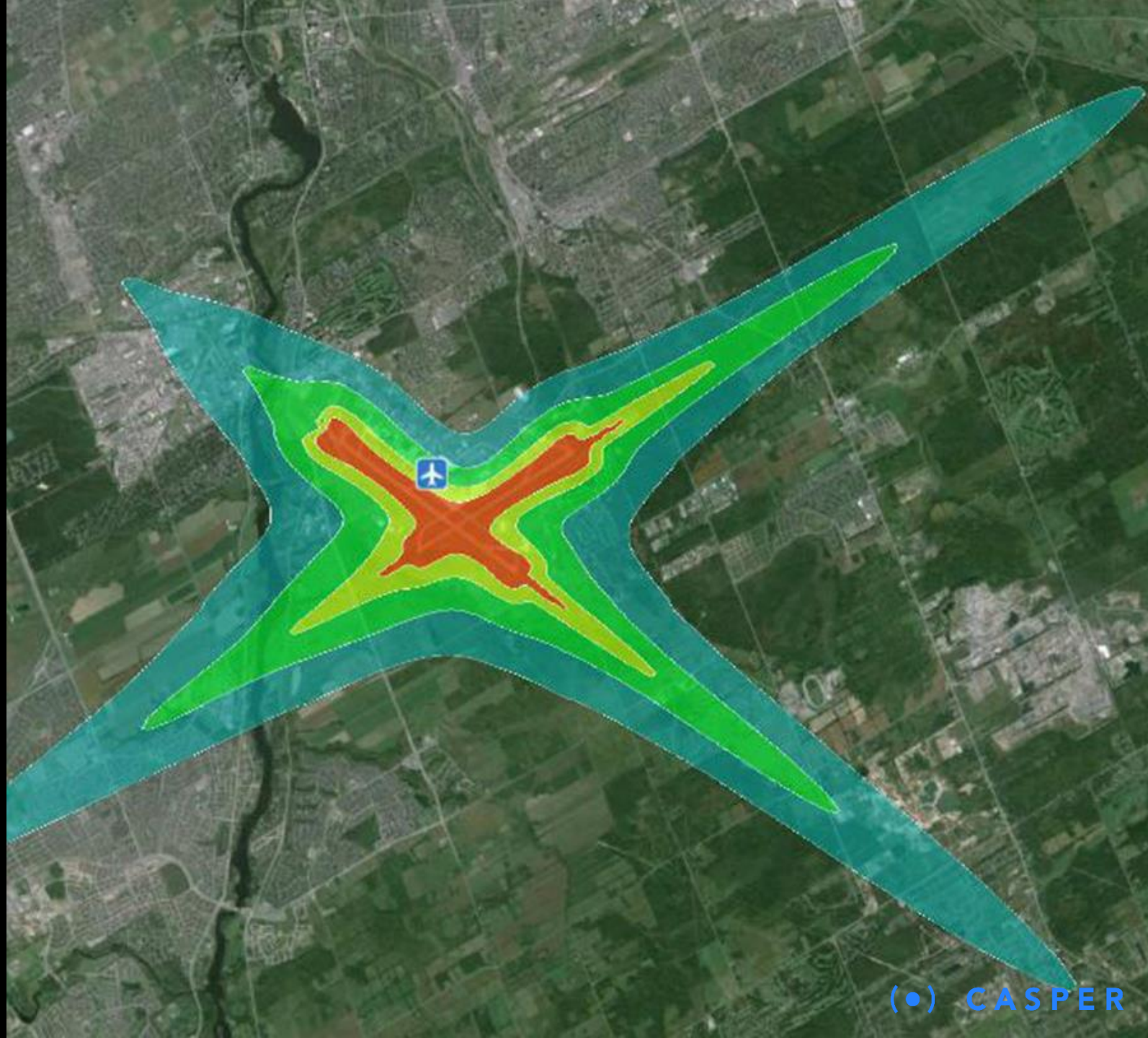


# CALCULATING DNL

In calculating DNL, the Leq level is used as the hourly equivalent sound level.

The hourly noise figures are summed for the 15 hours of daylight (7 a.m. to 10 p.m.) and added to the sum of Leq hourly figures for the remaining 9 hours of nighttime with a 10 dB penalty added to the nighttime figures (to reflect added human sensitivity to nighttime noise).

The result is the DNL noise level or a 24 hour summary of noise levels for a given location. When aircraft noise contours are calculated, however, the noise levels are solely due to the aircraft and do not include other noise sources



# EQUIVELANT DNL NOISE LEVELS



1 Event/Day SEL 114.4 dBA = 65 DNL



10 Events/Day SEL 104.4 dBA = 65 DNL



100 Events/Day SEL 94.4 dBA = 65 DNL (original graphic credited to ESA)

# WHO REGULATES AIRPLANE NOISE IN THE UNITED STATES?

Federal Aviation Regulations Part 36 –  
Noise Standards: Aircraft Type and  
Airworthiness Certification Subpart B –  
Transport Category Large Airplanes and Jet  
Airplanes

- FAR 36.101 – Noise Measurement and Evaluation
- FAR 36.103 – Noise Limits





# EFFECTIVE PERCEIVED NOISE LEVEL (EPNL)

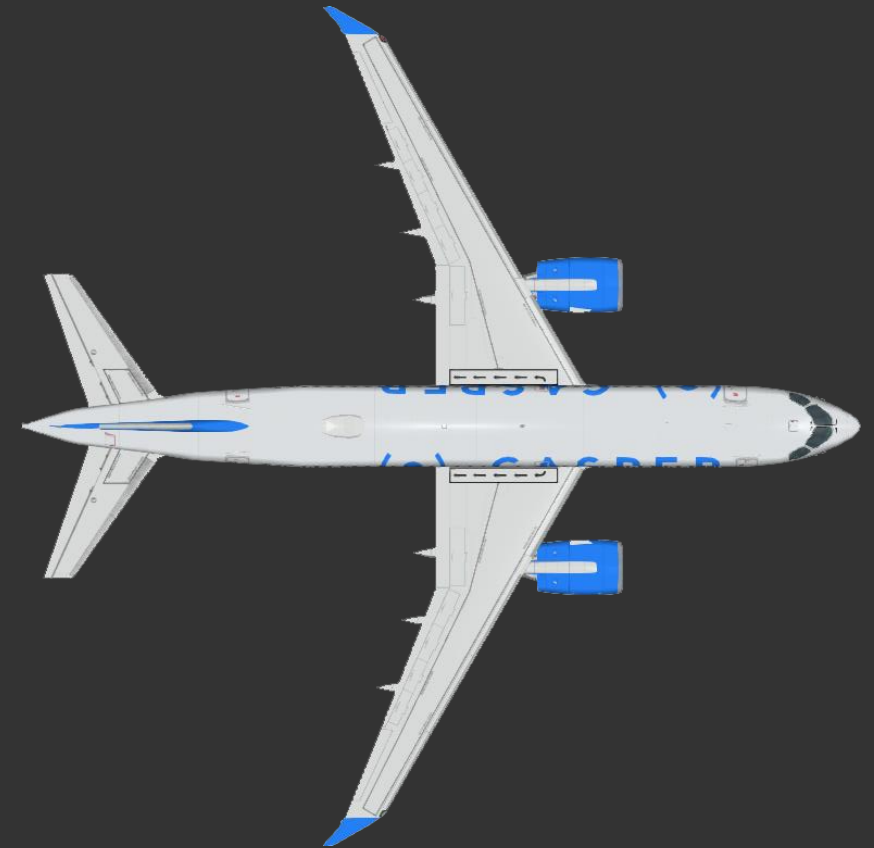
EPNL – A modification of the Perceived Noise Level (PNL) that takes into account tone components in aircraft broad band noise, as well as the duration of the noise. It is measured in EPNdB, and defined as the Perceived Noise Level (PNL) in PNdB, plus a tone correction and a duration correction. It is used by the FAA in aircraft certification.

The EPNL measurement is based on the following equation:

$$\text{EPNL} = \text{PNL}_{\text{max}} + 10 \log (t_{10}/20) + F \text{ (dB)}$$

where  $\text{PNL}_{\text{max}}$  is the maximum perceived noise level during flyover in PNdB,  $t_{10}$  is the duration (in seconds) of the noise level within 10 dB of the peak PNL, and

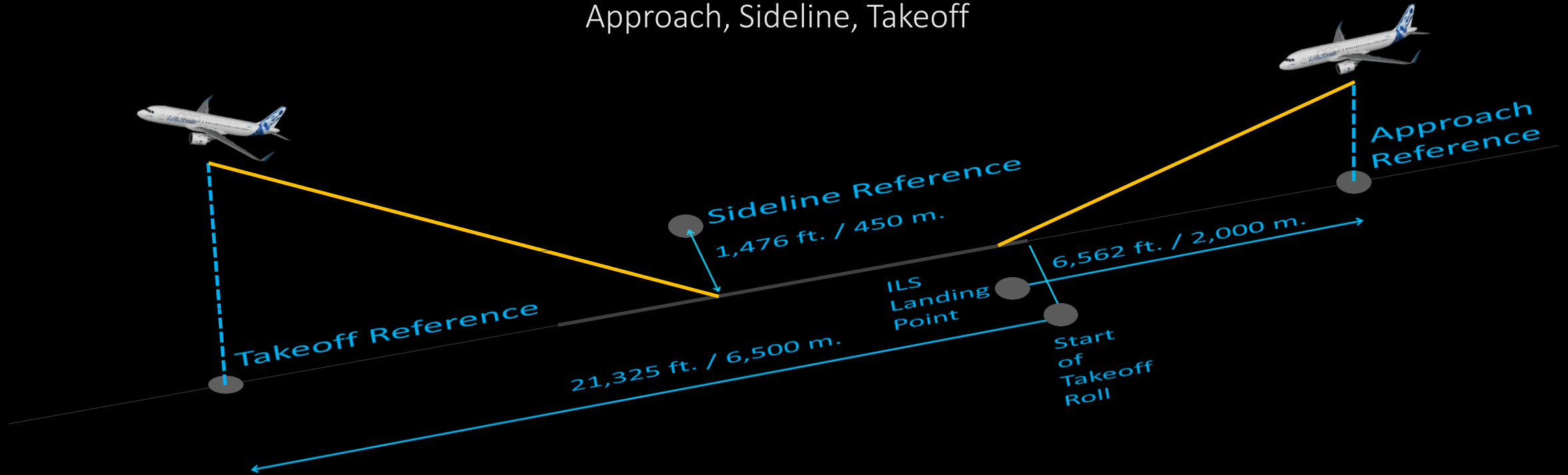
$F$  is a correction for PURE TONES (which are generally found to be more annoying than broad band noise without perceived tones). In practice,  $F$  is about +3 dB.





# HOW IS AIRCRAFT NOISE MEASURED?

EPNL Aircraft Noise Certification Points:  
Approach, Sideline, Takeoff



Aircraft Noise is measured in A weighted decibels (dBA)

# HOW LOUD CAN A COMMERCIAL JET BE?

Boeing 747-8I, Max Takeoff Weight = 987,000 lb.

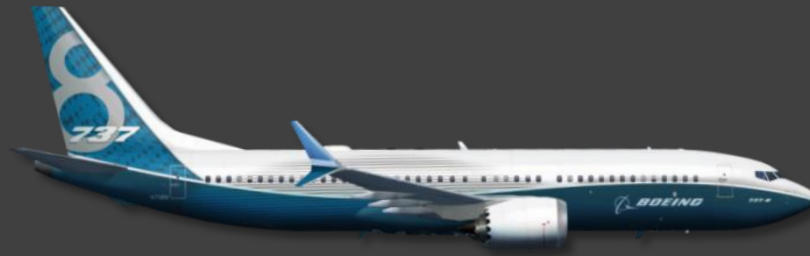
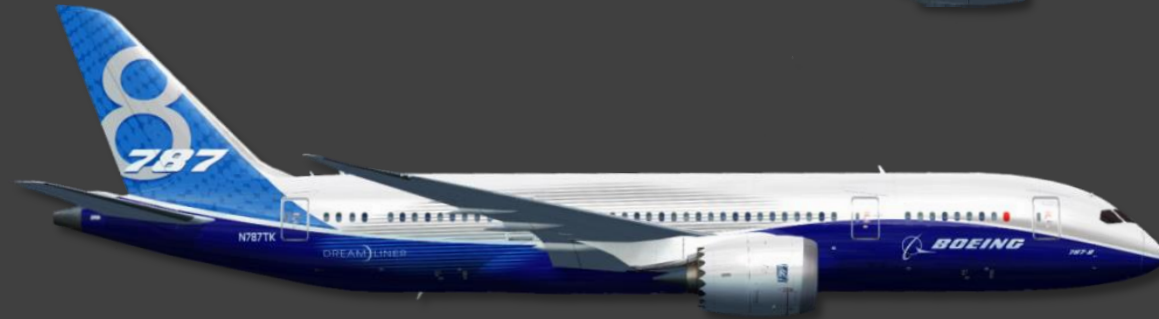
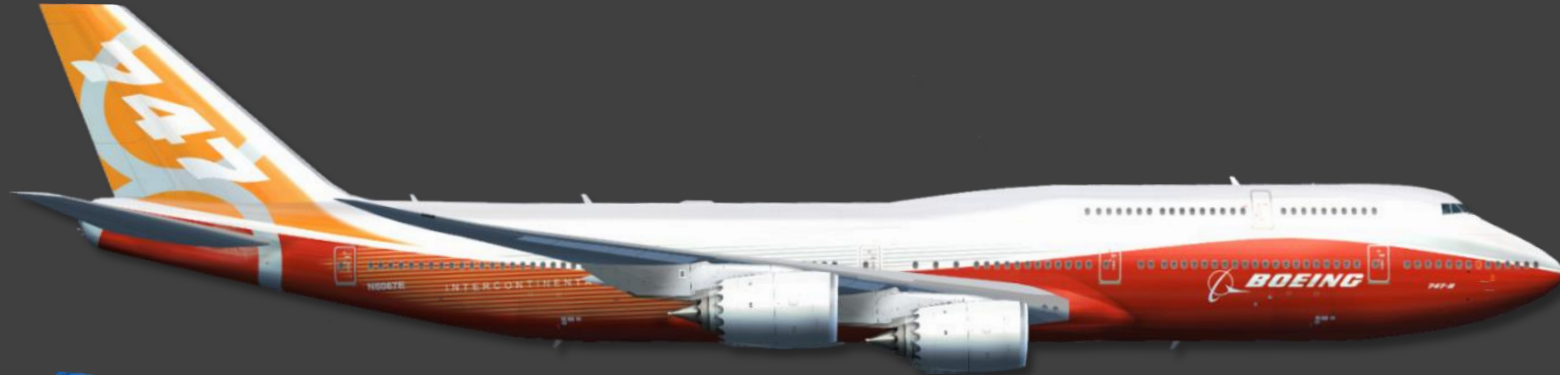
Certification Level	Sideline	Approach	Takeoff
Noise Level (EPNdB)	94.0	100.9	94.5
Noise Limit (EPNdB)	103.0	105.0	106.0
Margin Below Stage IV	9.0	4.1	11.5

Boeing 787-8, Max Takeoff Weight = 502,500 lb.

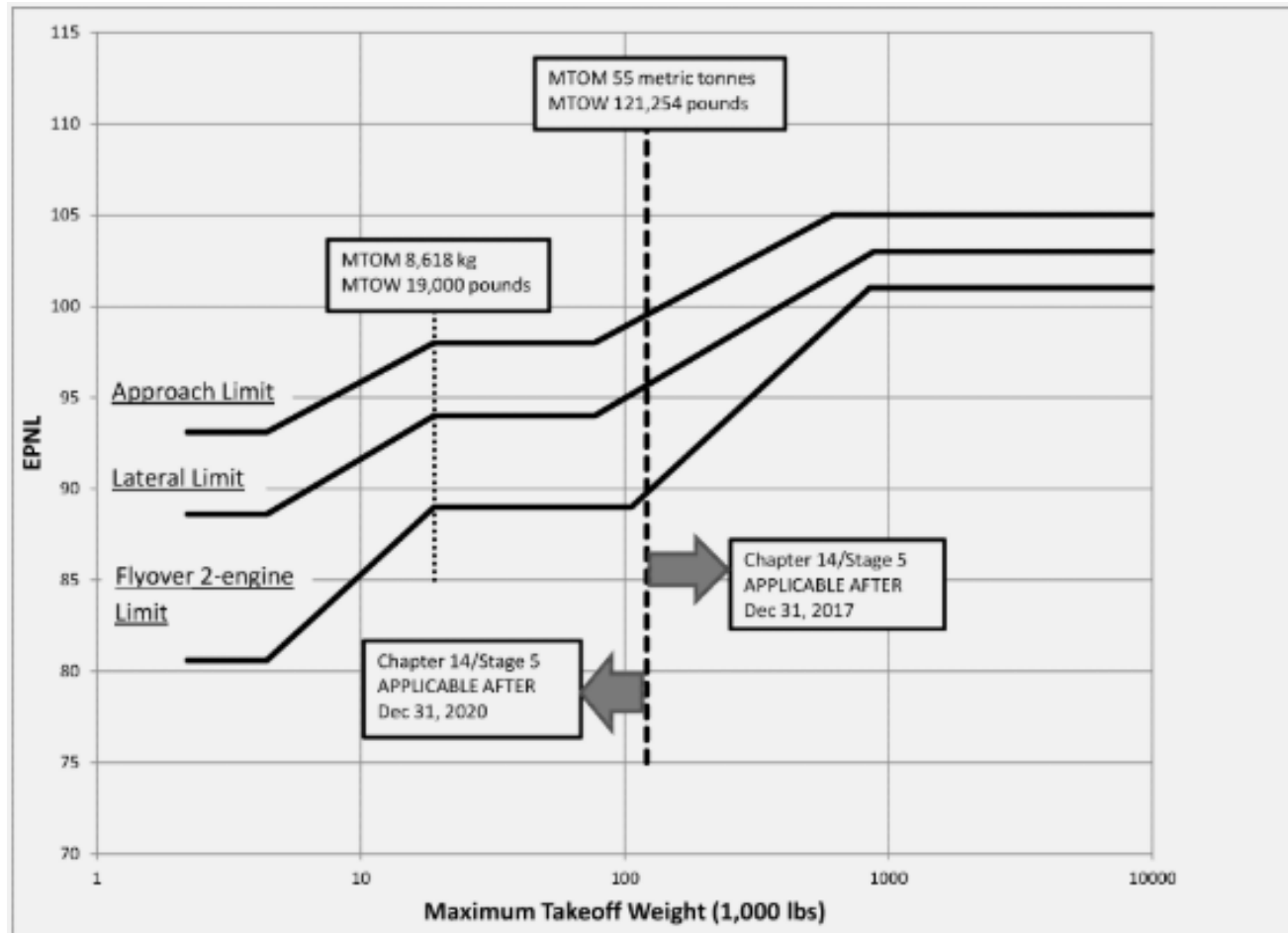
Certification Level	Sideline	Approach	Takeoff
Noise Level (EPNdB)	91.6	94.2	86.6
Noise Limit (EPNdB)	100.9	104.3	98.0
Margin Below Stage IV	9.3	10.1	11.4

Boeing 737-8 MAX, Max Takeoff Weight = 181,200 lb.

Certification Level	Sideline	Approach	Takeoff
Noise Level (EPNdB)	88.5	94.2	82.6
Noise Limit (EPNdB)	97.2	100.9	92.1
Margin Below Stage IV	8.7	6.7	9.5



# FAA STAGE V – NOISE STANDARD



Stage 5, applies to any person submitting an application for a new airplane type design with a maximum certificated takeoff weight of 121,254 pounds (55,000 kg) or more on or after December 31, 2017; or with maximum certificated takeoff weight of less than 121,254 pounds (55,000 kg) on or after December 31, 2020.

The Stage V noise standard requires the cumulative noise level at the three certification measuring points to be 7 EPNdB below the Stage IV levels.

The new standard also introduces a condition in addition to the cumulative reduction requirement, that mandates a margin of not less than 1.0 dB below Chapter 3<sup>[3]</sup> limits at each certification point.



# AIRCRAFT NOISE SOURCES





# APPROACH NOISE SOURCES

In modern commercial jet aircraft in widespread use today AIRFRAME noise contributes more to the total aircraft noise during the approach phase of flight than engine noise.

The largest contributors to airframe noise are:

- Landing Gear
- Slats
- Flaps
- Spoilers
- Gear / Aircraft Wake Interaction



# WHY WAS 65 DNL CHOSEN AS THE THRESHOLD?

Federal Interagency Committee on Urban Noise  
(FICUN)

Guidelines for Considering Noise in Land Use  
Planning and Control (1980)

<http://www.nonoise.org/epa/Roll7/roll7doc20.pdf>

This report established the Federal government's  
DNL 65 dB standard and related guidelines for land  
use compatibility





# HOW DOES THE FAA DEFINE SIGNIFICANT NOISE?

According to the FAA noise levels of DNL 65 dB or above are generally considered incompatible with residential land uses and people living within the DNL 65 dB or higher contour are considered to be significantly impacted by aircraft noise.





# AVIATION SAFETY AND NOISE ABATEMENT ACT OF 1979

First federal legislation specifically addressing airport noise compatibility

<http://airportnoiselaw.org/usca475-1.html>

Part 150 Program Instituted by the FAA - adopted DNL metric and established the 65 db land use compatibility guideline

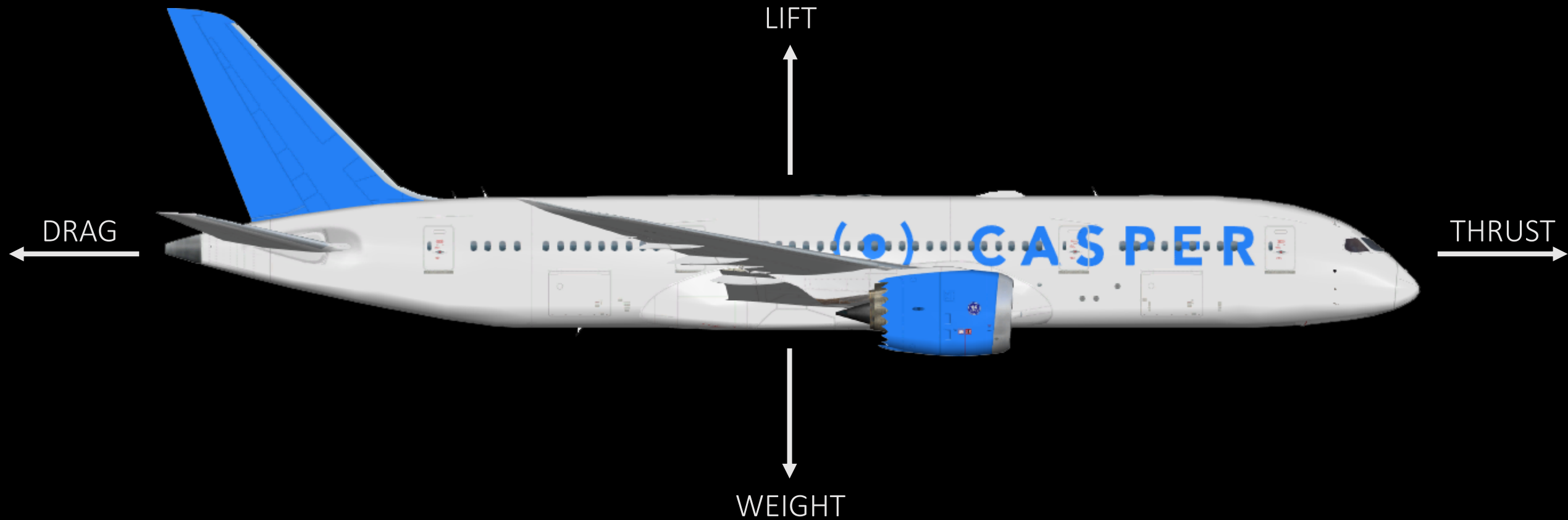
Established DNL 65 dB as the threshold for federal funding of noise mitigation





# AIRCRAFT TAKEOFF PERFORMANCE AND NOISE

# AERODYNAMIC FORCES ACTING ON AN AIRPLANE



# FACTORS THAT EFFECT AIRCRAFT TAKEOFF PERFORMANCE

1

Aircraft  
Weight

Plane + Payload + Fuel

2

Weather  
Conditions

Temp vs. Thrust

3

Airport  
Elevation

Air Density vs. Lift

4

Available  
Runway

Length vs. Payload

# HOW MUCH DOES A BOEING 787-8 WEIGH?



## BOEING 787-8 with GENx 1B70 PIP II Engines

Operating Empty Weight	264,500 lb. / 119,975 kg.
Maximum Structural Payload	90,500 lb. / 41,050 kg.
Maximum Zero Fuel Weight	355,000 lb. / 161,025 kg.
Maximum Fuel Capacity	223,378 lb. / 101,323 kg.
Maximum Taxi Weight	504,100 lb. / 228,656 kg.
Maximum Takeoff Weight	502,500 lb. / 227,930 kg.
Maximum Landing Weight	380,000 lb. / 172,365 kg.



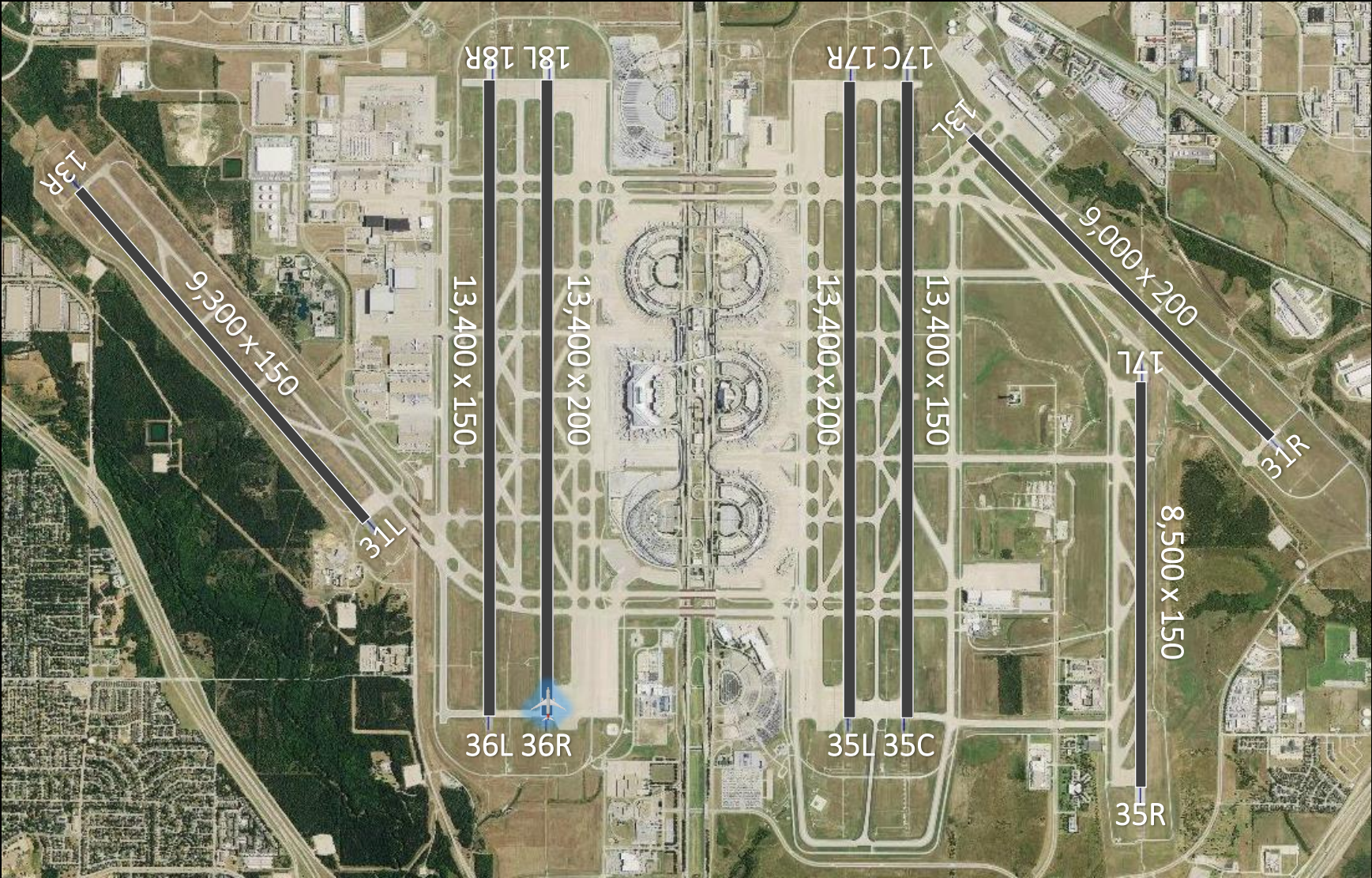


# REAL WORLD FLIGHT COMPARISON





# HOW MUCH RUNWAY DO WE NEED TO TAKEOFF?





# AIRCRAFT FLIGHT PLANNING

AAL2360 DFW-LAX

Flt Plan Distance = 1,464 mi.

Flight Time = 2hr 50 min.

Empty Weight = 264,500 lb.

AAL263 DFW-PEK



Flt Plan Distance = 7,217 mi.

Flight Time = 13hr 19 min.

Empty Weight = 264,500 lb.



# HOW ARE CARGO WEIGHTS CALCULATED?

FAA Avg. Baggage Weights	Palletized and Containerized Cargo
 <p data-bbox="555 1063 1121 1192">Checked Bag 30 lb.      Carry-on Bag 16 lb.      Heavy Bag 50+ lb.</p>	
Carry-on included in Pax Weights	Weighed prior to Loading



# CARGO LOAD PLANNING

AAL2360 DFW-LAX

Flt Plan Distance = 1,464 mi.

Flight Time = 2hr 50 min.

Empty Weight = 264,500 lb.

Bags / Cargo = 19,040 lb.

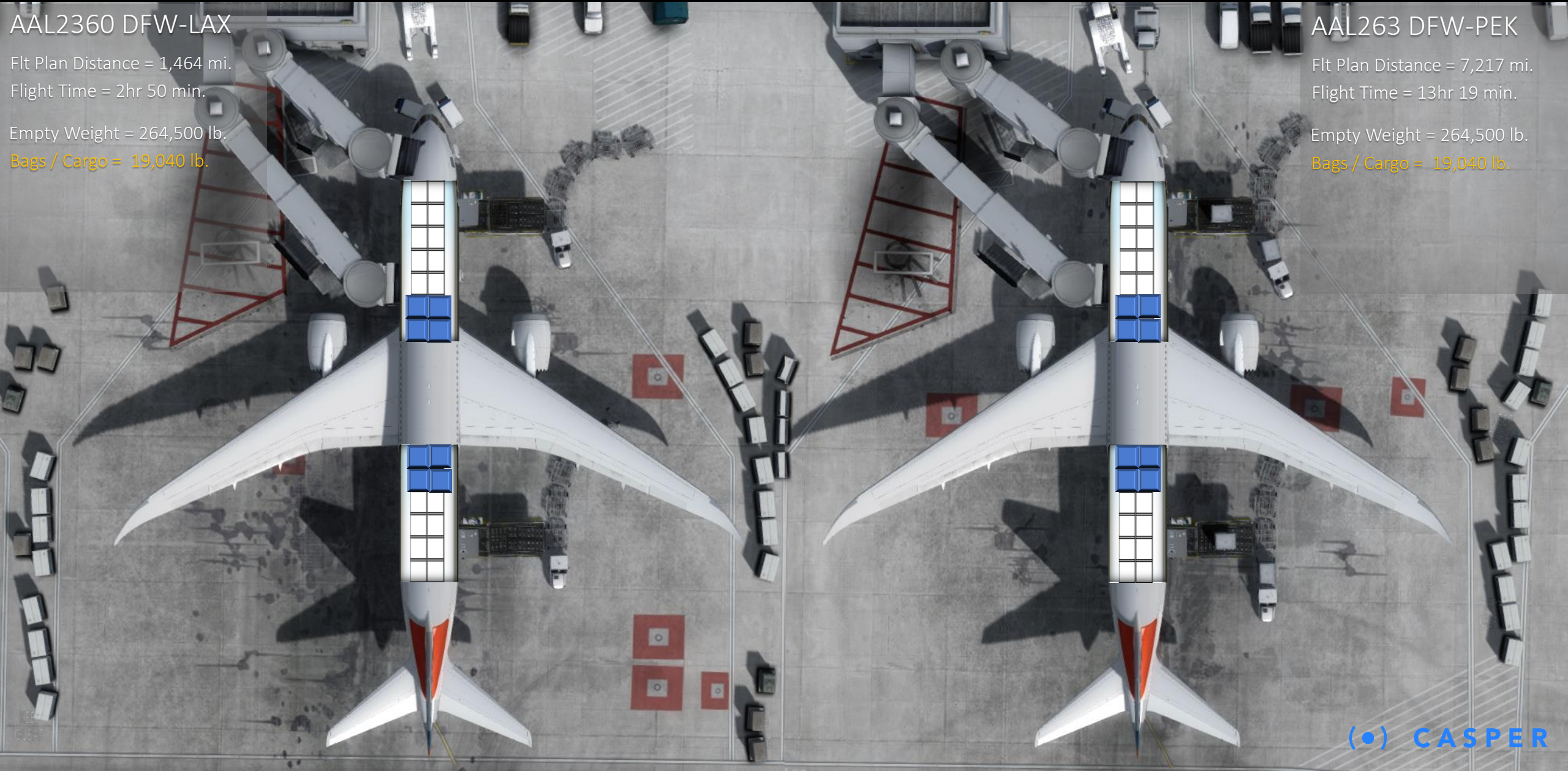
AAL263 DFW-PEK

Flt Plan Distance = 7,217 mi.

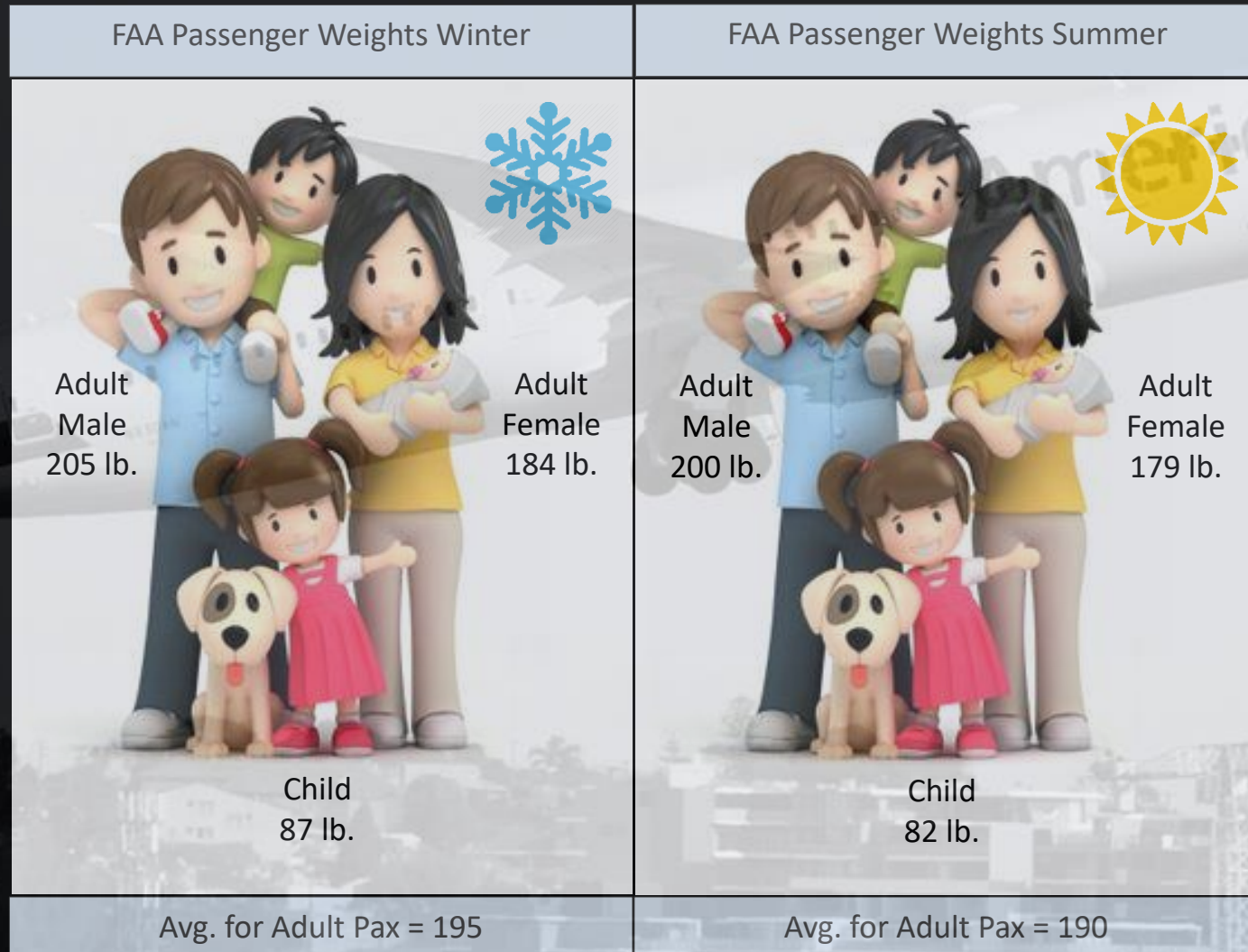
Flight Time = 13hr 19 min.

Empty Weight = 264,500 lb.

Bags / Cargo = 19,040 lb.



# HOW ARE PASSENGER WEIGHTS CALCULATED?





# PASSENGER LOAD PLANNING

## AAL2360 DFW-LAX

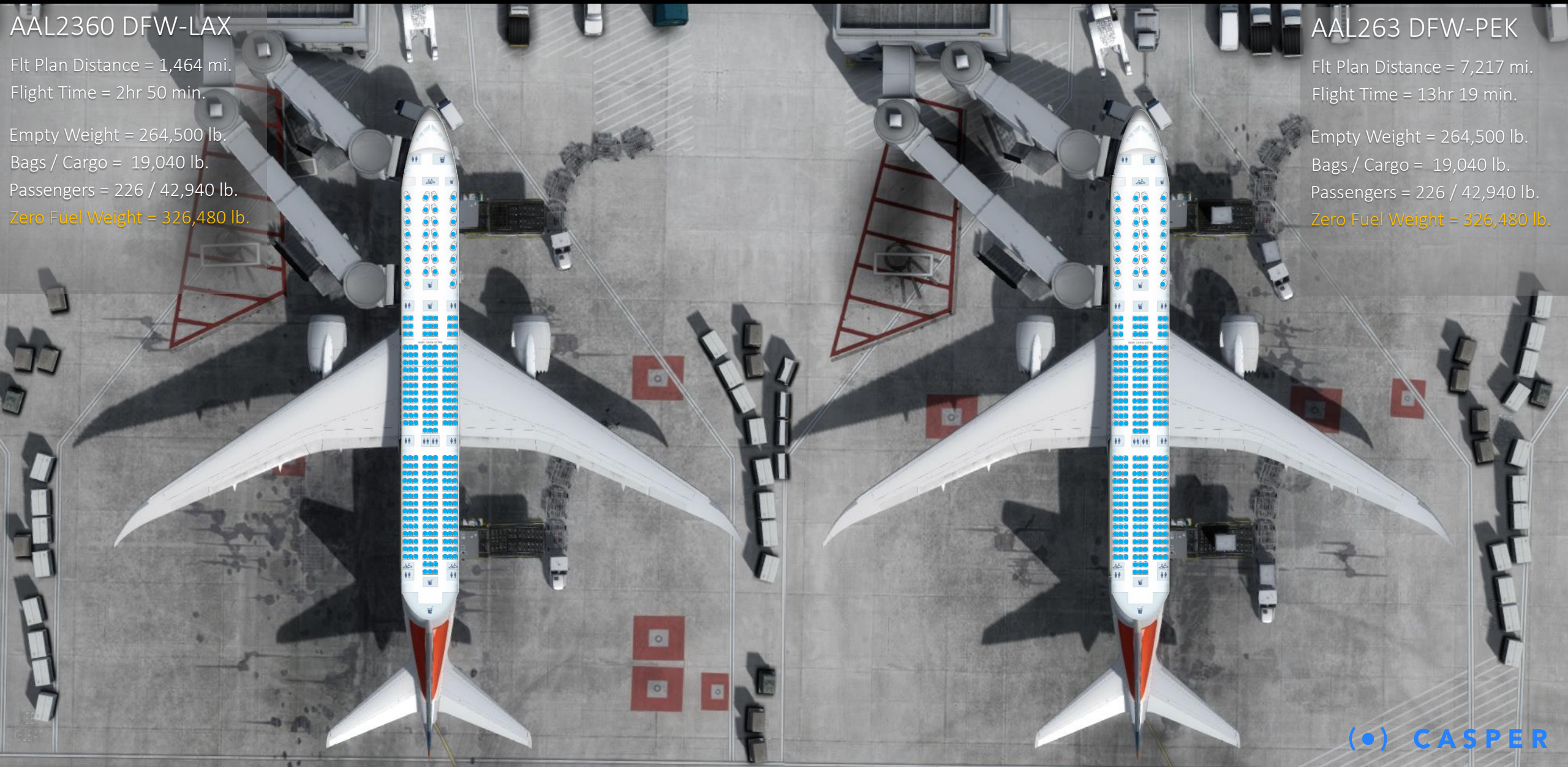
Flt Plan Distance = 1,464 mi.  
Flight Time = 2hr 50 min.

Empty Weight = 264,500 lb.  
Bags / Cargo = 19,040 lb.  
Passengers = 226 / 42,940 lb.  
Zero Fuel Weight = 326,480 lb.

## AAL263 DFW-PEK

Flt Plan Distance = 7,217 mi.  
Flight Time = 13hr 19 min.

Empty Weight = 264,500 lb.  
Bags / Cargo = 19,040 lb.  
Passengers = 226 / 42,940 lb.  
Zero Fuel Weight = 326,480 lb.



# HOW MUCH FUEL DO WE NEED?

## Fuel Planning Schematic 787-8 GEnx-1B70 (STANDARD UNITS)

FLIGHT: AAL2360 KDFW/DFW – KLAX/LAX

Basic Operating Empty Weight: 264,500  
Payload: 61,980  
Zero Fuel Weight: 326,480  
Zero Fuel Weight: 326,480  
Minimum Landing Fuel: 4,088  
Alternate Fuel: 7,999  
Contingency Fuel: 2,558  
Planned Landing Weight: 341,125  
Planned Landing Weight: 341,125  
+ Flight Plan Fuel: 29,015  
Planned Gross Takeoff Weight: 370,140  
Planned Gross Takeoff Weight: 370,140  
+ Taxi Fuel Burn Off: 1,100  
Planned Taxi-Out Weight: 371,240

### Boeing 787-8 Fuel Capacity

Capacity = 223,378 lb.    Useable = 220,878 lb.    Unusable = 2,500 lb.  
101,323 kg.                      100,189 kg.                      1,134kg.

## Fuel Planning Schematic 787-8 GEnx-1B70 (STANDARD UNITS)

FLIGHT: AAL263 KDFW/DFW – ZBAA/PEK

Basic Operating Empty Weight: 264,500  
Payload: 61,980  
Zero Fuel Weight: 326,480  
Zero Fuel Weight: 326,480  
Minimum Landing Fuel: 4,120  
Alternate Fuel: 8,665  
Contingency Fuel: 7,399  
Planned Landing Weight: 346,664  
Planned Landing Weight: 346,664  
+ Flight Plan Fuel: 147,973  
Planned Gross Takeoff Weight: 494,637  
Planned Gross Takeoff Weight: 494,637  
+ Taxi Fuel Burn Off: 1,100  
Planned Taxi-Out Weight: 495,737

### Boeing 787-8 Fuel Capacity

Capacity = 223,378 lb.    Useable = 220,878 lb.    Unusable = 2,500 lb.  
101,323 kg.                      100,189 kg.                      1,134kg.



# HOW MUCH FUEL DO WE NEED FOR OUR TRIP?

AAL2360 DFW-LAX

Flt Plan Distance = 1,464 mi.

Flight Time = 2hr 50 min.

Empty Weight = 264,500 lb.

Bags / Cargo = 19,040 lb.

Passengers = 226 / 42,940 lb.

Zero Fuel Weight = 326,480 lb.

Total Fuel = 44,760 lb.

Taxi Weight = 371,240 lb.

AAL263 DFW-PEK

Flt Plan Distance = 7,217 mi.

Flight Time = 13hr 19 min.

Empty Weight = 264,500 lb.

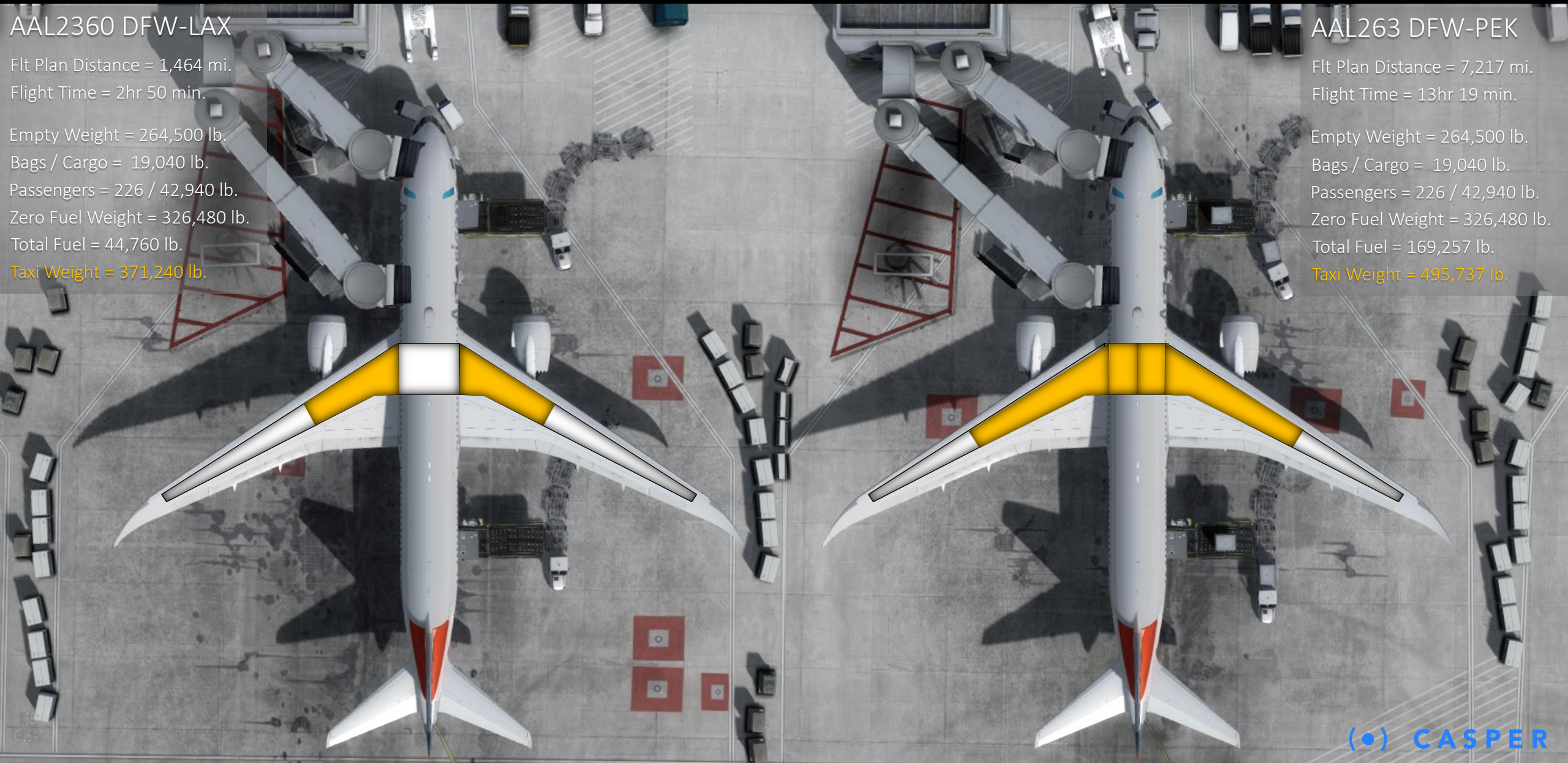
Bags / Cargo = 19,040 lb.

Passengers = 226 / 42,940 lb.

Zero Fuel Weight = 326,480 lb.

Total Fuel = 169,257 lb.

Taxi Weight = 495,737 lb.



# FACTORS THAT EFFECT AIRCRAFT TAKEOFF PERFORMANCE

1

Aircraft  
Weight

Plane + Payload + Fuel

2

Weather  
Conditions

Temp vs. Thrust

3

Airport  
Elevation

Air Density vs. Lift

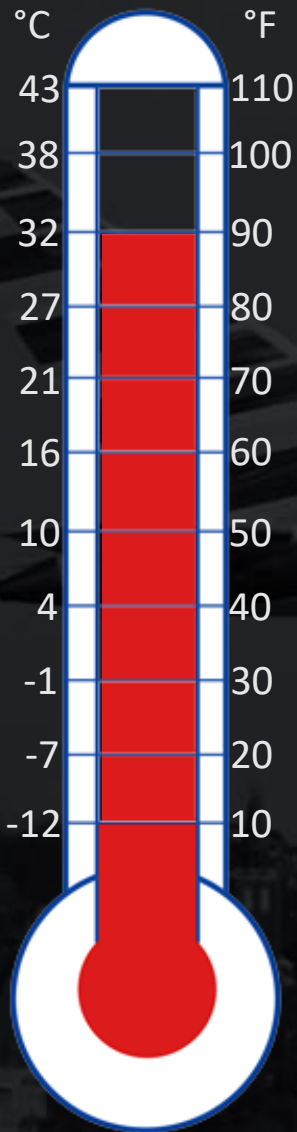
4

Available  
Runway

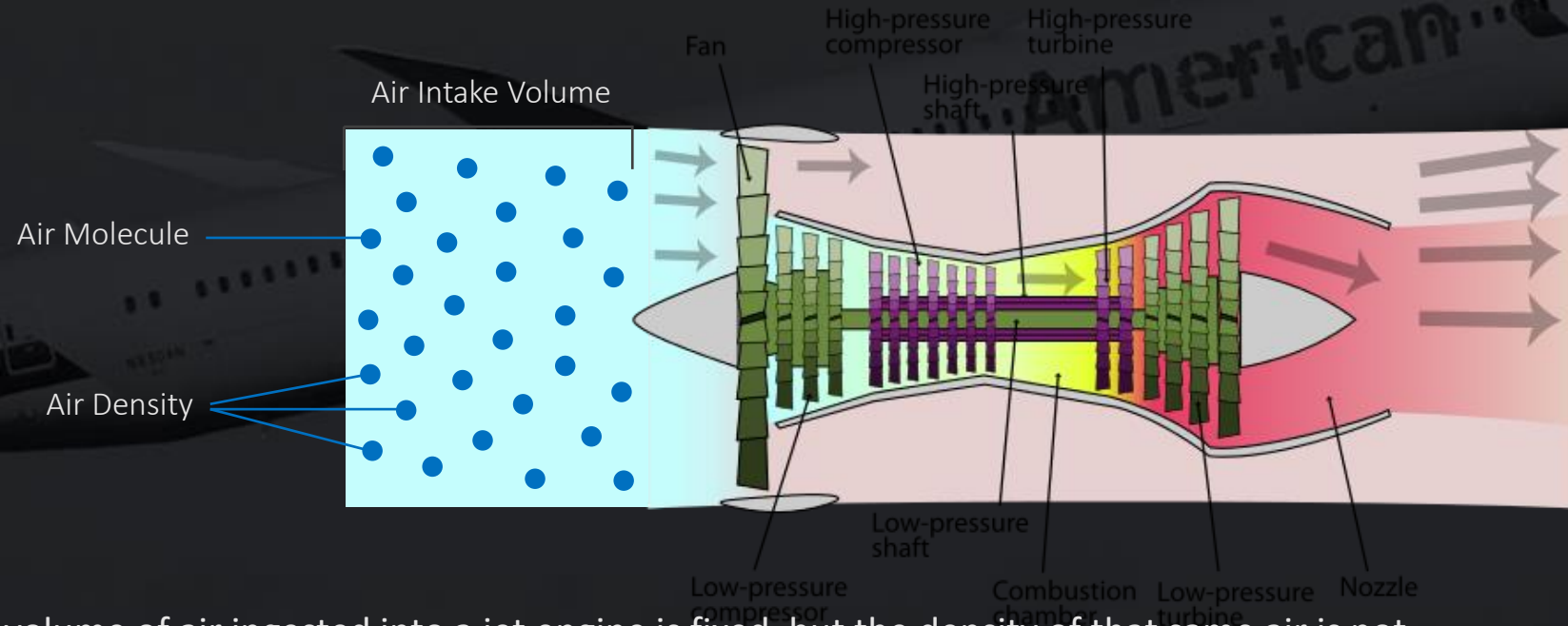
Length vs. Payload



# TEMPERATURE'S EFFECT ON AIRCRAFT PERFORMANCE



TEMPERATURE HAS AN INVERSE CORRELATION WITH AIR DENSITY



The volume of air ingested into a jet engine is fixed, but the density of that same air is not.

Hot air is less dense than cold air and thus the warmer the temperature the less net thrust a jet engine produces. Warmer temperatures also decrease lift, which increases the length of runway needed for takeoff, reduces climb performance and lessens the payload weight that can be lifted.

# TAKEOFF SCENARIO 1 – TEMP 30° F

Current Automatic Terminal Information Service (ATIS): Dallas/Fort Worth Int'l Airport (DFW)



Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
30°F / -1°C	10°F / -12°C	0 kts / ---°	29.92 in / 1013 mb.	607 ft. / 185 m.	Runway 36R

## AAL2360 DFW-LAX

Density Altitude = -1,187 ft. / -362 m.

Takeoff Weight = 370,140 lb. / 167,893 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 4,692 ft. / 1,430 m.

Takeoff Speeds =  $V_1$  - 138 kts.  $V_R$  - 138 kts.  $V_2$  - 148 kts.

## AAL263 DFW-PEK

Density Altitude = -1,187 ft. / -362 m.

Takeoff Weight = 494,637 lb. / 224,364 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 8,346 ft. / 2,544 m.

Takeoff Speeds =  $V_1$  - 155 kts.  $V_R$  - 157 kts.  $V_2$  - 169 kts.



# TAKEOFF SCENARIO 2 – TEMP 60° F

Current Automatic Terminal Information Service (ATIS): Dallas/Fort Worth Int'l Airport (DFW)



Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
60°F / 16°C	40°F / 4°C	0 kts / ---°	29.92 in / 1013 mb.	607 ft. / 185 m.	Runway 36R

## AAL2360 DFW-LAX

Density Altitude = 925 ft. / 282 m. (+2,112 ft. / +644 m.)

Takeoff Weight = 370,140 lb. / 167,893 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 4,978 ft. / 1,517 m. (+286 ft. / +87 m.)

Takeoff Speeds =  $V_1$  - 138 kts.  $V_R$  - 138 kts.  $V_2$  - 148 kts.

## AAL263 DFW-PEK

Density Altitude = 925 ft. / 282 m. (+2,112 ft. / +644 m.)

Takeoff Weight = 494,637 lb. / 224,364 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 8,745 ft. / 2,665 m. (+399 ft. / +121 m.)

Takeoff Speeds =  $V_1$  - 155 kts.  $V_R$  - 157 kts.  $V_2$  - 169 kts.

# TAKEOFF SCENARIO 3 – TEMP 90° F

Current Automatic Terminal Information Service (ATIS): Dallas/Fort Worth Int'l Airport (DFW)



Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
90°F / 32°C	70°F / 21°C	0 kts / ---°	29.92 in / 1013 mb.	607 ft. / 185 m.	Runway 36R

## AAL2360 DFW-LAX

Density Altitude = 3,033 ft. / 924 m. (+2,108 ft. / +643 m.)

Takeoff Weight = 370,140 lb. / 167,893 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 5,445 ft. / 1,660 m. (+467 ft. / +143 m.)

Takeoff Speeds =  $V_1$  - 138 kts.  $V_R$  - 138 kts.  $V_2$  - 148 kts.

## AAL263 DFW-PEK

Density Altitude = 3,033 ft. / 924 m. (+2,108 ft. / +643 m.)

Takeoff Weight = 494,637 lb. / 224,364 kg.

Flap Setting: 15°

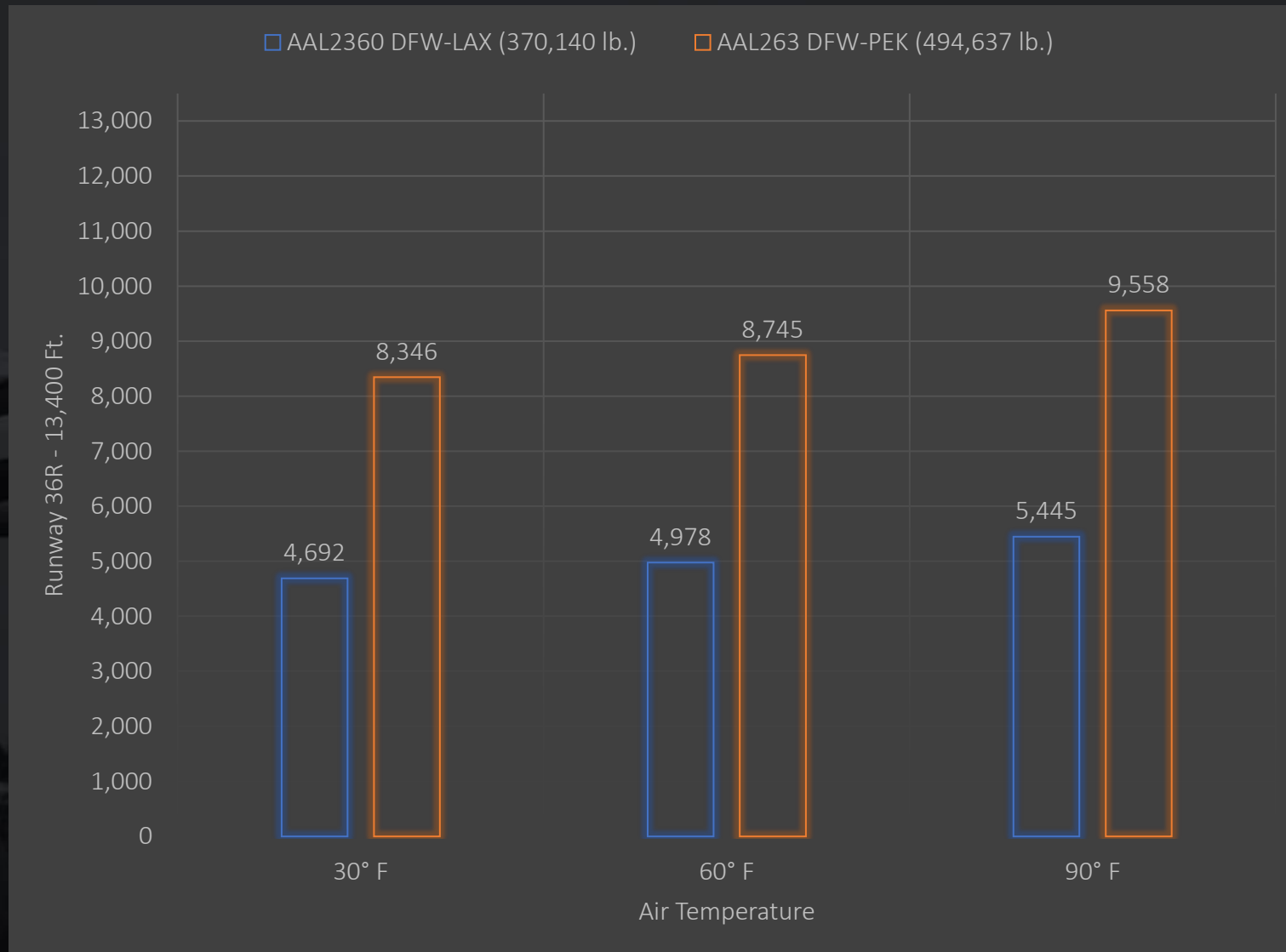
Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 9,558 ft. / 2,913 m. (+813 ft. / +248 m.)

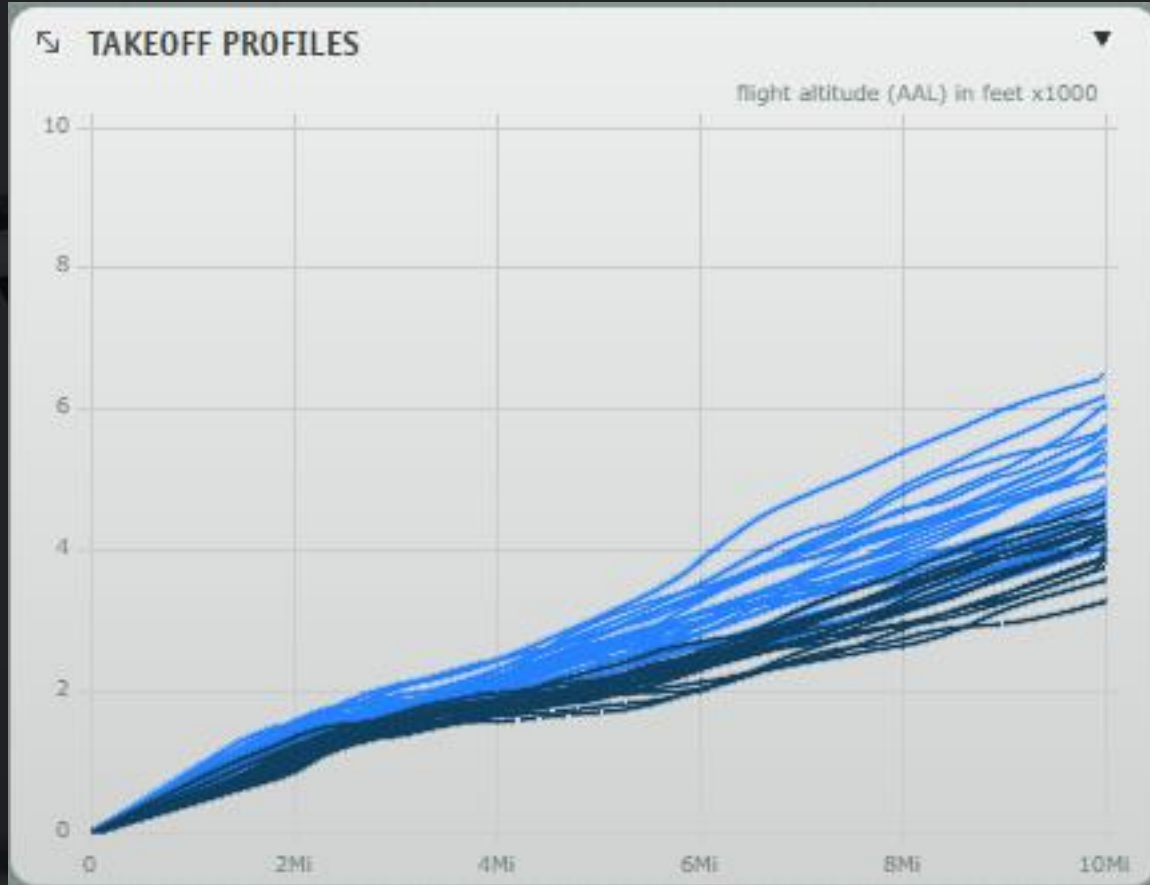
Takeoff Speeds =  $V_1$  - 155 kts.  $V_R$  - 157 kts.  $V_2$  - 169 kts.

# TAKEOFF LENGTH COMPARISON BY TEMPERATURE



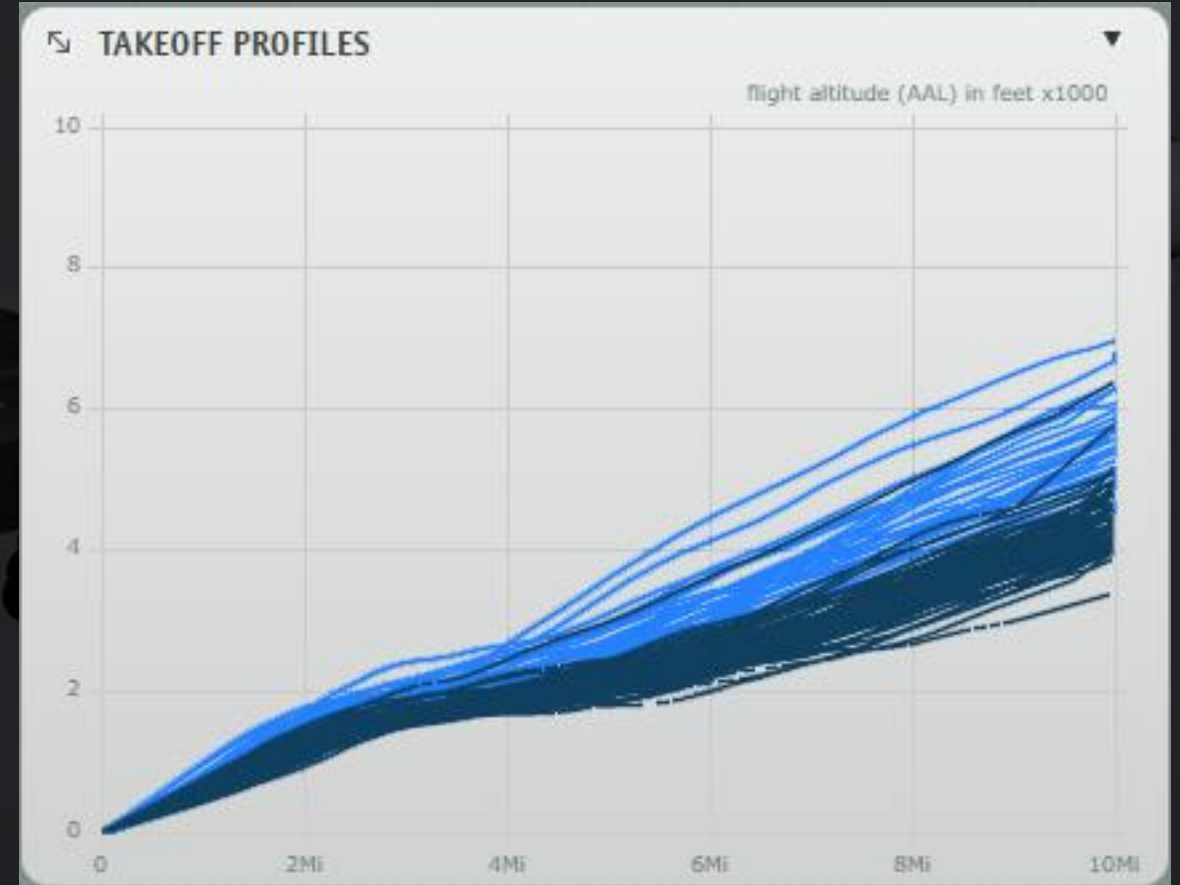


# AVERAGE DEPARTURE TRACK COMPARISON



AAL263 (DFW-PEK) Departure Profiles

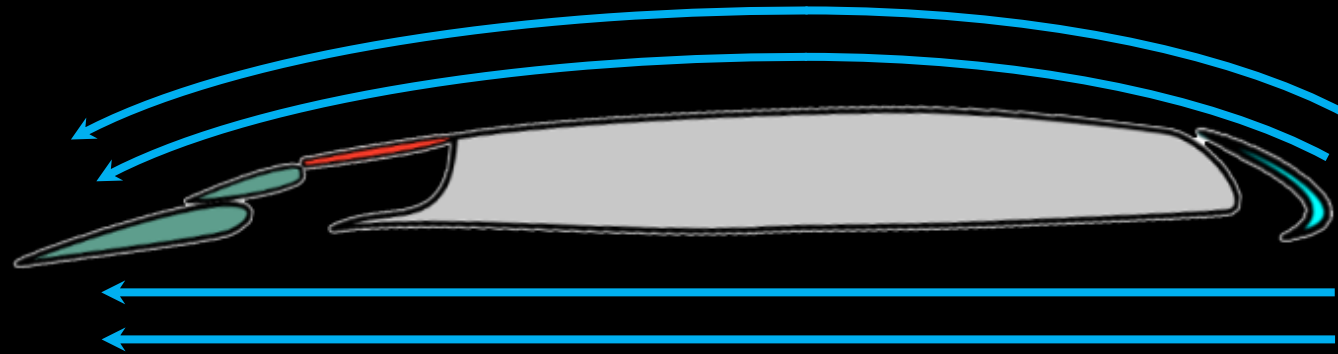
Winter — Summer —



AAL2360 (DFW-LAX) Departure Profiles

Winter — Summer —

# WIND'S EFFECT ON TAKEOFF PERFORMANCE



A headwind equals airspeed over the wings which increases lift

Airplanes takeoff and land into the wind to increase lift and reduce the amount of runway needed for takeoff and landing. An aircraft sitting at the end of the runway pointed into a 15 knot headwind has ground speed of 0 and an airspeed of 15 knots.

# TAKEOFF SCENARIO 1 – WINDS 0 KTS. / 0°

Current Automatic Terminal Information Service (ATIS): Dallas/Fort Worth Int'l Airport (DFW)



Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
60°F / 16°C	40°F / 4°C	0 kts / ---°	29.92 in / 1013 mb.	607 ft. / 185 m.	Runway 36R

## AAL2360 DFW-LAX

Density Altitude = 925 ft. / 282 m.

Takeoff Weight = 370,140 lb. / 167,893 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 4,978 ft. / 1,517 m.

Takeoff Speeds =  $V_1$  - 138 kts.  $V_R$  - 138 kts.  $V_2$  - 148 kts.

## AAL263 DFW-PEK

Density Altitude = 925 ft. / 282 m.

Takeoff Weight = 494,637 lb. / 224,364 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 8,745 ft. / 2,665 m.

Takeoff Speeds =  $V_1$  - 155 kts.  $V_R$  - 157 kts.  $V_2$  - 169 kts.



# TAKEOFF SCENARIO 2 – WINDS 15 KTS. / 360°

Current Automatic Terminal Information Service (ATIS): Dallas/Fort Worth Int'l Airport (DFW)



Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
60°F / 16°C	40°F / 4°C	15 kts / 360°	29.92 in / 1013 mb.	607 ft. / 185 m.	Runway 36R

## AAL2360 DFW-LAX

Density Altitude = 925 ft. / 282 m.

Takeoff Weight = 370,140 lb. / 167,893 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 4,582 ft. / 1,397 m. (-396 ft. / -121 m.)

Takeoff Speeds =  $V_1$  - 138 kts.  $V_R$  - 138 kts.  $V_2$  - 148 kts.

## AAL263 DFW-PEK

Density Altitude = 925 ft. / 282 m.

Takeoff Weight = 494,637 lb. / 224,364 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 8,243 ft. / 2,512 m. (-502 ft. / -153 m.)

Takeoff Speeds =  $V_1$  - 155 kts.  $V_R$  - 157 kts.  $V_2$  - 169 kts.

# TAKEOFF SCENARIO 3 – WINDS 30 KTS. / 360°

Current Automatic Terminal Information Service (ATIS): Dallas/Fort Worth Int'l Airport (DFW)



Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
60°F / 16°C	40°F / 4°C	30 kts / 360°	29.92 in / 1013 mb.	607 ft. / 185 m.	Runway 36R

## AAL2360 DFW-LAX

Density Altitude = 925 ft. / 282 m.

Takeoff Weight = 370,140 lb. / 167,893 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 4,202 ft. / 1,281 m. (-380 ft. / -116 m.)

Takeoff Speeds =  $V_1$  - 138 kts.  $V_R$  - 138 kts.  $V_2$  - 148 kts.

## AAL263 DFW-PEK

Density Altitude = 925 ft. / 282 m.

Takeoff Weight = 494,637 lb. / 224,364 kg.

Flap Setting: 15°

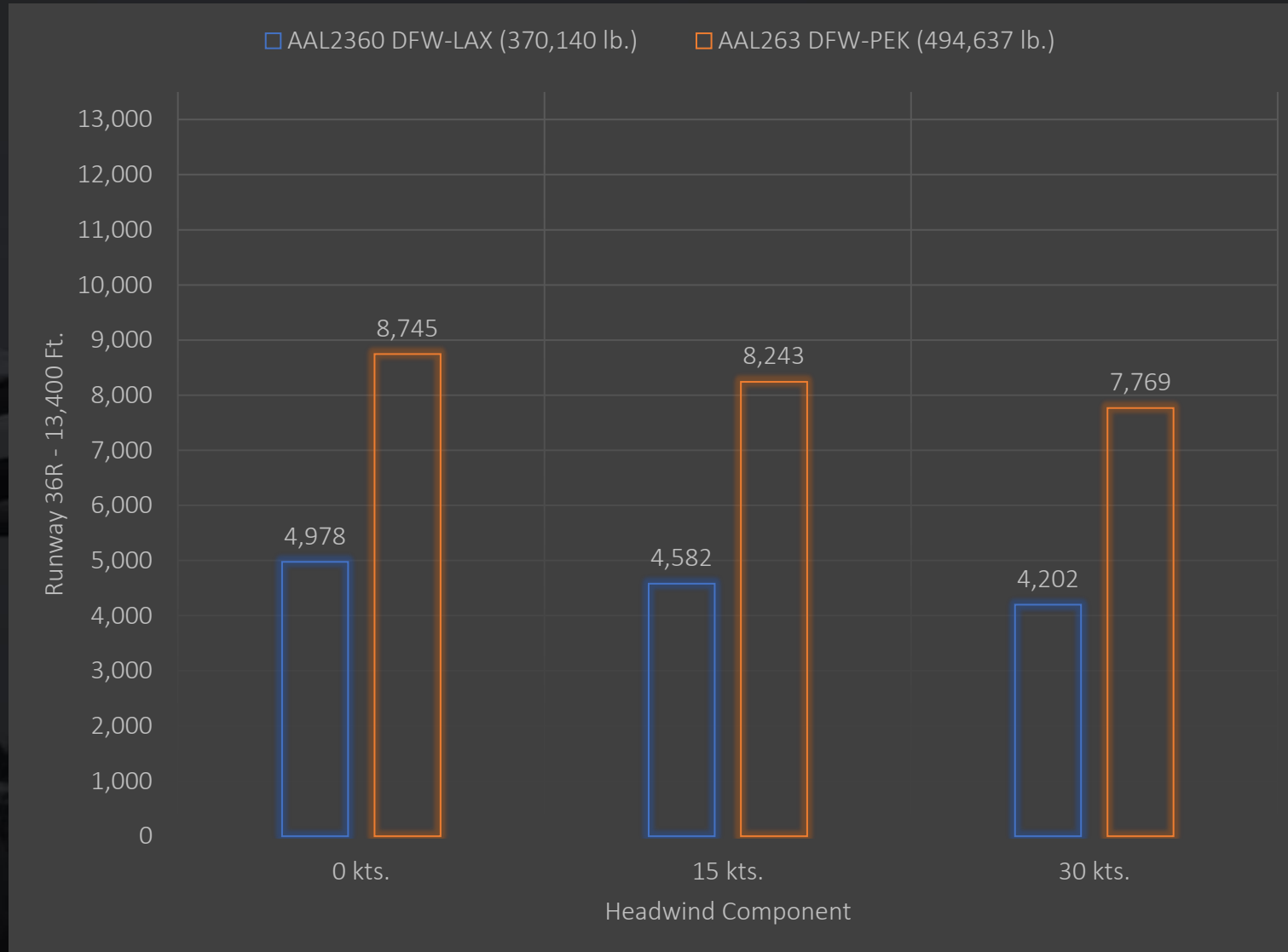
Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 7,769 ft. / 2,368 m. (-474 ft. / -144 m.)

Takeoff Speeds =  $V_1$  - 155 kts.  $V_R$  - 157 kts.  $V_2$  - 169 kts.

# TAKEOFF LENGTH COMPARISON WITH HEADWIND





# FACTORS THAT EFFECT AIRCRAFT TAKEOFF PERFORMANCE

1

Aircraft  
Weight

Plane + Payload + Fuel

2

Weather  
Conditions

Temp vs. Thrust

3

Airport  
Elevation

Air Density vs. Lift

4

Available  
Runway

Length vs. Payload

# FIELD ELEVATION'S EFFECT ON TAKEOFF PERFORMANCE



Temperature = 60°F / 16°C

Dew Point = 40°F / 4°C

Altimeter = 29.92 Hg.

Winds = Calm

DFW Field Elevation = 607 ft. / 185 m.

DEN Field Elevation = 5,434 ft. / 1,656 m.

Field Elevation has an inverse correlation with air density

At higher elevations the air is less dense, decreasing the lifting effectiveness of the wing. Elevation also effects engine performance, reducing the net thrust output from a jet engine. Both of these factors combined increase the amount of runway needed for takeoff, negatively impact aircraft climb performance and restrict the payload weight that can be lifted.

# TAKEOFF SCENARIO 1 – ELEVATION 607 FT.

Current Automatic Terminal Information Service (ATIS): Dallas/Fort Worth Int'l Airport (DFW)



Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
60°F / 16°C	40°F / 4°C	0 kts / ---°	29.92 in / 1013 mb.	607 ft. / 185 m.	Runway 36R

## AAL2360 DFW-LAX

Density Altitude = 925 ft. / 282 m.

Takeoff Weight = 370,140 lb. / 167,893 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 4,978 ft. / 1,517 m.

Takeoff Speeds =  $V_1$  - 138 kts.  $V_R$  - 138 kts.  $V_2$  - 148 kts.

## AAL263 DFW-PEK

Density Altitude = 925 ft. / 282 m.

Takeoff Weight = 494,637 lb. / 224,364 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 8,745 ft. / 2,665 m.

Takeoff Speeds =  $V_1$  - 155 kts.  $V_R$  - 157 kts.  $V_2$  - 169 kts.



# TAKEOFF SCENARIO 2 – ELEVATION 2,389 FT.

## Current Automatic Terminal Information Service (ATIS): Tucson Int'l Airport (TUS)



Temperature  
60°F / 16°C

Dew Point  
40°F / 4°C

Winds  
0 kts / ---°

Altimeter Setting  
29.92 in / 1013 mb.

Field Elevation  
2,389 ft. / 728 m.

Departing  
Runway 29R

### AAL2360 DFW-LAX

Density Altitude = 3,125 ft. / 953 m. (+2,200 ft. / +671 m.)

Takeoff Weight = 370,140 lb. / 167,893 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 29R (10,996 ft. / 3,352 m. available)

Takeoff Distance = 5,465 ft. / 1,666 m. (+487 ft. / +148 m.)

Takeoff Speeds =  $V_1$  - 138 kts.  $V_R$  - 139 kts.  $V_2$  - 141 kts.

### AAL263 DFW-PEK

Density Altitude = 3,125 ft. / 953 m. (+2,200 ft. / +671 m.)

Takeoff Weight = 490,360 lb. / 222,424 kg. (-4,277 lb. / -1,940 kg.)

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 29R (10,996 ft. / 3,352 m. available)

Takeoff Distance = 9,336 ft. / 2,846 m. (+591 ft. / +180 m.)

Takeoff Speeds =  $V_1$  - 154 kts.  $V_R$  - 156 kts.  $V_2$  - 160 kts.

# TAKEOFF SCENARIO 3 – ELEVATION 5,434 FT.

Current Automatic Terminal Information Service (ATIS): Denver Int'l Airport (DEN)



Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
60°F / 16°C	40°F / 4°C	0 kts / ---°	29.92 in / 1013 mb.	5,434 ft. / 1,656 m.	Runway 34R

## AAL2360 DFW-LAX

Density Altitude = 6,871 ft. / 2,094 m. (+3,746 ft. / +1,142 m.)

Takeoff Weight = 370,140 lb. / 167,893 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 34R (12,000 ft. / 3,658 m. available)

Takeoff Distance = 6,520 ft. / 1,987 m. (+1,055 ft. / +322 m.)

Takeoff Speeds =  $V_1$  - 138 kts.  $V_R$  - 139 kts.  $V_2$  - 141 kts.

## AAL263 DFW-PEK

Density Altitude = 6,871 ft. / 2,094 m. (+3,746 ft. / +1,142 m.)

Takeoff Weight = 456,416 lb. / 207,027 kg. (-33,944 lb. / -15,397 kg.)

Flap Setting: 15°

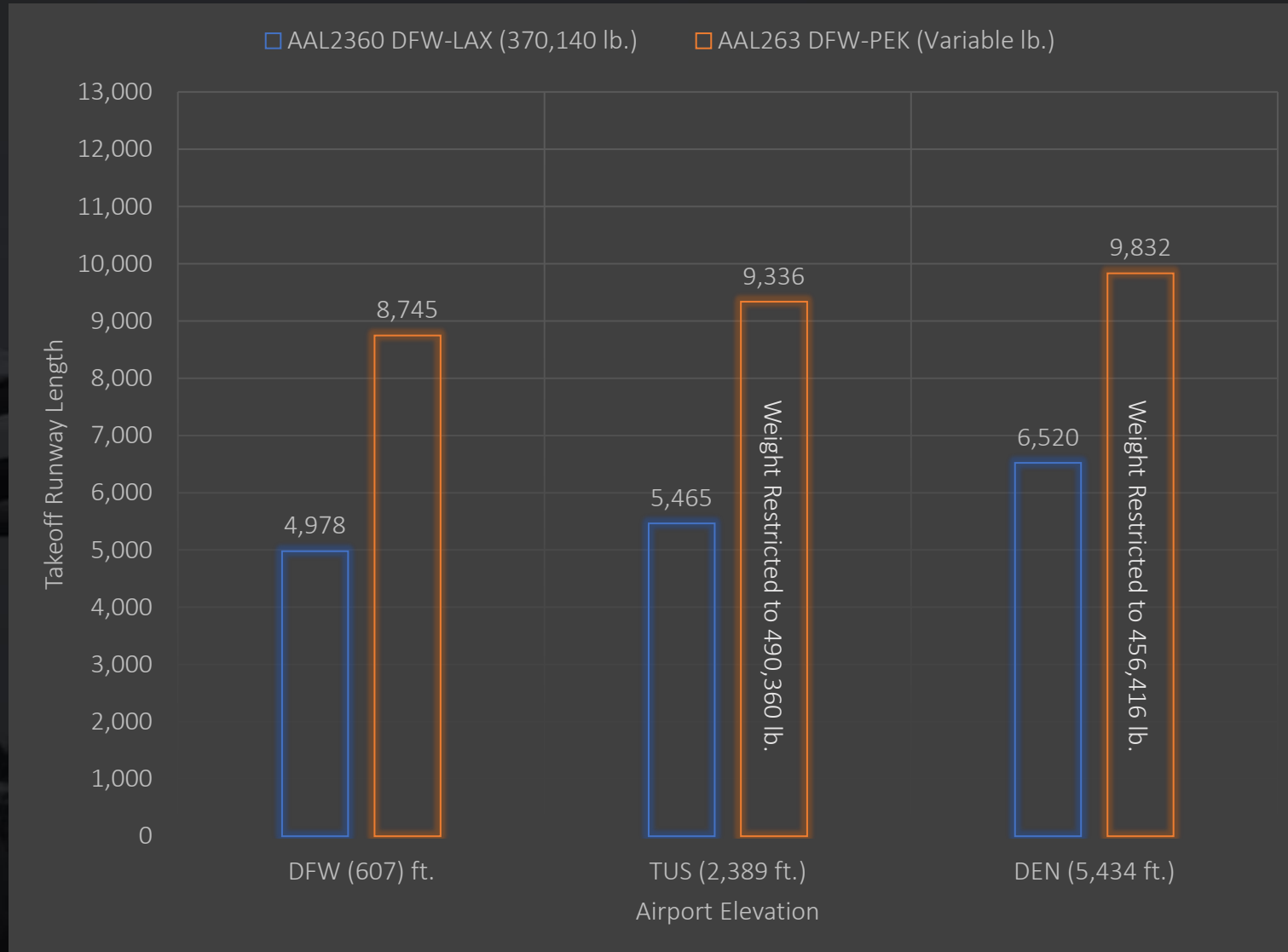
Power Setting: TO (0% Derate)

Takeoff Runway = 36R (12,000 ft. / 3,658 m. available)

Takeoff Distance = 9,832 ft. / 2,997 m. (+496 ft. / +151 m.)

Takeoff Speeds =  $V_1$  - 151 kts.  $V_R$  - 152 kts.  $V_2$  - 156 kts.

# TAKEOFF LENGTH COMPARISON WITH ELEVATION





# FACTORS THAT EFFECT AIRCRAFT TAKEOFF PERFORMANCE

1

Aircraft  
Weight

Plane + Payload + Fuel

2

Weather  
Conditions

Temp vs. Thrust

3

Airport  
Elevation

Air Density vs. Lift

4

Available  
Runway

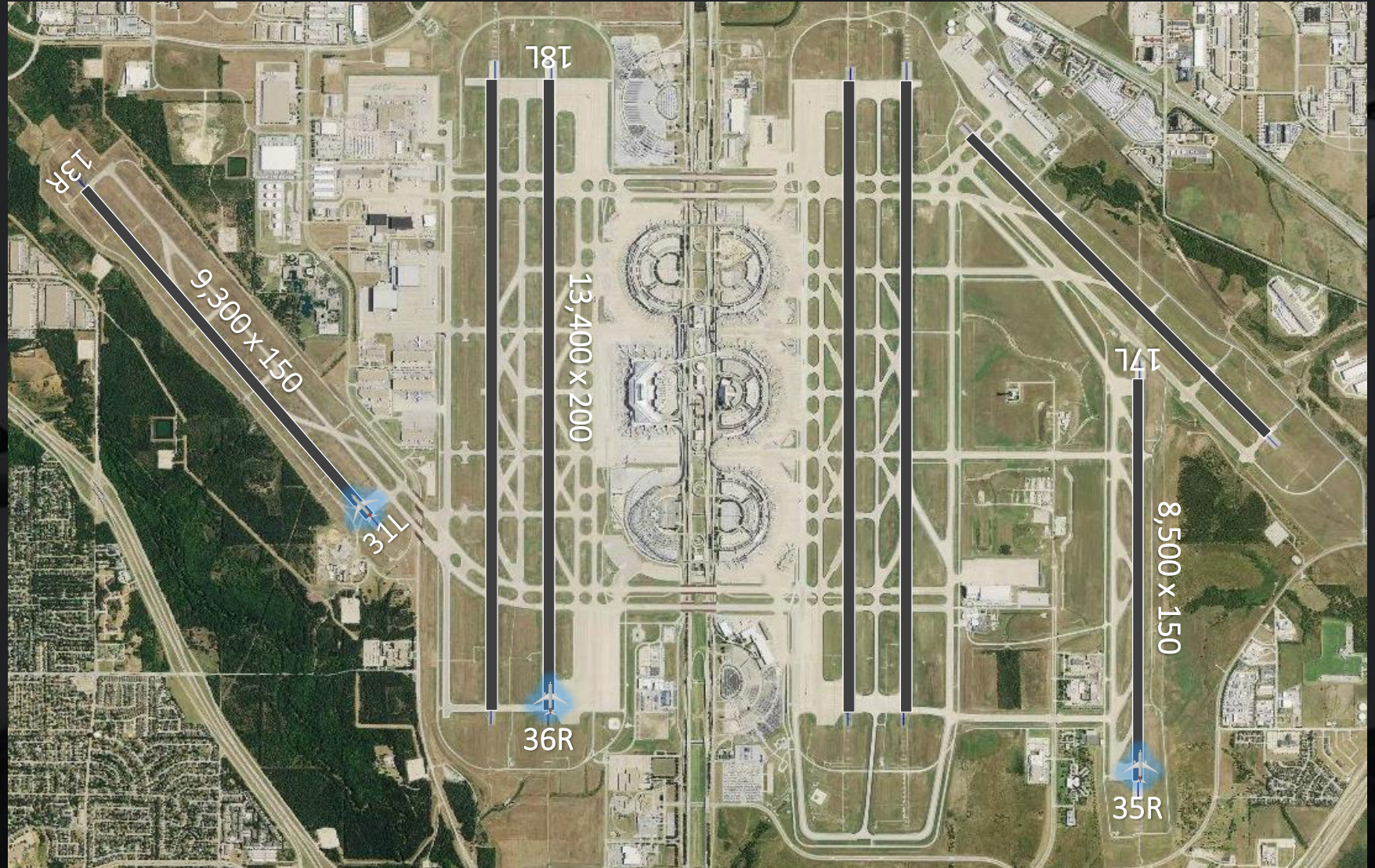
Length vs. Payload

# TAKEOFF COMPARISON WITH RUNWAY RESTRICTION

Scenario 1 - Takeoff  
Rwy 36R – 13,400 ft.

Scenario 2 - Takeoff  
Rwy 31L – 9,300 ft.

Scenario 3 - Takeoff  
Rwy 35R – 8,500 ft.





# TAKEOFF SCENARIO 1 – RUNWAY 36R

Current Automatic Terminal Information Service (ATIS): Dallas/Fort Worth Int'l Airport (DFW)



Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
60°F / 16°C	40°F / 4°C	0 kts / ---°	29.92 in / 1013 mb.	607 ft. / 185 m.	Runway 36R

## AAL2360 DFW-LAX

Density Altitude = 925 ft. / 282 m.

Takeoff Weight = 370,140 lb. / 167,893 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 4,978 ft. / 1,517 m.

Takeoff Speeds =  $V_1$  - 138 kts.  $V_R$  - 138 kts.  $V_2$  - 148 kts.

## AAL263 DFW-PEK

Density Altitude = 925 ft. / 282 m.

Takeoff Weight = 494,637 lb. / 224,364 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)


Takeoff Runway = 36R (13,400 ft. / 4,084 m. available)

Takeoff Distance = 8,745 ft. / 2,665 m.

Takeoff Speeds =  $V_1$  - 155 kts.  $V_R$  - 157 kts.  $V_2$  - 169 kts.

# TAKEOFF SCENARIO 2 – RUNWAY 31L

Current Automatic Terminal Information Service (ATIS): Dallas/Fort Worth Int'l Airport (DFW)



Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
60°F / 16°C	40°F / 4°C	0 kts / ---°	29.92 in / 1013 mb.	607 ft. / 185 m.	Runway 36R

## AAL2360 DFW-LAX

Density Altitude = 925 ft. / 282 m.

Takeoff Weight = 370,140 lb. / 167,893 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 31L (9,300 ft. / 2,835 m. available)

Takeoff Distance = 4,978 ft. / 1,517 m. (Remaining 4,322 ft. / 1,317 m.)

Takeoff Speeds =  $V_1$  - 138 kts.  $V_R$  - 138 kts.  $V_2$  - 148 kts.

## AAL263 DFW-PEK

Density Altitude = 925 ft. / 282 m.

Takeoff Weight = 494,637 lb. / 224,364 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 31L (9,300 ft. / 2,835 m. available)

Takeoff Distance = 8,745 ft. / 2,665 m. (Remaining 555 ft. / 169 m.)

Takeoff Speeds =  $V_1$  - 153 kts.  $V_R$  - 156 kts.  $V_2$  - 168 kts.



# TAKEOFF SCENARIO 3 – RUNWAY 35R

Current Automatic Terminal Information Service (ATIS): Dallas/Fort Worth Int'l Airport (DFW)



Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
60°F / 16°C	40°F / 4°C	0 kts / ---°	29.92 in / 1013 mb.	607 ft. / 185 m.	Runway 36R

## AAL2360 DFW-LAX

Density Altitude = 925 ft. / 282 m.

Takeoff Weight = 370,140 lb. / 167,893 kg.

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 35R (8,500 ft. / 2,591 m. available)

Takeoff Distance = 4,978 ft. / 1,517 m. (Remaining 3,522 ft. / 1,074 m.)

Takeoff Speeds =  $V_1$  - 138 kts.  $V_R$  - 138 kts.  $V_2$  - 148 kts.

## AAL263 DFW-PEK

Density Altitude = 925 ft. / 282 m.

Takeoff Weight = 488,250 lb. / 221,466 kg. (-6,387 lb. / 2,897 kg.)

Flap Setting: 15°

Power Setting: TO (0% Derate)

Takeoff Runway = 35R (8,500 ft. / 2,591 m. available)

Takeoff Distance = 8,226 ft. / 2,507 m. (Remaining 274 ft. / 84 m.)

Takeoff Speeds =  $V_1$  - 151 kts.  $V_R$  - 155 kts.  $V_2$  - 166 kts.

# TAKEOFF LENGTH COMPARISON WITH AVAILABLE RUNWAY

