<table>
<thead>
<tr>
<th>TOPIC</th>
<th>PRESENTER</th>
<th>TIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction/Ice Breaker</td>
<td>Steve &amp; Greg</td>
<td>12:30</td>
</tr>
<tr>
<td>Evolution of Aviation Noise</td>
<td>Steve</td>
<td>12:45</td>
</tr>
<tr>
<td>Science of Aviation Noise</td>
<td>Greg</td>
<td>13:15</td>
</tr>
<tr>
<td>Quantifying Aviation Noise</td>
<td>Steve</td>
<td>13:45</td>
</tr>
<tr>
<td>Break</td>
<td>---------------</td>
<td>14:15</td>
</tr>
<tr>
<td>Regulating Aviation Noise</td>
<td>Steve</td>
<td>14:30</td>
</tr>
<tr>
<td>Aircraft Performance and Noise</td>
<td>Greg</td>
<td>15:00</td>
</tr>
<tr>
<td>Mitigating Aviation Noise</td>
<td>Steve</td>
<td>15:30</td>
</tr>
<tr>
<td>Questions/Wrap up</td>
<td>Steve &amp; Greg</td>
<td>16:00</td>
</tr>
<tr>
<td>Session Ends</td>
<td>---------------</td>
<td>16:15</td>
</tr>
</tbody>
</table>
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?
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

= 60 dB

= 70 dB
WEATHER’S EFFECT ON SOUND TRANSMISSION

Calm and Cloudy

Calm and Sunny

Windy

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

Sec.

| 0 | 0.5 | 1 | 1.5 | 2 | 2.5 | 3 | 3.5 | 4 | 4.5 | 5 | 5.5 | 6 | 6.5 | 7 | 7.5 | 8 | 8.5 | 9 | 9.5 | 10 | 11 | 11.5 | 12 | 12.5 | 13 | 13.5 | 14 | 14.5 | 15 | 15.5 | 16 | 16.5 | 17 | 17.5 | 18 | 18.5 | 19 | 19.5 | 20 |
| 65.0 | 66.0 | 67.0 | 69.0 | 71.0 | 74.0 | 78.0 | 82.0 | 85.0 | 87.0 | 87.0 | 88.0 | 88.0 | 87.0 | 85.0 | 82.0 | 78.0 | 74.0 | 71.0 | 69.0 | 67.0 | 66.0 | 65.0 | 64.0 | 65.0 | 66.0 | 67.0 | 69.0 | 71.0 | 74.0 | 71.0 | 69.0 | 67.0 | 66.0 | 65.0 | 64.0 | 63.0 | 65.0 | 66.0 | 67.0 | 69.0 | 71.0 | 74.0 | 71.0 | 69.0 | 67.0 | 66.0 | 65.0 | 64.0

(●) CASPER
SEL - The sound level that would be experienced if all the sound energy of a single event were compressed into 1 second.
**Equivalent 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)
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.
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.
EQUIVALENT 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:

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

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.
Aircraft Noise is measured in A weighted decibels (dBA)

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.

<table>
<thead>
<tr>
<th>Certification Level</th>
<th>Sideline</th>
<th>Approach</th>
<th>Takeoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise Level (EPNdB)</td>
<td>94.0</td>
<td>100.9</td>
<td>94.5</td>
</tr>
<tr>
<td>Noise Limit (EPNdB)</td>
<td>103.0</td>
<td>105.0</td>
<td>106.0</td>
</tr>
<tr>
<td>Margin Below Stage IV</td>
<td>9.0</td>
<td>4.1</td>
<td>11.5</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Certification Level</th>
<th>Sideline</th>
<th>Approach</th>
<th>Takeoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise Level (EPNdB)</td>
<td>91.6</td>
<td>94.2</td>
<td>86.6</td>
</tr>
<tr>
<td>Noise Limit (EPNdB)</td>
<td>100.9</td>
<td>104.3</td>
<td>98.0</td>
</tr>
<tr>
<td>Margin Below Stage IV</td>
<td>9.3</td>
<td>10.1</td>
<td>11.4</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Certification Level</th>
<th>Sideline</th>
<th>Approach</th>
<th>Takeoff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise Level (EPNdB)</td>
<td>88.5</td>
<td>94.2</td>
<td>82.6</td>
</tr>
<tr>
<td>Noise Limit (EPNdB)</td>
<td>97.2</td>
<td>100.9</td>
<td>92.1</td>
</tr>
<tr>
<td>Margin Below Stage IV</td>
<td>8.7</td>
<td>6.7</td>
<td>9.5</td>
</tr>
</tbody>
</table>
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 limits at each certification point.
AIRCRAFT 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)

This report established the Federal government’s DNL 65 dB standard and related guidelines for land use compatibility.
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/usc475-1.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

- **Lift**
- **Weight**
- **Drag**
- **Thrust**
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?**

<table>
<thead>
<tr>
<th></th>
<th>Operating Empty Weight</th>
<th>Maximum Structural Payload</th>
<th>Maximum Zero Fuel Weight</th>
<th>Maximum Fuel Capacity</th>
<th>Maximum Taxi Weight</th>
<th>Maximum Takeoff Weight</th>
<th>Maximum Landing Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BOEING 787-8 with GEnx 1B70 PIP II Engines</strong></td>
<td>264,500 lb. / 119,975 kg.</td>
<td>90,500 lb. / 41,050 kg.</td>
<td>355,000 lb. / 161,025 kg.</td>
<td>223,378 lb. / 101,323 kg.</td>
<td>504,100 lb. / 228,656 kg.</td>
<td>502,500 lb. / 227,930 kg.</td>
<td>380,000 lb. / 172,365 kg.</td>
</tr>
</tbody>
</table>
REAL WORLD FLIGHT COMPARISON

Dallas/Fort Worth (DFW) to Beijing (PEK)
Aircraft Assigned: Boeing 787-8 (N800AN)
Flight Plan Distance: 7,217 miles

Dallas/Fort Worth (DFW) to Los Angeles (LAX)
Aircraft Assigned: Boeing 787-8 (N802AN)
Flight Plan Distance: 1,464 miles
HOW MUCH RUNWAY DO WE NEED TO TAKEOFF?
AIRCRAFT FLIGHT PLANNING

AAL2360 DFW-LAX
Flight Plan Distance = 1,464 mi.
Flight Time = 2hr 50 min.
Empty Weight = 264,500 lb.

AAL263 DFW-PEK
Flight Plan Distance = 7,217 mi.
Flight Time = 13hr 19 min.
Empty Weight = 264,500 lb.
HOW ARE CARGO WEIGHTS CALCULATED?

<table>
<thead>
<tr>
<th>FAA Avg. Baggage Weights</th>
<th>Palletized and Containerized Cargo</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Checked Bag</strong> 30 lb.</td>
<td>Carry-on included in Pax Weights</td>
</tr>
<tr>
<td><strong>Carry-on Bag</strong> 16 lb.</td>
<td><strong>Weighed prior to Loading</strong></td>
</tr>
<tr>
<td><strong>Heavy Bag</strong> 50+ lb.</td>
<td></td>
</tr>
</tbody>
</table>
CARGO LOAD PLANNING

AAL2360 DFW-LAX
Flight Plan Distance = 1,464 mi.
Flight Time = 2hr 50 min.
Empty Weight = 264,500 lb.
Bags / Cargo = 19,040 lb.

AAL263 DFW-PEK
Flight 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?

FAA Passenger Weights Winter
- Adult Male: 205 lb.
- Adult Female: 184 lb.
- Child: 87 lb.
- Avg. for Adult Pax = 195

FAA Passenger Weights Summer
- Adult Male: 200 lb.
- Adult Female: 179 lb.
- Child: 82 lb.
- Avg. for Adult Pax = 190
AAL2360 DFW-LAX
Flight 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
Flight 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

**FLIGHT: AAL2360 KDFW/DFW – KLAX/LAX**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Operating Empty Weight</td>
<td>264,500</td>
</tr>
<tr>
<td>Payload</td>
<td>61,980</td>
</tr>
<tr>
<td>Zero Fuel Weight</td>
<td>326,480</td>
</tr>
<tr>
<td>Minimum Landing Fuel</td>
<td>4,088</td>
</tr>
<tr>
<td>Alternate Fuel</td>
<td>7,999</td>
</tr>
<tr>
<td>Contingency Fuel</td>
<td>2,558</td>
</tr>
<tr>
<td>Planned Landing Weight</td>
<td>341,125</td>
</tr>
<tr>
<td>+ Flight Plan Fuel</td>
<td>29,015</td>
</tr>
<tr>
<td>Planned Gross Takeoff Weight</td>
<td>370,140</td>
</tr>
<tr>
<td>+ Taxi Fuel Burn Off</td>
<td>1,100</td>
</tr>
<tr>
<td>Planned Taxi-Out Weight</td>
<td>371,240</td>
</tr>
</tbody>
</table>

### Boeing 787-8 Fuel Capacity

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

### Fuel Planning Schematic 787-8 GEnx-1B70

**FLIGHT: AAL263 KDFW/DFW – ZBAA/PEK**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Operating Empty Weight</td>
<td>264,500</td>
</tr>
<tr>
<td>Payload</td>
<td>61,980</td>
</tr>
<tr>
<td>Zero Fuel Weight</td>
<td>326,480</td>
</tr>
<tr>
<td>Minimum Landing Fuel</td>
<td>4,120</td>
</tr>
<tr>
<td>Alternate Fuel</td>
<td>8,665</td>
</tr>
<tr>
<td>Contingency Fuel</td>
<td>7,399</td>
</tr>
<tr>
<td>Planned Landing Weight</td>
<td>346,664</td>
</tr>
<tr>
<td>+ Flight Plan Fuel</td>
<td>147,973</td>
</tr>
<tr>
<td>Planned Gross Takeoff Weight</td>
<td>494,637</td>
</tr>
<tr>
<td>+ Taxi Fuel Burn Off</td>
<td>1,100</td>
</tr>
<tr>
<td>Planned Taxi-Out Weight</td>
<td>495,737</td>
</tr>
</tbody>
</table>

### Boeing 787-8 Fuel Capacity

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

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

**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.

**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 SCENARIO 2 – TEMP 60° F

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

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

## 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.)

## 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 SCENARIO 3 – TEMP 90° F

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

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

#### 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

Runway 36R - 13,400 Ft.

- AAL2360 DFW-LAX (370,140 lb.)
- AAL263 DFW-PEK (494,637 lb.)

Air Temperature

- 30° F: 4,692 ft.
- 60° F: 4,978 ft.
- 90° F: 5,445 ft.

- 30° F: 8,346 ft.
- 60° F: 8,745 ft.
- 90° F: 9,558 ft.
AVERAGE DEPARTURE TRACK COMPARISON

AAL263 (DFW-PEK) Departure Profiles
- Winter
- Summer

AAL2360 (DFW-LAX) Departure Profiles
- Winter
- Summer

(*) CASPER
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)

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

**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°

<table>
<thead>
<tr>
<th>AAL2360 DFW-LAX</th>
<th>AAL263 DFW-PEK</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density Altitude</strong></td>
<td>925 ft. / 282 m.</td>
</tr>
<tr>
<td><strong>Takeoff Weight</strong></td>
<td>370,140 lb. / 167,893 kg.</td>
</tr>
<tr>
<td><strong>Flap Setting</strong></td>
<td>15°</td>
</tr>
<tr>
<td><strong>Power Setting</strong></td>
<td>TO (0% Derate)</td>
</tr>
<tr>
<td><strong>Takeoff Runway</strong></td>
<td>36R (13,400 ft. / 4,084 m. available)</td>
</tr>
<tr>
<td><strong>Takeoff Distance</strong></td>
<td>4,582 ft. / 1,397 m. (-396 ft. / -121 m.)</td>
</tr>
<tr>
<td><strong>Density Altitude</strong></td>
<td>925 ft. / 282 m.</td>
</tr>
<tr>
<td><strong>Takeoff Weight</strong></td>
<td>494,637 lb. / 224,364 kg.</td>
</tr>
<tr>
<td><strong>Flap Setting</strong></td>
<td>15°</td>
</tr>
<tr>
<td><strong>Power Setting</strong></td>
<td>TO (0% Derate)</td>
</tr>
<tr>
<td><strong>Takeoff Runway</strong></td>
<td>36R (13,400 ft. / 4,084 m. available)</td>
</tr>
<tr>
<td><strong>Takeoff Distance</strong></td>
<td>8,243 ft. / 2,512 m. (-502 ft. / -153 m.)</td>
</tr>
</tbody>
</table>

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

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

---

**Runway 36R**

- **Departing Field Elevation**: 29.92 in / 1013 mb.
- **Altimeter Setting**: 15 kts / 360°
- **Winds**: 40° F / 4° C
- **Dew Point**: 60° F / 16° C
- **Temperature**: Current Automatic Terminal Information Service (ATIS):  Dallas/Fort Worth Int’l Airport (DFW)
## TAKEOFF SCENARIO 3 – WINDS 30 KTS. / 360°

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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Temperature</th>
<th>Dew Point</th>
<th>Winds</th>
<th>Altimeter Setting</th>
<th>Field Elevation</th>
<th>Departing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>60°F / 16°C</td>
<td>40°F / 4°C</td>
<td>30 kts / 360°</td>
<td>29.92 in / 1013 mb</td>
<td>607 ft. / 185 m</td>
<td>Runway 36R</td>
</tr>
</tbody>
</table>

### 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.)

### 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.)
<table>
<thead>
<tr>
<th>Headwind Component</th>
<th>0 kts.</th>
<th>15 kts.</th>
<th>30 kts.</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAL2360 DFW-LAX</td>
<td>4,978</td>
<td>4,582</td>
<td>4,202</td>
</tr>
<tr>
<td>AAL263 DFW-PEK</td>
<td>8,745</td>
<td>8,243</td>
<td>7,769</td>
</tr>
</tbody>
</table>

**TAKEOFF LENGTH COMPARISON WITH HEADWIND**

- **Runway 36R - 13,400 Ft.**
  - **0 kts.**
  - **15 kts.**
  - **30 kts.**
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 has an inverse correlation with air density.

At higher elevations the air is less dense, decreasing the lifting effectiveness of the wing. Elevation also affects 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.
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.

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 SCENARIO 2 – ELEVATION 2,389 FT.

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

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Dew Point</th>
<th>Winds</th>
<th>Altimeter Setting</th>
<th>Field Elevation</th>
<th>Departing Runway</th>
</tr>
</thead>
<tbody>
<tr>
<td>60°F / 16°C</td>
<td>40°F / 4°C</td>
<td>0 kts / ---°</td>
<td>29.92 in / 1013 mb.</td>
<td>2,389 ft. / 728 m.</td>
<td>29R</td>
</tr>
</tbody>
</table>

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.)
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.

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.

Current Automatic Terminal Information Service (ATIS): Denver Int’l Airport (DEN)
Temperature: 60°F / 16°C
Dew Point: 40°F / 4°C
Winds: 0 kts / ---°
Altimeter Setting: 29.92 in / 1013 mb.
Field Elevation: 5,434 ft. / 1,656 m.
Departing Runway: 34R

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.

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

Current Automatic Terminal Information Service (ATIS): Denver Int’l Airport (DEN)
Temperature: 60°F / 16°C
Dew Point: 40°F / 4°C
Winds: 0 kts / ---°
Altimeter Setting: 29.92 in / 1013 mb.
Field Elevation: 5,434 ft. / 1,656 m.
Departing Runway: 34R

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.

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

Current Automatic Terminal Information Service (ATIS): Denver Int’l Airport (DEN)
Temperature: 60°F / 16°C
Dew Point: 40°F / 4°C
Winds: 0 kts / ---°
Altimeter Setting: 29.92 in / 1013 mb.
Field Elevation: 5,434 ft. / 1,656 m.
Departing Runway: 34R

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.

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

Current Automatic Terminal Information Service (ATIS): Denver Int’l Airport (DEN)
Temperature: 60°F / 16°C
Dew Point: 40°F / 4°C
Winds: 0 kts / ---°
Altimeter Setting: 29.92 in / 1013 mb.
Field Elevation: 5,434 ft. / 1,656 m.
Departing Runway: 34R

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

<table>
<thead>
<tr>
<th></th>
<th>Takeoff Runway Length</th>
<th>Airport Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAL2360 DFW-LAX (370,140 lb.)</td>
<td>8,745 ft.</td>
<td>DFW (607 ft.)</td>
</tr>
<tr>
<td>Weight Restricted to 490,360 lb.</td>
<td>9,336 ft.</td>
<td>TUS (2,389 ft.)</td>
</tr>
<tr>
<td>Weight Restricted to 456,416 lb.</td>
<td>9,832 ft.</td>
<td>DEN (5,434 ft.)</td>
</tr>
</tbody>
</table>

DFW (607 ft.)
TUS (2,389 ft.)
DEN (5,434 ft.)
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)

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

**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.

**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 SCENARIO 2 – RUNWAY 31L

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.

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

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

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

Current Automatic Terminal Information Service (ATIS): Dallas/Fort Worth Int’l Airport (DFW)
AAL263 DFW-PEK
Density Altitude = 925 ft. / 282 m.
Takeoff Weight = 488,250 lb. / 221,466 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.

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.

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

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

Runway 36R
Departing 607 ft. / 185 m.
Field Elevation 29.92 in / 1013 mb.
Altimeter Setting 0 kts / ---°
Winds 40°F / 4°C
Dew Point 60°F / 16°C
Temperature Current Automatic Terminal Information Service (ATIS): Dallas/Fort Worth Int’l Airport (DFW)

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

<table>
<thead>
<tr>
<th>Route</th>
<th>Takeoff Weight</th>
<th>Runway Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAL2360 DFW-LAX</td>
<td>370,140 lb.</td>
<td>13,400</td>
</tr>
<tr>
<td>AAL263 DFW-PEK</td>
<td>Variable lb.</td>
<td>8,745</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9,300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8,500</td>
</tr>
</tbody>
</table>