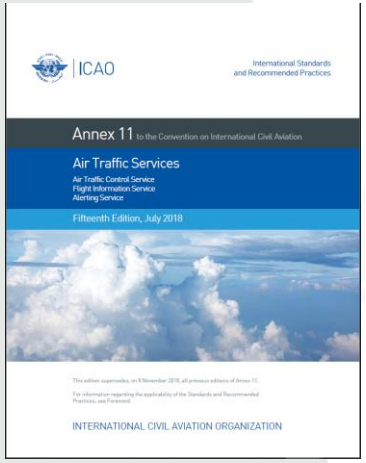
Maximizing Efficiency in Sector Capacity Calculation and Declaration Leveraging Fast-Time Simulations with CAPAN, Brazil, and FAA methodologies

The Nineth Meeting of the MID ATFM Task Force (MID ATFMTF/9)
(Dubai, UAE, 27 February 2025)

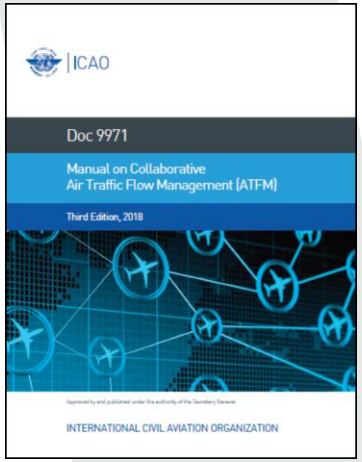
dans
دبي لخدمات الملاحة الجوية
DUBAI AIR NAVIGATION SERVICES

ICAO • OACI • ИКАО
国际民航组织 • ايكاو

AIRSPACE CAPACITIES DEFINITION- ICAO REFERENCES



Declared capacity. A measure of the ability of the ATC system or any of its subsystems or operating positions to provide service to aircraft during normal activities. It is expressed as the number of aircraft entering a specified portion of airspace in a given period of time, taking due account of weather, ATC unit configuration, staff and equipment available, and any other factors that may affect the workload of the controller responsible for the airspace.

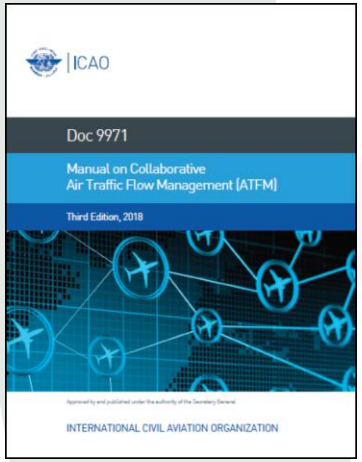


3.1.4 Airspace capacities

3.1.4.1 The capacity for an airspace sector (terminal or en-route) is defined either as an entry count (maximum number of aircraft entering an airspace sector in a given period of time) or a maximum occupancy count over a specific time period (e.g., 15 minutes). Airspace capacity represents the total number of flights that a controller can handle within a sector.

3.1.4.2 In some cases, instantaneous or short duration occupancy counts (e.g., one minute) can be used to complement entry counts and allow higher values for such entry counts. Such occupancy count capacities require accurate and frequent live ATC message and surveillance data updates to the ATFM system. Occupancy counts should be available in advance of the flight entry into the given airspace and on a frequent basis.

AIRSPACE CAPACITIES METHODS - ICAO REFERENCES



3.1.7 Capacity determining methods

3.1.7.1 It would be extremely complex to establish a universal rule to calculate capacity. Capacity can be affected by so many variables and external considerations that standardization is simply not possible. It is therefore up to each ANSP to decide how to determine its capacity by choosing from either basic methods based on observation or highly sophisticated mathematical models.

3.1.7.2 In any case, capacity limits may be assessed using feedback from control staff, incident reports where heavy workload is a factor and real-time observations. Post-operations analysis and monitoring provide essential feedback and can be of great use to refine capacity determination.

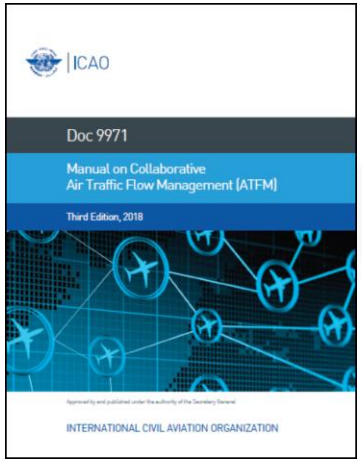
3.1.7.4 Capacity measurement and calculation methodologies should be developed according to the requirements and conditions of their operational environment. Calculation methodologies have already been established by States in several ICAO regions and the various methods have different levels of complexity. Examples are provided in Appendices II-B, II-C and II-D.

3.1.7.5 Each State is responsible for determining capacity, while using the methodology of its choice. Due consideration should, however, be given to the methods employed by neighbouring States, so as to ensure as much consistency as possible in the methods used to determine capacity for sectors or airports used by the same traffic flows. When regional agreements are established, this specific provision should be addressed.

*Note.— See Annex 11 — Air Traffic Services, 3.7.5.2 "**Recommendation.**— ATFM should be implemented on the basis of regional air navigation agreements or, if appropriate, through multilateral agreements. Such agreements should make provisions for common procedures and common methods of capacity determination."*

3.1.7.6 There are two schools of thought on how to assess and establish ATC sector capacity: mathematical occupancy and complexity models, and controller workload assessment models. In both cases it is essential that the capacity calculated using these models be validated by other means (e.g., real-time observations, real-time simulations).

ATC CONTROLLER WORKLOAD - ICAO REFERENCES AND MAIN FACTORS



3.1.7.8 Controller workload assessment models break down the controller workload into a set of definable and measurable tasks for which average execution times are defined. These tasks include coordination, handling flight data, radio frequency, communications and conflict management. Since the amount of mental reasoning a controller uses cannot be measured, an acceptable workload threshold is normally established and capacity is assessed to be at the point where this threshold is reached. Such models require intensive participation by the control staff in establishing task execution workload metrics.

- Aircraft Complexity (Number of types, performance differences)
- Airspace Density (Number of aircraft, proximity)
- Traffic Flow (Arrivals/Departures, crossing traffic)
- Weather (Visibility, wind, turbulence)
- System Support (Automation, tools available)
- Controller Experience (Years of service, training)
- Communication Load (Frequency of radio calls)
- Sector Characteristics (Size, complexity of routes)

WHY ATC WORKLOAD PREDICTION MATTERS?

- Effective ATC Workload management is crucial for ensuring safety and efficiency
- A high ATC workload can lead to stress, fatigue, and reduced performance, increasing the risk of errors and accidents
- ATC Workload estimation supports strategic decision-making in **capacity planning and resource allocation**

CONTROLLER WORKLOAD ASSESSMENT

How can we assess the Controller Workload ?

Taskload Based Methods	Physiological Measures	Subjective Measures	Hybrid Methods
Time Based Analysis	Heart Rate Variability (HRV)	NASA-TLX (Task Load Index)	Combining Objective and Subjective Measures
Event Based Analysis	Eye Tracking	Rating Scales	
Operational Complexity Metrics	Brain Activity (EEG)	Interviews and Observations	

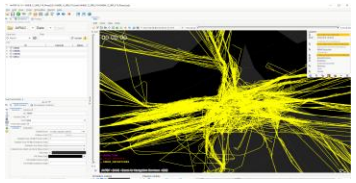
TASKLOAD BASED MODEL - METHODOLOGY

Preliminary Analysis

- Literature Research
- Review of published methods
- ATCO, SME interviews

Structured Analysis

- Scenarios Definition
  - Peak/non-peak, military/VFR, arrival/departure
- Data Collections and Process

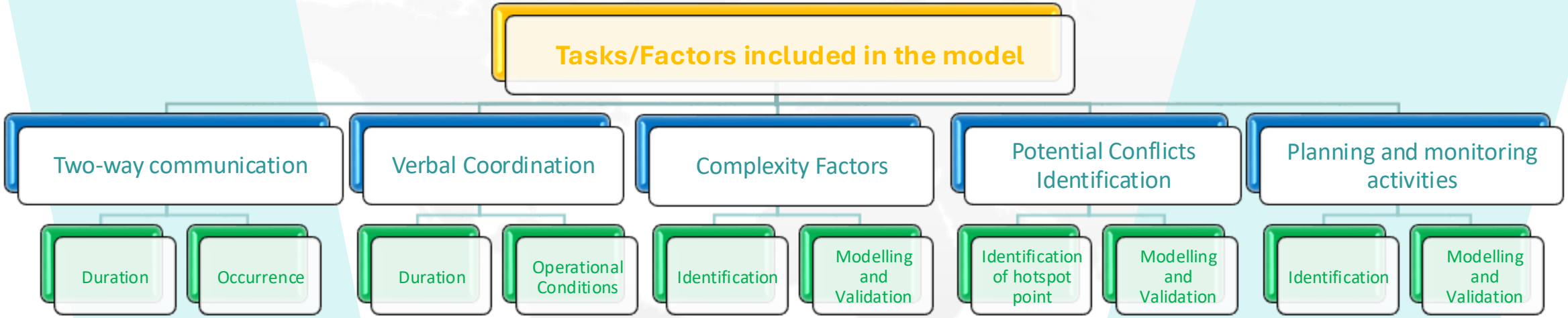


ATC Taskload Model

- Taskload Model drafting
- Taskload Model Validation
- Consolidated Taskload Model

TASKLOAD BASED MODEL DUBAI CTA – INPUT DATA COLLECTION

- Collection of data to develop the Task Load Model for the different controller positions managing Dubai CTA

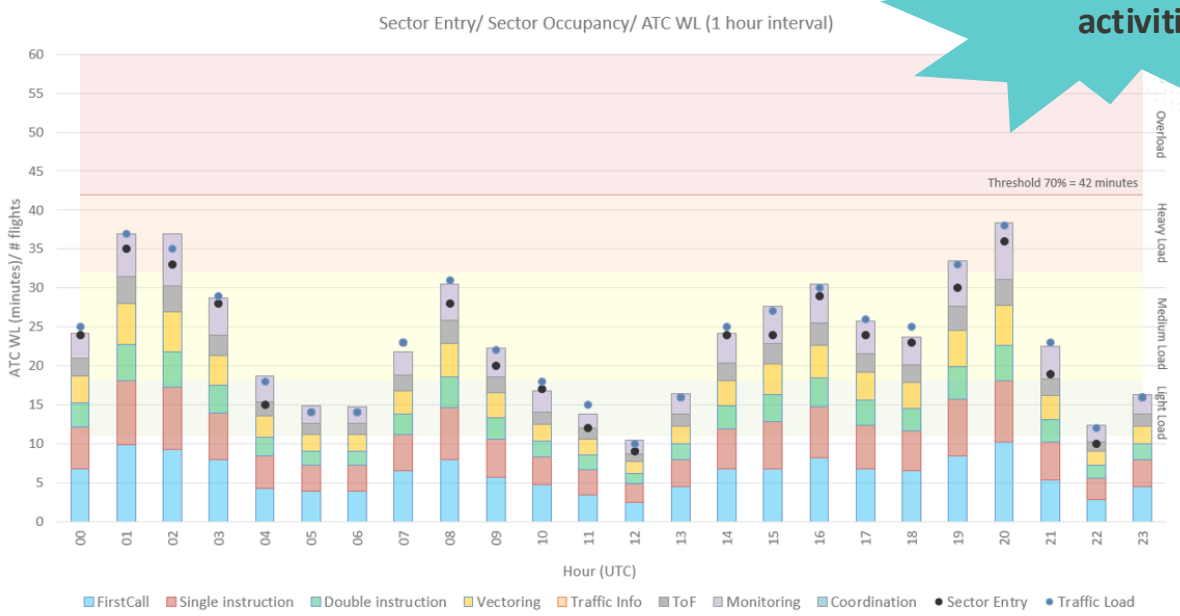


TASKLOAD BASED MODEL DUBAI CTA : DATA PROCESING AND VALIDATION

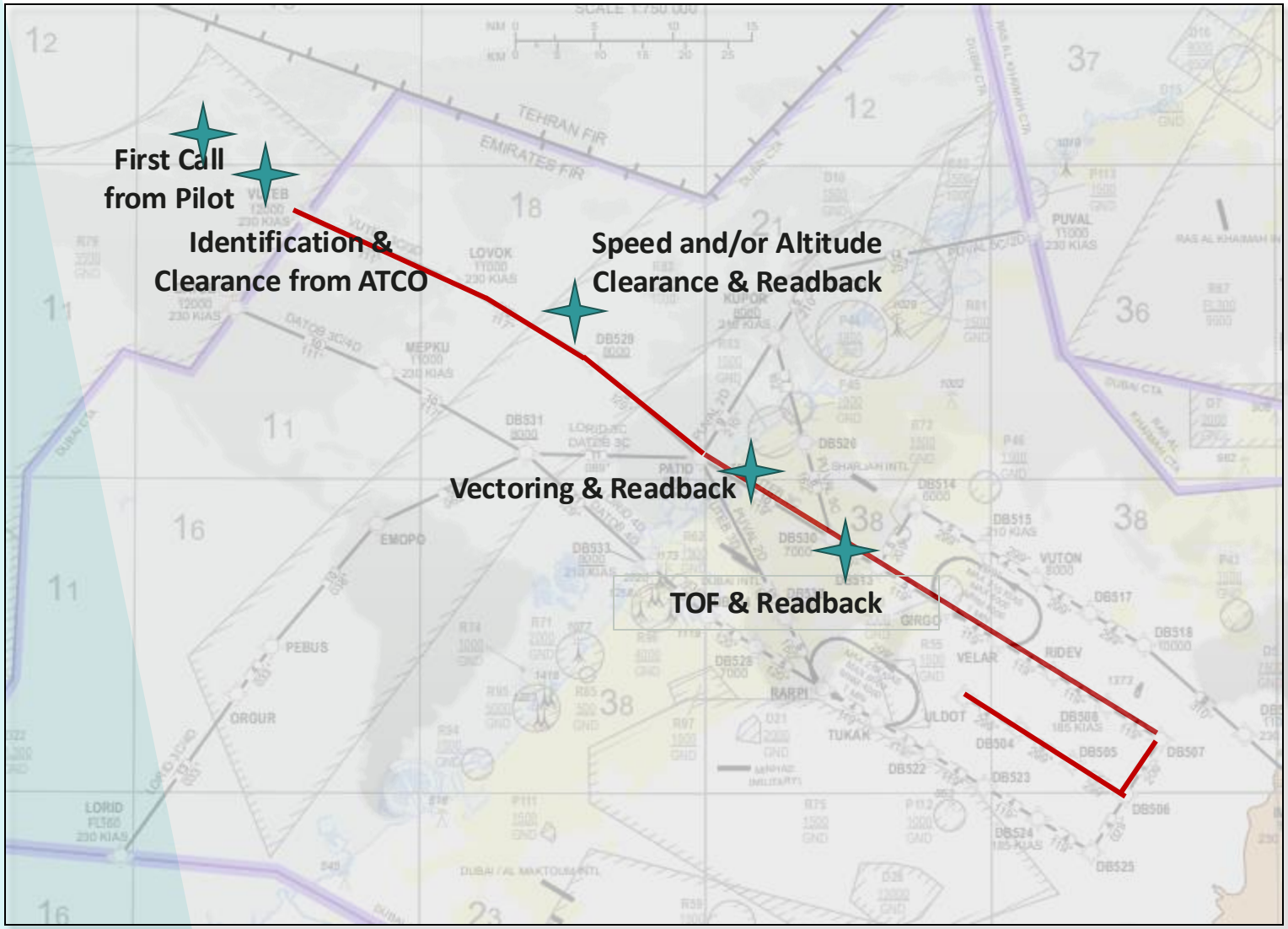
Task Group Category	Task Description	AVG DEP	AVG ARR	%DEP	%ARR
First Contact	First Call from Pilot	t_1	t_1	100%	100%
	Identification				
	Identification+ Single instruction	t_3	t_4	XX%	YY%
	Received from pilot	t_5	t_6	XX%	YY%
	Identification+ Double instruction	t_7	t_8	XZ%	YZ%
	Received from pilot	t_9	t_{10}	XZ%	YZ%

Sample of Tasks

Sample of Validation activities



DUBAI CTA SECTOR CAPACITY: EXAMPLE APPLICATION TASKLOAD MODEL



- Coordination
- Monitoring
- Complexity

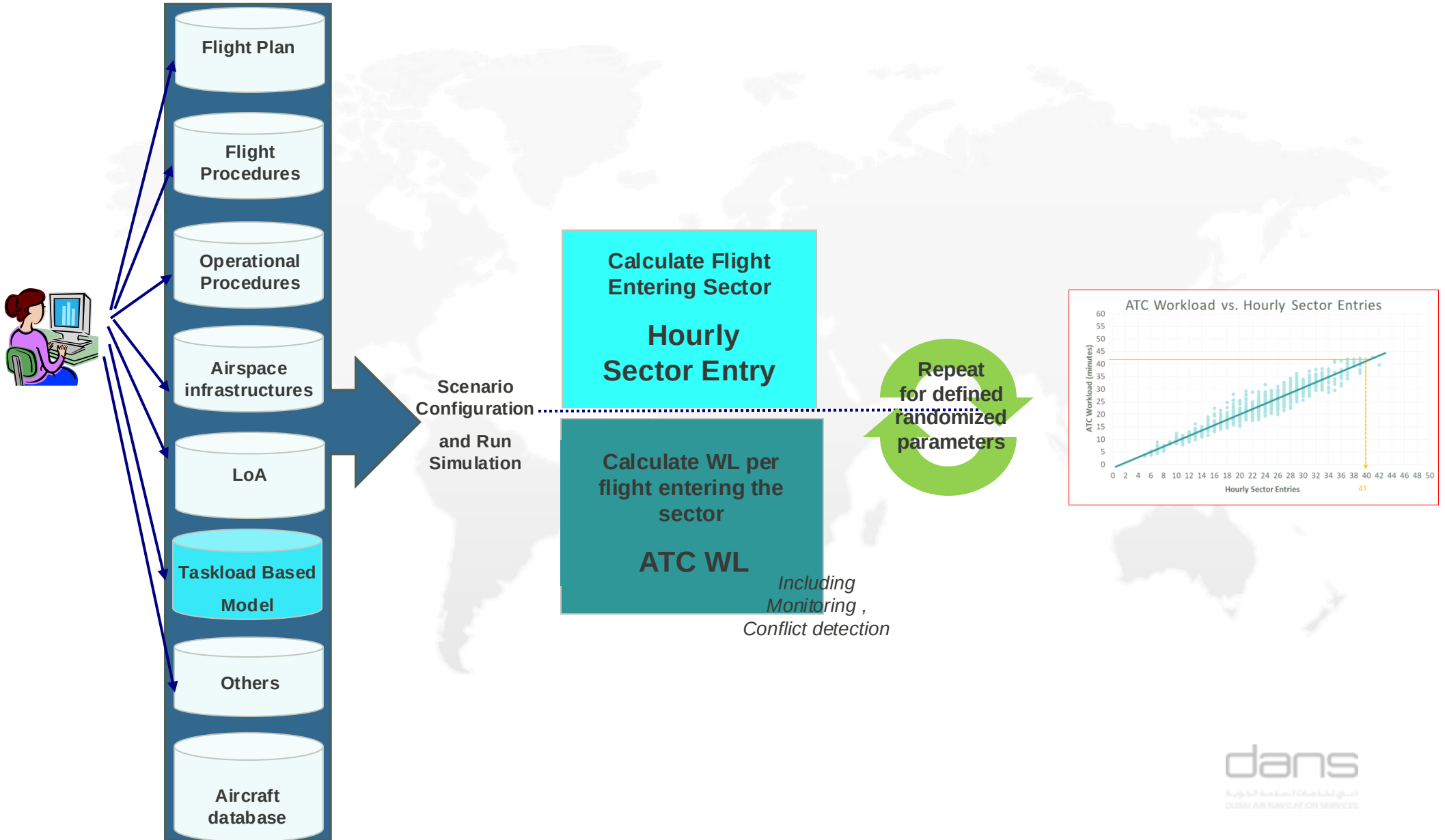
TASKLOAD BASED MODEL - APPLICATION

- Supporting the Airspace Capacity Declaration Process
- Assessing and monitoring the existing Airspace Capacities
- Supporting the definition of ATFM measures
- Evaluating the impact of new systems/procedures/flight procedures on the ATCO Workload
- Identifying the bottlenecks and investigating feasible solutions

CASE STUDY: DUBAI CTA SECTOR CAPACITY CALCULATION

- Theoretical Sector Capacity calculated for Dubai CTA Sectors
- Calculation of ATC Workload following Doratask Methodology
  - The workload is determined by totaling the time a controller spends conducting all essential tasks, both observable and non-observable, related to air traffic flow within their sector and specific working position. Sector capacity is established by adding the overall task load to a factor that reflects the required recovery time for controllers
- Data sampling: FTS to create different combinations of entries and workload (calculated based on the task load model developed)
- A regression analysis is applied to derive the average sector capacity in terms of hourly entry rates or occupancy.
- Aligned with EUROCONTROL CAPAN Methodology

CASE STUDY: DUBAI CTA SECTOR CAPACITY CALCULATION



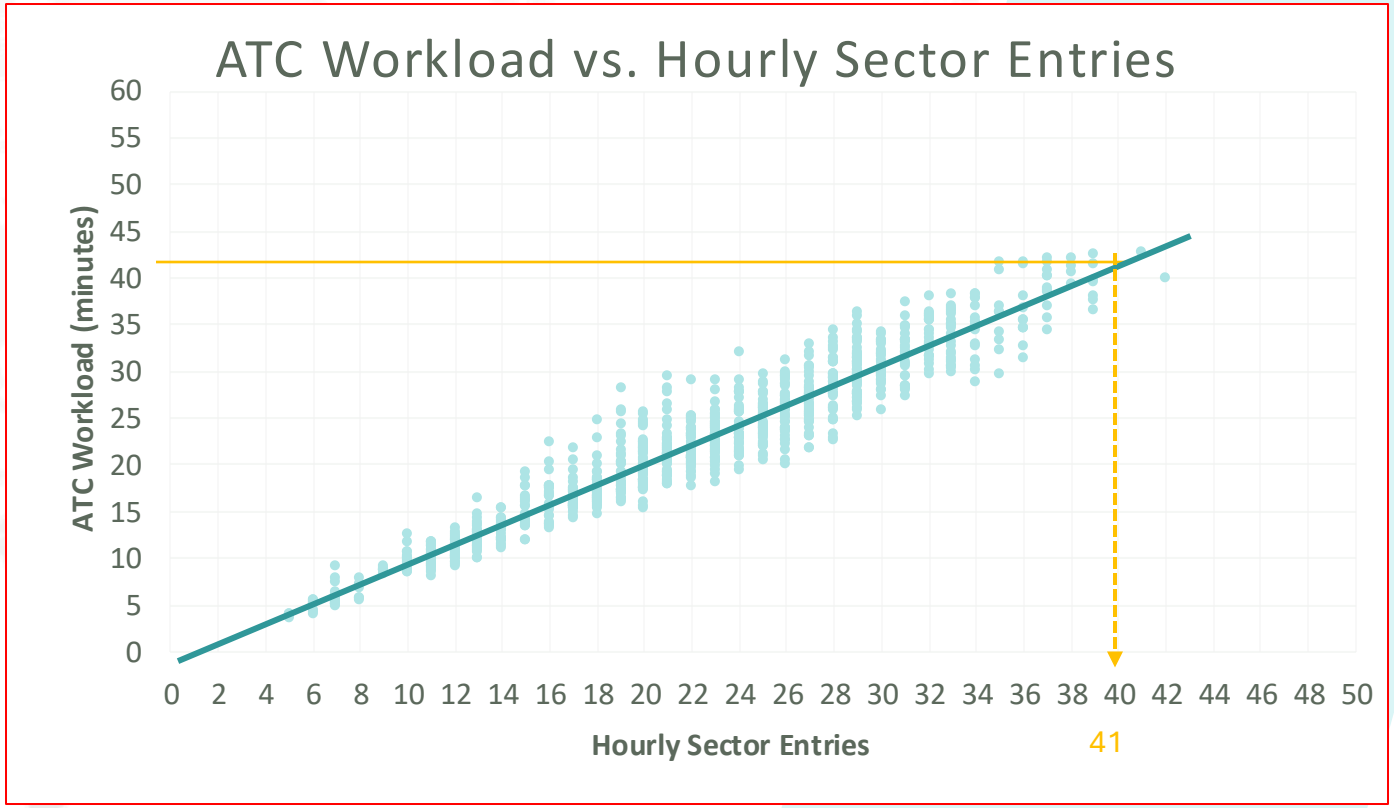
DUBAI CTA SECTOR CAPACITY: THEORETICAL CAPACITY CALCULATION

Traffic Demand	Run
2024	10
2024+5%	10
2024+10%	10
2024+20%	10

ATC's workload is defined by the time needed for executing
- "observable" tasks
- "non-observable" tasks

The capacity is defined as the workload level by which the ATC has enough time for "recovery"

Pessimistic sector capacity Estimation (Eurocontrol)



Application of Brazilian and FAA methods using FTS data

- Mid Region ATFM Plan (Ed 2022)
  - Sector Capacity based on FAA methodology (Appendix E)

    Sector capacity is determined using the average sector flight time in minutes from 7 a.m. to 7 p.m., Monday through Friday, for any 15 minute period.

    Sector Capacity value optimum $= \frac{(Average\ sector\ Flight\ Time\ in\ seconds)}{36sec}$ +/- adjustment factors

  - ATC Sector Capacity Calculation Model Used in Brazil (Appendix F)

    The number of aircraft that can be controlled simultaneously by a single controller (N) in a given sector is estimated using the following formula:

$$N = \frac{(Average\ Flight\ Time\ \ of\ aircraft\ in\ sector) * Availability\ factor\ ATCO}{(number\ of\ communications) * (mean\ duration\ of\ each\ message)}$$

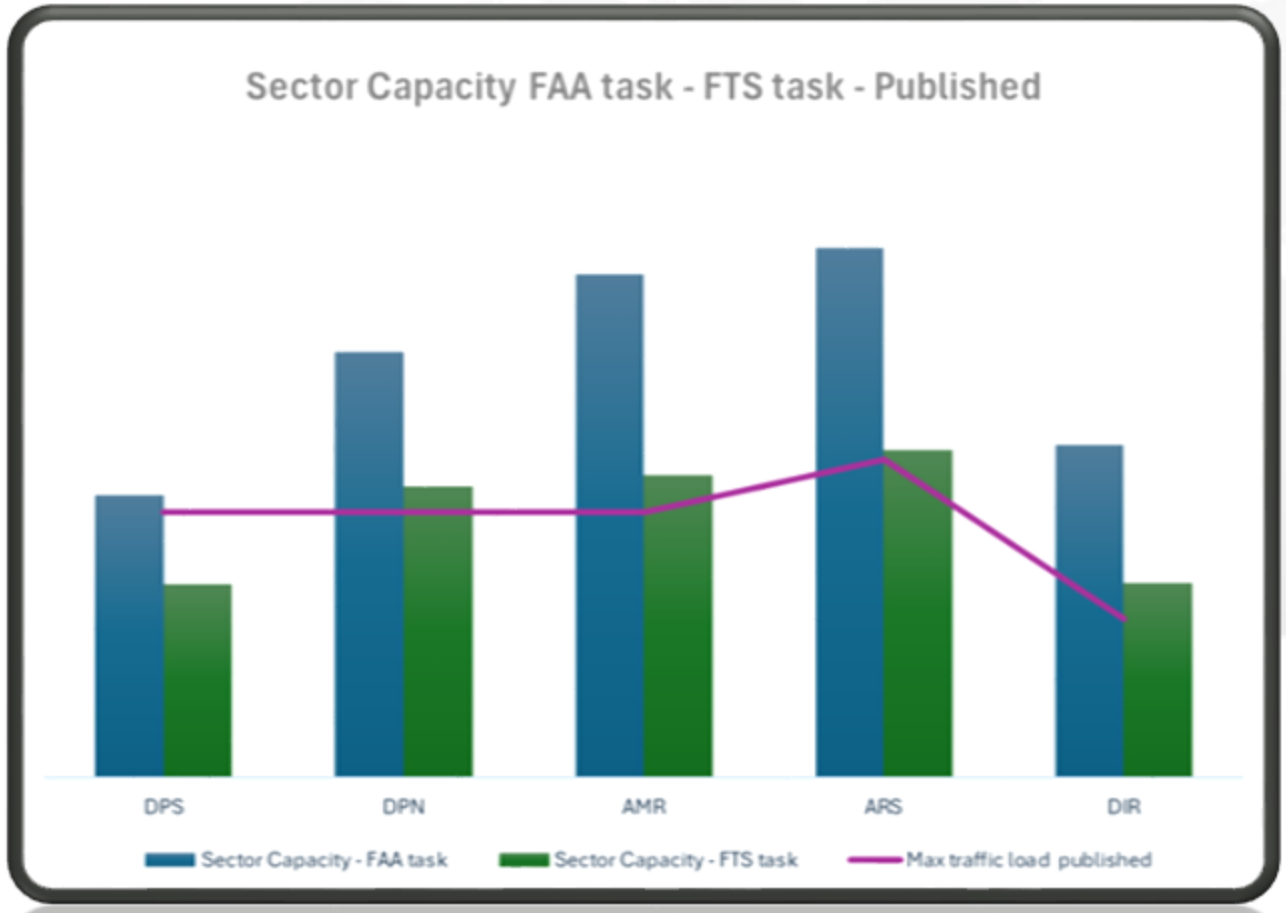
$$N_{ref} = \frac{T*}{(Tcom + TTS) * 1.30}$$

$$N_{pico} = \frac{Tmax * \alpha}{(Tcommin + TTSmin) * 1.30}$$

Sector Capacity based on FAA methodology

Sector Capacity FAA task $\frac{(Average\ sector\ Flight\ Time\ in\ seconds)}{36sec}$ +/- adjustment factors

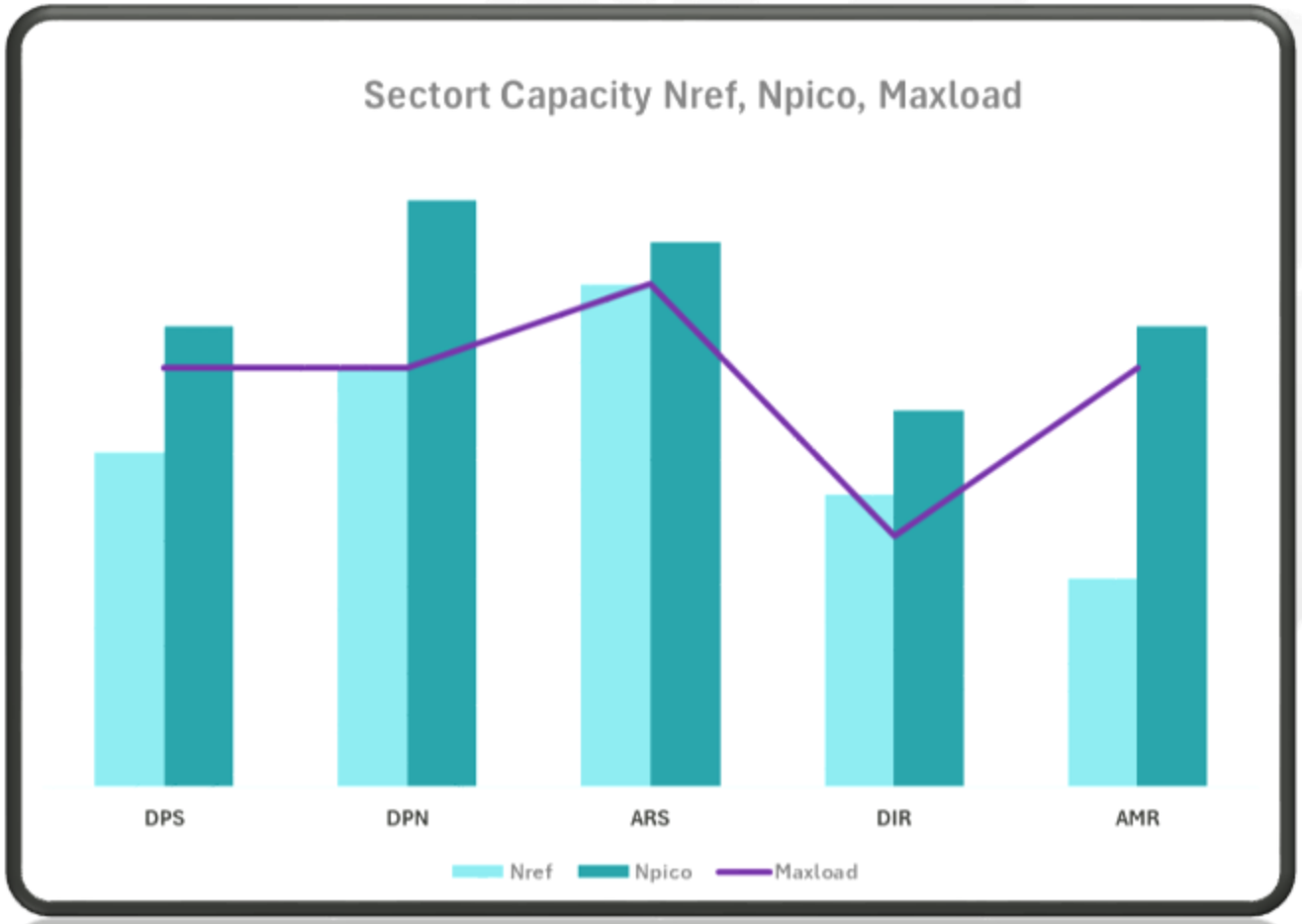
Sector Capacity FTS task $\frac{(Average\ sector\ Flight\ Time\ in\ seconds)}{FTS\ Task\ duration\ per\ sector}$



Sector Capacity based on Brazilian Method

Sector Capacity Optimum $\frac{T * \alpha}{(Tcom + TTS) * 1.30}$

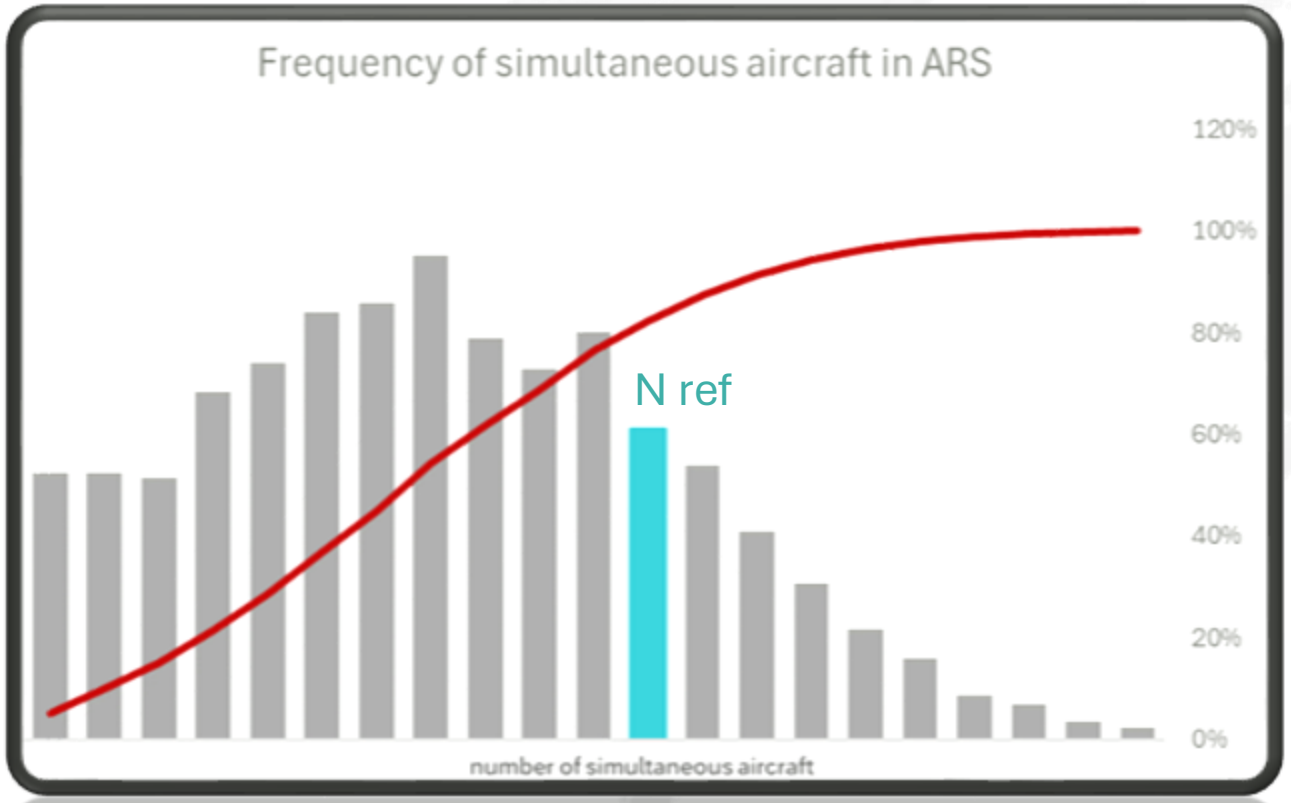
Sector Capacity Peak $\frac{Tmax * \alpha}{(Tcommin + TTSmin) * 1.30}$



Nref- Optimum

Npico - Sector capacity that a sector can keep for a maximum of 19min in case of peak demand

Brazilian Method vs. Sector real data



82% of the times <= Nref

FUTURE RESEARCH

- Further Refinement of FAA and Brazilian methods applied to Dubai CTA sectors
- Relationship between Sector Entries and Number of aircraft on frequency
- Airport ATCO Task Load model – to complement RWY KPIs

THANK YOU