# Air Traffic Control and Runway Separations




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# Discussion of Flight Rules Used in Aviation

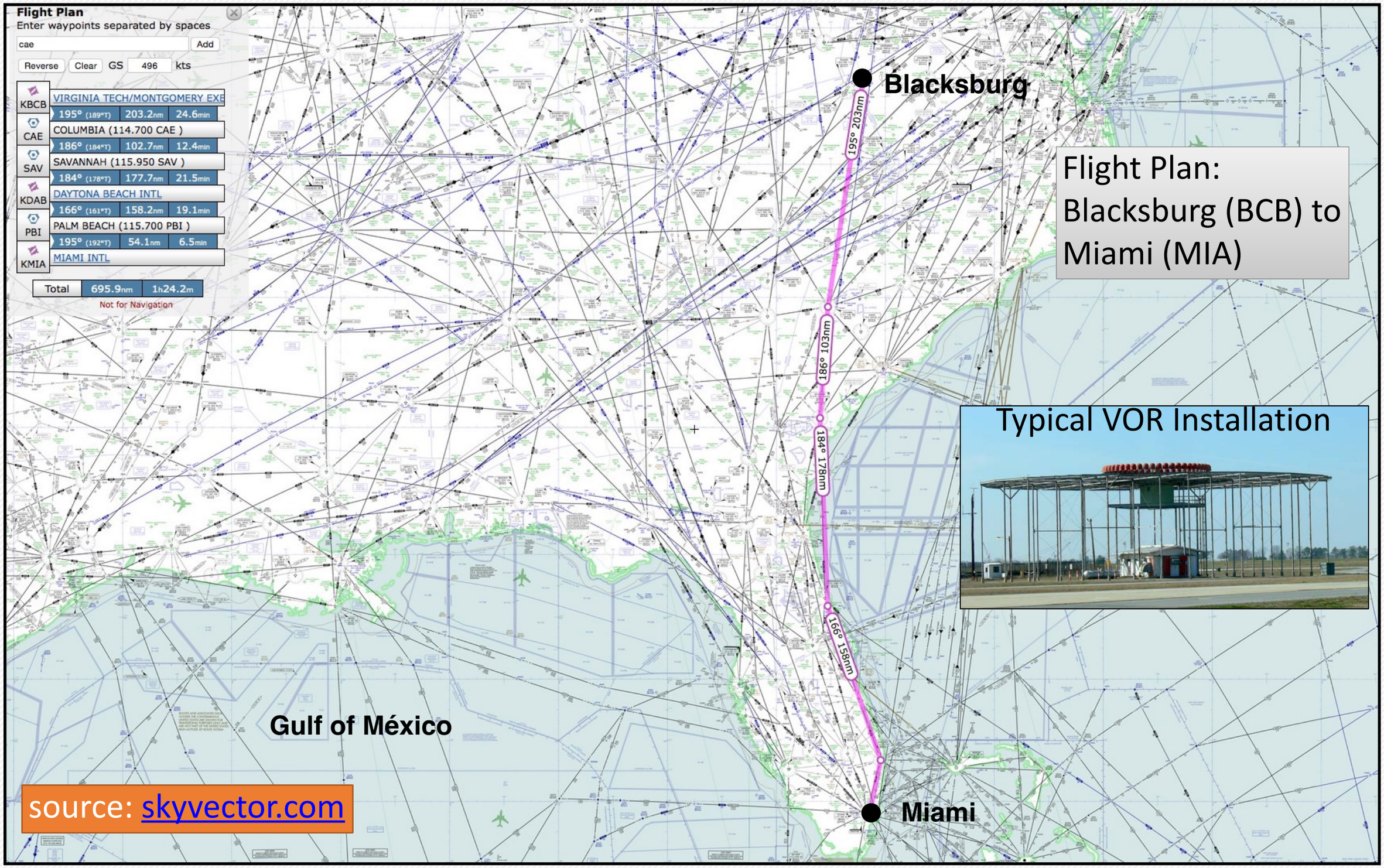
## Flight Rules

- IFR - instrument flight rules (ATC controlled flights)
- VFR - visual flight rules (> 3 nm visibility and 1000 ft. from clouds)

## Weather conditions

- VMC - visual meteorological conditions
- IMC - instrument meteorological conditions

An airliner could fly in VMC conditions (i.e., good weather) but is always subject to IFR flight rules.


Flight Plan
Enter waypoints separated by spaces
cae
Add
Reverse
Clear
GS 496 kts
KBCB
VIRGINIA TECH/MONTGOMERY EXE
195° (189°T) 203.2nm 24.6min
CAE
COLUMBIA (114.700 CAE )
186° (184°T) 102.7nm 12.4min
SAV
SAVANNAH (115.950 SAV )
184° (178°T) 177.7nm 21.5min
KDAB
DAYTONA BEACH INTL
166° (161°T) 158.2nm 19.1min
PBI
PALM BEACH (115.700 PBI )
195° (192°T) 54.1nm 6.5min
KMIA
MIAMI INTL
Total 695.9nm 1h24.2m
Not for Navigation
Blacksburg
195° 203nm
186° 103nm
184° 178nm
166° 158nm
Miami
Gulf of México
Flight Plan: Blacksburg (BCB) to Miami (MIA)
Typical VOR Installation
source: skyvector.com

# The Role of Air Traffic Control

Air traffic controllers maintain aircraft separations and help pilots navigate to their destination providing verbal and datalink instructions



# Classification of ATC Services

There are three control components of ATC and one support component. These components interact all time among themselves via telephone or microwave data links.

**Control Components**:

- Air Traffic Control Systems Command Center (ATCSCC)
- Air Route Traffic Control Centers (ARTCC)
- Terminal Approach/Departure Control Facilities (TCA - TRACON)
- Airport Traffic Control Tower (ATCT)

**Support Component** (Information)

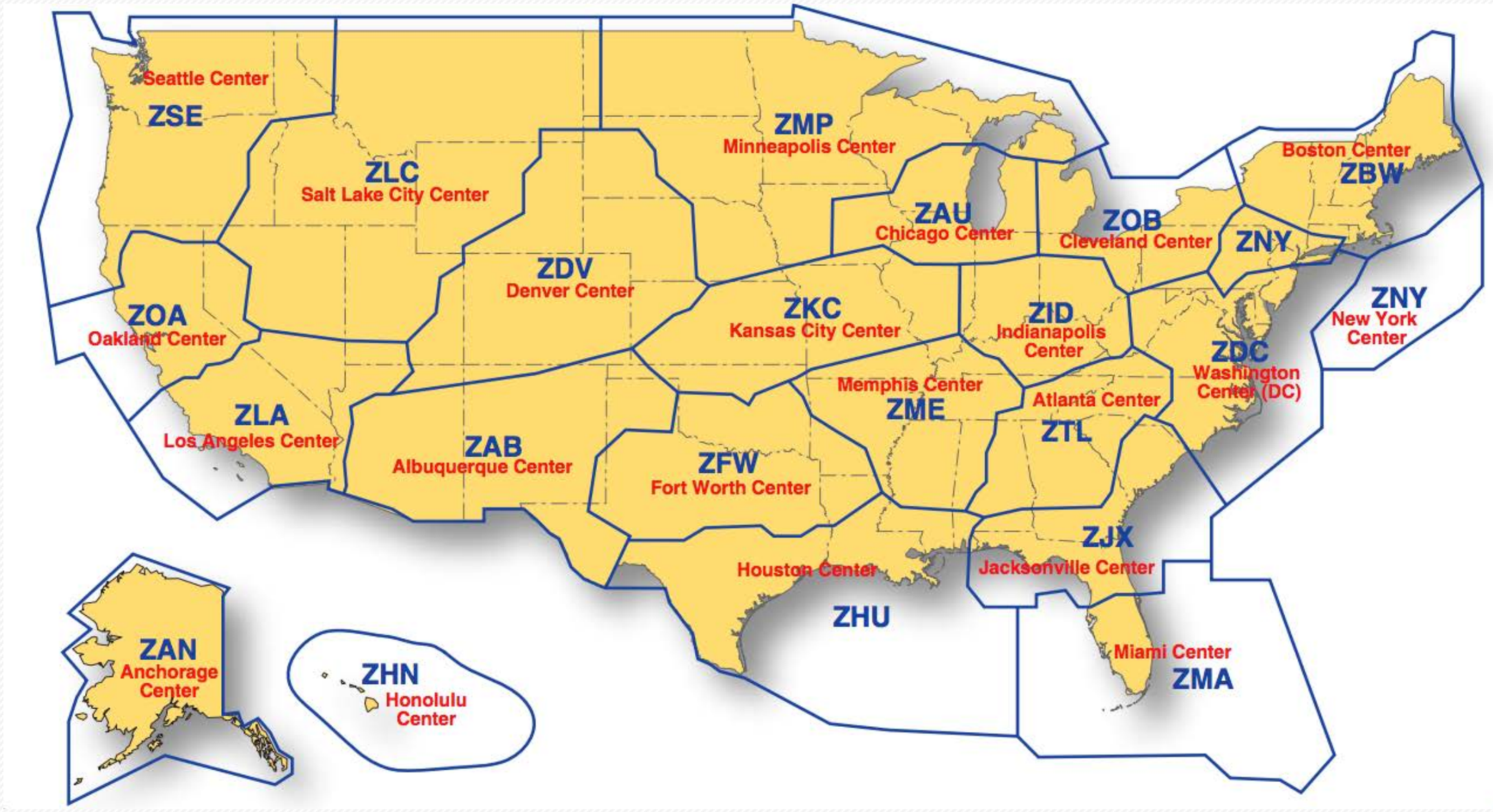
- Flight Service Stations (FSS)

# US Air Route Traffic Control Centers (ARTCC)

- Twenty one ARTCC facilities in the U.S.
- 30-50 sectors (horizontal and vertical) in each ARTCC
- Control over 200-300 nm from radar sites (use of multiple radars to track targets at long distances) Today, surveillance is also done using ADS-B systems
- Use of long range radars for surveillance (12 seconds between scans or update rate)
- The size of the ARTCC varies according to traffic density over NAS (see next page)

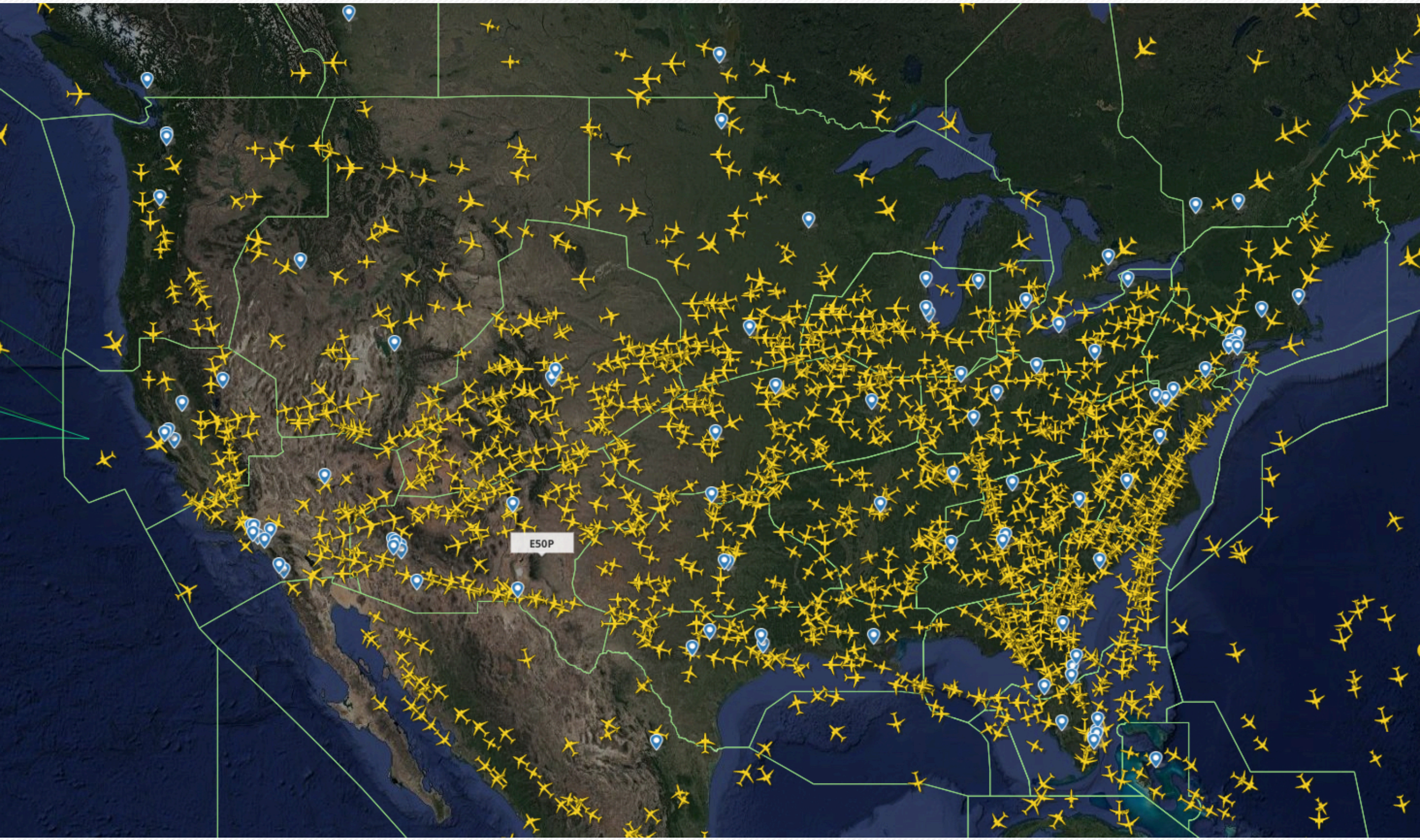
# Enroute Control Centers in the US

- A well organized and hierarchical system
- Communications are typically carried via Voice channels (one channel per controller).




Source: FAA Instrument Procedures Handbook

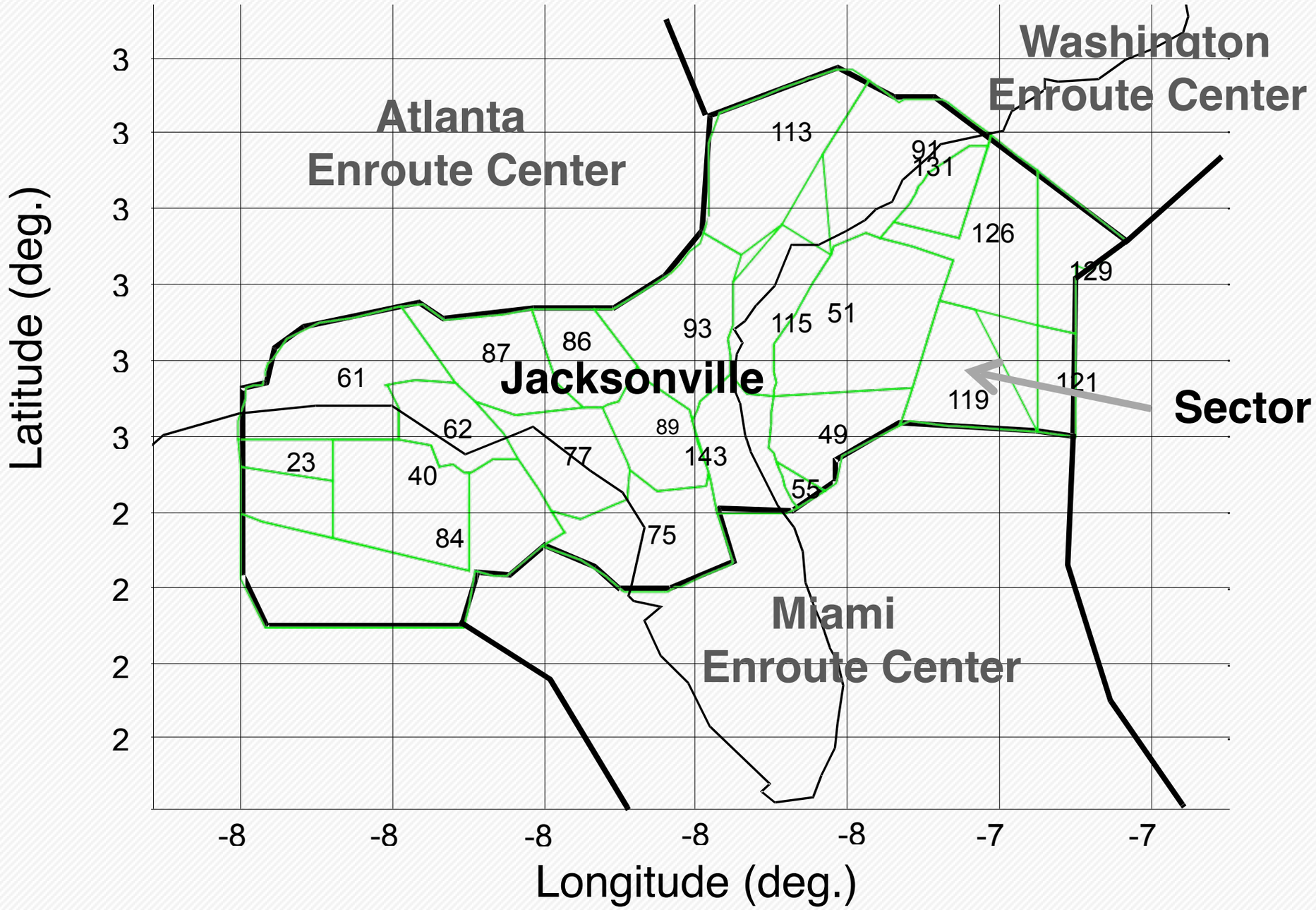
# Enroute Control Centers (ARTCC) in the US




Source: Flightradar24

# Airspace Sectorization to Control Flights inside ATRCC

- The ARTCC Center airspace is divided into **Sectors** to control flights
- Each sector is manned by 1-3 ATC controllers (depending on workload)



# Standard Horizontal Separations (with Radar)

**If radar surveillance and aircraft location is less or equal than 40 nm from radar antenna**

- 3 nm minimum
- Assumes no wake vortex effect

**If radar surveillance and aircraft location is more than 40 nm from radar antenna**

- 5 nm minimum
- Assumes no wake vortex effect

# Enroute Separations (Vertical)

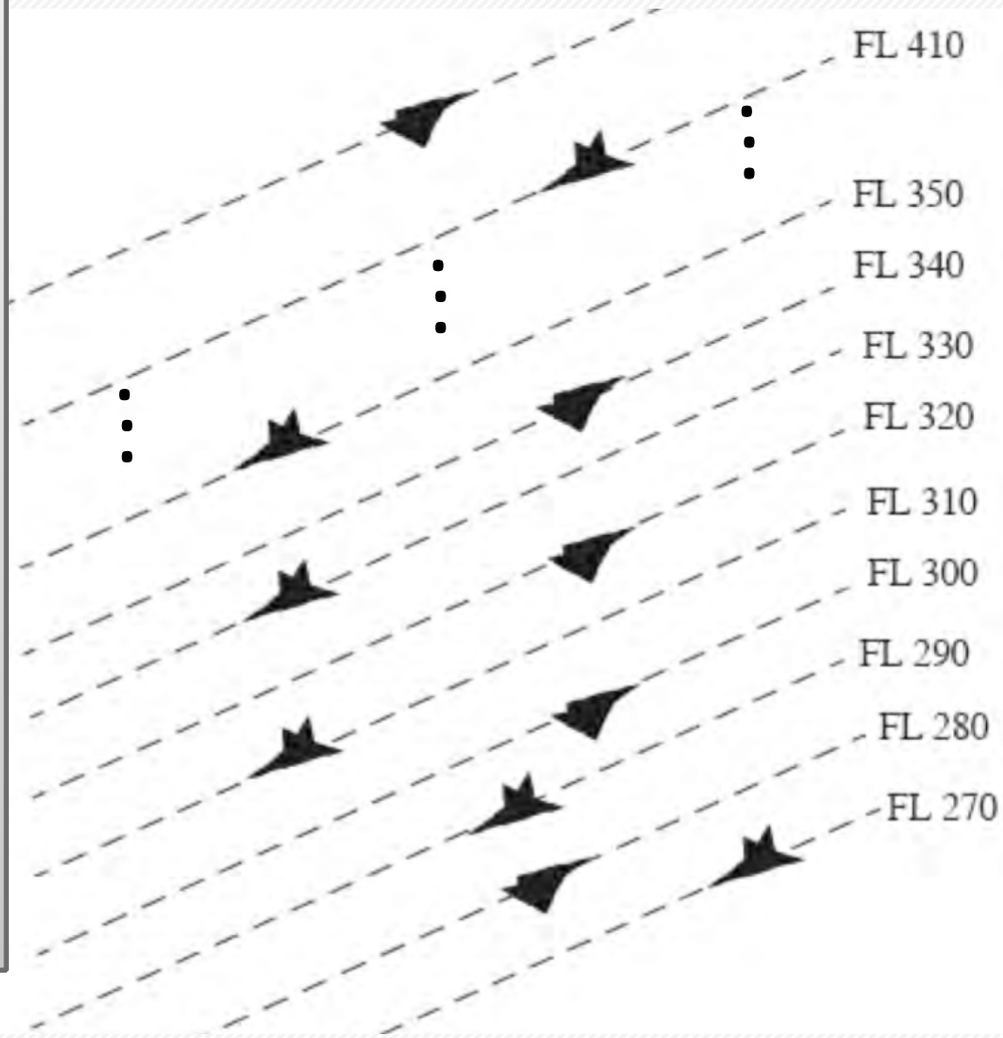
- In January 20, 2005 the FAA instituted Reduced Vertical Separation Minima (RVSM) in the domestic US airspace
- Canada and Mexico (and Gulf of Mexico) also implemented the same RVSM rules on the same day
- The new vertical separations allow six new flight levels to be selected every 1,000 between flight levels 290 and 410
- North Atlantic operations use RVSM since March 1997 and Pacific operations since February 2000
- Europe started RVSM operations in January 2002

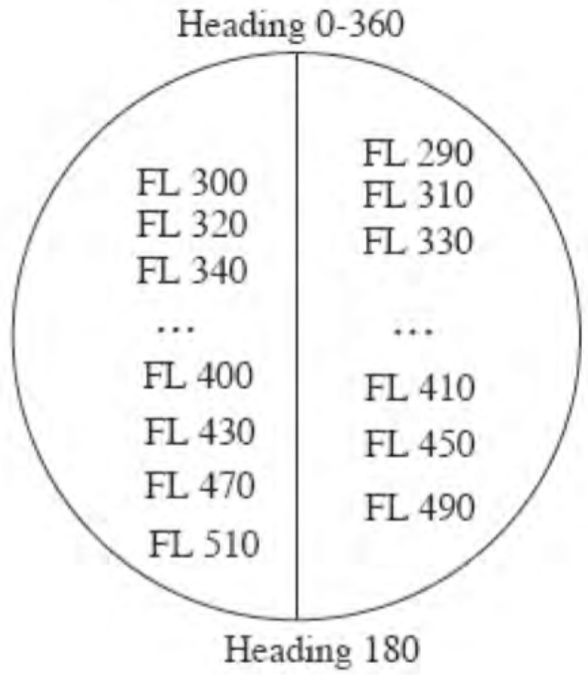
# Vertical Separations in the NAS

- Below 41,000 feet (Flight level 410), flights are separated by 1,000 feet (one flight level)
- Above flight level 410, separations are 2,000 feet

**Example:**
Flight from
JFK (New York) to LAX (Los Angeles) flies generally a West heading (~270 degrees)

Possible flight levels to use are: 340 (34,000 feet), 360 (36,000 feet), 380 (38,000 feet) and 400 (40,000 feet)



# Altitude Assignments in the National Airspace

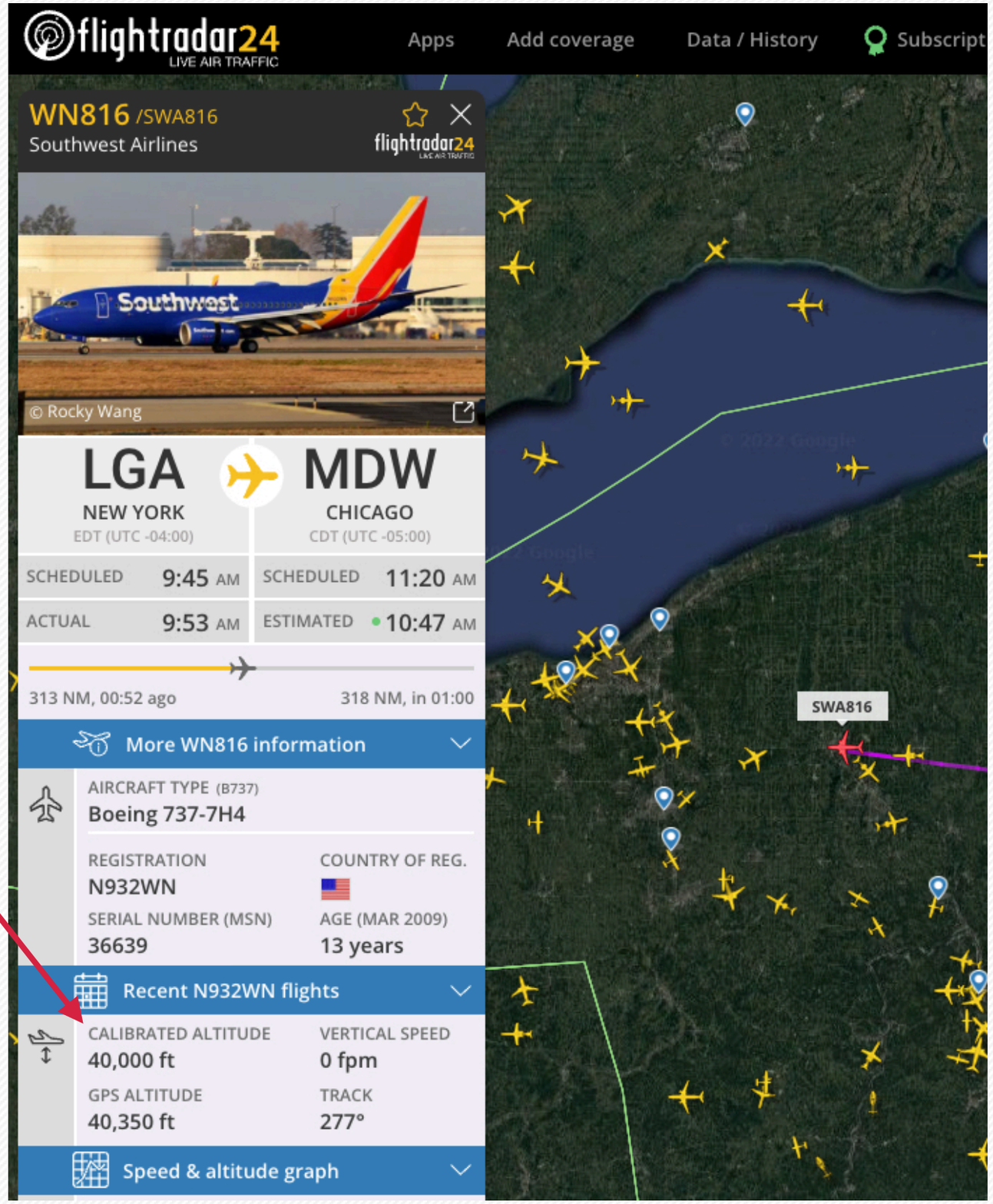
**Altitude Assignment**

| Aircraft Operating | On course degrees magnetic | Assign | Examples |
|---|---|---|---|
| Below 3,000 feet above surface | Any course | Any altitude | |
| At and below FL 410 | 0 through 179 | Odd cardinal altitude or flight levels at intervals of 2,000 feet | 3,000, 5,000, FL 310, FL 330 |
| | 180 through 359 | Even cardinal altitude or flight levels at intervals of 2,000 feet | 4,000, 6,000, FL 320, FL 340 |
| Above FL 410 | 0 through 179 | Odd cardinal flight levels at intervals of 4,000 feet beginning with FL 450 | FL 450, FL 490, FL 530 |
| | 180 through 359 | Odd cardinal flight levels at intervals of 4,000 feet beginning with FL 430 | FL 430, FL 470, FL 510 |
| One way routes (except in composite systems) | Any course | Any cardinal altitude or flight level below FL 410 or any odd cardinal flight level above FL 410 | FL 270, FL 280, FL 290, FL 300, FL 310, FL 410, FL 430, FL 450 |
| Within an ALTRV | Any course | Any altitude or flight level | |
| In aerial refueling tracks and anchors | Any course | Altitude blocks as requested. Any altitude or flight level | 050B080, FL 180B220, FL 280B310 |

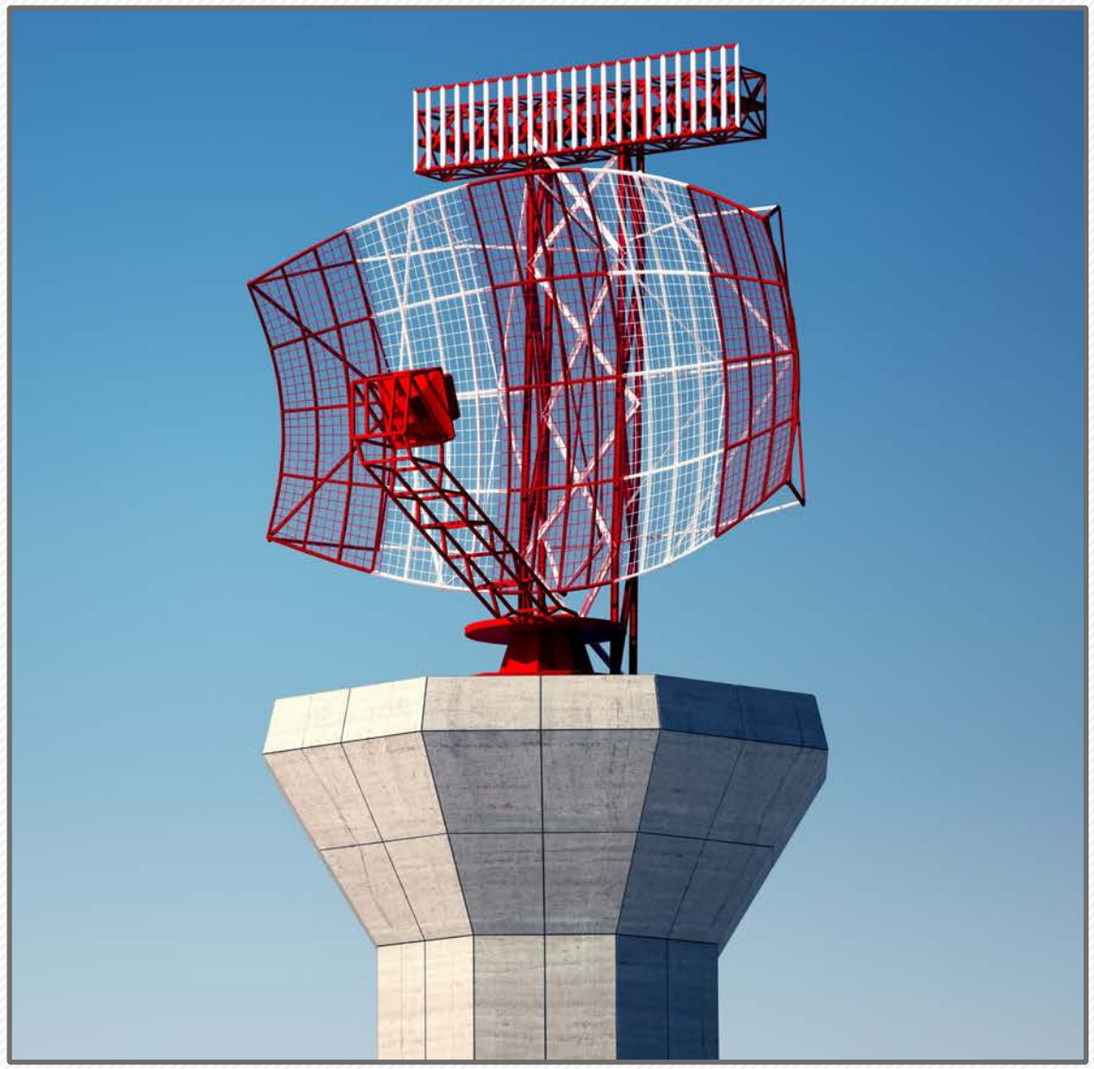
Source: Air Traffic Control Handbook (https://www.faa.gov/air_traffic/publications/atpubs/atc_html/chap4_section_5.html

# Vertical Separations in the NAS

- Southwest Airlines Boeing 737-700 flying from New York LGA to Chicago Midway airport (MDW)
- Flying at FL400
- Mach 0.78



# ATC Surveillance Mechanisms



**Radar (Still available)**



**ADS-B (mandatory in 2020)**

ADS = Automatic Dependent Surveillance
GPS = Global Positioning System

# Automatic Dependent Surveillance – Broadcast (ADS–B)

- Surveillance technology
- Aircraft determines its position via satellite navigation
- Ground stations improve the satellite position
- Started in January 2020, all aircraft operated in the National Airspace System are required to have ADS-B out capability
- Benefits:
  - Efficiency
  - Safety
  - Cockpit traffic information

# Terminal Approach and Departure Control Facilities (TRACON)

- Control terminal traffic (both arrivals and departures)
- Typically 50-80 nm from the airport
- Some TRACON control more than one airport (SW California)
- TRACONs are divided into sectors to ease workload for controllers
- TRACONs meter traffic approaching an airport facility
- Heavy use of verbal advisories (vectors)

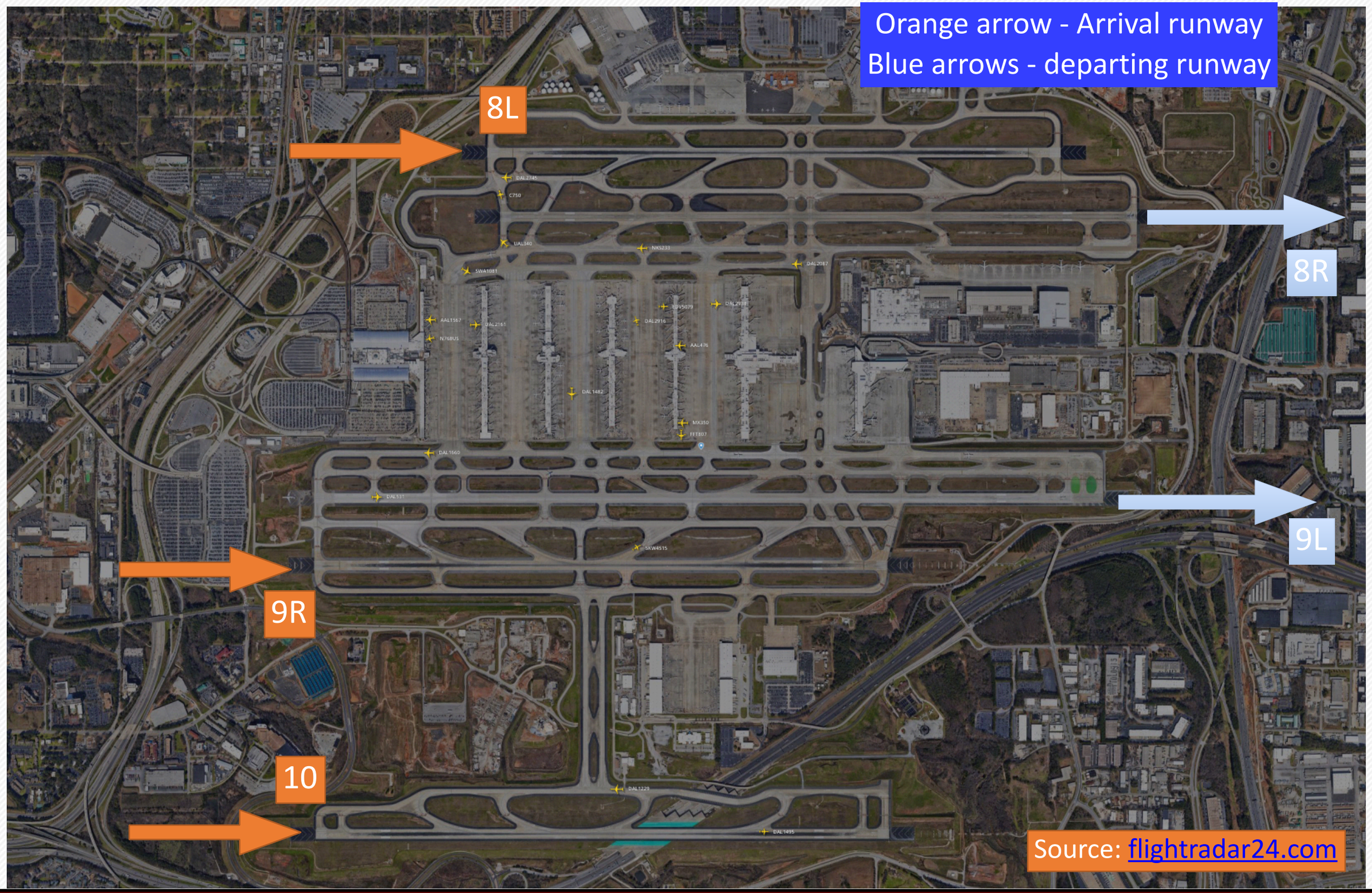
  AA52 turn right heading 120

  UA53 descent and maintain 170 (17,000 ft.)

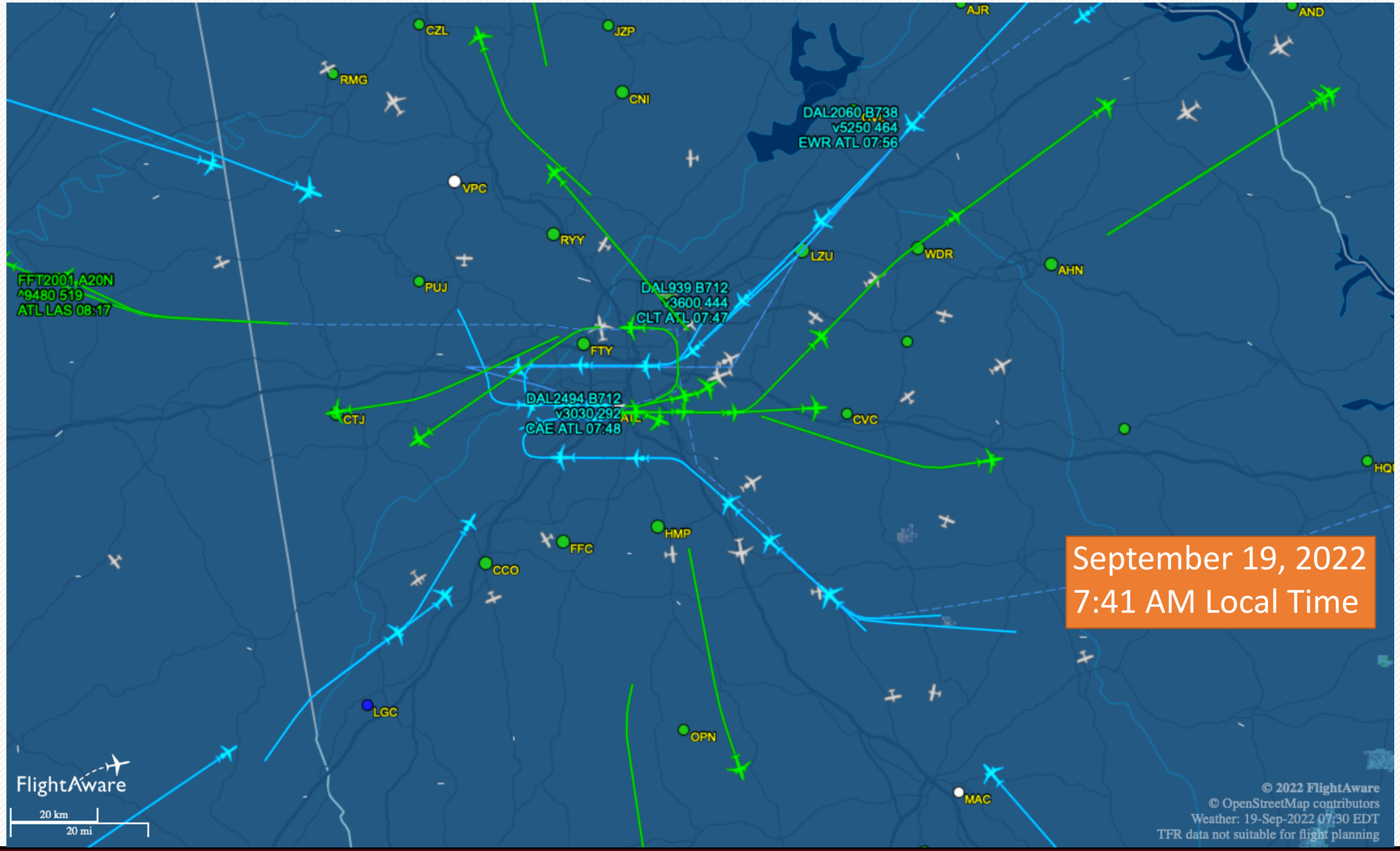
  Aeromexico reduce to 230 (IAS airspeed)

- Minimum separation inside TRACON is either 5 nm (>40 nm from radar antenna) or 3 nm (if < 40 nm from radar antenna) assuming no wake vortex effect is present

# Example of TRACON Organization (Atlanta)

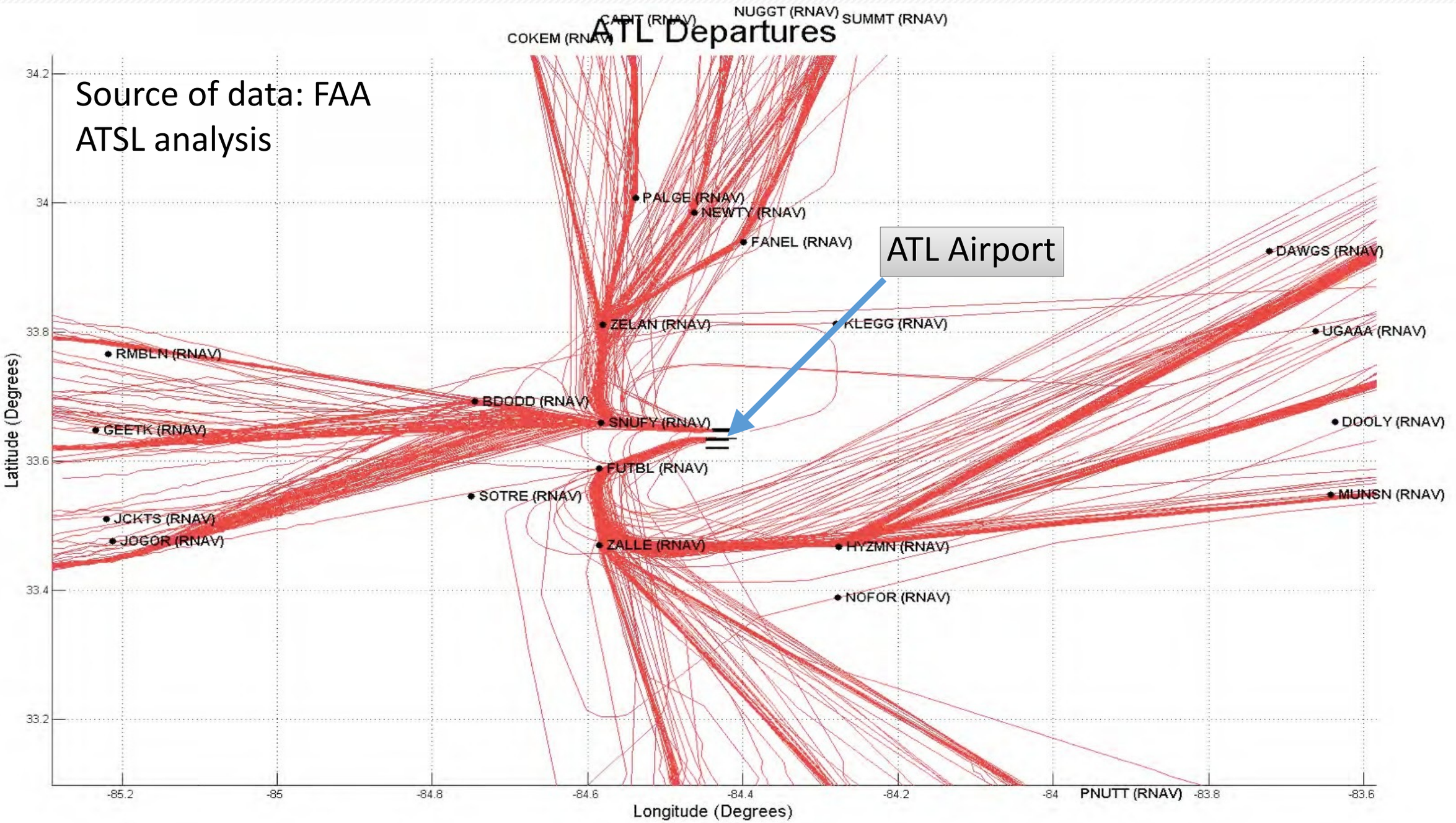


# Terminal Approach and Departure Control Facility (Traffic inside Atlanta TRACON)

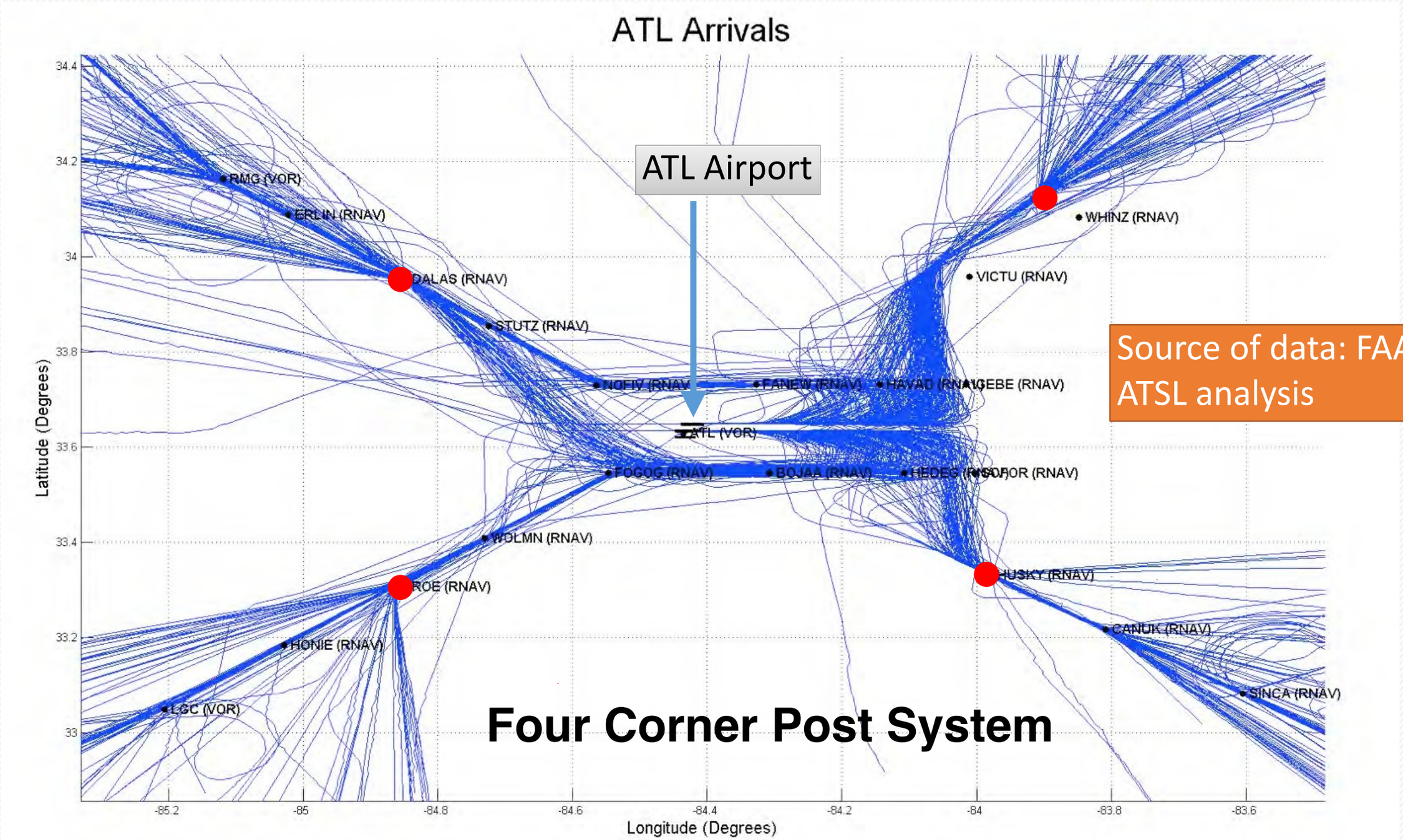


# Terminal Area Operations in Atlanta (Departures)

Source of data: FAA ATSL analysis



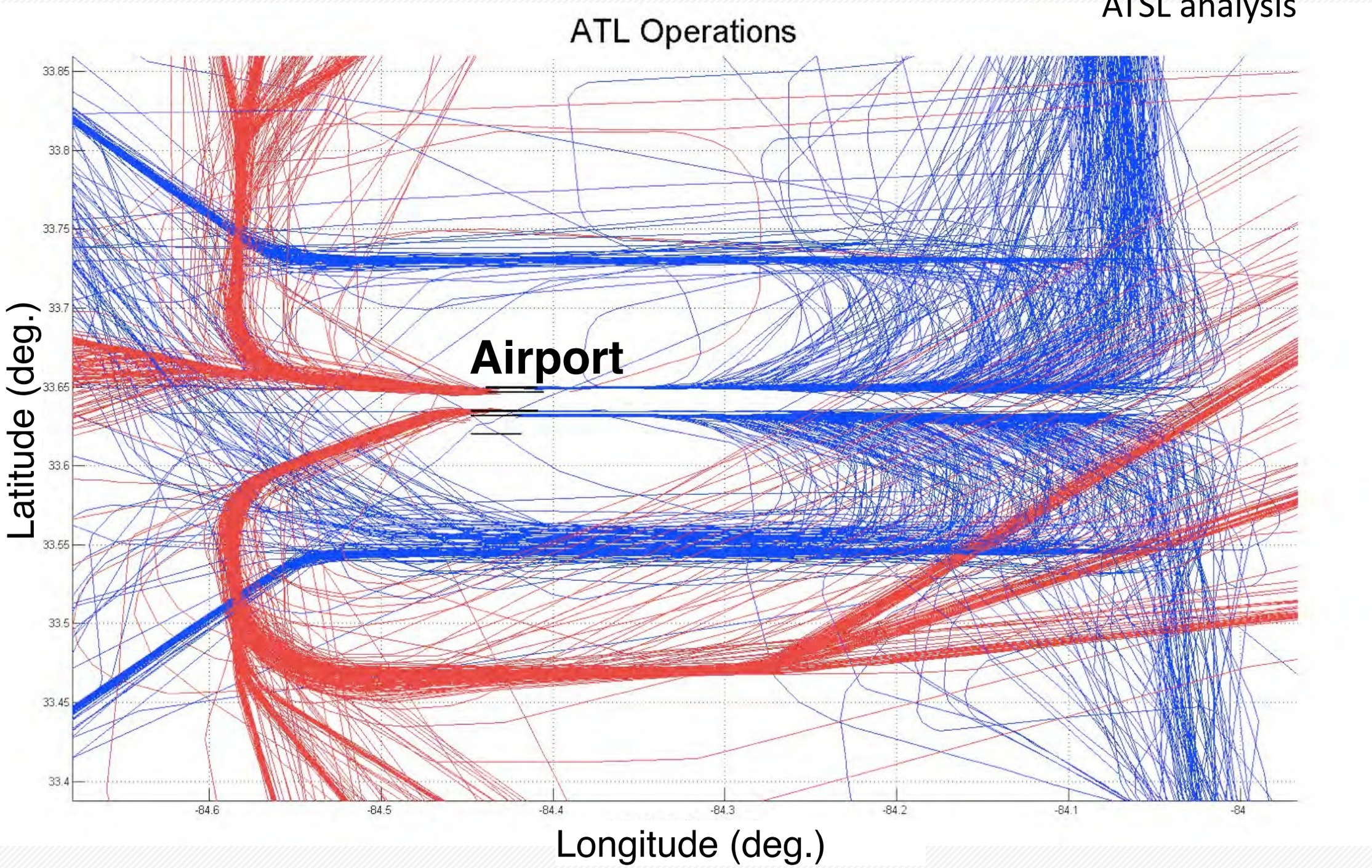
# Terminal Area Operations in Atlanta (Arrivals)



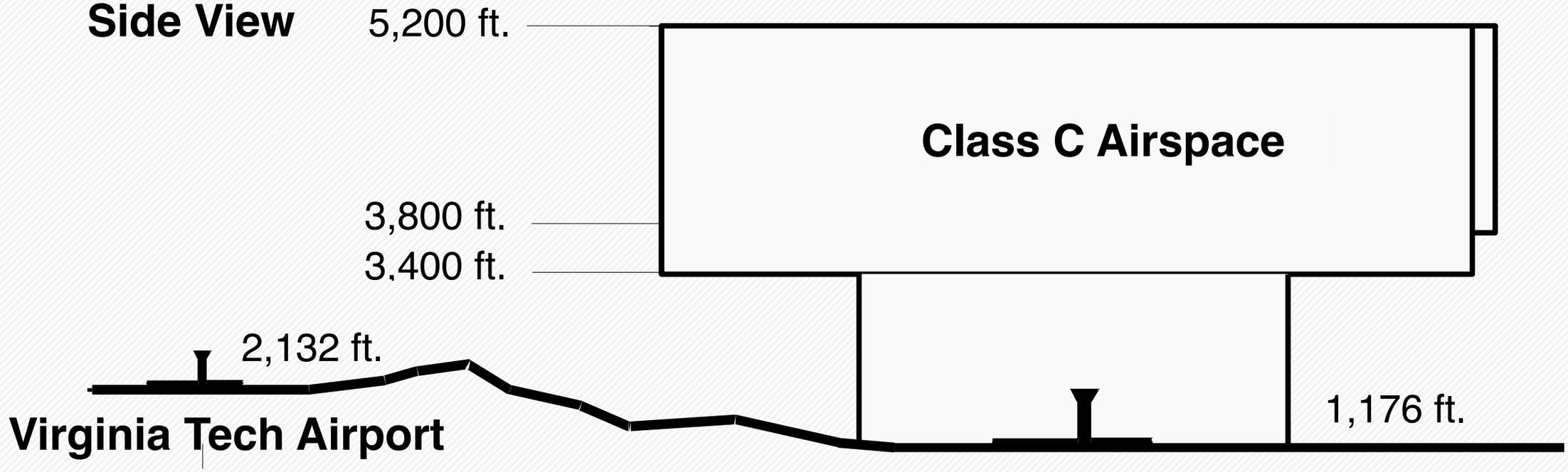
# Atlanta Arrival and Departure Patterns

**Departures** **Arrivals**

Source of data: FAA
ATSL analysis



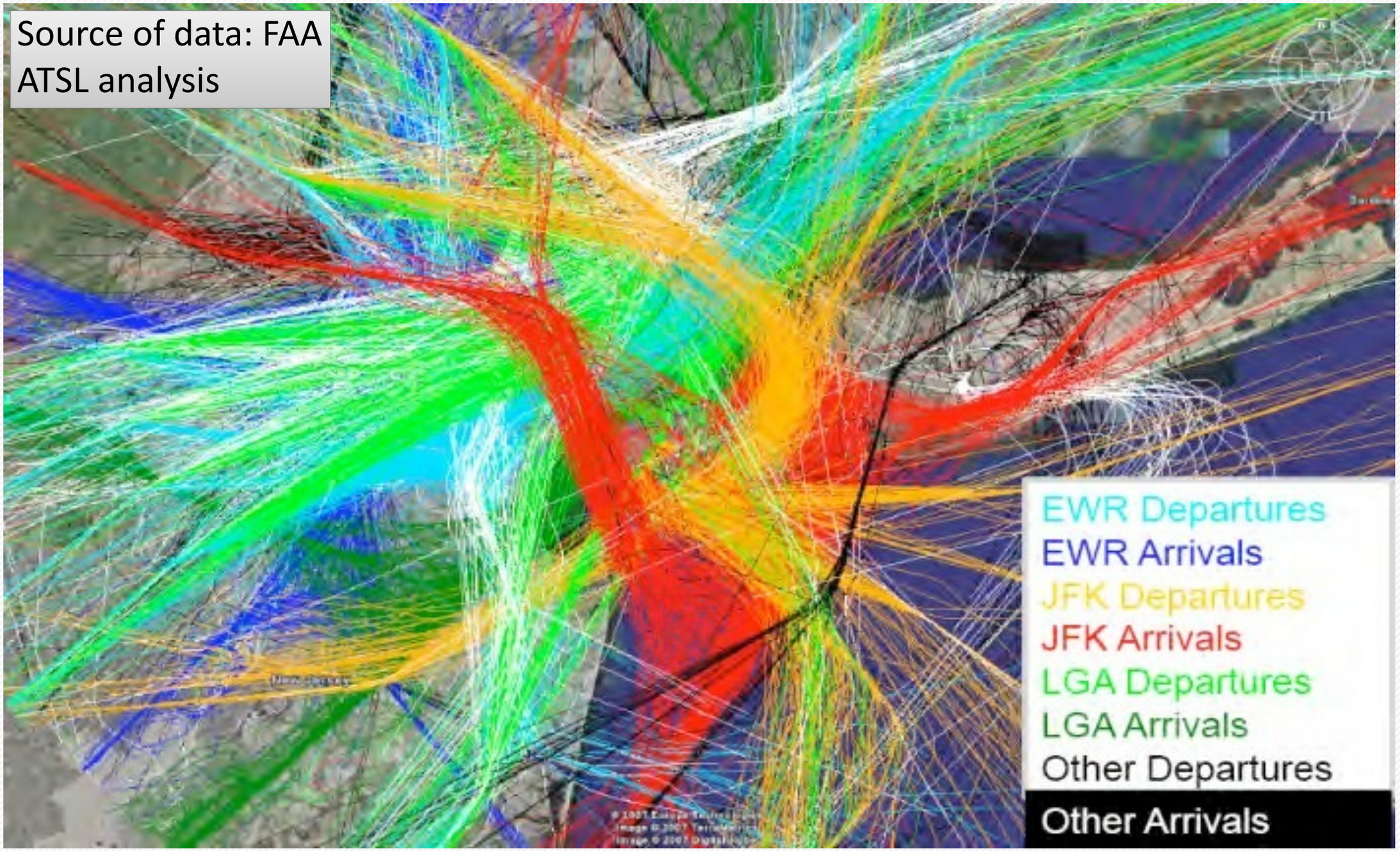
# A Small TRACON - Roanoke, Virginia




Notes:

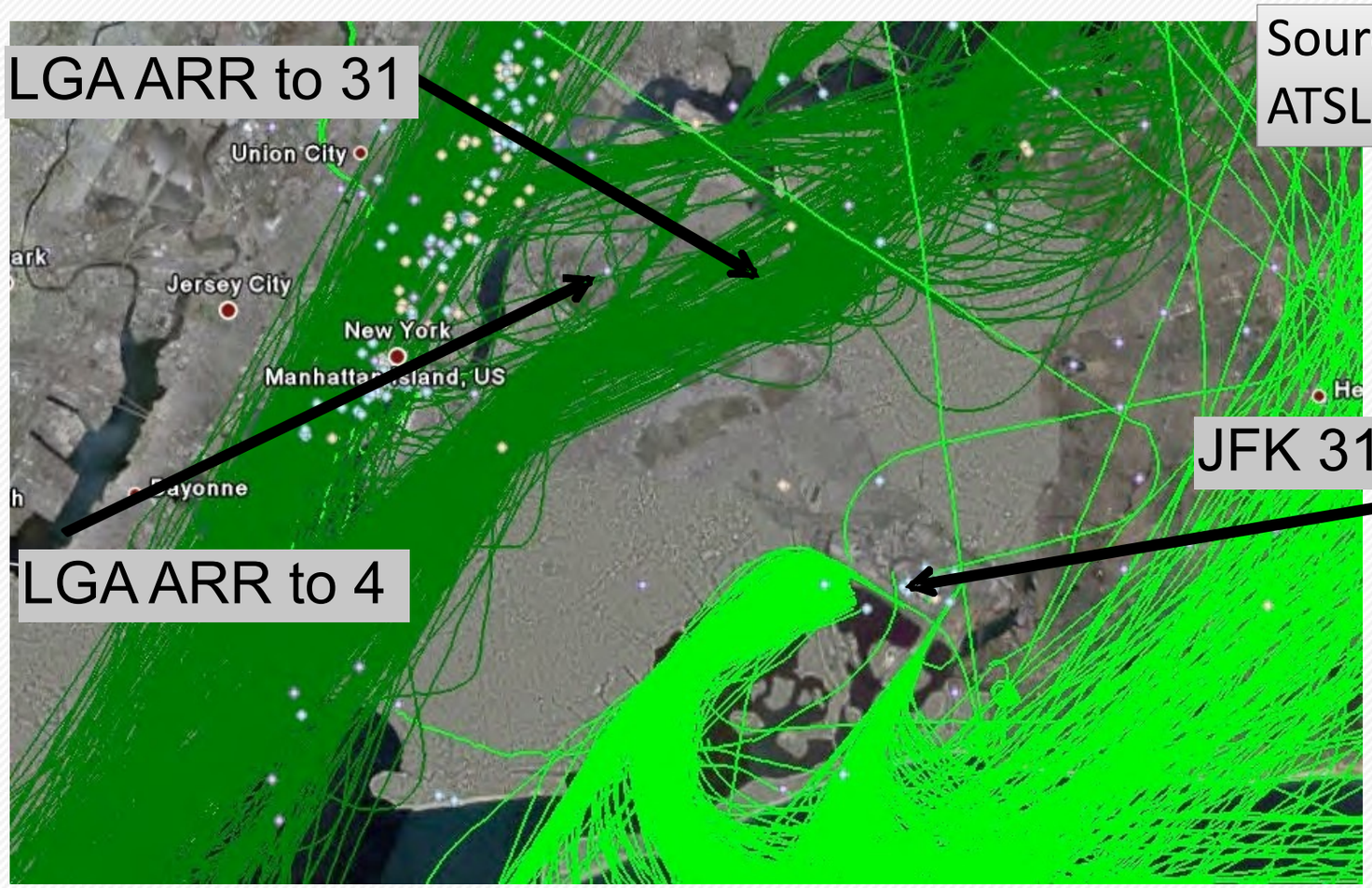
- The volume of airspace controlled by ROA Approach Control looks like an inverted wedding cake
- Typical of many TRACONs in the U.S.
- The complexity of the TRACON increases as traffic increases

# Terminal Area Operations in New York City




One Day of Traffic into five New York Area Airports

# Terminal Operations in New York




- Approaches to La Guardia Airport (LGA) (dark green color lines) are executed in close proximity with departures from JFK Airport (light green color lines)

- Operations at LGA, JFK and EWR require substantial coordination

# Air Traffic Control Tower



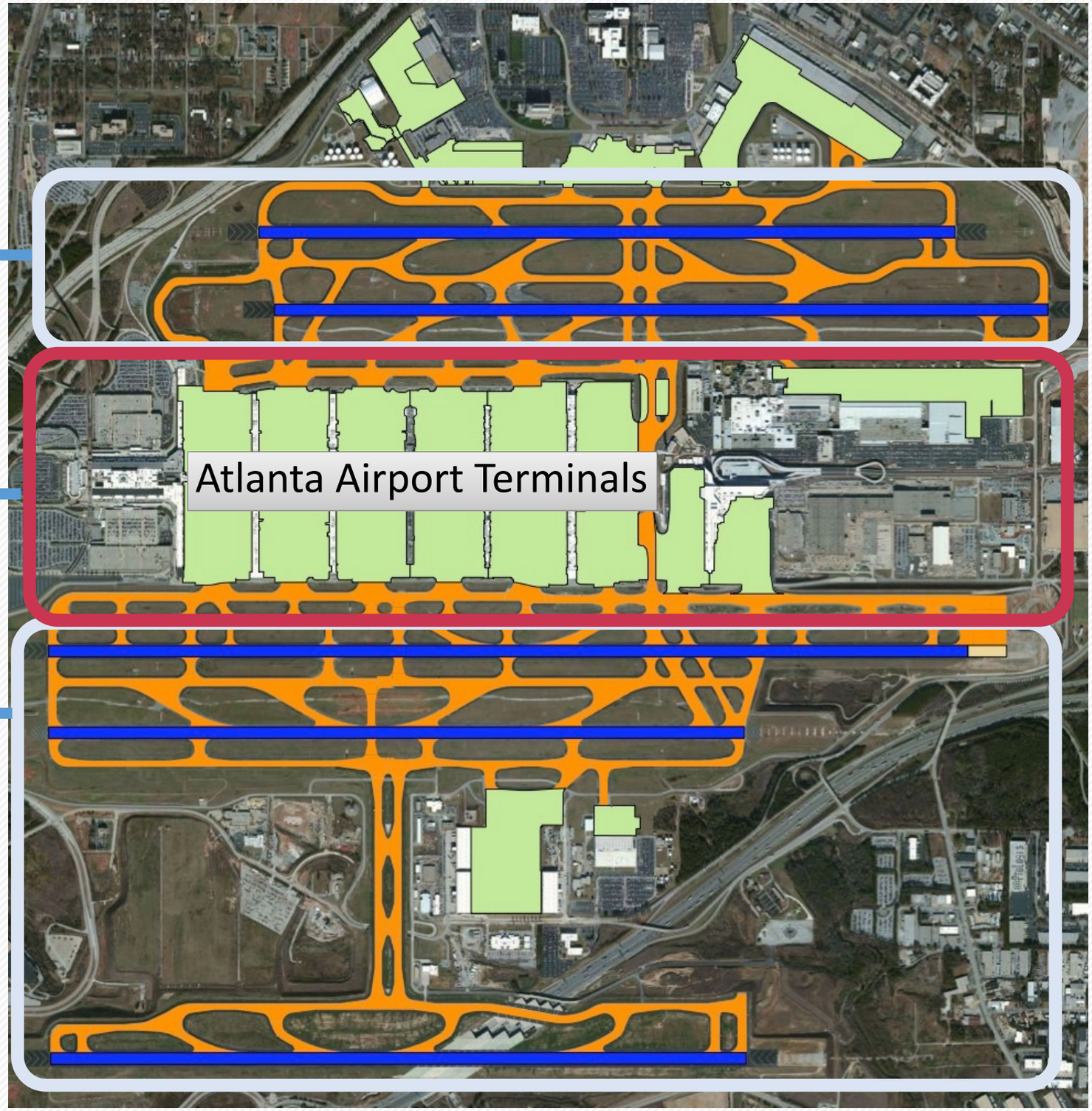

- Controls aircraft traffic (both arrivals and departures) at the airport (includes ramps near gates, taxiways, runways, and airspace up to 5 nm from airport)
- Three ATC controller posts
  - Local controller (runways and landing areas)
  - Ground control (taxiways and aprons)
  - Clearance delivery (provides information on flight plans)
- Some ATCT divide workload into East-West operations
- Use of short and precise language
  - AA52 taxi to RWY 36 via alpha-3
  - UA53 clear for takeoff, wind 040 at 12
  - Aeromexico clear to land RWY 36

# Atlanta International Airport (ATC Tower Responsibilities)

Area under control of
**Local Controller**

Area under control of
**Ground Controller**

Area under control of
**Local Controller**



# Legacy Aircraft Wake Categories Used in Air Traffic Control

- FAA aircraft groups (at maximum takeoff weight)
  - Small (< 41,000 lb)
  - Large (< 255,000 lb)
  - B757 (255,000 to 300,000 lb)
  - Heavy (> 255,000 lb)
  - Superheavy (Airbus A380 and Antonov 225)
- ICAO groups
  - Light (< 7 metric tons)
  - Medium (> 7 tons but < 136 tons)
  - Heavy (> 136 tons)
  - Superheavy (A380 and Antonov 225)

# Issues in Separating Aircraft Near Runways

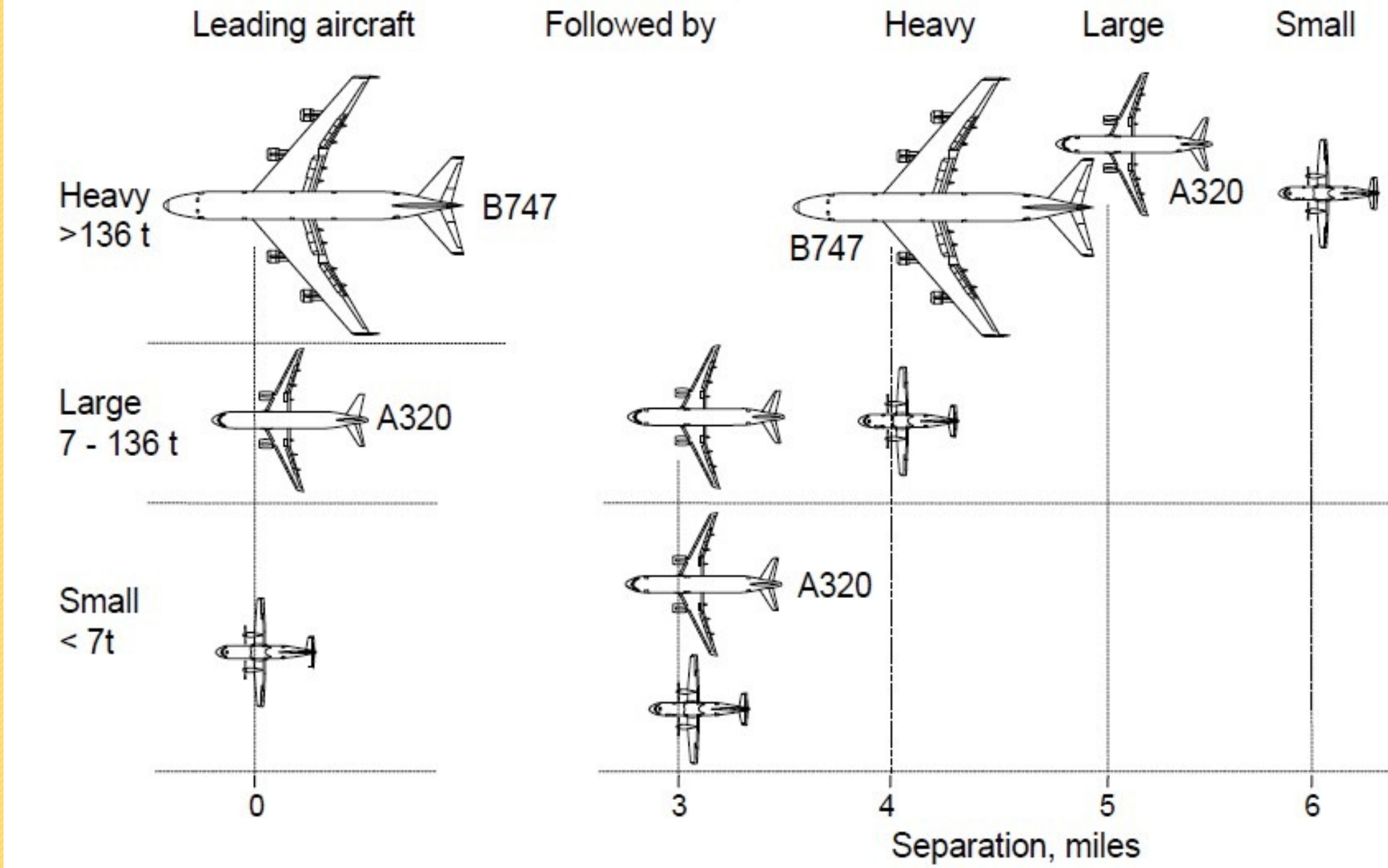
Airspace criteria are intrinsically used for runway separations:

- Minimum radar separations (driven by the ability to differentiate targets in a radar display)
- Wake vortex separations - driven by the hazard created by flying behind the wake of a lead aircraft

Runway occupancy time (ROT)

- Can also be an important factor in separations on final approach
- If ROT is small (i.e., due to high speed runway exits), the airspace separations may need to be increased to avoid simultaneous occupancy of the runway

# Example of In-Trail Wake Airspace Separations IMC Conditions (ICAO)




Source: Lang, Eriksen and Tittsworth, WakeNet 3 Europe, 2010

# Typical Minimum Values of Aircraft Separations in the United States under IMC Conditions (with Radar)

| Minimum Separation Matrix (mn) | Arrivals - Arrivals | | | | |
|---|---|---|---|---|---|
| Trailing Aircraft (Header Columns - in Orange) | | | | | |
| Lead (Column 1) | Small | Large | B757 | Heavy | Superheavy |
| Small | 3 | 3 | 3 | 3 | 3 |
| Large | 4 | 3 | 3 | 3 | 3 |
| B757 | 5 | 4 | 3 | 3 | 3 |
| Heavy | 6 | 5 | 4 | 4 | 4 |
| Superheavy | 8 | 8 | 8 | 8 | 8 |

Highlighted values are minimum radar separations

**Minimum radar separations are 2.5 nm if ROT <= 50 seconds**

# Consolidated Wake Turbulence Recategorization Classification (CWT)

- FAA Introduced a **consolidated wake re-categorization in 2019**
- Consult FAA Order JO 7110.126A

**U.S. DEPARTMENT OF TRANSPORTATION**
FEDERAL AVIATION ADMINISTRATION
Air Traffic Organization Policy

**ORDER JO 7110.126A**

**Effective Date**:
September 28, 2019

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

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

**2. Audience**. This order applies to all Air Traffic Organization (ATO) personnel authorized to use this order and anyone involved in the implementation and monitoring of Consolidated Wake Turbulence separation standards.

**3. Where Can I Find This Order?** This change is available on the FAA Website at http://faa.gov/air_traffic/publications and https://employees.faa.gov/tools_resources/orders_notices/.

**4. What This Order Cancels.** FAA Order JO 7110.126, Consolidated Wake Turbulence Radar

# Consolidated Wake Vortex Recategorization Classification

- *"FAA Order JO 7110.659 (RECAT 1.5) classified aircraft according to certificated takeoff weight, landing speed, wingspan, and the aircraft's ability to withstand a wake encounter."*
- *"FAA Order JO 7110.123 (RECAT Phase II), Appendix A and Appendix B, described a pairwise separation matrix developed for the most common ICAO type identifier aircraft. Each aircraft was addressed as both a leader and a follower in each pair."*
- *"The development of a **pairwise separation matrix** relied on wake-based data, rather than weight-based data."*
- *"Separation reductions were achieved with a better understanding of wake behavior and with pairwise separation of aircraft."*
- *"CWT is based on a nine category system that further refines the grouping of aircraft, provides throughput gains at many of today's constrained airports, and is manageable for all airports throughout the NAS."*

Source: FAA Order JO 7110.126A

# Consolidated Wake Turbulence (CWT) Re-categorization Classification

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

Source: FAA Order JO 7110.126A

# Consolidated Wake Vortex Recategorization Classification

**Aircraft Types Categorized**

| A Super | B Upper Heavy | C Lower Heavy | D Non-Pairwise Heavy | | E B757 | F Upper Large | | G Lower Large | | H Upper Small | I Lower Small |
|---|---|---|---|---|---|---|---|---|---|---|---|
| A388 | A332 | A306 | A124 | DC85 | B752 | A318 | C130 | AT43 | E170 | ASTR | BE10 |
| | A333 | A30B | A339 | DC86 | B753 | A319 | C30J | AT72 | E45X | B190 | BE20 |
| | A343 | A310 | A342 | DC87 | | A320 | CVLT | CL60 | E75L | BE40 | BE58 |
| | A345 | B762 | A3ST | E3CF | | A321 | DC93 | CRJ1 | E75S | B350 | BE99 |
| | A346 | B763 | A400 | E3TF | | B712 | DC95 | CRJ2 | F16 | C560 | C208 |
| | A359 | B764 | A50 | E6 | | B721 | DH8D | CRJ7 | F18H | C56X | C210 |
| | B742 | C17 | AN22 | E767 | | B722 | E190 | CRJ9 | F18S | C680 | C25A |
| | B744 | DC10 | B1 | IL62 | | B732 | GL5T | CRJX | F900 | C750 | C25B |
| | B748 | K35R | B2 | IL76 | | B733 | GLEX | DC91 | FA7X | CL30 | C402 |
| | B772 | MD11 | B52 | IL86 | | B734 | GLF5 | DH8A | GLF2 | E120 | C441 |
| | B773 | | B703 | IL96 | | B735 | GLF6 | DH8B | GLF3 | F2TH | C525 |
| | B77L | | B741 | K35E | | B736 | MD82 | DH8C | GLF4 | FA50 | C550 |
| | B77W | | B743 | KE3 | | B737 | MD83 | E135 | SB20 | GALX | P180 |
| | B788 | | B74D | L101 | | B738 | MD87 | E145 | SF34 | H25B | PAY2 |
| | B789 | | B74R | MYA4 | | B739 | MD88 | | | LJ31 | PA31 |
| | C5 | | B74S | R135 | | | MD90 | | | LJ35 | PC12 |
| | C5M | | B78X | T144 | | | | | | LJ45 | SR22 |
| | | | BLCF | T160 | | | | | | LJ55 | SW3 |
| | | | BSCA | TU95 | | | | | | LJ60 | |
| | | | C135 | VMT | | | | | | SH36 | |
| | | | C141 | | | | | | | SW4 | |

Source: FAA Order JO 7110.126A

# Consolidated Wake Vortex Separations - **Directly Behind**

**WAKE TURBULENCE APPLICATION**

Source: FAA Order JO 7110.126A

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

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

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

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

**Wake Turbulence Separation for Directly Behind**

| | | Follower | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | A | B | C | D | E | F | G | H | I |
| Leader | A | | 4.5 NM | 6 NM | 6 NM | 7 NM | 7 NM | 7 NM | 7 NM | 8 NM |
| | B | | 3 NM | 4 NM | 4 NM | 5 NM | 5 NM | 5 NM | 5 NM | 5 NM |
| | C | | | | | 3.5 NM | 3.5 NM | 3.5 NM | 5 NM | 5 NM |
| | D | | 3 NM | 4 NM | 4 NM | 5 NM | 5 NM | 5 NM | 5 NM | 5 NM |
| | E | | | | | | | | | 4 NM |
| | F | | | | | | | | | |
| | G | | | | | | | | | |
| | H | | | | | | | | | |
| | I | | | | | | | | | |

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

# Consolidated Wake Vortex Separations - **On Approach**

**h.** *ON APPROACH.* In addition to subparagraph g, separate an aircraft on approach behind another aircraft to the same runway by ensuring the separation minima in TBL 5–5–2 will exist at the time the preceding aircraft is over the landing threshold.

***NOTE–***
*Consider parallel runways less than 2,500 feet apart as a single runway because of the possible effects of wake turbulence.*

**Wake Turbulence Separation for On Approach**

| | | Follower | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** |
| **Leader** | **A** | | 4.5 NM | 6 NM | 6 NM | 7 NM | 7 NM | 7 NM | 7 NM | 8 NM |
| | **B** | | 3 NM | 4 NM | 4 NM | 5 NM | 5 NM | 5 NM | 5 NM | 6 NM |
| | **C** | | | | | 3.5 NM | 3.5 NM | 3.5 NM | 5 NM | 6 NM |
| | **D** | | 3 NM | 4 NM | 4 NM | 5 NM | 5 NM | 5 NM | 6 NM | 6 NM |
| | **E** | | | | | | | | | 4 NM |
| | **F** | | | | | | | | | 4 NM |
| | **G** | | | | | | | | | |
| | H | | | | | | | | | |
| | I | | | | | | | | | |

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

Source: FAA Order JO 7110.126A

# Visual Meteorological Conditions (VMC) Separations

- Under visual meteorological conditions, pilots are expected to be responsible for separations
- Data collected at airfields in the United States indicates that VMC separations are 10% below those observed under IMC conditions
- Therefore:
  - Runways have more capacity under VMC conditions for the same fleet mix
  - Higher runway utilization is possible under VMC conditions
  - Runway occupancy times and VMC airspace separations are closer in magnitude

# Air Traffic Control (ATC) Departure-Departure In-Trail Separations

Typical In-trail Separations (in seconds) for Departing Aircraft on the same Runway

| Lead Aircraft | Trailing Aircraft | | | | |
|---|---|---|---|---|---|
| | Superheavy | Heavy | B757 | Large | Small |
| Superheavy | 120 | 120 | 120 | 120 | 120 |
| Heavy | 120 | 120 | 120 | 120 | 120 |
| B757 | 120 | 120 | 120 | 120 | 120 |
| Large | 60 | 60 | 60 | 60 | 60 |
| Small | 60 | 60 | 60 | 60 | 60 |

Separations are in seconds

# Separations in the North Atlantic Today

- 1000 foot separation between Flight levels 290 and 390
- 1 (one) degree of latitude separation between tracks in the Organized Track System
- 1/2 degree core tracks
- 10 minute in-trail separation if aircraft are not equipped with FANS 1/A technology and the aircraft have the same speed
- In-trail reduction possible for two equipped aircraft (5 minutes if flying the same Mach number)
- Track capacity is driven by in-trail separations and fleet mix composition

# North Atlantic Organized Track System

Westbound tracks

Source: flightradar24.com

# North Atlantic Organized Track System




Note: Aircraft are spaced 1,000 ft vertically flying in the same direction in the North Atlantic Organized Track System

# FANS 1/A Technology

- FANS = Future Air Navigation System
- Technology in the flight deck that allows pilots and ATC controllers to communicate over datalink channels
- Datalink communications:
  - ATC control clearances
  - Pilot requests (i.e., climb requests, weather detours)
  - Position reports (automatic or pilot initiated)

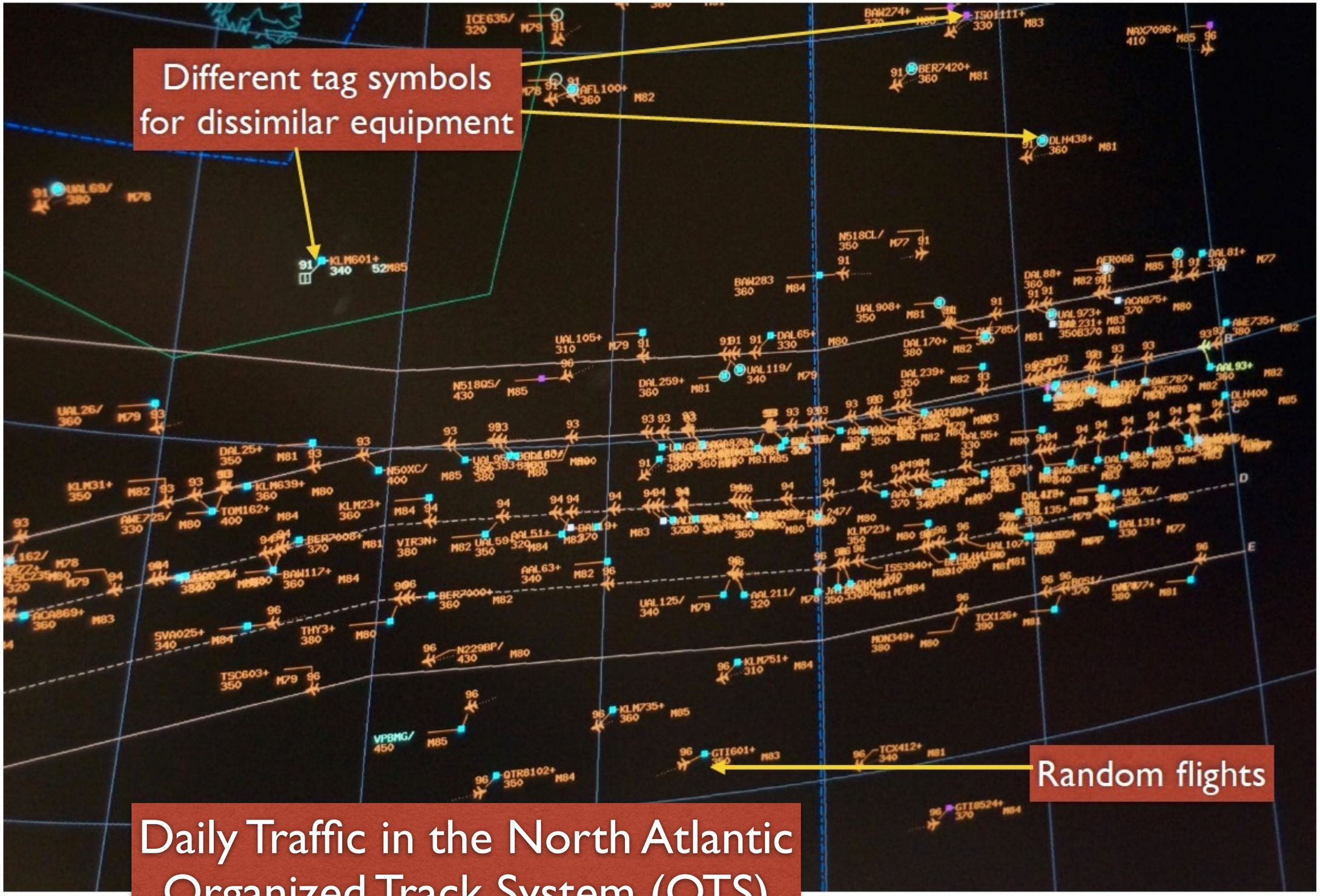
Check videos on the internet by Eurocontrol and Duncan Aviation:

https://www.youtube.com/watch?v=EK87g6Nlcyk

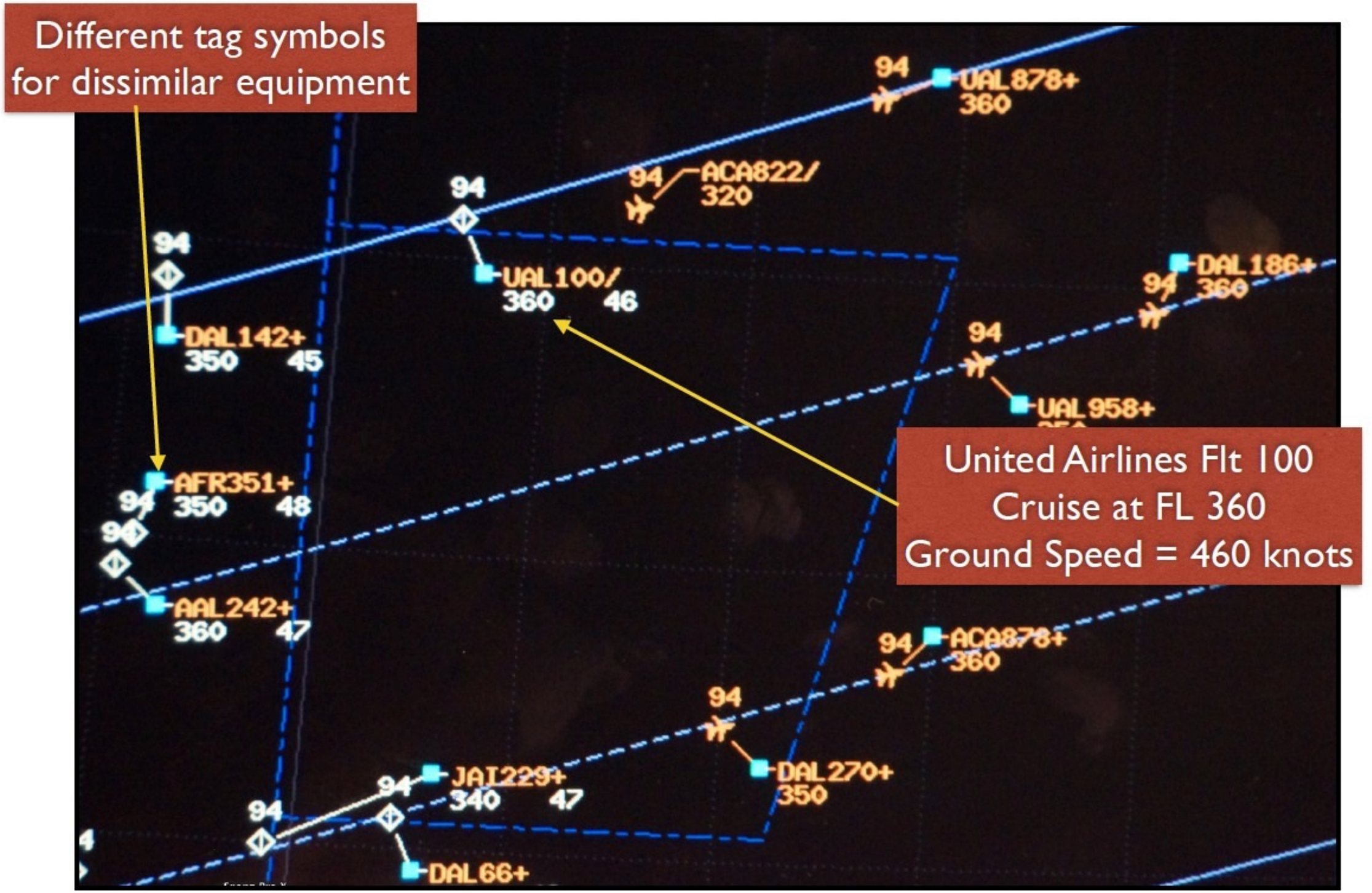
https://www.youtube.com/watch?v=KTqe5nQeWV0

43a

# Separations in the North Atlantic Today



# Symbology to Help ATC Personnel



# OTS System Improvements

- Allowing climbs inside the tracks at busy times
- Reduce in-trail separations (RlonSM) below 5 minutes (requires better information on aircraft position)
- Reduce distance between adjacent tracks (RlatSM) from 1 to 1/2 degree for all tracks

Phase 1 – 2015 – introduce 25 NM lateral separation by implementing ½ degree spacing between the two core tracks within the vertical limits applicable to the airspace associated with the NAT Region Data Link Mandate (NAT SPG Conclusion 46/2 refers); only aircraft with the appropriate RNP approval, ADS-C and CPDLC would be permitted to operate on the ½ degree spaced tracks.

Phase 2 – To Be Determined – introduce 25 NM lateral separation by implementing ½ degree spacing through the entire NAT Organised Track System (OTS), within the vertical limits applicable to the airspace associated with the NAT Region Data Link Mandate; only aircraft with the appropriate RNP approval, ADS-C and CPDLC would be permitted to operate on the ½ degree spaced tracks.

43c

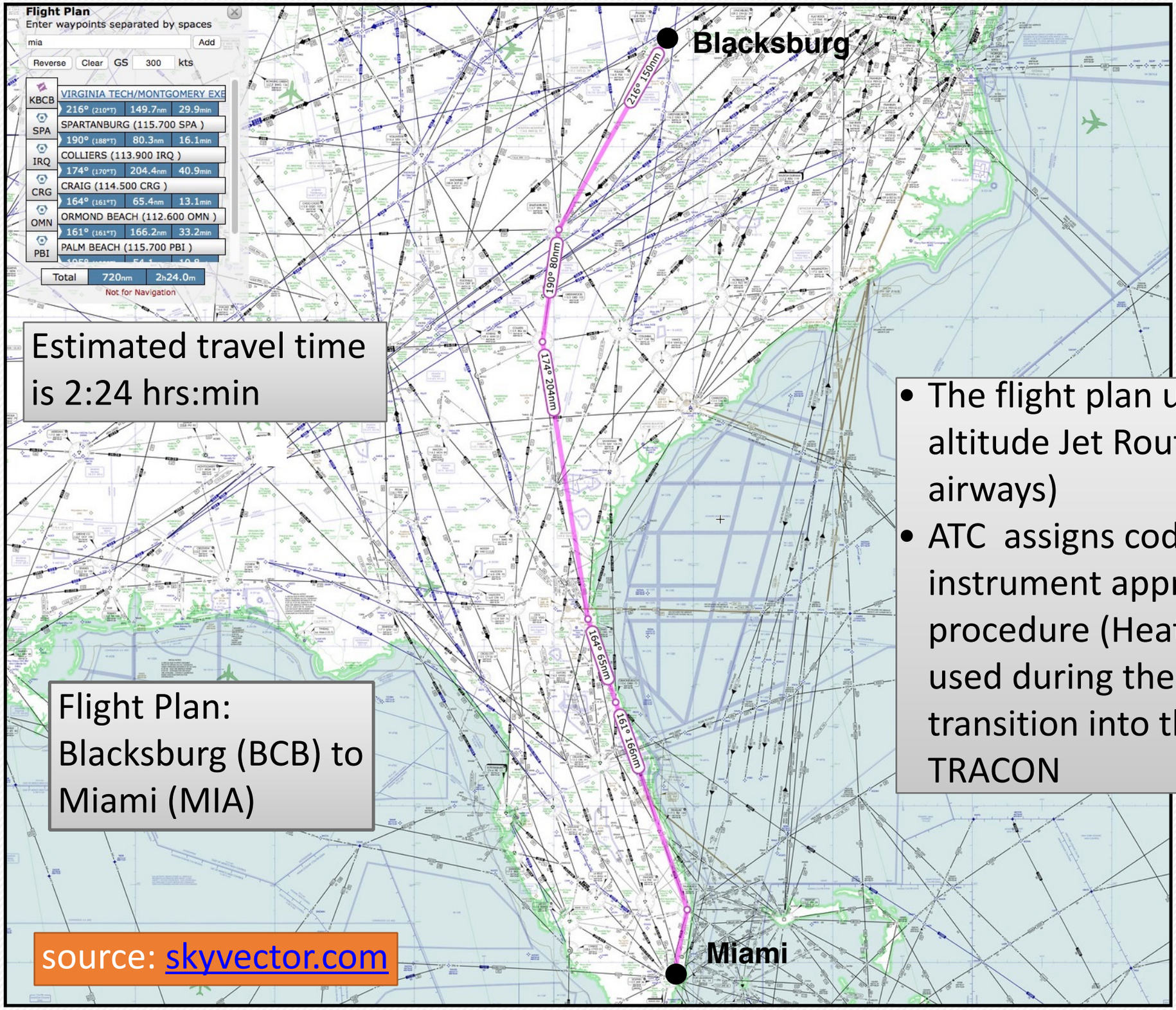
# A Hypothetical Flight

- Suppose we fly a Cessna Citation II from Virginia Tech Airport (BCB) to Miami International airport (MIA)
- The flight takes us across four ARTCC Centers in the U.S. (Washington, Atlanta, Jacksonville, and Miami)
- The aircraft is under continuos control of ATC services even if the day is clear (CAVU conditions)





# A Hypothetical Flight: The Flight Pan

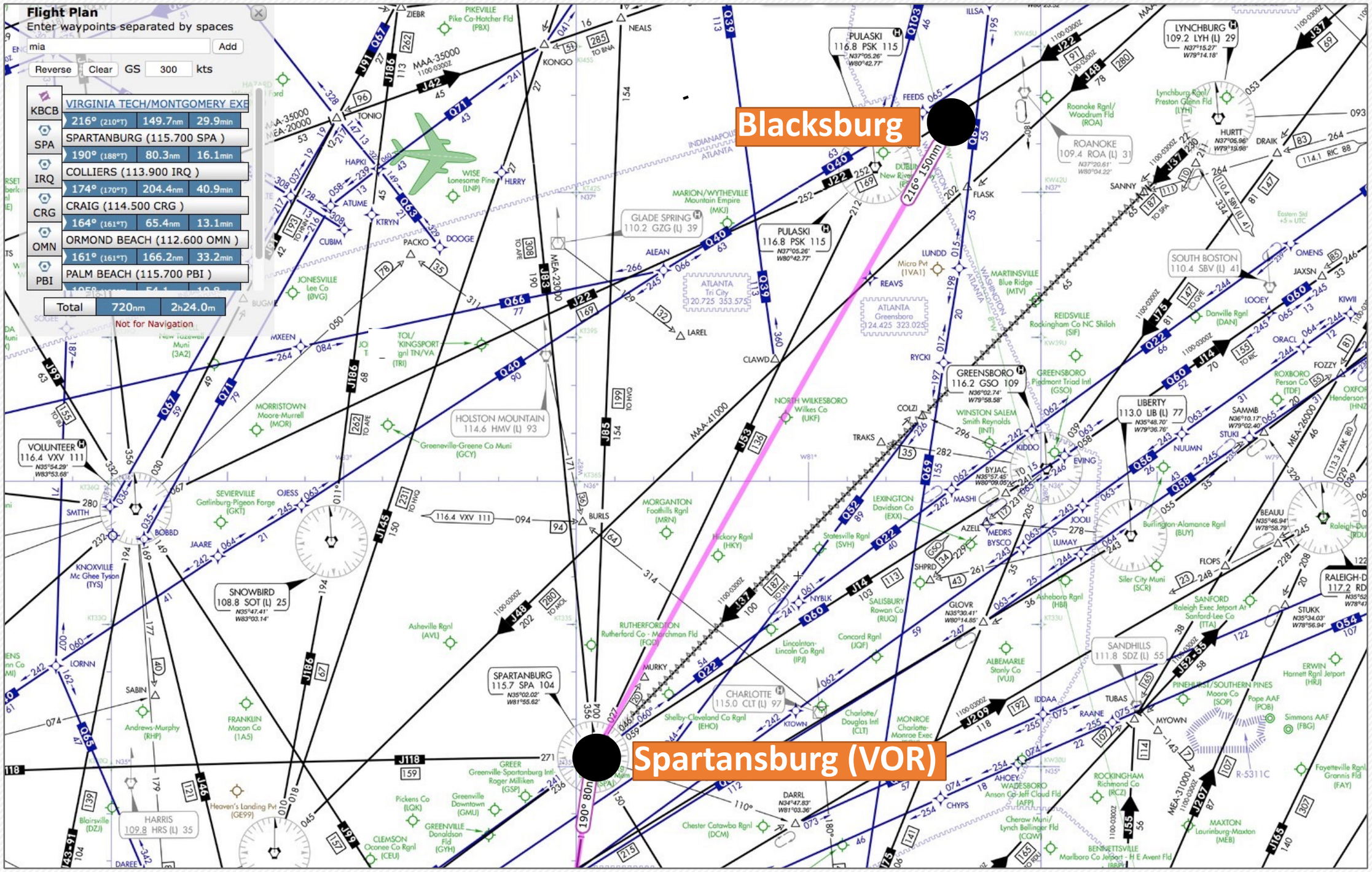



- The flight plan uses high-altitude Jet Routes (Jet airways)
- ATC assigns codified instrument approach procedure (Heath II) is used during the transition into the Miami TRACON

# Activities of the Flight

- Pilots arrive to Virginia Tech Airport (BCB) an hour before the flight (to review weather and submit a flight plan)
- Few minutes before departure they contact Roanoke ATC for flight plan approval
- BCB has no control tower (but a UNICOM frequency is used to establish intent - blind verbal statements)
- Out of BCB pilots contact Roanoke TRACON for climb instructions (to intercept J-48 a Jet Route)
- At FL 100 (10,000 ft.) the pilots contact Washington Center - ZDC (briefly)
- A few minutes later ZDC hands-off the flight to ZTL (Atlanta ARTCC)

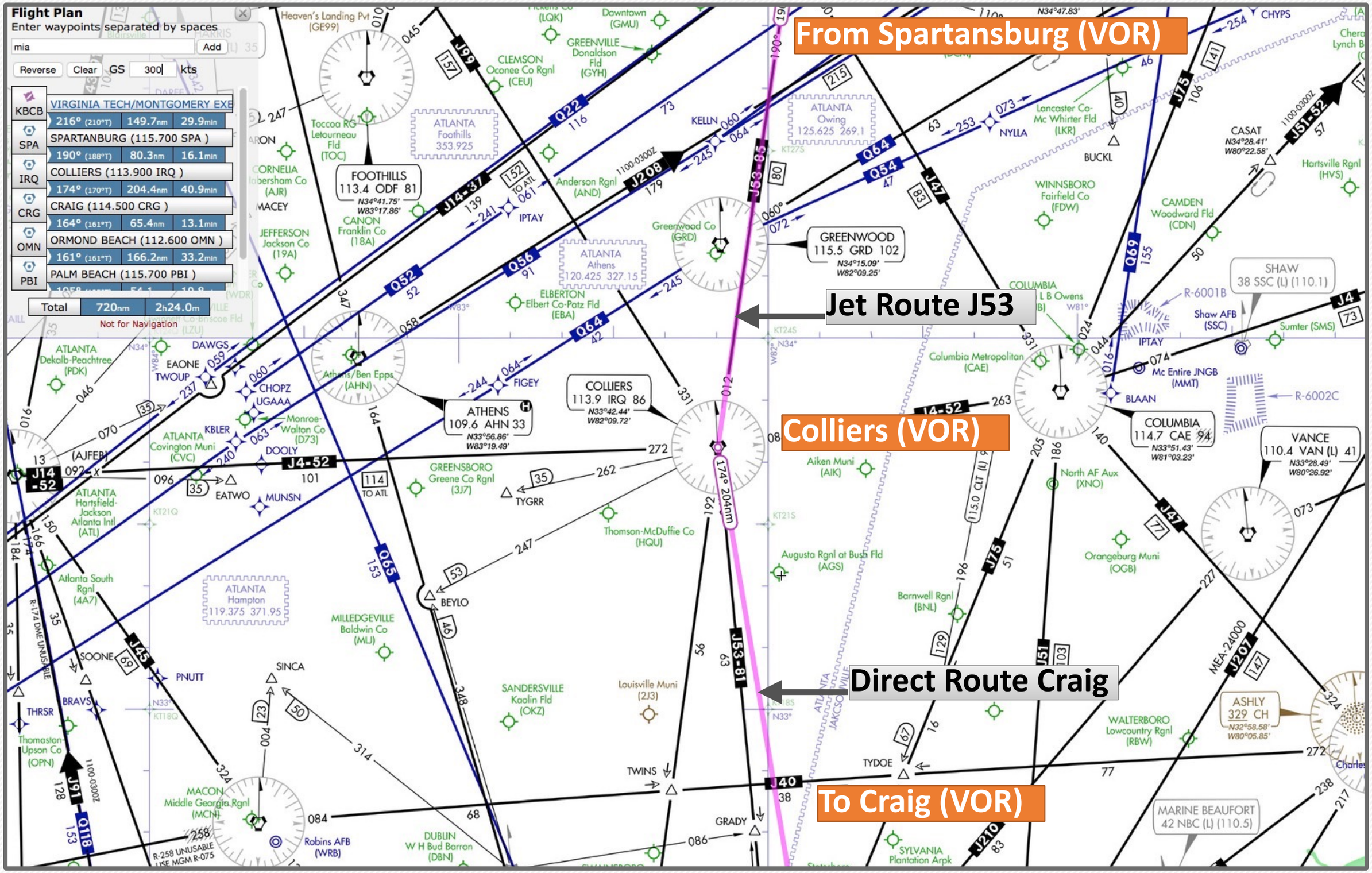
# Details of the Flight Plan



# Flight Activities

- ZTL controllers (4 sectors total for this trip) direct this flight to switch to J-53 to Spartanburg VOR (a NAVAID facility)
- The aircraft reaches its enroute cruising altitude of FL 350 (heading is around 187 degrees - South)
- The flight then moves over to J-81 West of Augusta, GA
- 100 nm North of Jacksonville ZTL controllers hand-off the flight to ZJX controllers (Jacksonville Center)
- The flight takes J-45 and passes a few miles West of Daytona Beach (flies over Daytona Beach VOR called DAB)
- The flight is handed-off to ZMA (Miami ARTCC Center)
- ZMA controllers start descending the flight 100 nm from MIA VOR near Vero Beach VOR

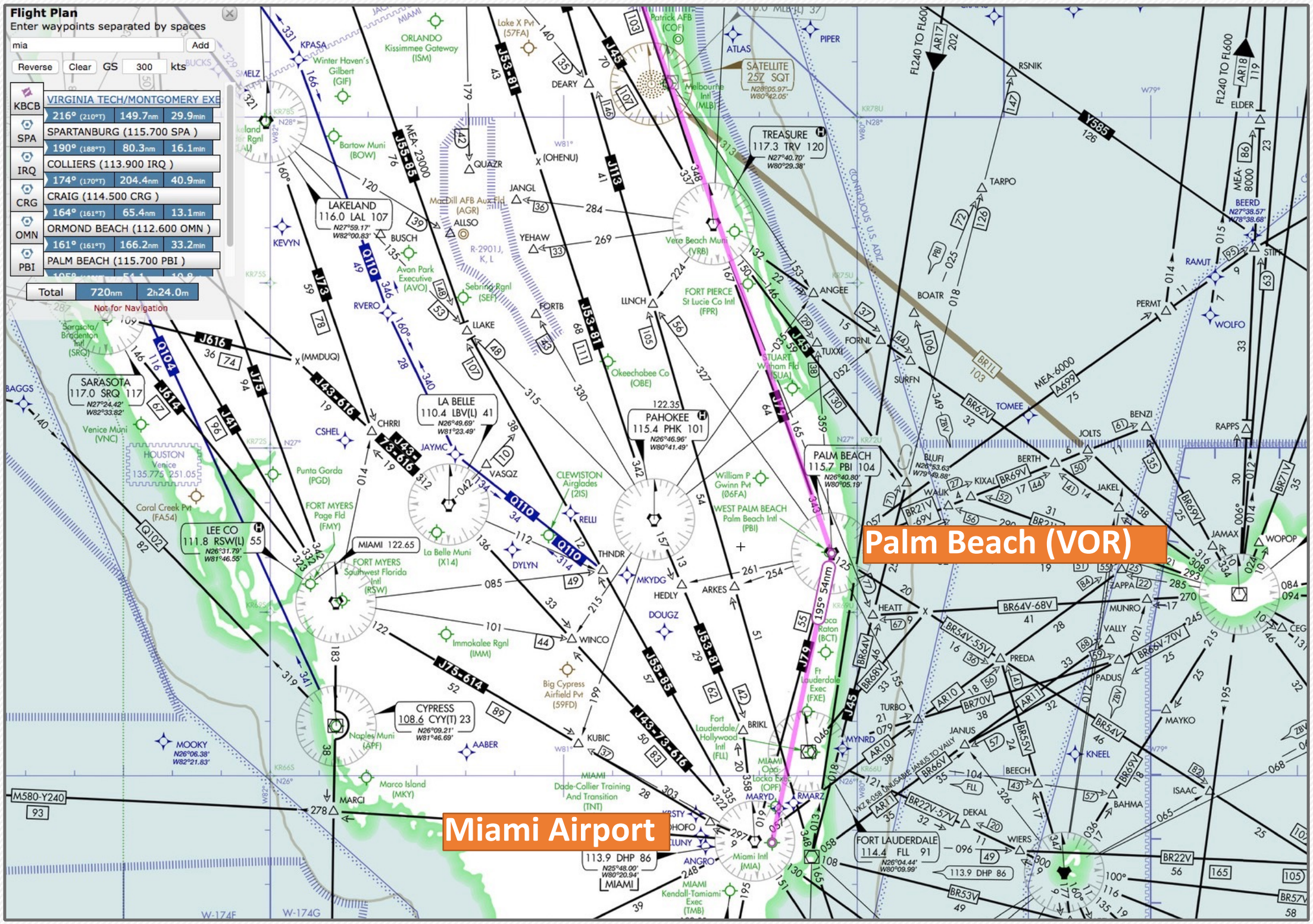
# Details of the Flight Plan



# Flight Activities

- The flight is handed over to MIA TRACON 60 nm from the airport East of the West Palm Beach VOR
- The flight progresses inside the MIA terminal area flying a codified Standard Terminal Arrival Route (STAR)
- The flight is continuously given vectors inside the 50 nm radius from MIA
- The TRACON controller sequences our flight behind a heavy (Boeing 757 of American Airlines) and establishes 6 nm of separation
- 5 nm from MIA airport the flight is handed-off to MIA tower
- The flight lands on RWY 27 R per local controller instructions
- The flight taxis to the ramp following instructions of a ground controller

# Details of the Flight Plan



# Aircraft Instrumentation and Navigation

- Modern transport aircraft have plenty of instrumentation to navigate across the U.S. and over the oceans
- Over the oceans, there is no radar hence aircraft horizontal seperations vary from 80-30 nm



# Separations in the National Airspace System (FAA)

Much smaller than over NATS (5 nm for distance > 40 nm from radar)

Positive control (radar control for all IFR flights)

2000 ft. above 41,000 ft. (flight level 410)

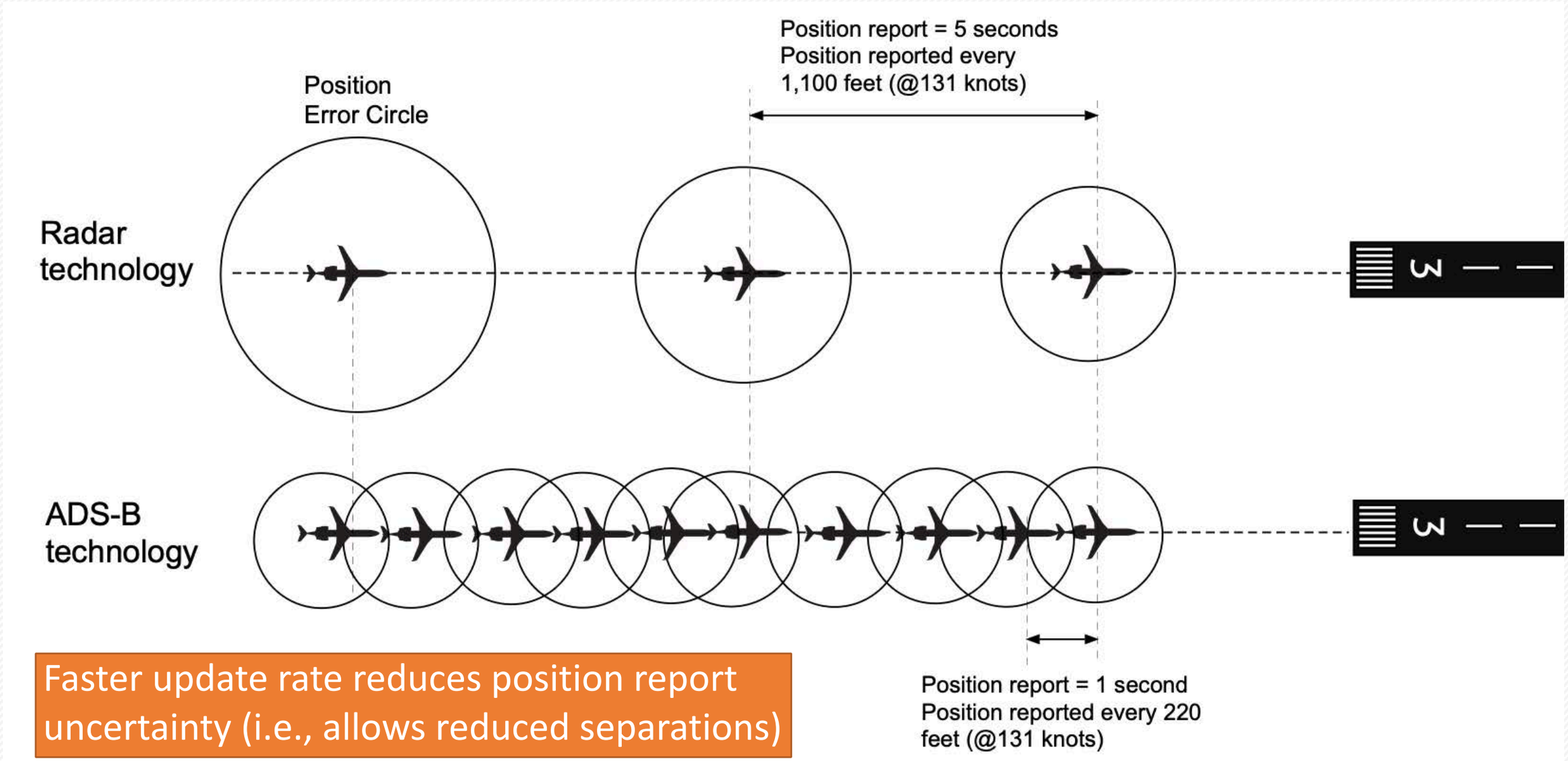
1000 ft. below FL 410

Above FL 290 RVSM requires aircraft equipment certification

# Airport Surveillance Technology Affects Runway Separation

Various systems have been developed to track aircraft:

- Radar, ADS-B, Multilateration, ASDE-X




Faster update rate reduces position report uncertainty (i.e., allows reduced separations)

# **Old Standard**: Independent Precision Approaches (ILS type) in IMC Conditions

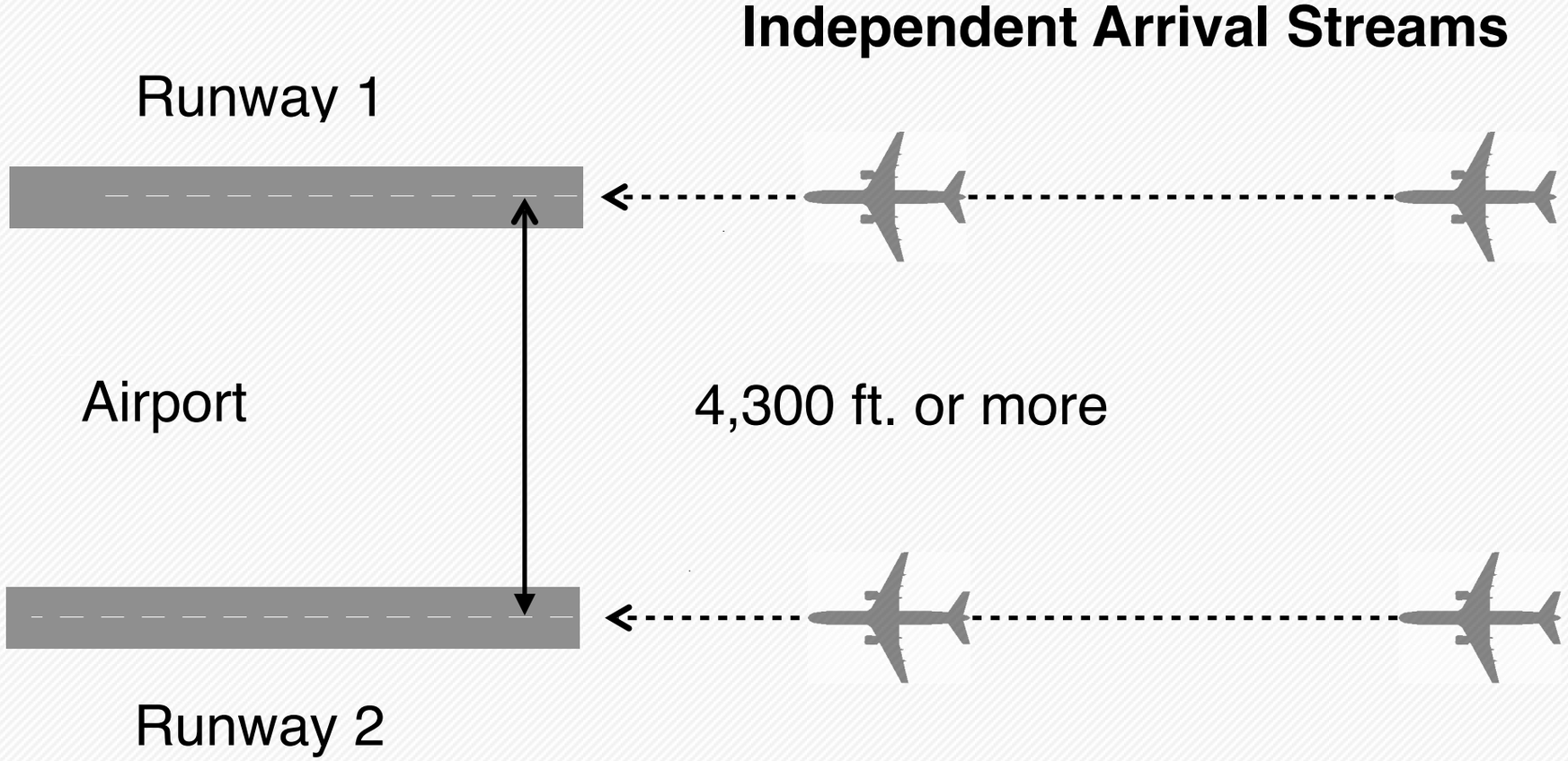
In 2013 FAA amended the rule so that independent close parallel approaches can be conducted down to 3,200 feet without fast scan radar

IFR operational conditions

4,300 ft. between runway centerlines

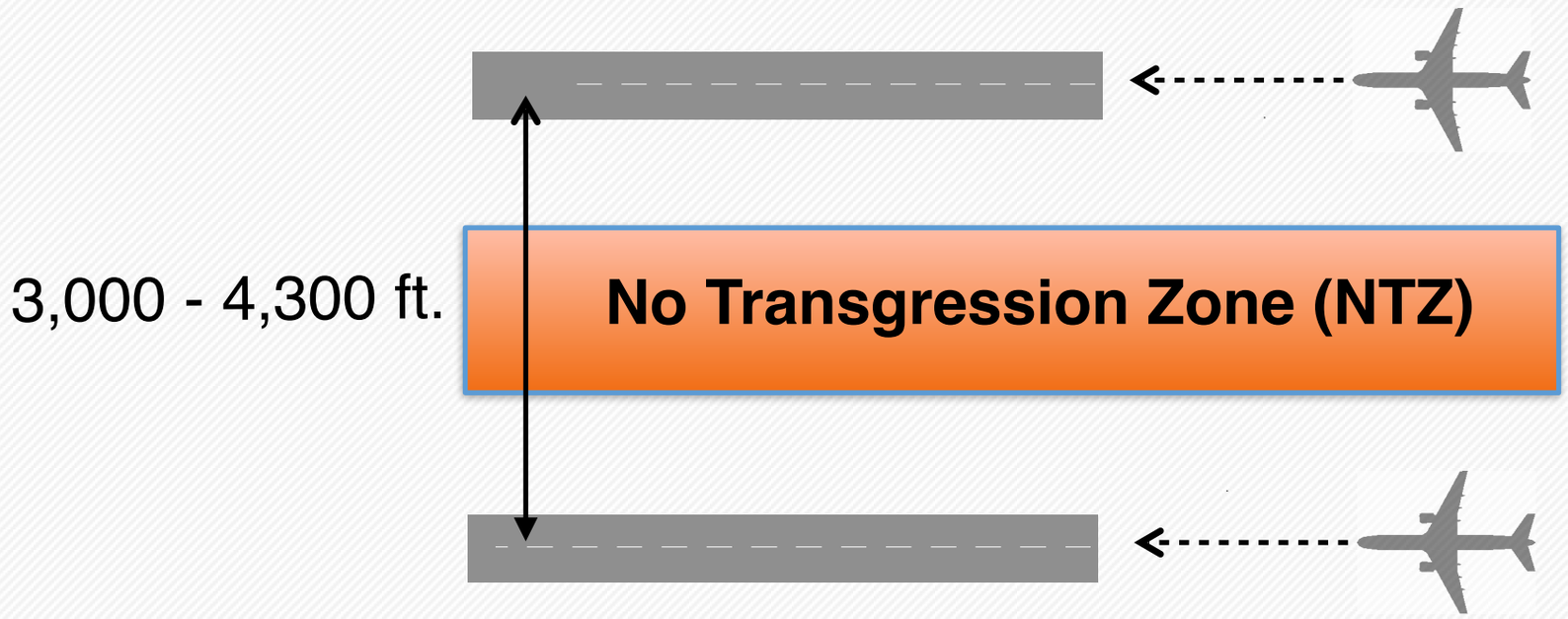
Standard radar system (scan rate of 4 seconds or better)

Radar surveillance is available



# Independent Parallel Approaches using the Precision Runway Monitor (PRM) under IMC Conditions

- The purpose of this standard is to use the Precision Runway Monitor (PRM) to allow independent ILS approaches to parallel runways separated down to 3,000 feet (FAA, 1998)
- This standard currently applies with PRM (fast-scan technology)
- Radar scan rate of 1 second or less



# New Parallel Runway Separation Standards (Section 3.9 in FAAAC 150/5300-13B)

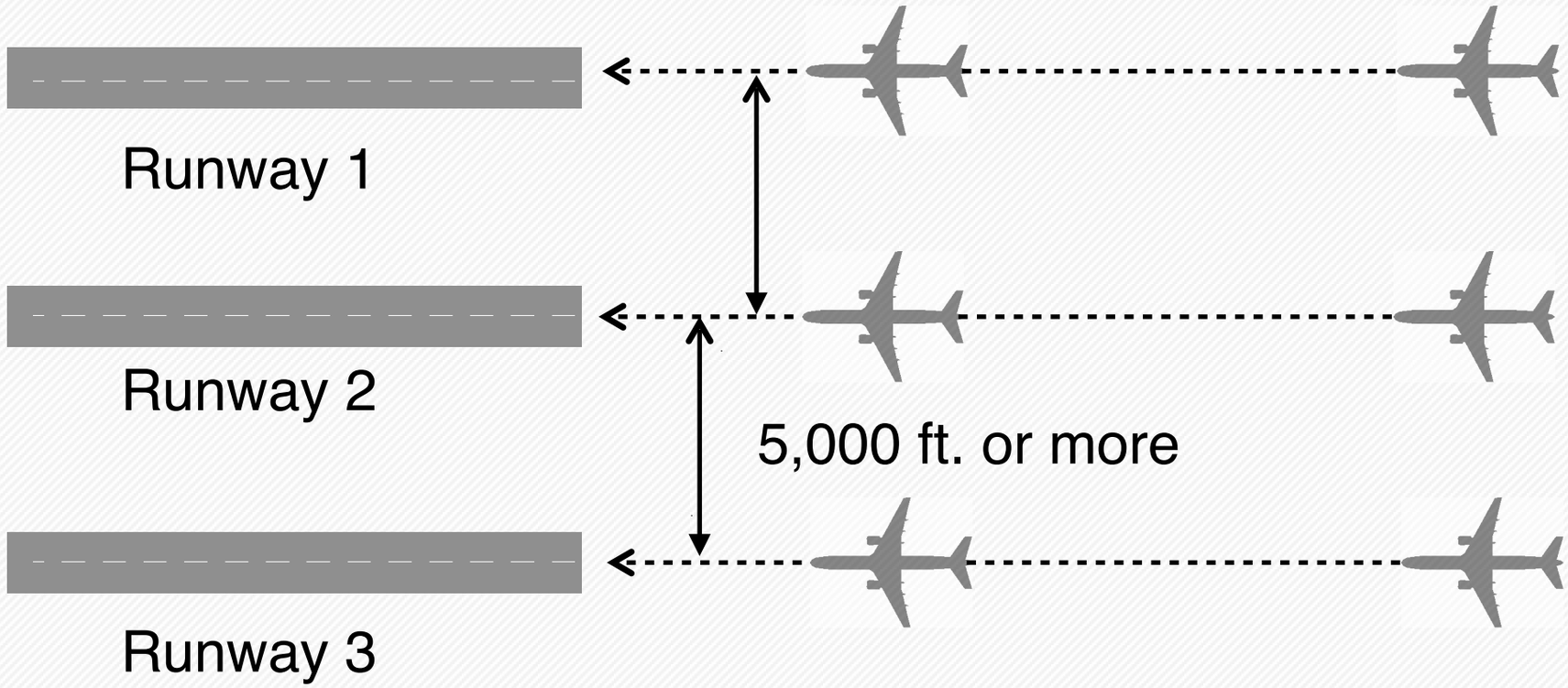
- Dual simultaneous instrument approaches with **high-update surveillance** (ADS-B or PRM)
  - *"For straight-in approaches, the minimum parallel runway centerline separation between adjacent runways is **3,200 feet (975 m)**"*

- *"**Separation of 2,500 feet (762 m)** between adjacent parallel runways is allowable with an offset approach to one runway end"*

# **Old Standard:** Independent Triple and Quadruple Approaches To Parallel Runways (IFR)

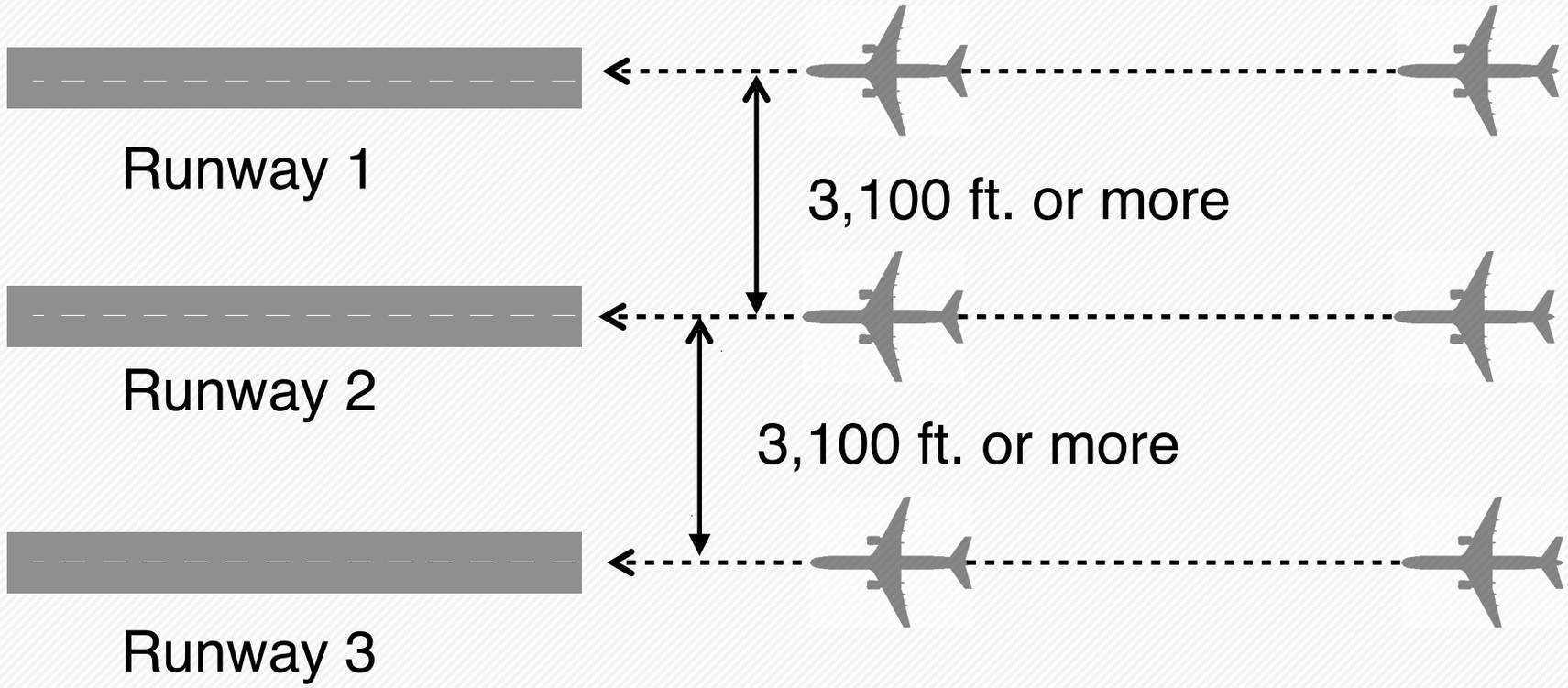
- Allows triple and quadruple parallel approaches to runways separated by 5,000 feet (or more) using standard radar systems (scan update rate of 4.8 seconds) at airports having field elevations of less than 1,000 feet.

- Increase to 5,300 ft. spacing between runways for elevations above 5,000 ft.



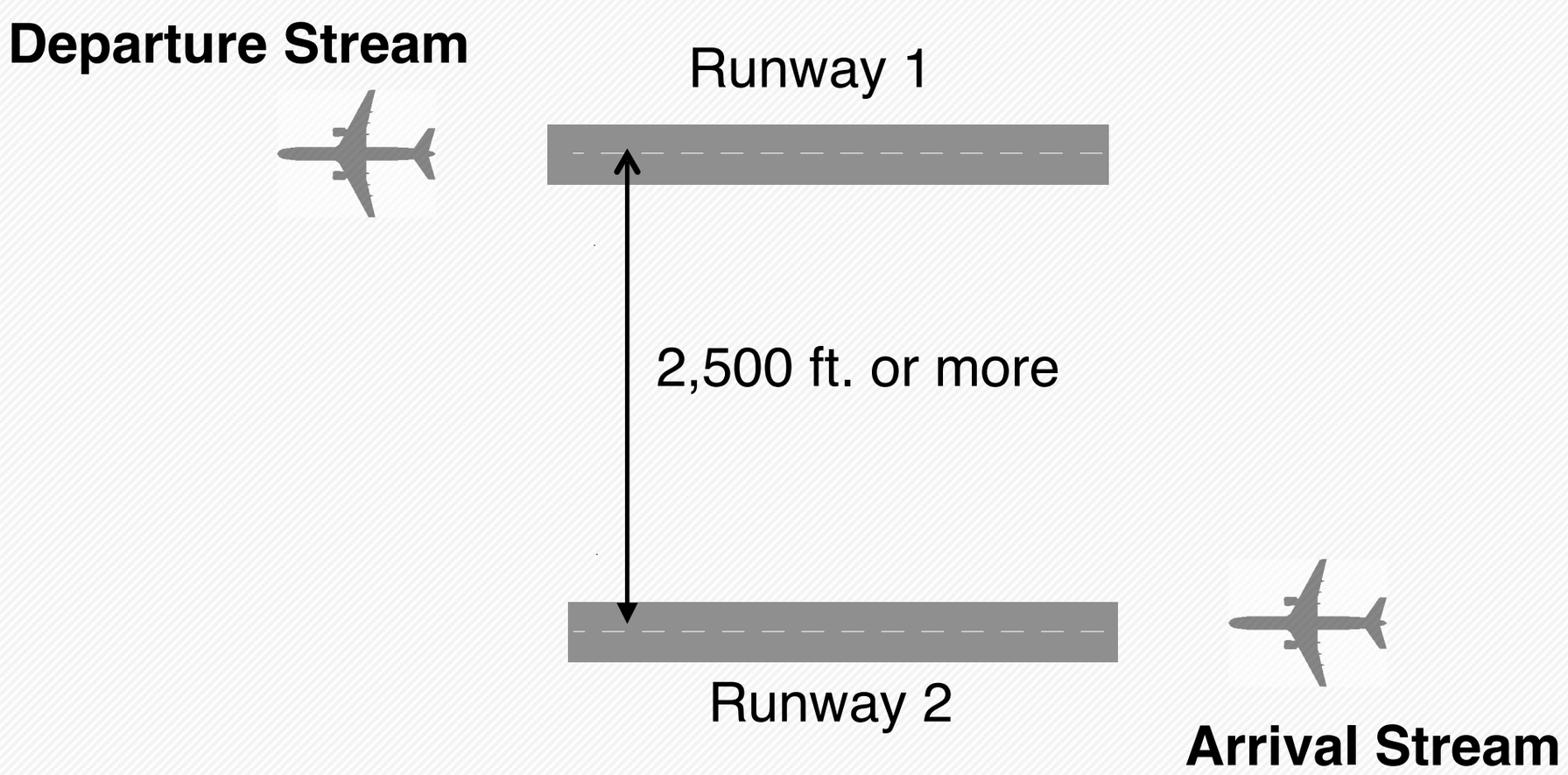
# **New Standard:** Independent Triple and Quadruple Approaches To Parallel Runways (IMC)

- *"For triple simultaneous instrument approaches for airports with high update rate surveillance, when using straight-in approaches, the minimum parallel runway centerline separation is 3,100 feet (945 m) between adjacent runways"*



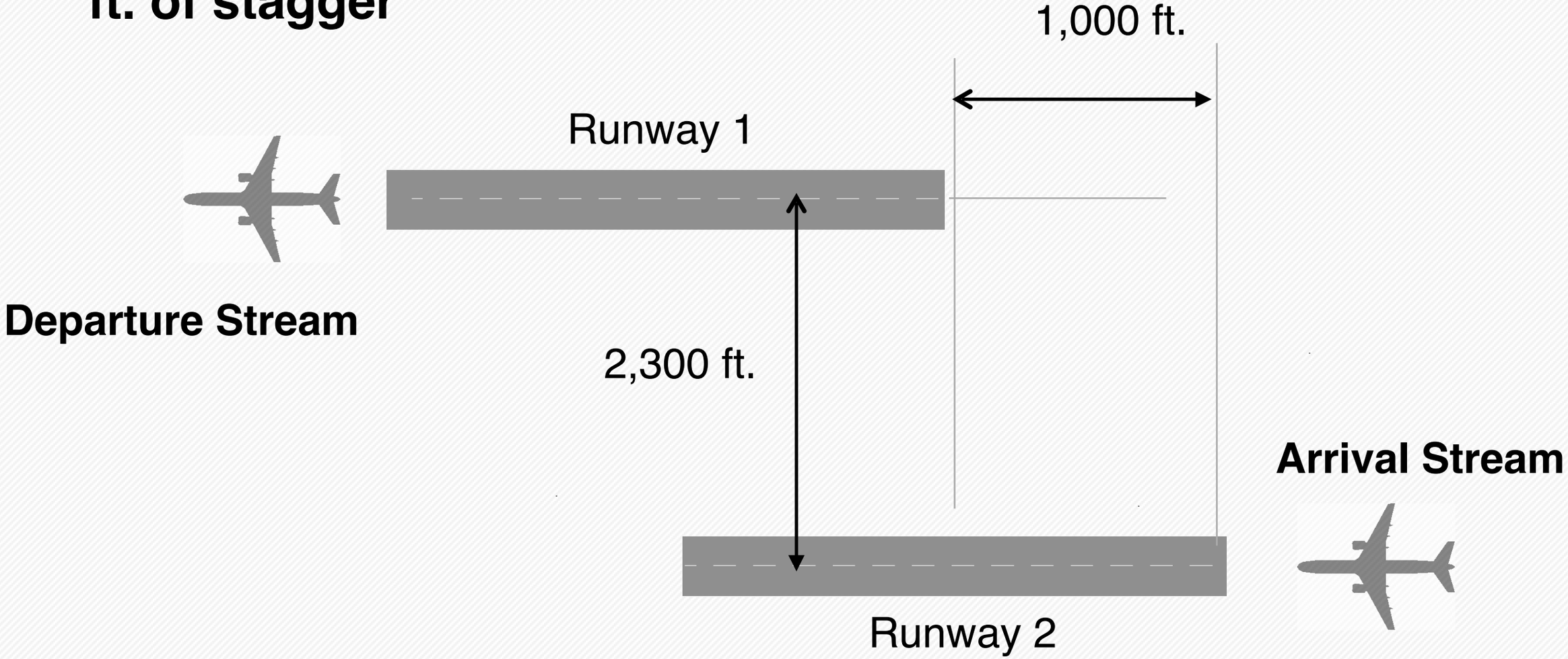
# Independent Departures and Arrivals in IMC Conditions and Standard Radar (Radar Scan Rate = 4.8 s.)

**Simultaneous departures and arrivals** can be conducted if two parallel runways are located 2,500 ft. or more



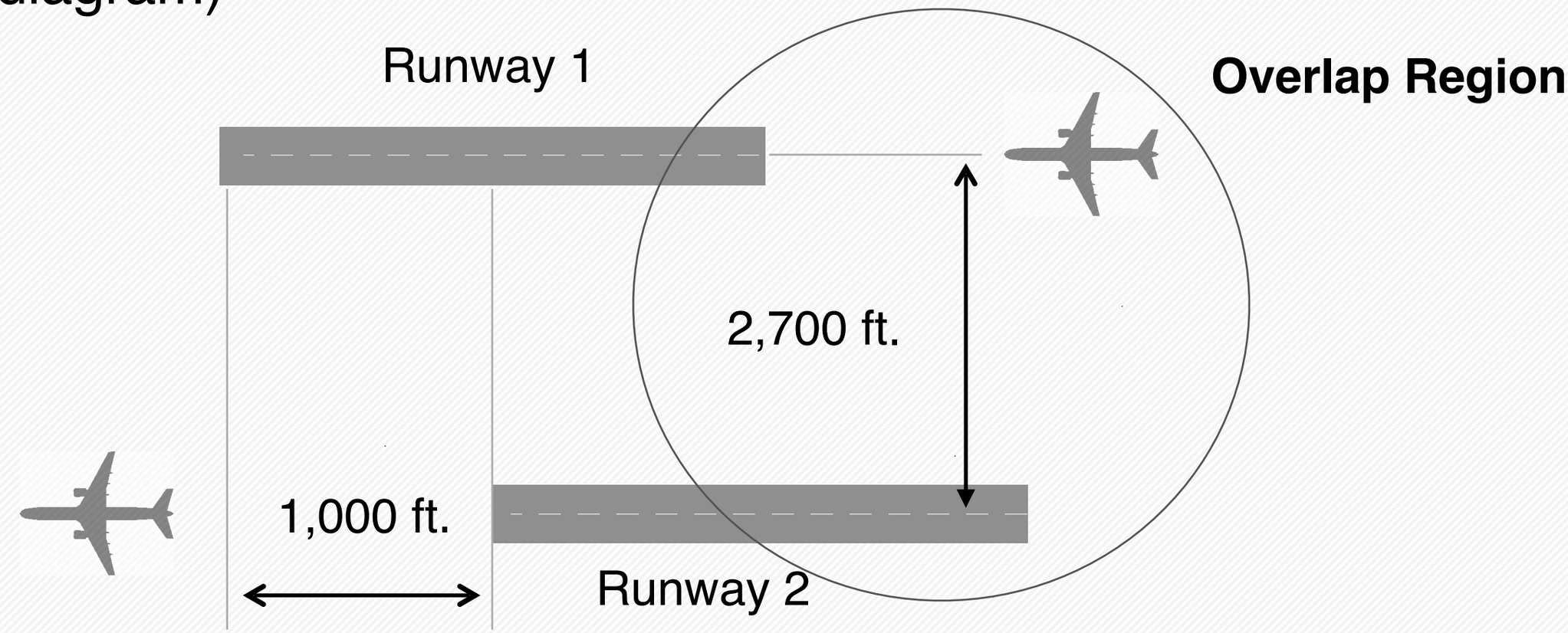
# Staggered Runways Rule (Decreasing Separation)

- If two parallel runways are staggered (i.e., their runway thresholds are offset) use:
- **Decrease runway centerline separation by 100 ft. for every 500 ft. of stagger**



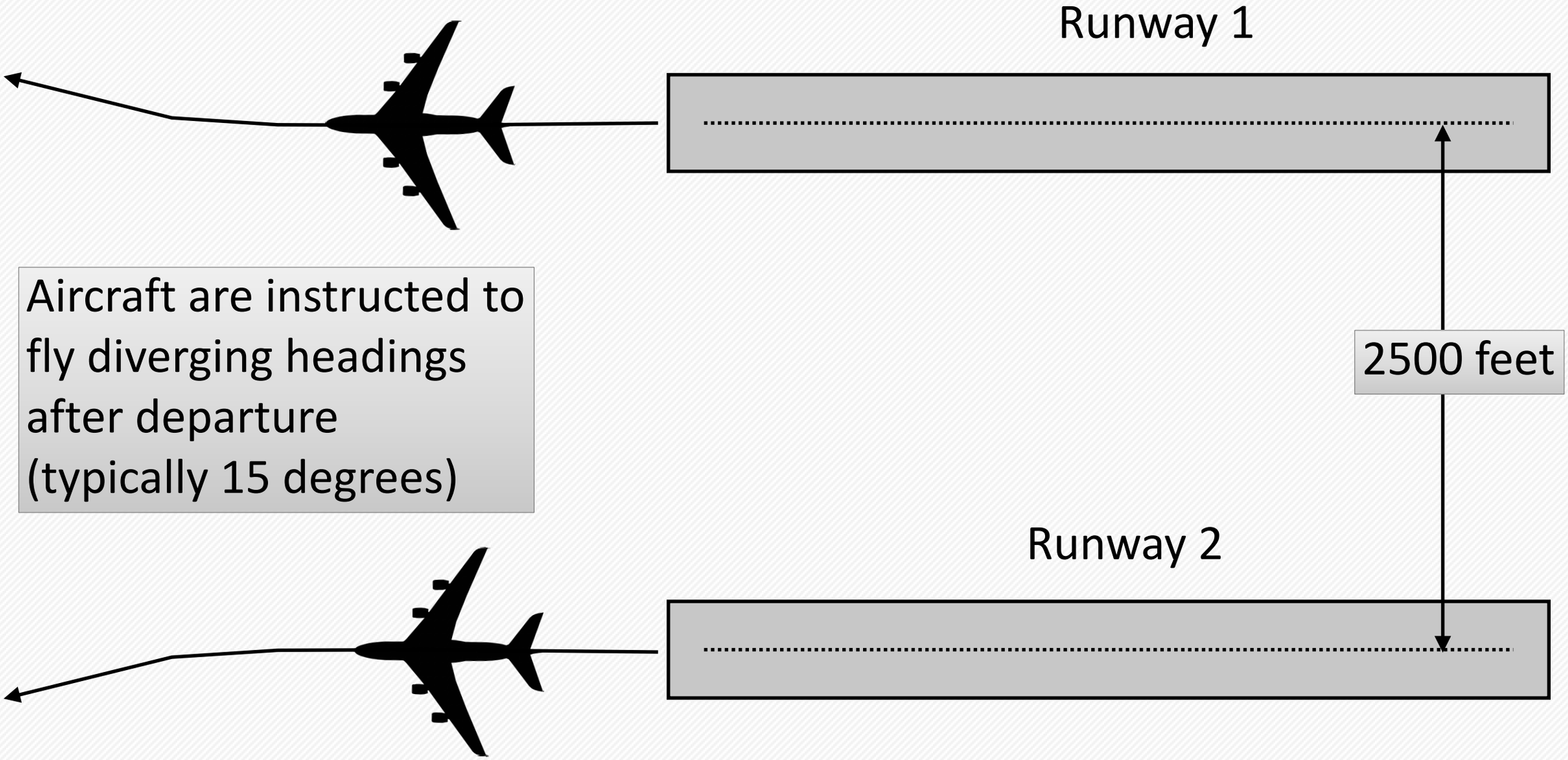
# Staggered Runways Rule (Increasing Runway Centerline Separation)

- If two parallel runways are staggered (i.e., their runway thresholds are offset) use:
- Increase runway centerline separation by 100 ft. for every 500 ft. of stagger if an overlap region exists between arrival and departures (see diagram)



# Simultaneous Independent Departures

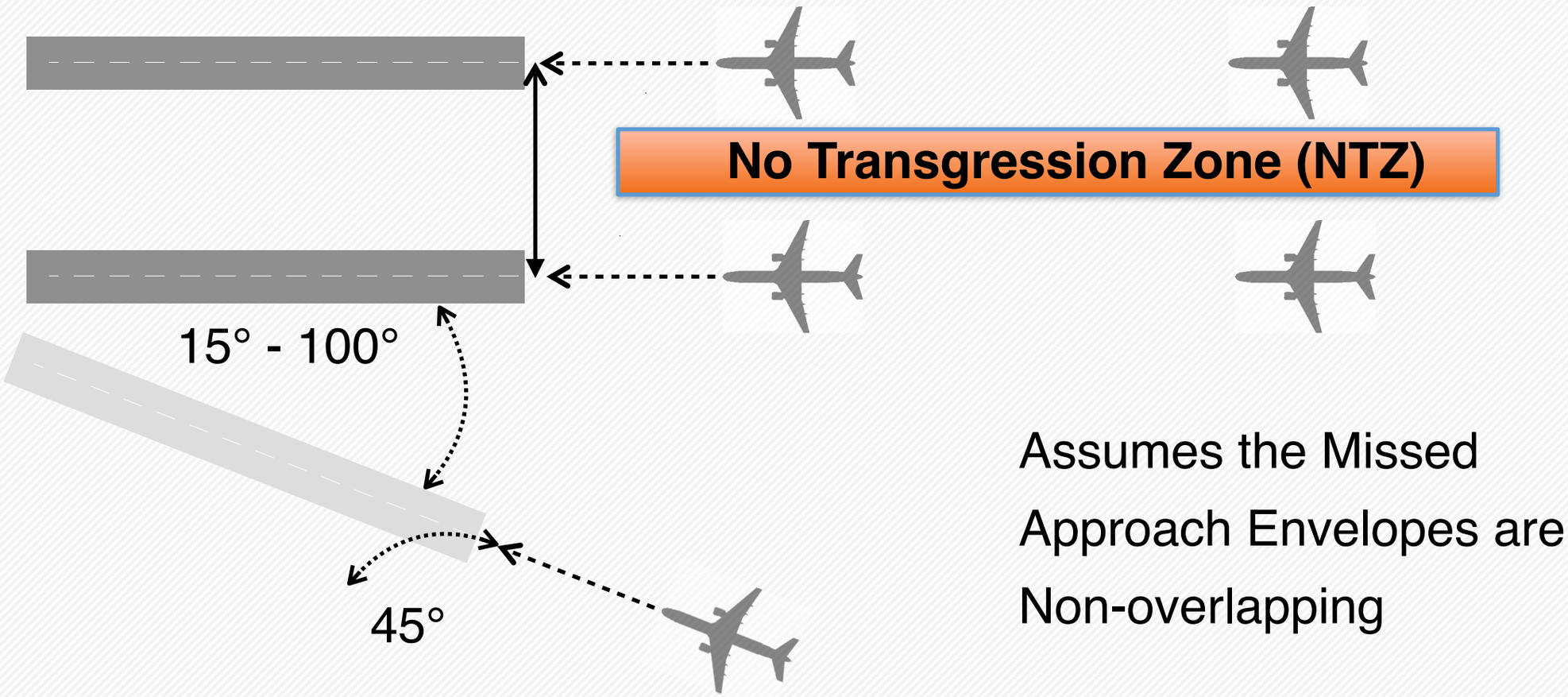
- Use a standard airport surveillance radar (radar scan rate ~4.8 seconds)
- Air traffic control tower




Aircraft are instructed to fly diverging headings after departure (typically 15 degrees)

# Independent Simultaneous Approaches to Converging Runways

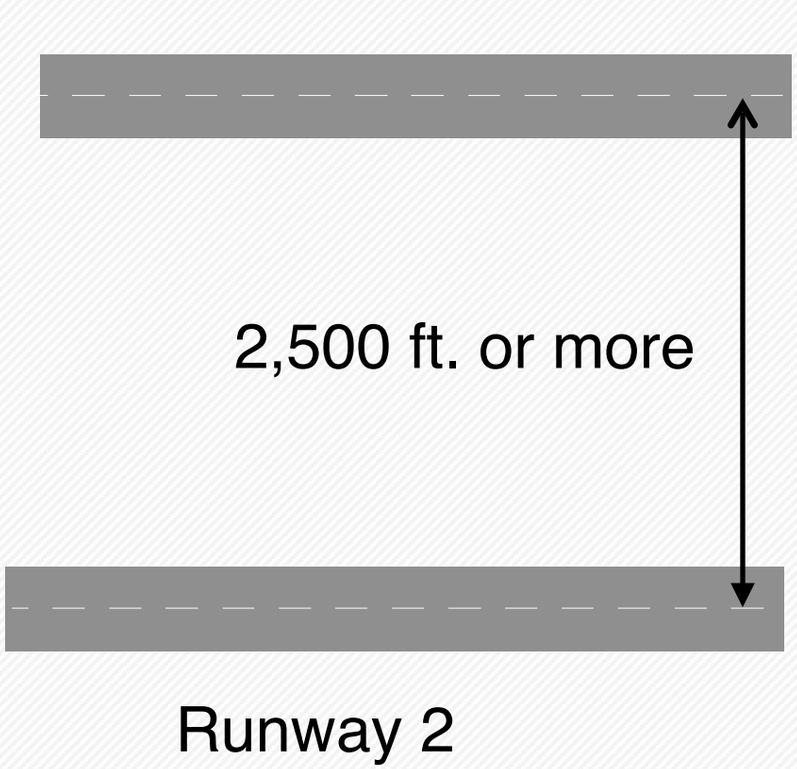
- Procedures governing independent converging approaches require that the distance between the missed approach points be 3 n.m.
- Terminal Instrument Procedures (TERPS) surfaces not overlap
- Because of these restrictions, the approach minimums are high, thereby limiting the number of airports that take advantage of this procedure

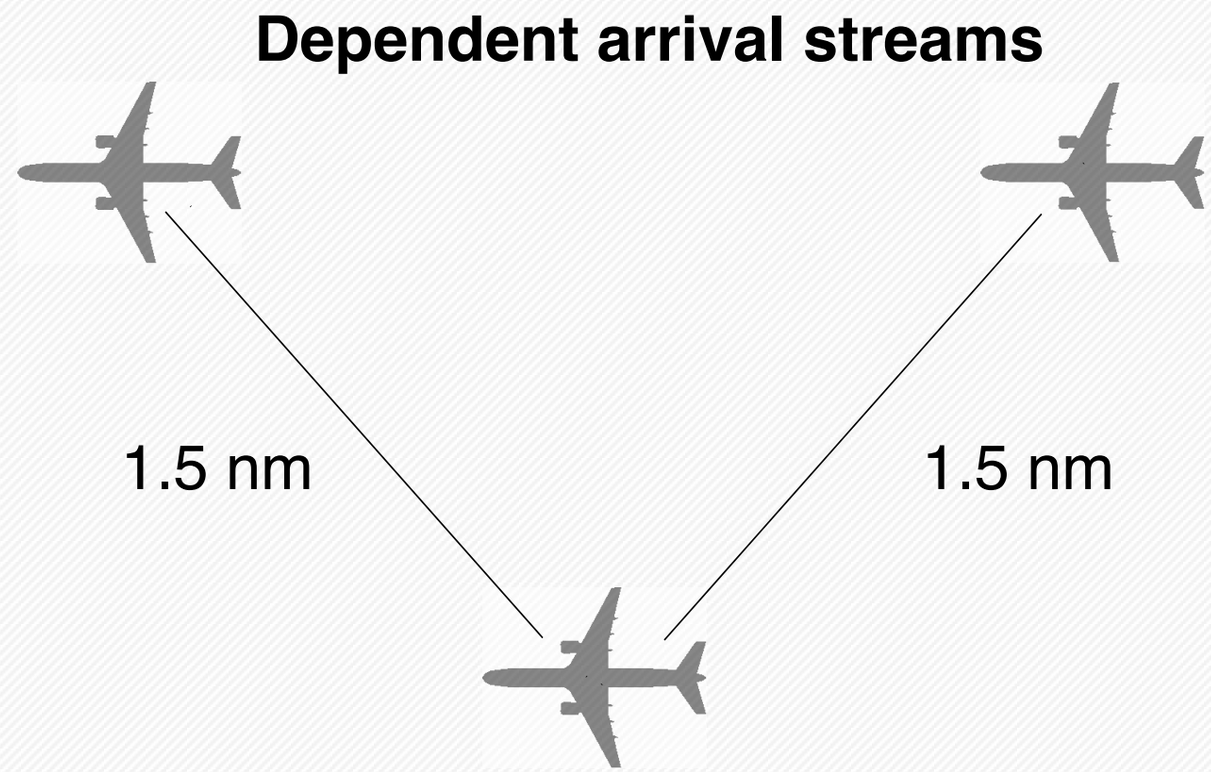



Assumes the Missed Approach Envelopes are Non-overlapping

# Dependent Approaches to Parallel Runways (IFR)

- Procedures allows dependent arrivals when runway separation is below 4,300 ft. and above 2,500 ft. (standard radar)
- A 1.5 nm diagonal separation is enforced between arrivals

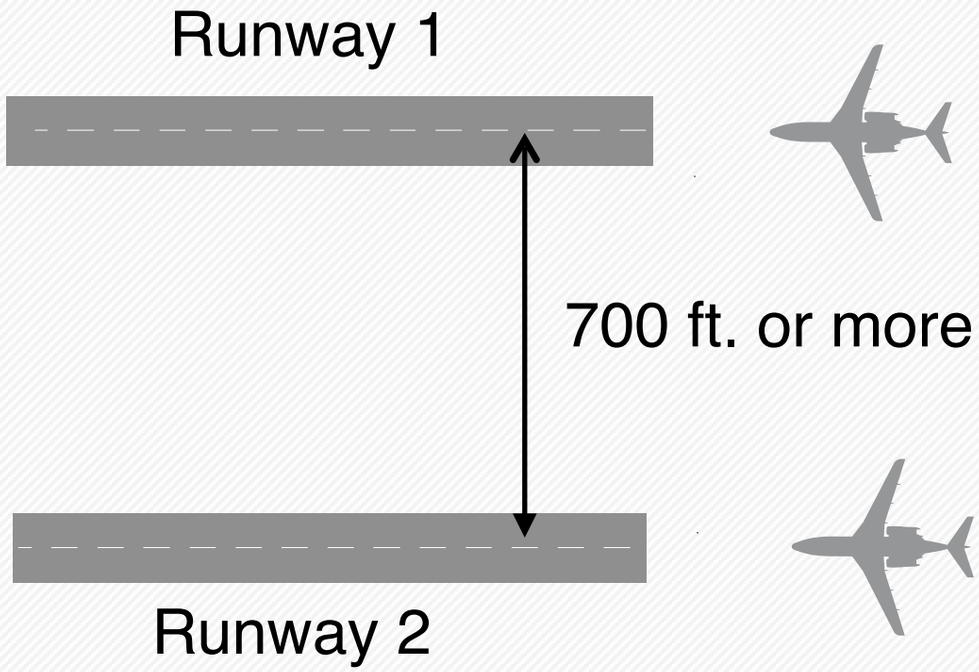


# Independent Arrivals under VFR Conditions

- Independent simultaneous arrivals can be conducted with at least 700ft between runway centerlines if:
- VFR conditions (visibility > 3 nm)

- No wake vortex effect is present




**Independent arrival streams**

No wake vortex effect

(seldom the case)

Increase to 1,200 ft. if aircraft belongs to Design Groups (ADG) V and VI

# Simultaneous Offset Instrument Approaches (SOIA)

- Allows simultaneous approaches to runways spaced less than 3,000 ft. but more than 750 ft.
- San Francisco International airport was the first airport approved for the procedure (see diagram on next page)

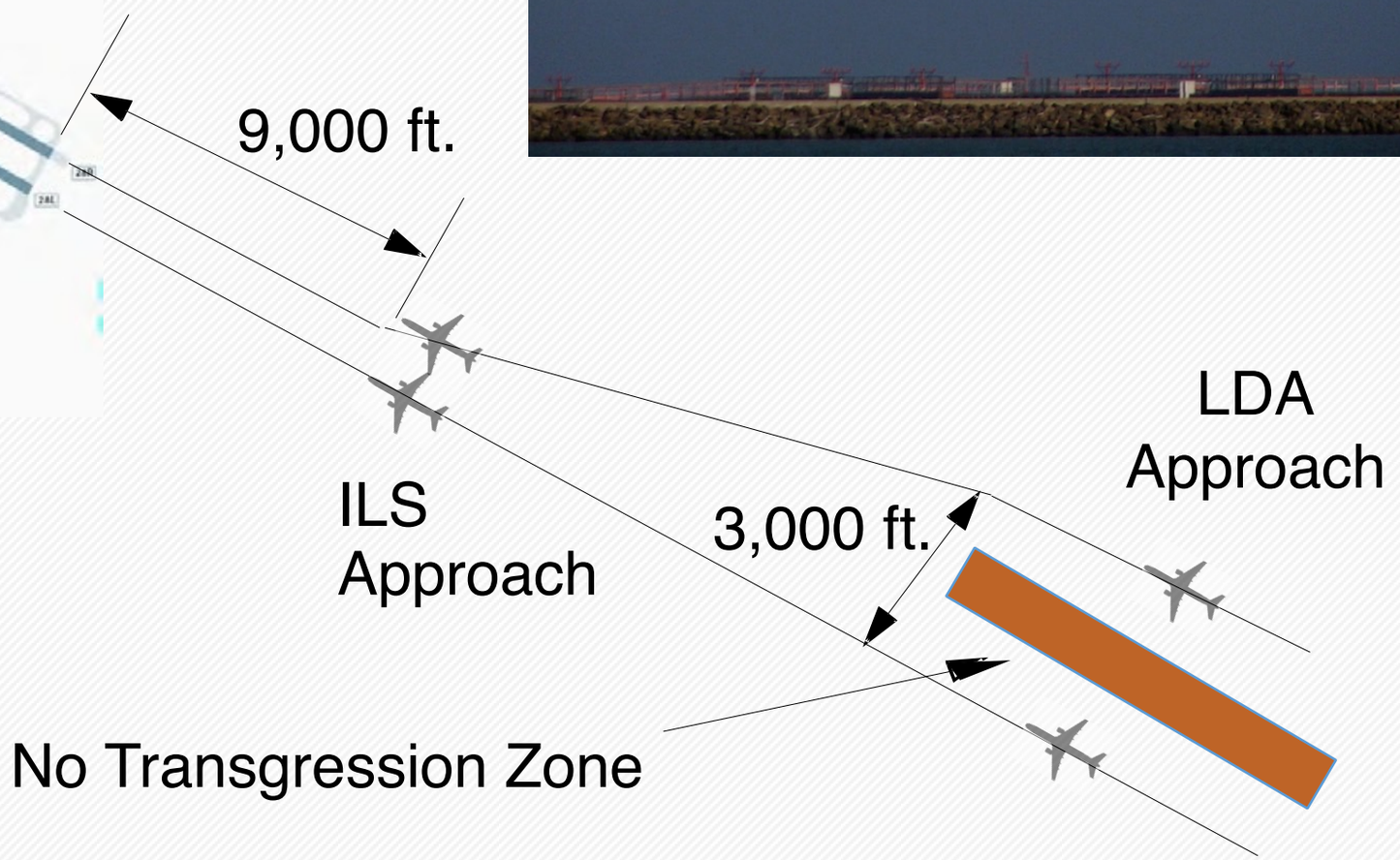
- Requirements:
  - Pilot training
  - Dual communications
  - ATC software/hardware (PRM radar)

# Simultaneous Offset Instrument Approaches (SOIA)









# Runway Configuration at SFO Airport



# Simultaneous Offset Instrument Approaches (SOIA) at SFO in Place for 21 Years (2005-2026)



Boeing 737-800 landing on runway 28R



Gulfstream 500 landing on runway 28L

A.A. Trani

# Simultaneous Offset Instrument Approaches (SOIA) at SFO were **Banned** in March 2026

- A new staggered procedure was developed
- Procedure is in place since August 2026




Airbus A320 landing on runway 28L

Embraer 175 landing on runway 28R

A.A. Trani

# Recent FAA Directive that Affect Runway Capacity at US Airports

- Converging Runway Operations (CRO)
- Following four incidents at Las Vegas (Nevada), the FAA developed more conservative guidelines for operations on converging runways

**NOTICE**

**U.S. DEPARTMENT OF TRANSPORTATION**
FEDERAL AVIATION ADMINISTRATION
Air Traffic Organization Policy

**N JO 7210.860**

**Effective Date:**
January 15, 2014

**Cancellation Date:**
January 14, 2015

**SUBJ:** Converging Runway Operations

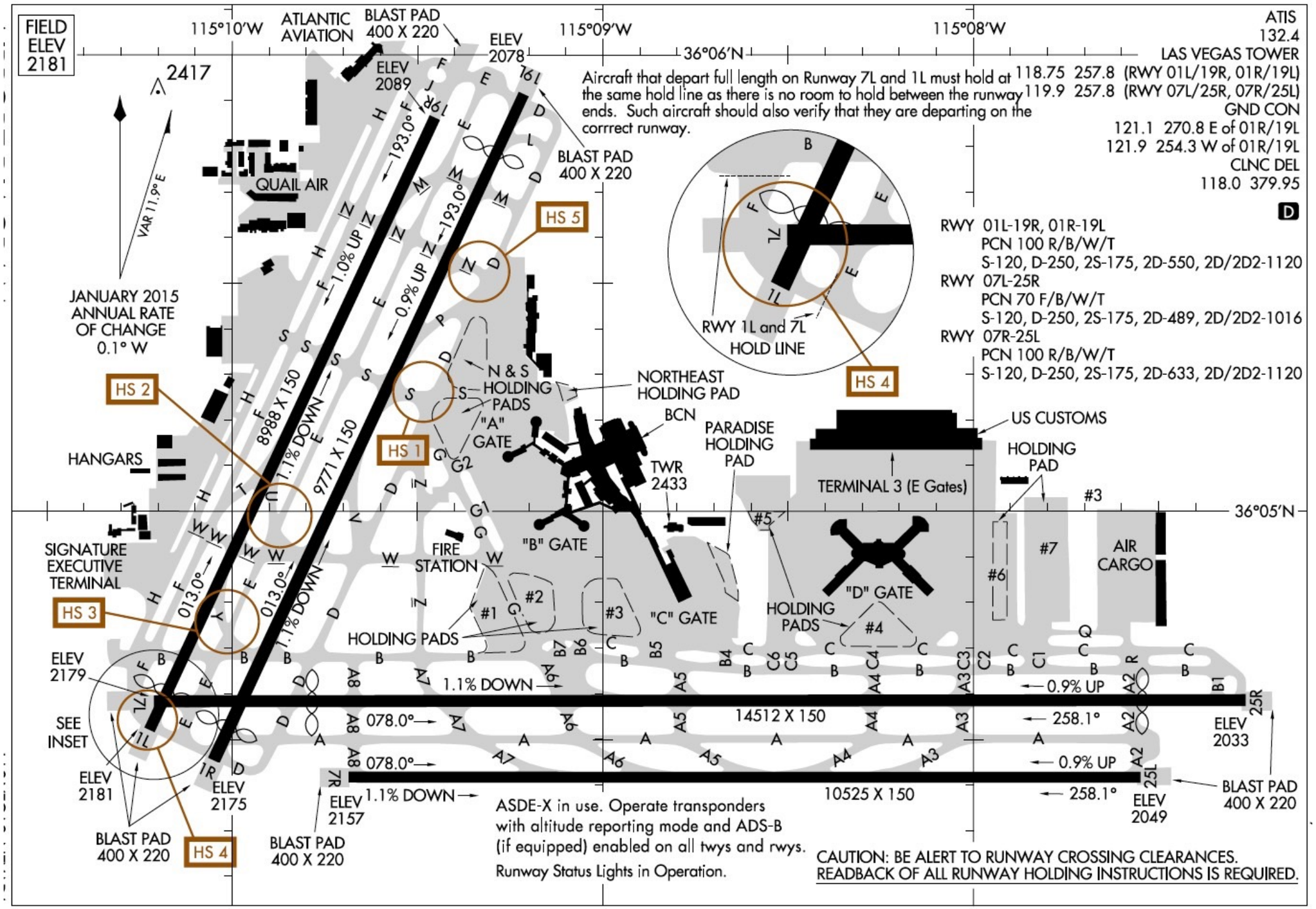
**1. Purpose of This Notice.** This notice amends Federal Aviation Administration (FAA) Order JO 7210.3, Facility Operation and Administration, paragraphs 3-7-3, Display Map Data, and paragraph 10-3-14, Go-Around/Missed Approach.

This notice incorporates changes that will be applied at LAS, CLT, JFK, IAD, IAH, ORD, and BOS beginning January 15, 2014. Secondly, this change will apply to DFW, MSP, DEN, BWI, HNL, MEM, MIA, PHL, SLC, and TPA beginning April 2, 2014. Lastly, this change will apply to all additional affected airports beginning July 9, 2014.

Information of N JO 7210.860 is now part of the FAA Task Order 7110.65 (ATC Handbook)

Airports affected by new CRO rule

# Las Vegas International Airport



# NTSB Reports that Prompted CRO

## NTSB Identification: OPS13IA071

Incident occurred Thursday, July 04, 2013 in Las Vegas, NV
Probable Cause Approval Date: 03/10/2015
Aircraft: GULFSTREAM GIV - UNDESIGNAT, registration:
Injuries: Unavailable

*"A Boeing 737 (737) executing a go-around from runway 25L and a Gulfstream 4 that had just departed from runway 19R experienced an airborne conflict. When passing over runway 25L, the 737 pilot announced his intention to go around because the airplane was encountering a 20-knot tailwind.*

*The tower controller responsible for runway 25L acknowledged the report, immediately advised the pilot of traffic "just lifting off" from runway 19R, and instructed the pilot to report the traffic in sight. The tower controller then instructed the pilot to fly the runway heading and climb to 7,000 ft. The pilot read back the clearance and reported the traffic in sight. The controller told the pilot to maintain visual separation from the traffic. The 737 subsequently completed another approach and landed."*

# NTSB Reports that Prompted CRO

## NTSB Identification: OPS13IA071

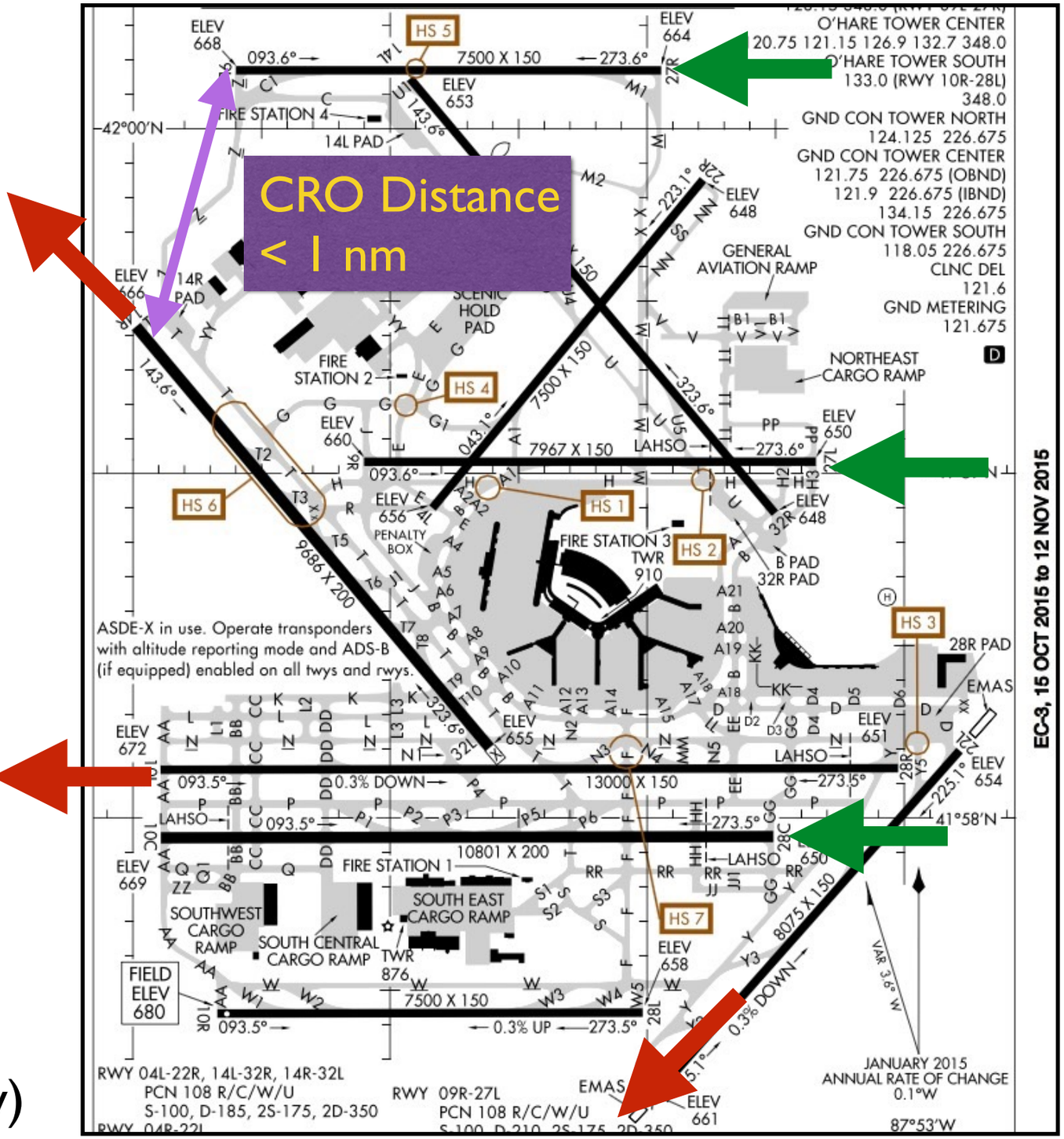
Incident occurred Thursday, July 04, 2013 in Las Vegas, NV
Probable Cause Approval Date: 03/10/2015
Aircraft: GULFSTREAM GIV - UNDESIGNAT, registration:
Injuries: Unavailable

*"At the time of the incident, the FAA did not have procedures requiring specific separation between aircraft operating on nonintersecting runways where flightpaths may intersect despite the occurrence of several previous similar incidents.*

*Following this incident and another similar incident, the FAA amended FAA Notice 7110.65, "Air Traffic Control," by adding paragraph 3-9-9, "Non-Intersecting Converging Runway Operations," which directed changes in converging runway operations to prevent similar reoccurrences."*

# Example of CRO Effect (ORD Airport)

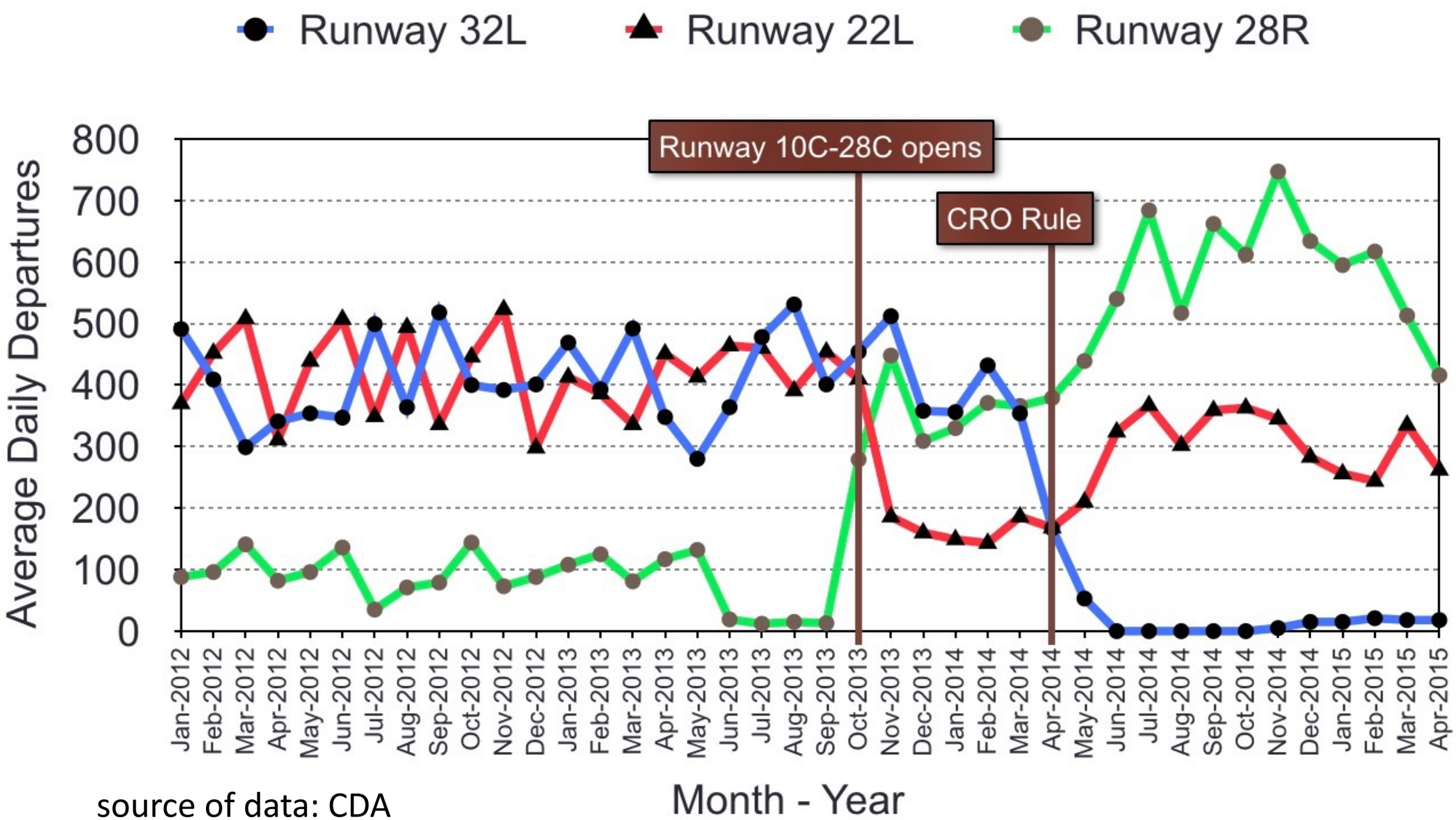
- In the summer 2014, ORD lost 1/3 of its departure capacity for one of the most heavily used configurations
- Runway 32L become almost unusable during daytime hours




Arrival runways (west flow)

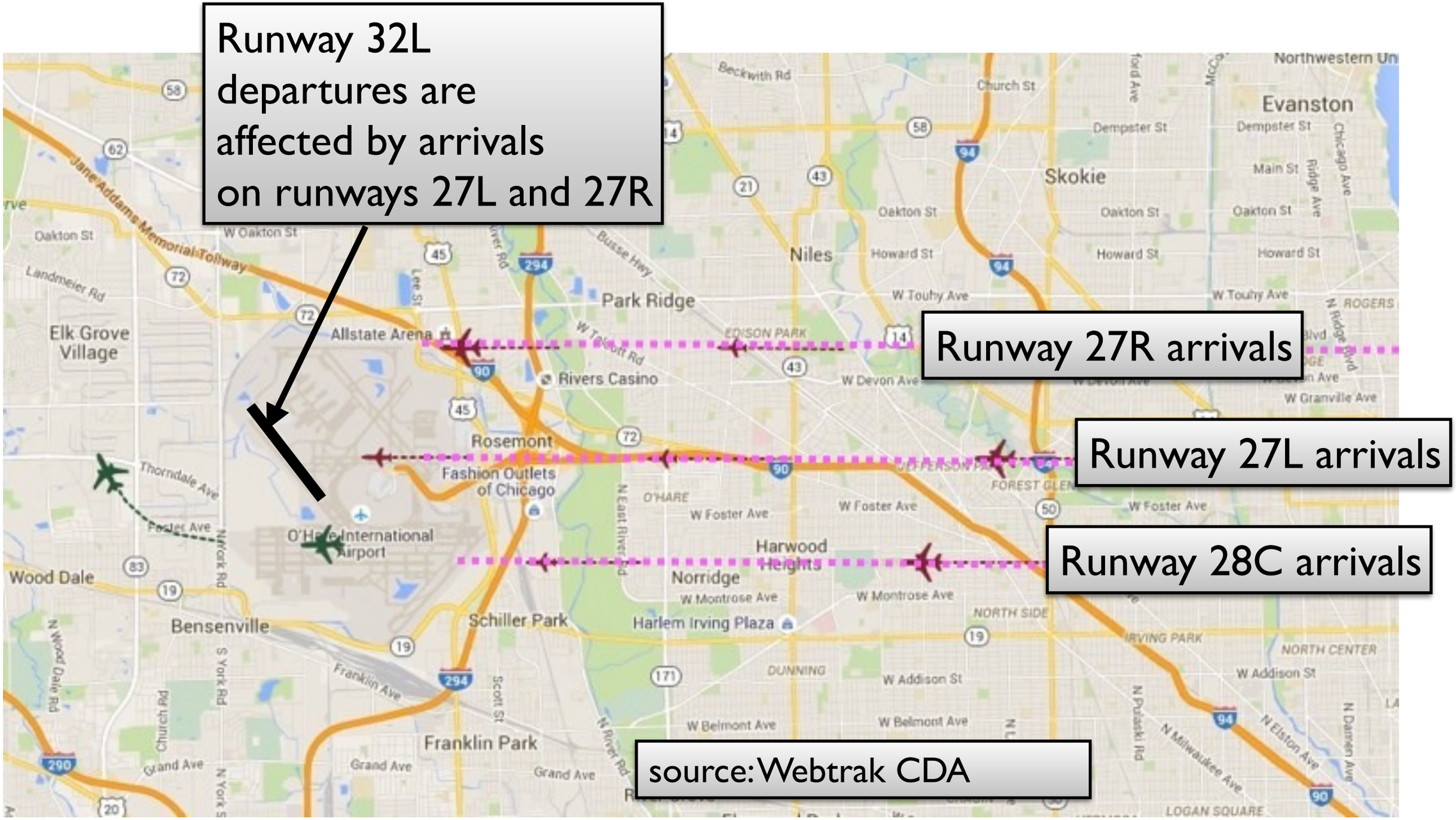
Departure runways (west flow)

# Example of CRO Effect (ORD Airport)

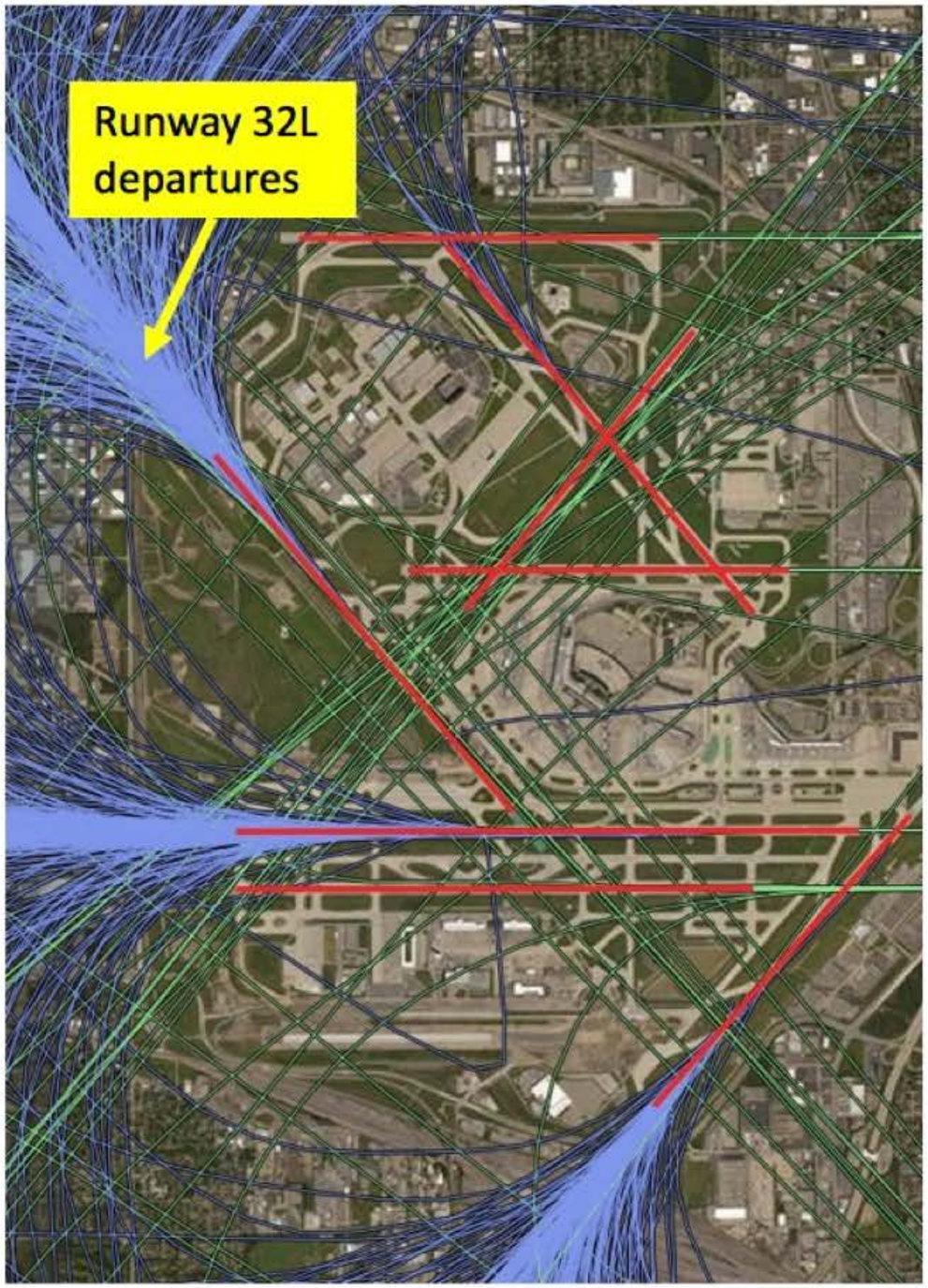



source of data: CDA

# Example of CRO Effect

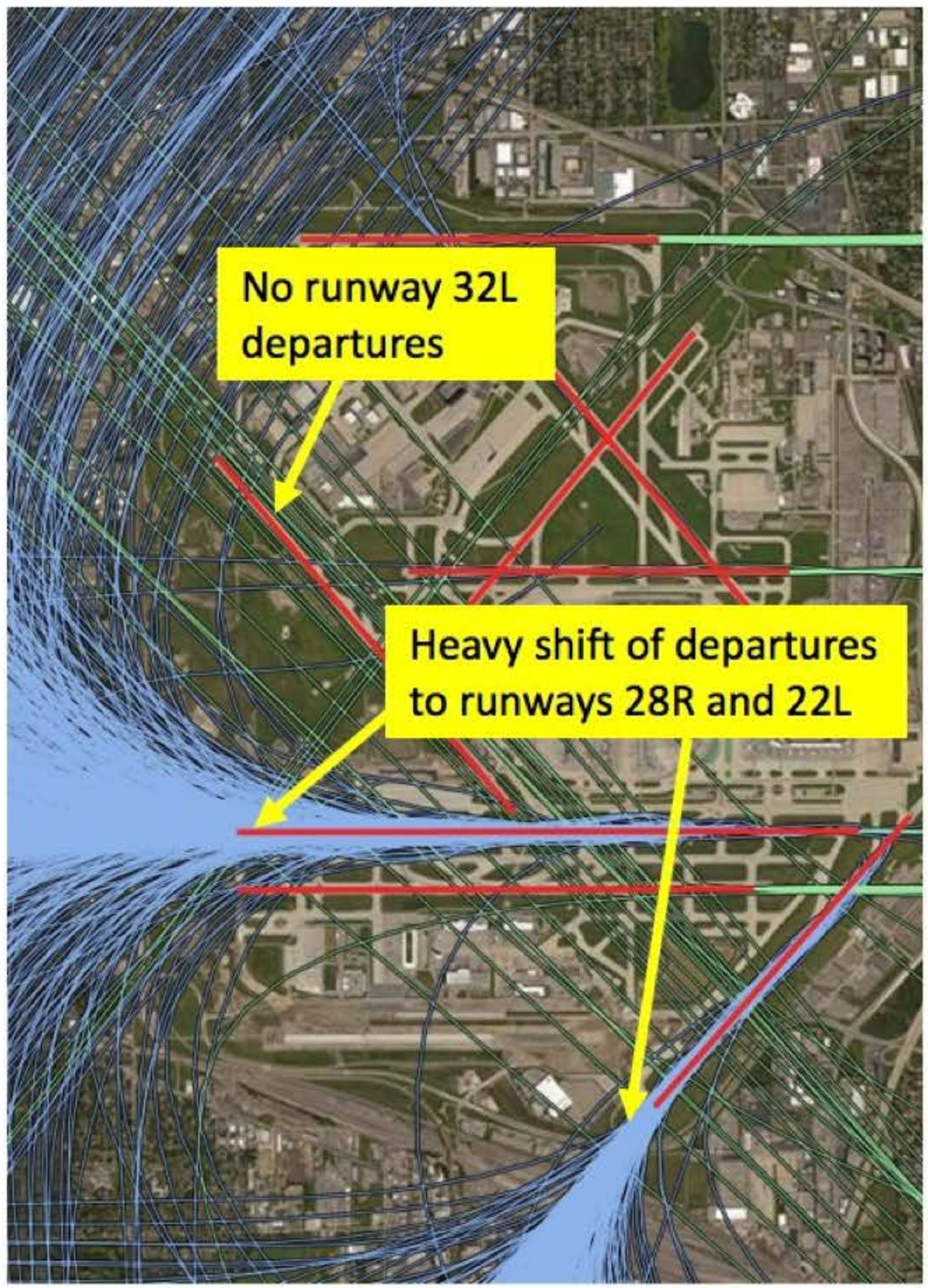


# CRO Rule at Chicago O'Hare Intl. Airport




Before CRO Rule

source of data: CDA




After CRO Rule

# ICAO Aerodrome Reference Code

ICAO Aerodrome Reference Code used in Airport Design

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

# ICAO Aerodrome Reference Code
# Code Element 2

| Design Group | Wingspan (m) | Outer Main Landing Gear Width (m) | Example Aircraft |
|---|---|---|---|
| A | < 15 | < 4.5 | All single engine aircraft, Some business jets |
| B | 15 to < 24 | 4.5 to < 6 | Commuter aircraft, large business jets (EMB - 120, Saab 2000, Saab 340, etc.) |
| C | 24 to < 36 | 6 to < 9 | Medium-range transports (B727, B737, MD-80, A320) |
| D | 36 to < 52 | 9 to < 14 | Heavy transports (B757, B767, MD-80, A300) |
| E | 52 to < 65 | 9 to < 14 | Heavy transport aircraft (Boeing 747, A340, B777) |
| F | 65 to < 80 | 14 to < 16 | A380, Antonov 225 |

# Runway Separations According to ICAO Standards (Visual Conditions)

Where parallel **non-instrument** runways are to be provided for simultaneous use, the following separations are recommended:

- **120 meters** (394 ft) for Aerodrome Runway Code 1
- **150 meters** (492) for Aerodrome Runway Code 2
- **210 meters** (689 ft) for Aerodrome Runway Codes 2 and 4

Note: In the US we use 700 feet for visual operations for all runway categories

# Runway Separations According to ICAO Standards (Non-Visual Conditions)

Parallel **non-instrument** runways that meet PANS-ATM Doc 4444 and PANS-OPS 8168, the following separations are recommended:

- **1035 meters** (3395 ft) for independent parallel approaches
- **915 meters** (3000 ft) for dependent parallel approaches
- **760 meters** (2493 ft) for independent parallel departures
- **760 meters** (2493 ft) for segregated operations

Note: **In the US we use 2500 feet** for independent parallel departures and also for independent segregated operations