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AVIATION NOISE 101

Gregory Maxwell – Casper Airport Solutions

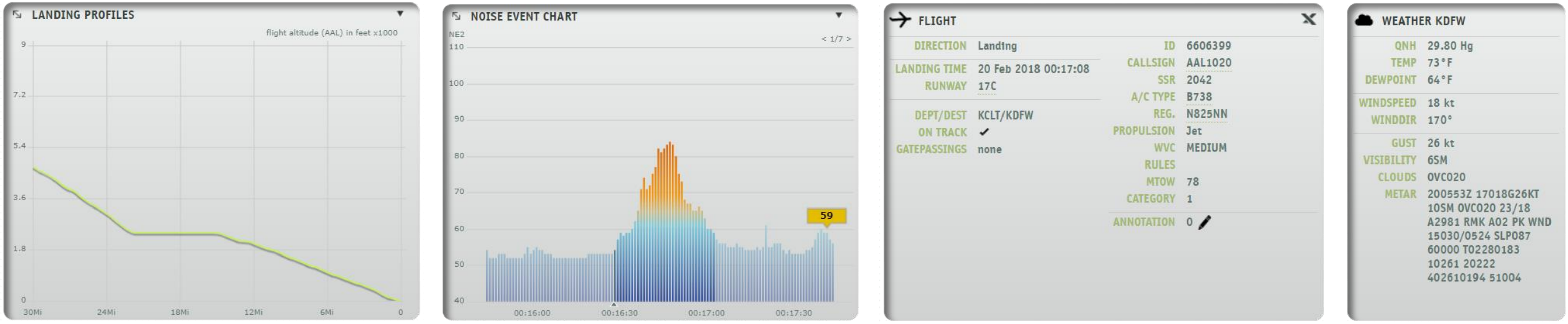
UC Davis Aviation Noise & Emissions Symposium: February 25, 2017 – Long Beach, CA

FLIGHTPLAN

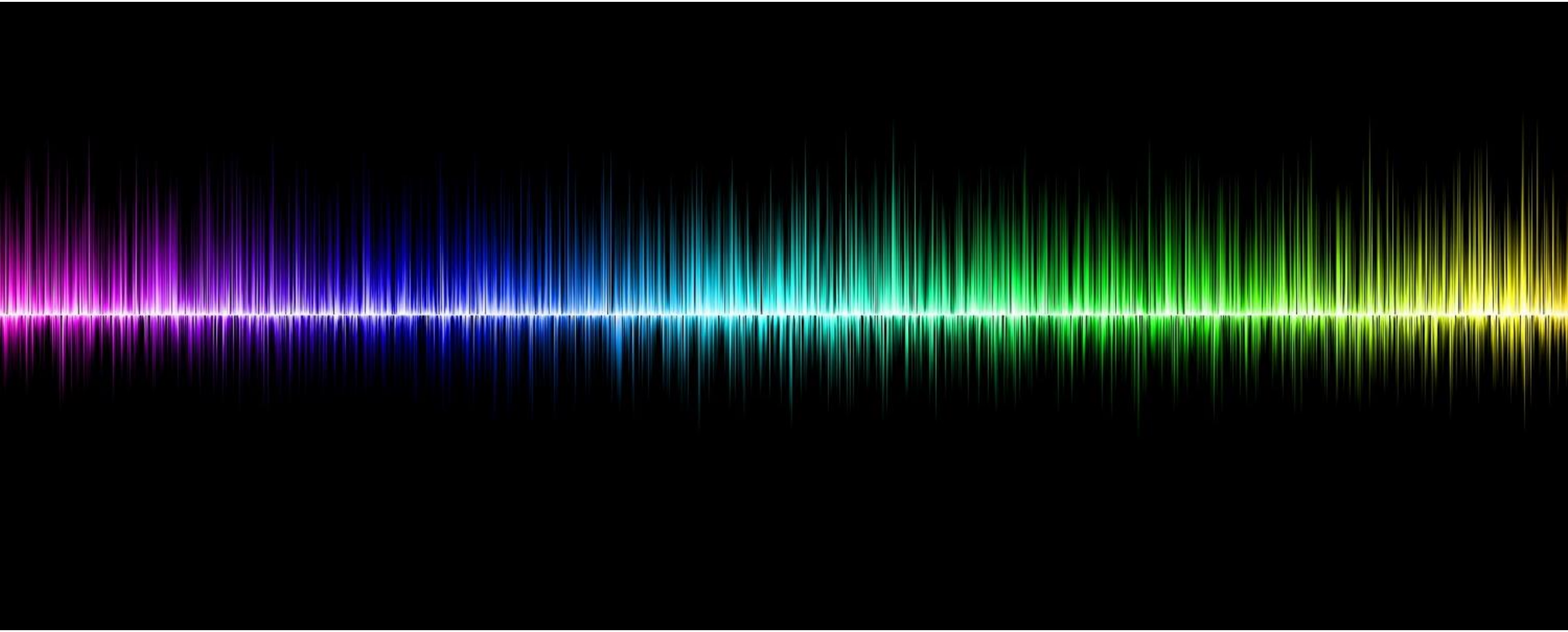
CASPER Shared Insight

TOPIC	PRESENTER	TIME
Introduction/Ice Breaker	Steve & Greg	12:00
Evolution of Aviation Noise	Steve	12:15
Break	-----------------	13:00
Science of Aviation Noise	Gregory	13:15
Quantifying Aviation Noise	Steve	13:45
Break	-----------------	14:15
Regulating Aviation Noise	Steve	14:30
Mitigating Aviation Noise	Steve	15:00
Break	-----------------	15:30
Aircraft Performance and Noise	Greg	15:45
Performance Based Navigation	Greg	16:15
Flight Procedure Design	Greg	16:35

THE SCIENCE OF AVIATION NOISE



WHAT IS SOUND?



A mechanical wave that results from the back and forth vibration of the particles of the medium through which the sound wave is moving

HOW DOES SOUND TRAVEL?

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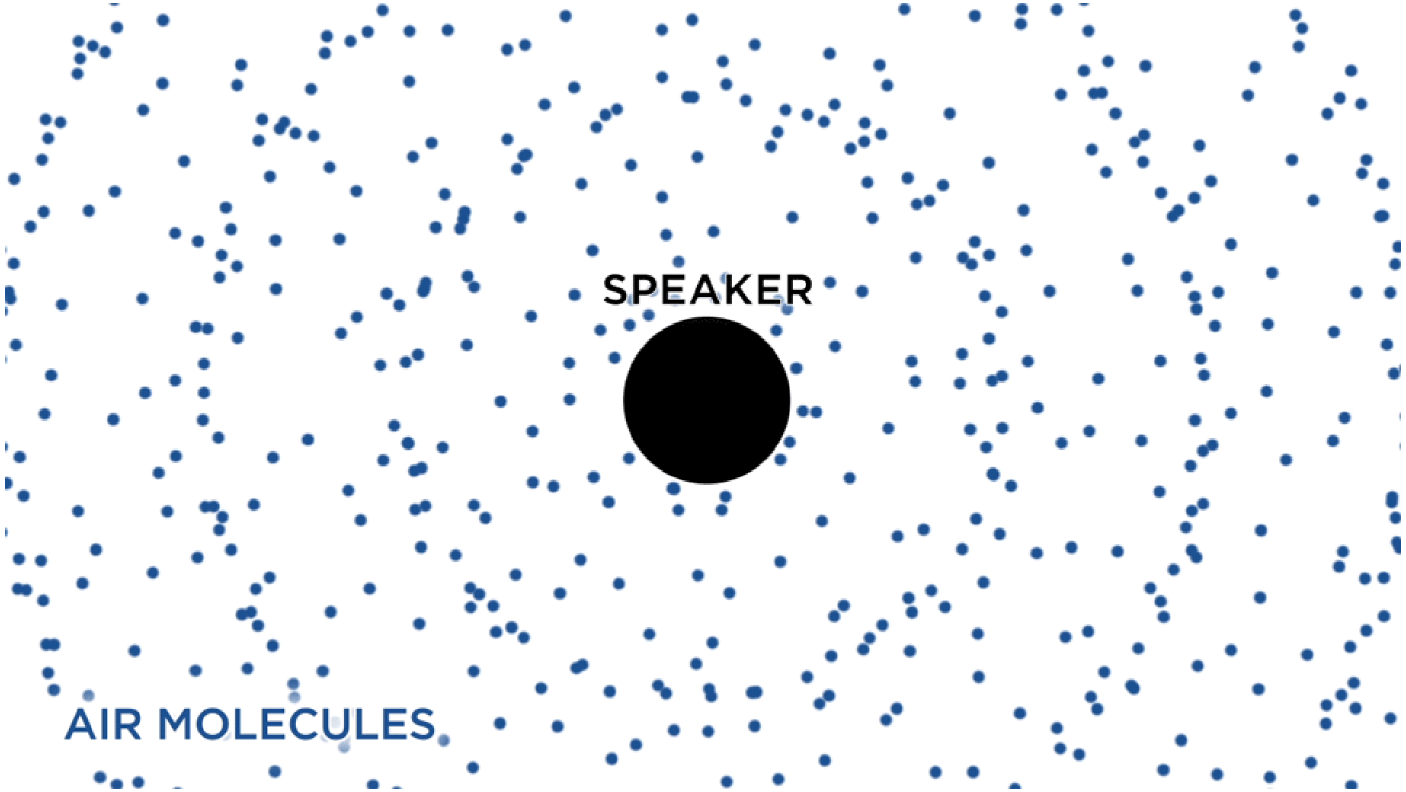

Sound is transmitted through the air by the vibration of air molecules

HOW IS SOUND ENERGY MEASURED?

	dB	Sound Energy	Perceived Loudness
Rock Concert	120	1,000,000	64x
Ambulance	110	100,000	32x
Fire Alarm	100	10,000	16x
Subway Train	90	1,000	8x
Urban Street	80	100	4x
Department Store	70	10	2x
Typical Conversation	60	1	1
Suburban Area	50	.1	1/2x
Rural Area	40	.01	1/4x
Whisper	30	.001	1/8x
Wilderness	20	.0001	1/16x
Breathing	10	.00001	1/32x
Threshold of Hearing	0	.000001	1/64x

WEATHER'S EFFECT ON SOUND TRASMISSION

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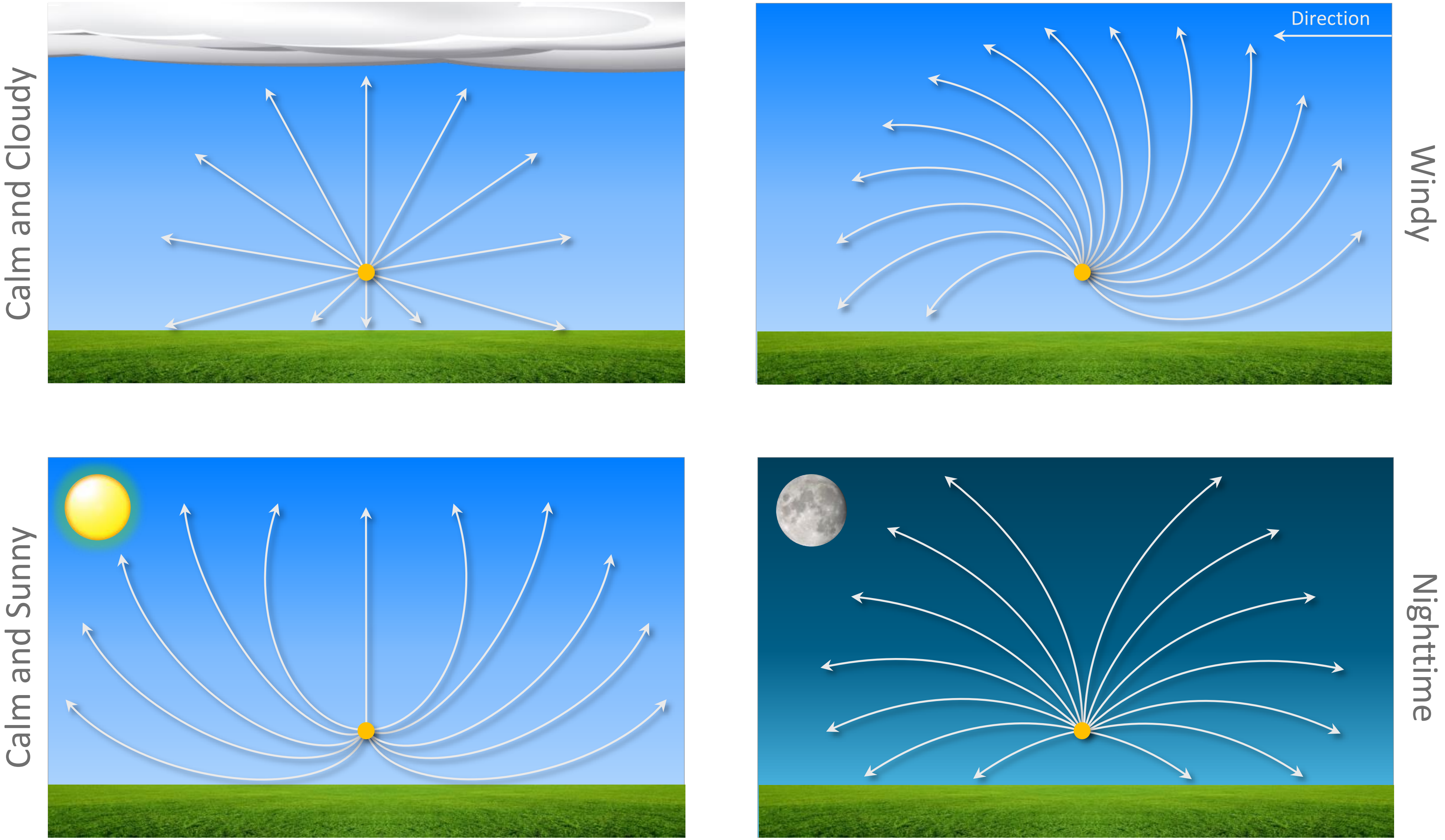

WHAT IS NOISE?

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

AIRPORT NOISE SOURCES

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Aircraft Departures

Engine Run-Ups

Running APU

Aircraft Arrivals

Reverse Thrust

Aircraft Idling / Taxiing

AIRCRAFT NOISE SOURCES

Photo - Victor J. Pody

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

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HOW IS AIRCRAFT NOISE MEASURED?

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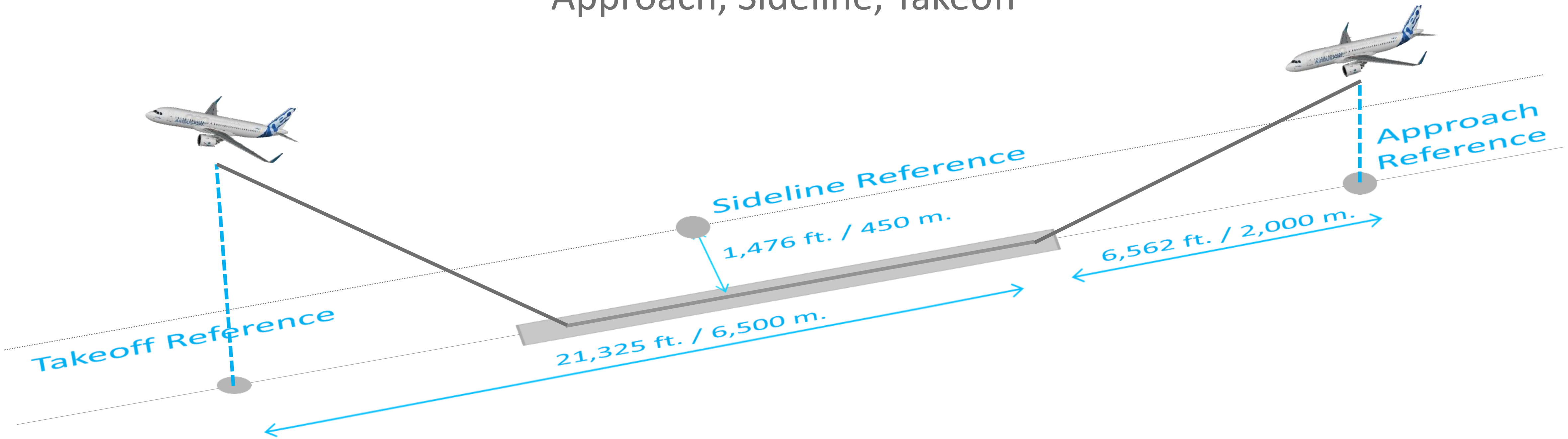
Aircraft Noise Certification Points:
Approach, Sideline, Takeoff



Aircraft Noise is measured in A weighted decibels (dBA)

HOW LOUD CAN A COMMERCIAL JET BE?

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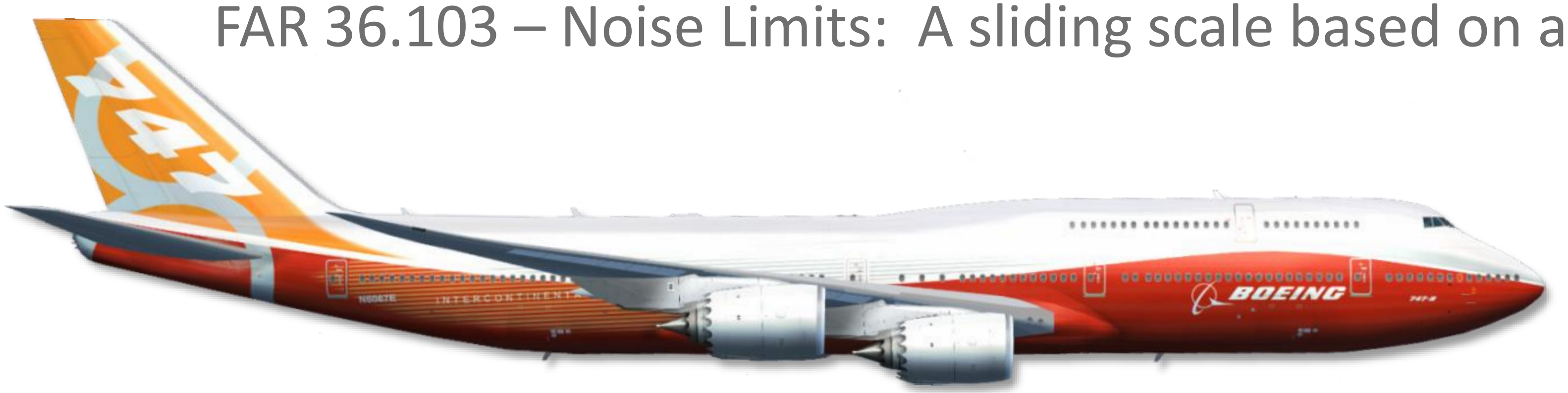
FAR 36.103 – Noise Limits: A sliding scale based on aircraft weight (Stage IV)



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

WHAT DOES A 10 DECIBEL INCREASE IN NOISE EQUATE TO?

= 60 dB

= 70 dB

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

HOW DOES THE FAA QUANTIFY AIRPLANE NOISE?

DNL – Day-night average sound level over a 24-hour period

DNL NIGHTTIME NOISE PENALTY

DAYTIME AIRCRAFT NOISE	NIGHTTIME AIRCRAFT NOISE
	
1 Event = 1 Event	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

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

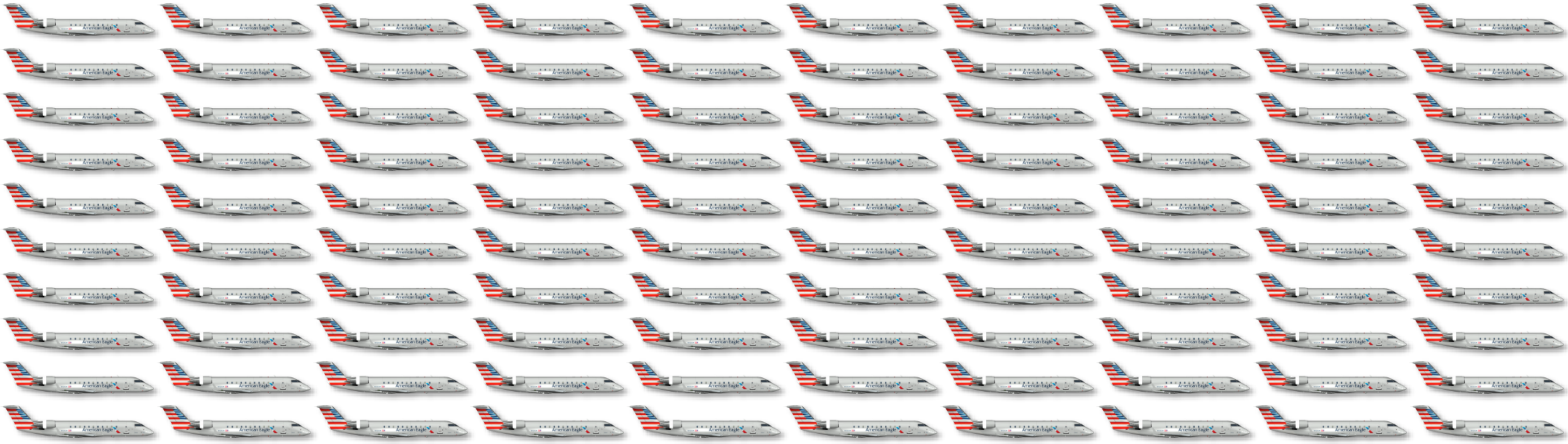
HOW DOES THE FAA DEFINE SIGNIFICANT NOISE?

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.

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

HOW DOES NOISE GET INTO MY HOME?

AIRCRAFT PERFORMANCE AND NOISE

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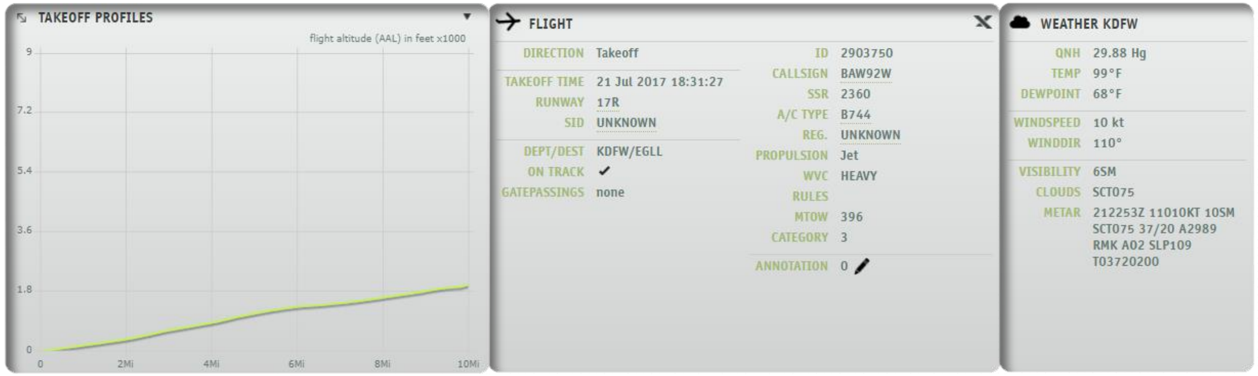
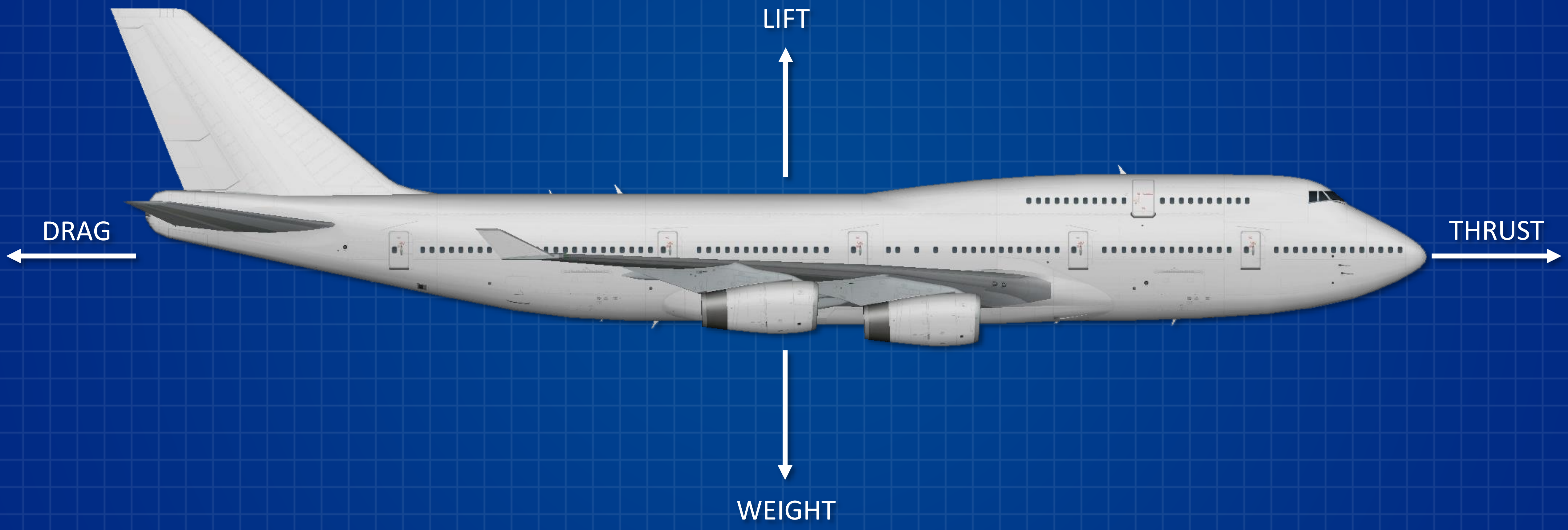
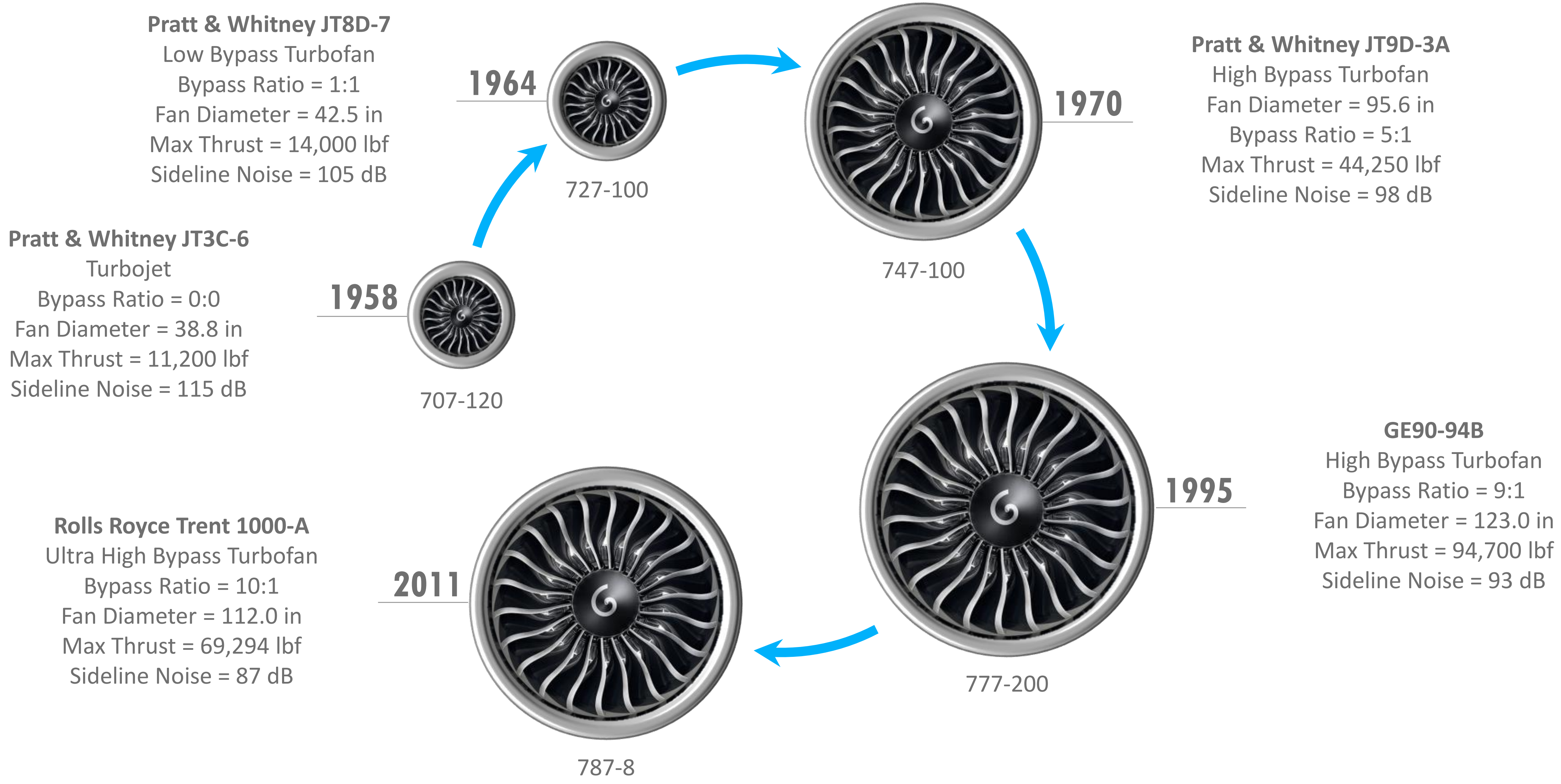


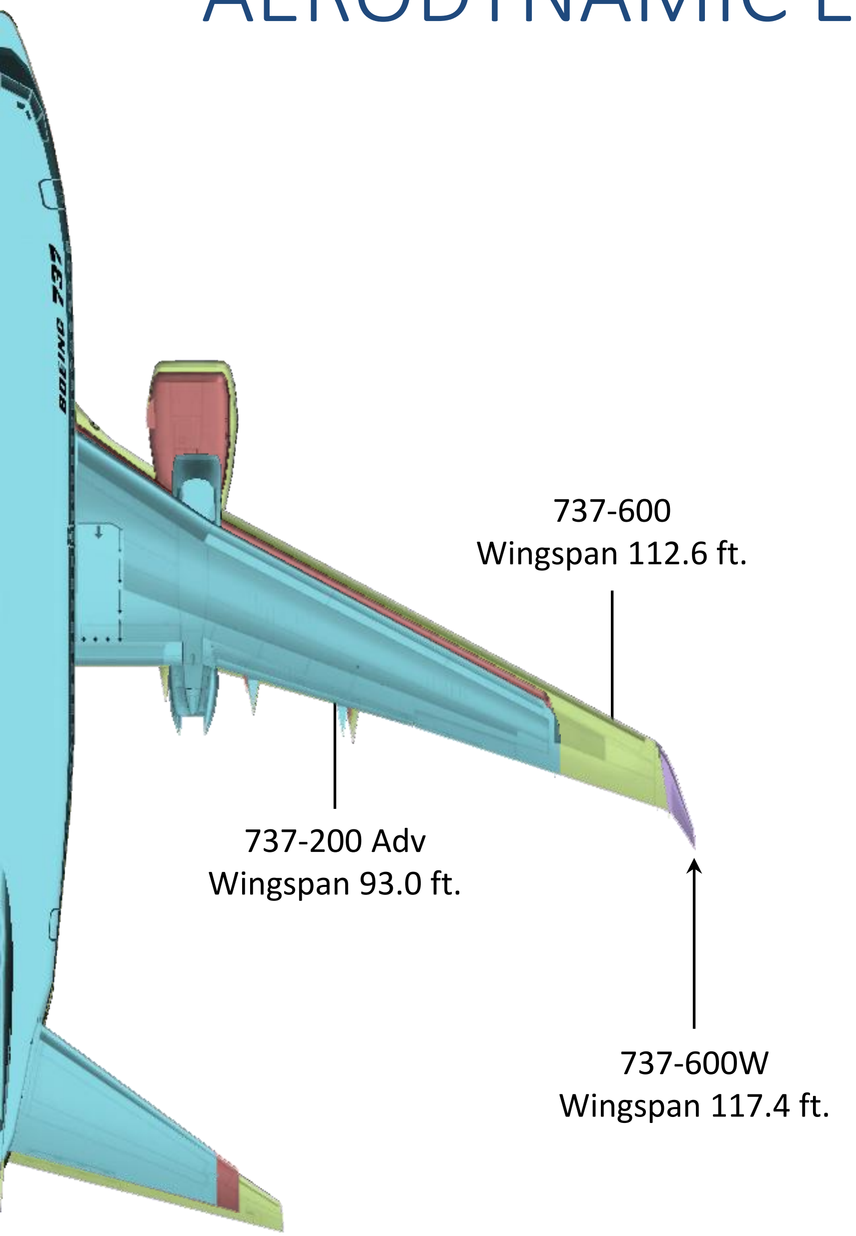
AERODYNAMIC FORCES ACTING ON AN AIRPLANE

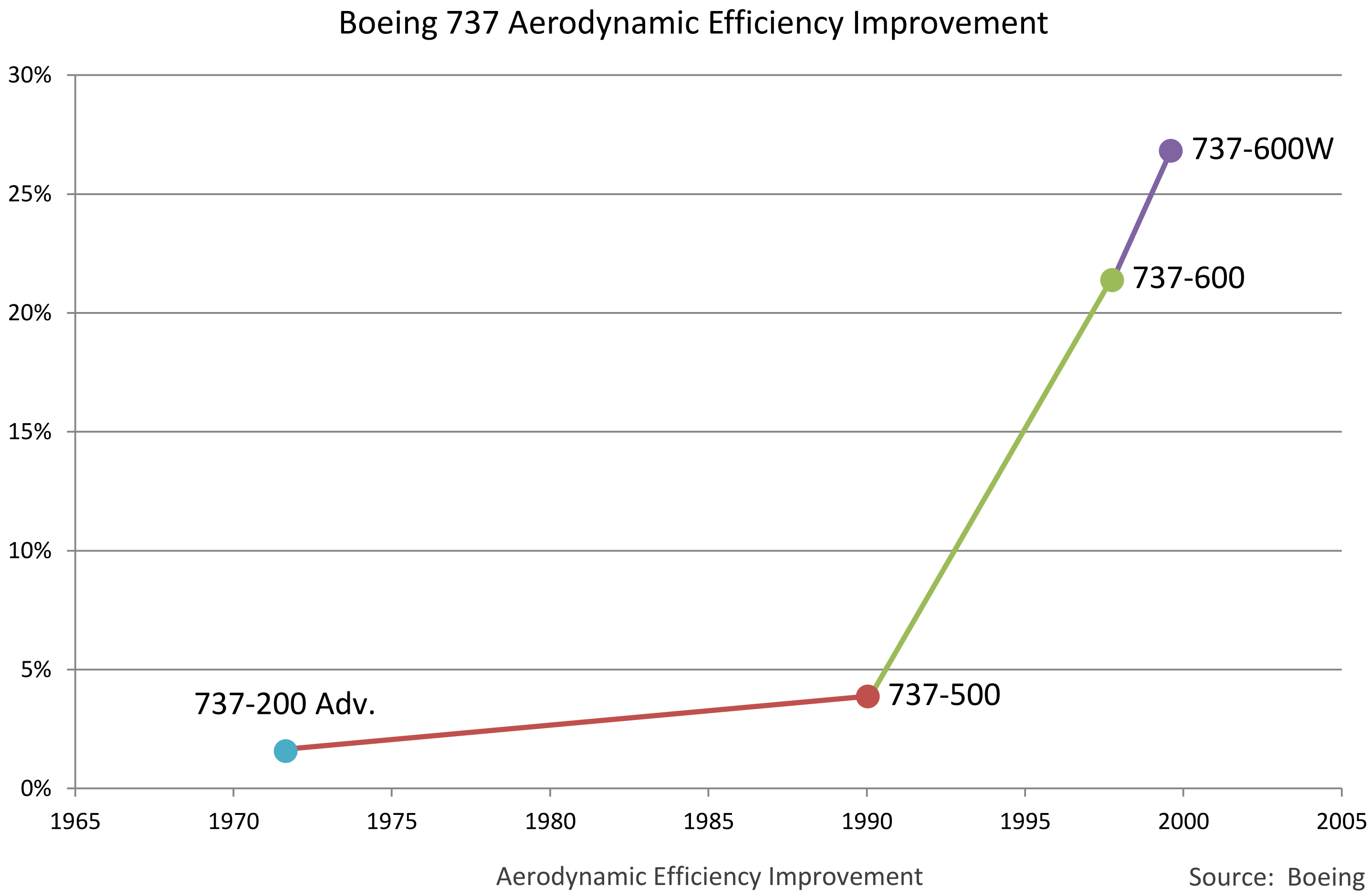


THE EVOLUTION OF THE COMMERCIAL JET ENGINE

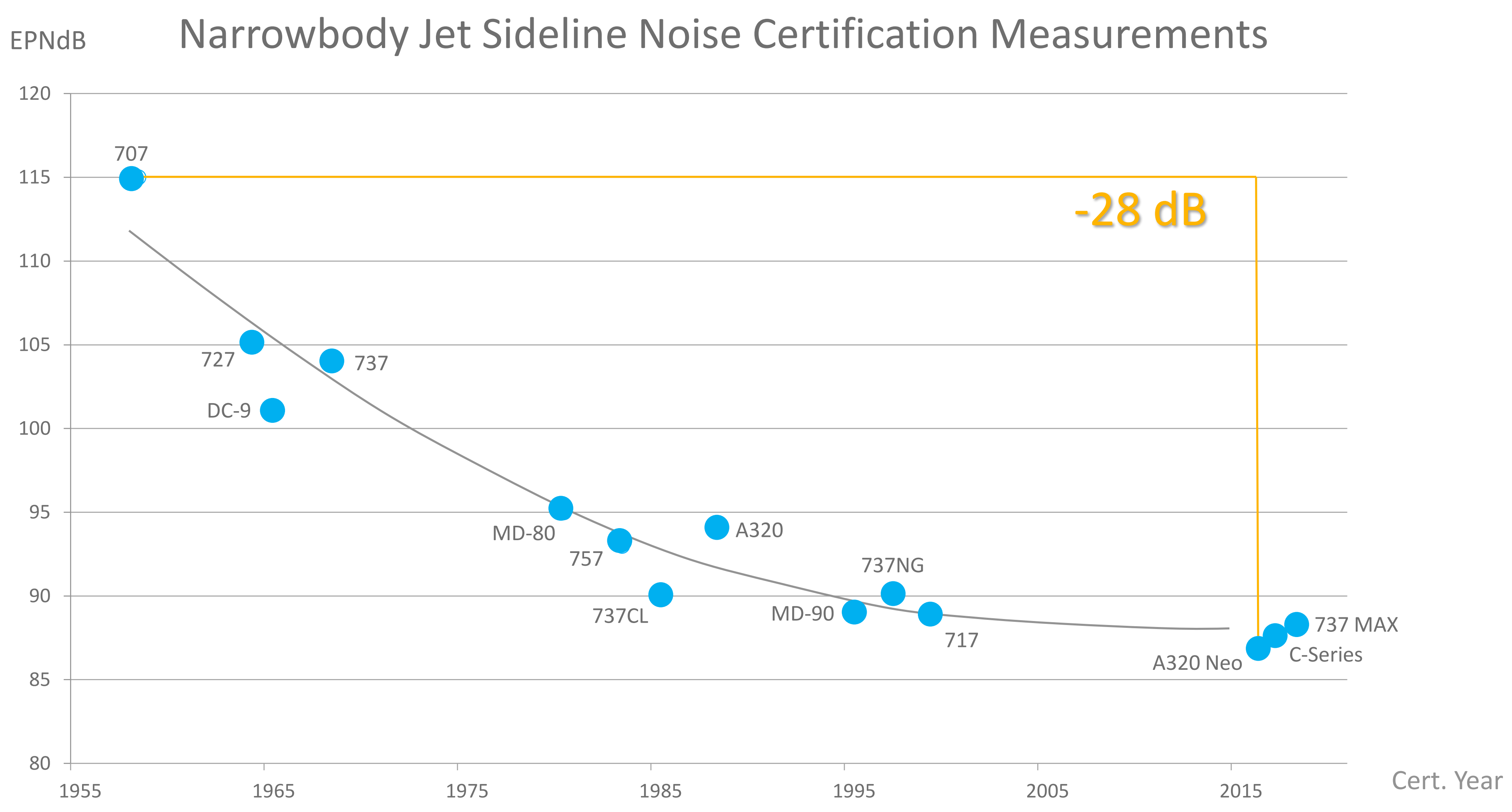


AERODYNAMIC EVOLUTION OF THE BOEING 737 FAMILY





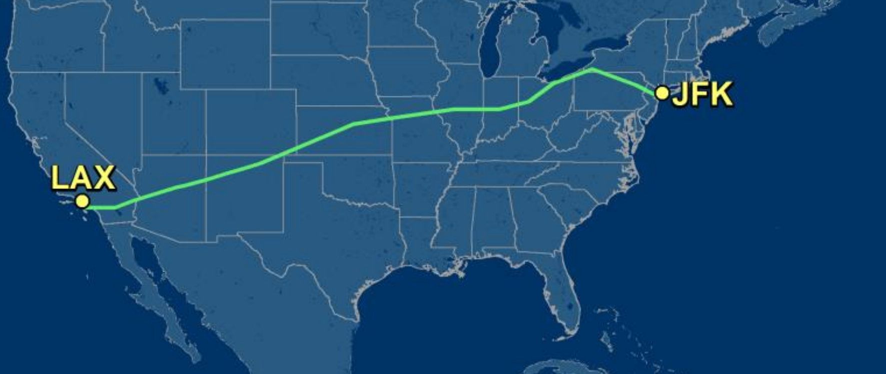
EVOLUTION OF THE NARROWBODY COMMERCIAL JET



FACTORS THAT EFFECT AIRCRAFT TAKEOFF PERFORMANCE

Aircraft Weight			Weather Conditions			Airport Elevation			Runway Length		
Plane	Payload	Fuel	Hotter Reduced Thrust	Engine Thrust	Colder Increased Thrust	Higher Less Dense Air	Lift Produced	Lower More Dense Air	Longer Higher Weight	Payload Uplift	Shorter Lower Weight

EXPLAINING THE VARIABILITY IN DEPARTURE PROFILES



Los Angeles (**LAX**) to Sydney (**SYD**)

Aircraft Assigned: Boeing 747-438 *(VH-OJS)*

Flight Plan Distance: 7,560 miles

Los Angeles (**LAX**) to New York (**JFK**)

Aircraft Assigned: Boeing 747-438 (*VH-OJT*)

Flight Plan Distance: 2,536 miles

HOW MUCH DOES A BOEING 747 WEIGH?

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BOEING 747-400 (4x RB211-524H) WEIGHTS	
OPERATING EMPTY WEIGHT	394,088 lb. / 178,755 kg.
MAX STRUCTURAL PAYLOAD	148,412 lb. / 67,319 kg.
MAX ZERO FUEL WEIGHT	542,500 lb. / 246,074 kg.
MAX USEABLE FUEL	382,336 lb. /173,425 kg.
MAX TAXI WEIGHT	877,000 lb. / 397,801 kg.
MAX TAKEOFF WEIGHT	875,000 lb. / 396,893 kg.
MAX LANDING WEIGHT	630,000 lb. / 285,763 kg.

HOW MUCH FUEL DO WE NEED FOR OUR TRIP?

Fuel Planning Schematic 747-400

(STANDARD UNITS)

Basic Operating Empty Weight:	394,000lbs
Payload:	105,727lbs
Zero Fuel Weight:	499,815lbs (Must be less than 535,000)

Zero Fuel Weight:	499,815lbs
+ Minimum Landing Fuel:	24,000lbs
+ Alternate Fuel:	11,400lbs
+ Contingency Fuel:	11,139lbs
Planned Landing Weight:	546,354lbs (Must be less than 630,000)

Planned Landing Weight:	546,354lbs
+ Flight Plan Fuel:	324,164lbs
Planned Gross Takeoff Weight:	870,518lbs (Must be less than 875,000)

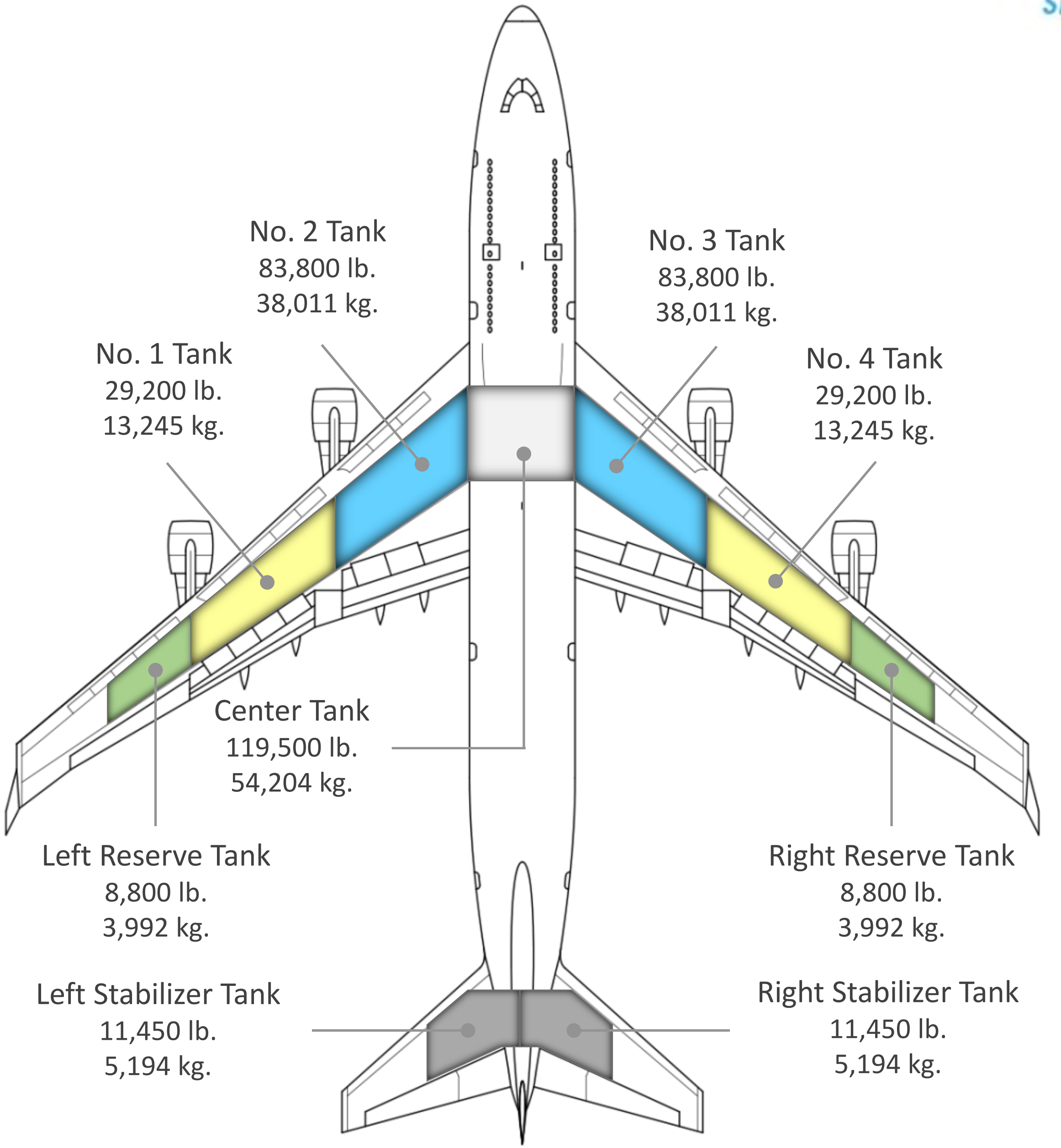
Planned Gross Takeoff Weight:	870,518lbs
+ Taxi Fuel Burn Off:	3,000lbs
Planned Taxi-Out Weight:	873,518lbs (Must be less than 877,000)

Schematic should be used to ensure compliance with structural weight limits.

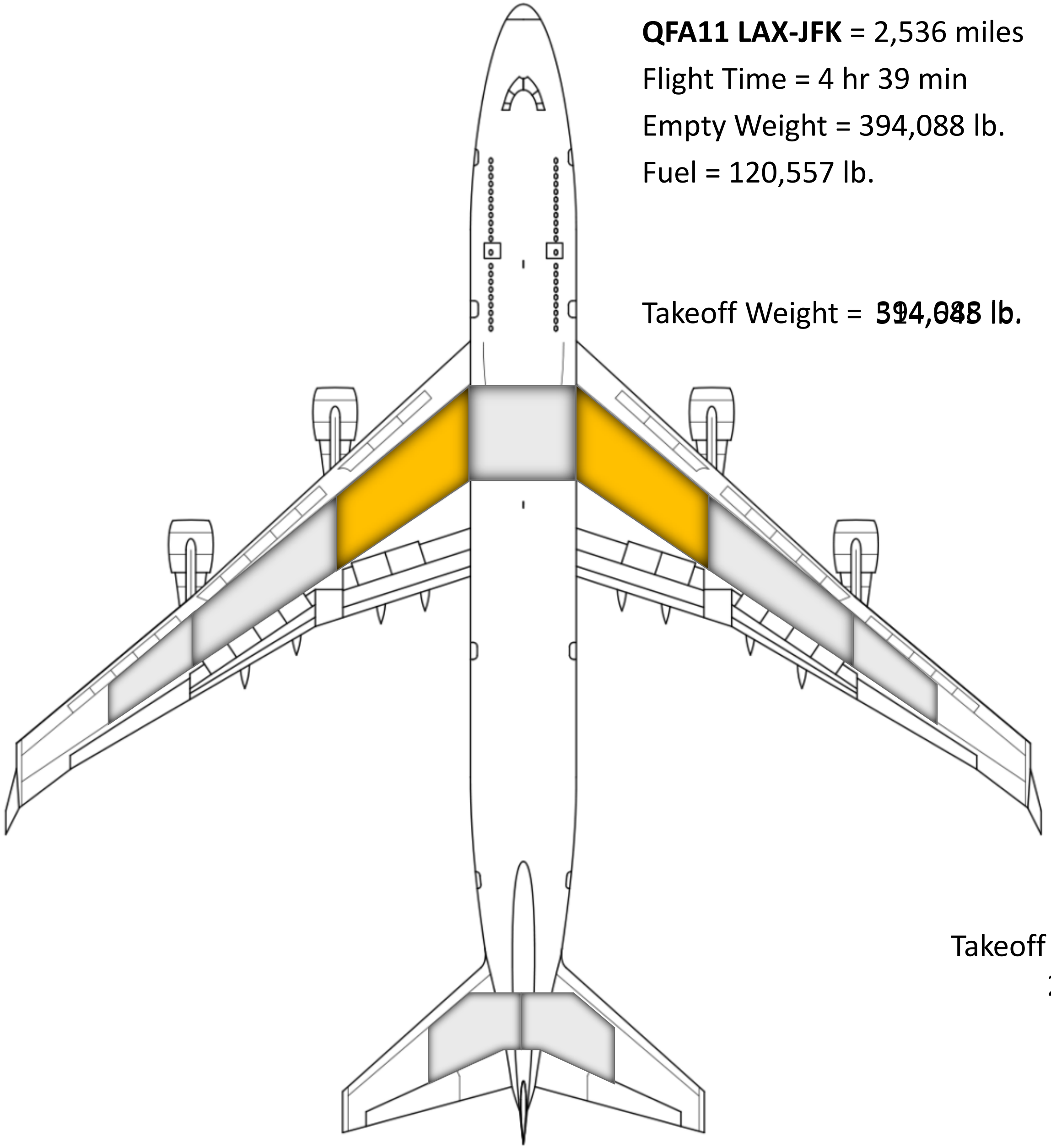
Crews should verify that planned takeoff and planned landing weights are not limited by reduced runway lengths or high density altitudes.

Boeing 747-400 Fuel Capacity

Capacity	Useable	Unusable
Capacity = 386,000 lb. 175,087 kg.	Useable = 382,336 lb. 173,425 kg.	Unusable = 3,664 lb. 1,662 kg.

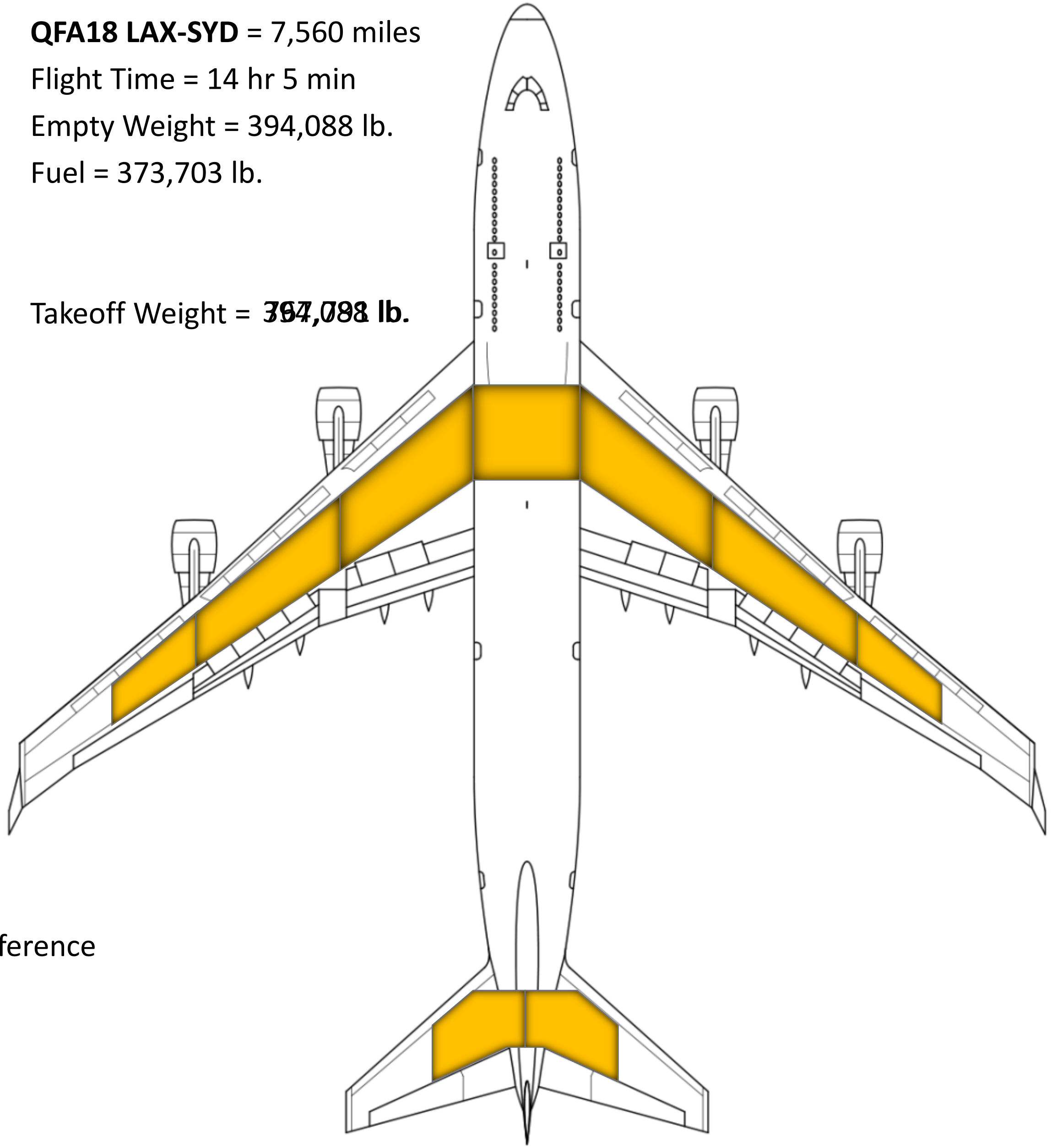


FUEL LOAD PLANNING



QFA11 LAX-JFK = 2,536 miles
Flight Time = 4 hr 39 min
Empty Weight = 394,088 lb.
Fuel = 120,557 lb.

Takeoff Weight = 514,645 lb. / 394,088 lb.



QFA18 LAX-SYD = 7,560 miles
Flight Time = 14 hr 5 min
Empty Weight = 394,088 lb.
Fuel = 373,703 lb.

Takeoff Weight = **767,791 lb.** / 394,088 lb.

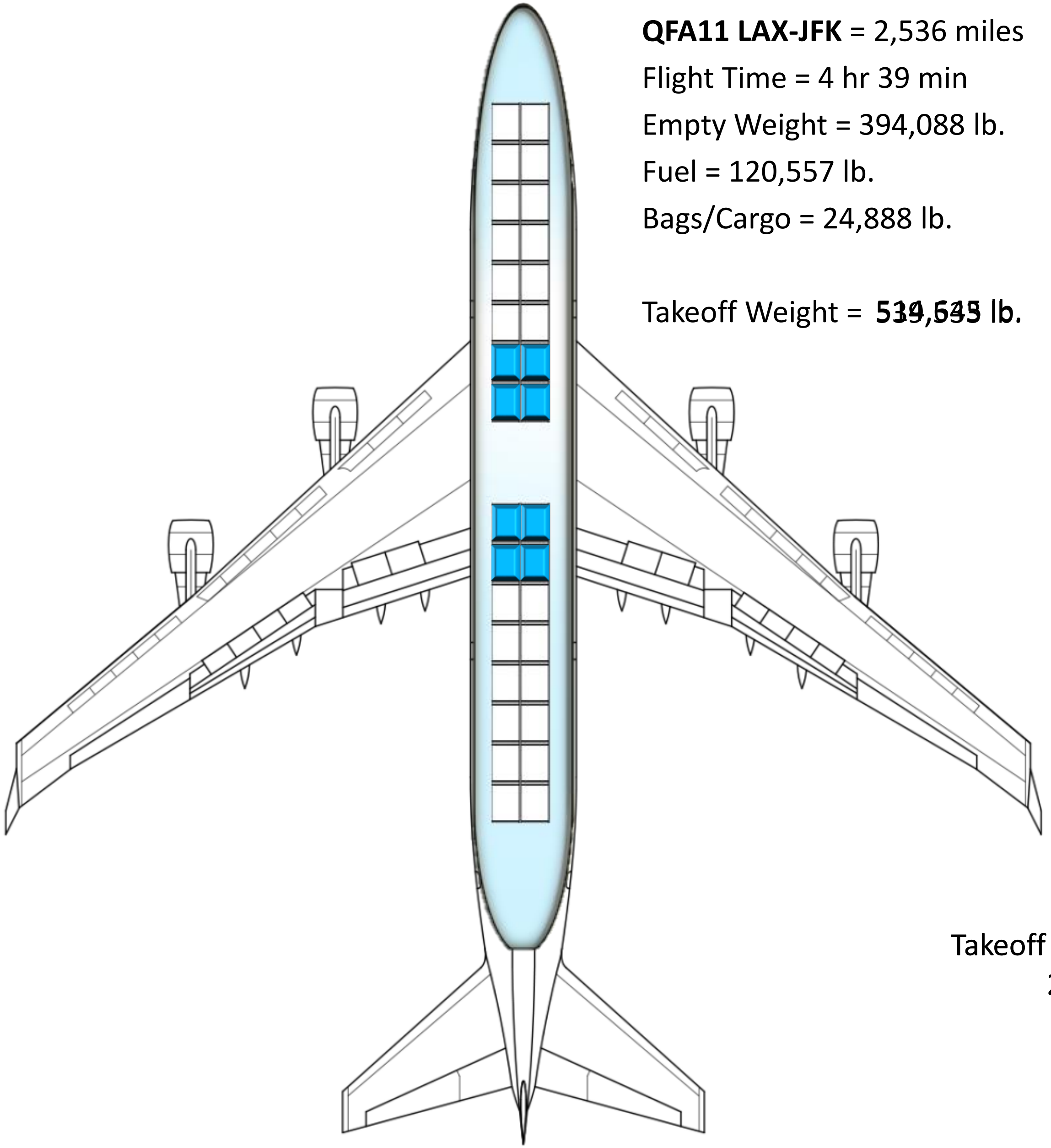
Takeoff Weight Difference
253,146 lb. / 0 lb.

HOW ARE PASSENGER AND CARGO WEIGHTS CALCULATED?

FAA Average Summer Weights (Estimates)	Palletized and Containerized Cargo

Adult | Child (2-13 years) | Checked | Carry-On | Overweight | Weighed prior to loading

CARGO LOAD PLANNING

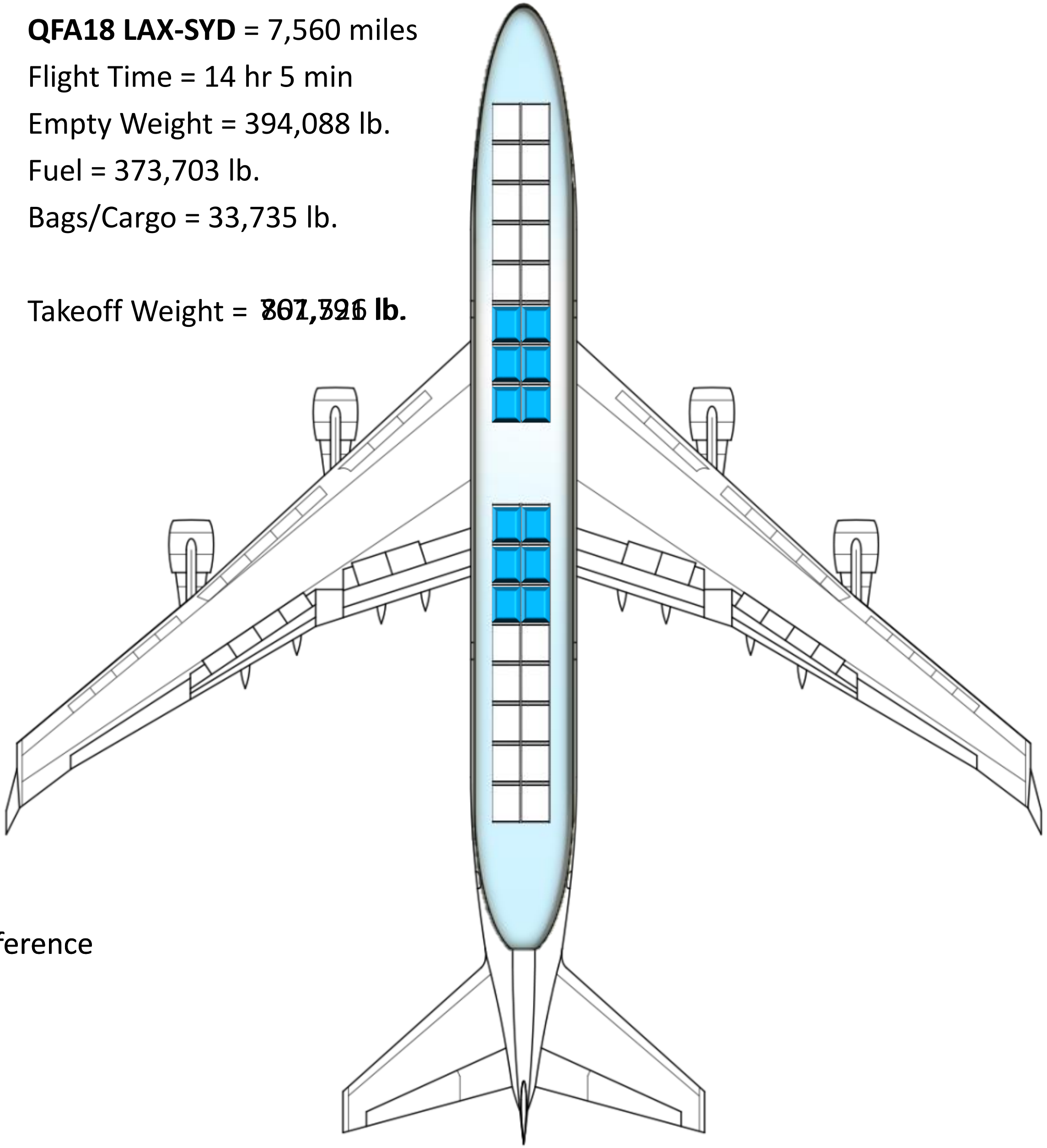


QFA11 LAX-JFK = 2,536 miles
Flight Time = 4 hr 39 min
Empty Weight = 394,088 lb.
Fuel = 120,557 lb.
Bags/Cargo = 24,888 lb.

Takeoff Weight = 539,533 lb.

QFA18 LAX-SYD = 7,560 miles
Flight Time = 14 hr 5 min
Empty Weight = 394,088 lb.
Fuel = 373,703 lb.
Bags/Cargo = 33,735 lb.

Takeoff Weight = **801,526 lb.**



Takeoff Weight Difference
261,993 lb.

PASSENGER LOAD PLANNING

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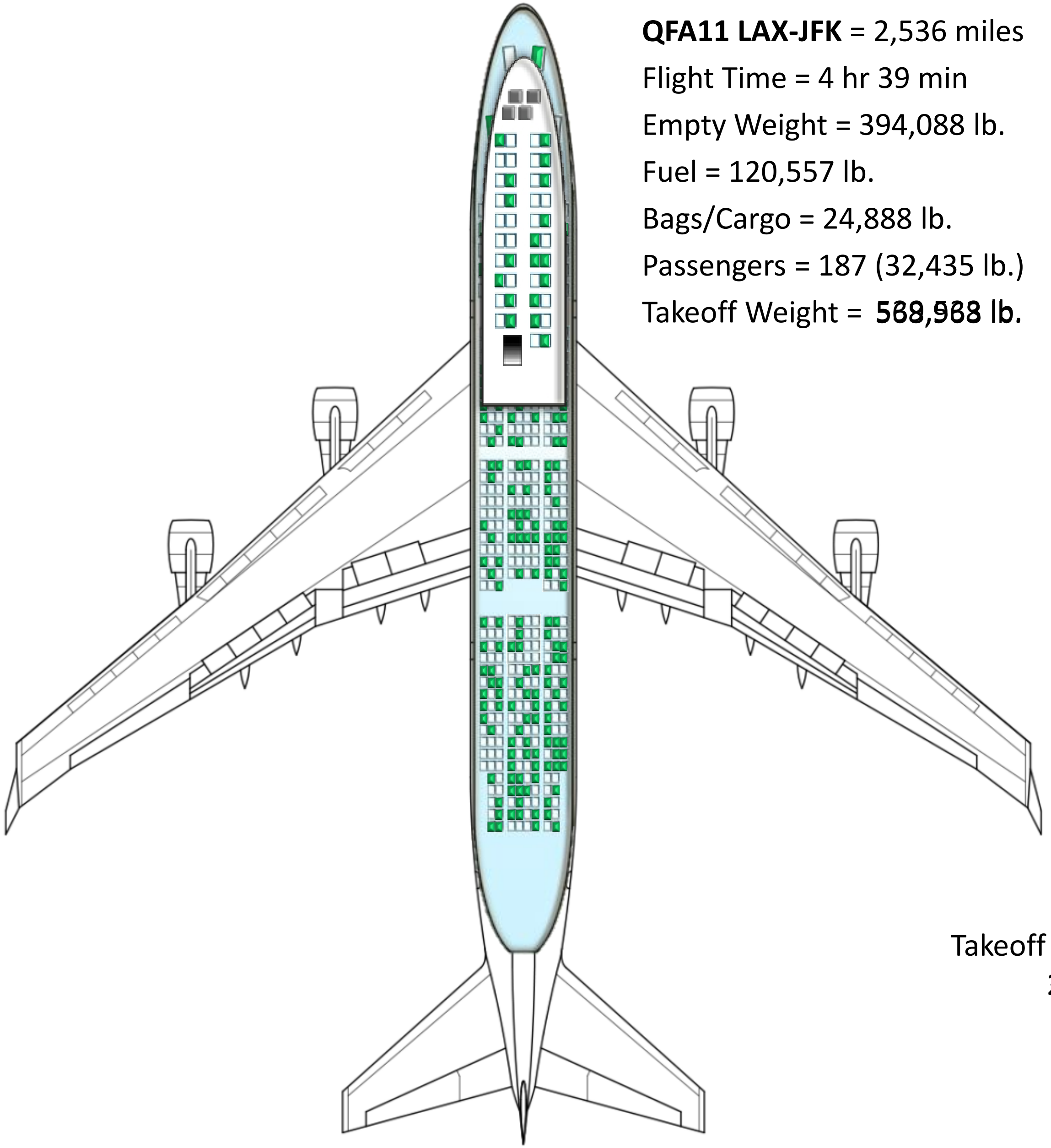
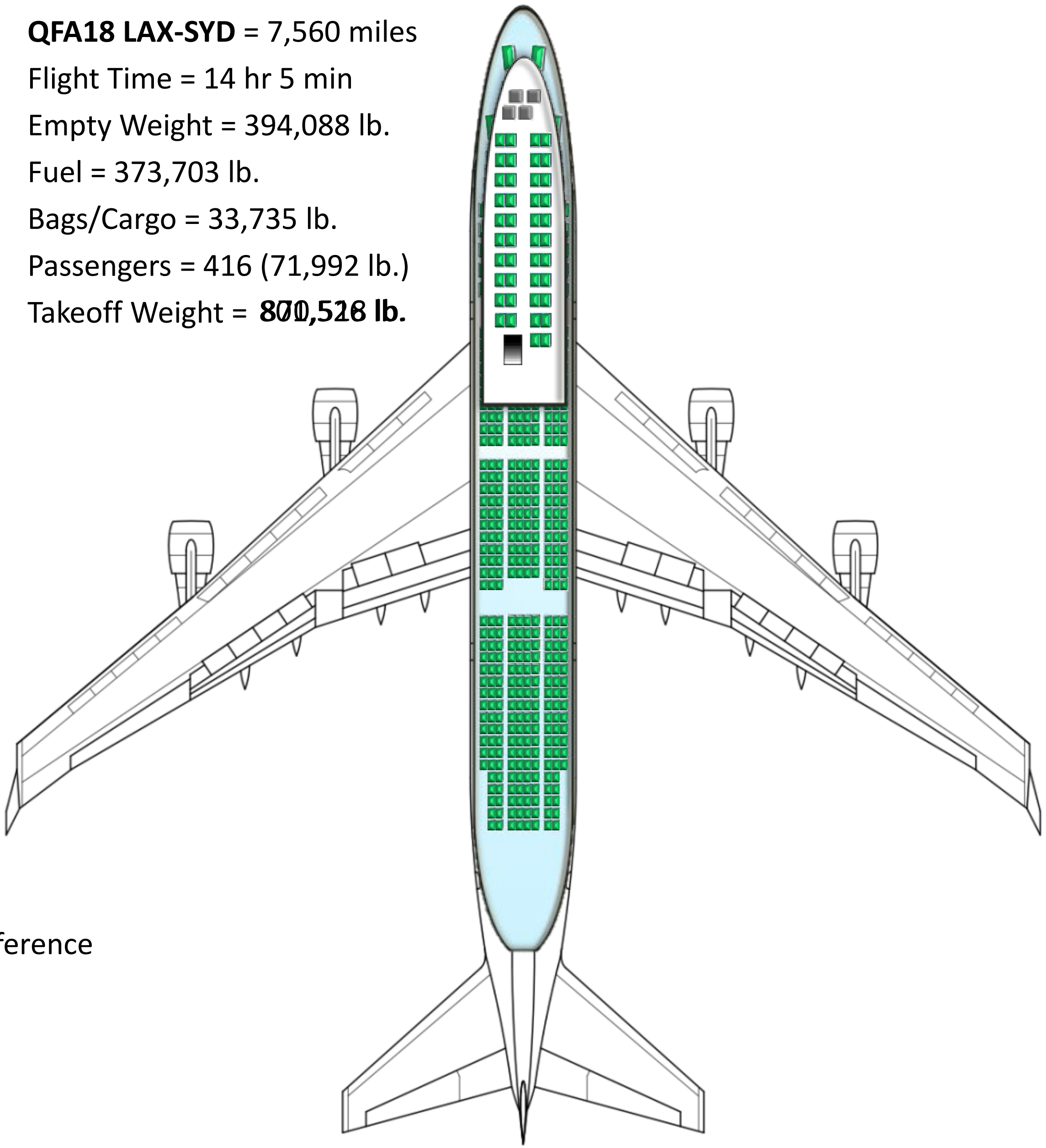


QFA11 LAX-JFK = 2,536 miles
Flight Time = 4 hr 39 min
Empty Weight = 394,088 lb.
Fuel = 120,557 lb.
Bags/Cargo = 24,888 lb.
Passengers = 187 (32,435 lb.)
Takeoff Weight = **568,968 lb.**



QFA18 LAX-SYD = 7,560 miles
Flight Time = 14 hr 5 min
Empty Weight = 394,088 lb.
Fuel = 373,703 lb.
Bags/Cargo = 33,735 lb.
Passengers = 416 (71,992 lb.)
Takeoff Weight = **870,518 lb.**

Takeoff Weight Difference
301,990 lb.

HOW MUCH RUNWAY DO WE NEED TO TAKEOFF?

CALCULATING TAKEOFF DISTANCE

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Current Automatic Terminal Information Service (ATIS): Los Angeles Int'l Airport (**LAX**)

Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
59°F / 15°C	36°F / 2°C	Calm	29.92 in / 1030 mb.	128 ft. / 39 m.	Runway 25R

QFA11 LAX-JFK

Density Altitude = 251 ft. / 77 m.

Takeoff Weight = 568,968 lb. / 258,079 kg.

Flap Setting: 20°

Power Setting: 1.76 EPR (0% Derate)

Takeoff Runway = 25R (12,091 ft. / 3,685 m. available)

Takeoff Distance = 6,050 ft. / 1,844 m.

Takeoff Speeds = V1-126 kts. VR-126 kts. V2-146 kts.

QFA18 LAX-SYD

Density Altitude = 251 ft. / 77 m.

Takeoff Weight = 870,518 lb. / 394,860 kg.

Flap Setting: 20°

Power Setting: 1.76 EPR (0% Derate)

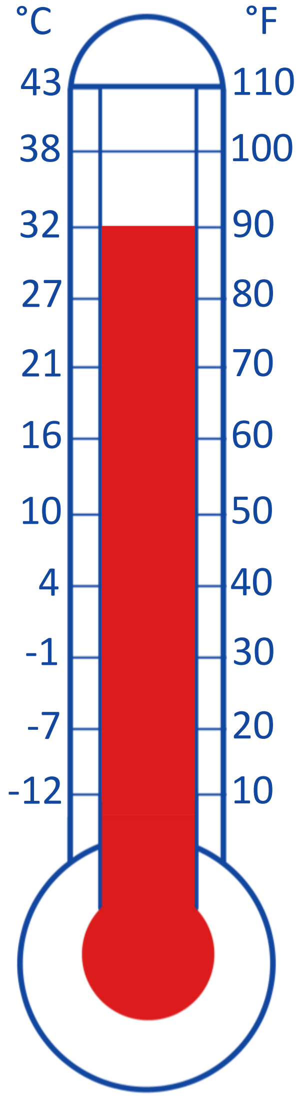
Takeoff Runway = 25R (12,091 ft. / 3,685 m. available)

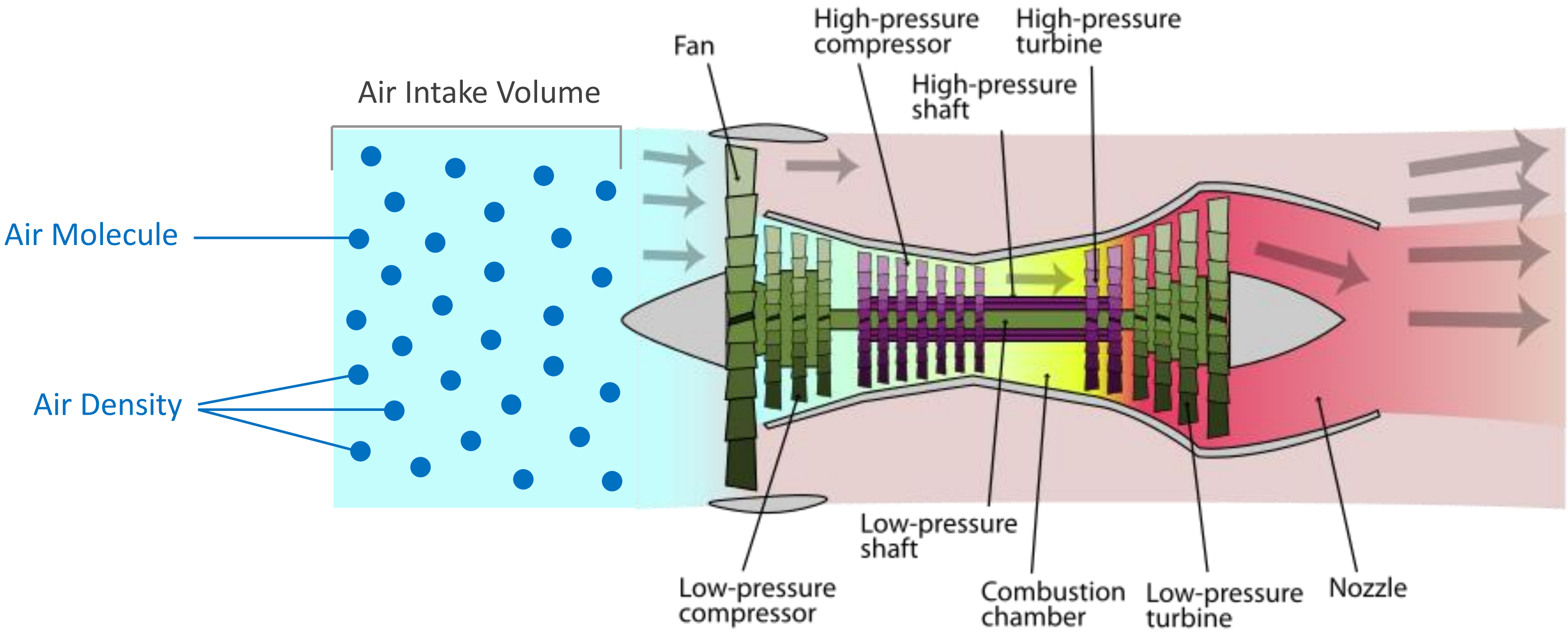
Takeoff Distance = 10,323 ft. / 3,146 m.

Takeoff Speeds = V1-153 kts. VR-168 kts. V2-180 kts.

TEMPERATURE AND PERFORMANCE

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





Temperature has an inverse correlation with Air Density

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.

TEMPERATURE’S EFFECT ON TAKEOFF PERFORMANCE

Current Automatic Terminal Information Service (ATIS): Los Angeles Int’l Airport (**LAX**)

Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
59°F / 15°C	36°F / 2°C	Calm	29.92 in / 1030 mb.	128 ft. / 39 m.	Runway 25R

QFA11 LAX-JFK

Density Altitude = 2,518 ft. / 767 m.

Takeoff Weight = 568,968 lb. / 258,079 kg.

Flap Setting: 20°

Power Setting: 1.75 EPR (0% Derate)

Takeoff Runway = 25R (12,091 ft. / 3,685 m. available)

Takeoff Distance = 6,050 ft. / 1,844 m.

Takeoff Speeds = V1-126 kts. VR-126 kts. V2-146 kts.

Takeoff Length Difference = 0 ft. / 0 m.

QFA18 LAX-SYD

Density Altitude = 2,518 ft. / 767 m.

Takeoff Weight = 870,518 lb. / 394,860 kg.

Flap Setting: 20°

Power Setting: **1.75 EPR (0% Derate)**

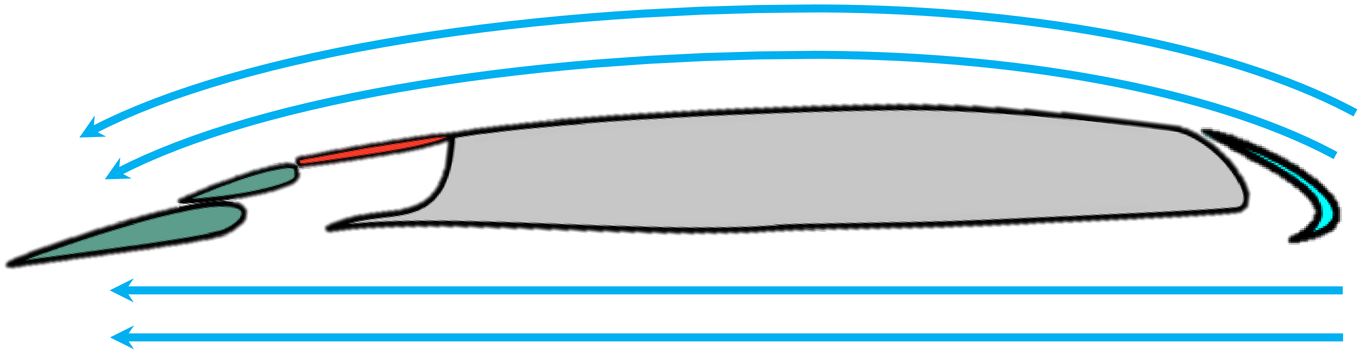
Takeoff Runway = 25R (12,091 ft. / 3,685 m. available)

Takeoff Distance = **10,802 ft. / 3,292 m.**

Takeoff Speeds = V1-153 kts. VR-168 kts. V2-180 kts.

Takeoff Length Difference = 479 ft. / 146 m.

WHY DO AIRPLANES TAKEOFF AND LAND INTO THE WIND?



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.

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WIND'S EFFECT ON TAKEOFF PERFORMANCE

Current Automatic Terminal Information Service (ATIS): Los Angeles Int'l Airport (**LAX**)

Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
59°F / 15°C	36°F / 2°C	Calm / 250°/15	29.92 in / 1030 mb.	128 ft. / 39 m.	Runway 25R

QFA11 LAX-JFK

Density Altitude = 251 ft. / 77 m.

Takeoff Weight = 568,968 lb. / 258,079 kg.

Flap Setting: 20°

Power Setting: 1.76 EPR (0% Derate)

Takeoff Runway = 25R (12,091 ft. / 3,685 m. available)

Takeoff Distance = 6,050 ft. / 1,844 m. / 5,601 ft. / 1,707 m.

Takeoff Speeds = V1-126 kts. VR-126 kts. V2-146 kts.

Takeoff Length Difference = 0 ft. / 0 m. / -449 ft. / -137 m.

QFA18 LAX-SYD

Density Altitude = 251 ft. / 77 m.

Takeoff Weight = 870,518 lb. / 394,860 kg.

Flap Setting: 20°

Power Setting: 1.76 EPR (0% Derate)

Takeoff Runway = 25R (12,091 ft. / 3,685 m. available)

Takeoff Distance = 10,370 ft. / 3,146 m. / 9,723 ft. / 2,949 m.

Takeoff Speeds = V1-153 kts. VR-168 kts. V2-180 kts.

Takeoff Length Difference = 0 ft. / 0 m. / -647 ft. / -197 m.

ALTITUDE AND TAKEOFF PERFORMANCE

Temperature = 59°F / 15°C
Dew Point = 36°F / 2°C
Altimeter = 29.92 Hg.
Winds = Calm

LAX Field Elevation = 128 ft. / 39 m.

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

Altitude has an inverse correlation with air density

At higher altitudes the air is less dense, decreasing the lifting effectiveness of the wing. Altitude 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.

ALTITUDE’S EFFECT ON TAKEOFF PERFORMANCE

Current Automatic Terminal Information Service (ATIS): Los Angeles Int’l Airport (**LAX**)

Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
59°F / 15°C	36°F / 2°C	Calm	29.92 in / 1030 mb.	128 ft. / 39 m. 5,433 ft. / 1,656 m.	Runway 25R

QFA11 LAX-JFK

Density Altitude = 2,571 ft. / 772 m. 6,790 ft. / 2,069 m.

Takeoff Weight = 568,968 lb. / 258,079 kg.

Flap Setting: 20°

Power Setting: 1.70 EPR (0% Derate)

Takeoff Runway = 25R (12,091 ft. / 3,685 m. available)

Takeoff Distance = 6,050 ft. / 1,844 m.

Takeoff Speeds = **V1-126 kts. VR-126 kts. V2-146 kts.**

Takeoff Length Difference = 0 ft. / 0 m.

QFA18 LAX-SYD

Density Altitude = 2,571 ft. / 772 m. 6,790 ft. / 2,069 m.

Takeoff Weight = 870,518 lb. / 394,860 kg.

Flap Setting: 20°

Power Setting: 1.70 EPR (0% Derate)

Takeoff Runway = 25R (12,091 ft. / 3,685 m. available)

Takeoff Distance = 10,321 ft. / 3,147 m. 15,703 ft. / 4,786 m.

Takeoff Speeds = V1-153 kts. VR-160 kts. V2-180 kts.

Takeoff Length Difference = 0 ft. / 0 m. 5,378 ft. / 1,639 m.

WEIGHT RESTRICTION DUE TO RUNWAY LENGTH

AVAILABLE RUNWAY LENGTH'S EFFECT ON AIRCRAFT WEIGHT

Current Automatic Terminal Information Service (ATIS): Los Angeles Int'l Airport (**LAX**)

Temperature	Dew Point	Winds	Altimeter Setting	Field Elevation	Departing
59°F / 15°C	36°F / 2°C	Calm	29.92 in / 1030 mb.	128 ft. / 39 m.	Runway 24R / 25R

QFA11 LAX-JFK

Density Altitude = 251 ft. / 77 m.

Takeoff Weight = 568,968 lb. / 258,079 kg.

Flap Setting: 20°

Power Setting: 1.76 EPR (0% Derate)

Takeoff Runway = 24L / 25R (12,091 ft. / 3,685 m. available) (9,935 ft. / 3,028 m. available)

Takeoff Distance = 6,050 ft. / 1,844 m.

Takeoff Speeds = V1-126 kts. VR-126 kts. V2-146 kts.

Takeoff Weight Difference = 0 lb. / 0 kg.

QFA18 LAX-SYD

Density Altitude = 251 ft. / 77 m.

Takeoff Weight = 820,500 lb. / 372,890 kg. / 773,208 lb. / 351,467 kg. (0 Bags/Cargo and -74 Passengers)

Flap Setting: 20°

Power Setting: 1.76 EPR (0% Derate)

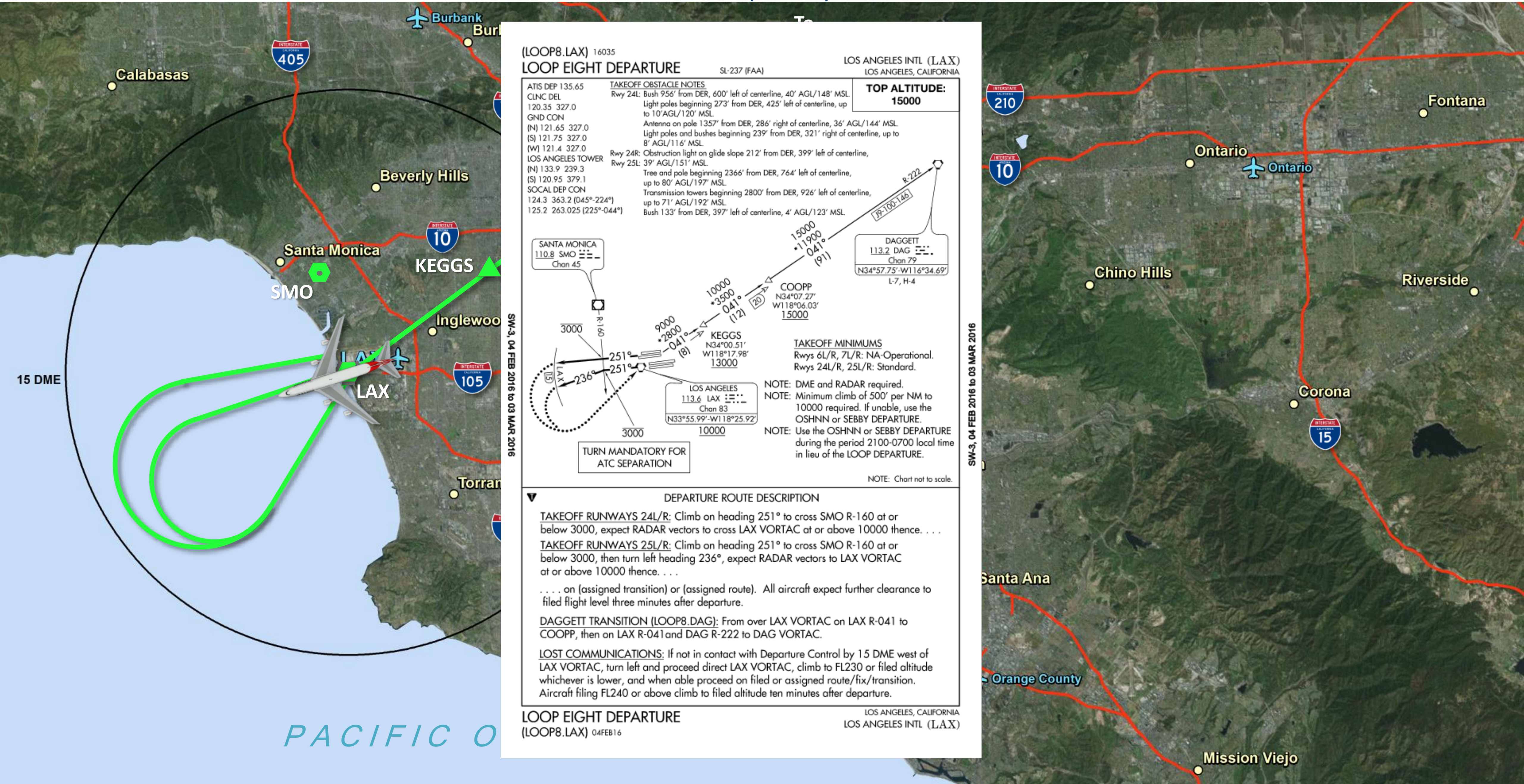
Takeoff Runway = 24L / 25R (12,091 ft. / 3,685 m. available) (9,935 ft. / 3,028 m. available)

Takeoff Distance = 10,623 ft. / 3,238 m. / 9,153 ft. / 2,796 m.

Takeoff Speeds = V1-148 / V1-153 kts. VR-168 kts. V2-180 / V2-177 kts.

Takeoff Weight Difference = 0 lb. / 0 kg. / -47,318 lb. / -21,463 kg.

QFA11 LOS ANGELES INT'L (LAX) LOOP.8 DEPARTURE SID



(LOOP8.LAX) 16035
LOOP EIGHT DEPARTURE
SL-237 (FAA)
LOS ANGELES INTL (LAX)
LOS ANGELES, CALIFORNIA

ATIS DEP 135.65
CLNC DEL
120.35 327.0
GND CON
(N) 121.65 327.0
(S) 121.75 327.0
(W) 121.4 327.0
LOS ANGELES TOWER
(N) 133.9 239.3
(S) 120.95 379.1
SOCAL DEP CON
124.3 363.2 (045°-224°)
125.2 263.025 (225°-044°)

TAKEOFF OBSTACLE NOTES
Rwy 24L: Bush 956' from DER, 600' left of centerline, 40' AGL/148' MSL.
Light poles beginning 273' from DER, 425' left of centerline, up to 10' AGL/120' MSL.
Antenna on pole 1357' from DER, 286' right of centerline, 36' AGL/144' MSL.
Light poles and bushes beginning 239' from DER, 321' right of centerline, up to 8' AGL/116' MSL.
Rwy 24R: Obstruction light on glide slope 212' from DER, 399' left of centerline, 39' AGL/151' MSL.
Rwy 25L: Tree and pole beginning 2366' from DER, 764' left of centerline, up to 80' AGL/197' MSL.
Transmission towers beginning 2800' from DER, 926' left of centerline, up to 71' AGL/192' MSL.
Bush 133' from DER, 397' left of centerline, 4' AGL/123' MSL.

TOP ALTITUDE: 15000

SANTA MONICA
110.8 SMO
Chan 45

DAGGETT
113.2 DAG
Chan 79
N34°57.75'-W116°34.69'
L-7, H-4

R-222
J9-100-146
15000
•11900
041°
(91)
COOPP
N34°07.27'
W118°06.03'
15000
(20)
10000
•3500
041°
(12)
9000
•2800
041°
(8)
KEGGS
N34°00.51'
W118°17.98'
13000
R-160
3000
251°
251°
236°
LAX
15
LOS ANGELES
113.6 LAX
Chan 83
N33°55.99'-W118°25.92'
10000
3000
TURN MANDATORY FOR ATC SEPARATION

TAKEOFF MINIMUMS
Rwys 6L/R, 7L/R: NA-Operational.
Rwys 24L/R, 25L/R: Standard.

NOTE: DME and RADAR required.
NOTE: Minimum climb of 500' per NM to 10000 required. If unable, use the OSHNN or SEBBY DEPARTURE.
NOTE: Use the OSHNN or SEBBY DEPARTURE during the period 2100-0700 local time in lieu of the LOOP DEPARTURE.

NOTE: Chart not to scale.

SW-3, 04 FEB 2016 to 03 MAR 2016

DEPARTURE ROUTE DESCRIPTION

TAKEOFF RUNWAYS 24L/R: Climb on heading 251° to cross SMO R-160 at or below 3000, expect RADAR vectors to cross LAX VORTAC at or above 10000 thence. . . .

TAKEOFF RUNWAYS 25L/R: Climb on heading 251° to cross SMO R-160 at or below 3000, then turn left heading 236°, expect RADAR vectors to LAX VORTAC at or above 10000 thence. . . .

. . . . on (assigned transition) or (assigned route). All aircraft expect further clearance to filed flight level three minutes after departure.

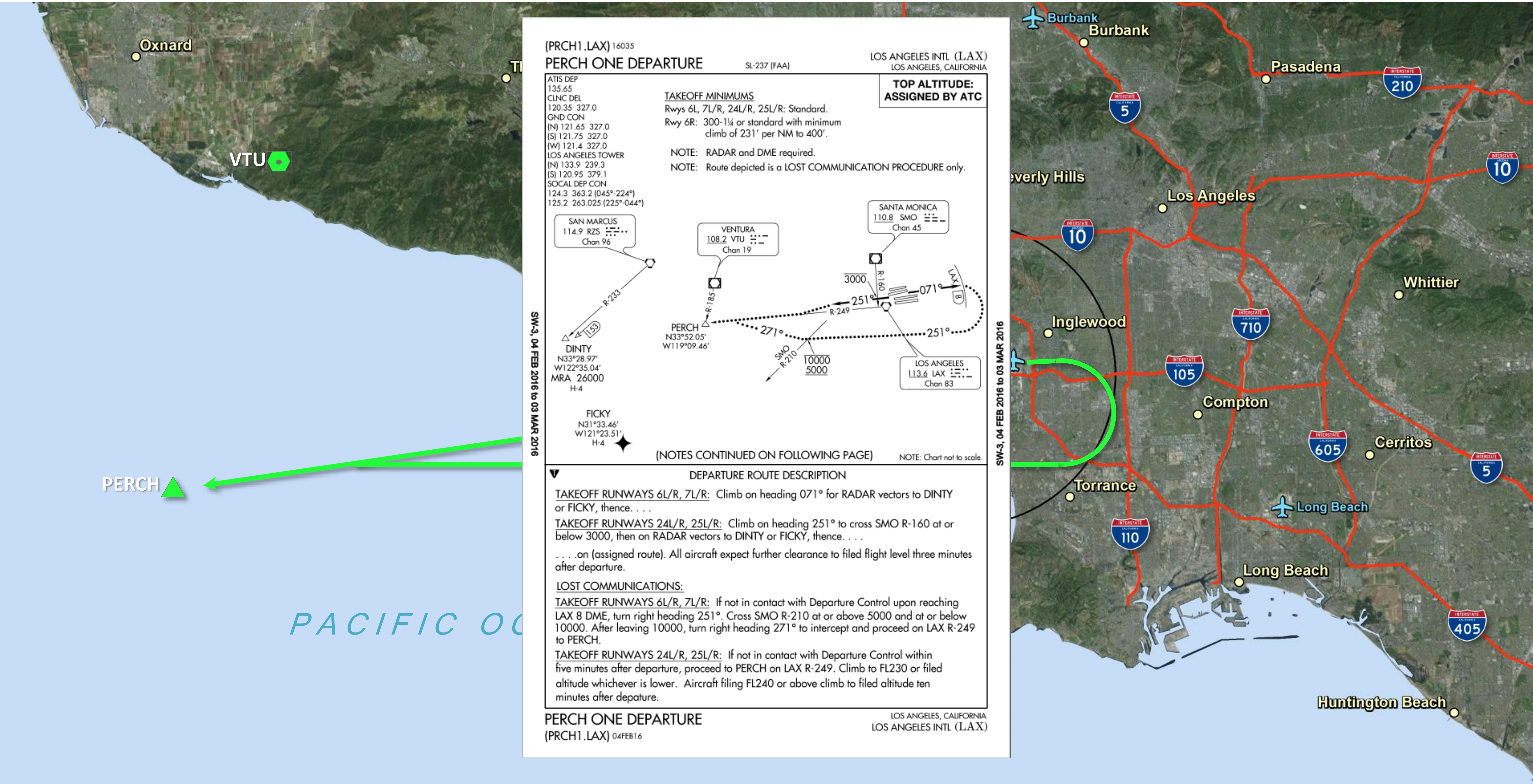
DAGGETT TRANSITION (LOOP8.DAG): From over LAX VORTAC on LAX R-041 to COOPP, then on LAX R-041 and DAG R-222 to DAG VORTAC.

LOST COMMUNICATIONS: If not in contact with Departure Control by 15 DME west of LAX VORTAC, turn left and proceed direct LAX VORTAC, climb to FL230 or filed altitude whichever is lower, and when able proceed on filed or assigned route/fix/transition. Aircraft filing FL240 or above climb to filed altitude ten minutes after departure.

LOOP EIGHT DEPARTURE
(LOOP8.LAX) 04FEB16
LOS ANGELES, CALIFORNIA
LOS ANGELES INTL (LAX)

SW-3, 04 FEB 2016 to 03 MAR 2016

QFA18 LOS ANGELES (LAX) PERCH.1 DEPARTURE SID



(PRCH1.LAX) 16035

PERCH ONE DEPARTURE

SL-237 (FAA)

LOS ANGELES INTL (LAX)
LOS ANGELES, CALIFORNIA

ATIS DEP 135.65
CLNC DEL 120.35 327.0
GND CON (N) 121.65 327.0 (S) 121.75 327.0 (W) 121.4 327.0
LOS ANGELES TOWER (N) 133.9 239.3 (S) 120.95 379.1
SOCAL DEP CON 124.3 363.2 (045°-224°) 125.2 263.025 (225°-044°)

TAKEOFF MINIMUMS
Rwys 6L, 7L/R, 24L/R, 25L/R: Standard.
Rwy 6R: 300-1¼ or standard with minimum climb of 231′ per NM to 400′.

NOTE: RADAR and DME required.
NOTE: Route depicted is a LOST COMMUNICATION PROCEDURE only.

TOP ALTITUDE: ASSIGNED BY ATC

SW-3, 04 FEB 2016 to 03 MAR 2016

(NOTES CONTINUED ON FOLLOWING PAGE)

NOTE: Chart not to scale.

DEPARTURE ROUTE DESCRIPTION

TAKEOFF RUNWAYS 6L/R, 7L/R: Climb on heading 071° for RADAR vectors to DINTY or FICKY, thence. . . .

TAKEOFF RUNWAYS 24L/R, 25L/R: Climb on heading 251° to cross SMO R-160 at or below 3000, then on RADAR vectors to DINTY or FICKY, thence. . . .

. . . .on (assigned route). All aircraft expect further clearance to filed flight level three minutes after departure.

LOST COMMUNICATIONS:

TAKEOFF RUNWAYS 6L/R, 7L/R: If not in contact with Departure Control upon reaching LAX 8 DME, turn right heading 251°. Cross SMO R-210 at or above 5000 and at or below 10000. After leaving 10000, turn right heading 271° to intercept and proceed on LAX R-249 to PERCH.

TAKEOFF RUNWAYS 24L/R, 25L/R: If not in contact with Departure Control within five minutes after departure, proceed to PERCH on LAX R-249. Climb to FL230 or filed altitude whichever is lower. Aircraft filing FL240 or above climb to filed altitude ten minutes after depature.

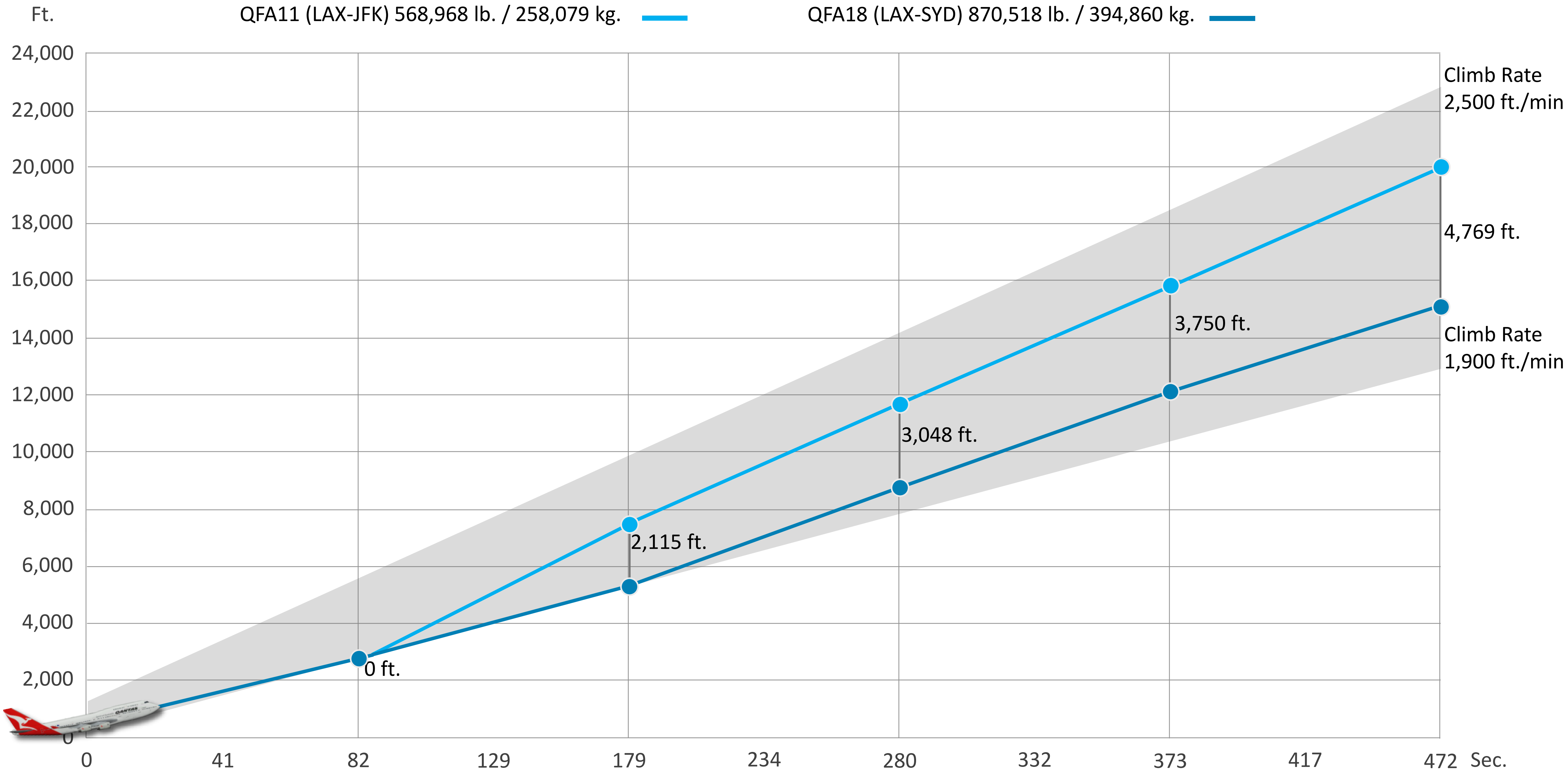
SW-3, 04 FEB 2016 to 03 MAR 2016

PERCH ONE DEPARTURE
(PRCH1.LAX) 04FEB16

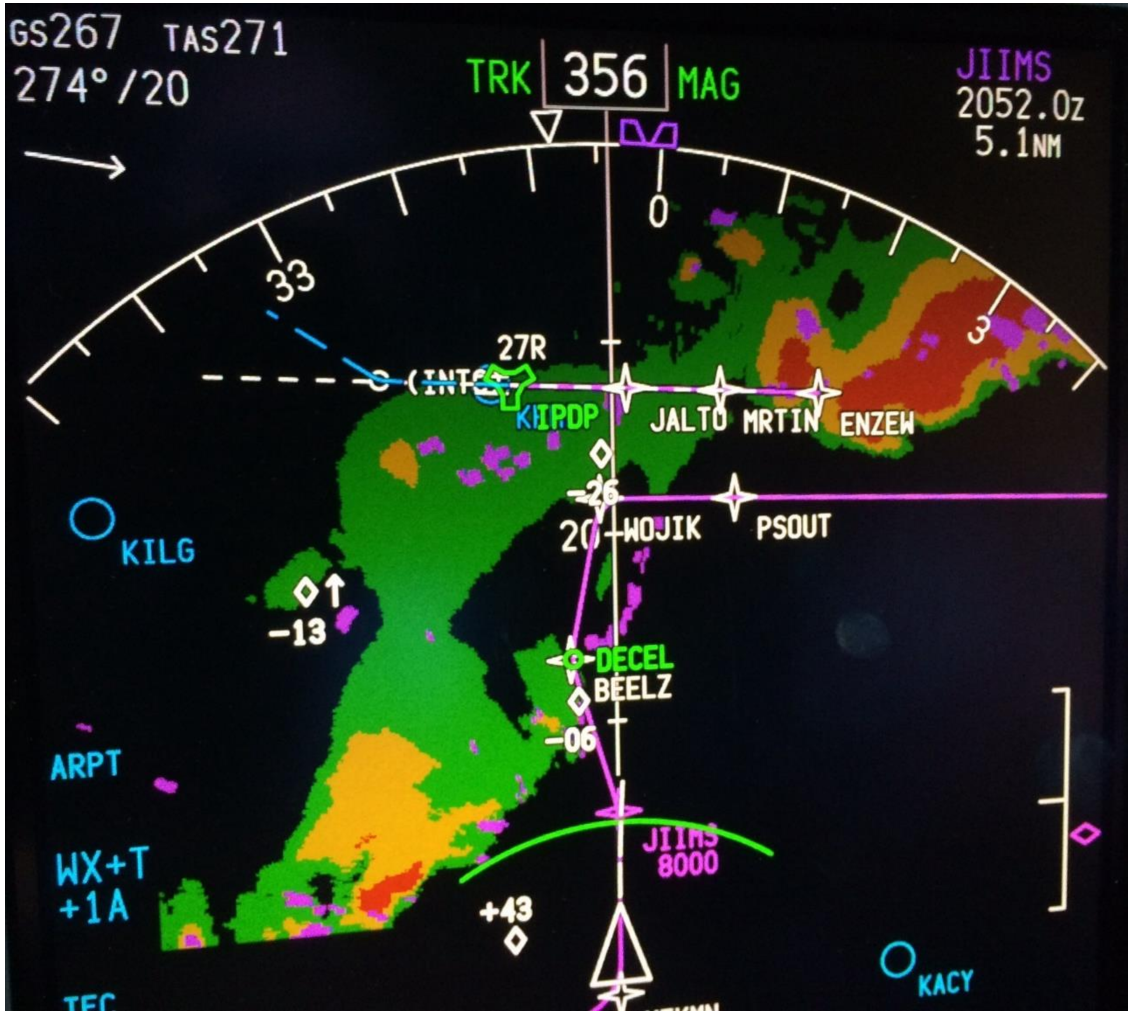
LOS ANGELES, CALIFORNIA
LOS ANGELES INTL (LAX)

AVERAGE DEPARTURE TRACK PROFILE COMPARISON

(•) CASPER Shared Insight



PERFORMANCE BASED NAVIGATION

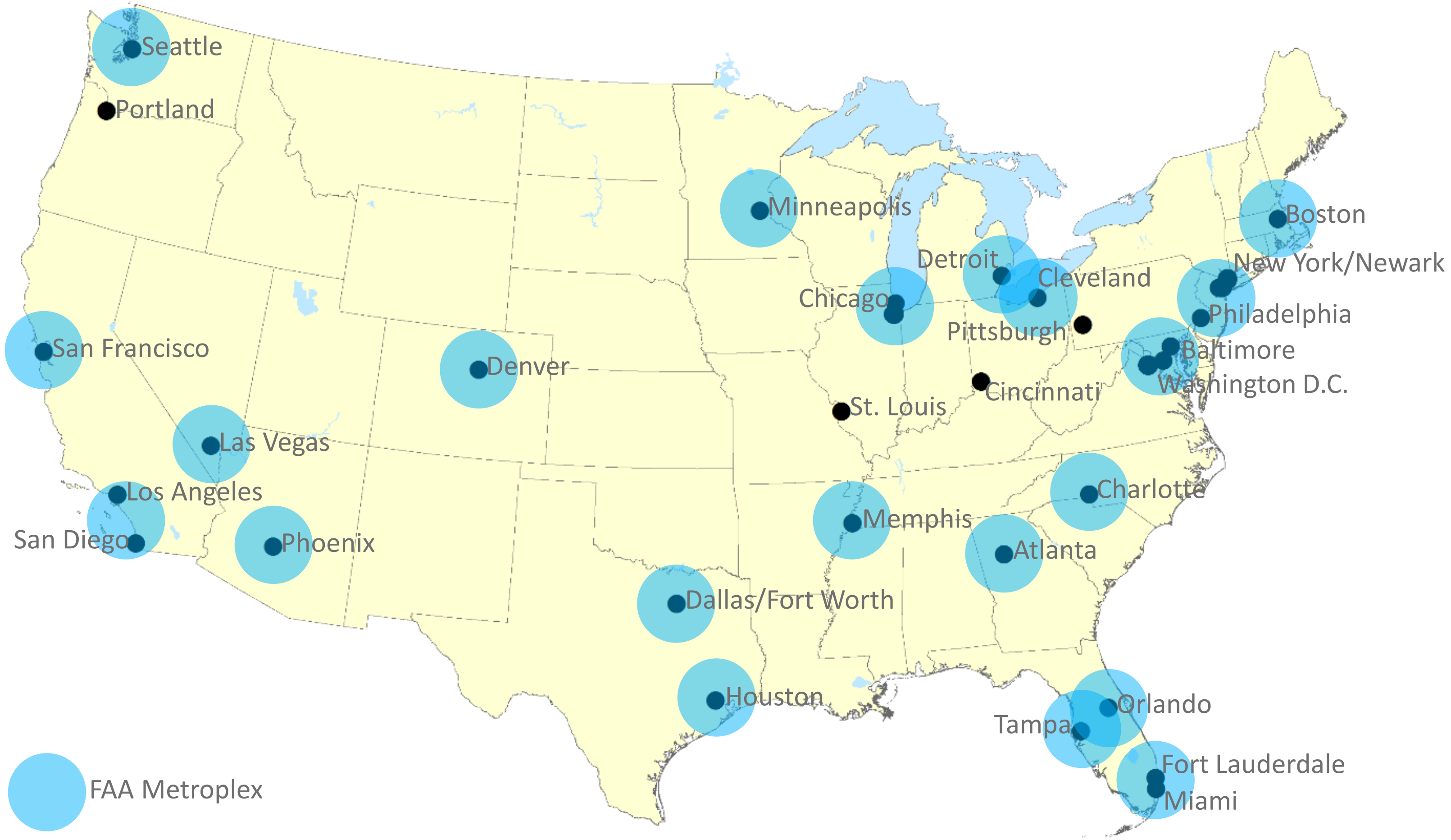


WHAT IS A METROPLEX?

METROPLEX

Geographic area that includes several commercial and general aviation airports in close proximity serving large metropolitan areas.

The FAA has identified **21** metroplex areas where airspace congestion and other limiting factors such as environmental constraints combine to create bottlenecks that effect system efficiency nation wide.



WHAT IS OAPM?

Optimization of Airspace & Procedures in the Metroplex

Optimization of the airspace and procedures encompassing multiple airports in a metroplex region provides for the most efficient traffic management solutions on both a regional and national basis.

By examining airspace problems on a regional scale the FAA can customize the solutions to ensure they maximize throughput of airplanes through the entire airspace in the safest and most efficient manner possible while at the same time customizing procedures to meet the unique requirements of individual airports.

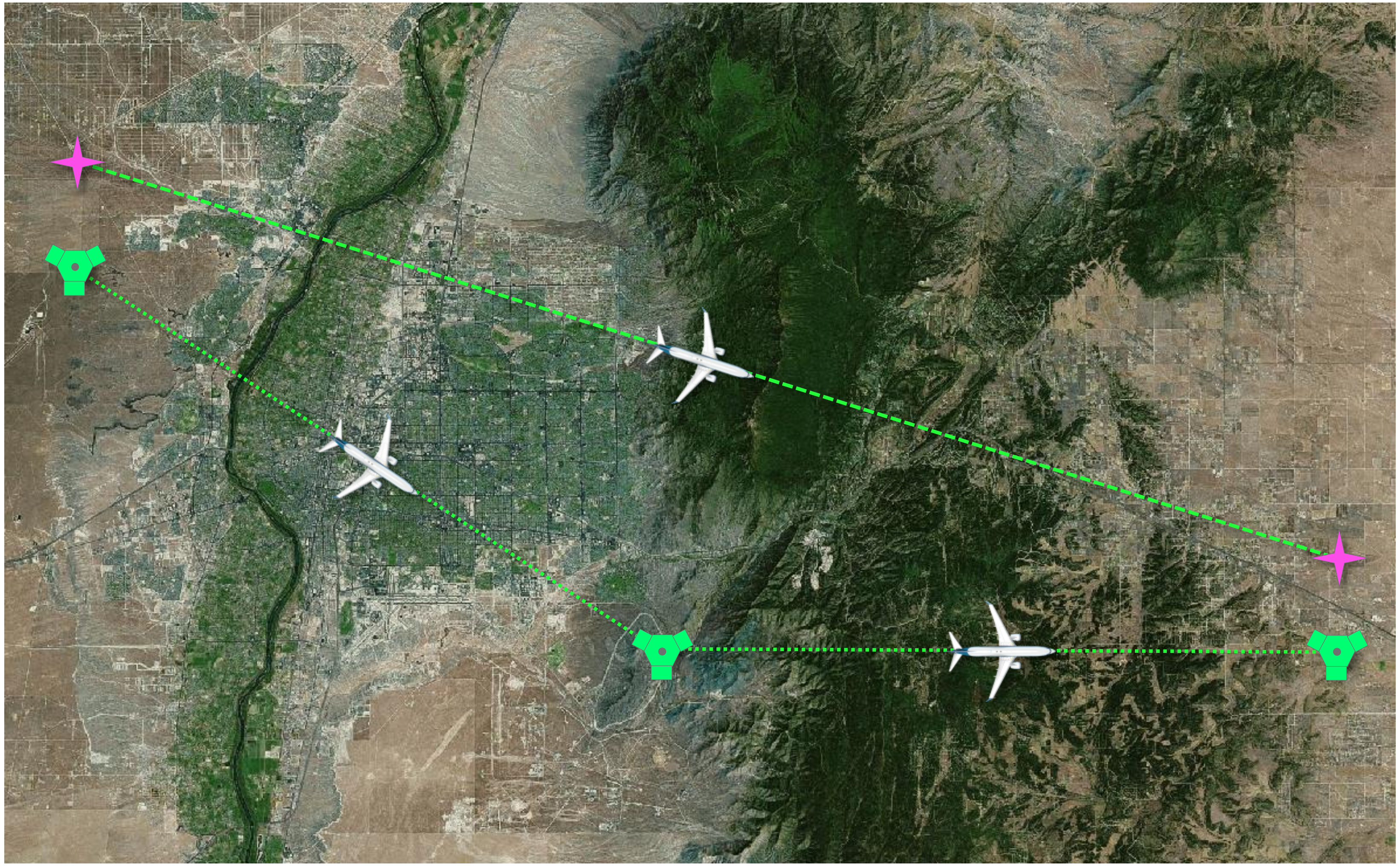
WHAT IS PBN?

CASPER
Shared Insight

Performance Based Navigation

A transformational change from conventional ground-based navigation aids and procedures to satellite-based navigation aids and area navigation procedures, which are more accurate and allow for shorter, more direct routes between two given points as well as more efficient takeoffs and landings.

PBN enables aircraft to fly on any desired flight path within the coverage of ground or satellite based navigation aids using the aircraft's capability to navigate by means of performance standards utilizing either Area Navigation (RNAV) or Required Navigation Performance (RNP).

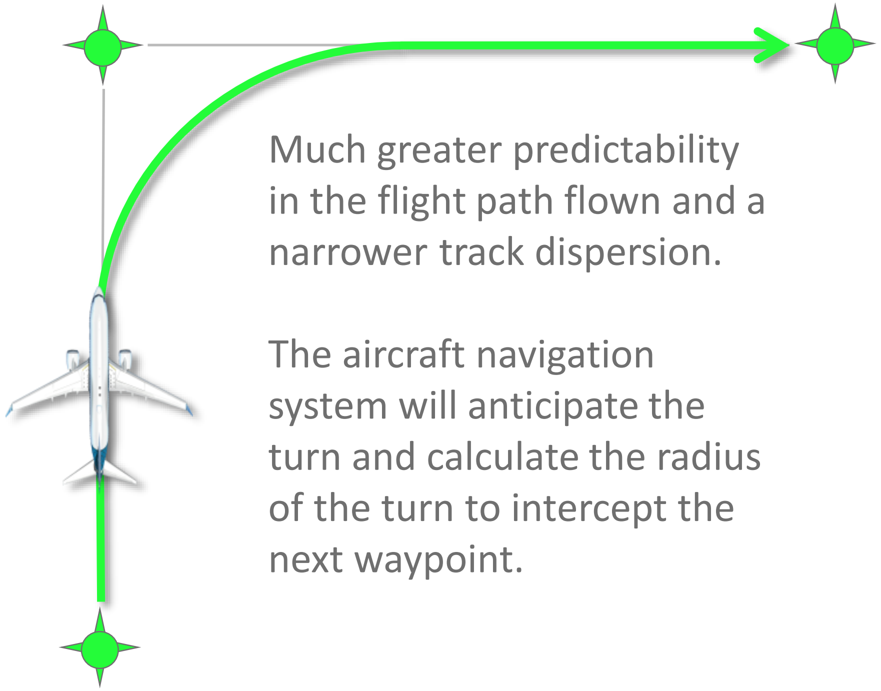


Ground Based Navigational Aid

Satellite Based Navigational Aid

WAYPOINT TYPES

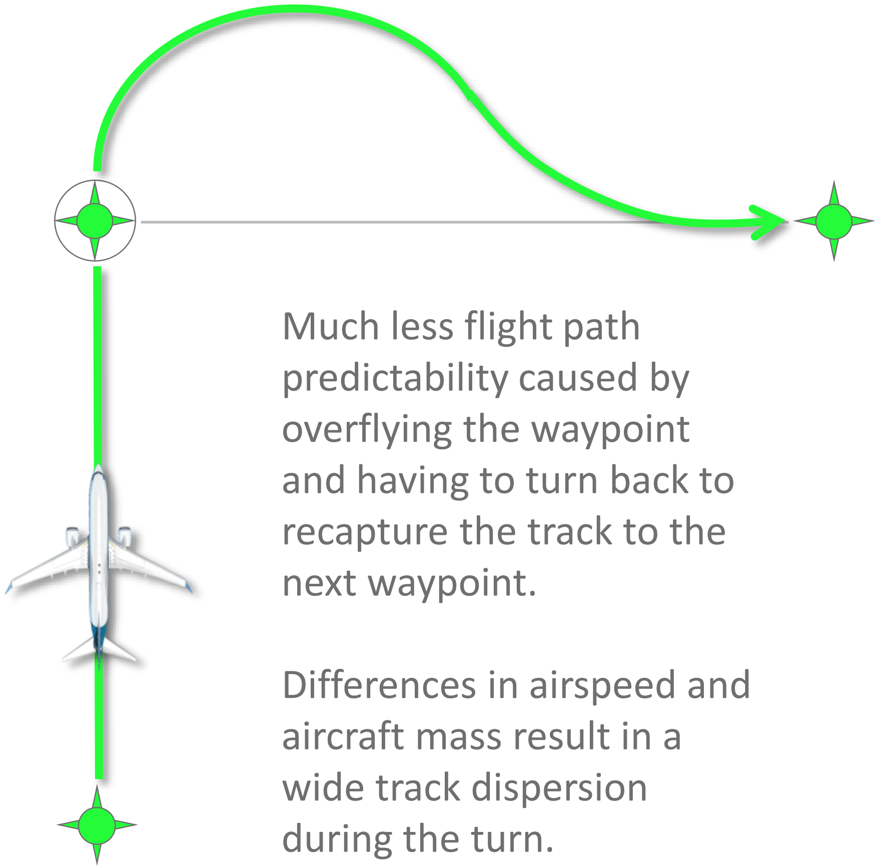
Fly-By Waypoint



Much greater predictability in the flight path flown and a narrower track dispersion.

The aircraft navigation system will anticipate the turn and calculate the radius of the turn to intercept the next waypoint.

Fly-Over Waypoint



Much less flight path predictability caused by overflying the waypoint and having to turn back to recapture the track to the next waypoint.

Differences in airspeed and aircraft mass result in a wide track dispersion during the turn.

WHAT IS RNAV?

Area Navigation

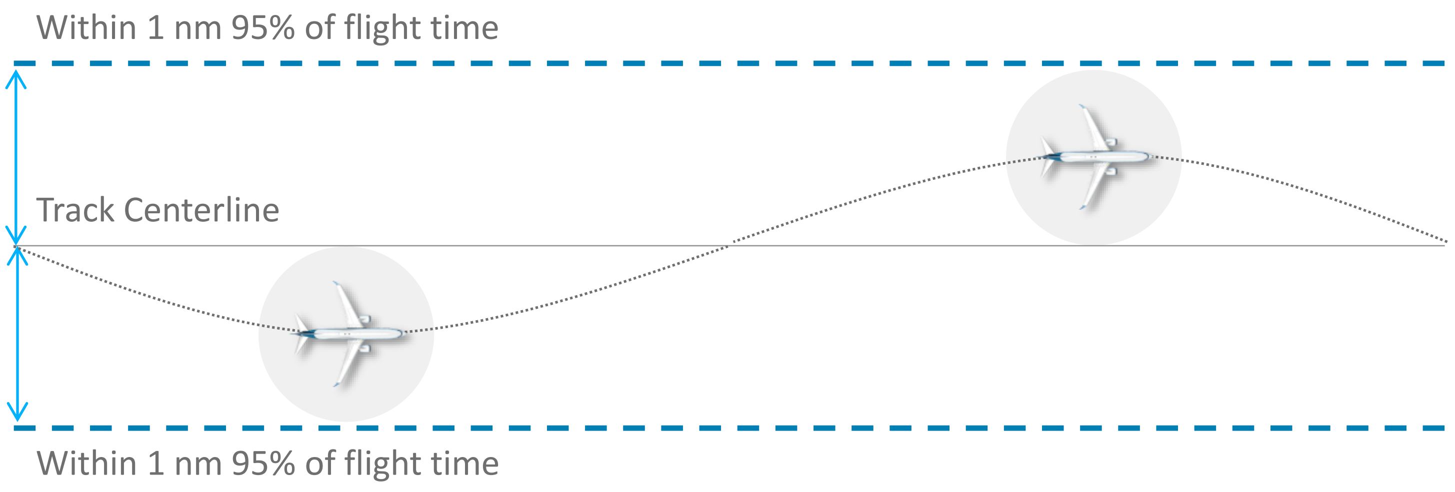
Developed in the 1960s, with the first routes being published and flown in the 1970s.

This method of instrument flight rules (IFR) navigation allows an aircraft to choose any course within a network of navigation beacons, rather than navigate directly to and from the beacons.

RNAV requires an aircraft to be equipped with a GPS navigation system like a Flight Management System (FMS) which uses the GPS to triangulate the aircraft's position to within a circle with a defined radius.

RNAV is primarily used for departure procedures and/or arrival procedures that do not require the narrow tolerances defined by RNP procedures.

RNAV 1



RNAV 1 – implies you have a 95% probability of keeping within 1 nm of your track course

FLYING AN RNAV DEPARTURE

CASPER Shared Insight

WHAT IS RNP?

CASPER
Shared Insight

Required Navigation Performance

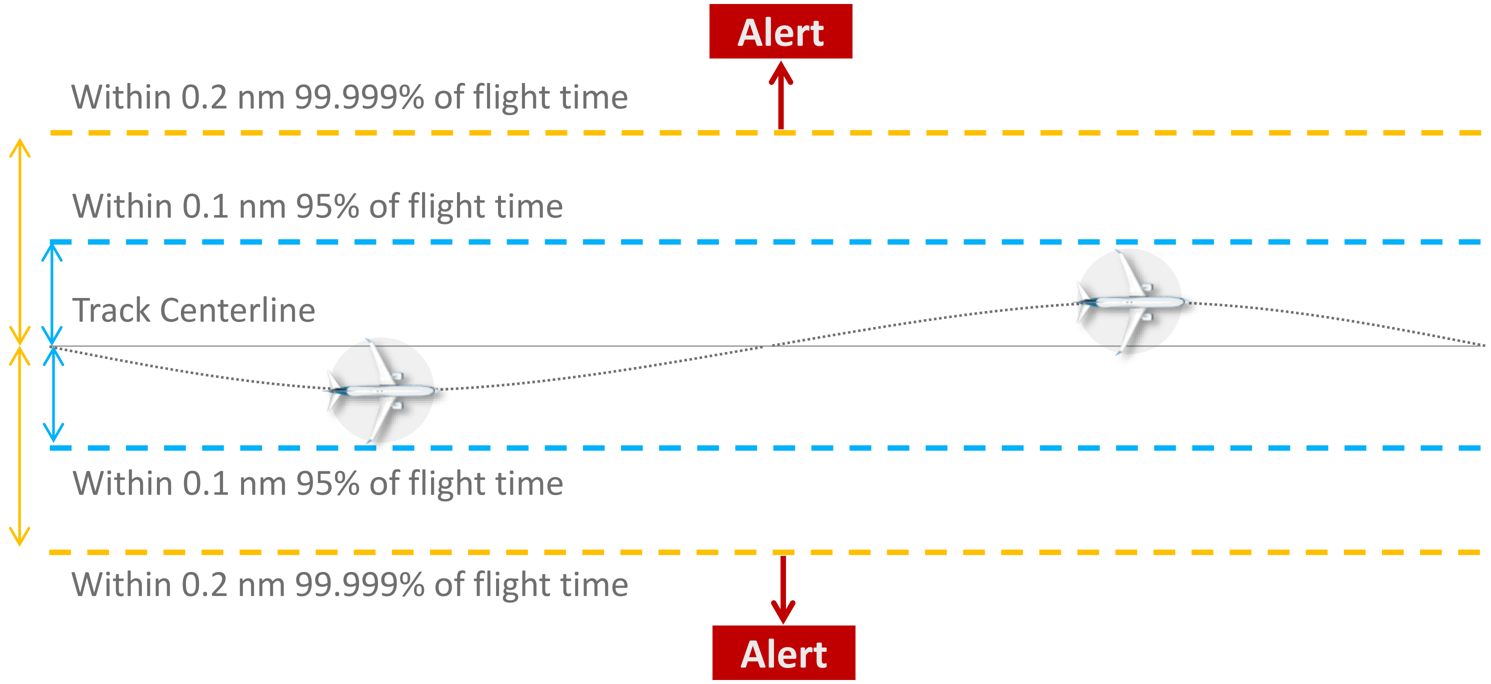
Developed in the early 1990s, with the first route being published and flown in 1996 by Alaska Airlines at Juneau, Alaska.

This method of instrument flight rules (IFR) navigation is fundamentally similar to RNAV with the difference being that RNP incorporates onboard performance monitoring and alerting.

The Flight Management System (FMS) uses position data from two independent GPS receivers as well as inertial navigation data to crosscheck and monitor the position of the aircraft. The system reports to the pilots if the position accuracy falls outside the tolerances for the given procedure.

RNP is primarily used for approaches into airports surrounded by mountainous terrain and/or other obstacles.

RNP 0.1



RNP 0.1 – implies you have a 95% probability of keeping within 0.1 nm of your track course

RNP 0.2 – implies you have a 95% probability of keeping within 0.2 nm of your track course

RNP 0.3 – implies you have a 95% probability of keeping within 0.3 nm of your track course

RNP 0.1 - Alert if the probability of keeping within 0.2 nm of the course centerline is less than 99.999%

FLYING AN RNP APPROACH

WHAT IS A SID?

(•) CASPER Shared Insight

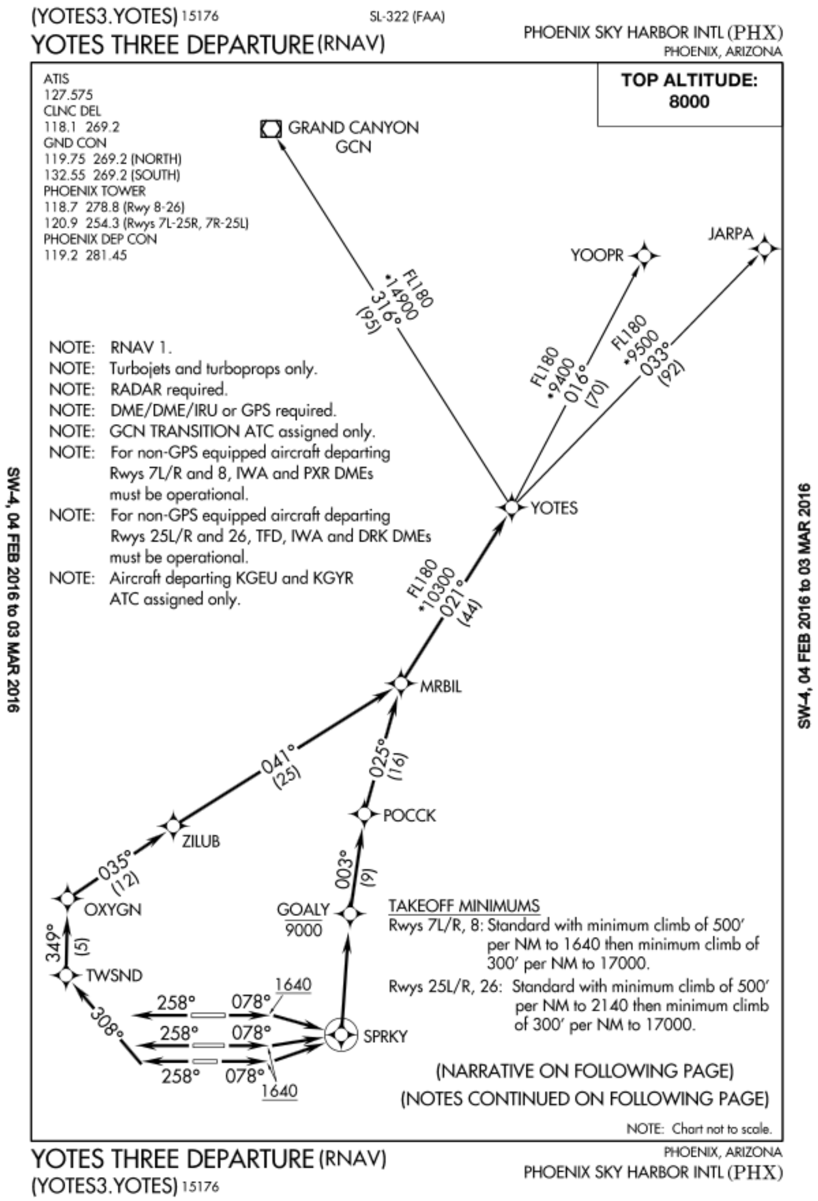
Standard Instrument Departure

An IFR air traffic control departure procedure that utilizes a series of specific waypoints, headings and altitudes to organize traffic departing the airport and place aircraft on a fixed route with defined transition points exiting the airspace.

SIDs are optimized for air traffic control routing efficiency while striking a balance between terrain and obstacle avoidance, noise abatement and airspace management.

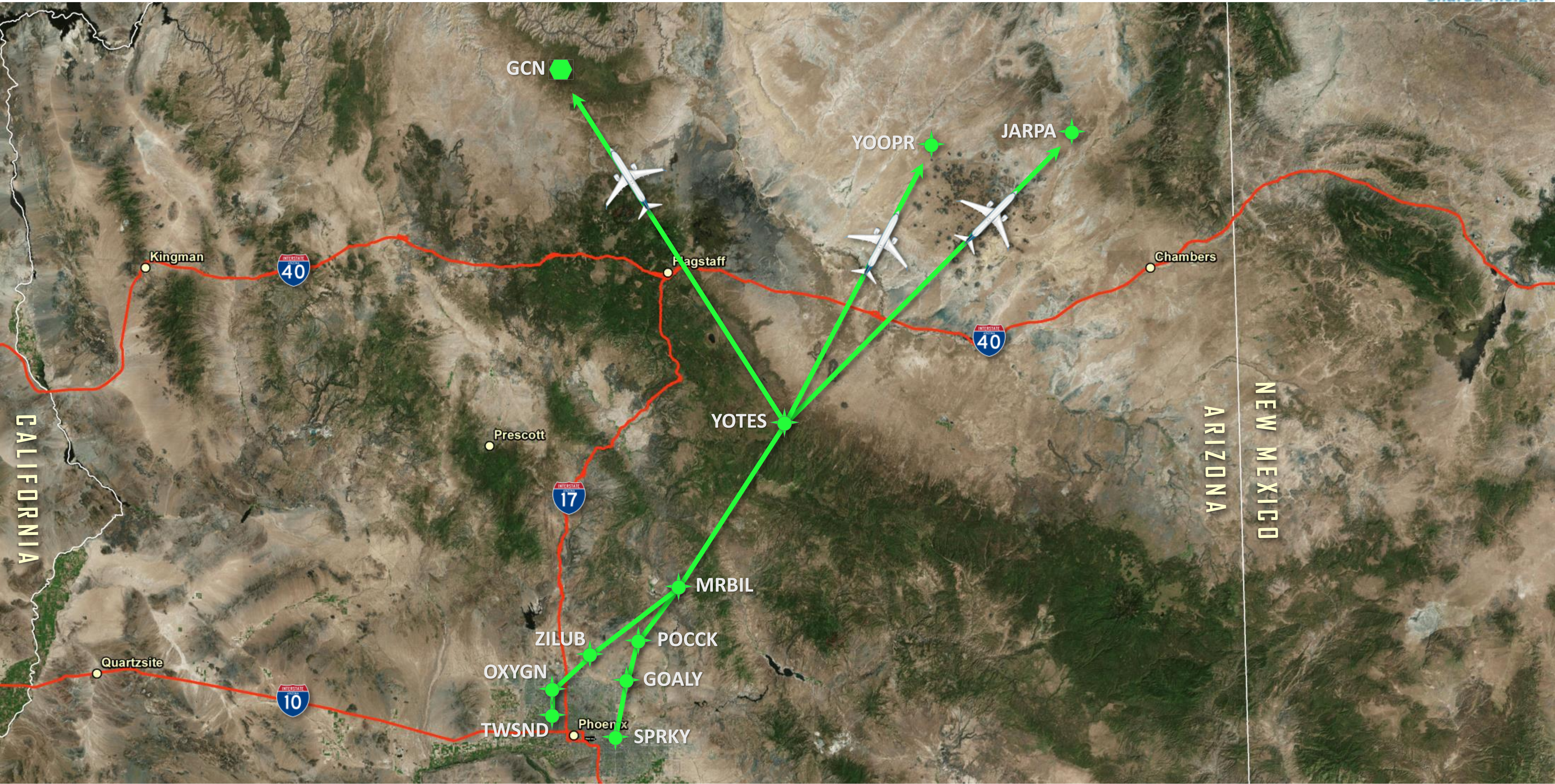
A specific SID is assigned to an IFR flight by ATC based on a combination of the aircraft's destination, the first waypoint in the flight plan and the takeoff runway assigned.

Phoenix Sky Harbor Int'l
KPHX - YOTES.3 SID Illustrated



PHOENIX SKY HARBOR INT'L (PHX) YOTES.3 DEP. RNAV SID

CASPER
Shared Insight



WHAT IS A STAR?

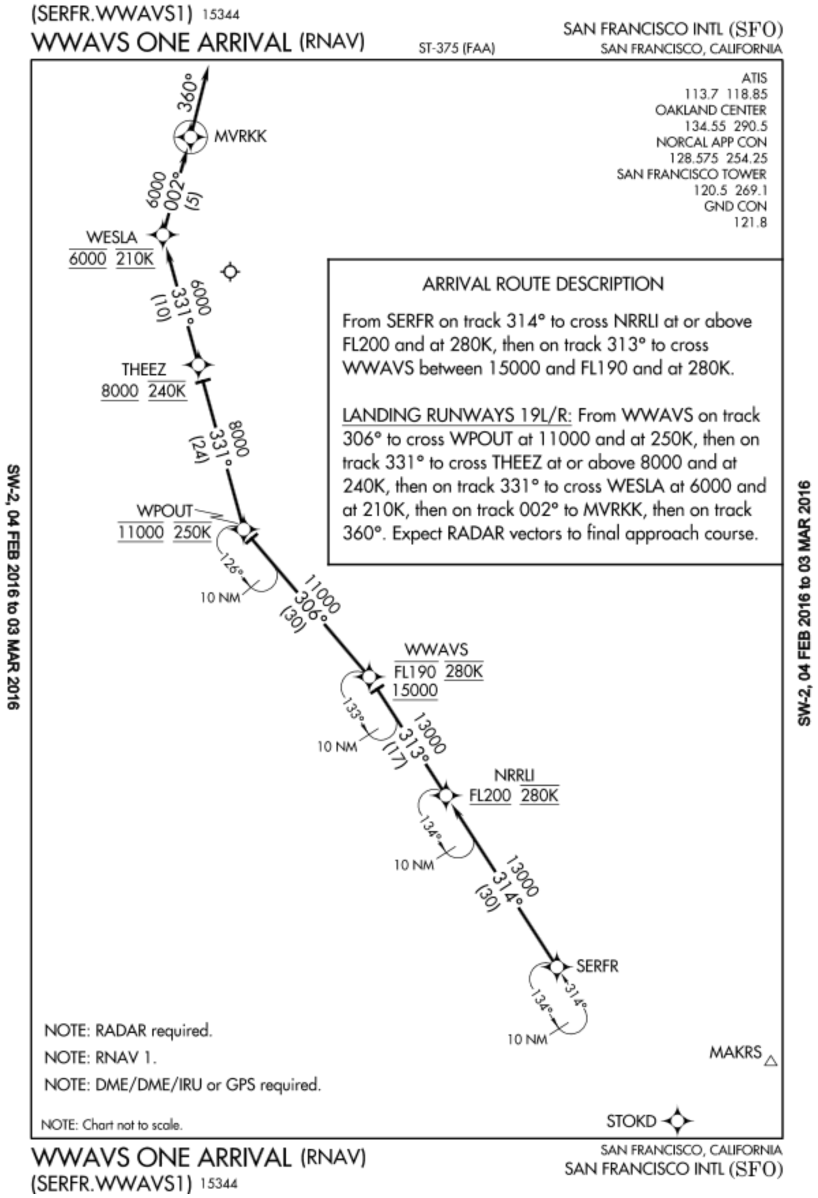
Standard Terminal Arrival Route

An IFR air traffic control arrival procedure that utilizes a series of specific waypoints, headings and altitudes to organize traffic arriving to the airport by placing airplanes on fixed routes with defined transition points entering the airspace.

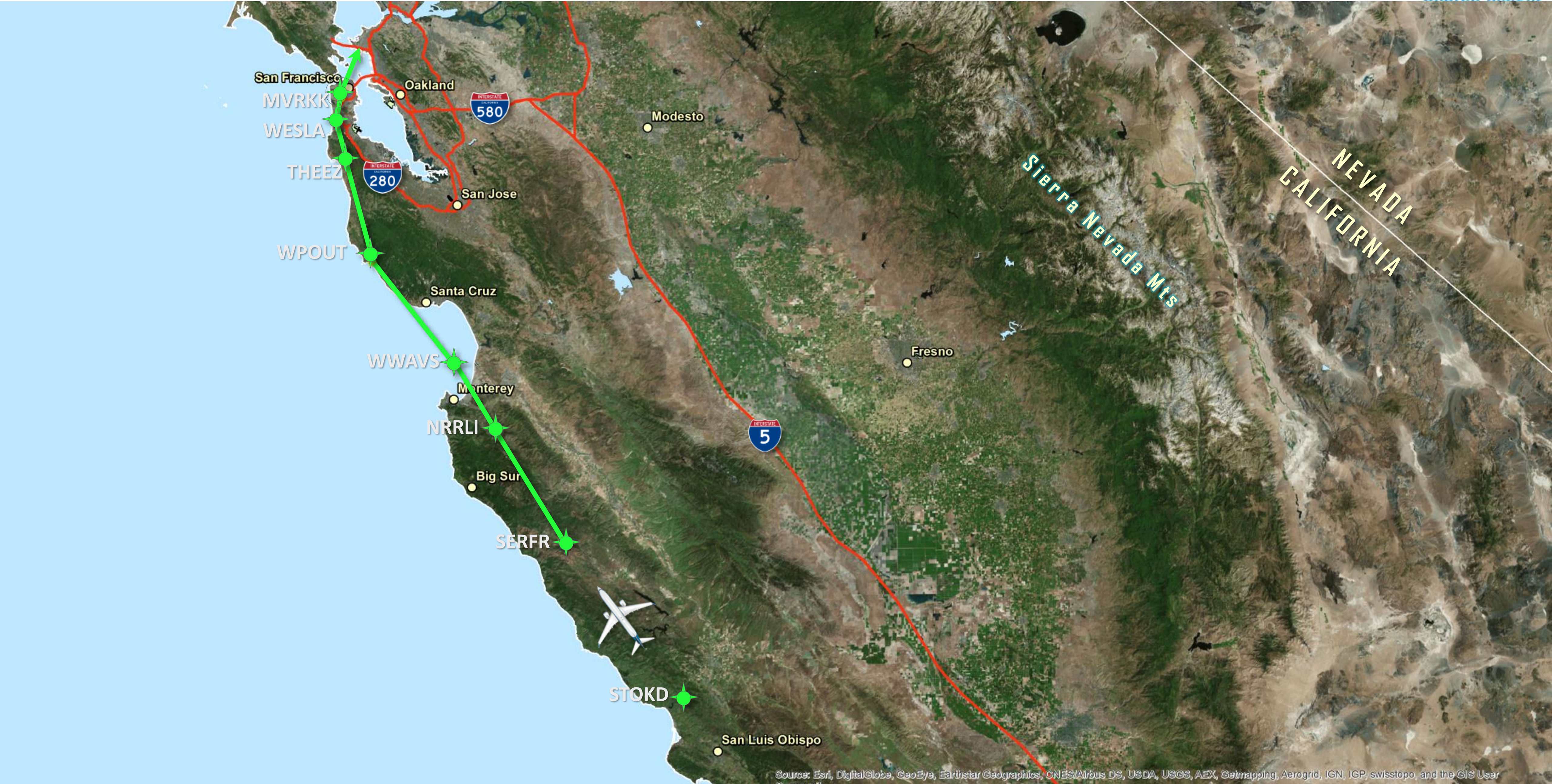
STARs cover the portion of the flight between the top of descent and the initial approach fix to the runway.

The STAR simplifies ATC clearance procedures and allows for a smooth transition of aircraft between en-route and approach controllers. Assignment of STARs by ATC is dictated by many factors including the weather conditions, runway/approach in use as well as airport congestion.

San Francisco Int'l
KSFO - WWAVS.1 STAR Illustrated



SAN FRANCISCO INT'L (SFO) WWAVS.1 ARR. RNAV STAR

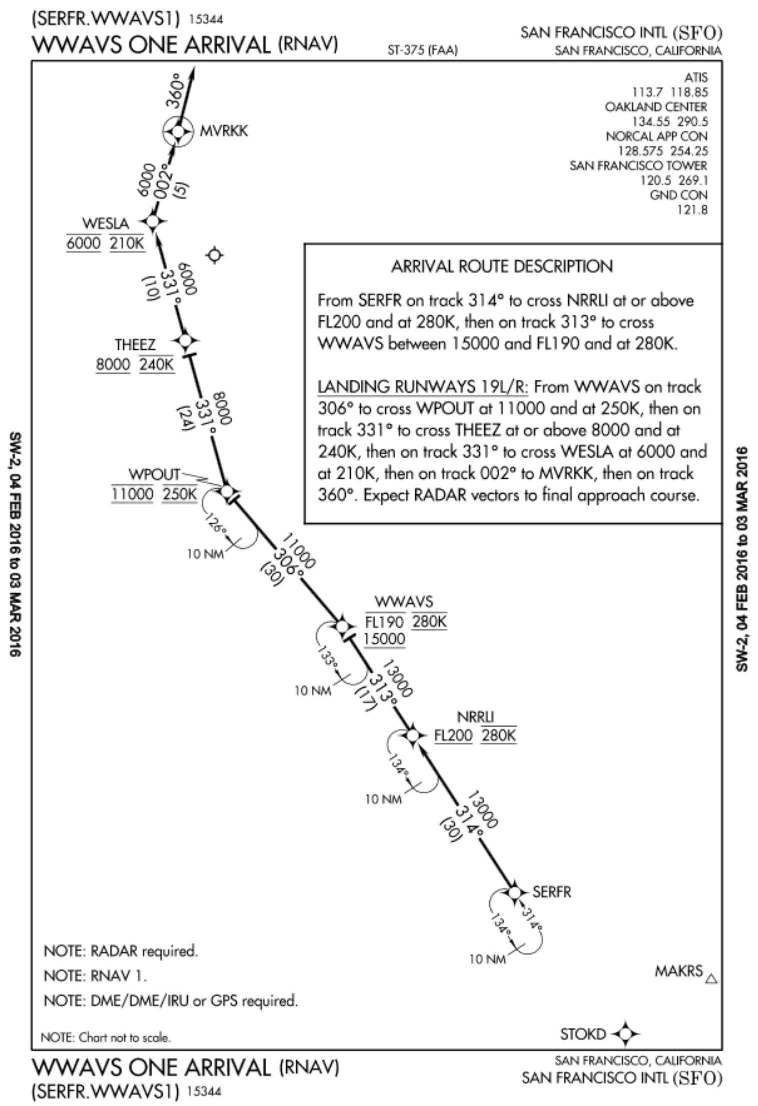


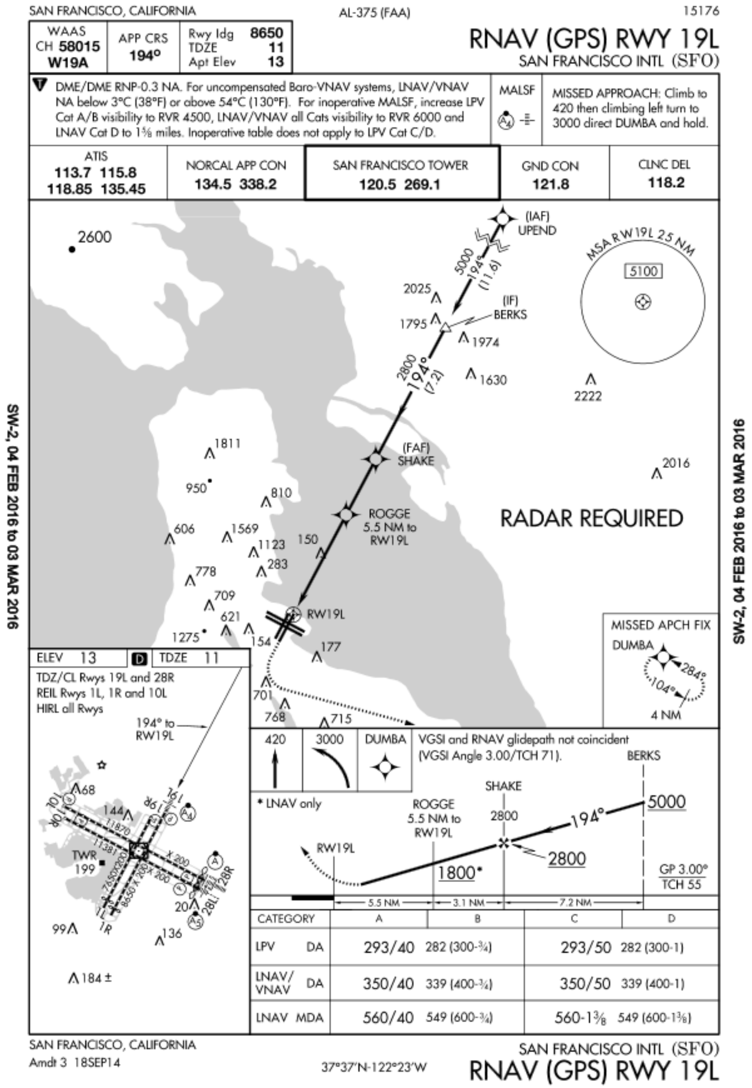
WHAT'S THE DIFFERENCE BETWEEN AN ARRIVAL AND AN APPROACH?

Arrival

An arrival procedure covers the portion of the flight from the top of descent point in cruise flight down to a position just short of the initial fix on a specific approach.

Arrivals don't end at a runway end, but rather usually terminate near the initial fix for a specific approach.





Approach

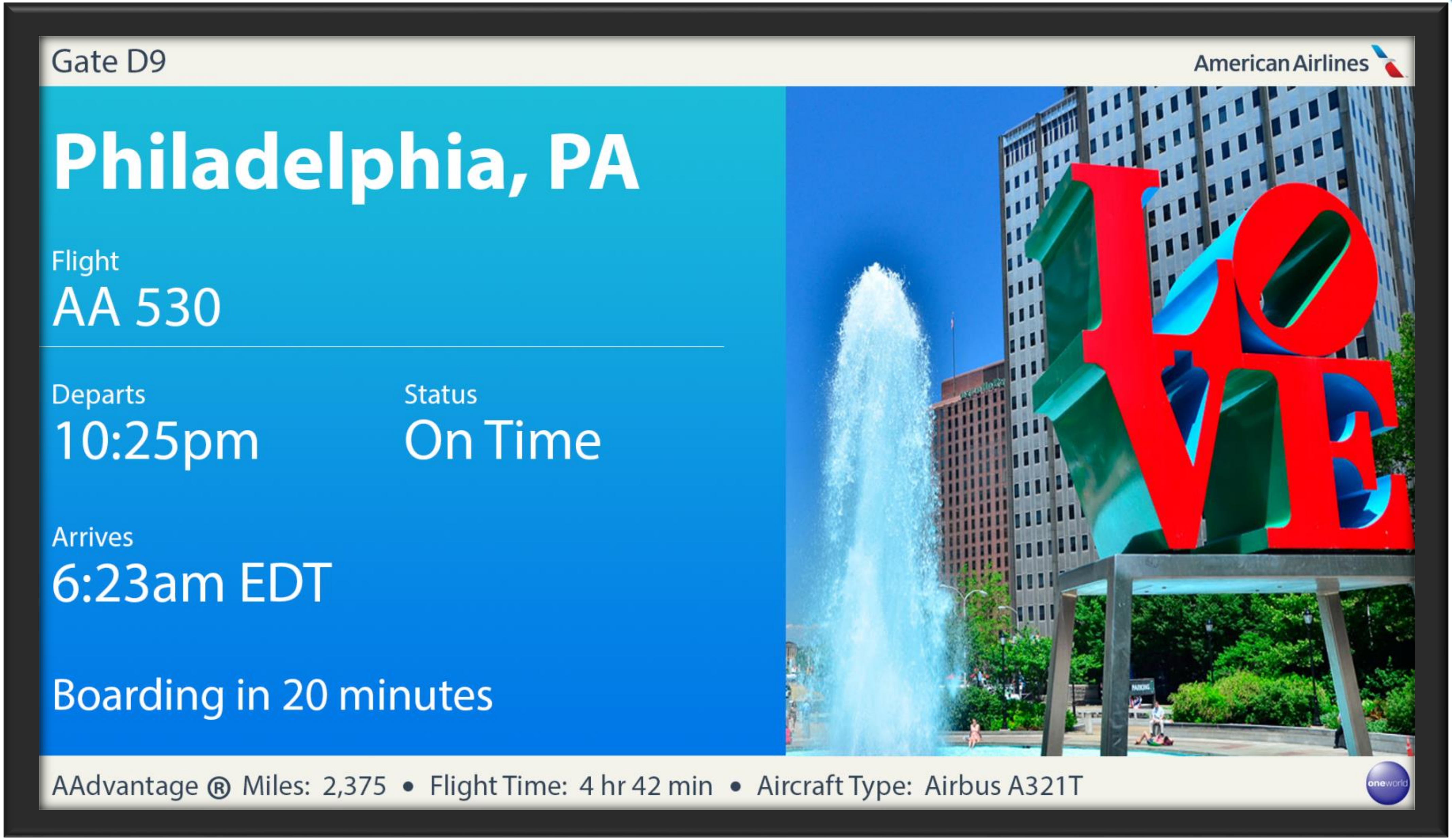
An approach procedure cover the portion of the flight from the initial approach fix down to the runway.

ATC sequences airplanes onto an approach to a specific runway at set intervals. The approach procedure guides the aircraft down to the runway.

CASPER Shared Insight

REAL WORLD EXAMPLE AAL530 (SEA-PHL)

CASPER Shared Insight



AAL530 FLIGHT DETAILS

(•) CASPER
Shared Insight

AIRBUS A321-231T (Transcon)

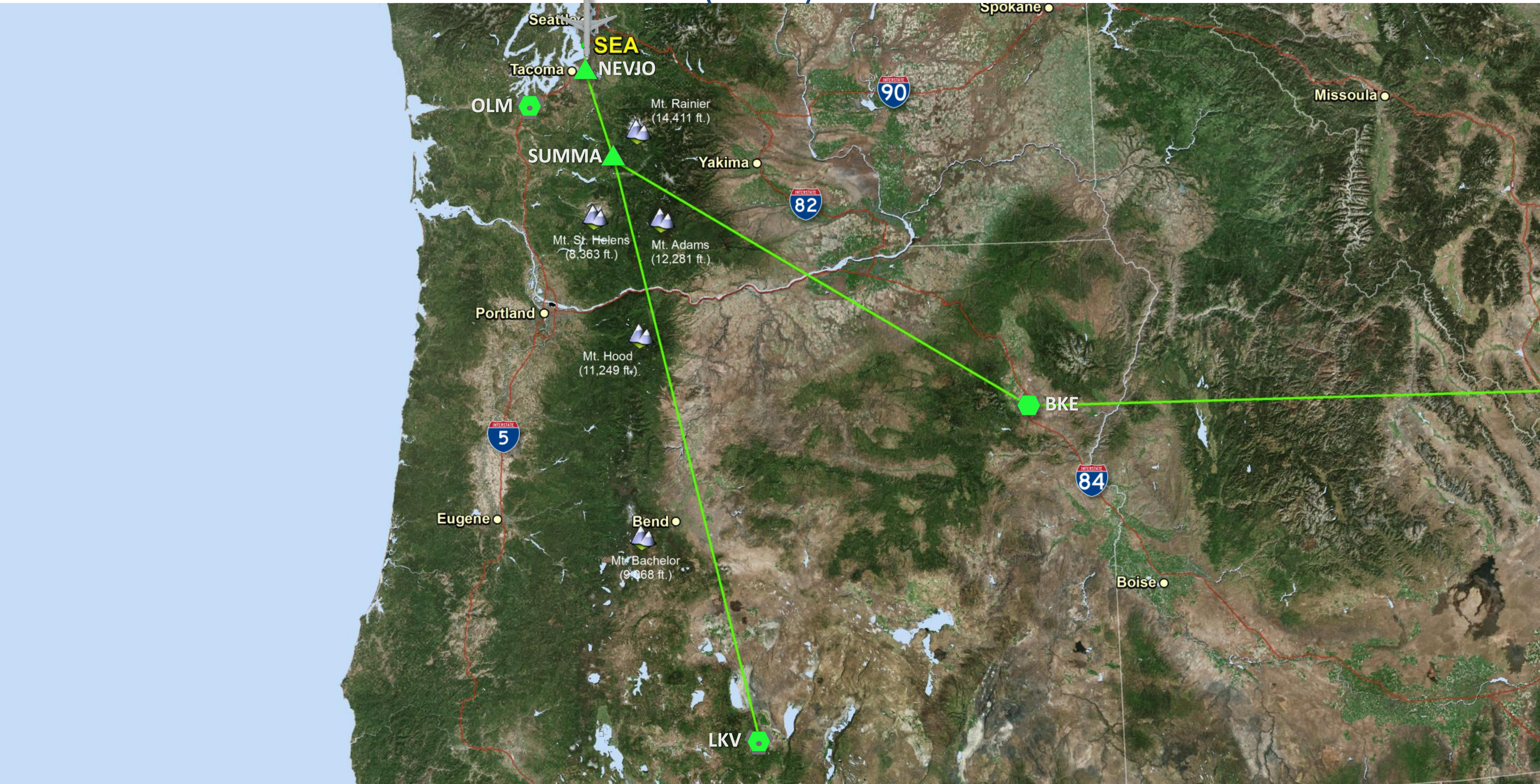
Aircraft: N102NN

Filed: FL330

ETE: 4 hr 42 min

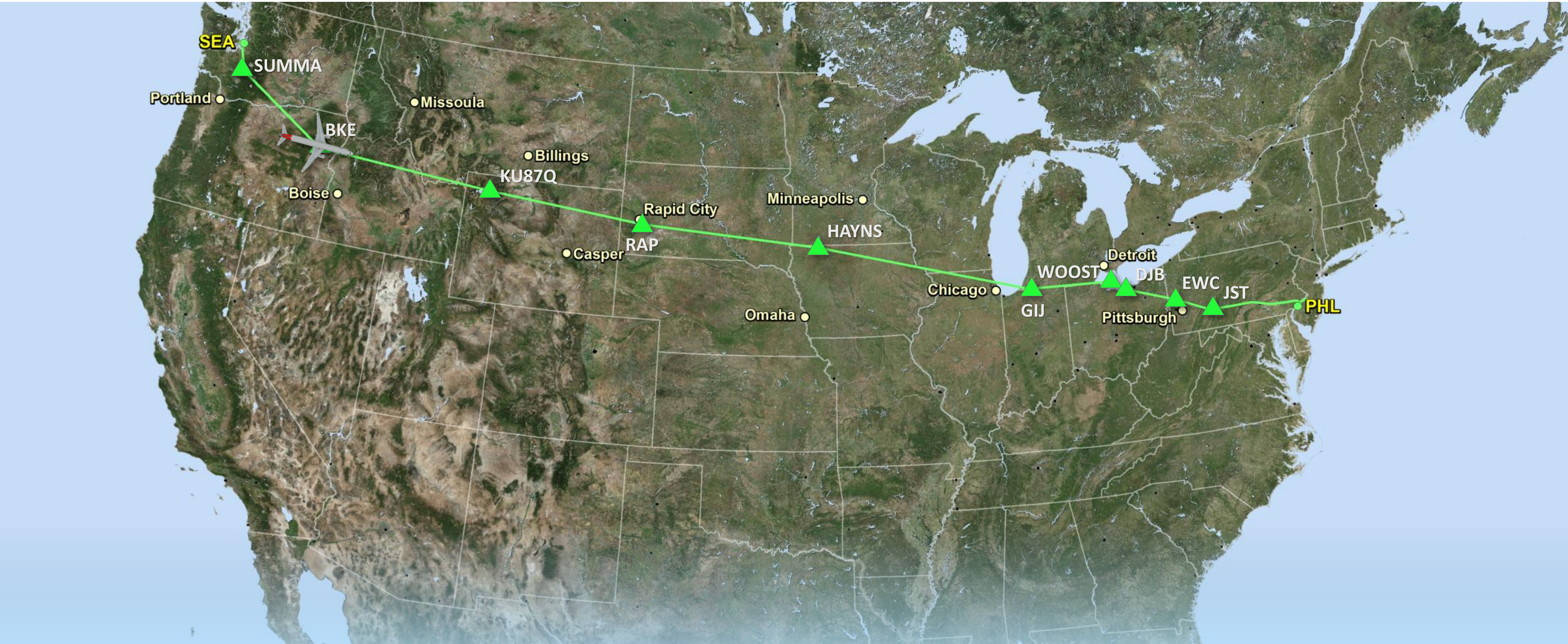
Route: KSEA SUMMA8 SUMMA J54 BKE KU87Q RAP HAYNS GIJ J146 WOOST J34 DJB EWC JST BOJID1 KPHL

SEATTLE-TACOMA (SEA) SUMMA.8 DEP. SID



AAL530 ENROUTE FLIGHTPATH

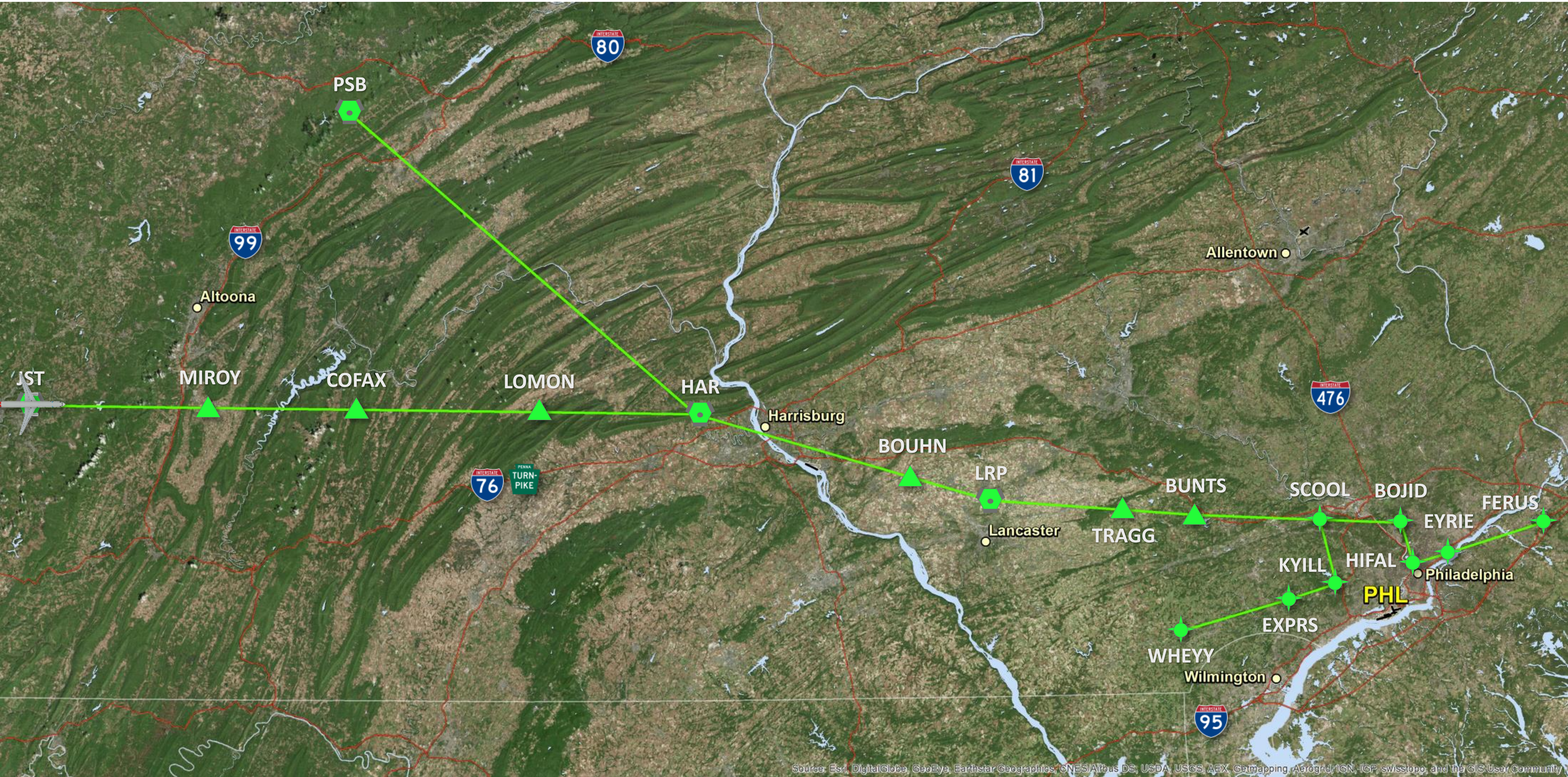
CASPER Shared Insight



Route: KSEA SUMMA8 SUMMA J54 BKE KU87Q RAP HAYNS GIJ J146 WOOST J34 DJB EWC JST BOJID1 KPHL

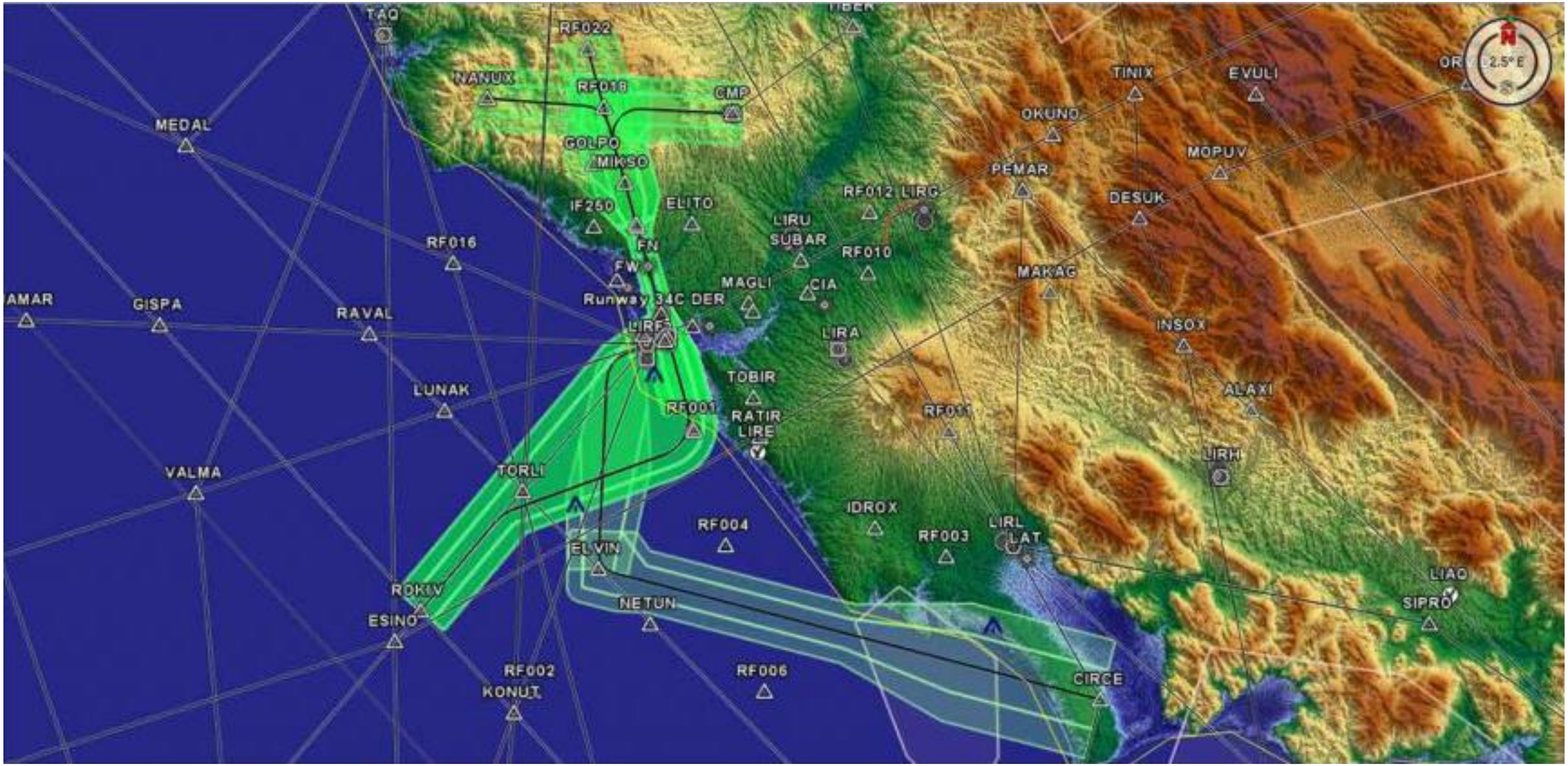
↑ Origin (KSEA) ↑ SID (SUMMA8) ↑ Waypt. (SUMMA) ↑ Trans. (BKE) ↑ VOR (RAP) ↑ Airway (J146) ↑ Trans. (JST) ↑ STAR (BOJID1) ↑ Dest. (KPHL)

PHILADELPHIA INT'L (PHL) BOJID.1 RNAV ARR. STAR



FLIGHT PROCEDURE DESIGN

(•) CASPER
Shared Insight



PRIMARY DESIGN CONSIDERATIONS

(•) CASPER Shared Insight

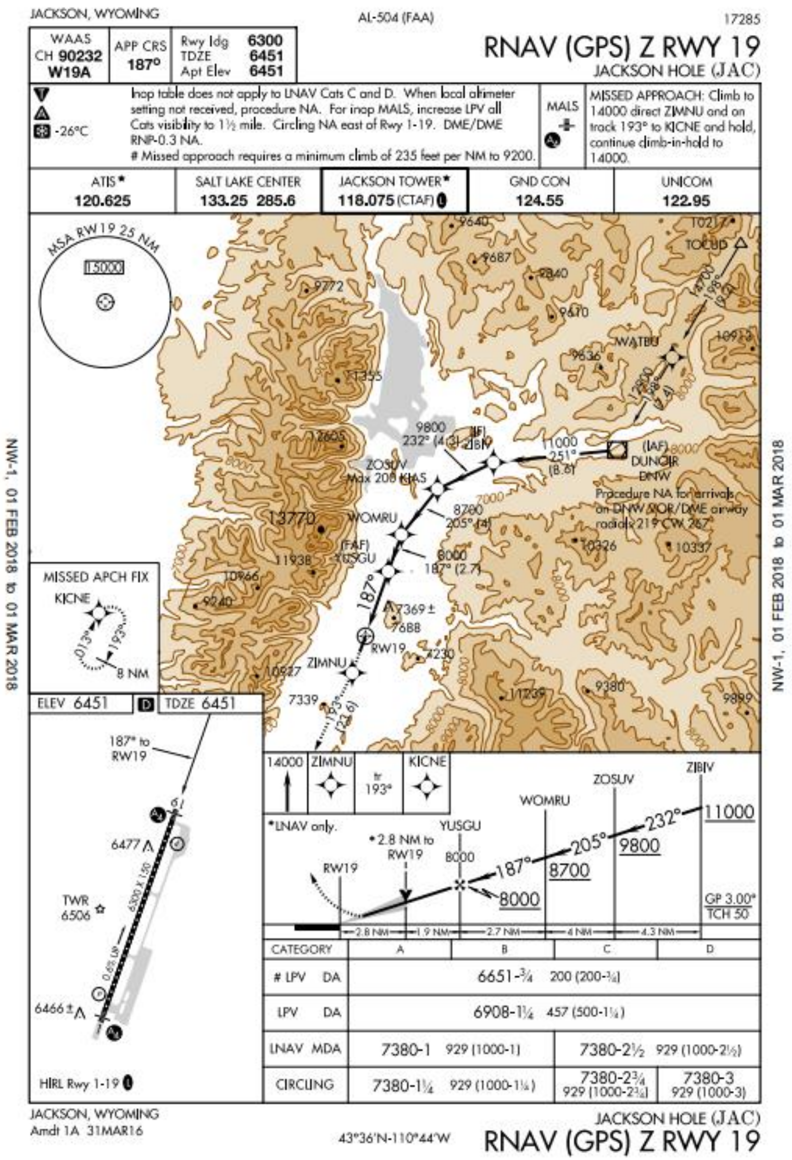
SAFETY OF FLIGHT

- Terrain Clearance
- Obstacle Clearance
- Aircraft Performance Limitations
- Traffic Separation
- Traffic Deconfliction

AIRSPACE EFFICIENCY

- Increase System Throughput
- Increase Predictability of Operations
- Reduce Required Aircraft Spacing
- Reduce Track Miles Flown
- Reduce Radio Communications

TERRAIN AND OBSTACLE CLEARANCE



Maintain Separation

- Minimum Climb Gradient
- Maximum Descent Gradient
- Altitude Crossing Limits
- Minimum Turn Radius
- Airspeed Restrictions
- Navigation Error Tolerance
- Aircraft Restrictions

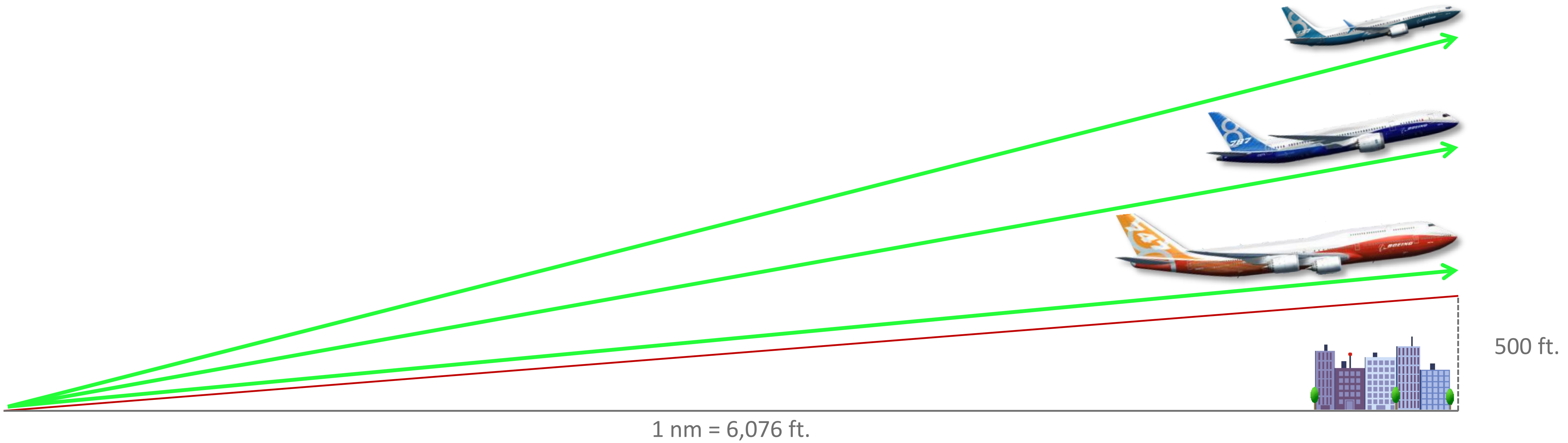
AIRCRAFT PERFORMANCE LIMITATIONS

Vertical Profile – Climb Gradient

Minimum climb gradients are predicated on the worst case scenario:

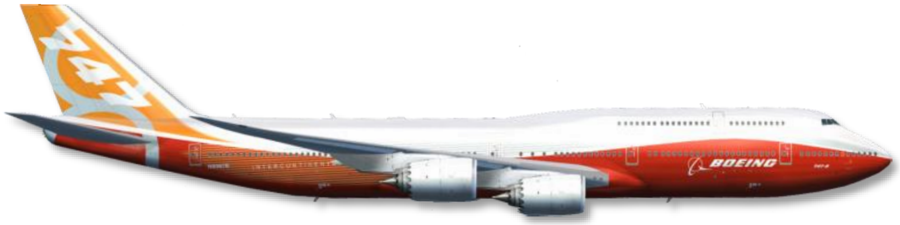
Losing an engine on takeoff with the aircraft at maximum takeoff weight on a very hot day.

The vertical profile must allow all aircraft to clear all obstacles safely with one engine inoperative.



AIRCRAFT PERFORMANCE LIMITATIONS

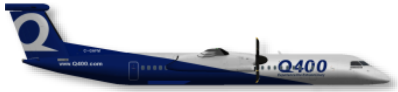
(•) CASPER
Shared Insight



Max Takeoff Weight = 987,000 lb. / 447,696 kg.

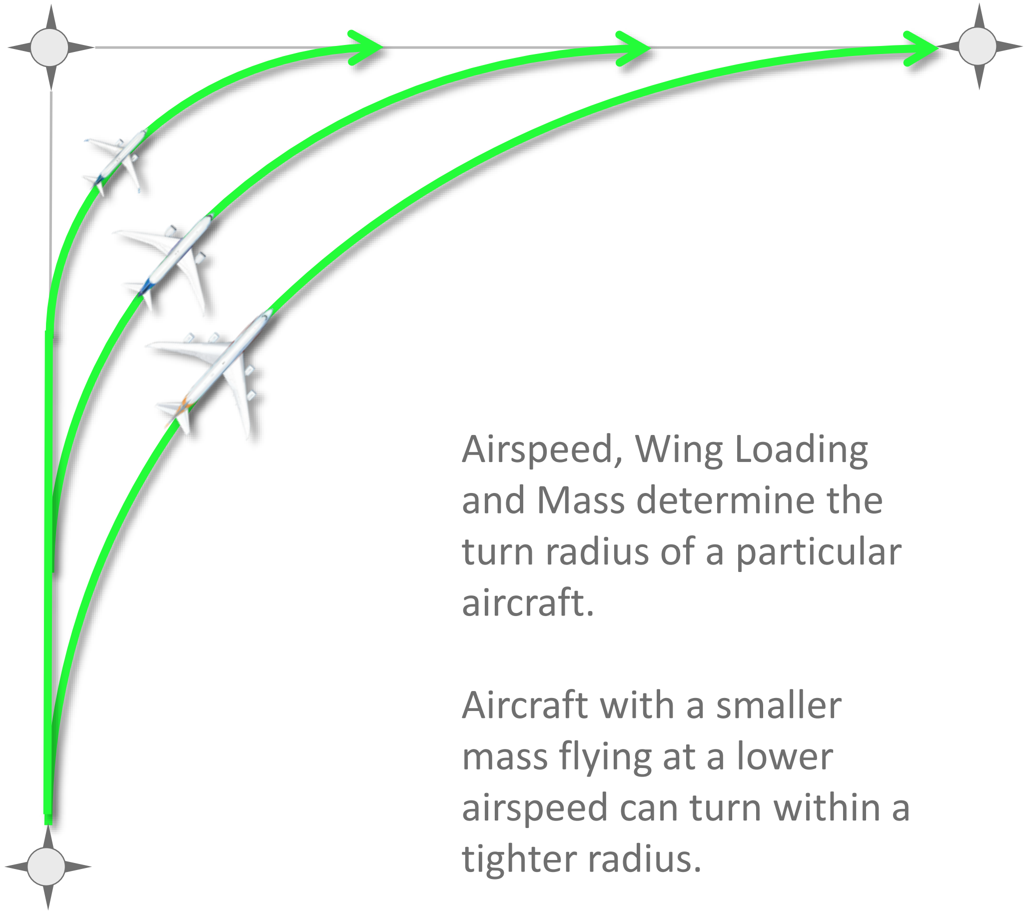
Max Takeoff Weight = 502,500 lb. / 227,930 kg.

Max Takeoff Weight = 181,200 lb. / 82,191 kg.



Max Takeoff Weight = 64,500 lb. / 29,257 kg.

Lateral Profile – Turn Radius



Airspeed, Wing Loading and Mass determine the turn radius of a particular aircraft.

Aircraft with a smaller mass flying at a lower airspeed can turn within a tighter radius.

TRAFFIC SEPARATION / DECONFLICTION

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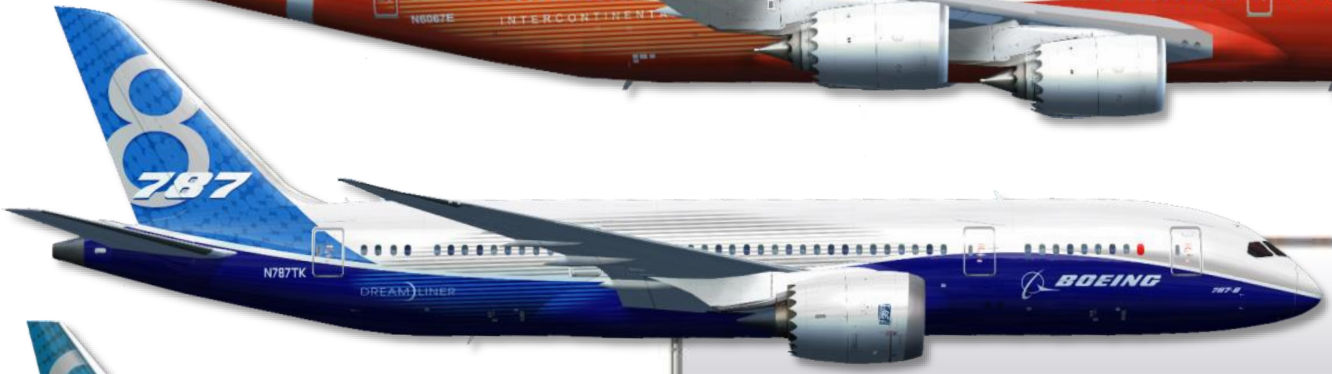
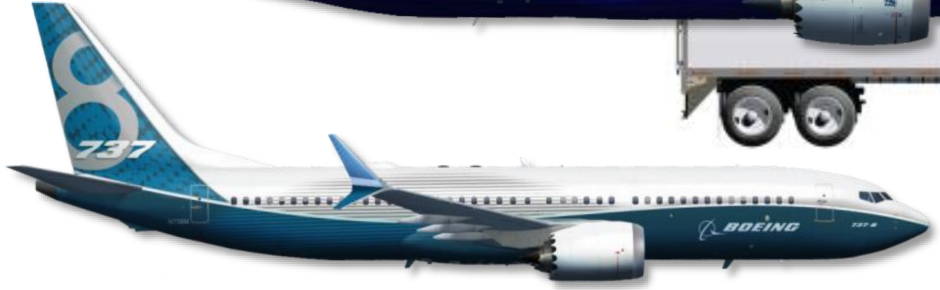
Shared Insight

Boeing 747-8I
Cruise Speed = 570 mph
Approach Speed = 172 mph
Max Takeoff Weight = 987,000 lb.



Boeing 787-8
Cruise Speed = 560 mph
Approach Speed = 161 mph
Max Takeoff Weight = 502,500 lb.

Semi-Truck
Cruise Speed = 70 mph
Max Weight = 80,000 lb.



Boeing 737-8 Max
Cruise Speed = 522 mph
Approach Speed = 163 mph
Max Takeoff Weight = 181,200 lb.

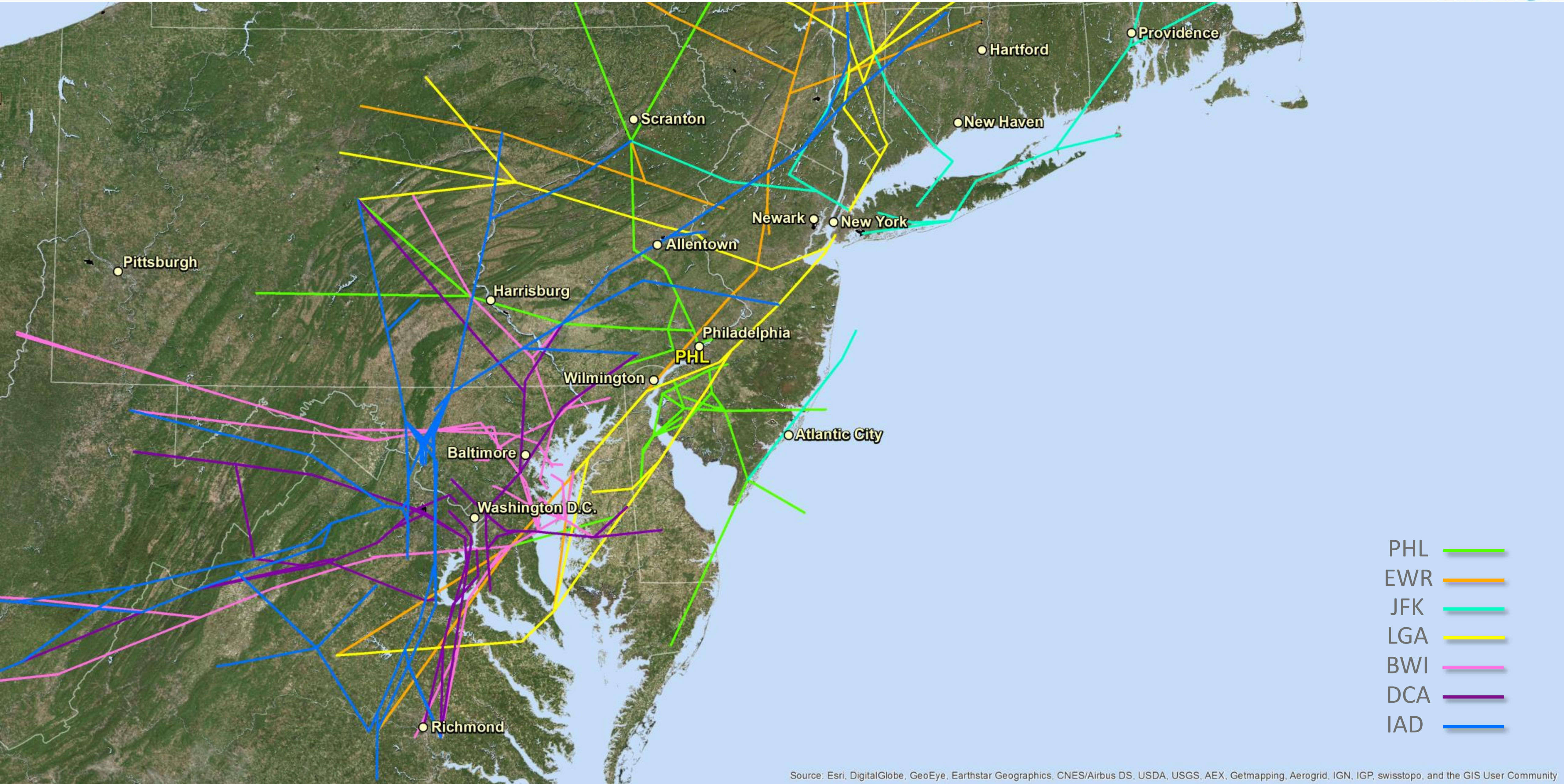
Bicycle
Cruise Speed = 15 mph
Avg. Weight = 200 lb.

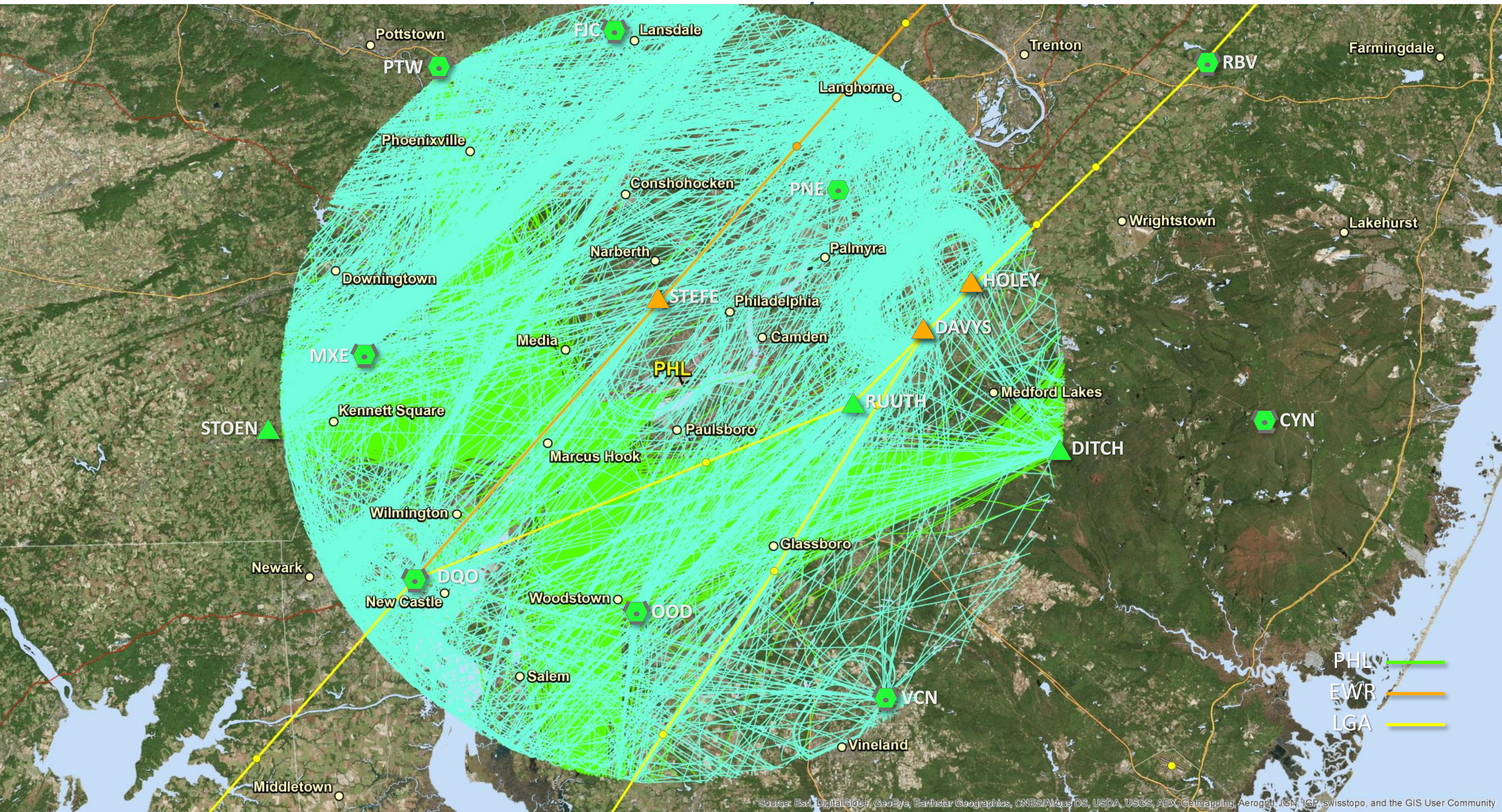
Bombardier Q400
Cruise Speed = 414 mph
Approach Speed = 145 mph
Max Takeoff Weight = 64,500 lb.

Cessna 172
Cruise Speed = 140 mph
Approach Speed = 75 mph
Max Takeoff Weight = 2,550 lb.

TRAFFIC SEPARATION / DECONFLICTION

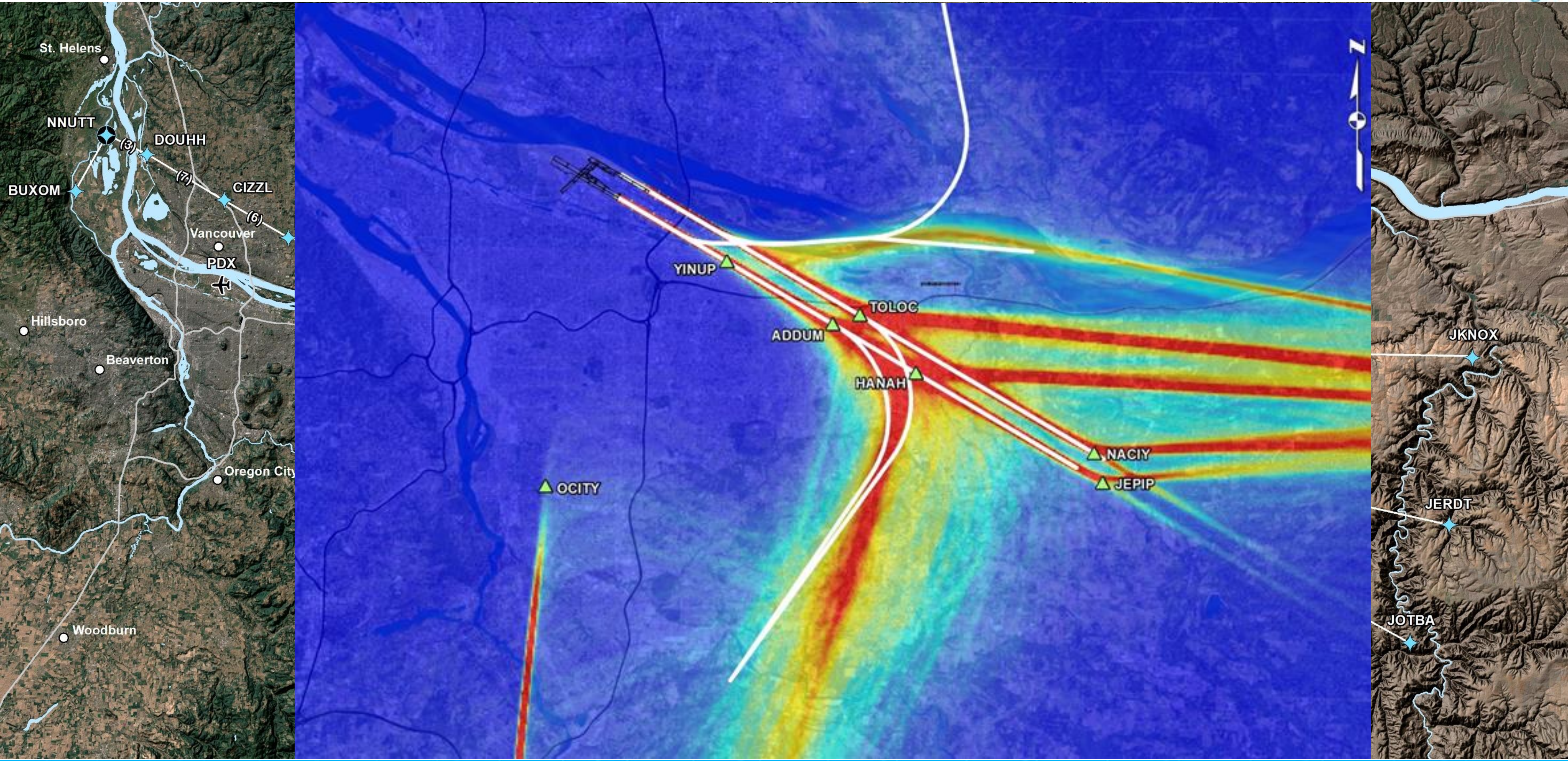
(•) CASPER Shared Insight





FJC
Lansdale
Pottstown
PTW
Trenton
RBV
Farmingdale
Langhorne
Phoenixville
Conshohocken
PNE
Wrightstown
Lakehurst
Narberth
Palmyra
Downingtown
HOLEY
STEFE
Philadelphia
DAVYS
Camden
MXE
Media
PHL
RUUTH
Medford Lakes
Kennett Square
STOEN
Paulsboro
CYN
DITCH
Marcus Hook
Wilmington
Glassboro
Newark
DQO
New Castle
Woodstown
OOD
Salem
VCN
Vineland
Middletown
PHL
EWR
LGA
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

INCREASE THROUGHPUT / PREDICTABILITY



REDUCE REQUIRED AIRCRAFT SPACING

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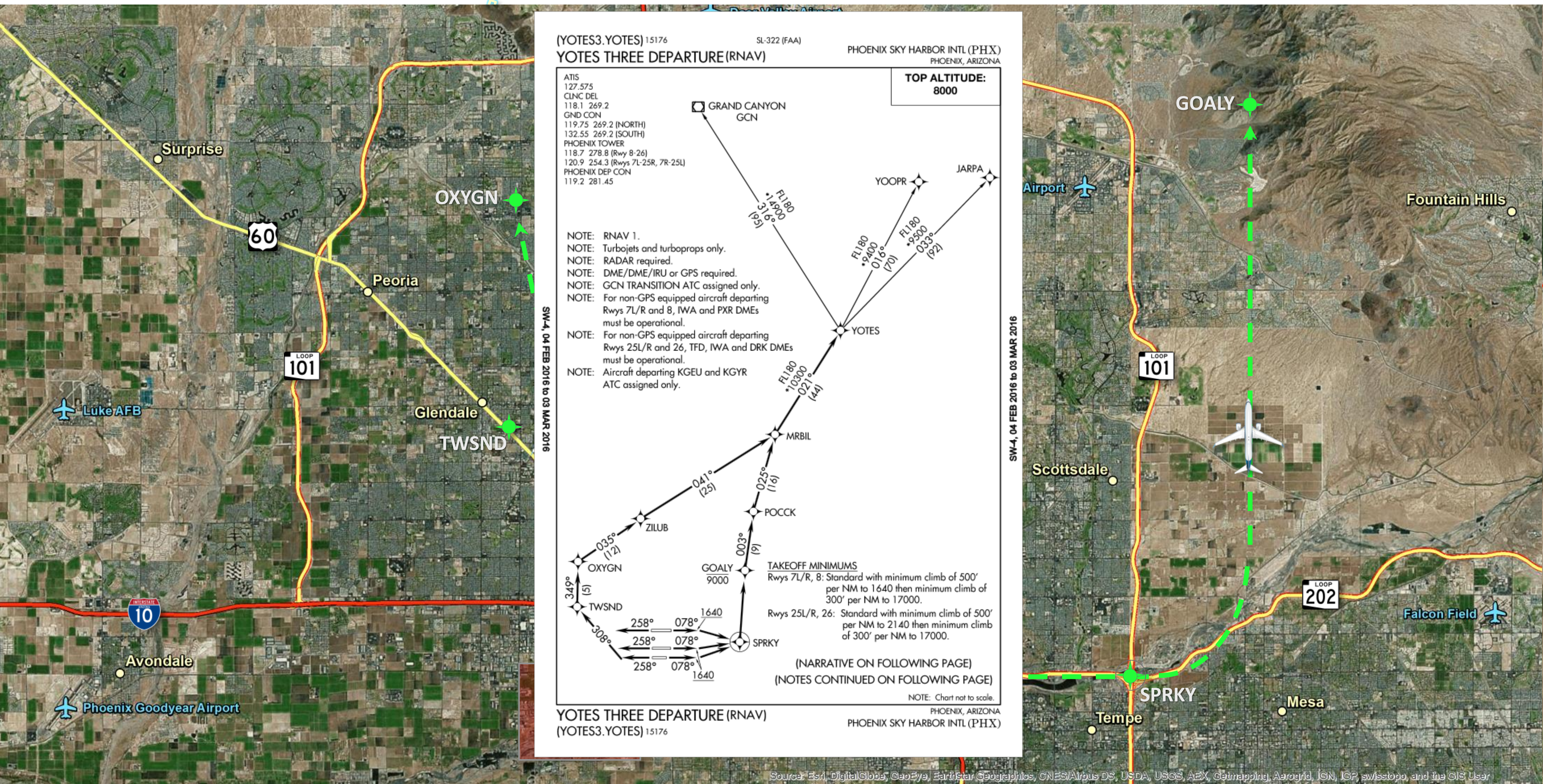
REDUCE TRACK MILES FLOWN



ACKNOWLEDGEMENTS

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The following programs and sources were used to create this presentation.

Casper Noise

Adobe Photoshop CC 2016

AirNav.com (airnav.com)

Boeing 747-400 Airplane Characteristics for Airport Planning (boeing.com/commercial/airports/plan_manuals.page)

Esri ArcGIS ArcMap v10.3.1

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International Civil Aviation Organization (icao.int)

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Microsoft PowerPoint 2016

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Precision Manuals Development Group Boeing 747-400 Simulation (precisionmanuals.com)

Professional Flight Planner X (flightsimsoft.com/pfpx)

Take-Off and Landing Performance Calculation Tool (flightsimsoft.com/topcat)

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QUESTIONS?