Air Traffic Control and Runway Separations

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Discussion of Flight Rules Used in Aviation

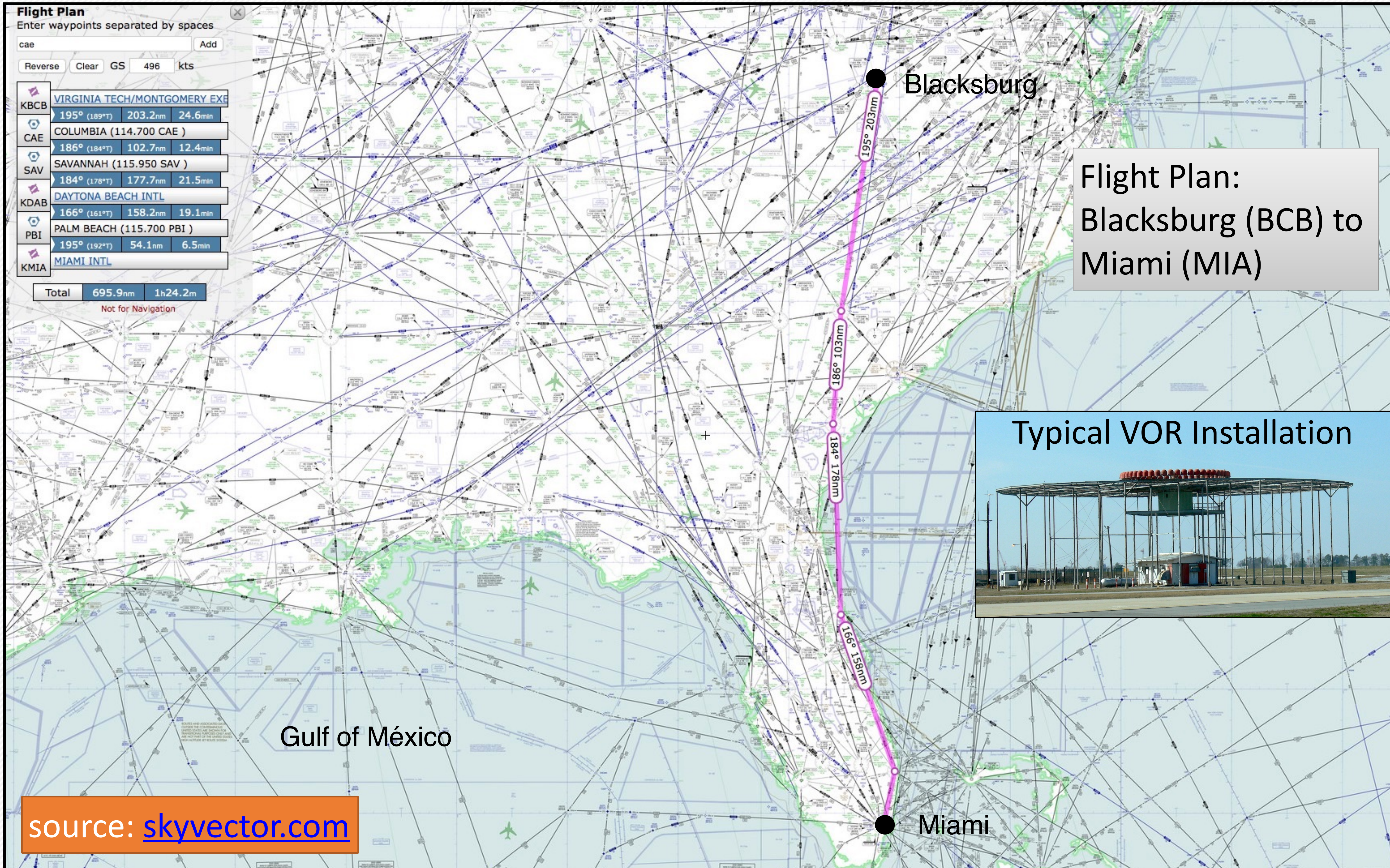
Flight Rules

- 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.



Typical VOR Installation

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)

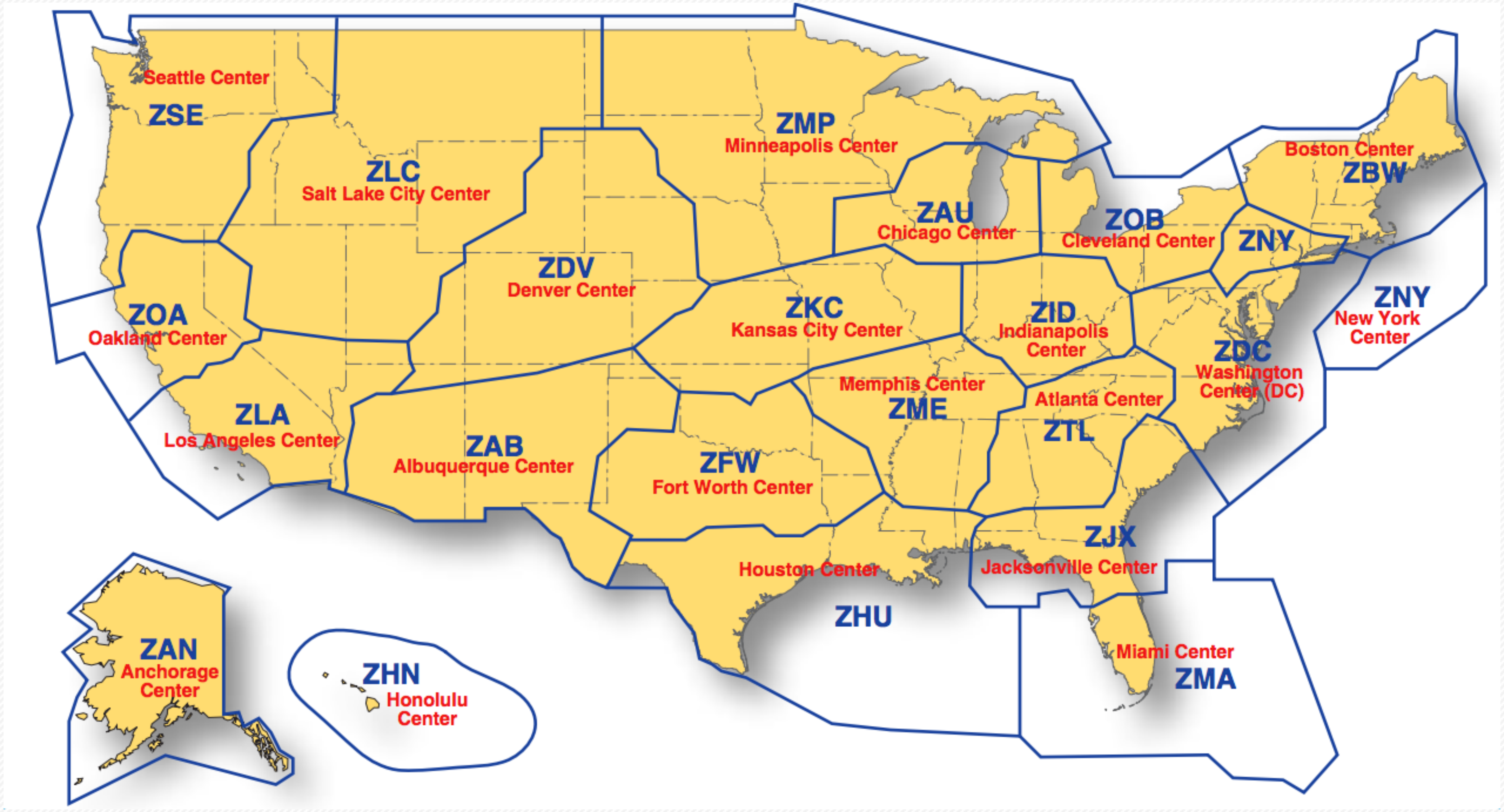
- Flight Service Stations (FSS)

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)

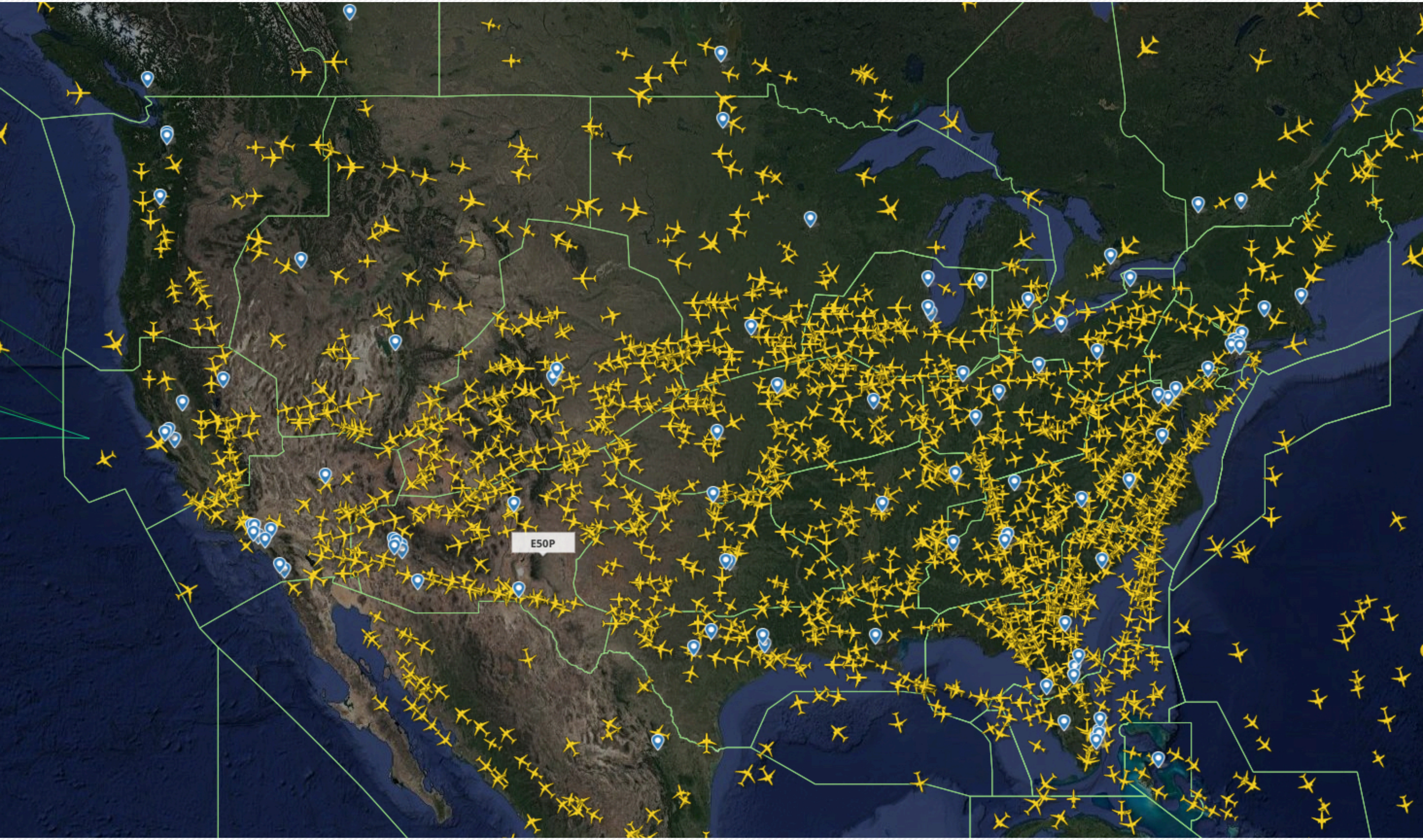
Enroute Control Centers in the US

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



Source: FAA Instrument Procedures Handbook

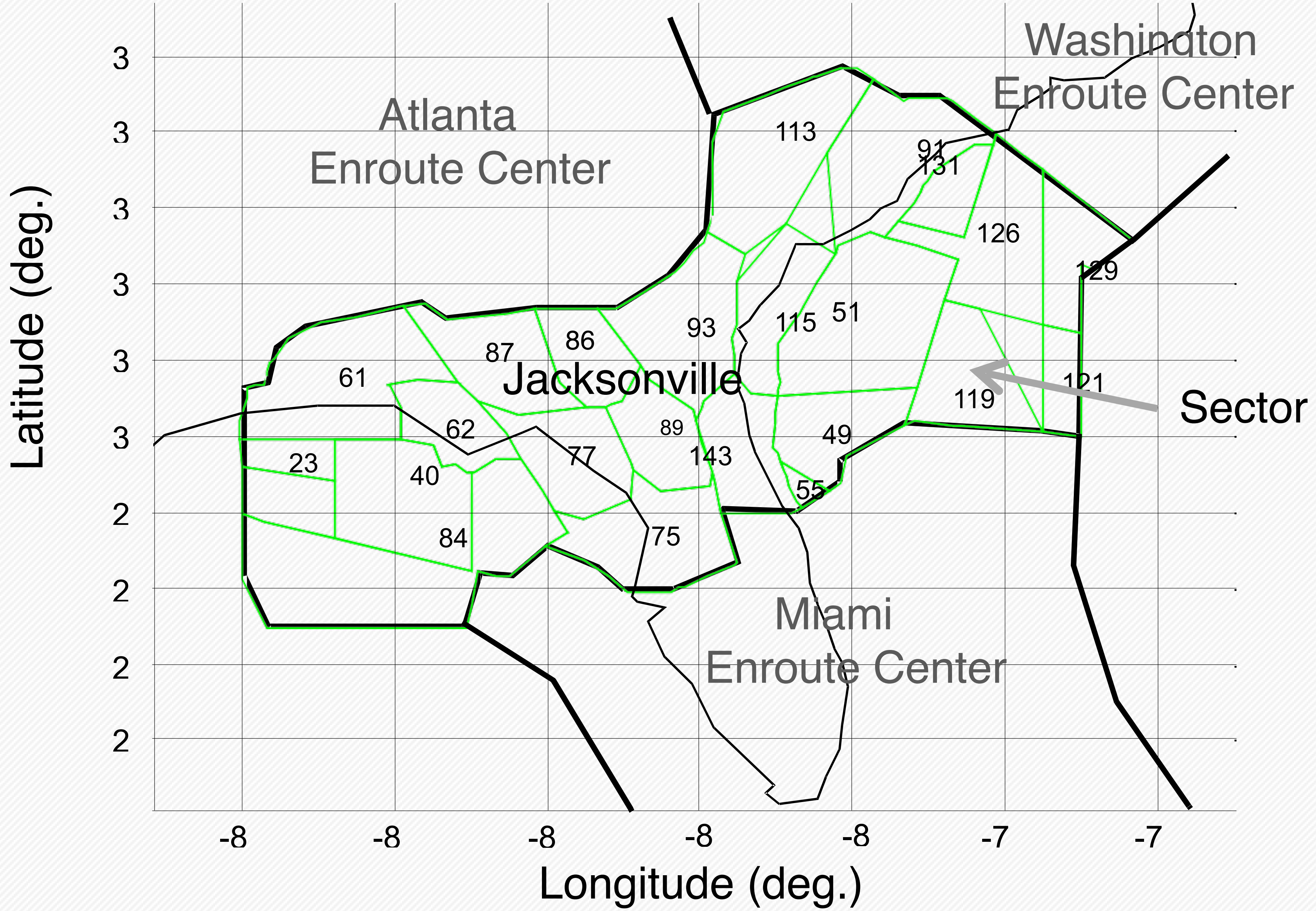
Enroute Control Centers (ARTCC) in the US



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)

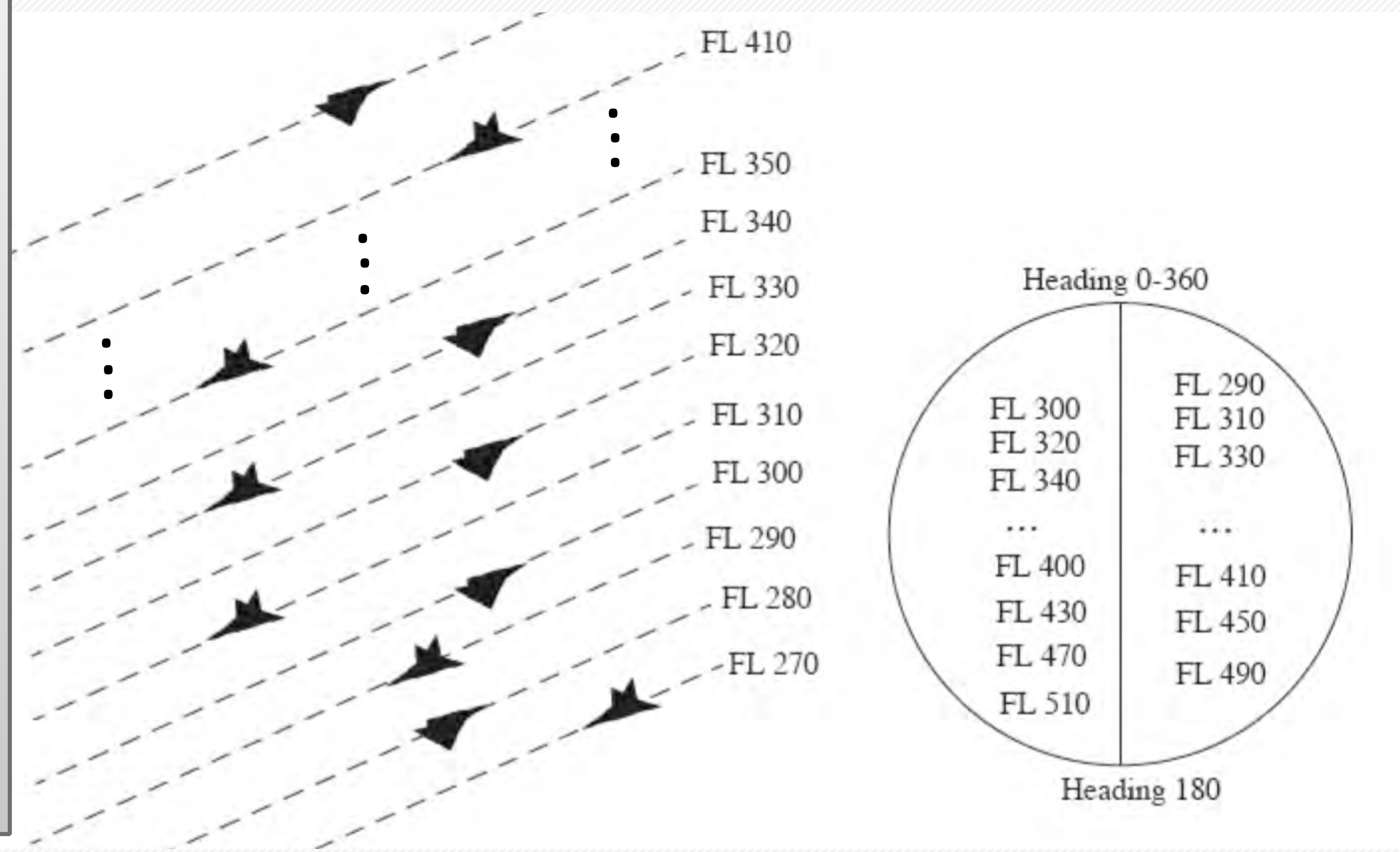
- In January 20, 2005 the FAA instituted Reduced Vertical Separation Minima (RVSM) in the domestic US airspace
- Canada and Mexico (and Gulf of Mexico) also implemented the same RVSM rules on the same day
- The new vertical separations allow six new flight levels to be selected every 1,000 between flight 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

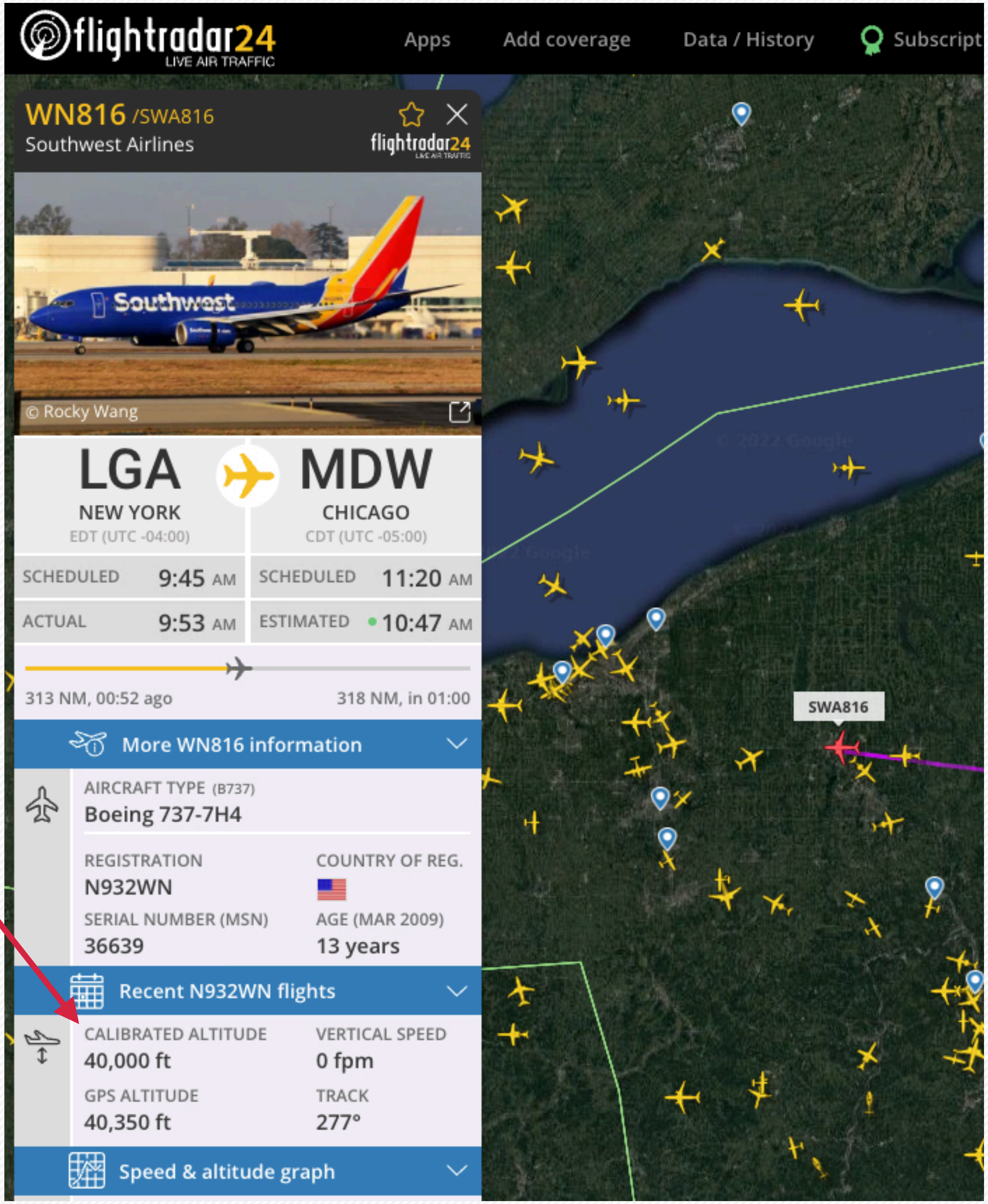
Altitude Assignment

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

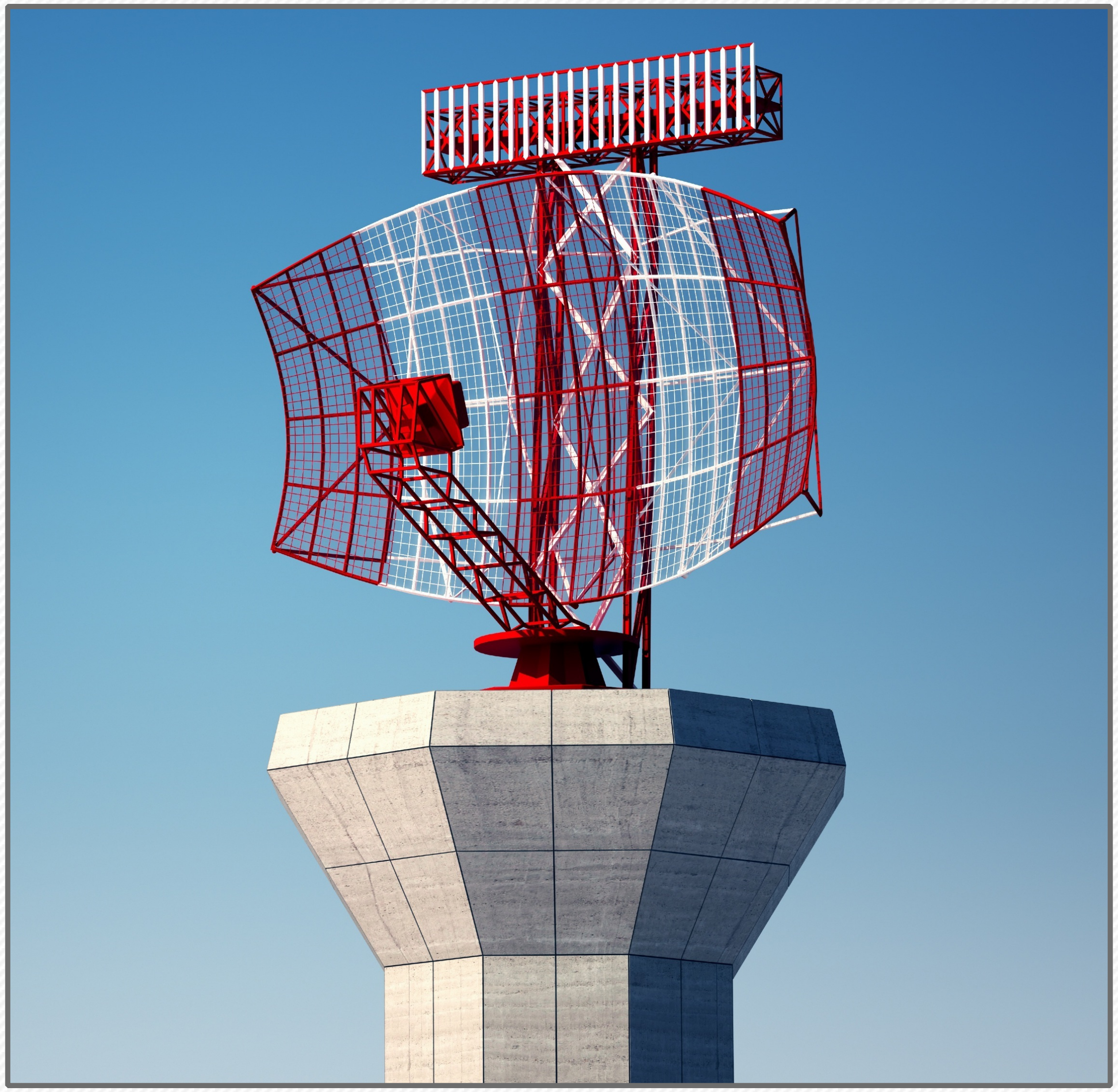
Source: Air Traffic Control Handbook (https://www.faa.gov/air_traffic/publications/atpubs/atc_html/chap4_section_5.html

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

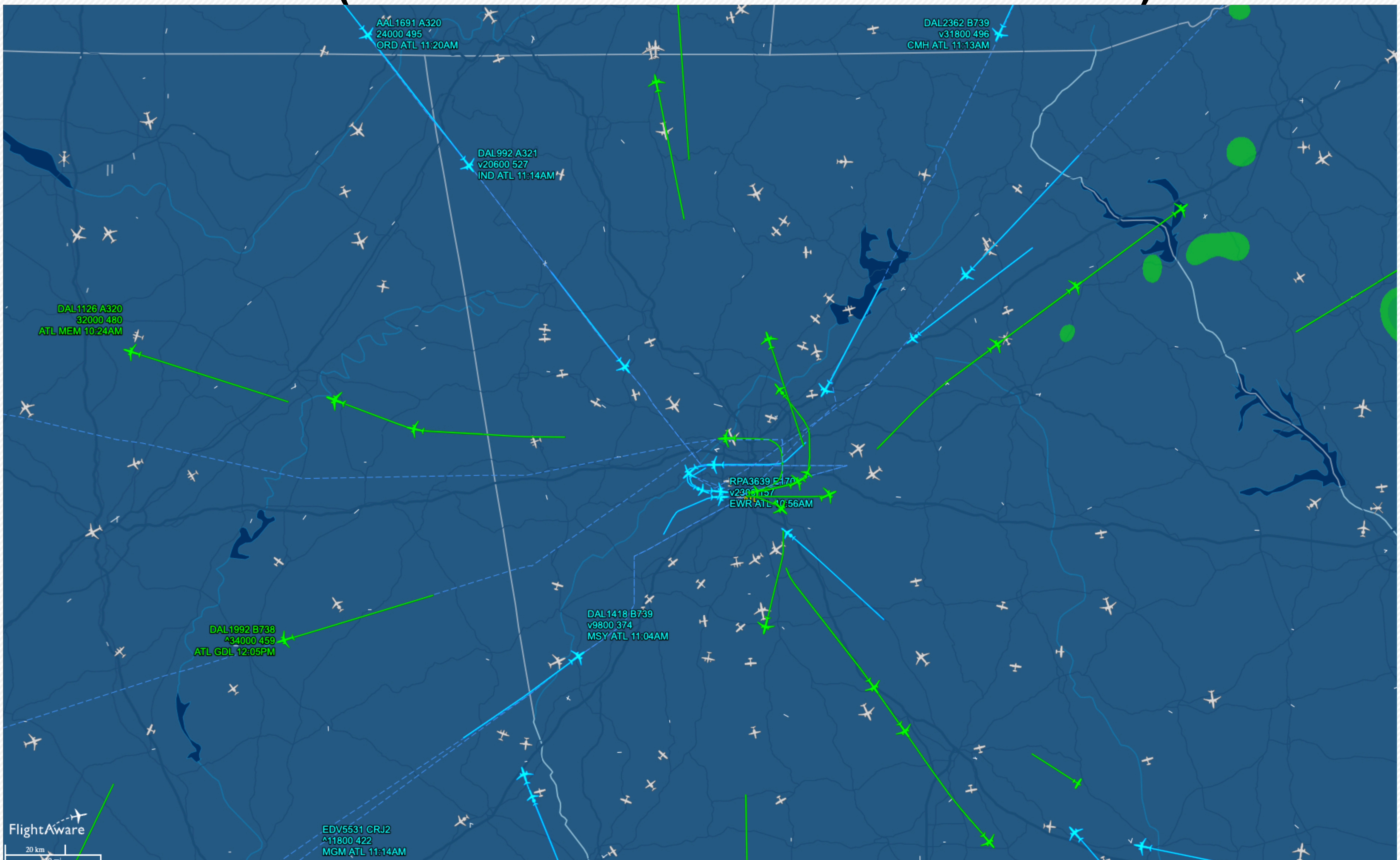
Terminal Approach and Departure Control Facilities (TRACON)

- 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)

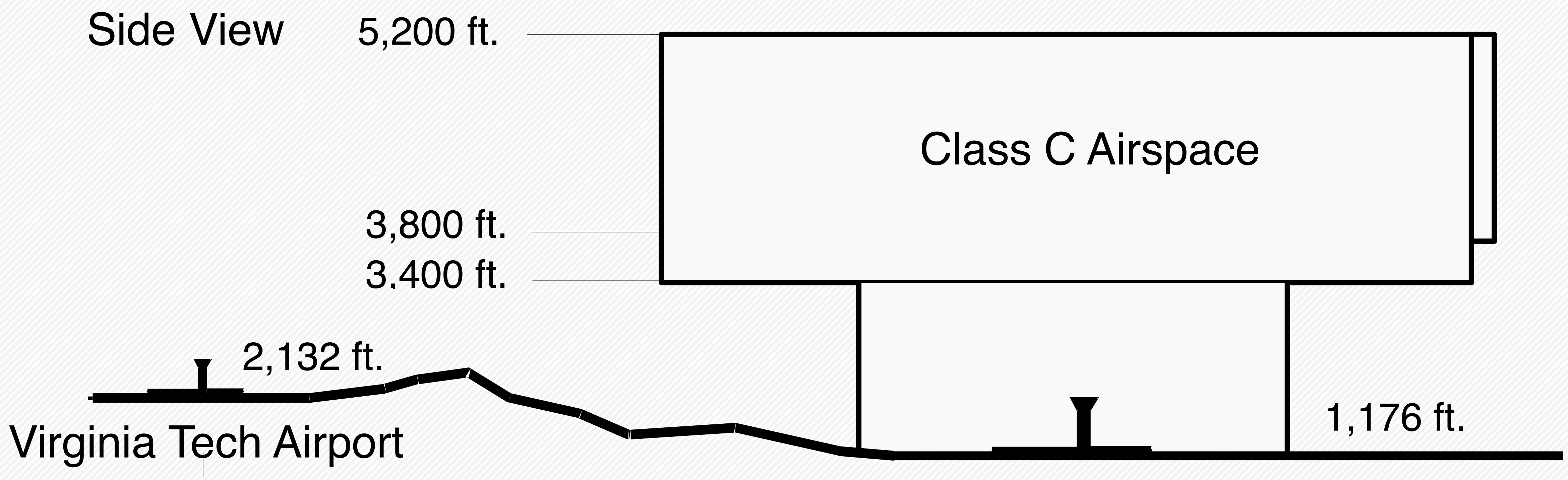
  AA52 turn right heading 120
  UA53 descent and maintain 170 (17,000 ft.)
  Aeromexico reduce to 230 (IAS airspeed)

- 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

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



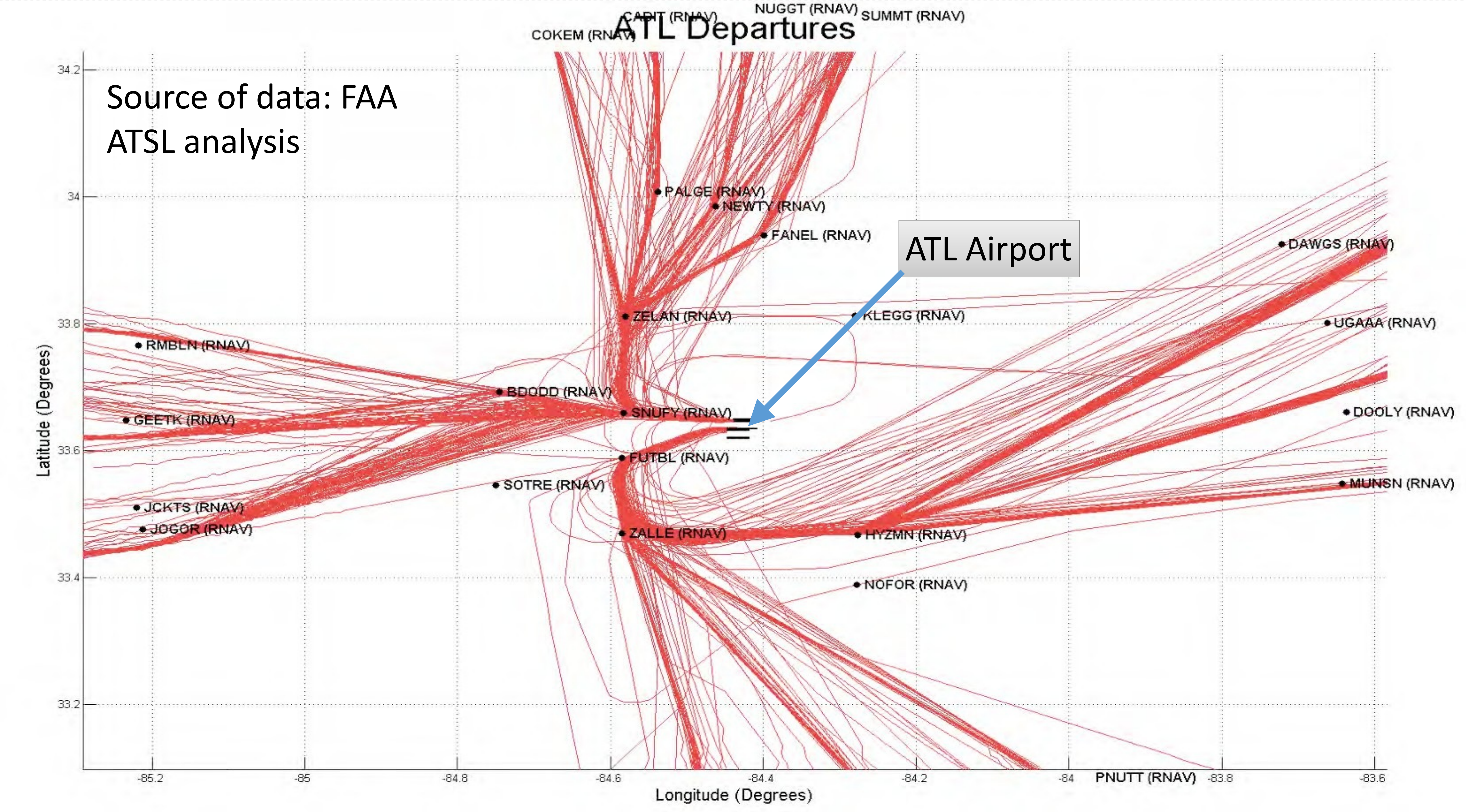
A Small TRACON - Roanoke, Virginia



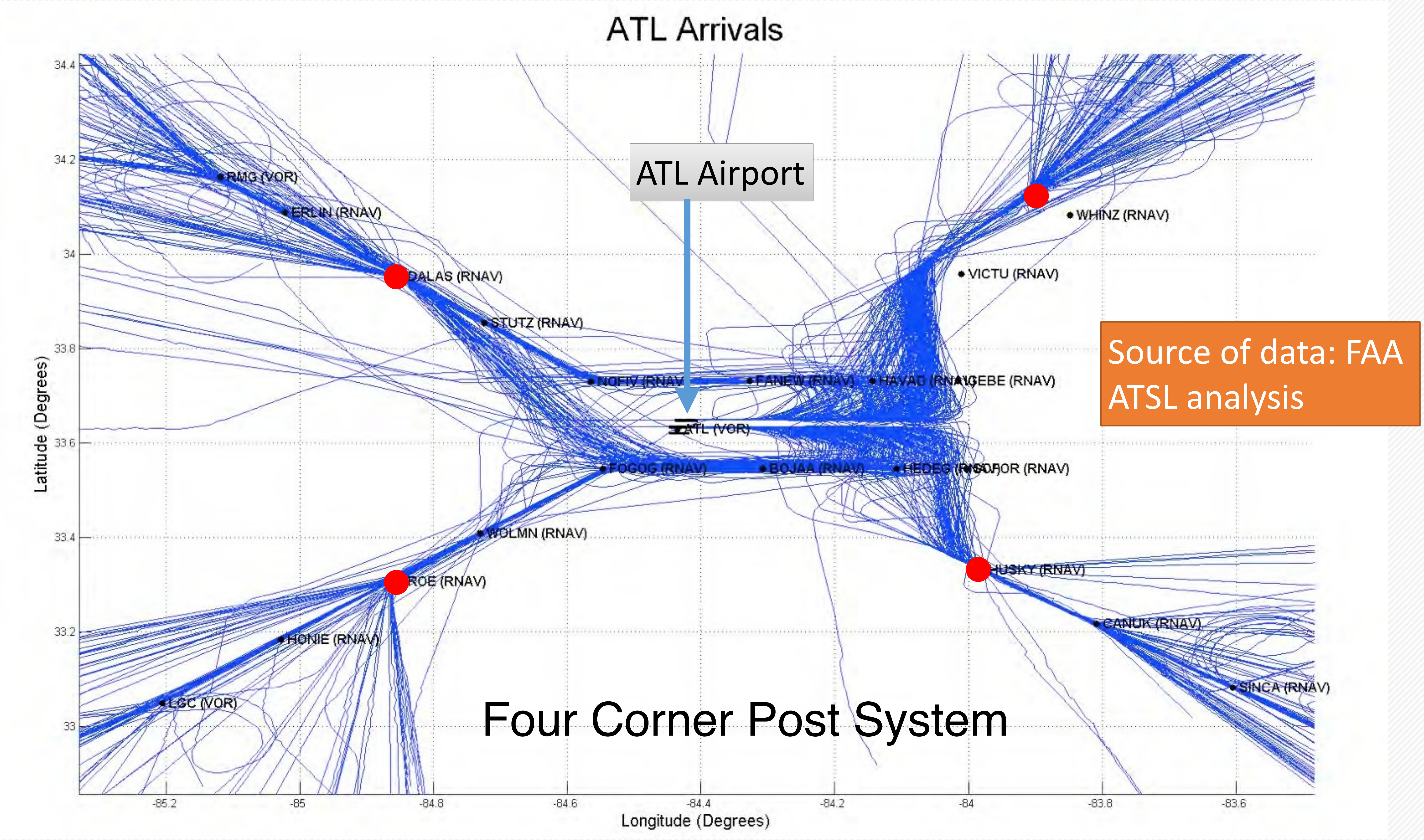
Notes:

- 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 Atlanta (Departures)



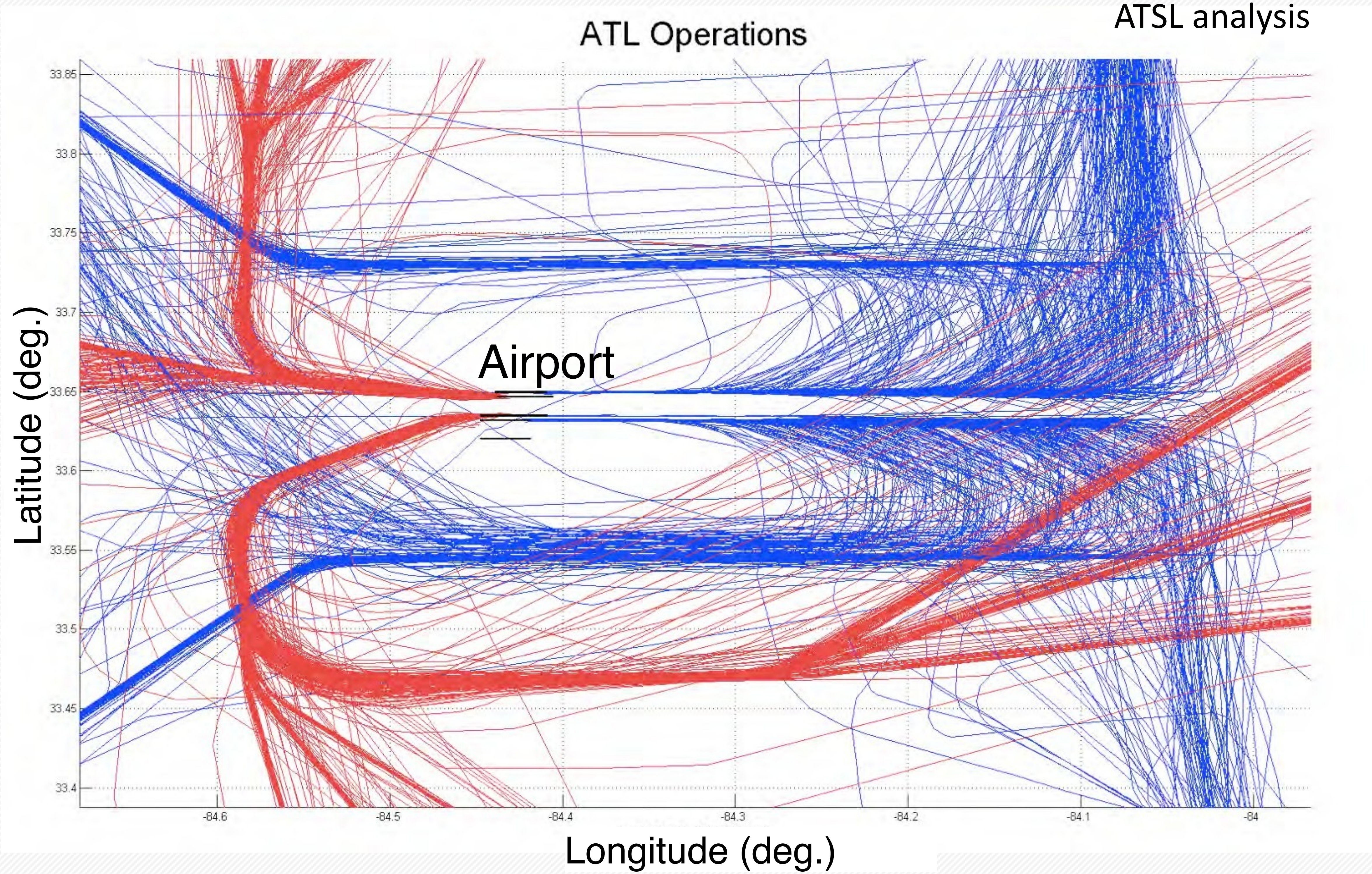
Terminal Area Operations in Atlanta (Arrivals)



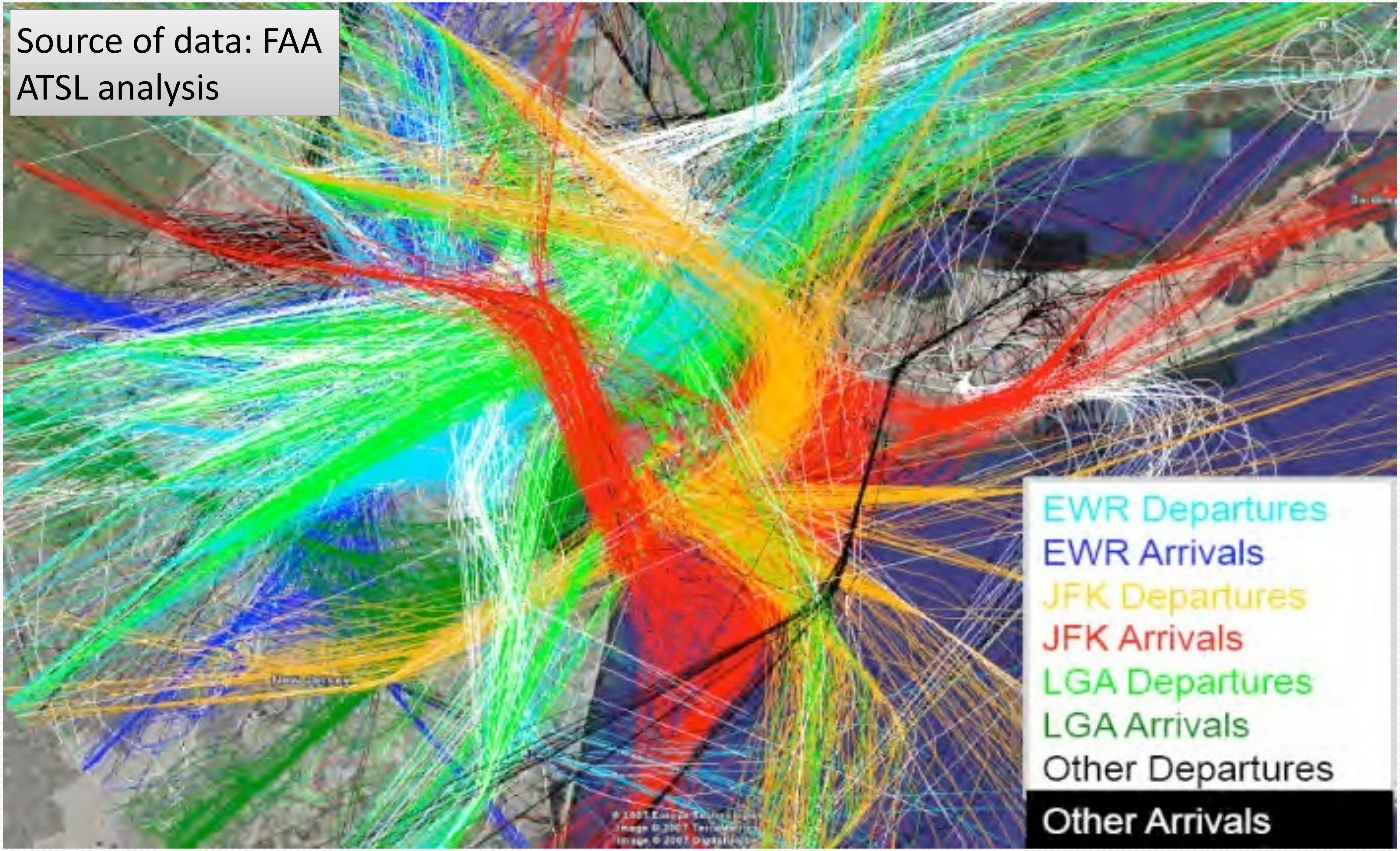
Atlanta Arrival and Departure Patterns

Departures   Arrivals

Source of data: FAA ATSL analysis

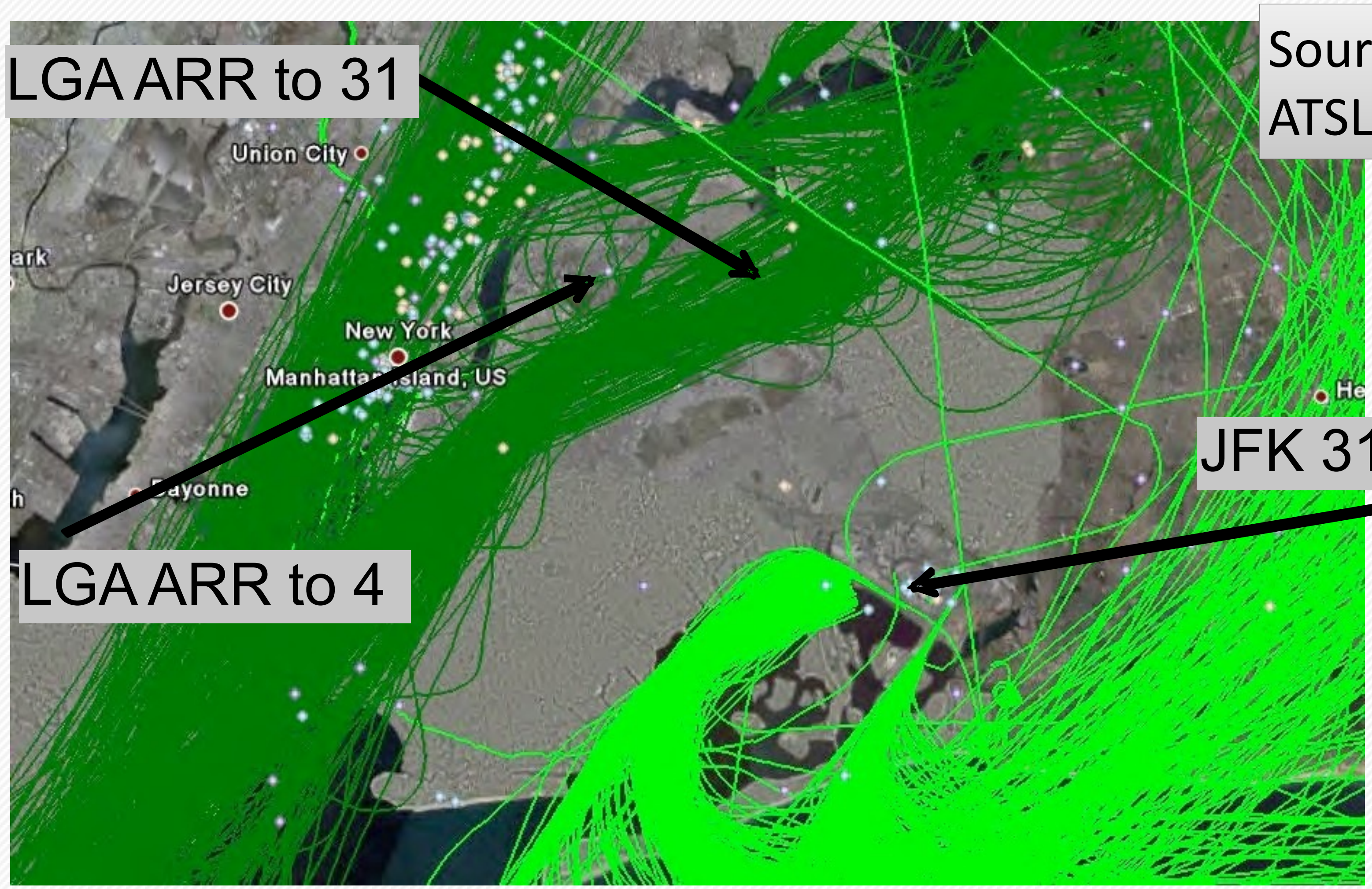


Terminal Area Operations in New York City



One Day of Traffic into five New York Area Airports

Terminal Operations in New York



Source of data: FAA
ATSL analysis

- 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

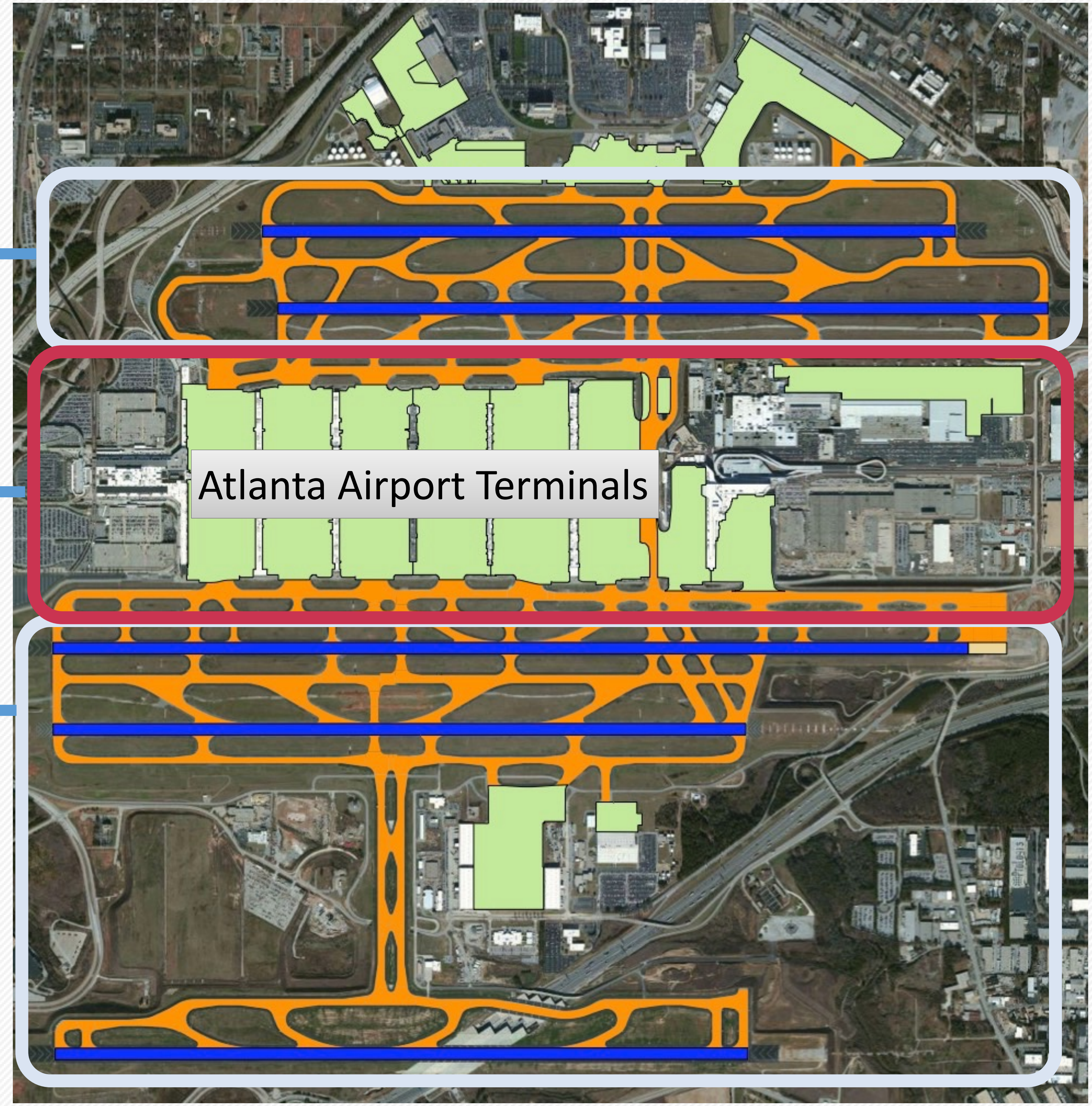
- Controls aircraft traffic (both arrivals and departures) at the airport (includes ramps near gates, taxiways, runways, and airspace up to 5 nm from airport)
- Three ATC controller posts
  - Local controller (runways and landing areas)
  - Ground control (taxiways and aprons)
  - Clearance delivery (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

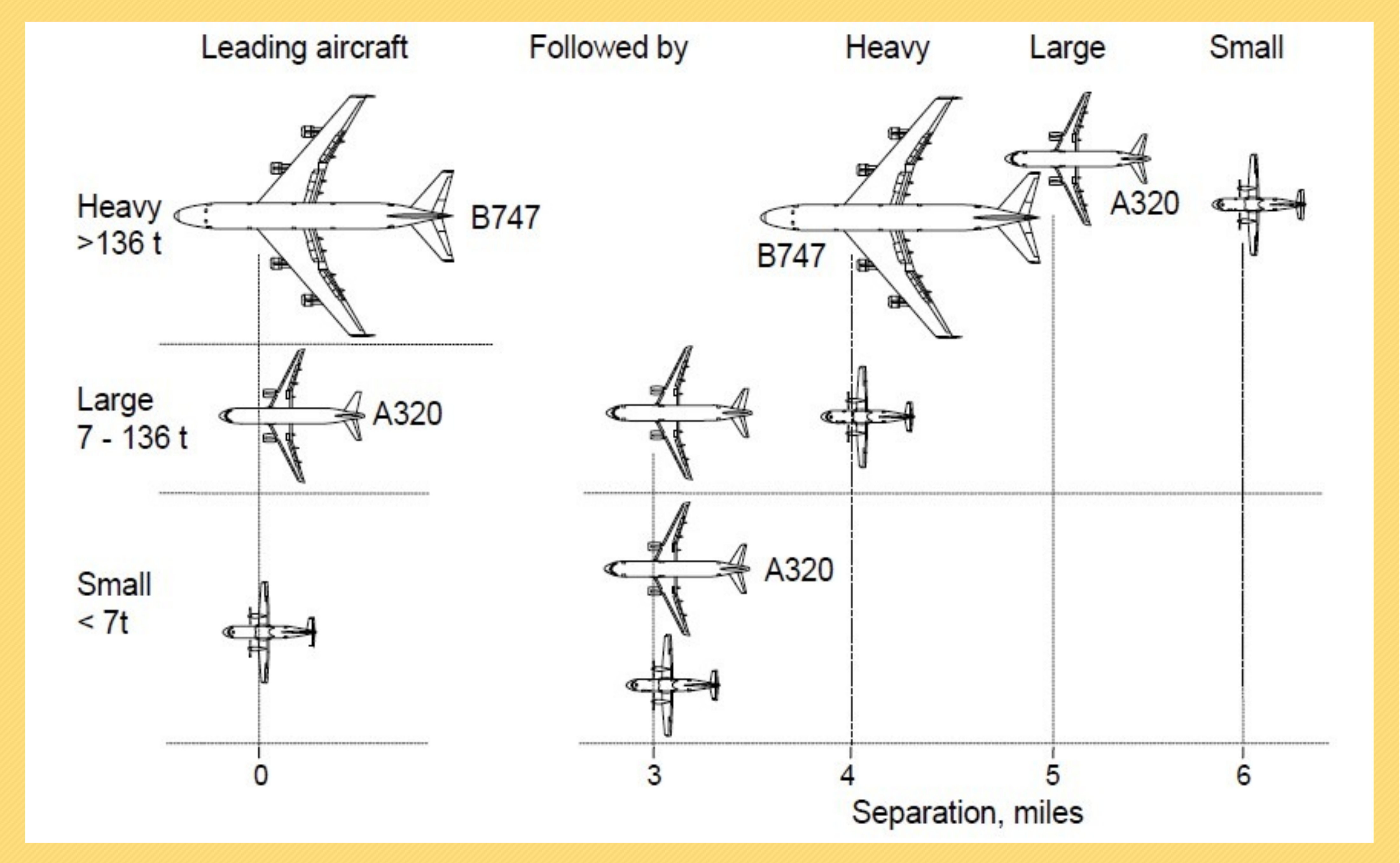
Airspace criteria are intrinsically used for runway separations:

- 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

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

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**

Source: FAA Order JO 7110.126A

WAKE TURBULENCE APPLICATION

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

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

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

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

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

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

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

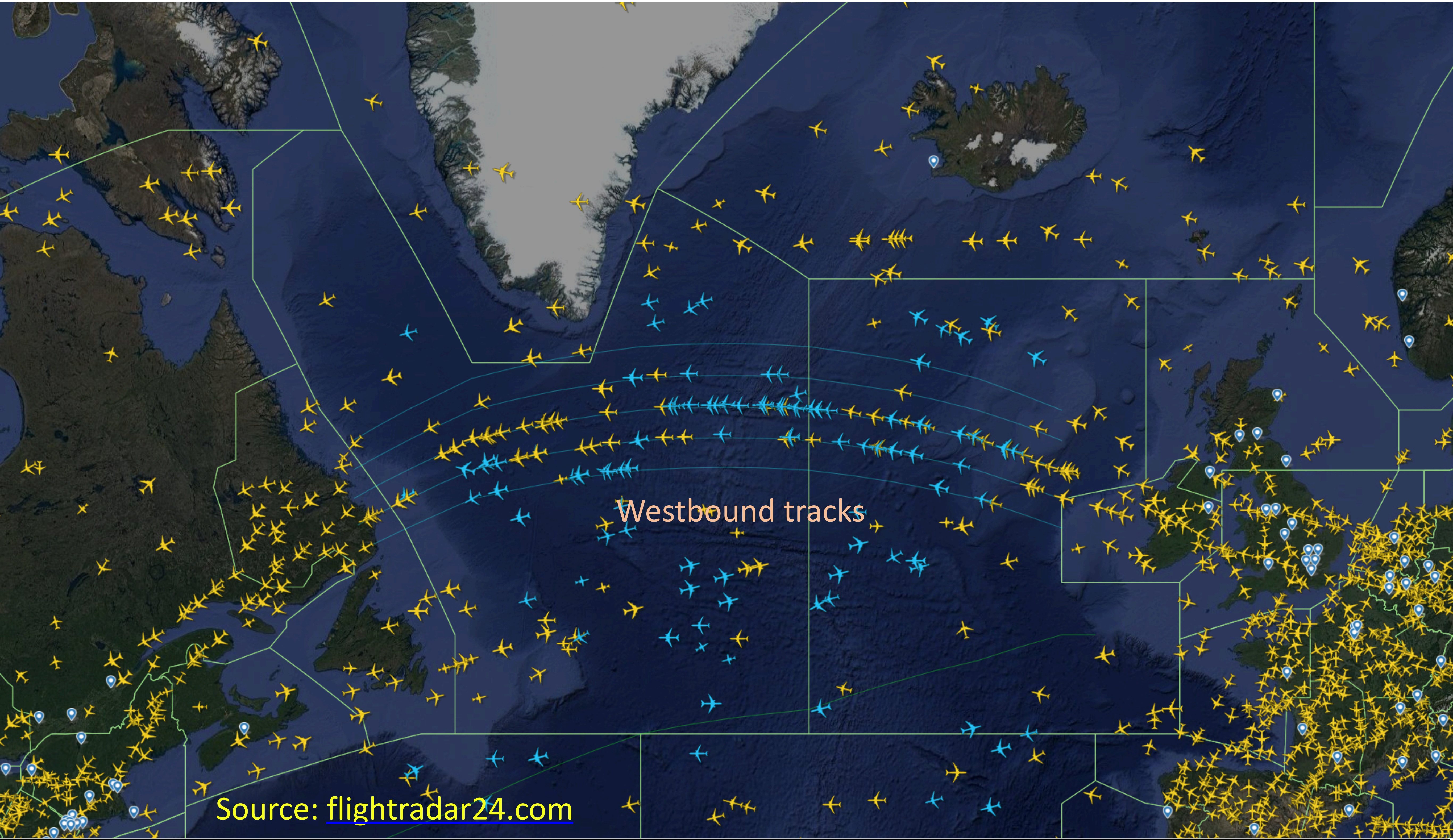
Lead Aircraft	Trailing Aircraft				
	Superheavy	Heavy	B757	Large	Small
Superheavy	120	120	120	120	120
Heavy	120	120	120	120	120
B757	120	120	120	120	120
Large	60	60	60	60	60
Small	60	60	60	60	60

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



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)

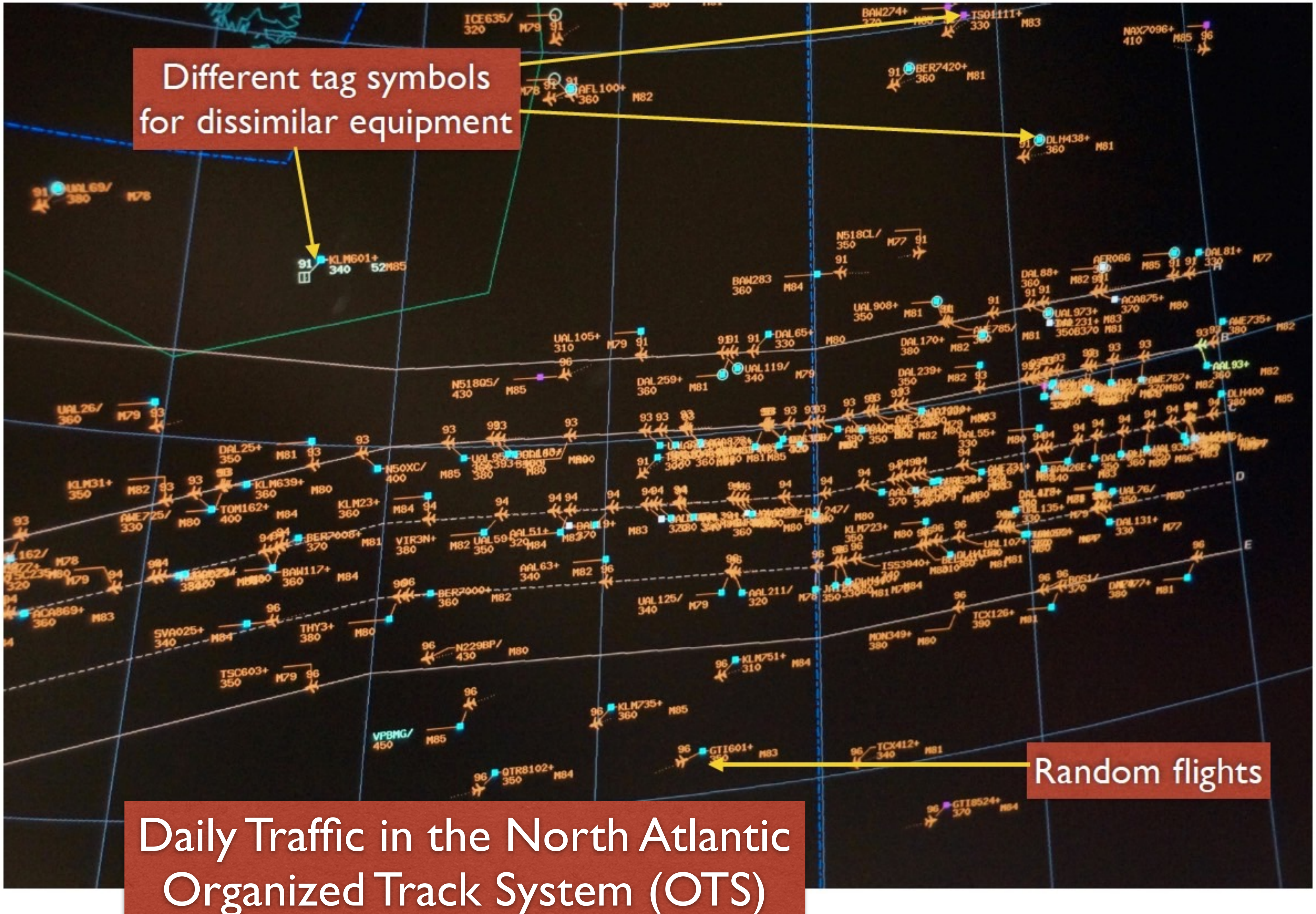
Check videos on the internet by Eurocontrol and Duncan Aviation:

https://www.youtube.com/watch?v=EK87g6NIcyk

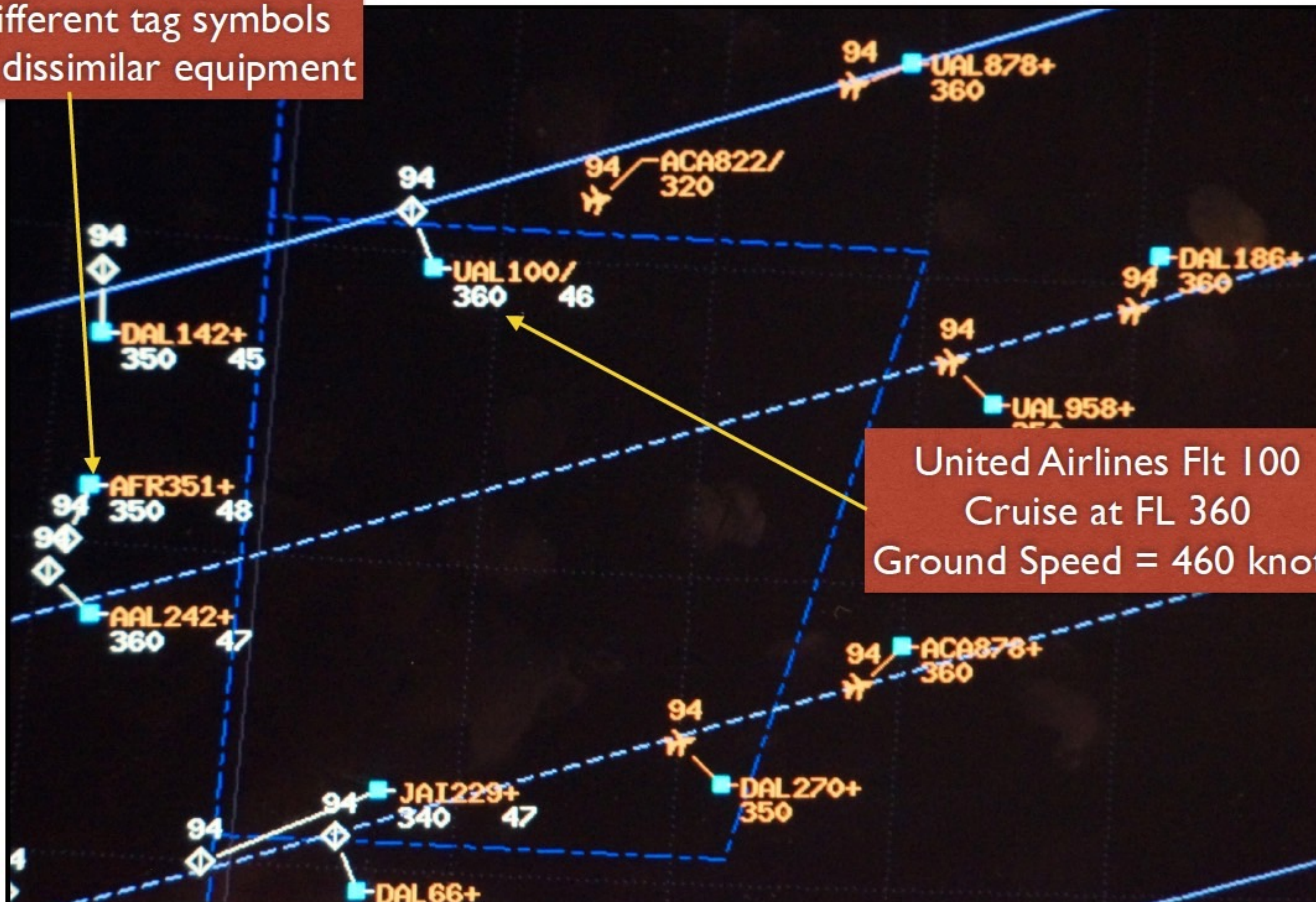
https://www.youtube.com/watch?v=KTqe5nQeWV0

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.

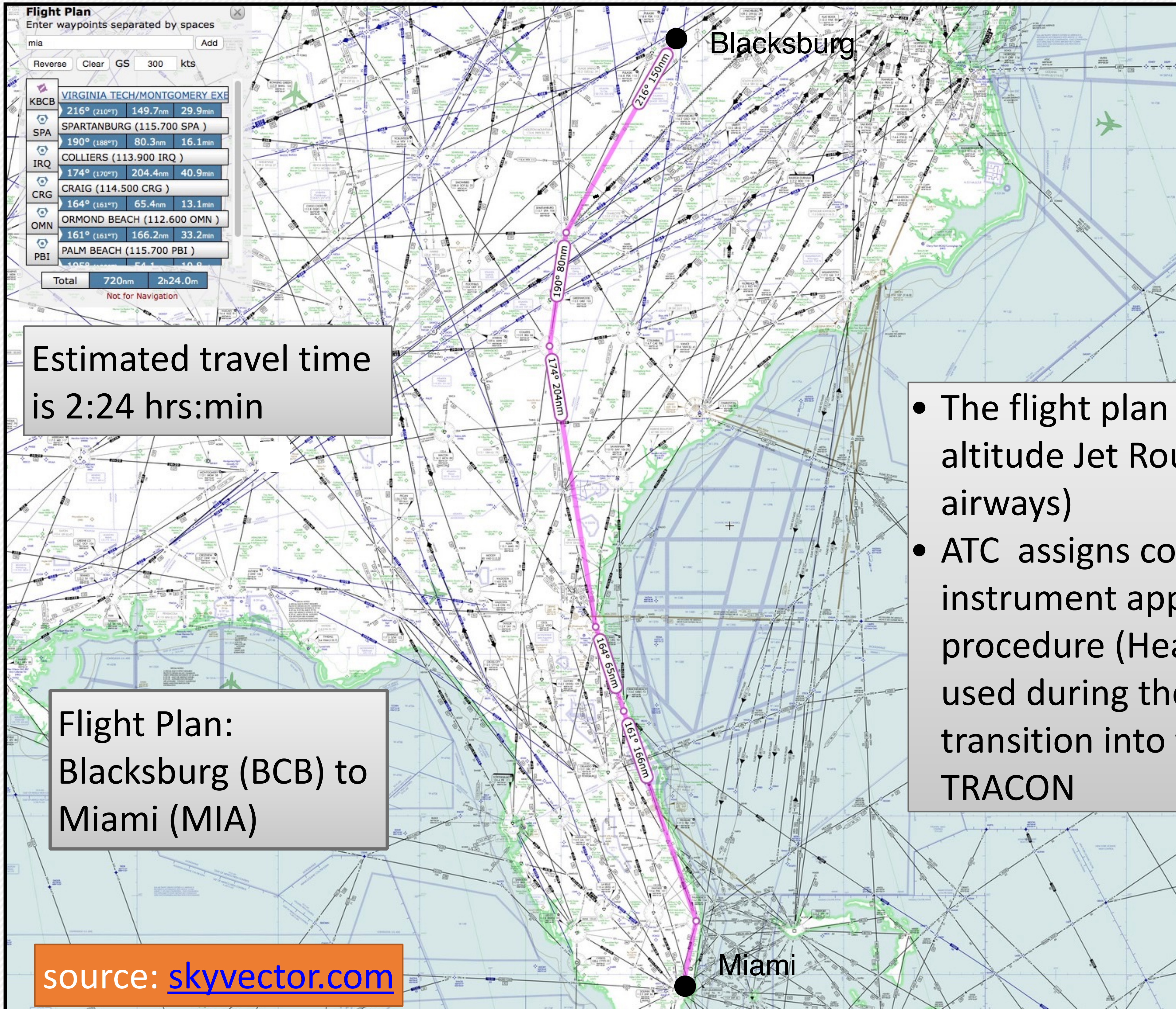
Phase 2 – To Be Determined – introduce 25 NM lateral separation by implementing ½ degree spacing through the entire NAT Organised Track System (OTS), within the vertical limits applicable to the airspace associated with the NAT Region Data Link Mandate; only aircraft with the appropriate RNP approval, 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



Estimated travel time is 2:24 hrs:min

Flight Plan: Blacksburg (BCB) to Miami (MIA)

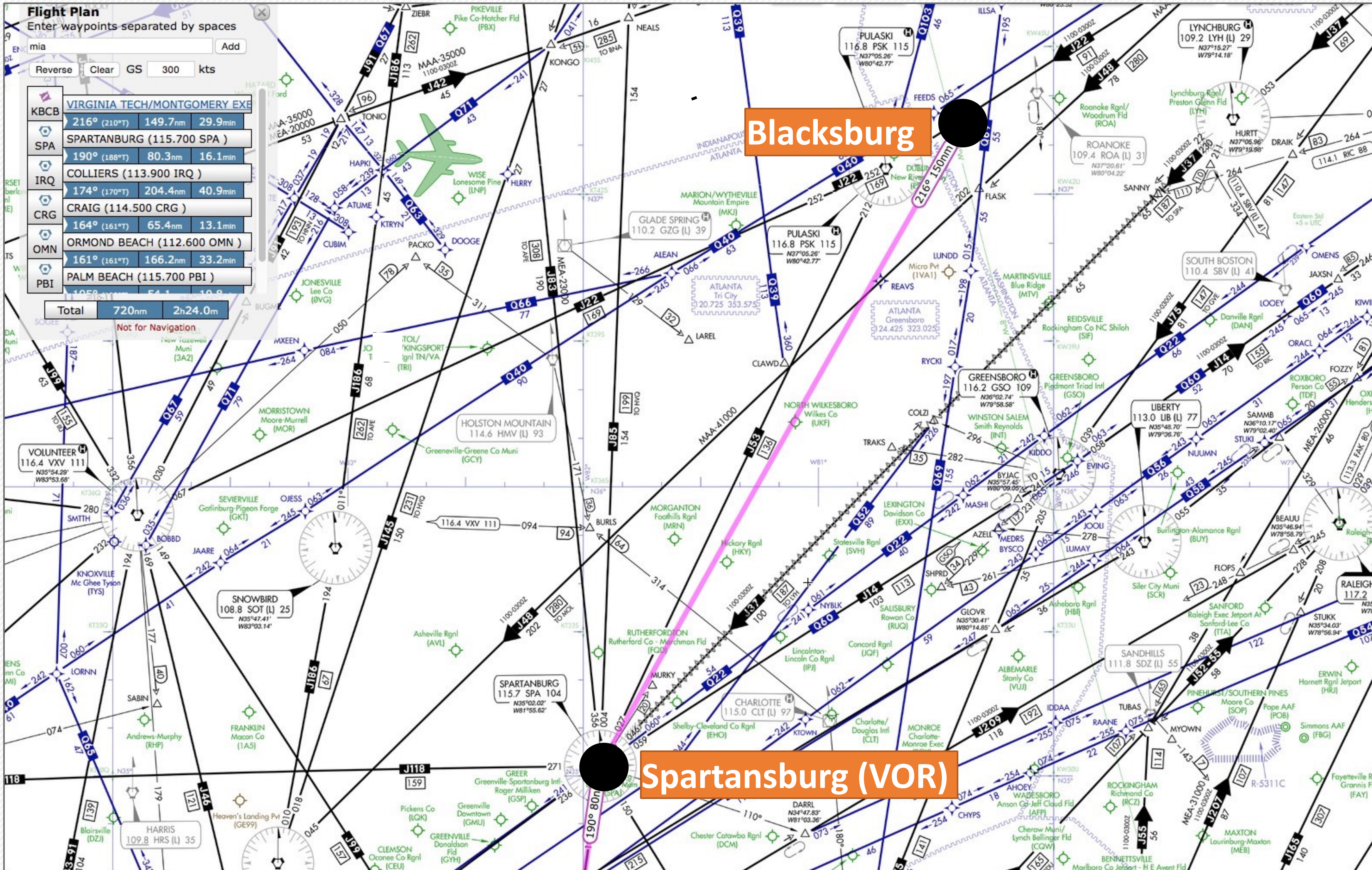
source: skyvector.com

- 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)

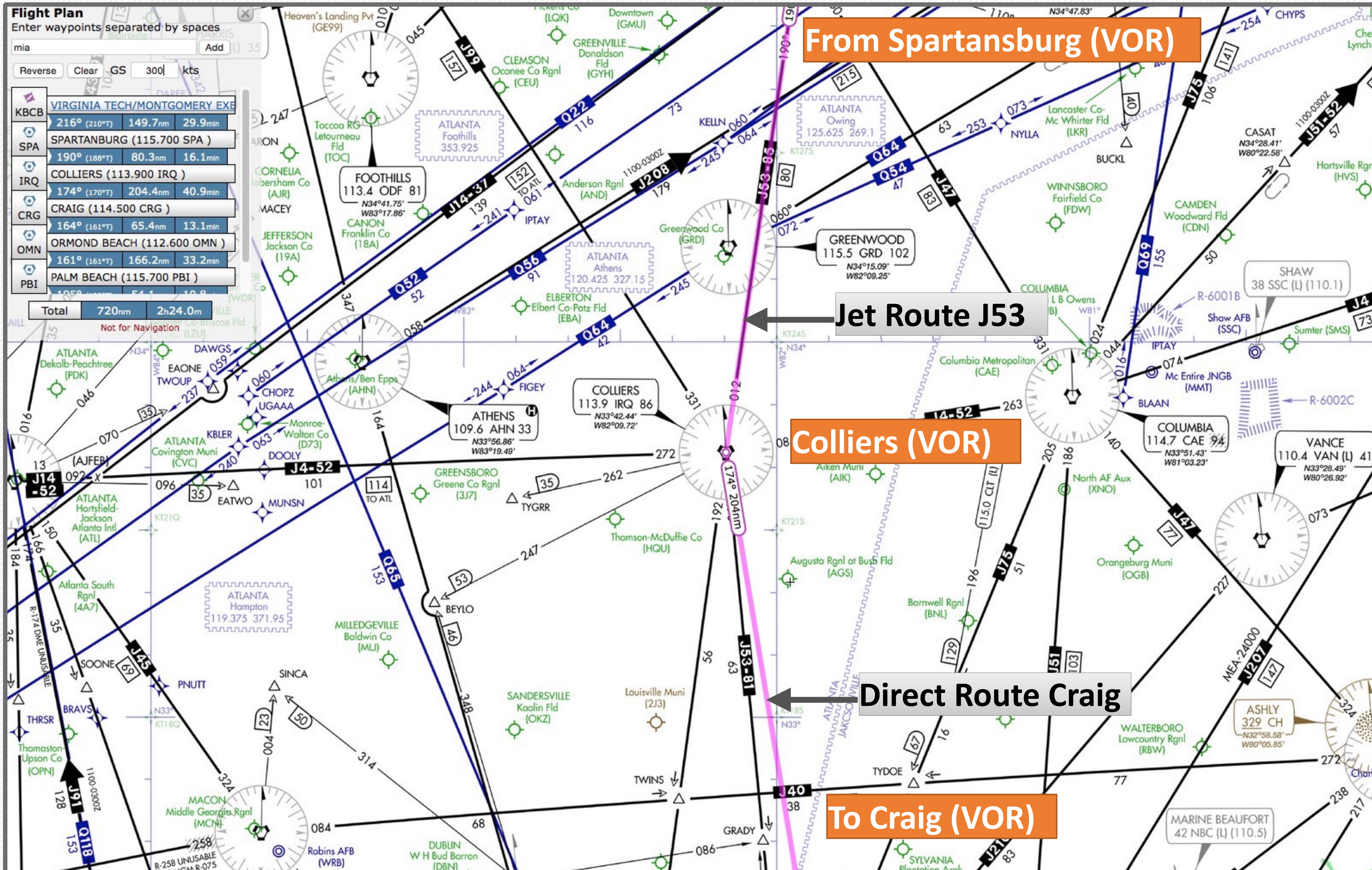
Details of the Flight Plan



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

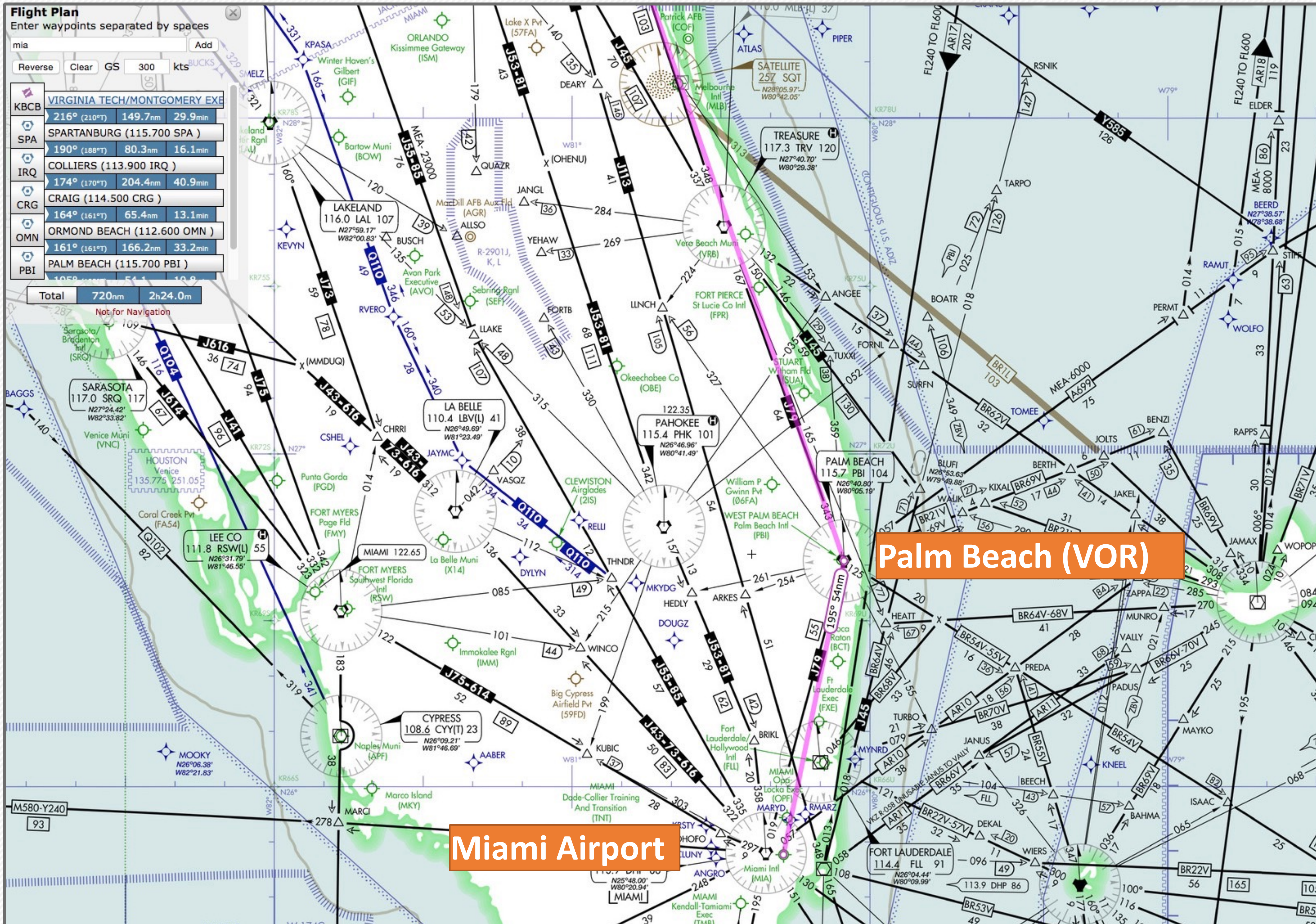
Details of the Flight Plan



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

Runway Separations at Airports Depend on Airport Surveillance Technology

The same technology used to establish the position of aircraft in the airspace is used to perform surveillance activities near airports

- Radar technology has inherent weaknesses for surveillance
- The farthest from the antenna, the larger the uncertainty to determine accurate positions
- Primary radar (skin paint)
- Secondary radar (transponder inside aircraft - Modes C and S)

Independent Instrument Landing System (ILS Precision Approaches)

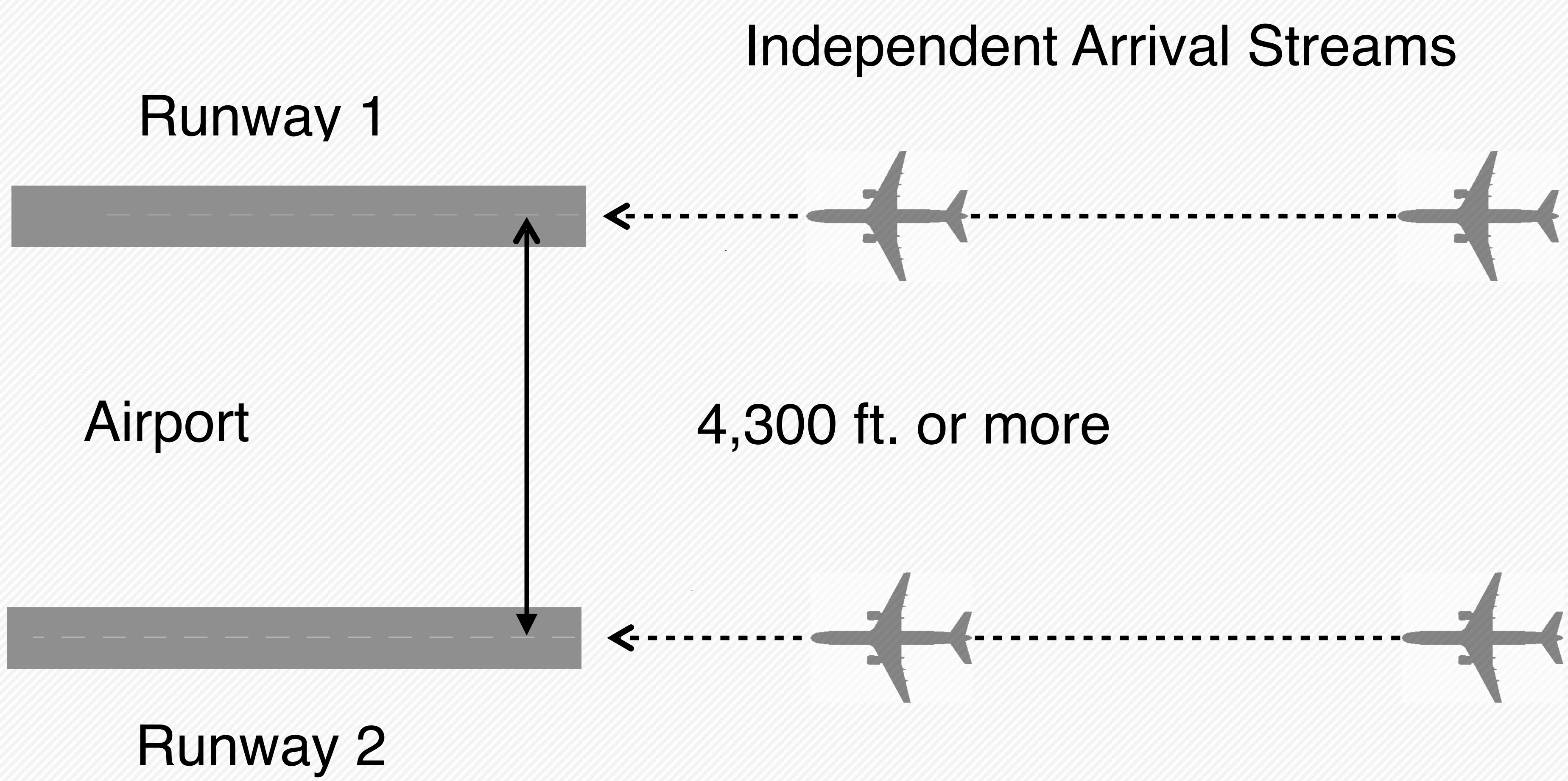
In 2013 FAA amended the rule so that independent close parallel approaches can be conducted down to 3,600 feet without fast scan radar

IFR operational conditions

4,300 ft. between runway centerlines

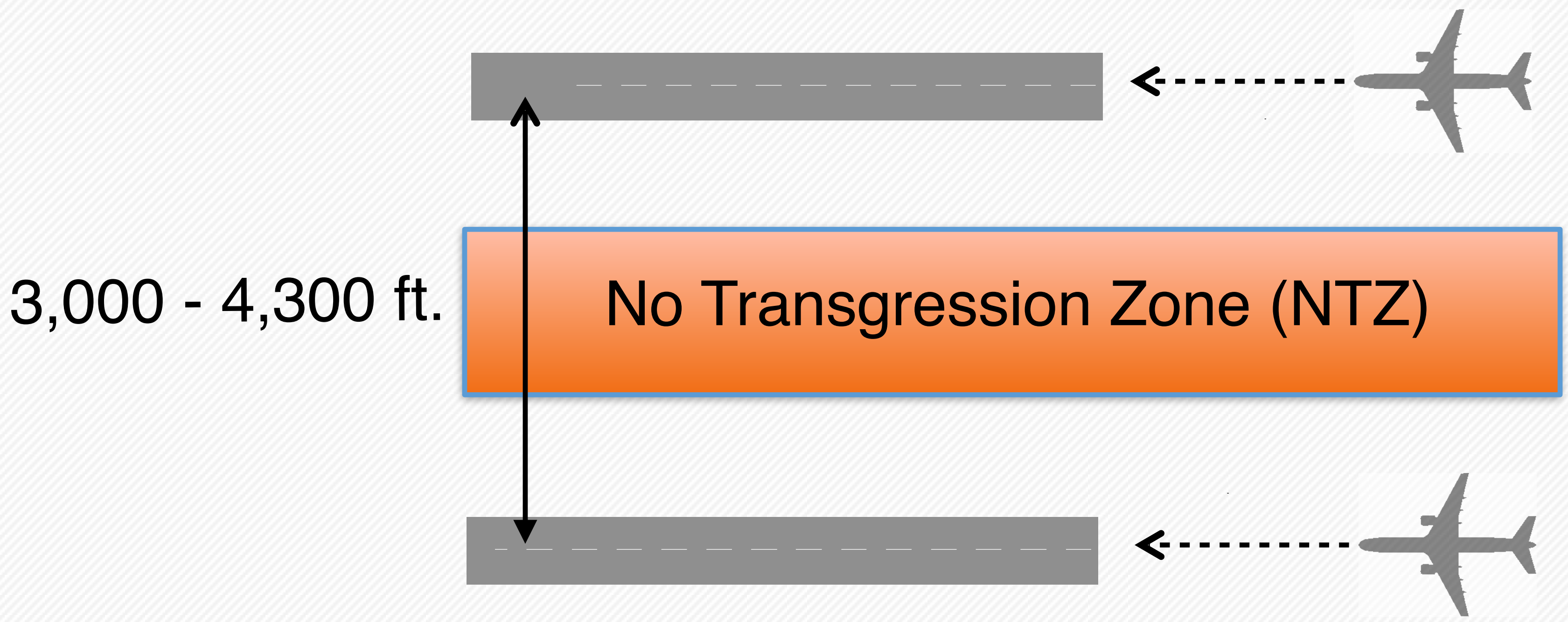
Standard radar system (scan rate of 4 seconds)

Radar surveillance is available



Independent Parallel Approaches using the Precision Runway Monitor (PRM) under IFR 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

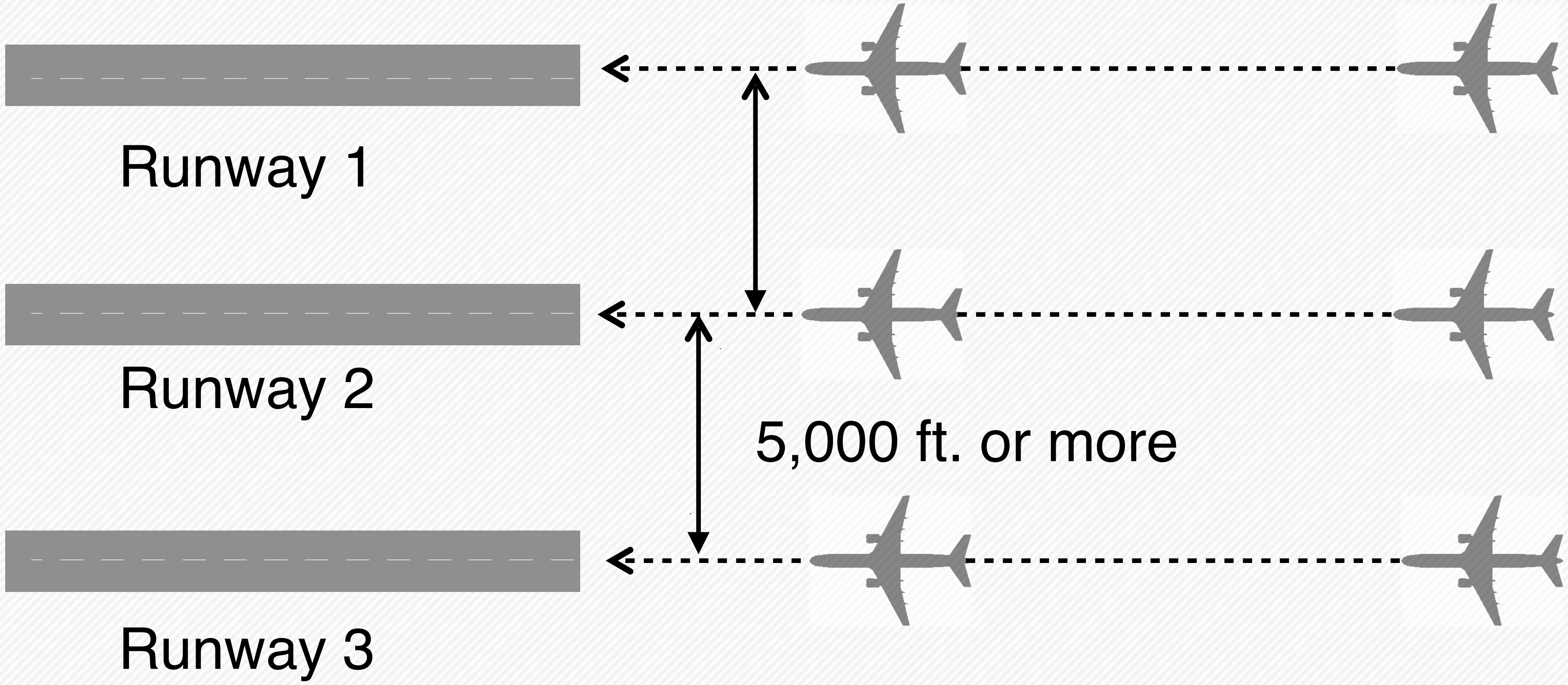


Implications of PRM System

- Two pieces of software and hardware comprise the PRM system:
  - Air Traffic Controller display (shows the aircraft blips plus the NTZ - No Transgression Zone (NTZ)
  - Fast scanning radar (with tau <= 1.0 seconds)
- This system reduces the uncertainty of knowing where aircraft are (i.e., thanks to its fast scan rate)

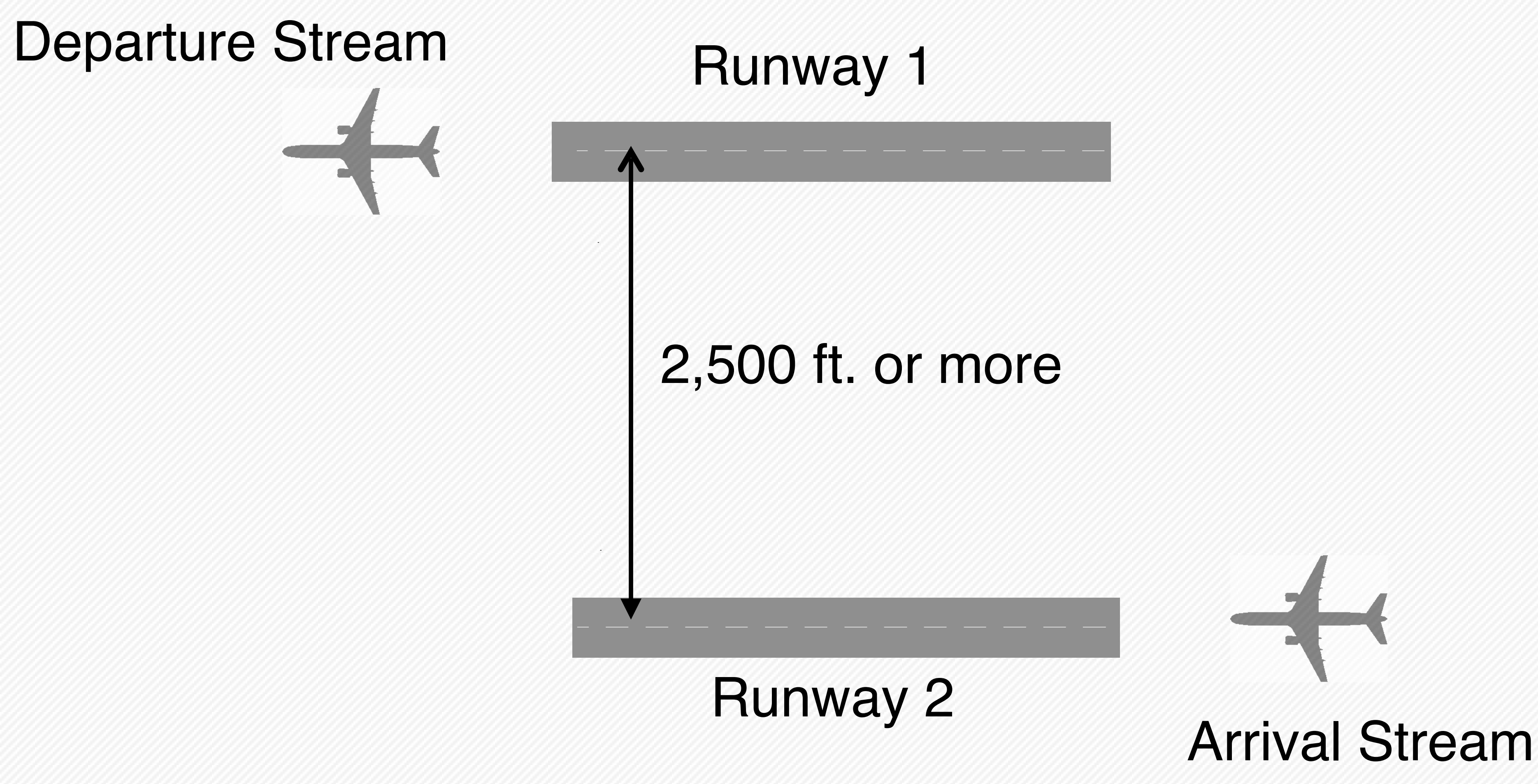
Independent Triple and Quadruple Approaches To Parallel Runways (IFR)

- 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.



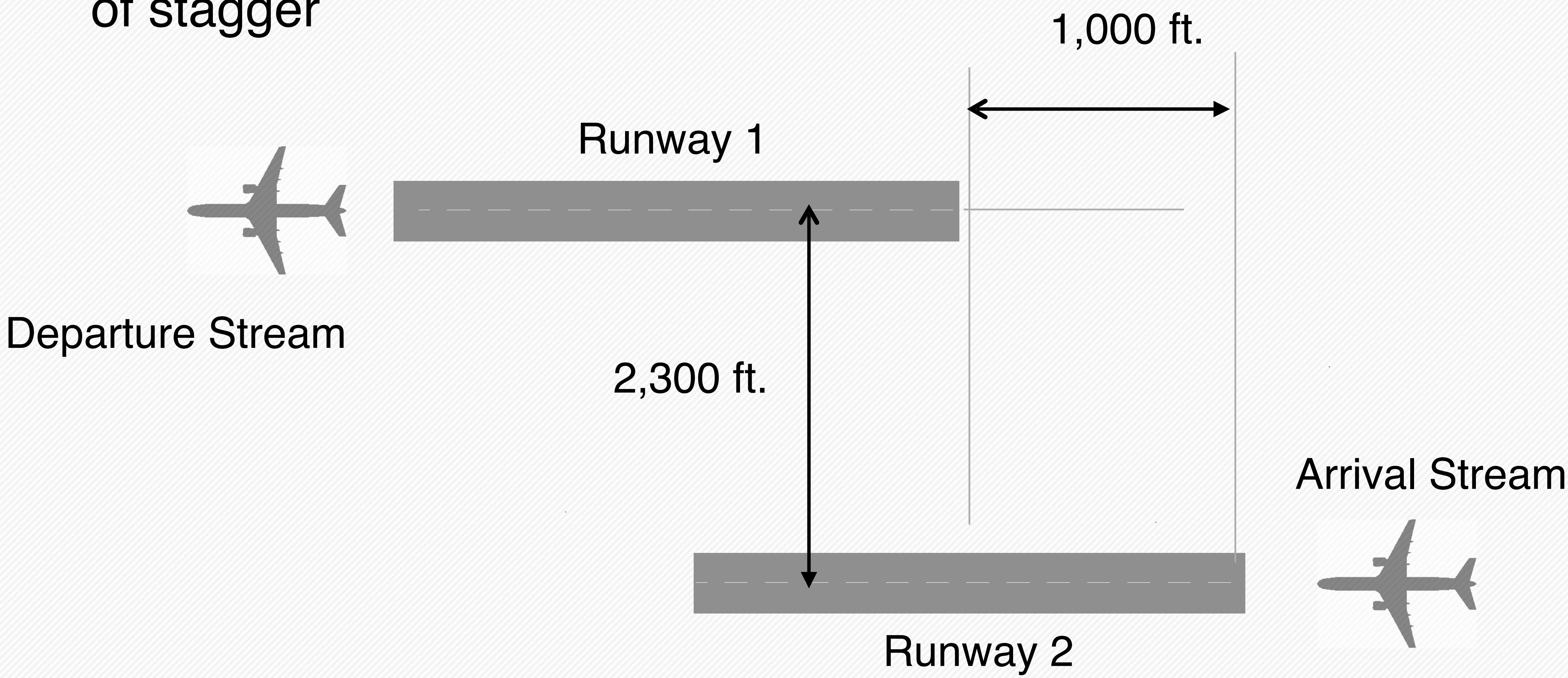
Independent Departures and Arrivals in IFR Conditions and Standard Radar (Radar Scan Rate = 4.8 s.)

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



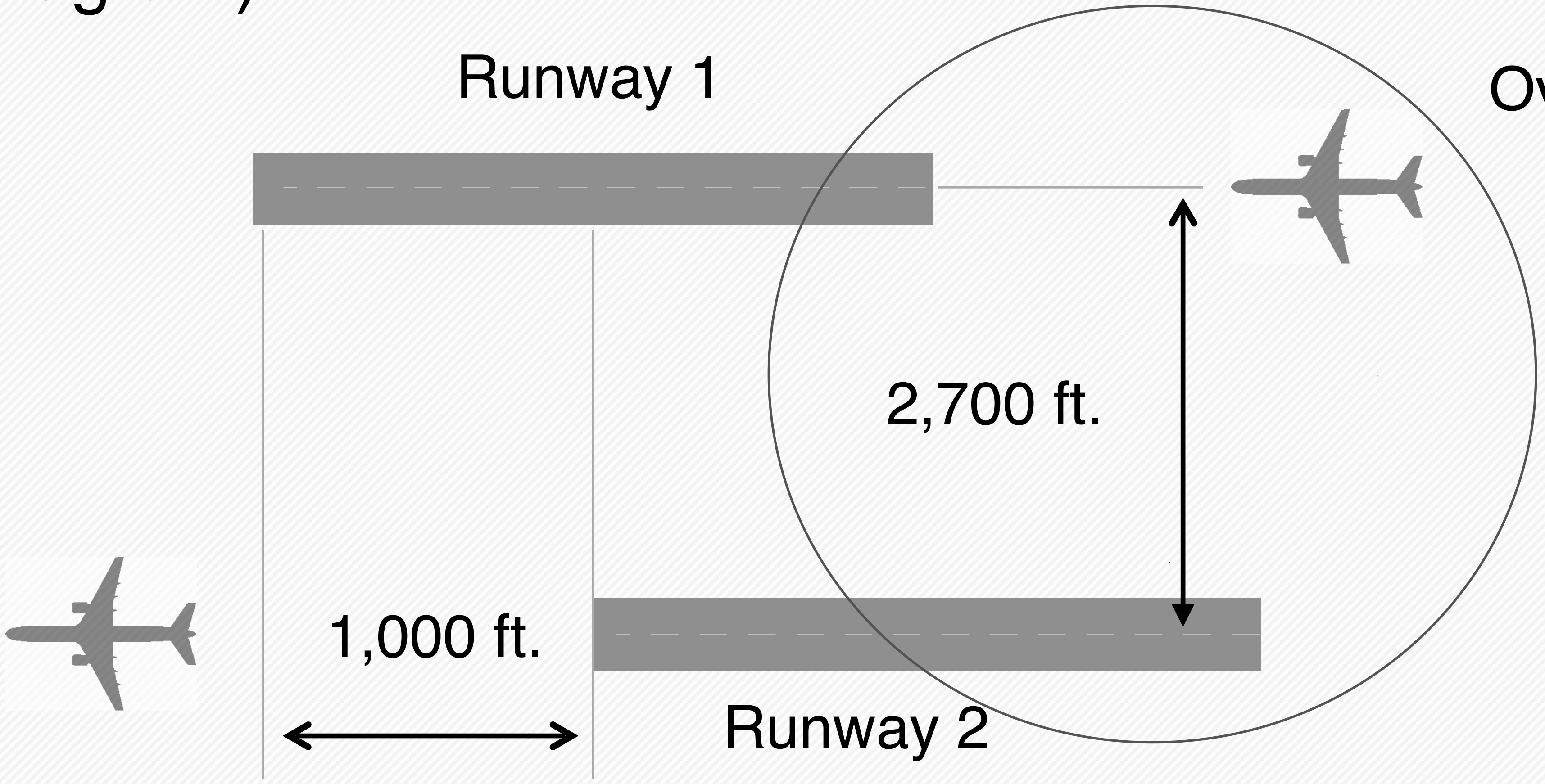
Staggered Runways Rule (Decreasing Separation)

- 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



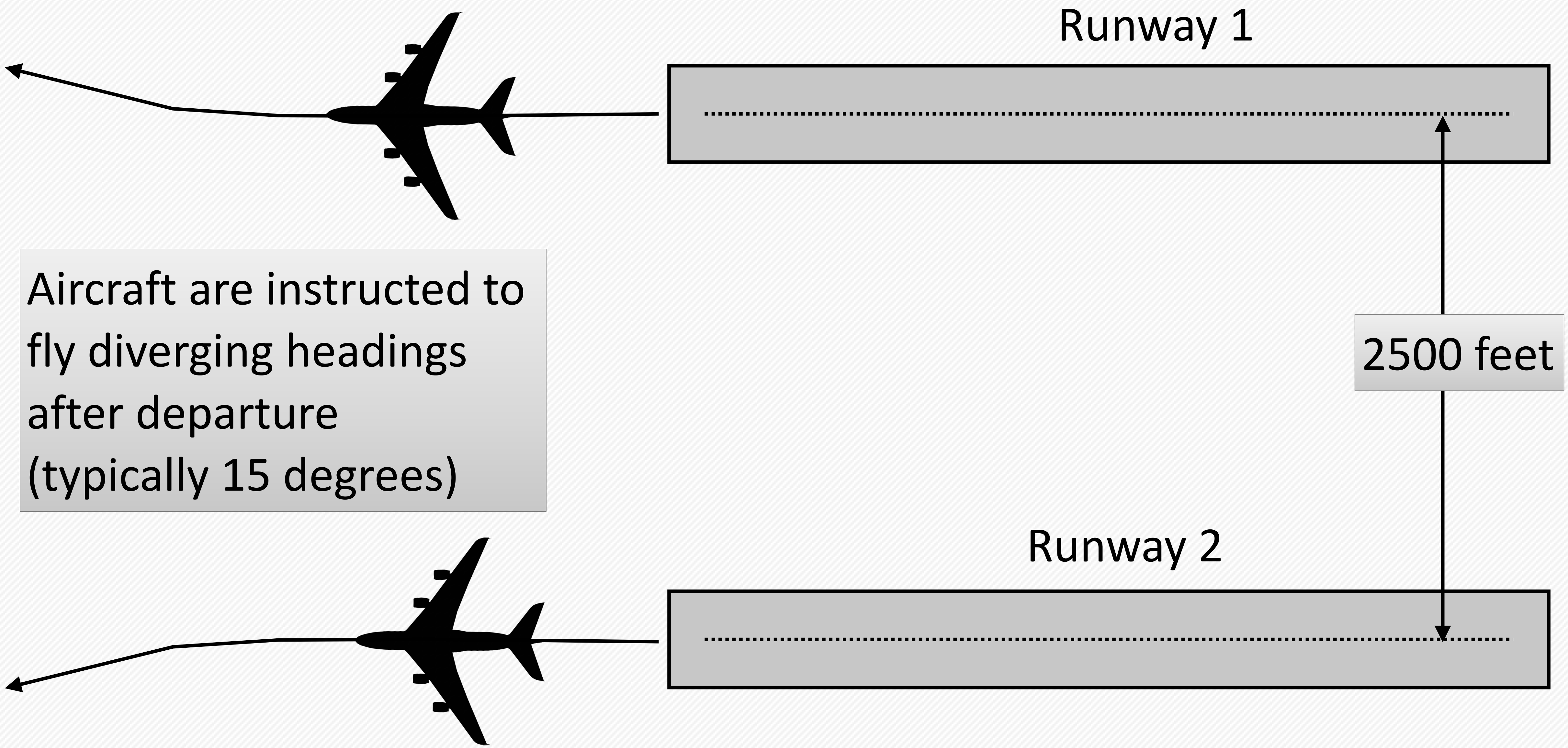
Staggered Runways Rule (Increasing Runway Centerline Separation)

- 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)



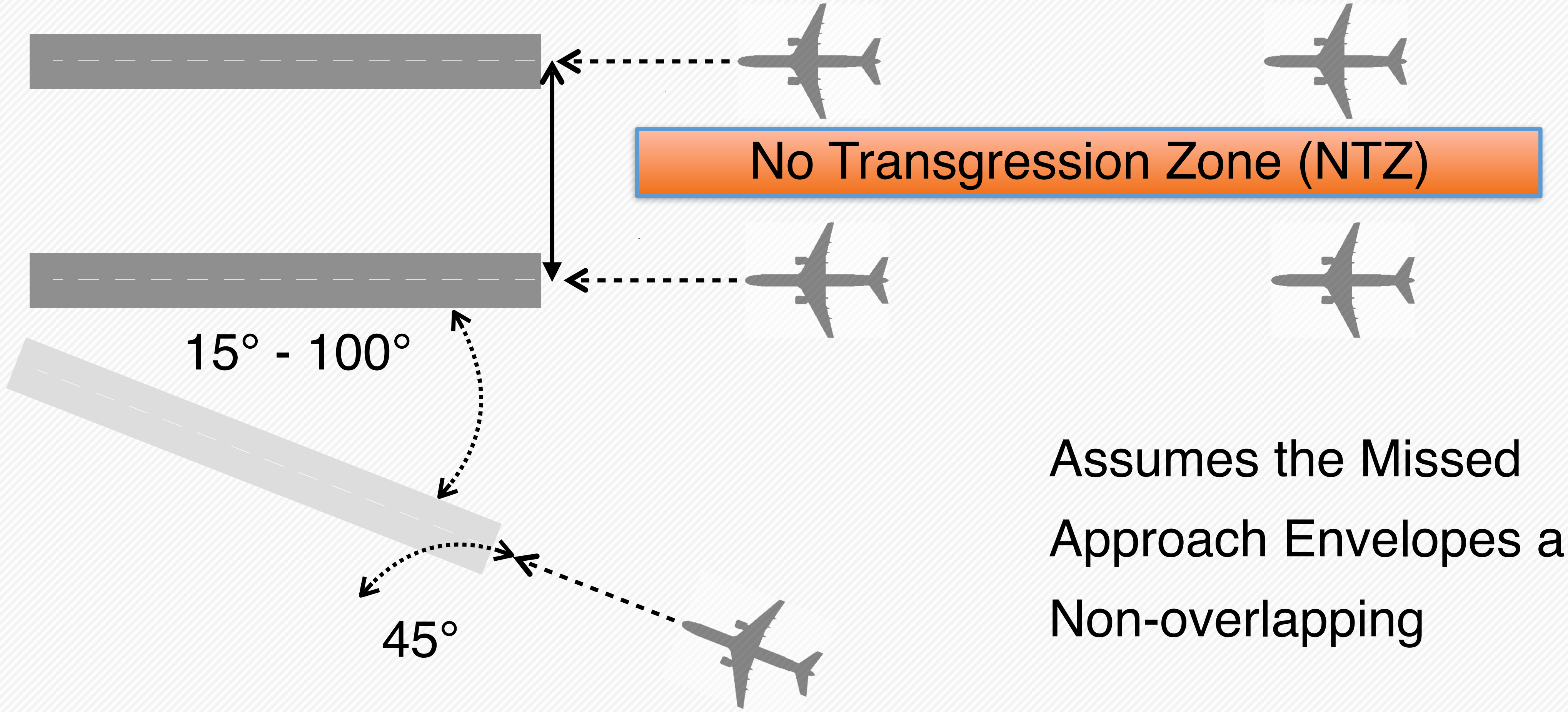
Simultaneous Independent Departures

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



Independent Simultaneous Approaches to Converging Runways

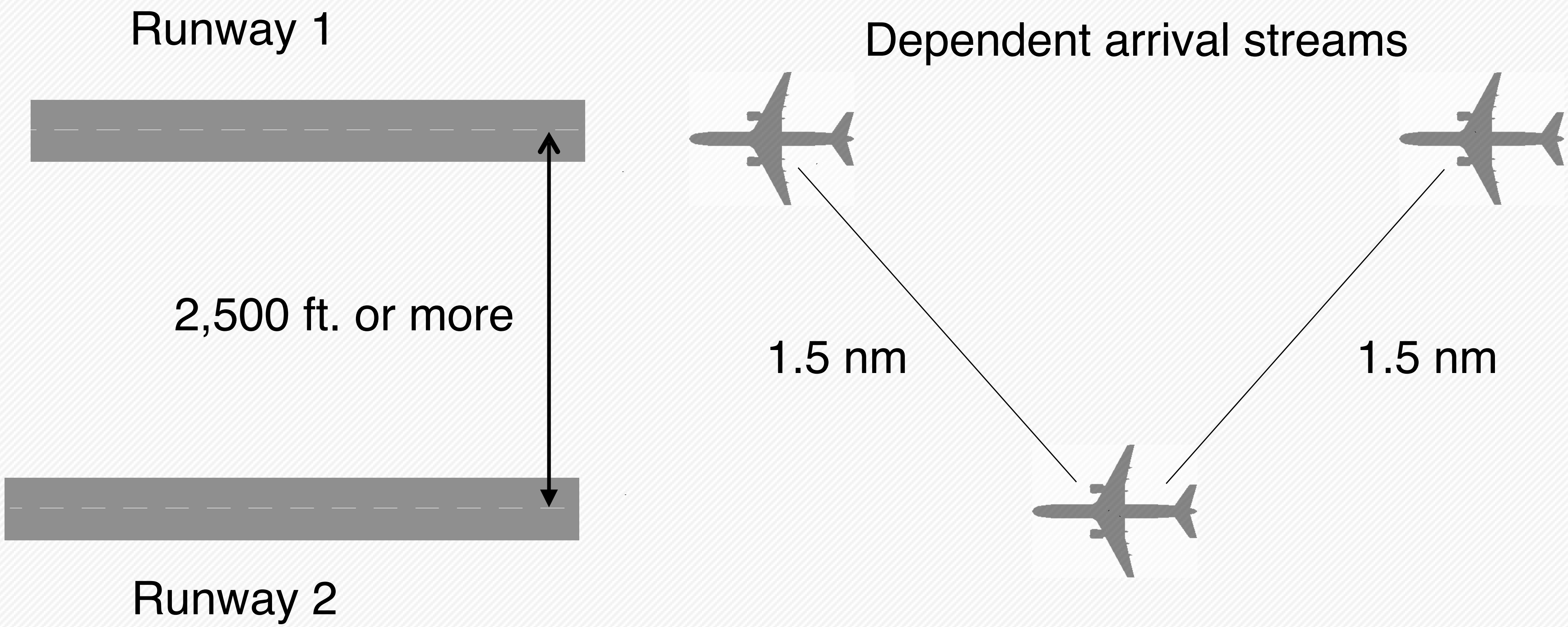
- Procedures governing independent converging approaches require that the distance between the missed approach points be 3 n.m.
- Terminal Instrument Procedures (TERPS) surfaces not overlap
- Because of these restrictions, the approach minimums are high, thereby limiting the number of airports that take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



Assumes the Missed Approach Envelopes are Non-overlapping

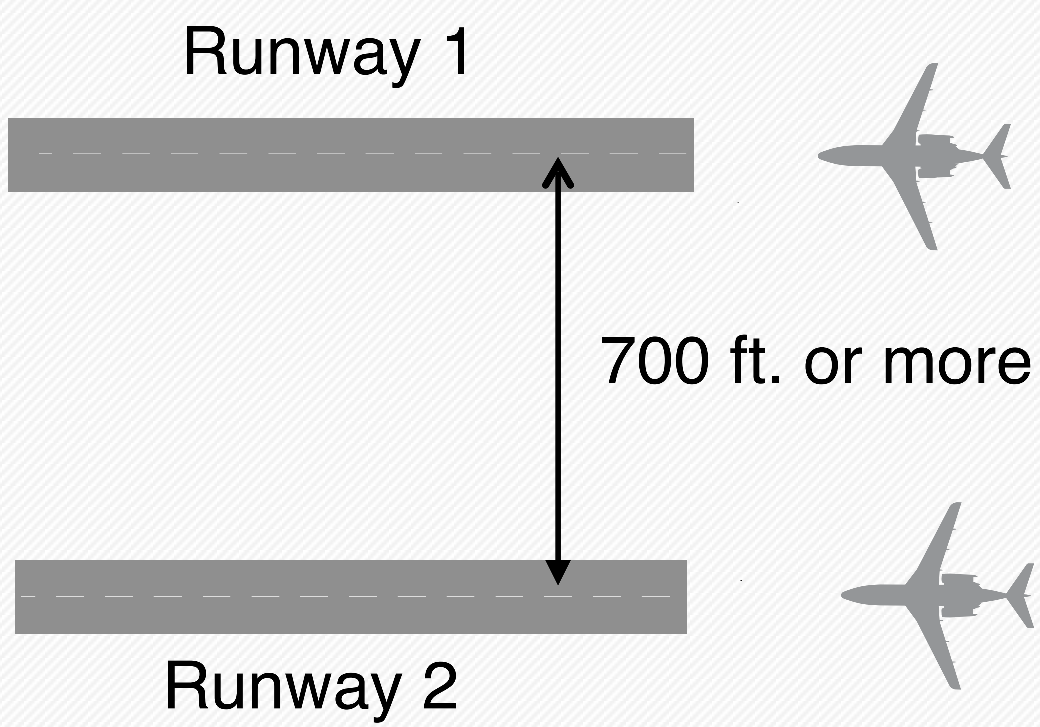
Dependent Approaches to Parallel Runways (IFR)

- 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

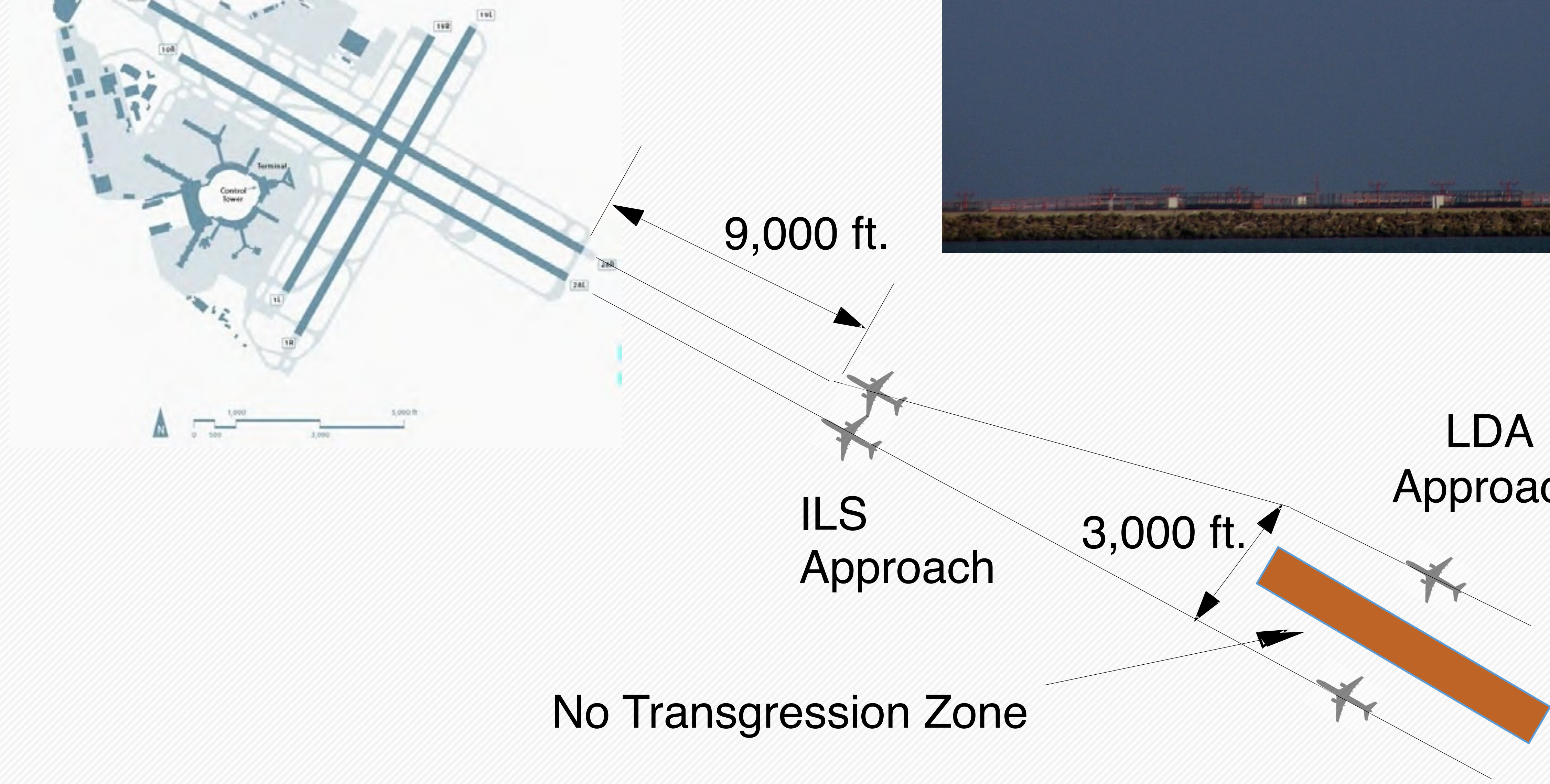
No wake vortex effect (seldom the case)

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

Simultaneous Offset Instrument Approaches (SOIA)

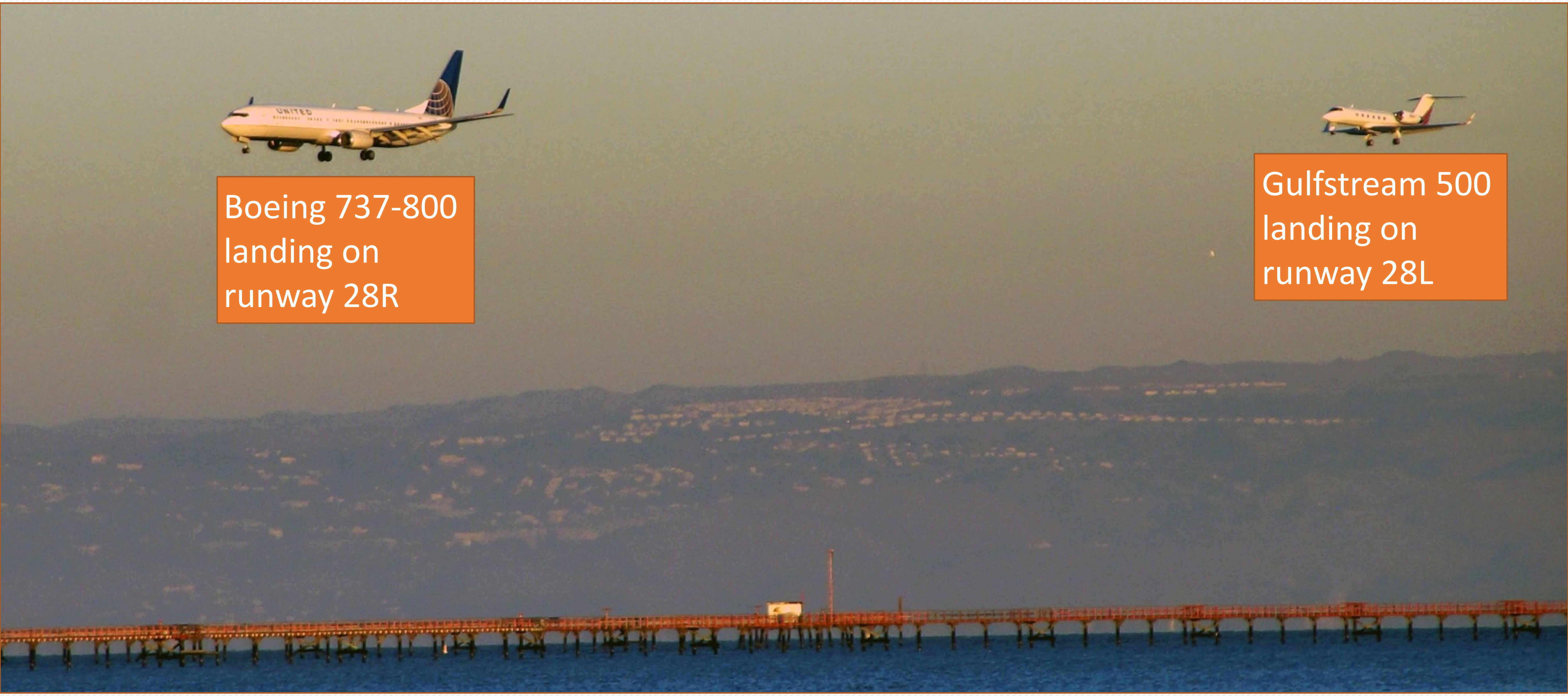
- Allows simultaneous approaches to runways spaced less than 3,000 ft. but more than 750 ft.
- San Francisco International airport was the first airport approved for the procedure (see diagram on next page)
- Requirements:
  - Pilot training
  - Dual communications
  - ATC software/hardware (PRM radar)

Simultaneous Offset Instrument Approaches (SOIA)



Runway Configuration at SFO Airport

Simultaneous Offset Instrument Approaches (SOIA) at SFO



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Simultaneous Offset Instrument Approaches (SOIA) at SFO

- The idea behind SOIA is to bring aircraft side by side to avoid wake effects
- SOIA procedures require special crew training, a PRM radar and ATC instrumentation (i.e., no transgression zone display and alerts)

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

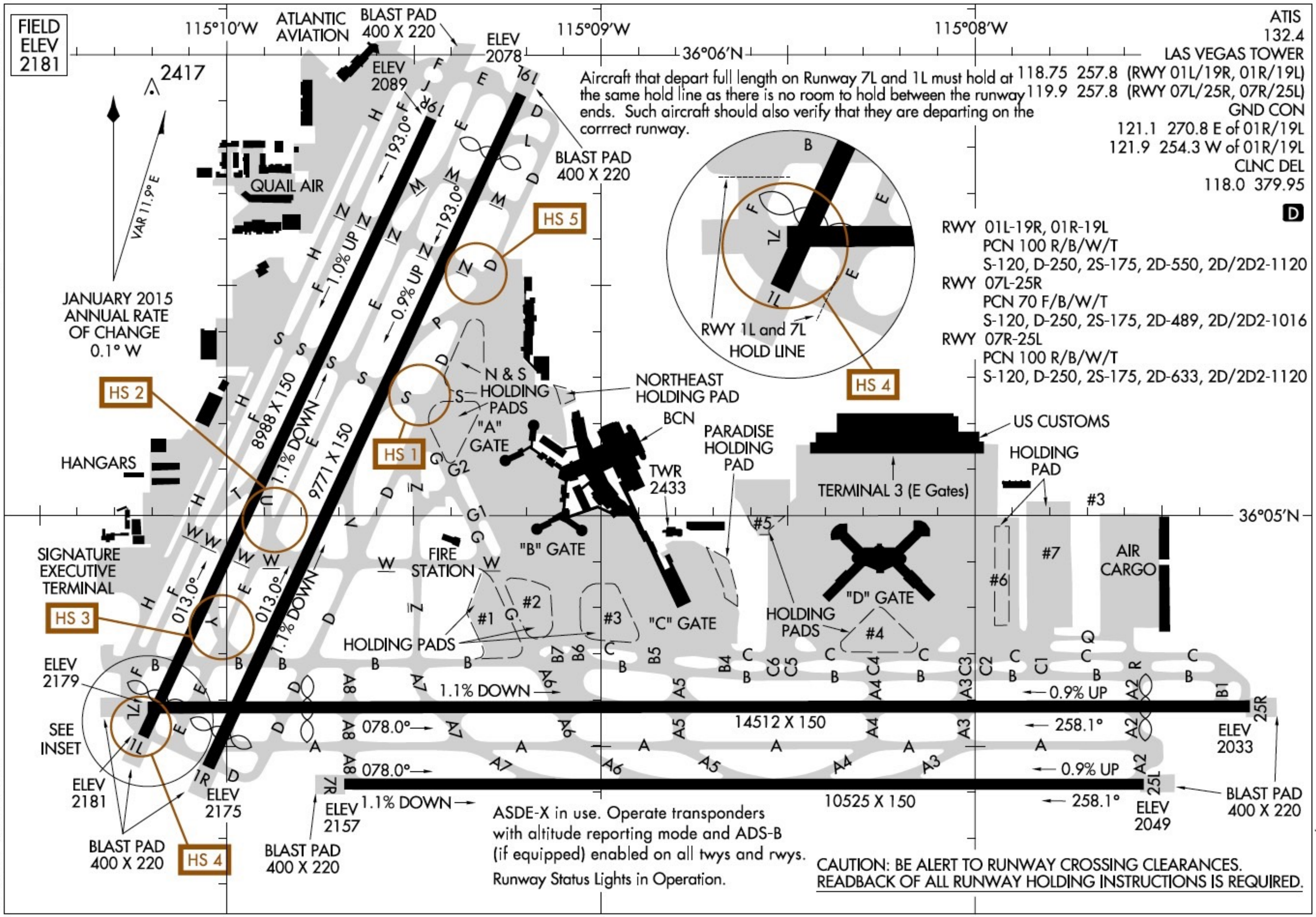
1. **Purpose of This Notice.** This notice amends Federal Aviation Administration (FAA) Order JO 7210.3, Facility Operation and Administration, paragraphs 3-7-3, Display Map Data, and paragraph 10-3-14, Go-Around/Missed Approach.

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

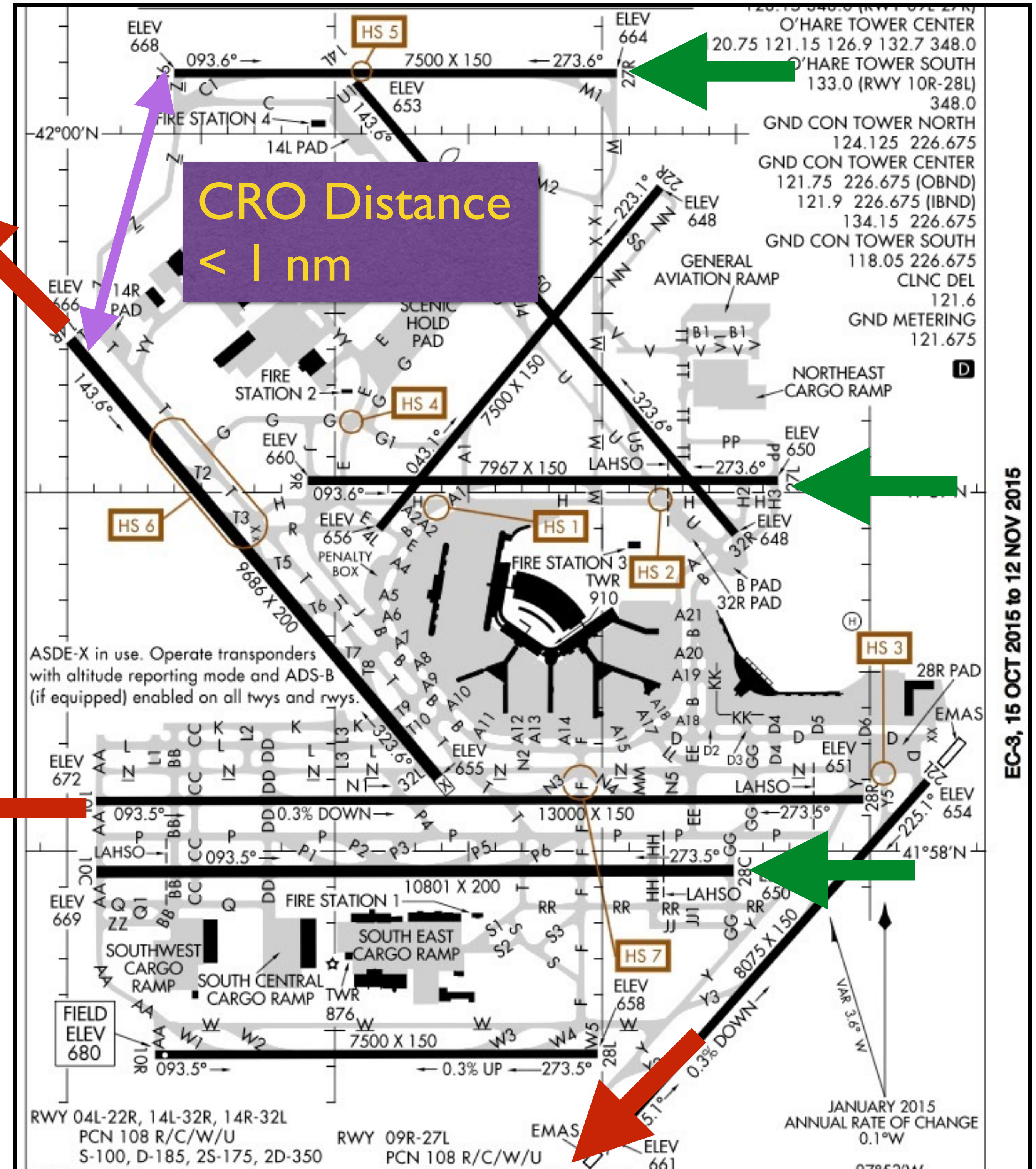
Incident occurred Thursday, July 04, 2013 in Las Vegas, NV
Probable Cause Approval Date: 03/10/2015
Aircraft: GULFSTREAM GIV - UNDESIGNAT, registration:
Injuries: Unavailable

"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)

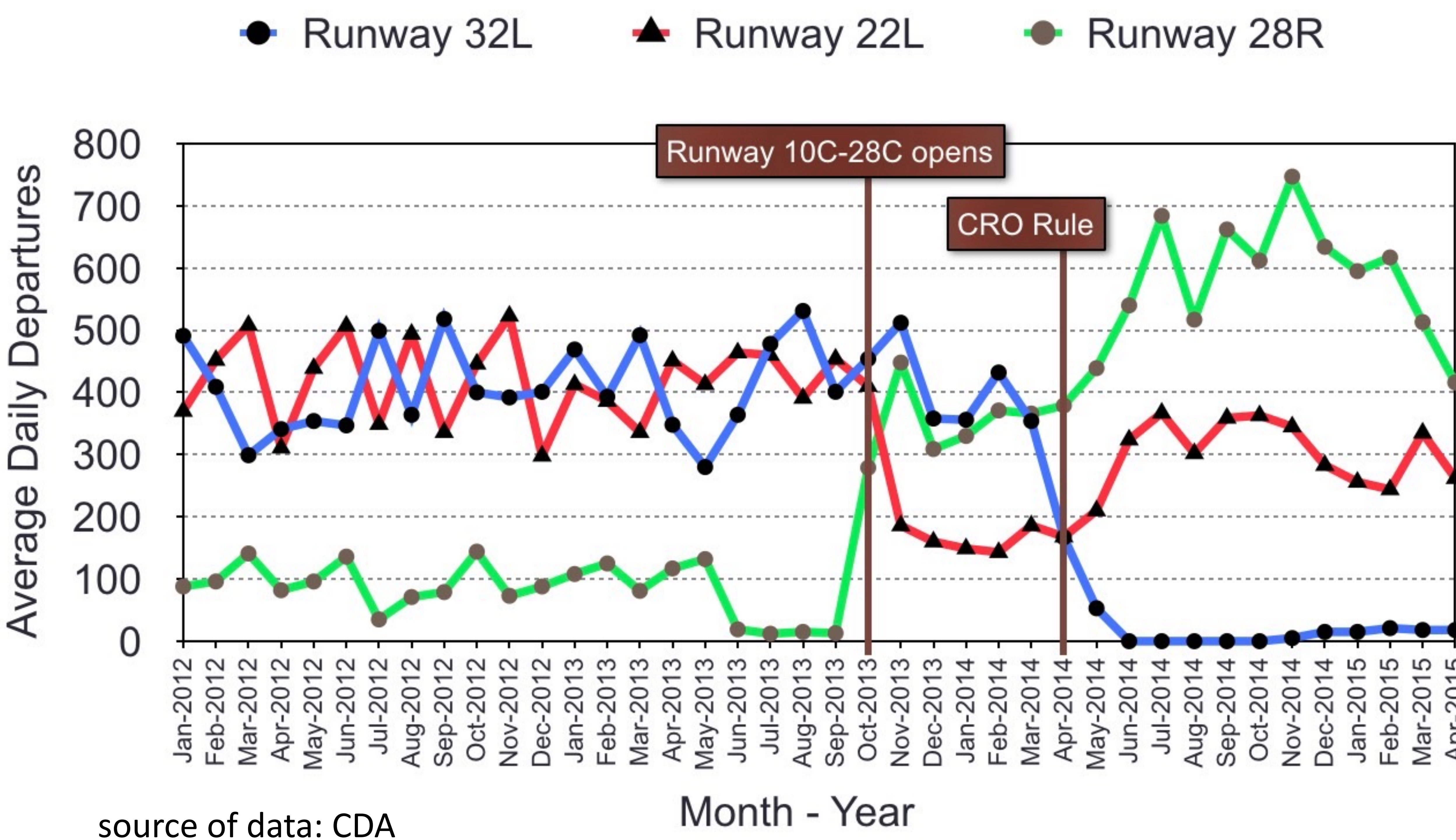
- In the summer 2014, ORD lost 1/3 of its departure capacity for one of the most heavily used configurations
- Runway 32L become almost unusable during daytime hours



Arrival runways (west flow)

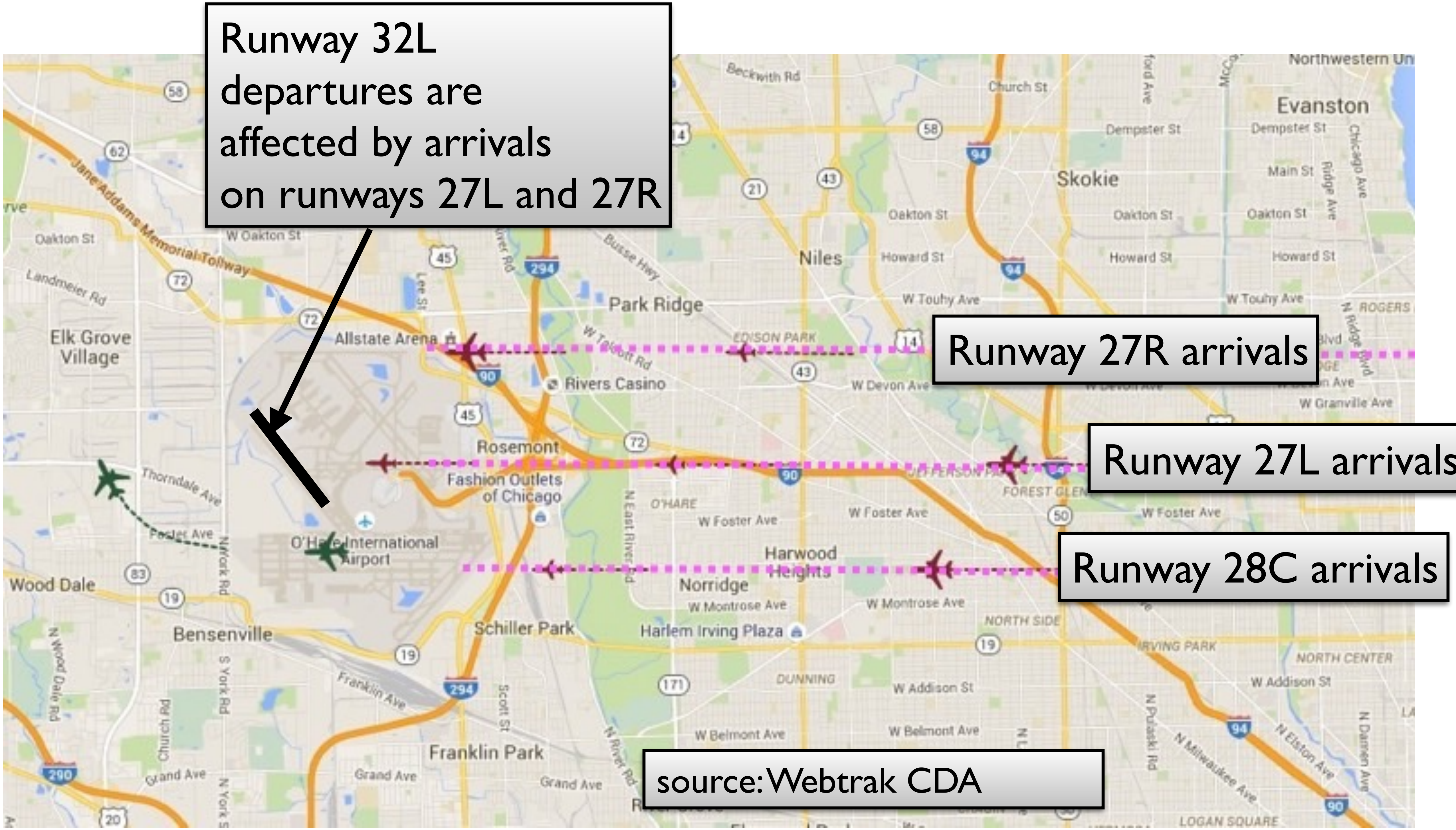
Departure runways (west flow)

Example of CRO Effect (ORD Airport)

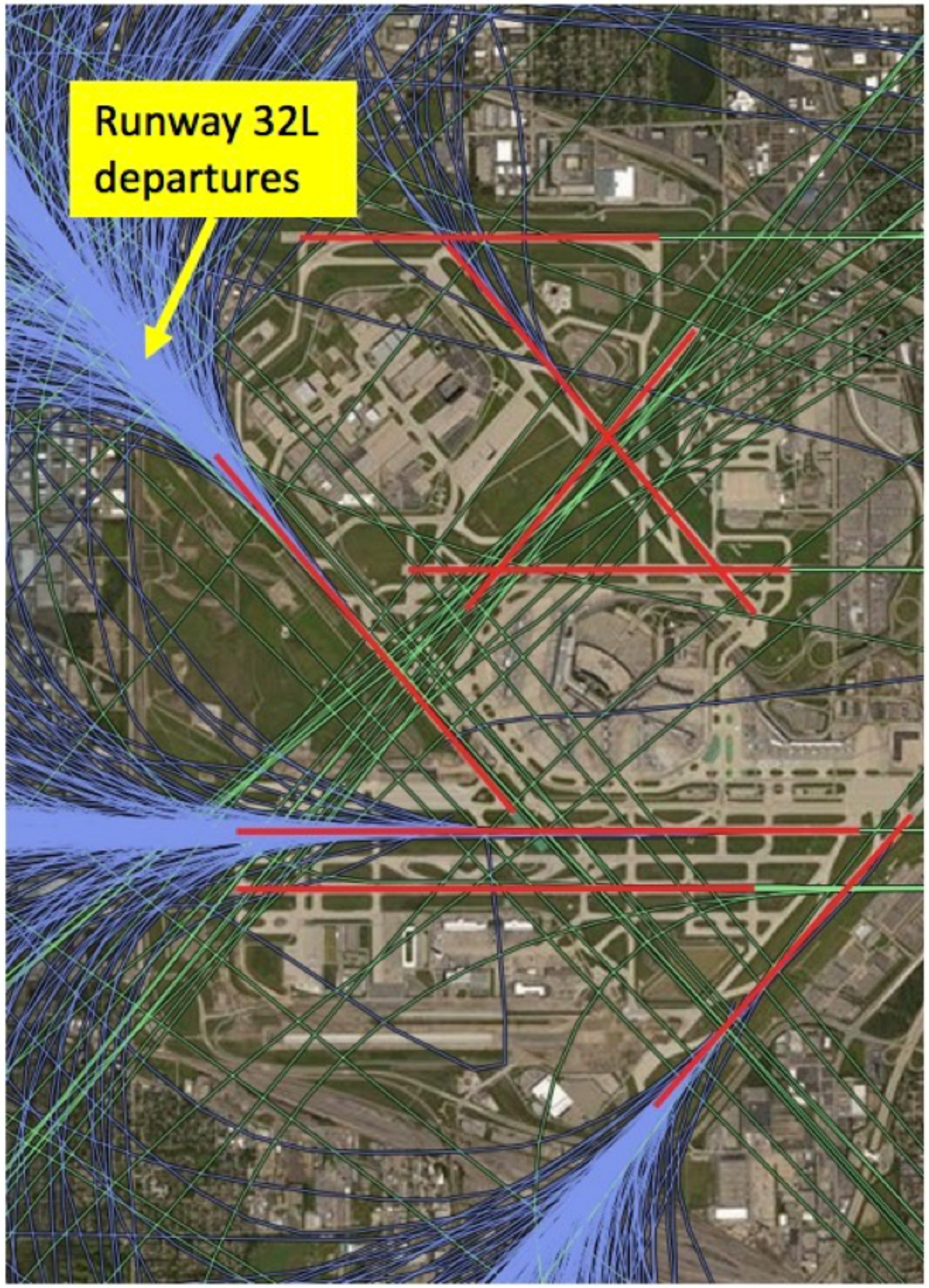


source of data: CDA

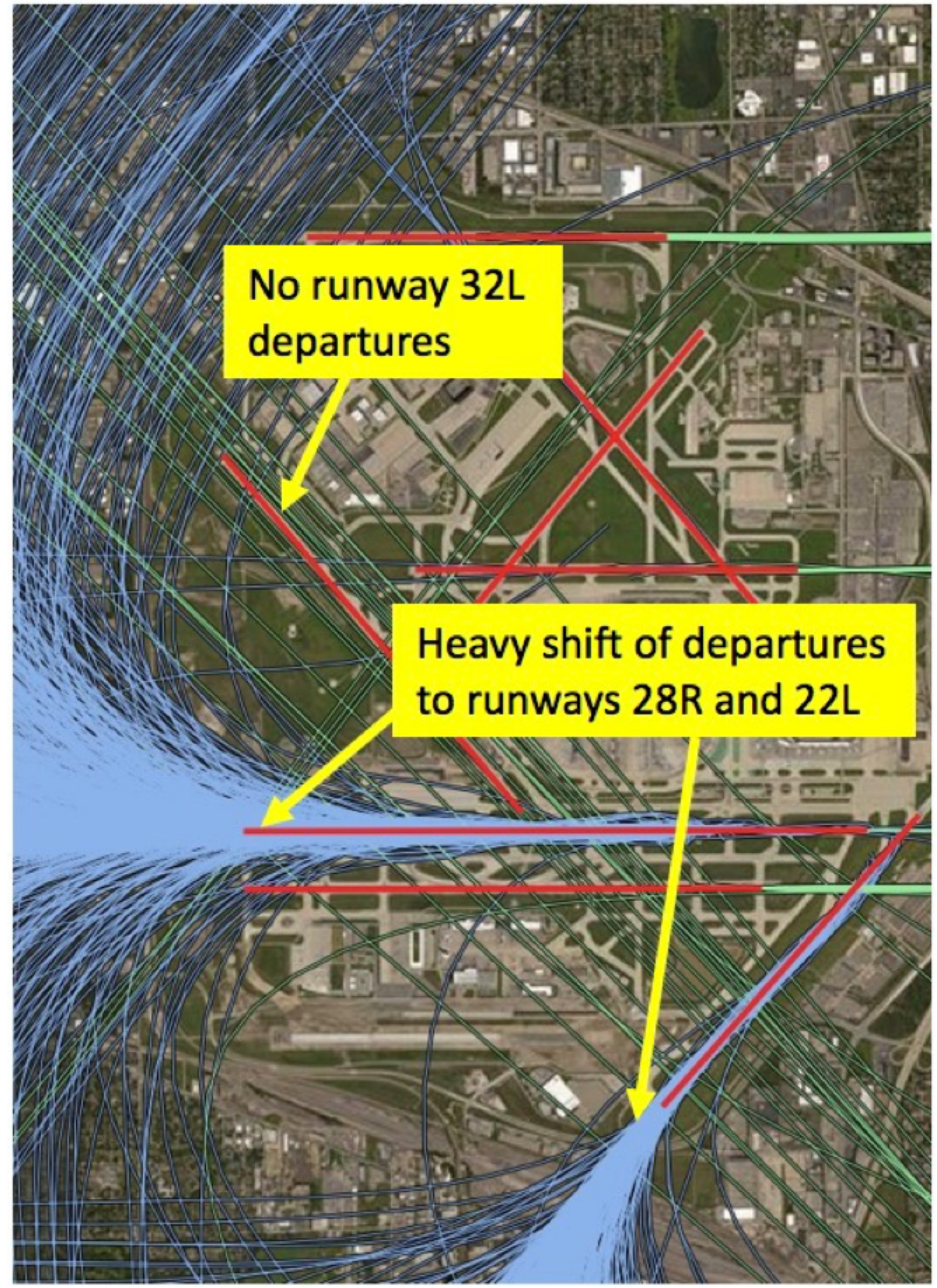
Example of CRO Effect



CRO Rule at Chicago O'Hare Intl. Airport



Before CRO Rule



After CRO Rule

source of data: CDA

ICAO Aerodrome Reference Code Code Element 1

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