Models to Determine Airspace Capacity

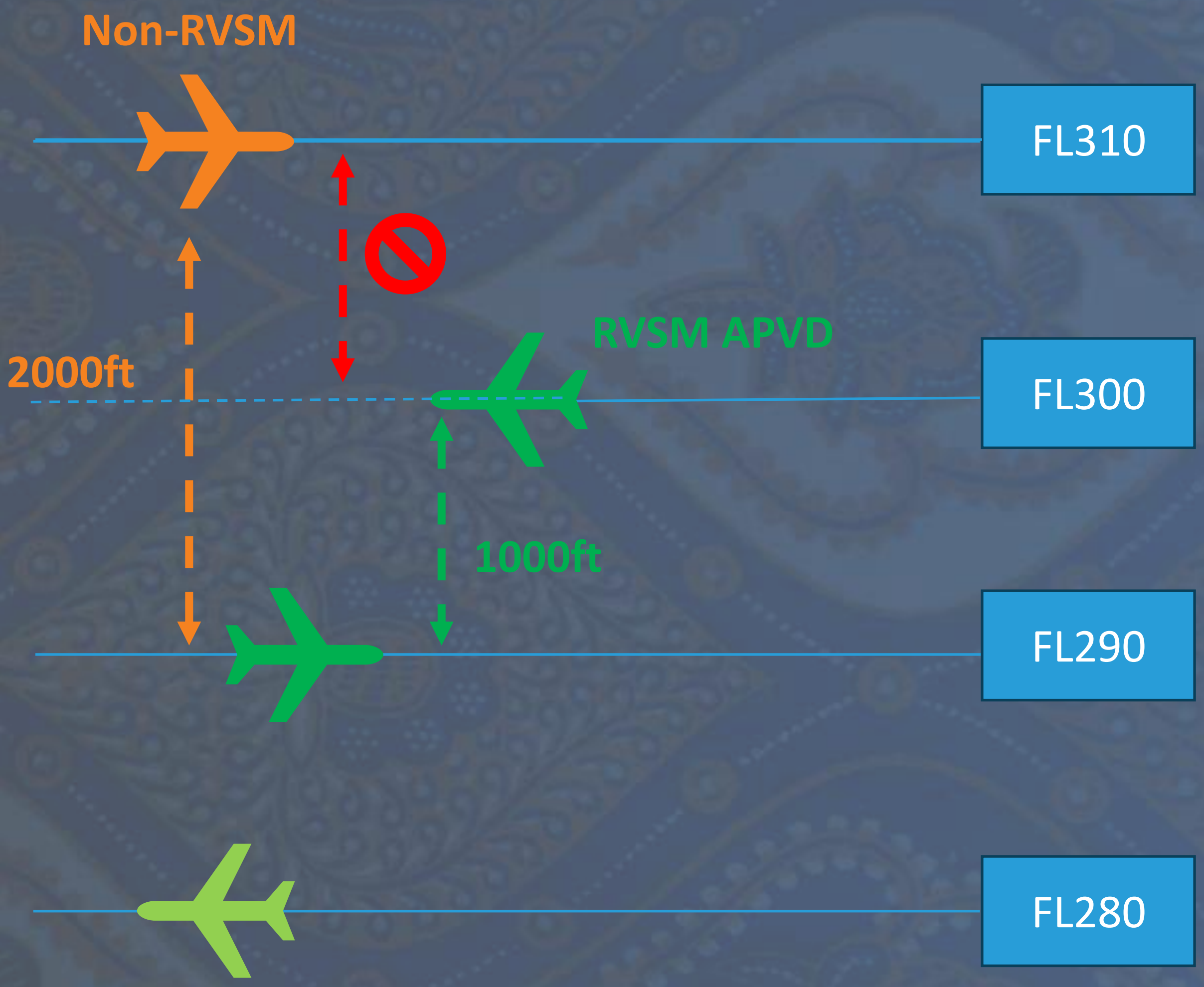
Federal Aviation Administration

Airspace Capacity & Separation Standards

- Airspace capacity is directly related to the applicable separation standard.
- The smaller the separation standard, the more aircraft fit in an airspace volume (sector).
- CNS improvements reduce controller workload and increase capacity
- The following slides depict the relationship between CNS and separation standards. Not all separation requirements are detailed, just the major ones.

Vertical Separation

Vertical	
< FL290	300 m (1,000 ft)
>= FL290	600 m (2,000 ft)
RVSM FL290-410	300 m (1,000 ft)



Procedural Separation: Lateral

Navigation	*APAC Regional Supplement*	*RNAV/RNP 10*	*RNP 4*	*RNP 4, RNP 2*	*RNP 2*
Communication		*N/A*	*CPDLC*	*RCP 240*	*VHF Voice*
Surveillance		*N/A*	*ADS*	*RSP 180*	*RSP 180*
Other		*N/A*	*N/A*	*ADS-C*	*N/A*
Lateral	185 KM (100 NM)	93 KM (50 NM) Select APAC FIRs	55.5 KM (30 NM) Select APAC FIRs	42.6 KM (20 NM)	27.8 KM (15 NM)

Source:
APAC Regional Supplement Requirement

Source:
PANS-ATM (DOC 4444)

Procedural Separation: Longitudinal

Navigation		*RNAV/RNP 10*	*RNP 10, RNP 4*	*RNP 2, RNP 4*	*RNP 2, RNP 4*
Comm		*Controller-Pilot Communication*	*RCP 240, RSP 180*	*RCP 240, RSP 180*	*RCP 240, RSP 180*
Surveillance		*Position Reports every 24 minutes*	*ADS-C 27 - 32 minute updates*	*ADS-C 12 Minute Updates*	*ADS-C 3.2 Minute Updates*
Longitudinal					
Time	3 - 15 Minutes depending on operation				
Distance (NavAid/GNSS)	93 KM (50 NM) - 73 KM (10 NM) depending on operation	93 KM (50 NM) Select APAC FIRs	93 KM (50 NM)	55.5 KM (30 NM)	37 KM (20 NM)
Mach Speed (Time)	5 - 10 minutes depending on speed difference				

Source:
APAC Regional Supplement Requirement

Source:
PANS-ATM (DOC 4444)

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Surveillance ATS System Separation

Navigation	*N/A*	*N/A*	*RNP 4, RNP 2*	*RNP 4, RNP 2*
Comm	*Controller-Pilot Communication*	*Controller-Pilot Communication*	*RCP 240*	*RCP 240*
Surveillance	*ADS-B, RADAR, MLAT*	*ADS-B, RADAR, MLAT*	*ADS-B, RADAR, MLAT*	*ADS-B, RADAR, MLAT*
Additional		*When Authorized by ATS Authority*		*When Authorized by ATS Authority*
Horizontal	9.3 KM (5 NM)	5.6 KM (3 NM)	35.2 - 31.5 KM (19 - 17 NM)	28 KM (15 NM)

Source:
PANS-ATM (DOC 4444)

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Relevant ICAO Documents

Annex 11, Chapter 2-3

- Doc 9426, Guidance material relating to the implementation of composite lateral/vertical separation is contained in the Air Traffic Services Planning Manual

Details of current separation minima prescribed by ICAO are contained in the PANS-ATM (Doc 4444) and the Regional Supplementary Procedures (Doc 7030).

- Doc 9574, Guidance material relating to vertical separation is contained in the Manual on a 300 m (1 000 ft) Vertical Separation Minimum Between FL 290 and FL 410 Inclusive
- Doc 9869, Performance-based Communication and Surveillance (PBCS) Manual
- Doc 9613, Performance-based Navigation (PBN) Manual
- Doc 10037, Global Operational Data Link (GOLD) Manual
- Circular 324, Guidelines for Lateral Separation of Arriving and Departing Aircraft on Published Adjacent Instrument Flight Procedures
- Circular 349, Guidelines for the Implementation of Lateral Separation Minima

Models to Determine Airspace Capacity

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Calculating and Expressing Airspace Capacity

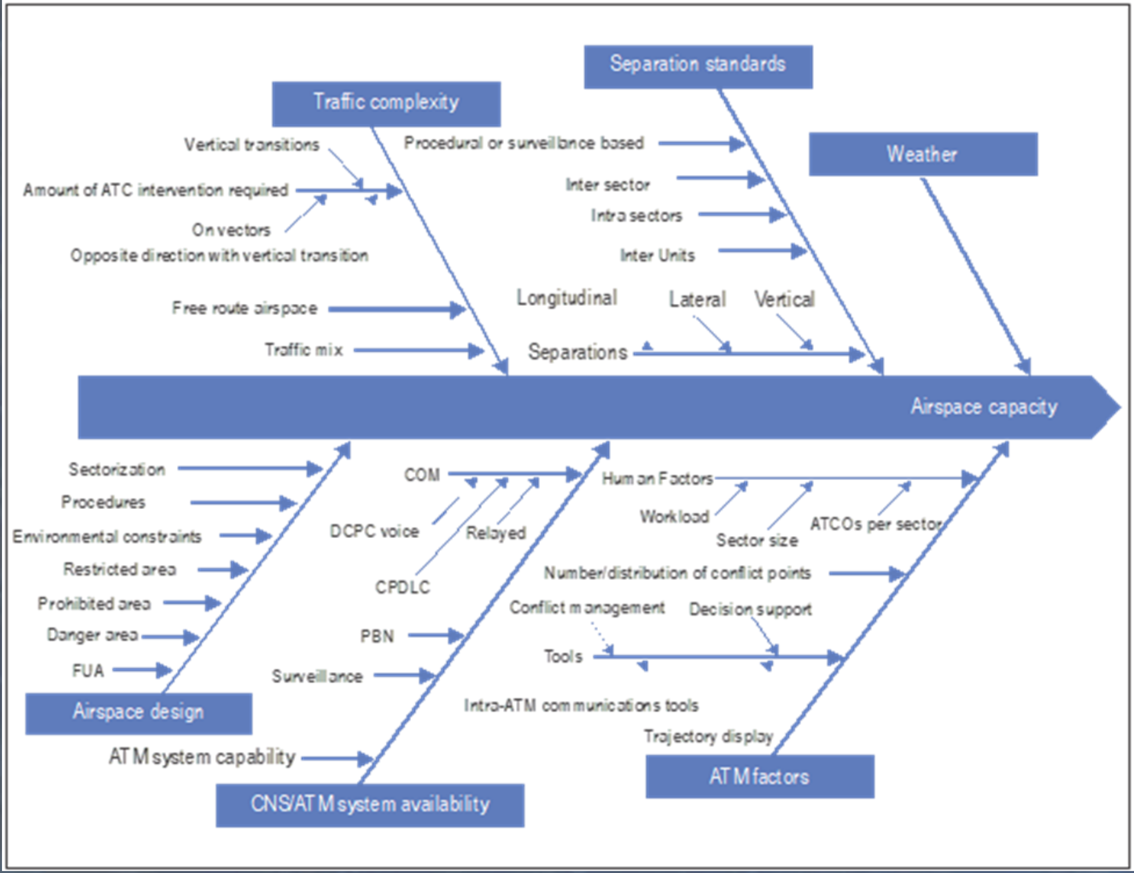
Annex 11

- The strategic capacity of controlled airspace and designated aerodromes is to be determined on a seasonal or annual basis and periodically reviewed and updated to account for changing circumstances, such as a new runway being commissioned, new automation systems being implemented, or a new separation standard being introduced.
- The operational capacity is initially set by considering the strategic capacity value, and re-calculated iteratively to account for dynamic, short-term, time-specific changes in factors affecting operating conditions and ATCO workload.
- There is no universal rule for calculating capacity because it can be affected by many variables and other considerations
  - Depending on the local regulatory environment, the State, appropriate ATS authority, ATC unit, and/or ATFM unit decide how to calculate capacity.
  - Methods range from observation-based basic models to highly sophisticated mathematical models.
  - Typically, capacity is normally using detailed analysis by specialist ATFM personnel, input from ATCOs and other operational ATS staff (e.g., planner and flow ATCOs, assistants and supervisors), review of safety information regarding high ATCO workload, and real-time observations
  - Due consideration should be given to the methods employed by neighboring States and within the region to ensure consistency in the methods that consider the same traffic flows.
  - Multilateral agreements are great tools for ensuring consistency in capacity calculation

Calculating and Expressing Airspace Capacity

Contributing Factors

- The capacity for a portion of airspace is normally expressed either as
  - an entry count monitoring value—the maximum number of aircraft which may enter the airspace in a given period of time, normally one hour, or
  - an occupancy count monitoring value — the number of aircraft which may simultaneously operate within the portion of airspace over a specific time period, normally one minute, and the average number of aircraft expected to be maintained over a longer elapsed period e.g., 10 minutes
- In some cases, instantaneous or short-duration occupancy counts can be used to complement entry counts
  - This allows for more granular analysis to mitigate and temporarily accept higher traffic demand values that exceed the entry counts monitoring value.
  - Such occupancy count capacities require accurate and frequent ATC movement messages and ATS surveillance system data updates to the ATFM service system.
  - Occupancy counts should be made available in advance of the flight entry into the given airspace and on a frequent basis.



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Calculating and Expressing Airspace Capacity

Evaluation Models

Mathematical occupancy and complexity models

Consider the impact of individual factors that describe operating conditions, including

- Traffic profile: cruise, climb, descent
- Traffic mix: light, heavy, speed mix
- Number and types of typical ATC interventions
- Sector flight times, and
- Default workload per flight

ATCO workload assessment models

Consider average execution times of definable and measurable tasks that contribute to ATCO workload, including:

- Coordination
- Handling flight data
- Radio frequency and/or CPDLC communications
- Conflict management

Irrespective of the model, it is essential to validate evaluated capacity by other means, e.g., real-time observations or real-time simulations

Air Traffic Controller (ATCO) Workload

- **ATCO workload is the key driver of airspace capacity in high-density/high-complexity traffic areas**
  - Ops experience suggests that a safer measure of capacity is based on ATCO's physical and mental work to ensure safe separation and control of traffic (as opposed to spatial-geometric constraints dependent on aircraft performance)
  - ATS authorities commonly use simulation techniques to model ATCO workload for estimation of airspace capacity; this allows greater flexibility in capacity estimation and ensuring impact assessment of wider ranges of capacity improvement proposals
- **While definition and evaluation of ATCO workload is not uniform, the underlying methods are used to formulate the relationship between the number of aircraft entering or within the sector and the workload generated by controlling the associated traffic in the sector over a given period of time.**
  - According to the scientific literature, methods for measuring ATCO workload are usually categorised as subjective and objective.
  - Several workload measurement methods of different state of maturity are currently known and used in the simulation, such as: Self-Assessment Techniques, Workload assessment questionnaires, Third-Person-Assessment Techniques, Primary/Secondary Task Performance, Technical measurements of any kind.

Calculating and Expressing Airspace Capacity

Evaluation Methodology Based on ATCO workload

Operational Experience

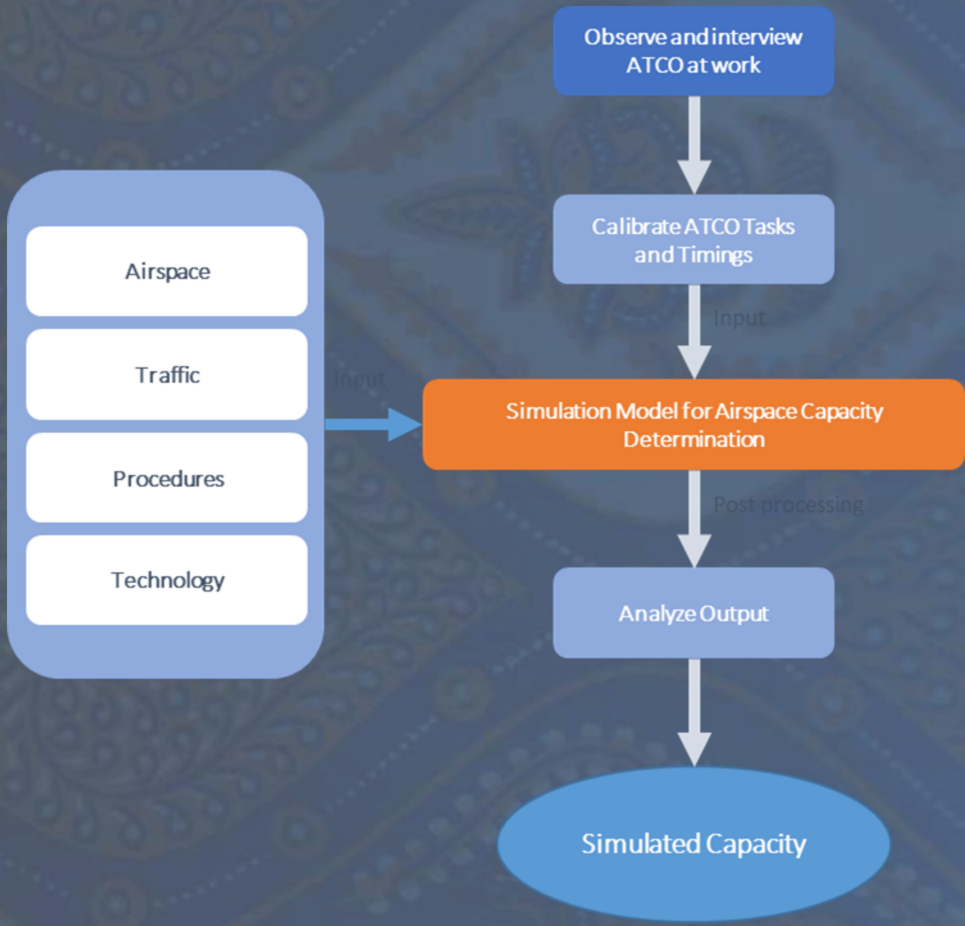
- Investigate how much traffic a particular volume of airspace can handle, followed by interviews to to ascertain the ATCOs perception of traffic load
- Limited ability to determine capacity for a future ATC setting

Fast Time Simulations (FTS)

- Often described as calculating task-load rather than workload, FTS do not aggregate the functional relationship between the traffic numbers, airspace sector factors and ATCO workload; as such, they lack ATCO judgement, experience and way of thinking.
- This can be mitigated by involving active ATC staff in an iterative process of simulation refinement through rigorous data ana

Real Time Simulations (RTS)

- RTS involve ATCOs, pseudo-pilots, and ATC system to create the full operational environment
- While realistically capturing the human element, they are often costlier and require additional infrastructure along with longer simulation time and training of personnel.



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Determining Sector Capacity (1/11)
Example: FAA Methodology

- **Simple methodology for determining sector capacity developed by the FAA assumes that the sectors under consideration work best when they handle:**
  - no more than 25 aircraft during any 15-minute period; and
  - no more than 18 aircraft during any one-minute period.

15 minutes x 60 seconds = 900 seconds
900 seconds / 25 aircraft = 36 seconds per aircraft

- **Therefore, each aircraft requires 36 seconds of a controller's work time**
- **Sector capacity is calculated using the average sector flight time in minutes from 0700 hours to 1900 hours, Monday through Friday, for any 15-minute time period**

$$Optimum\ Sector\ Capacity = \frac{60\ x\ Average\ Sector\ Flight\ Time\ (min)}{36\ (seconds)}$$

Optimum Sector Capacity (aircraft count)	5	7	8	10	12	13	15	17	18	18
Avg Sector Flight Time (minutes)	3	4	5	6	7	8	9	10	11	12+

Source: ICAO Doc 9971, Appendix C-1
Information provided by the U.S. Federal Aviation Administration (FAA)

Determining Sector Capacity (2/11)

Example: FAA Methodology

- **This simple methodology limits capacity by considering controller workload by assuming that a controller spends 36 seconds providing an ATC service to each flight.**
- **This optimum value needs to be adjusted for applicable factors, such as:**
  - ATS route structure;
  - airspace volume (vertically and laterally);
  - complexity;
  - climbing and descending traffic;
  - terrain and obstacles, if applicable;
  - number of adjoining sectors that require interaction; and
  - military
  - operations.
- **The 36-second assumption does not account for dynamic changes in sector traffic complexity characteristics over time and may not be applicable to future capabilities.**

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Determining Sector Capacity (3/11)
Example: FAA Methodology

Improvements to the simplified method: a workload model that considers the number of aircraft and their interactions with each other, ATC services needed by each aircraft, and the amount of time to provide services:

- Estimate the workload associated with imposed task demands by considering the difficulty, number, rate, and complexity of demands;
- Calculate time-on-task workload for the en route sector radar controller positions based on post-operation logs including sector configurations and
- Model sector tasks and task categories over a period of time to establish more accurate workload estimates for:
  - entry (identify aircraft, establish clearance plan, handoff, flight crew call-in, ack);
  - exit;
  - non-standard (non-radar) arrivals and/or departures;
  - vertical transitions (interim, altitude amendment),
  - scanning;
  - coordination (flash-through or point-out);
  - separation assurance; and
  - delay (vectoring, shortcut, reroute, holding, diversion).

Use industry-standard human performance modeling techniques to identify radar controllers' tasks per sector (or sector combination) and estimate task times:

- ***Feld observations at ACCs***
- ***Human-in-the-loop simulation***

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Determining Sector Capacity (4/11)
Example: FAA Methodology

Steps for building a workload model:

1. **Determine input and output parameters of the workload model:**
   a) Record task times and task distributions to execute each task; and
   b) Identify tasks performed over a period of time (e.g., Mon-Fri, 0700-1900);
   c) Sum the task times to estimate of workload for each time period (e.g., rolling 15-minute intervals for 1440 intervals in 24 hours).
2. **Set the workload threshold to 90% of the theoretical workload (e.g., 810 sec for a theoretical 15-minute/900 sec interval).**
3. **Describe the characteristics of traffic complexity for each period.**
   a) Consider three complexity types: cruise, transition (climb/descent), and delay – which may be individual or combined.
   b) For each complexity type, consider if separation-related activity is low or high.
4. **Determine the complexity profile that characterizes sector operations over a period of time; for each complexity type:**
   a) Set an alert value according to the highest observed traffic count – hence, less complex sector operations receive higher alert values and more complex sector operations receive lower alert values;
   b) Express the occurrence of each complexity type as a percentage;
   c) Calculate the weighted average by multiplying the values from a) and b); and
   d) the weighted averages are summed together and rounded to determine the monitoring value.

Determining Sector Capacity (5/11)
Example: FAA Methodology

Complexity-type	Avg. complexity type alert value for the sector	Frequency	Weighted average Complexity
Transition with low separation assurance workload	19	41%	***7.80***
Cruise with low separation assurance workload	22	32.4%	***8.13***
Delay and transition with low separation assurance workload	21	12.8%	***2.70***
Delay with low separation assurance workload	18	5.6%	***1.00***
Transition with high separation assurance workload	18	5.2%	***0.90***
Delay with high separation assurance workload	17	1.4%	***0.20***
Cruise with high separation assurance workload	19	0.8%	***0.15***
Delay with Transition with high separation assurance workload	17	0.5%	***0.09***
Calculated workload-based monitoring value (capacity)			***20***

- **ATC experts can further tune the monitoring value produced by the workload model to:**
  a) propose experience-based adjustments; and
  b) account for additional, frequently occurring sector combinations.
- **The monitoring value of the operational capacity can be dynamically adjusted during periods of reduced efficiency to reflect the ability to provide air traffic services (e.g., meteorological conditions, and temporary degradation of infrastructure). When efficiencies improve, the monitoring value is adjusted back to baseline.**

Determining Sector Capacity (6/11)
Example: Brazilian Methodology

- **In Brazil, the capacity of ACCs is calculated by observing the capacity of their sectors, which is analytically obtained according to the methodology established in the ICA 100-30, ATC personnel planning (DECEA, 2007).**
- **Calculated capacity value represents the maximum number of aircraft that can be simultaneously controlled by each operational position (ATCO). According to the current model, the controller's workload is the summation of the time spent on each of the following tasks:**
  a) Communications (transmission/reception);
  b) Manual activities (filling-out strips) and coordination; and
  c) Traffic planning and distribution.
- **The Brazilian methodology applies the concept of the controller's "availability factor" (ɸ), which is defined as the percentage of time available for the ATCO to plan the aircraft separation procedures. This availability factor is found, usually, between a minimum value of 40% of the ATCO time in a non-surveillance environment, and 60% in a surveillance environment.**

Source: ICAO Doc 9971, Appendix C-1
Information provided by the Brazilian Airspace Control Department (DECEA)

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Determining Sector Capacity (7/11)

Example: Brazilian Methodology

- **The number of aircraft that can be simultaneously controlled by a controller N, within the sector under consideration can be calculated as:**

$$N = \frac{\varphi * \delta}{\eta * \tau_m * \nu_m}$$

- **Sector capacity is the function of the following factors:**
  - φ: factor of controller availability, defined as the percentage of time available to plan the aircraft separation procedures;
  - δ: average distance flown by aircraft in the sector, which is a function of the ATS route structure within the sector;
  - η : number of controller-pilot communications for each aircraft in the sector;
  - τ m: average duration of each controller-pilot communication; and
  - vm: average speed of the aircraft in the sector
- **By replacing δ and v_m with the average time flown by aircraft in the sector T, where $T = \frac{\delta}{\nu_m}$, the number of aircraft that can be simultaneously controlled by a controller N can be calculated as:**

$$N = \frac{\varphi * T}{\eta * \tau_m}$$

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Determining Sector Capacity (8/11)

Example: Brazilian Methodology

- **The values of the factors φ , T, η and τ_m are collected empirically, following the standardized procedures specified by the appropriate ATS authority.**
- **Example for calculating the capacity:**
  - factor of controller availability: $\boldsymbol{\varphi}$ = 60%
  - average flight time spent by the aircraft crossing the sector: $\boldsymbol{T}$ = 12 minutes
  - number of controller-pilot communications for each aircraft in the sector: $\boldsymbol{\eta}$ = 6
  - average duration of each controller-pilot communication: $\boldsymbol{\tau_m}$ = 9 seconds

$$\boldsymbol{N = 60\% \cdot 12_{min} \cdot (6 \cdot 9_{sec})^{-1}}$$

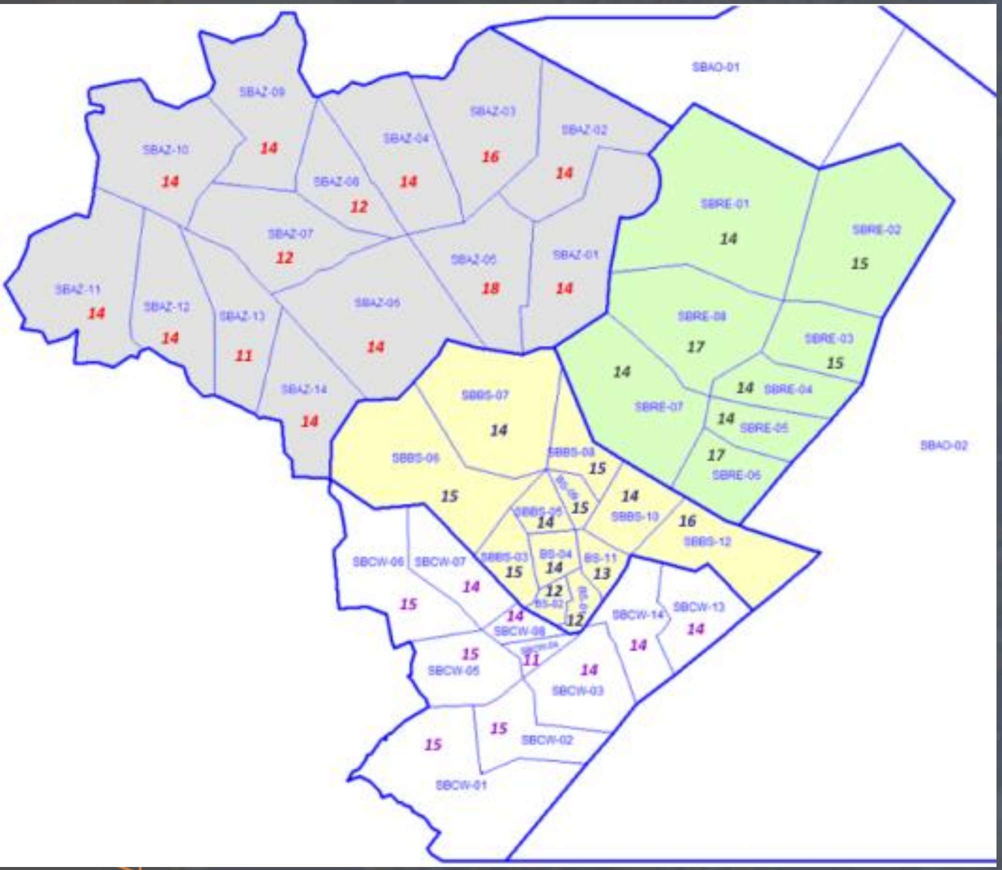
$$\boldsymbol{N = 60\% \cdot (12 * 60_{sec}) \cdot (6 \cdot 9_{sec})^{-1}}$$

Number of aircraft controlled simultaneously by a single controller

$$\boldsymbol{N = 8}$$

Determining Sector Capacity (9/11)

Example: Brazilian Methodology



- Dynamically changing conditions may necessitate updating sector capacity values to account for significant changes
- Data gathering needs to be meaningful to accommodate a reasonable range of operational uncertainties and represent trustworthy values to the ATC unit.
- In ideal conditions, data research shall be conducted when there is a heavy air traffic activity, for this reason to choose the ideal season is a factor to be considered, once it has a direct influence in final results.
- Brazil has calculated the capacities of all sectors, individual and combined. After calculating the initial sector capacity, further adjustment is made to account for the significant air traffic flows, the complexity of each sector, and the capacities of the adjacent sectors.

Determining Sector Capacity (10/11)

Example: Saudi Arabian Methodology

- **ATC sector capacity calculation is based on the equations to determine the theoretical number of aircraft that can be managed and handled by ATCO. The ATS unit must perform further validation by a group of experts to confirm the calculated sector capacity and consider all possible factors that may impact that capacity.**
- **The number of aircraft that can be controlled simultaneously by a single ATCO is calculated as:**

$$N = \frac{\varphi * T}{\eta * \tau_m}$$

- **Sector capacity is the function of the following factors:**
  - φ: ATCO Availability factor (expressed as %), defined as the percentage of time available for planning aircraft separation procedures;
  - T: Average flight time on the aircraft in the sector (the unit of time needs to be the same as for τ_m);
  - η : Number of controller-pilot communications for each aircraft in the sector;
  - τ_m: Mean duration of each controller-pilot communication (the unit of time needs to be the same as for T)

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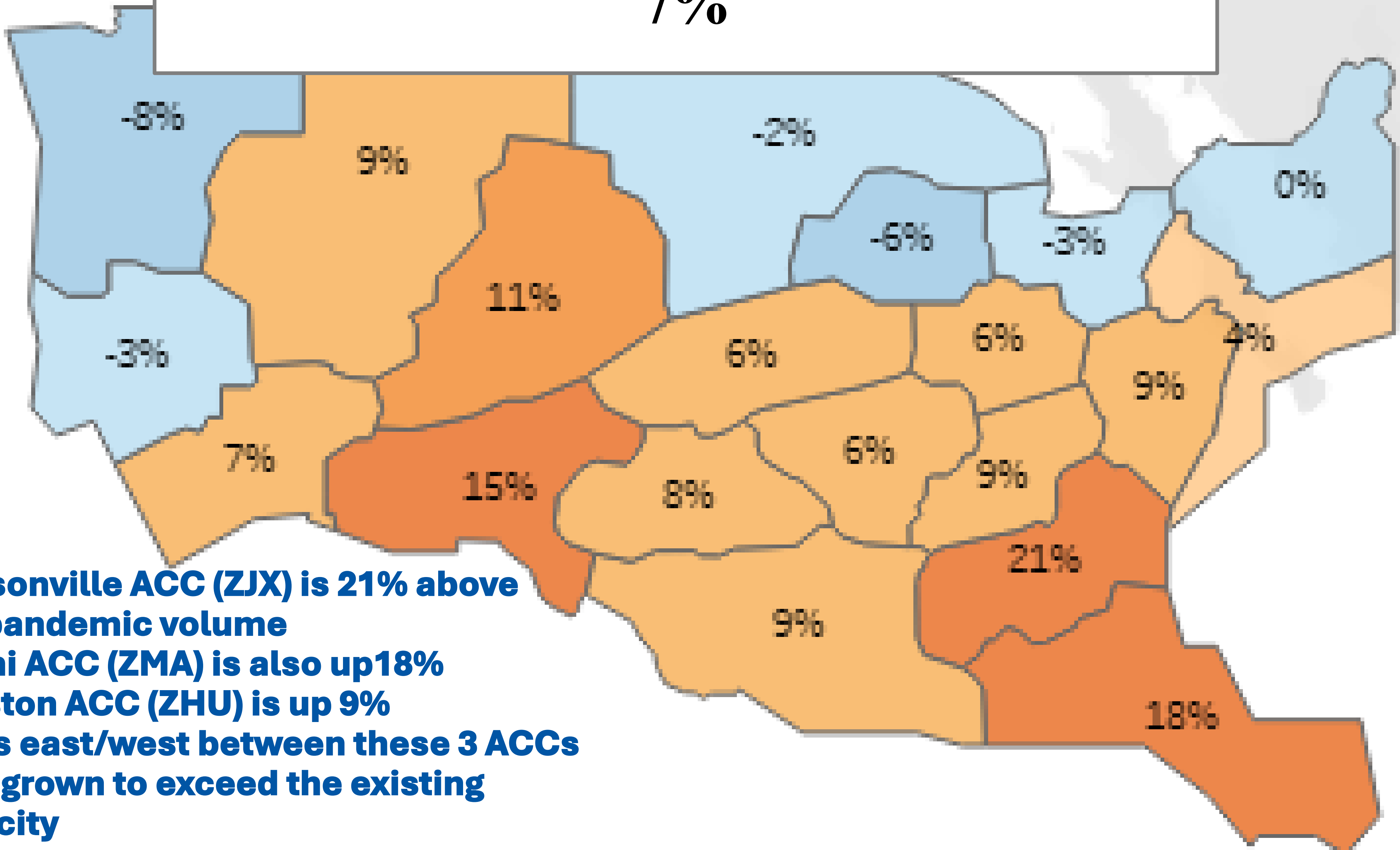
Source: ICAO Doc 9971, Appendix C-1
Information provided by the Saudi Air Navigation Services (SANS)

Determining Sector Capacity (11/11)
Example: Saudi Arabian Methodology

- A significant data sampling is required to accommodate a reasonable range of operational uncertainties and determine reliable values for the ATC unit
- According to the current model, controller workload is the summation of times spent on:
    - Communication (transmission /reception)
    - Manual activities (updating of flight progress strip) and coordination
    - Traffic planning and distribution
- Availability factor, φ, is defined as the percentage of time available for the ATCO to plan aircraft separation procedures. Its typical range is between 40% of ATCO time in a non-surveillance environment and 60% of ATCO time in a surveillance environment. It is thus clear that efforts need to focus on increasing the availability factor φ.
- Studies conducted by experts, who analysed the sampling techniques, show that it is advisable to make at least 25 observations of each parameter for an average controller, during peak traffic, respecting the minimum number of controllers specified by the sampling technique used.
- It is essential to collect as many observations from as many controllers as possible in the unit being assessed in order to eliminate extreme values and to minimise any type of trend (e.g., cases of controllers or pilots who are either too slow or too quick in their communications, affecting the arithmetical mean).

Ways to increase Airspace Capacity
FAA Case Studies

March 2025 vs Pre-COVID BL: 7%



Jacksonville ACC (ZJX) is 21% above pre-pandemic volume
Miami ACC (ZMA) is also up18%
Houston ACC (ZHU) is up 9%
Flows east/west between these 3 ACCs have grown to exceed the existing capacity

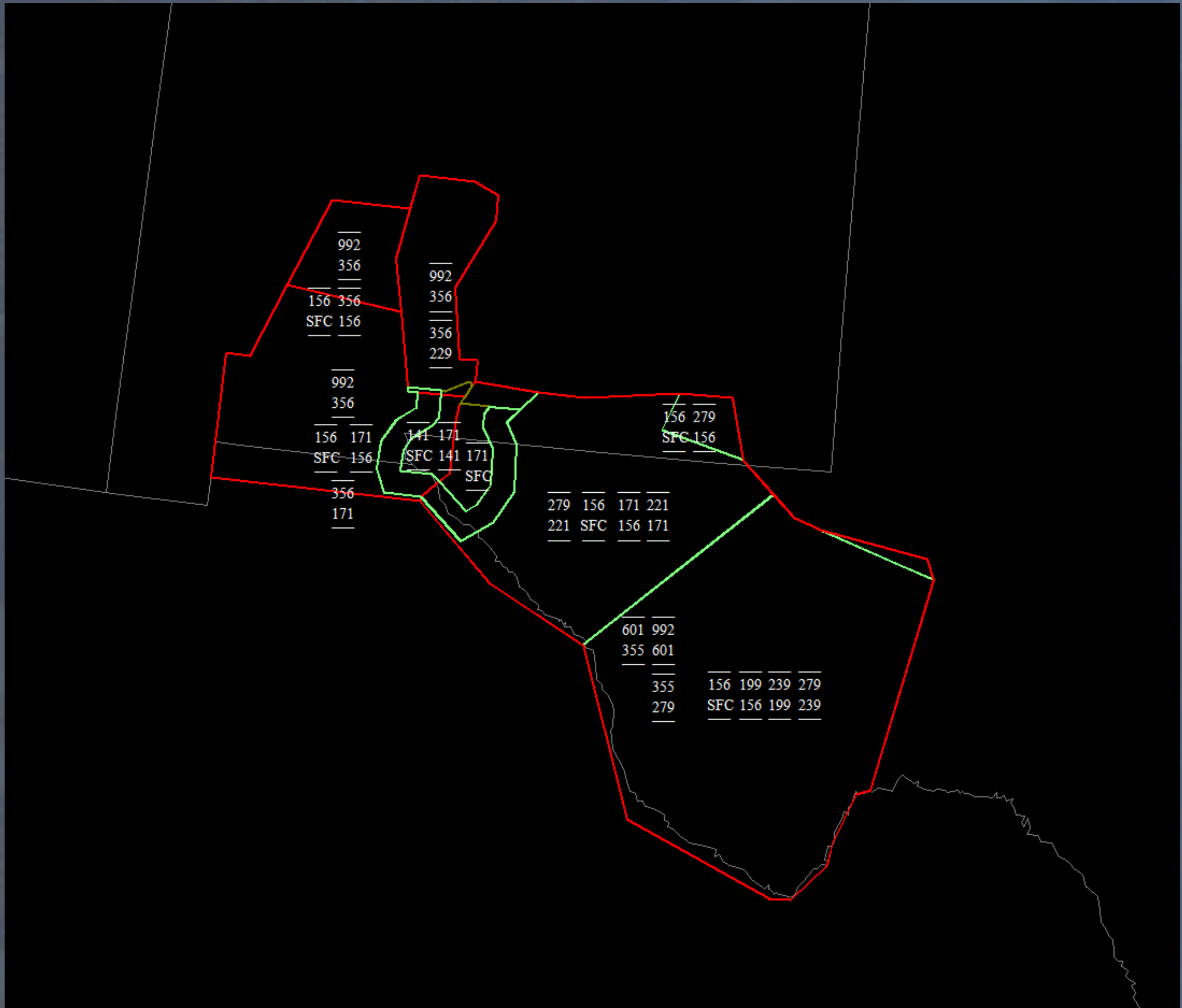
Sector Stratification

- **Method to reduce controller workload by creating multiple sectors vertically**
- **The sectors can be dynamically combined or de-combined to match demand**
- **Enabling technology includes**
  - Frequency assigned to each sector
  - Operational position for each sector
  - Update training as new sectors are created
  - Ability to transmit/receive on multiple frequencies so when sector are combined, controllers can continue to monitor/transmit on all frequencies

Sector Stratification – Example: West Texas, Southern New Mexico

El Paso (KELP) Approach underlies two low sectors, SFC to 170
West of KELP, Sector 19 is SFC to FL350
East of KELP, Sector 20 is SFC to FL260

Above Sector 19 is Sector 89, FL360 and above
Above Sector 20 is Sector 63, FL270 – FL350
Above Sector 63 is Sector 78, FL360 and above



Sector Stratification – Example: West Texas, Southern New Mexico

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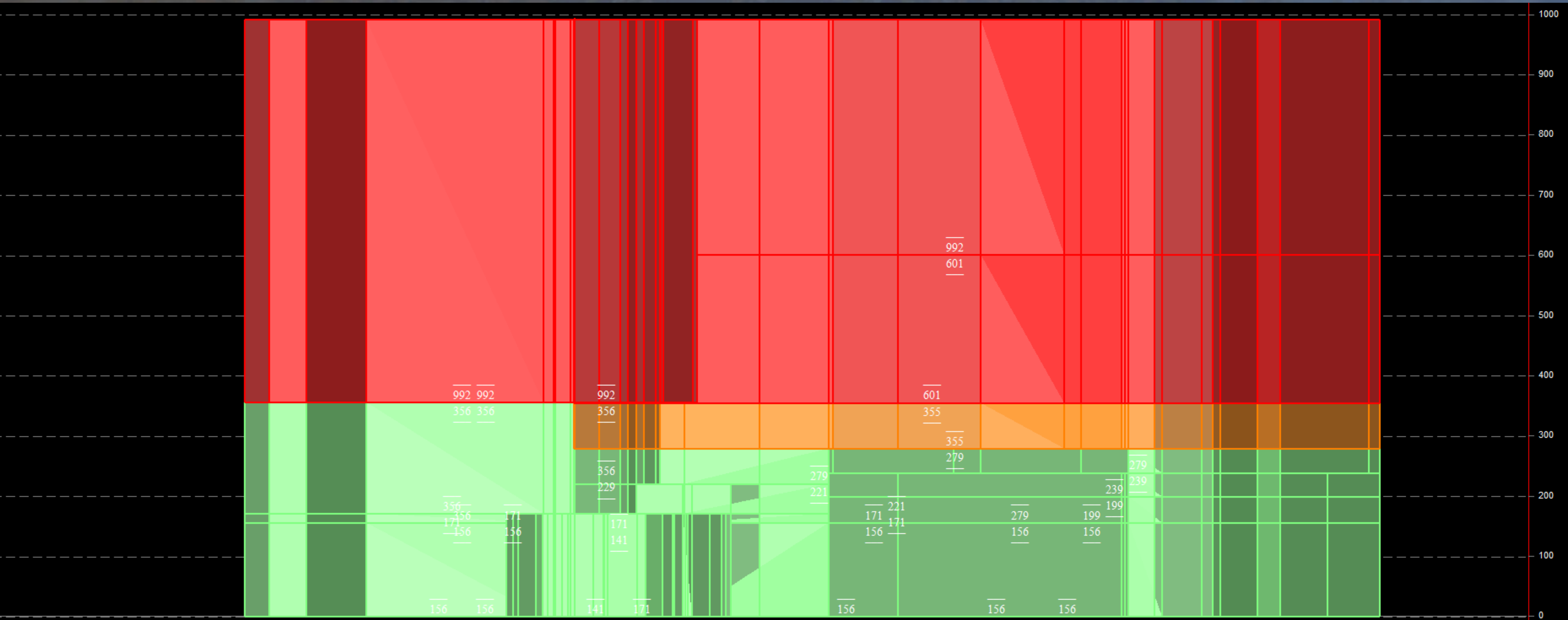
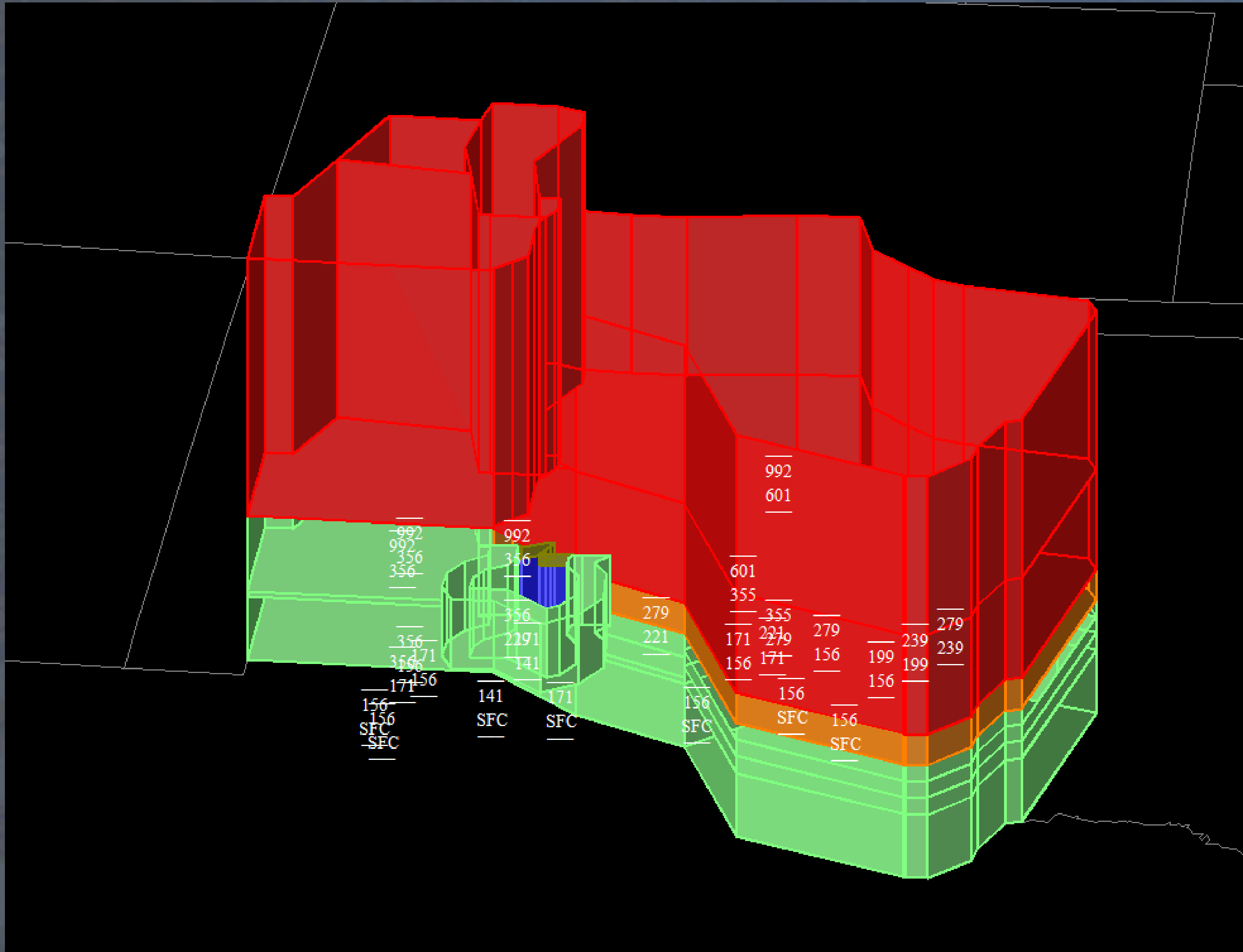
Side View



Sector Stratification – Example: West Texas, Southern New Mexico

3D View



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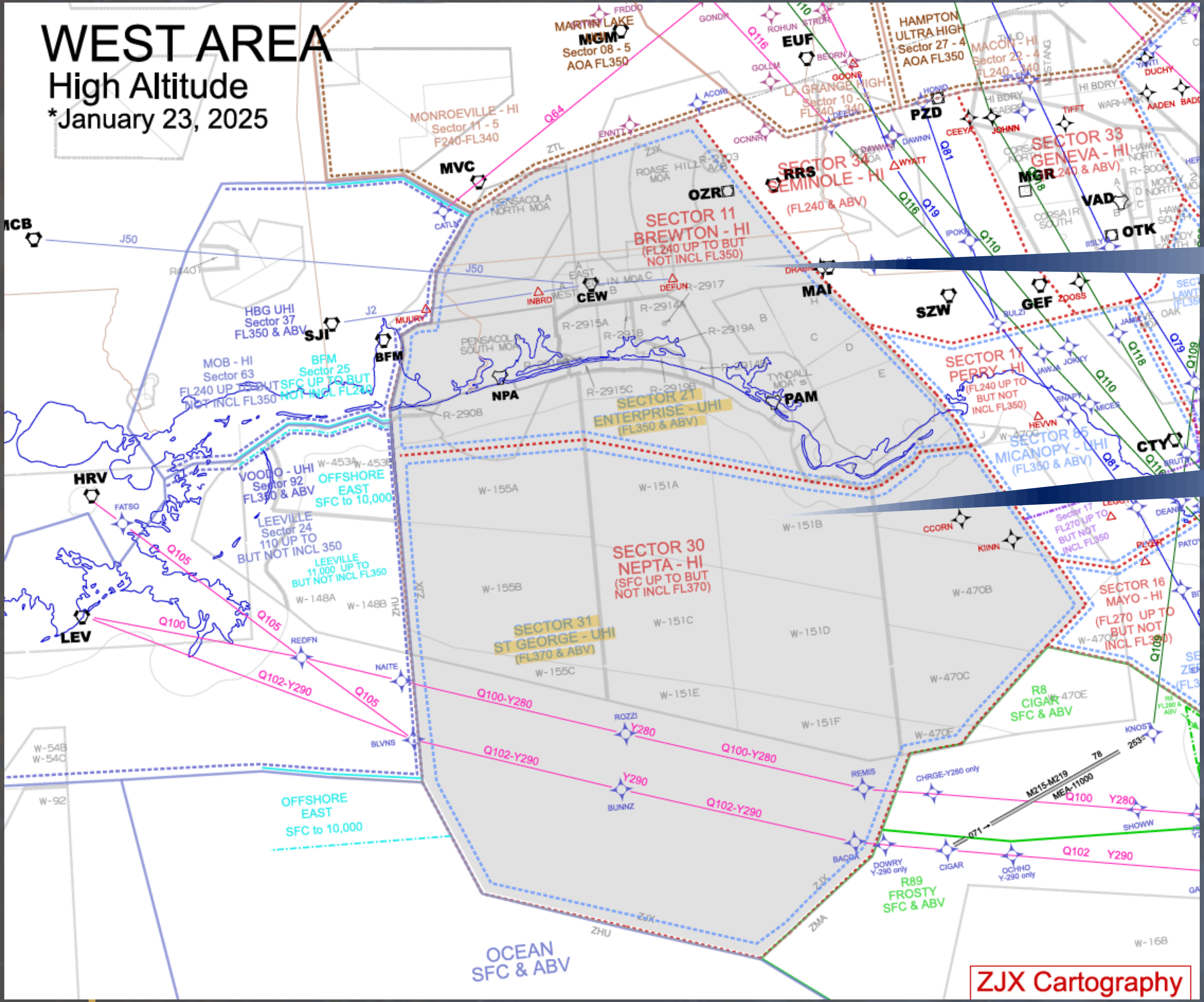
New ZJX Ultra-High ZJX31 and ZJX21



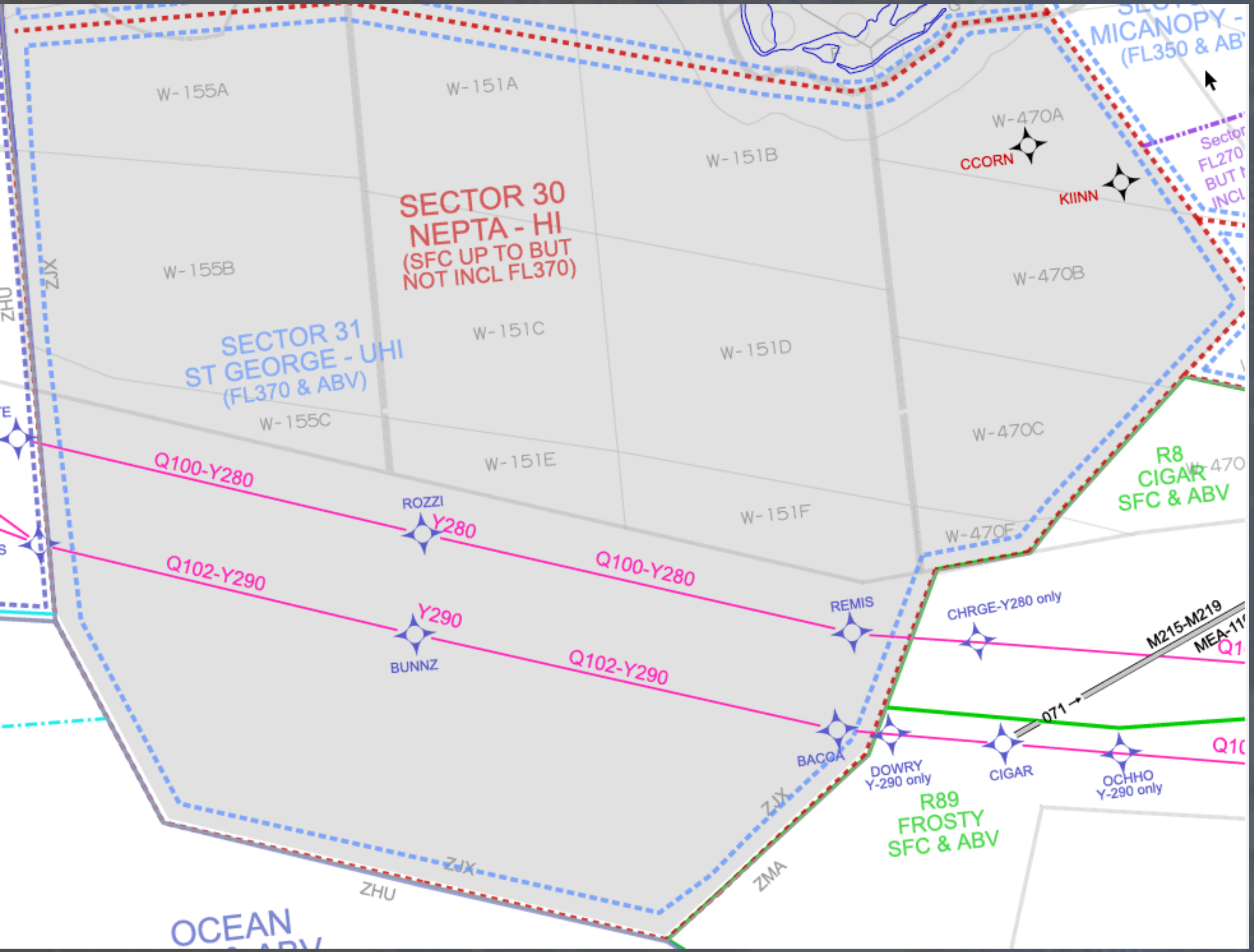
Opened 1/23/25

ZJX21 – Ultra-High overlies ZJX11 Altitudes FL350 & Above

ZJX31 – Ultra-High overlies ZJX30 Altitudes FL370 & Above

Designed to allow for increased volume in the Gulf

ZJX West Area Ultra-High Sectors



ZJX30

- Old Sector was not stratified – owned Surface and above. High Volume, routinely over capacity with traffic transitioning between ZMA and ZHU.
- New Sector ZJX31 stratifies within the same sector dimensions. ZJX30 Surface up to FL369 and ZJX31 FL370 and Above.
- Benefit: New sector increases capacity, through the Gulf on Q100/Y280 and Q102/Y290. New 15-minute peak capacities are:

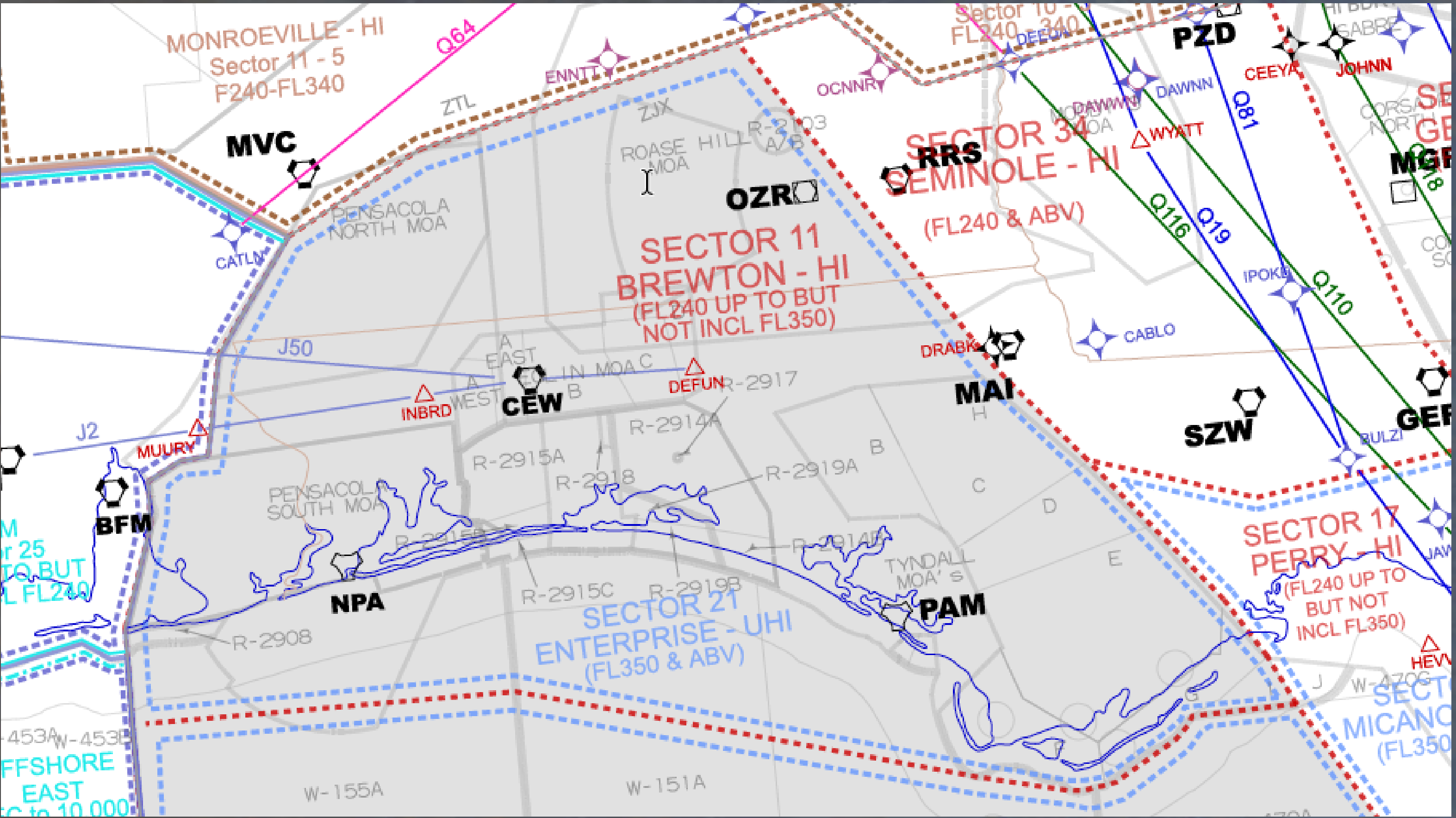
  ZJX30 – 20
  ZJX31 – 21

  VS

  ZJX 30 – 21

- Sector activated on January 23, 2025, with positive results

ZJX West Area Ultra-High Sectors



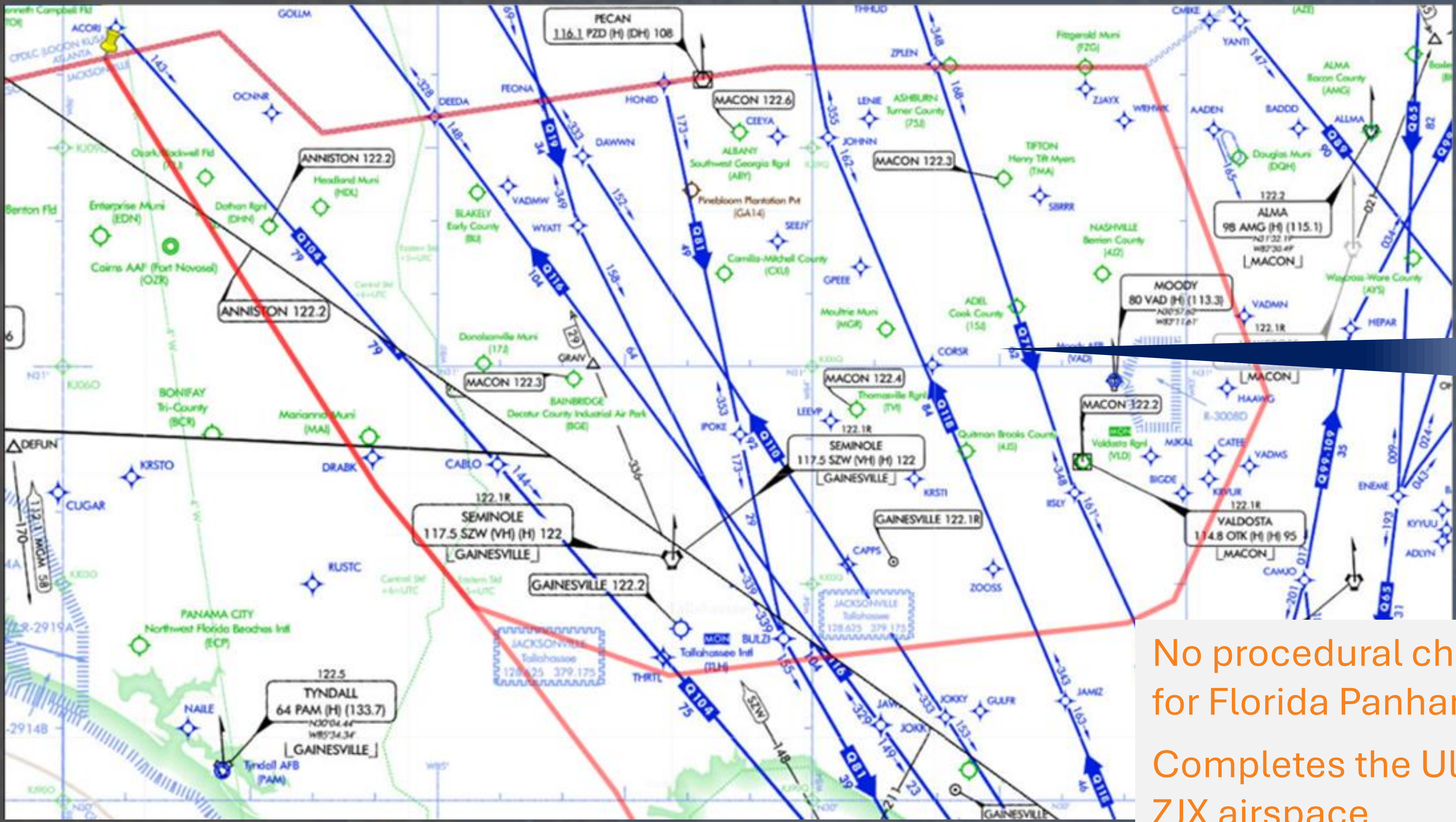
ZJX21

- Old Sector was not stratified – owned FL240 and above. High Volume, routinely over capacity with traffic transitioning between ZJX, ZTL and ZHU.
- New Sector ZJX21 stratifies within the same sector dimensions. ZJX11 FL240 up to FL349 and ZJX21 FL350 and Above.
- Benefit: New sector increases capacity. 15-minute peak capacity is:

  ZJX11 – 20
  ZJX21 – 21 VS ZJX11 – 21

- Sector activated on January 23, 2025 with positive results.
- Currently, limited use due to potential over-delivery of Eastbound traffic and Military Operations. Waiting on Central Ultra-High Eastbound

Coming Soon... ZJX32 Ultra-High



Expected Timeframe: Aug/Sep 2025

ZJX32 – Ultra-High
Overlies ZJX33 and ZJX34
Altitudes: FL370 & Above

No procedural changes for the new sector. Designed for Florida Panhandle and West Coast overflow volume.

Completes the Ultra-High sectorization for the Western ZJX airspace

Will improve North/South and East/West flow capacity

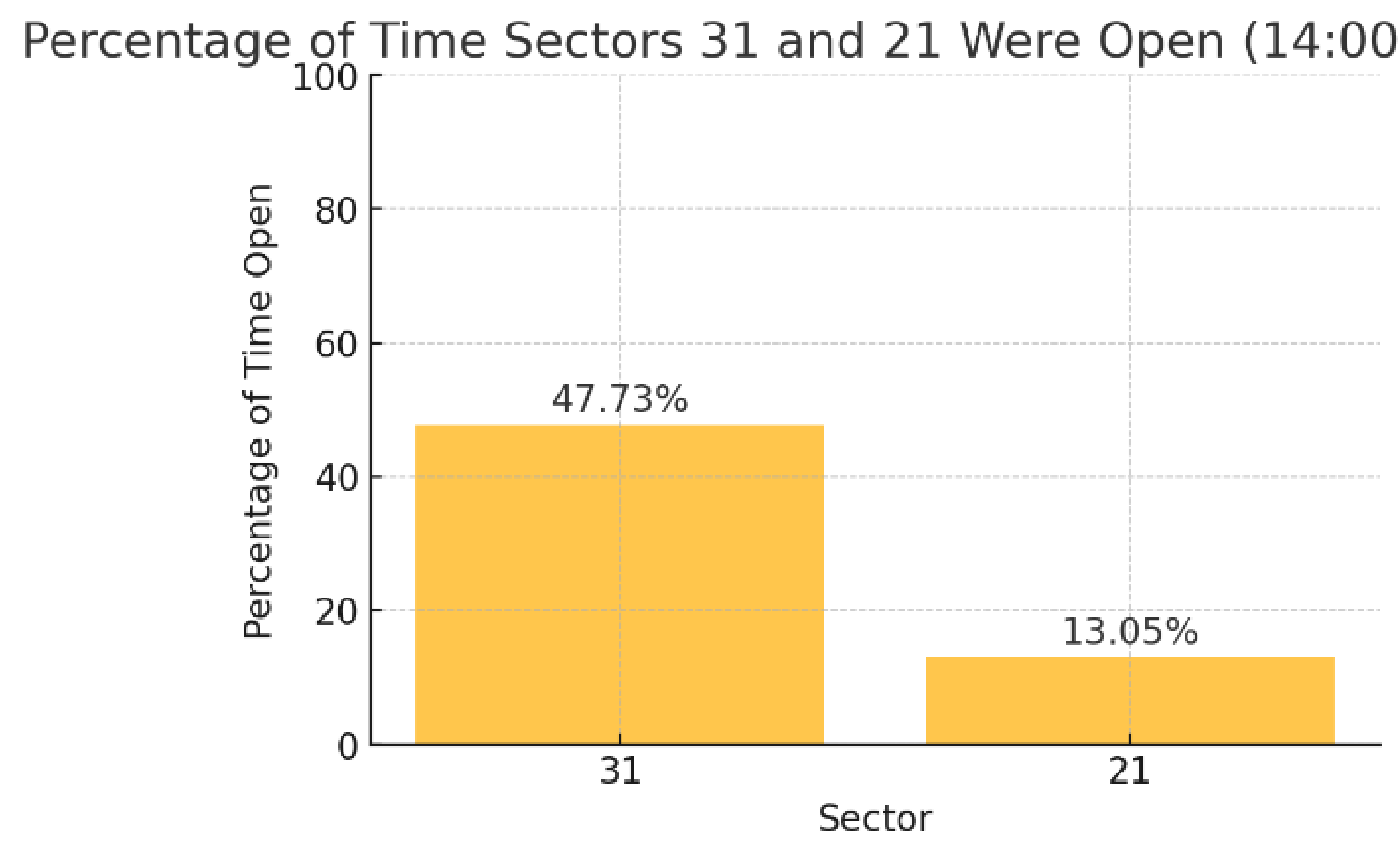
Expected Outcomes

- **Increased capacity in all ZJX Western Sectors.**
- **Anticipated reduction in MIT and Departure Delays for volume**
- **Anticipated reduction in need for Airspace Flow Programs for volume**
- **More efficient use of available airspace during Capping and Tunneling procedures**
- **More airspace availability for northbound departures during convective weather**

What we've seen so far…

- ZJX Sector 31 has been opening consistently with a marked improvement of sector load balancing
- ZJX Sector 21 has been used less frequently. This is due to ZJX32 not being operational. Until ZJX32 is opened, increased volume in ZJX21 overwhelms ZJX 33/34
- When open ZJX21 is showing better sector loading.
- Once the ZJX32 is operational, ZJX21 should be open more consistently.

New Sector Utilization
Jan 23, 2025 – Feb 24, 225



Example of sectors being dynamically opened when needed and combined on other sectors when demand is not high

Sector Load Comparison

* Values are average sector load per 15 minutes (UTC)

January 23, 2024 – Feb 24, 2024

Sector	16:00	16:15	16:30	16:45	17:00	17:15	17:30	17:45	18:00	18:15	18:30	18:45	19:00	19:15	19:30	19:45	20:00	20:15	20:30	20:45	21:00	21:15	21:30	21:45	22:00	22:15	22:30	22:45
11	10.61	10.39	10.21	10.18	10.52	11.58	10.79	11.21	10.94	10.12	10.39	11.03	10.03	11.15	13.09	14.15	12.64	12.21	10.55	10.27	11.52	11.48	11.42	12.15	12.24	11.16	11.28	11.88
30	13.70	13.06	14.52	14.42	15.45	15.64	16.97	16.67	15.73	15.79	14.91	13.50	14.30	17.85	21.21	20.52	18.52	17.73	16.52	15.91	17.09	17.00	17.91	17.79	18.27	18.61	17.73	18.09

January 23, 2025 – Feb 24, 2025

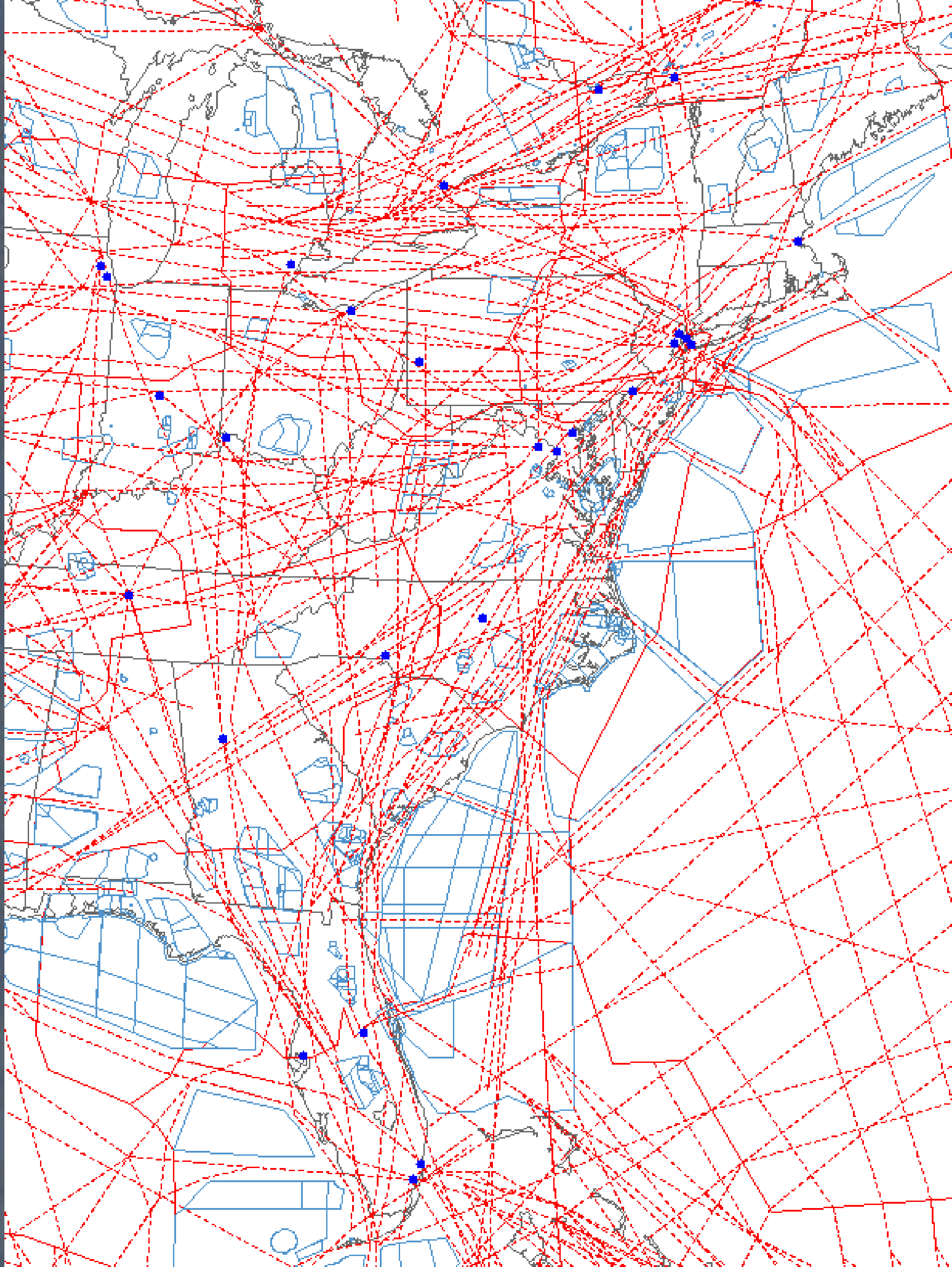
Sector	16:00	16:15	16:30	16:45	17:00	17:15	17:30	17:45	18:00	18:15	18:30	18:45	19:00	19:15	19:30	19:45	20:00	20:15	20:30	20:45	21:00	21:15	21:30	21:45	22:00	22:15	22:30	22:45
11	9.63	9.20	9.20	9.37	9.10	11.00	10.55	8.74	8.20	8.97	8.91	9.22	9.28	10.16	12.25	11.16	9.94	9.53	8.53	8.75	9.47	9.09	8.94	10.00	10.32	10.48	10.29	11.26
21	11.00	13.50	10.50	9.33	7.25	8.00	7.33	6.50	7.00	6.50	5.86	8.60	8.25	9.63	10.71	9.29	9.67	8.17	9.00	7.75	10.25	11.50	10.75	11.00	8.20	8.00	7.60	7.40
30	12.38	13.16	13.88	12.84	12.48	12.94	14.06	13.88	12.44	12.31	13.97	13.00	12.84	15.47	18.66	17.91	15.25	13.41	12.94	12.63	12.81	11.69	13.72	15.38	14.97	14.22	15.19	16.03
31	7.08	8.00	8.15	9.80	9.50	7.67	8.46	9.38	9.23	7.85	8.71	8.64	7.06	8.41	10.18	11.06	9.84	9.84	9.58	9.17	9.67	9.22	8.52	9.71	8.50	6.73	7.27	8.70

PBN vs FRA

- **Two ICAO Long Term Aspirational Goals**
- **Performance Based Navigation (PBN) routes and procedures**
- **Free Route Airspace (FRA)**
- **Both are beneficial for flight operators:**
  - PBN provides great precision in flight planning and optimized descent profiles for STARs.
  - FRA provides flexibility in planning for winds and fuel economies.
- **High volume, high complexity airspace can lead to situations where PBN and FRA conflict.**
- **The following slide depicts an FAA case study where what is good for the individual flight is not good for the system as a whole.**

And

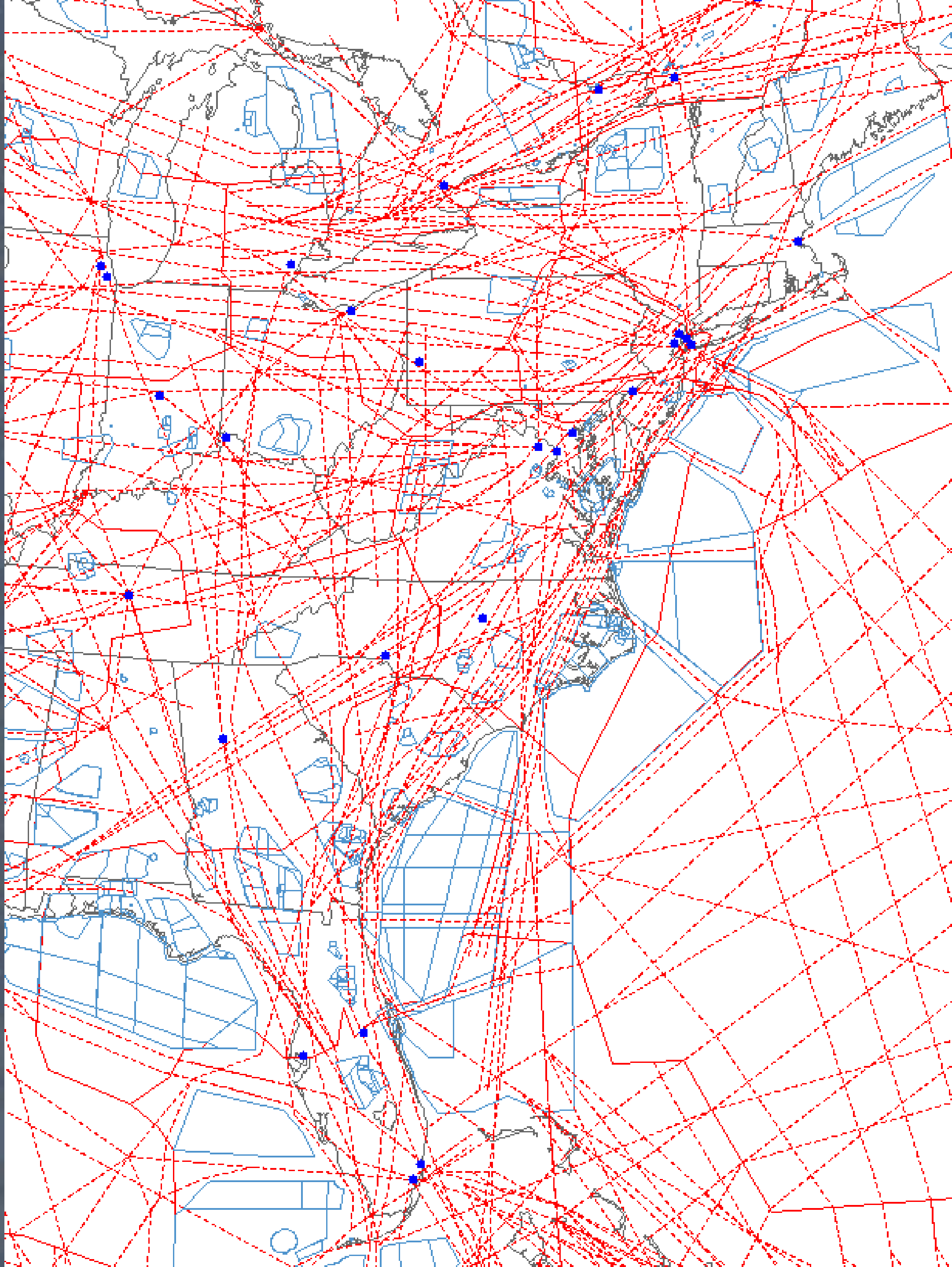
- East Coast of North America has the highest density air traffic in the world
- PBN routes have been implemented with as little as 6 NM lateral separation
- PBN airways wrap around Special Use Airspace (SUA)
- Two situations where FRA conflicts with PBN.
- When a flight attempts a random route, it crosses many flows/airways including transitioning aircraft. Separation and Safety become compromised
- Optimizing a route for a single aircraft can have detrimental effect on multiple other flights, delaying the system as a whole



- FAA and Nav Canada are working together to modify the North America Route Program (NRP) which sets forth the rules for FRA in the US and Canada. FRA has been implemented in US & Canadian airspace for over 25 years.

- Working on updating the rules to allow FRA west of a North/South line that runs from Atlanta to west of Toronto. East of that line, PBN airways will be required to by filed and flown.

- This will remove the threat to safety, improve system efficiency, while allowing for single flight efficiency in the rest of the two countries.



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Thank you

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