SUPPORTING EUROPEAN AVIATION

ACAP Airport Capacity and Assessment Performance Methodology

Models to Determine Airport Capacity

Valerio Cappellazzo
EUROCONTROL NM Airport Operations

CONSORTIUM COORDINATOR sesar DEPLOYMENT MANAGER
FOUNDING MEMBER sesar JOINT UNDERTAKING
NETWORK MANAGER

Assessment & Enhancement

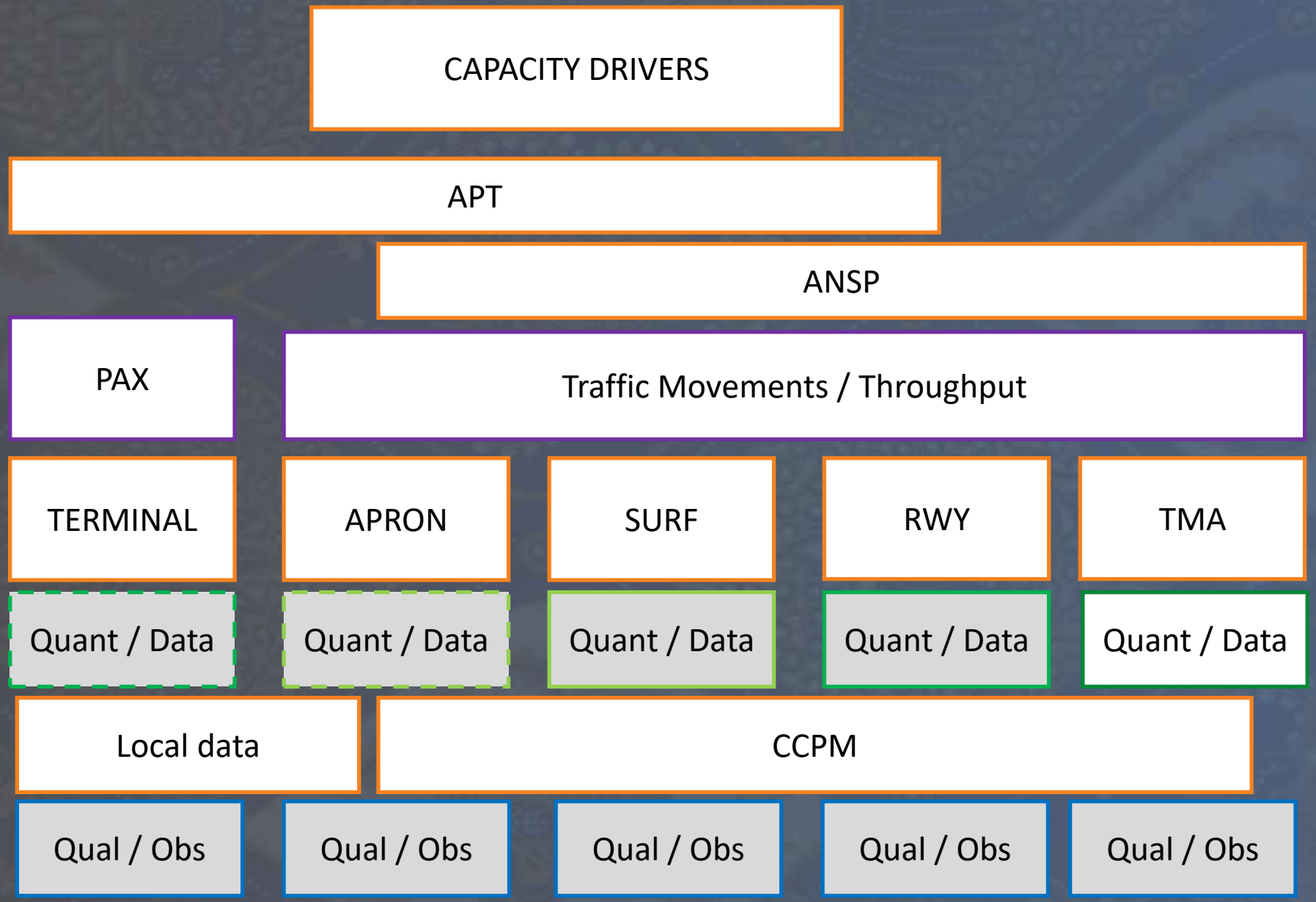
- Airside/Runway Capacity/ Throughput Assessment
- Aerodrome Capacity Assessment

- Current situation (Summer peak)
- Future traffic

- Quantitative
  - Traffic data
  - Passenger data
- Qualitative
  - Ops feedback
  - Survey

- ✈ Short-term (capacity management)
- ✈ Long-term (capacity enhancement)

Scope


CAPACITY DRIVERS
APT
ANSP
PAX
Traffic Movements / Throughput
TERMINAL
APRON
SURF
RWY
TMA
Quant / Data
Quant / Data
Quant / Data
Quant / Data
Quant / Data
Local data
CCPM
Qual / Obs
Qual / Obs
Qual / Obs
Qual / Obs
Qual / Obs

NM ACAP Process

1. Request received

2. Understanding the request background/scope / capacity needs (+ questionnaires)

3. Request feasibility evaluation

4. Support framework agreement

5. KoM + Airport ops context data gathering

6 Data collection / (CCPM)

7. RWY throughput assessment

8. Surface assessment

9. Landside processes (optional)

10. ATC Tower HF (optional)

11. Operational feedback/observations

12. Capacity evaluation

13. Recommendations / Results Presentation

14. Stakeholder consultation

15. Satisfaction survey

16. Follow-up of Recs impl.

ACAP recent studies

1. Understanding the request context

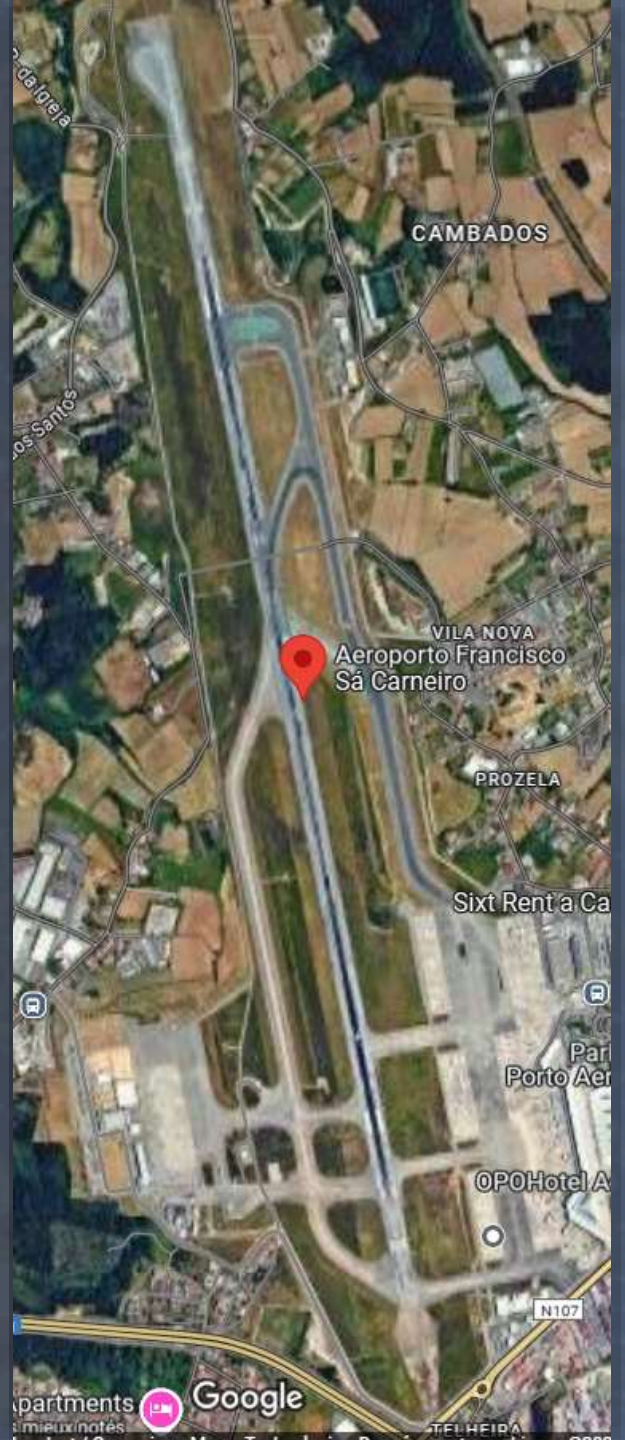
Capacity & Performance needs?

- Traffic evolution / growth
- Infrastructure development
- Operational limitations
- Delay impact

2. Airport Ops context

LPPR

Francisco Sá Carneiro Airport, Porto, Portugal



LPPR

Francisco Sá Carneiro Airport, Porto, Portugal

Public Airport Corner Strategic Airport Information
Data Services

STRATEGIC | EVENTS | DIVERSION CAPABILITIES

1. Airport Capacity
   - Current Capacity
     - Normal Conditions
     - Adverse Weather Conditions
     - Forecast Capacity
2. Traffic Forecast
3. A-CDM / Advanced ATC Tower
4. Pre-Crisis Management
5. Environmental Information
6. General Information
7. Weather Management
8. TMA / Approach
9. Infrastructure Services

Airport: LPPR / OPO - Porto (last update date: 22/01/2025 12:41 UTC)

Terminal Capacity

Please provide your terminal capacity (passengers/year):
Pax Flow / hour in / out (load factor 90%)

Terminal Departures : 3 850
Terminal Arrival : 3 200

Processed 15M PAX/2023

Global Yearly Current Capacity

Please provide your global yearly current capacity (movements/year):
212940
Comments
/

Capacities for different runway configurations

Runway Configuration	RWY Designator	Mode of operation per RWY designator	Capacity				Annual average of RWY configuration usage	RWY configuration most frequently used in peak hours
			Max Arrivals (movements/hour)	Max Departures (movements/hour)	Global (movements/hour)	Optimum		
17	17	Mixed mode - (ARR + DEP)	16	24	24	No	35 %	No
35	35	Mixed mode - (ARR + DEP)	16	24	24	Yes	65 %	Yes

Additional Information:
Daily, between 07:00/07:59, 11:00/12:59, 14:00/15:59 and 21:00/22:59 Max Arrivals are 16 movements/hour.
ATC does not regulate departures; arrival regulations only apply.

Separation Minima

Minimum radar separation required for two succeeding aircraft on the same approach:

IMC conditions:

Minimum surveillance separation 5NM.

VMC conditions:

Minimum surveillance separation 5NM.

Minimum radar separation required for two succeeding aircraft on parallel approaches (if applicable):

IMC conditions:

NA

VMC conditions:

NA

Do you apply local adaptations to the separation minima proposed by ICAO?

No

Application of separation minima

When considering two succeeding aircraft inside 10 NM from the runway threshold, at what point do you apply the minima?

Always.

Is there a difference between applying wake turbulence separation minima and radar separation minima at your airport?

No

Control and application of separation during approach

Where is the handover of aircraft from APP to TWR?

Transfer of communication:

15 NM final.

Transfer of control:

15 NM final.

Which controller (APP or TWR) is responsible for separation at which part of the approach?

APP controller responsible for surveillance separation until the beginning of the approach. After that TWR controller monitors surveillance information.

What are the procedural approach speeds that you use, and where do you expect aircraft to conform these? (If your speed management procedures/practices are published in the AIP, could you please provide a reference?)

AIP Portugal
ENR 1.5-2 (1.5.5)

3a. Last Summer delay assessment based on NM data

Departure and arrival punctualities

Monthly evolutions

Number of departures

	JUNE			JULY			AUGUST			SUMMER		
	2024	2023	%	2024	2023	%	2024	2023	%	2024	2023	%
Ndep	12006	10810	11%	13206	11811	12%	13124	11830	11%	38336	34451	11%

4% → Network

Punctualities

	JUNE			JULY			AUGUST			SUMMER		
	2024	2023	%	2024	2023	%	2024	2023	%	2024	2023	%
Departure punctuality	65%	63%	2%	58%	57%	1%	63%	63%	0%	62%	61%	1%
Arrival punctuality	57%	57%	1%	49%	54%	-5%	54%	61%	-8%	53%	57%	-4%

Network

	SUMMER		
	2024	2023	%
Departure punctuality	57%	58%	-1%
Arrival punctuality	65%	66%	-1%

Departure delays

Detailed per airline operating at specific Airport during Summer 2024

operator	Ndep	Traffic ratio	average dep delay [min]	average ground delay [min]	average dep delay due to ATFM EnRoute weather [min]	average dep delay due to ATFM EnRoute non-weather [min]	average dep delay due to ATFM Arrival weather [min]	average dep delay due to ATFM Arrival non-weather [min]	average reactionary [min]
All airlines	38336	100%	19.1	3.1	1.3	1.7	0.1	0.6	12.1
	458	1%	32.3	5.5	7.0	4.5	1.0	0.6	13.7
	14086	37%	15.2	3.3	0.7	1.0	0.1	0.7	9.4
	578	2%	30.2	2.8	3.0	2.4	0.3	0.8	20.9
	1130	3%	21.3	2.6	0.7	1.1	0.0	1.5	15.4
	407	1%	23.5	2.3	2.0	0.8	0.6	0.2	17.7
	2655	7%	10.3	2.3	0.0	0.4	0.0	0.2	7.4
	654	2%	30.4	2.1	4.3	3.0	0.8	0.2	20.1
	6476	17%	11.2	2.1	0.4	0.7	0.0	0.9	7.2
	1632	4%	32.2	1.9	3.4	3.8	0.1	0.4	22.6
	516	1%	25.5	0.9	2.5	2.4	0.0	0.3	19.4
Remaining airlines	9744	25%	27.4	4.2	2.4	3.4	0.1	0.5	16.8

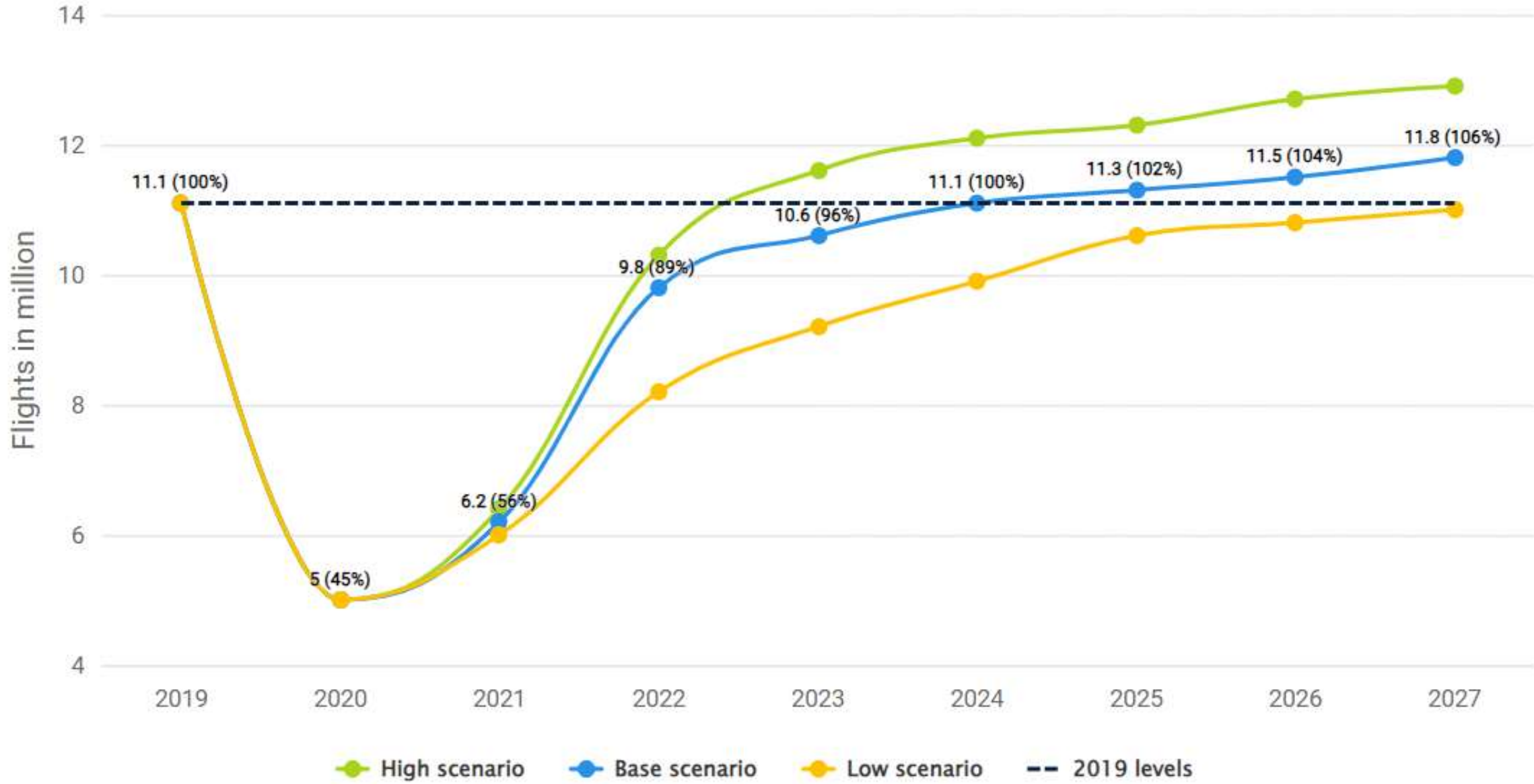
3b. Traffic Evolution forecast

Traffic forecast through the Agency Statistics and Forecast Service, STATFOR

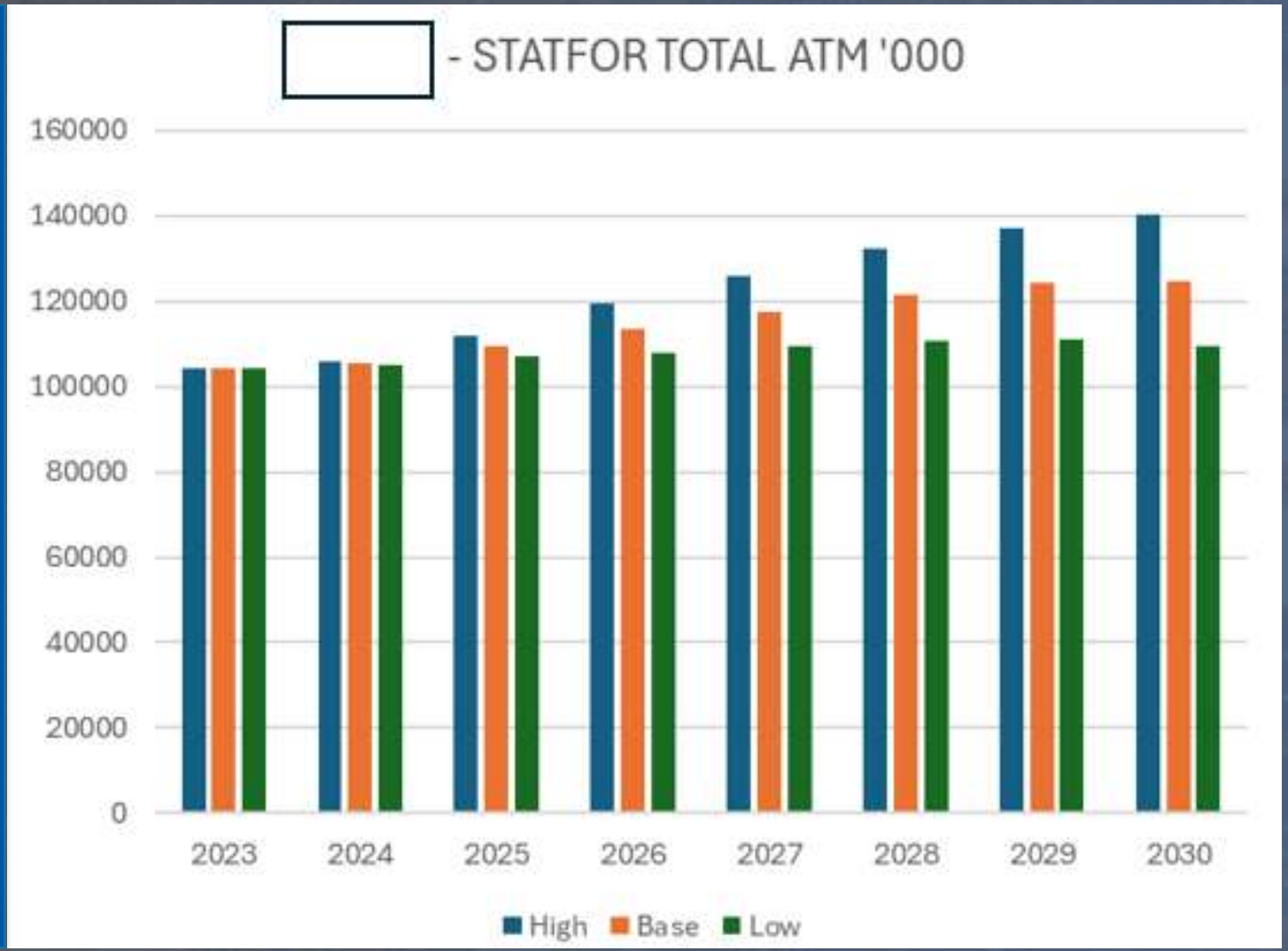
- **STATFOR develops a medium- and long-term forecast**
  - 2 year forecast (updated 3 times a year)
  - 7 year forecast (updated 2 times a year)
  - 20 year forecast (updated every 2 years), starts where 7 year forecast ends

EUROCONTROL 7-year forecast for *Europe 2021-2027

Actual and future IFR movements, % traffic compared to 2019

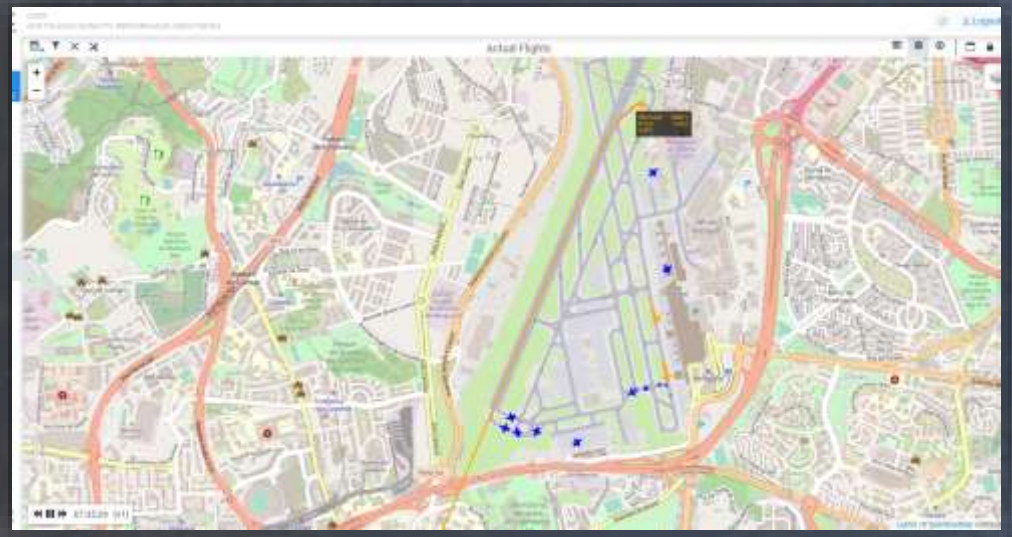


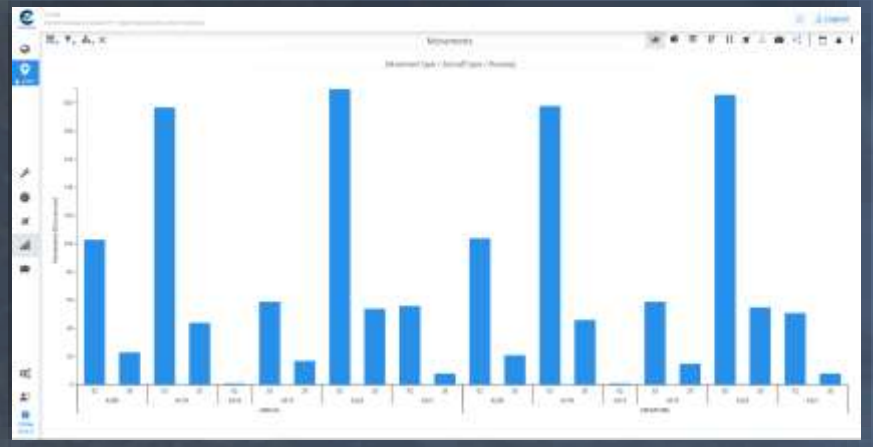
LOCAL FORECAST FROM STATFOR

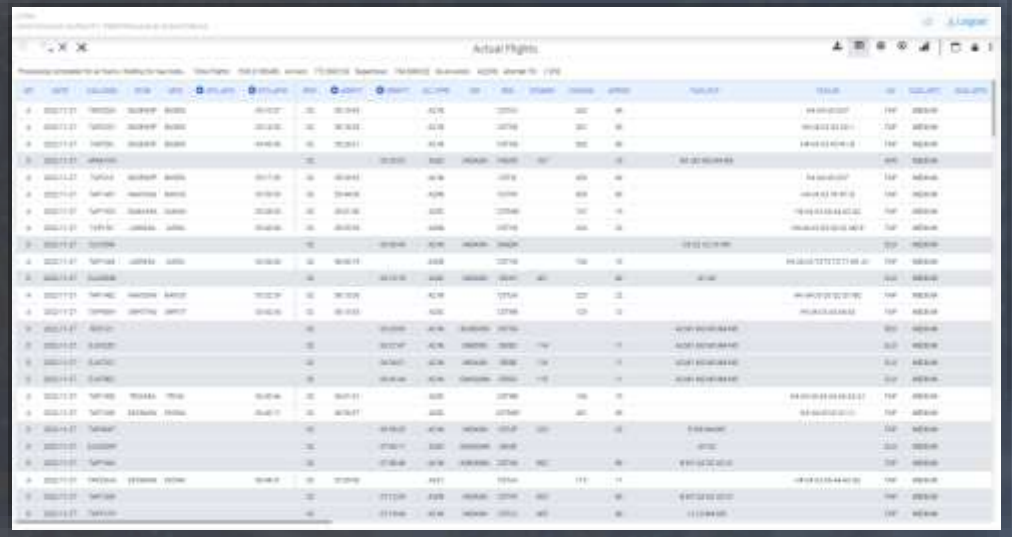


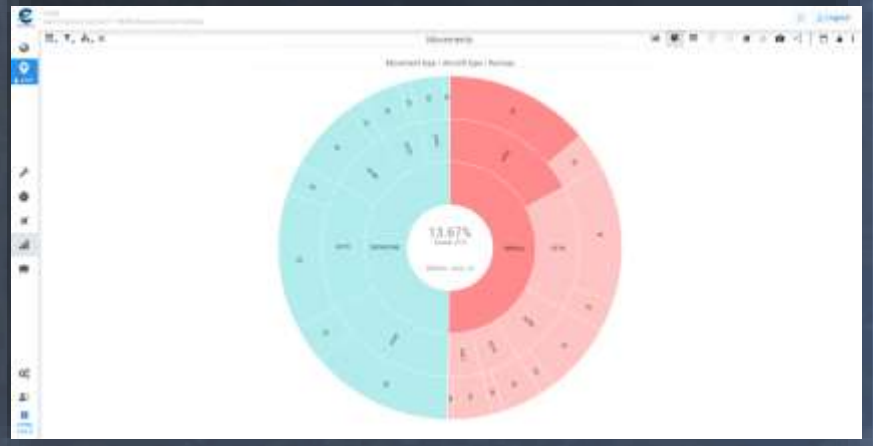
4. Quantitative analysis – Airside current operations

EUROCONTROL ‘CCPM’ Service
Continuous Capacity and Performance Monitoring





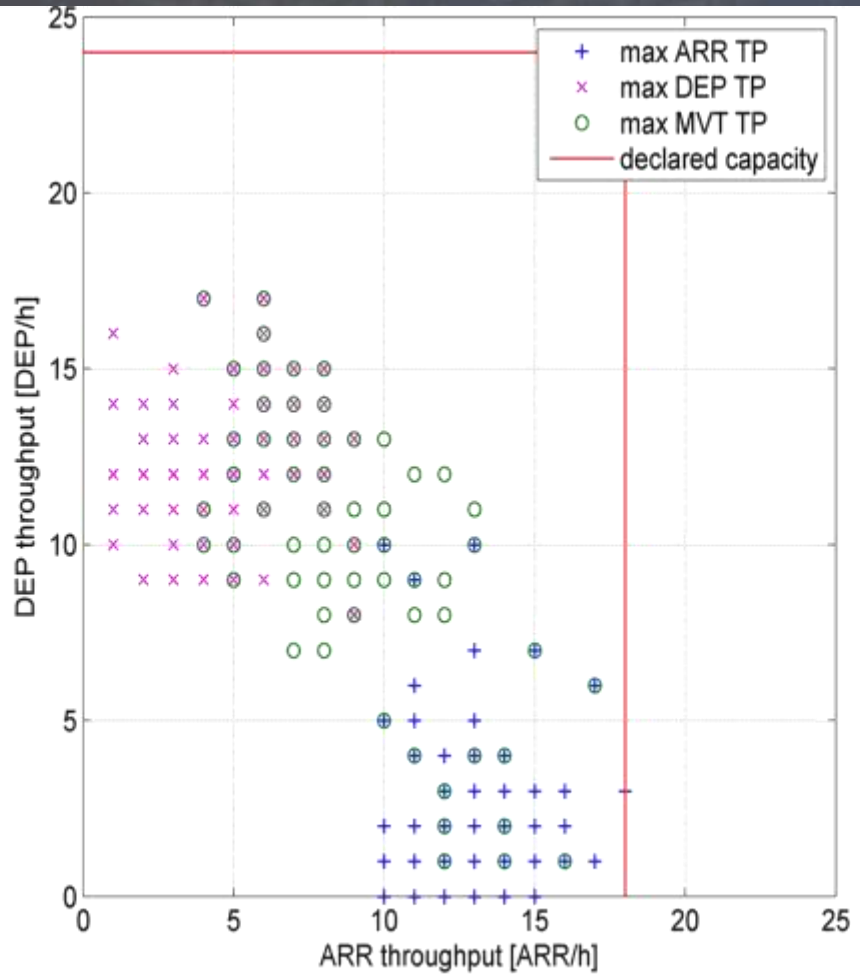


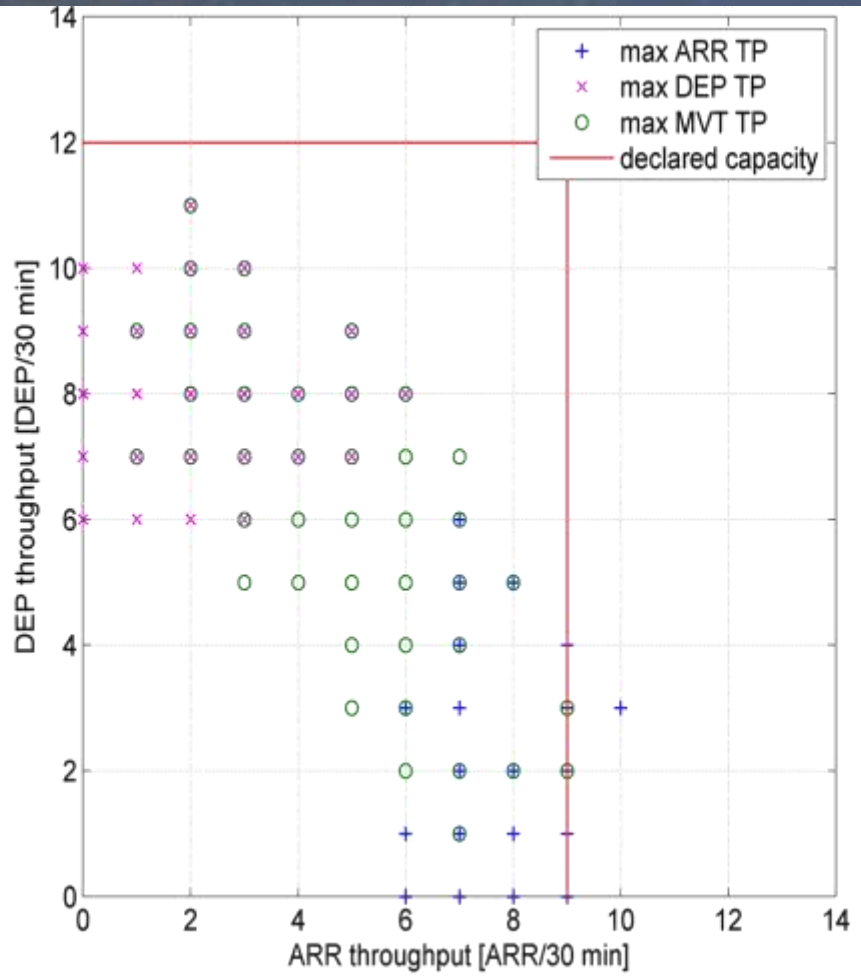


Traffic Analysis

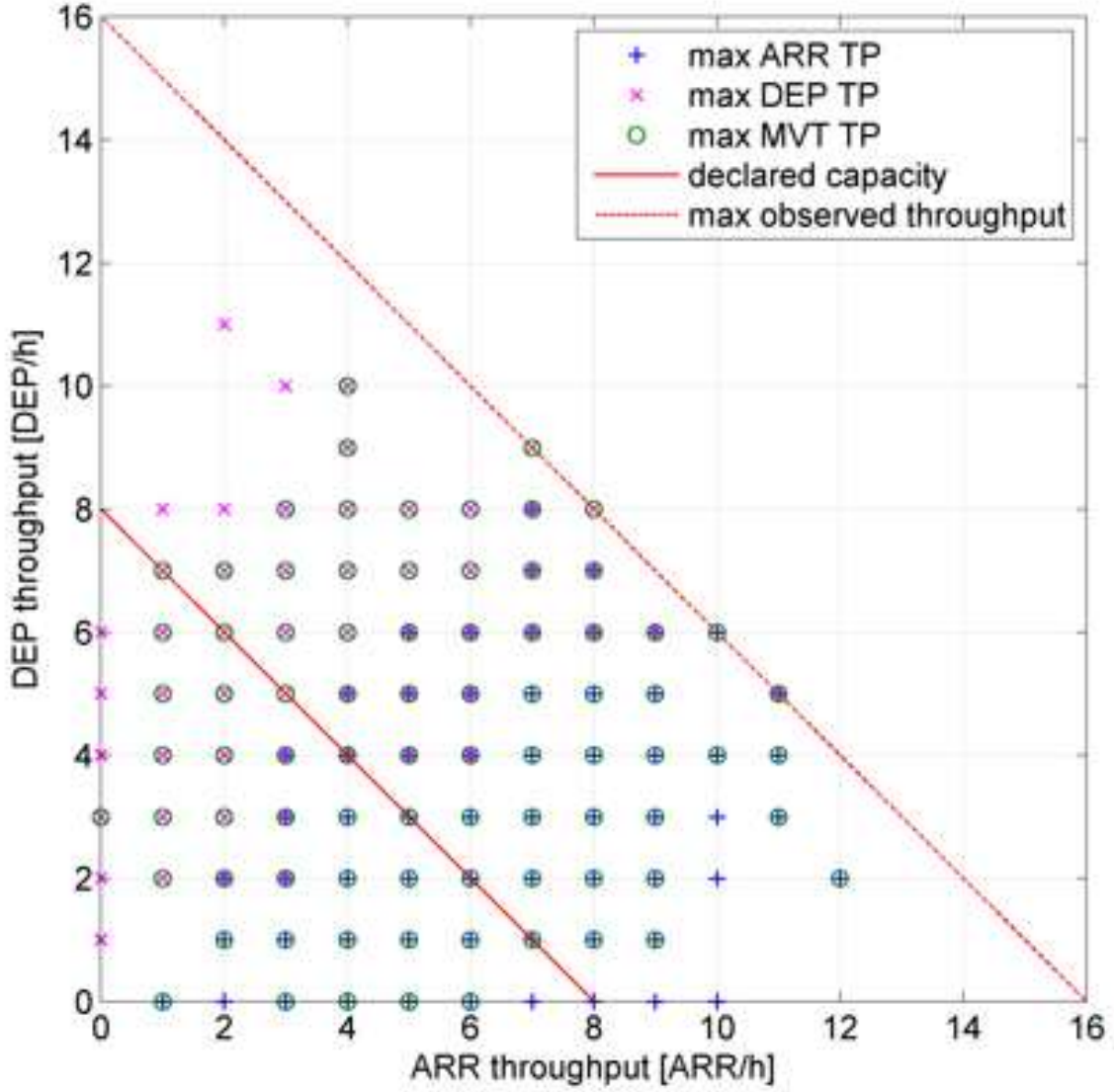
- **Traffic**
  - Average monthly, daily, hourly
  - Mix
  - Operators share
  - Patterns (AA/DD, ADA)
- **Runway use**
- **Max observed throughput in peak**
- **Arrival throughput**
- **Departure throughput**
- **ROT-A**
- **Runway exit usage**
- **ROT-D**
- **Runway entries usage**
- **Separation delivery**
  - Distance spacing distribution
  - Time spacing distribution
- **Surface throughput / Taxi pressure**

Airport throughput profile – RWY X



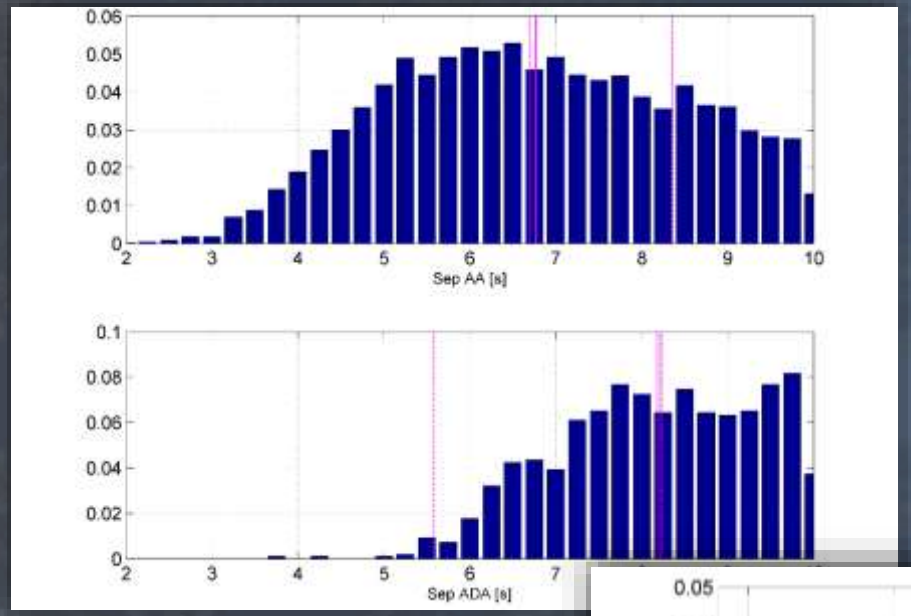


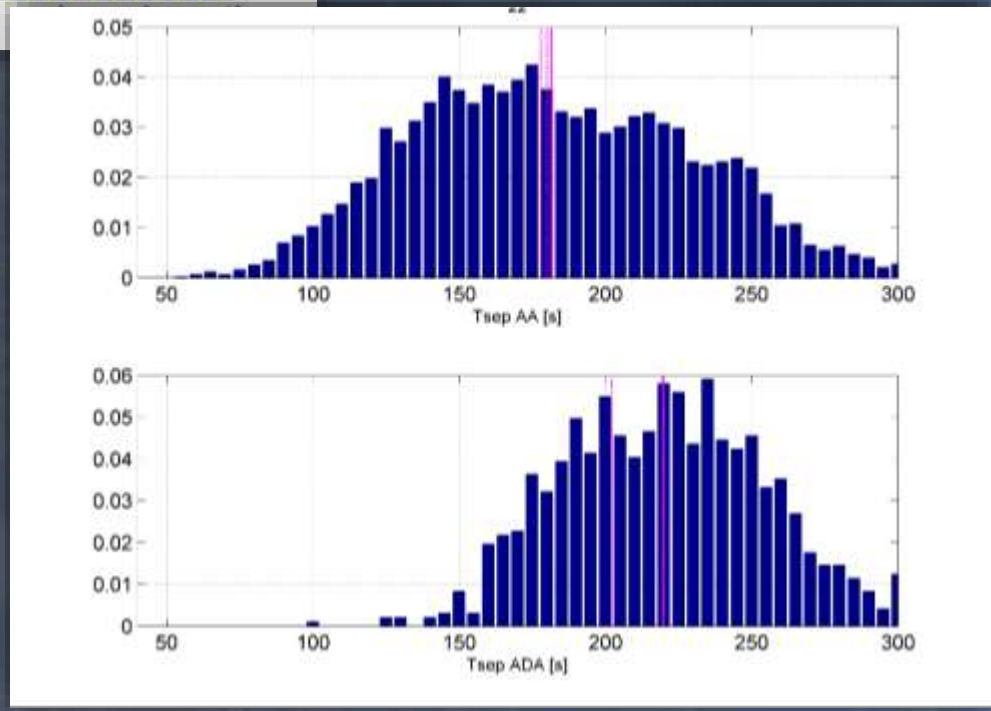
Airport throughput profile – RWY X



Runway Throughput / Use Statistics

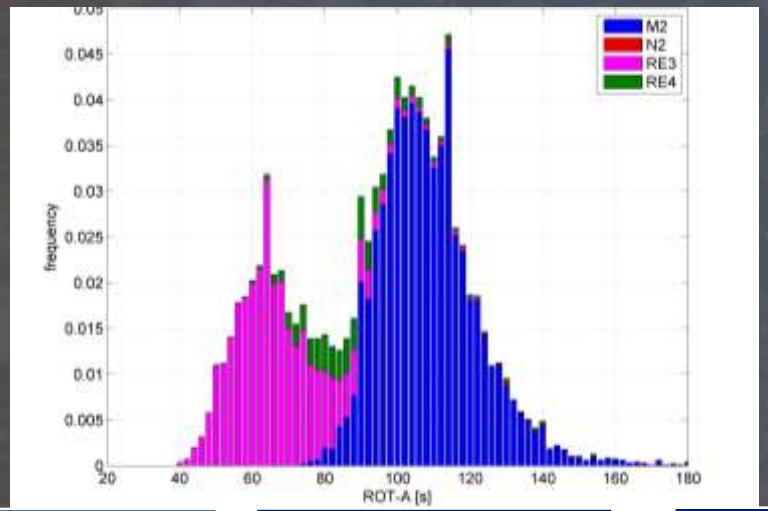
- Runway throughput
  - Segregated mode
  - Dependent operations
  - Mixed mode
- Arrival separation/spacing
  - Air separation
  - ROT-A
- Departure spacing
  - Air separation
  - ROT-D





Runway - Exits and ROT

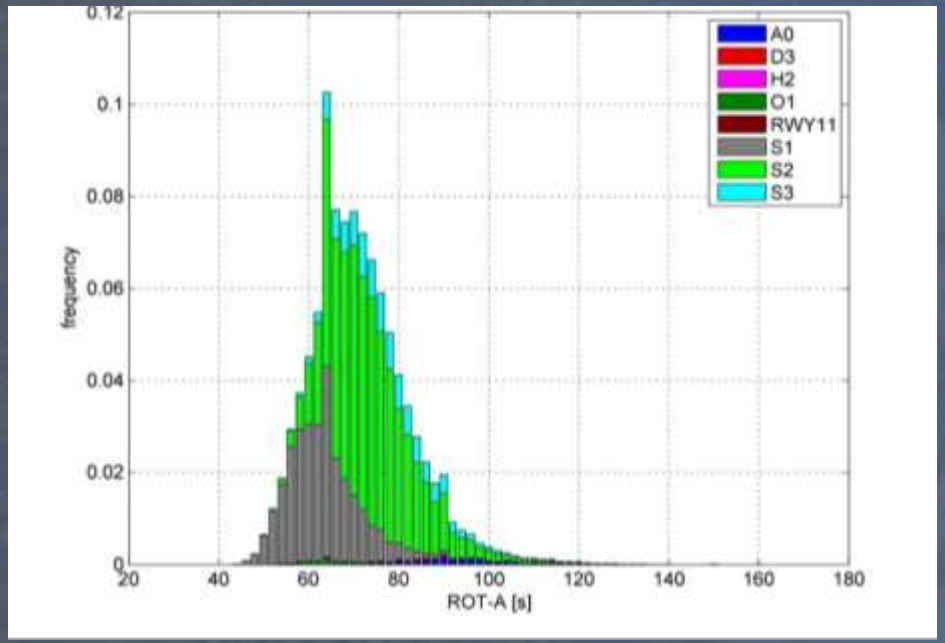
RWYXX ROT-A recorded across the reporting period



RWY EXIT Utilization	
Exit	All months
N2	0.4%
M2	62.5%
RE4 /W1	6.0%
RE3 / P2	31.1%

Mean ROT [s] WTC		
WTC	All pairs	Constrained pairs
J	110.8	112.7
H	109.4	109.1
M	92.0	92.6
L	102.4	100.7

Mean ROT[s] Exit	
Exit	Mean ROT-A [s]
N2	132.7
M2	109.3
RE4 / W1	88.0
RE3 / P2	67.3



RWY EXIT Utilization	
Exit	All months
A0	1.5%
S3 (RET)	10.5%
D3	1.5%
S2 (RET)	57.3%
S1 (RET)	29.2%

Mean ROT[s] Exit	
Exit	Mean ROT-A
A0	96.7
S3	77.3
D3	87.5
S2	73.8
O1	66.5
S1	63.3
RWY11	63.4

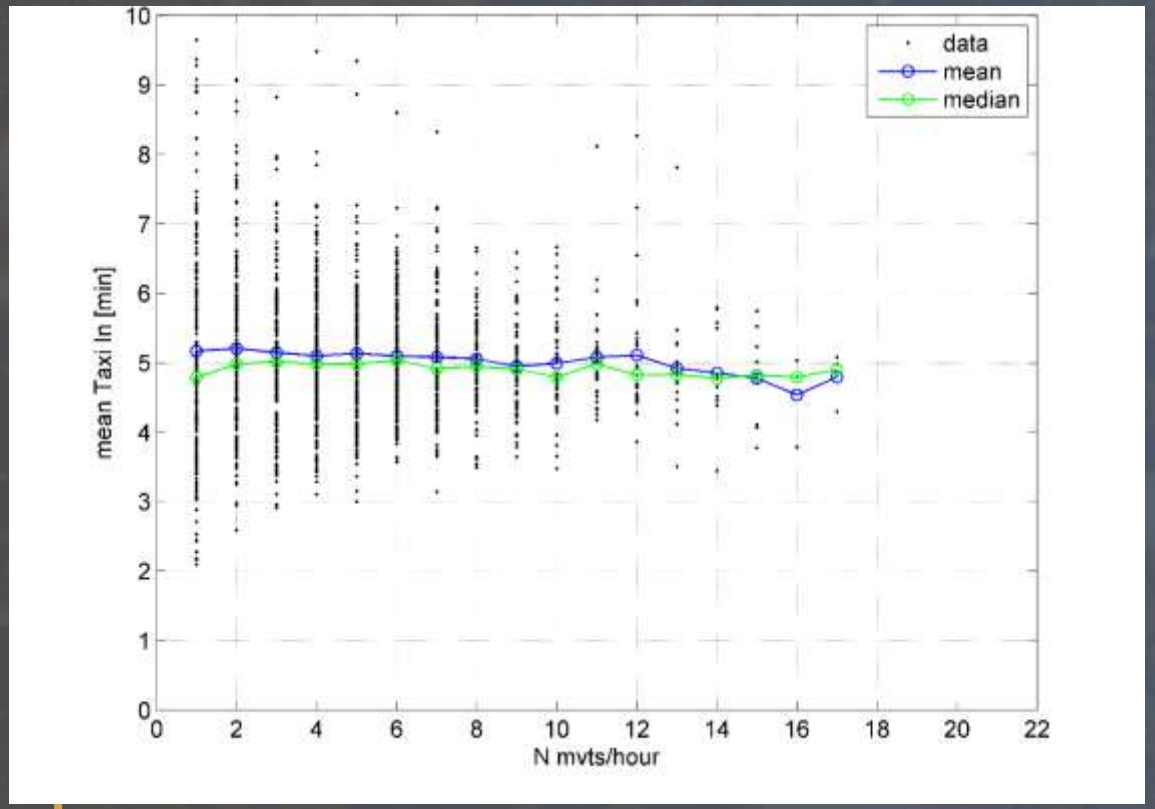
ROT-A Analysis

Average ROT / distribution

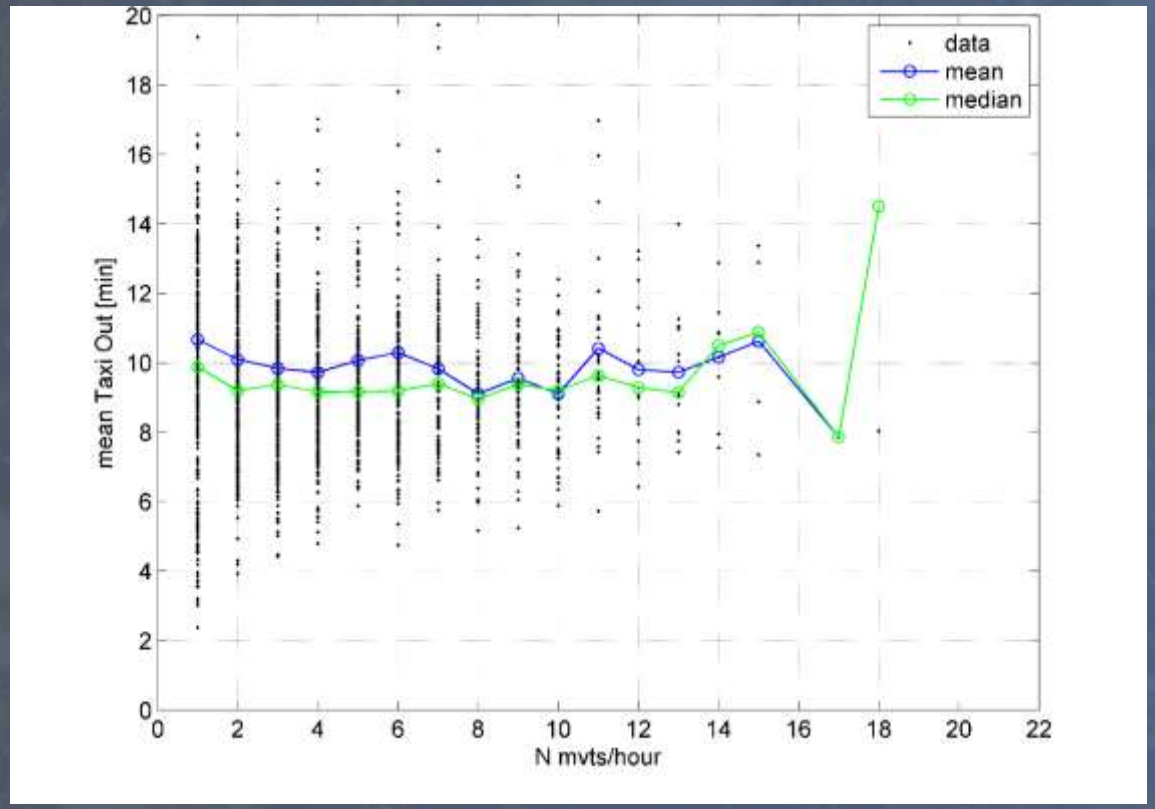
- ❑ Per airport
- ❑ Per runway
- ❑ Per QFU
- ❑ Per aircraft type
- ❑ Per operator
- ❑ Per runway exit
- ❑ Per runway braking conditions (GRF) (complementary analysis)

Taxi-in /-out time Analysis – Performance as function of ATMs

RWY xx Taxi – in performance



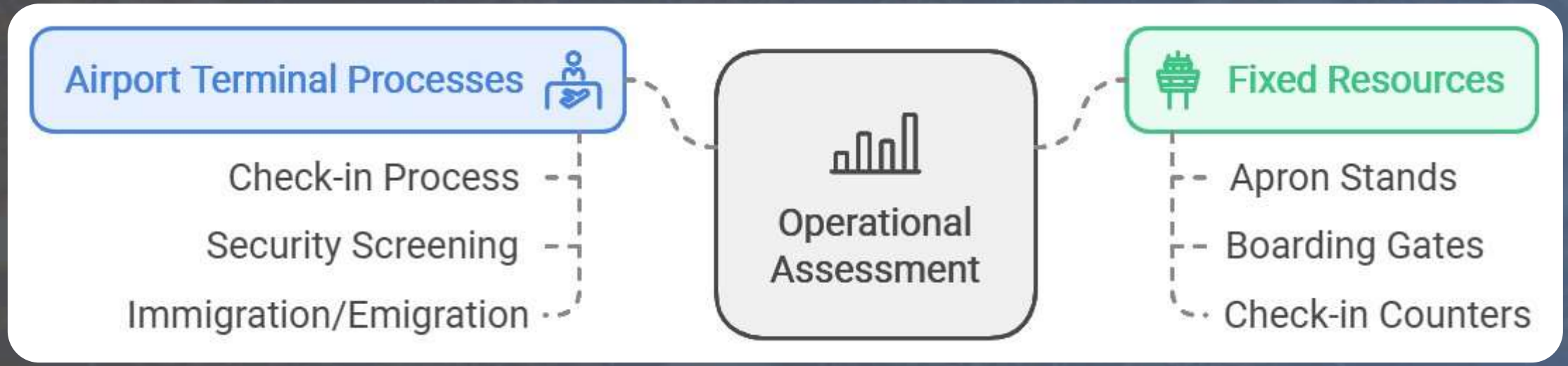
RWY xx Taxi – out performance



Quantitative analysis - Landside process (optional)

Landside Processing|

Analytical model is under development and validation



Landside Processing| High level Inputs and Outputs

Inputs

Processing facilities

Operations concept

Process design

Process data

Passenger profiles

Waiting time targets

Outputs

Show up against various facilities – based on FLT SCH

Calculated processor demand

Calculated Waiting Time

Calculated Qmax

- Pilot case with TIA Tirana
- Further validation of some parameters with TIA

5. Qualitative - Operational Challenges

Example – Push-back management

Surface procedures

Tower HF Analysis (optional)

What is Human Factors?

Human Factors (HF) is:

- the study of human performance in terms of human strengths, capabilities and limitations, expectations as well as factors that influence human performance either positively or negatively.....
- ....and the application of this knowledge to the design of work systems, methods / processes / procedures and environments to optimise overall system performance and safety (as well as well-being)

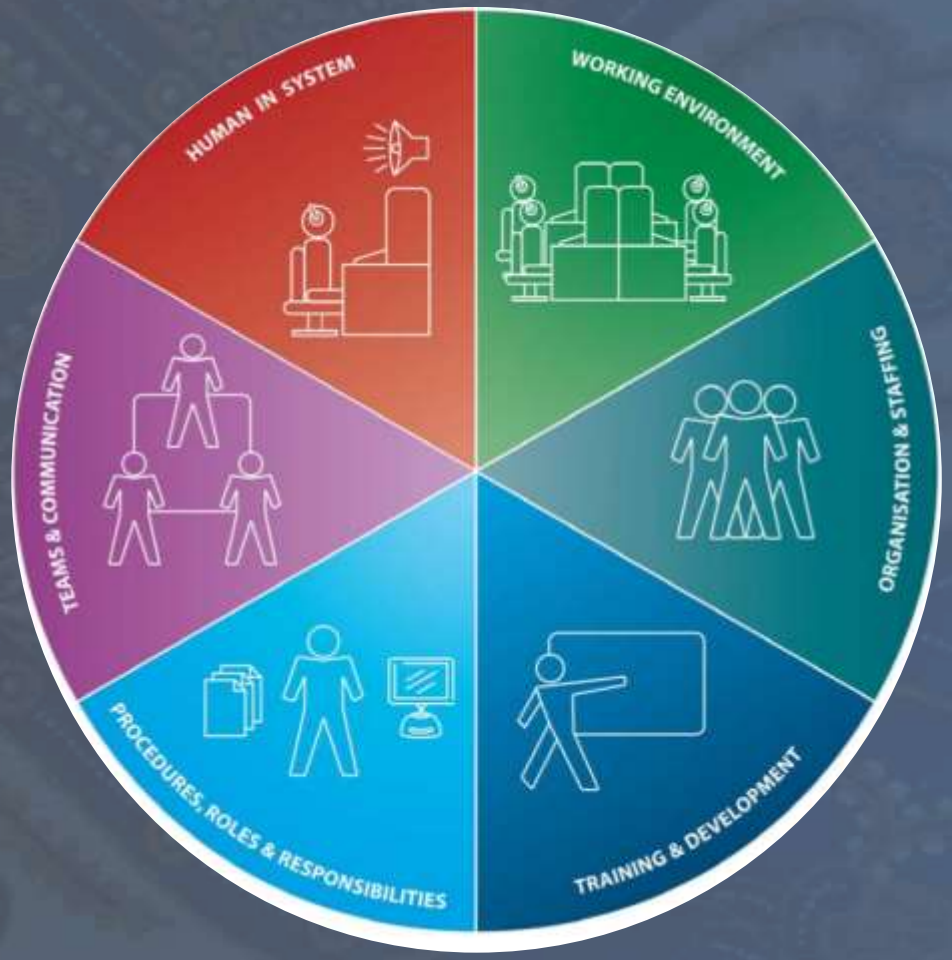
What is Human Factors?

***ICAO definition**: ''HF is concerned with the application of what we know about human beings, their abilities, characteristics and limitations, to the design of equipment they use, environments in which they function and jobs they perform.''*

What is a Human Factors assessment?

- A Human Factors (HF) assessment is a systematic process to identify, assess and manage human factors issues / aspects in the work environment (current or future) during a project life cycle

- The HF issues / aspects considered in a HF assessment cover several different areas of work:



Excerpt from the EUROCONTROL HF Case

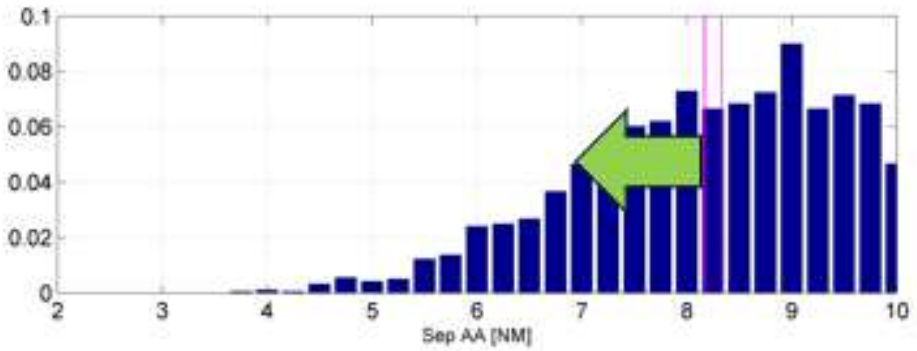
Why do a Human Factors assessment?

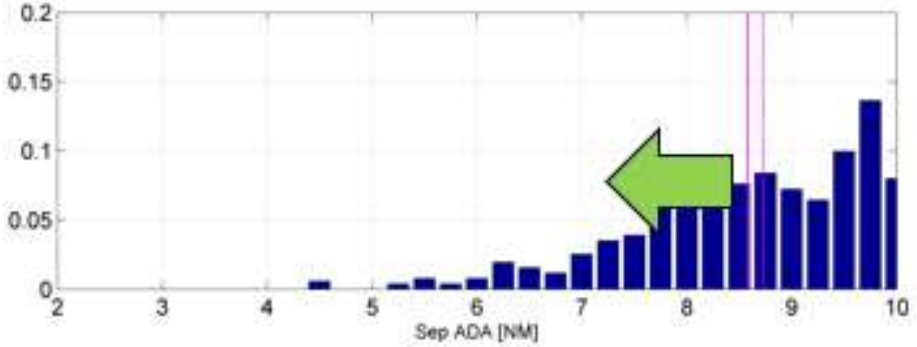
- In ATM, the role of the human is central: ATCOs are an integral part of the system
- If human / ATCO performance is negatively impacted or not optimised then the performance of the system as a whole will be impacted
- ATCO workload is often cited as a constraint that limits the number of a/c that can be handled per hour
- Hence, human performance and the role and tasks of the ATCOs in the tower are key components that can impact operations .....
- .....and so, the need for a HF assessment should be considered when performing an airport capacity and performance study
- Furthermore, if significant changes to operations are proposed, a HF assessment should be performed as part of the safety case in accordance with EASA regulation 373

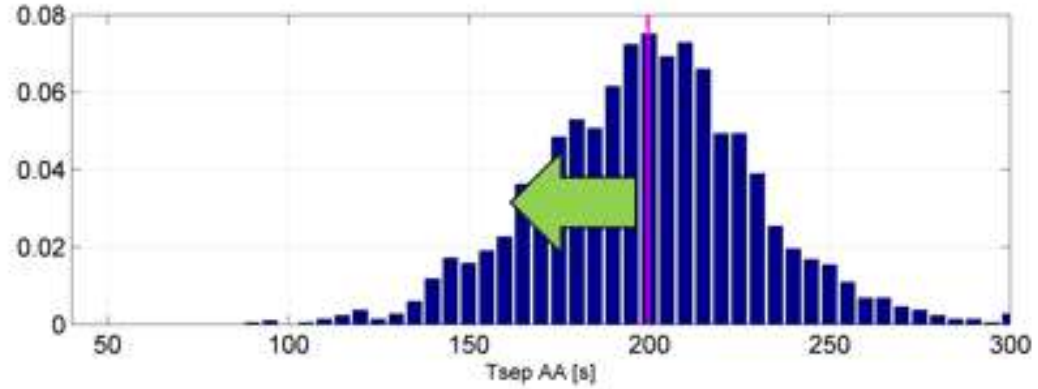
6. Projection for Runway Capacity / Throughput enhancement

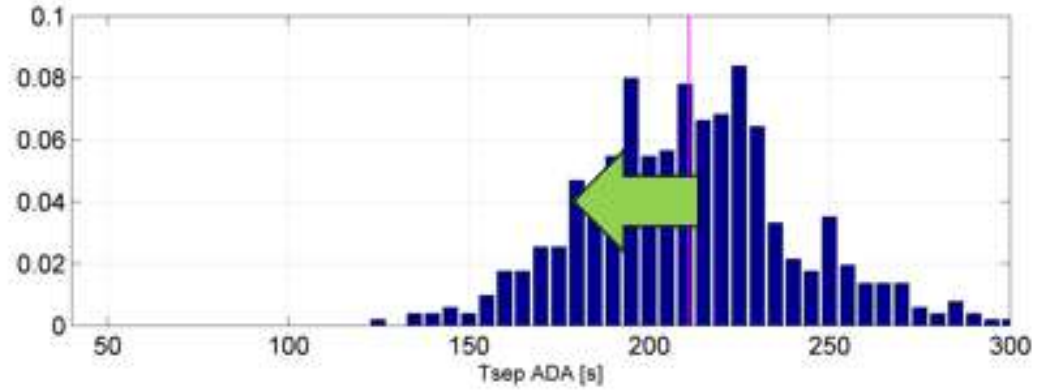
Runway– Arrival Peak Observed Separation

Distribution of distance separation for A-A and A-D-A pairs per ARR runway









7. Capacity / Throughput Enhancement Scenarios

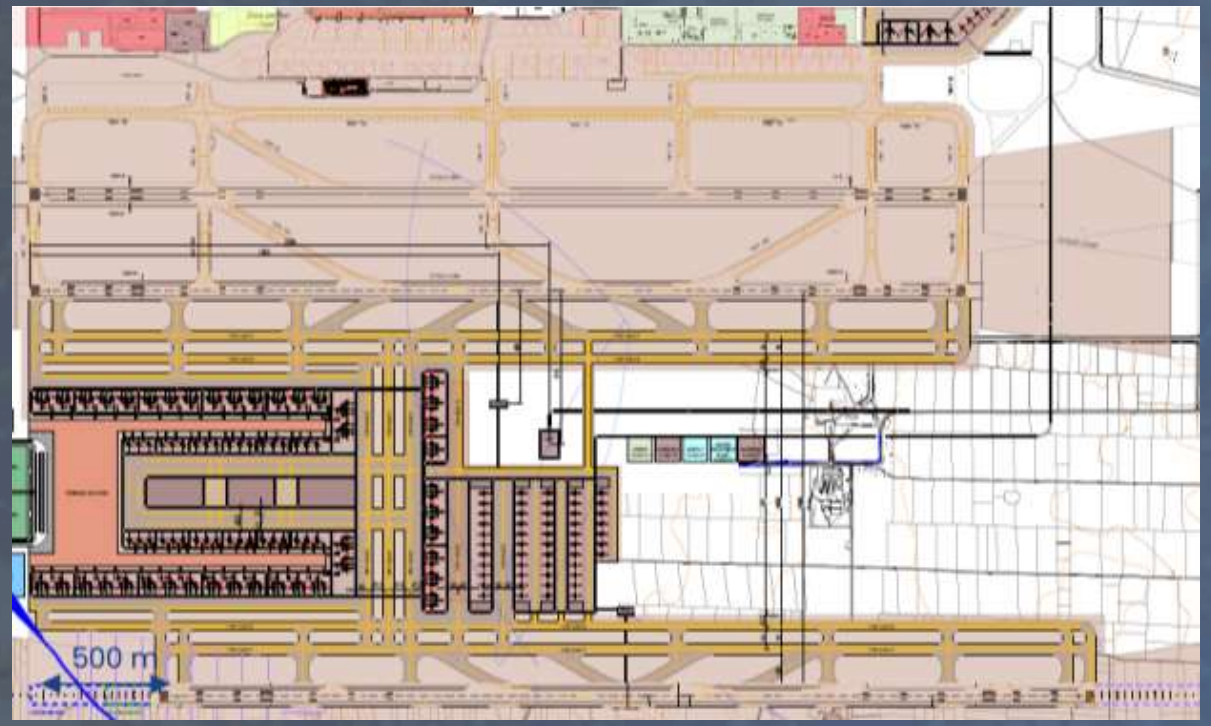
Scenario: Operations and capacity with future 3-Runway System (3RS)

1st Option) New RWY primarily use in segregated mode (ARR or DEP only)

- Keep separation minima to 5NM
- Reduce separation minima to 3NM (with suitable RET and surveillance capabilities)

2nd Option) New RWY primarily used in mixed mode

- Keep separation minima to 5NM
- Reduce separation minima to 3NM (with suitable RET and surveillance capabilities)



8. Capacity / Throughput Enhancement Solution Recommendations

Airside Optimisation

- Stakeholders collaboration
- Data / info exchanges
- Operational / Procedures
- System / Automation support
- Infrastructure

Recommendations – Example RWY Operations

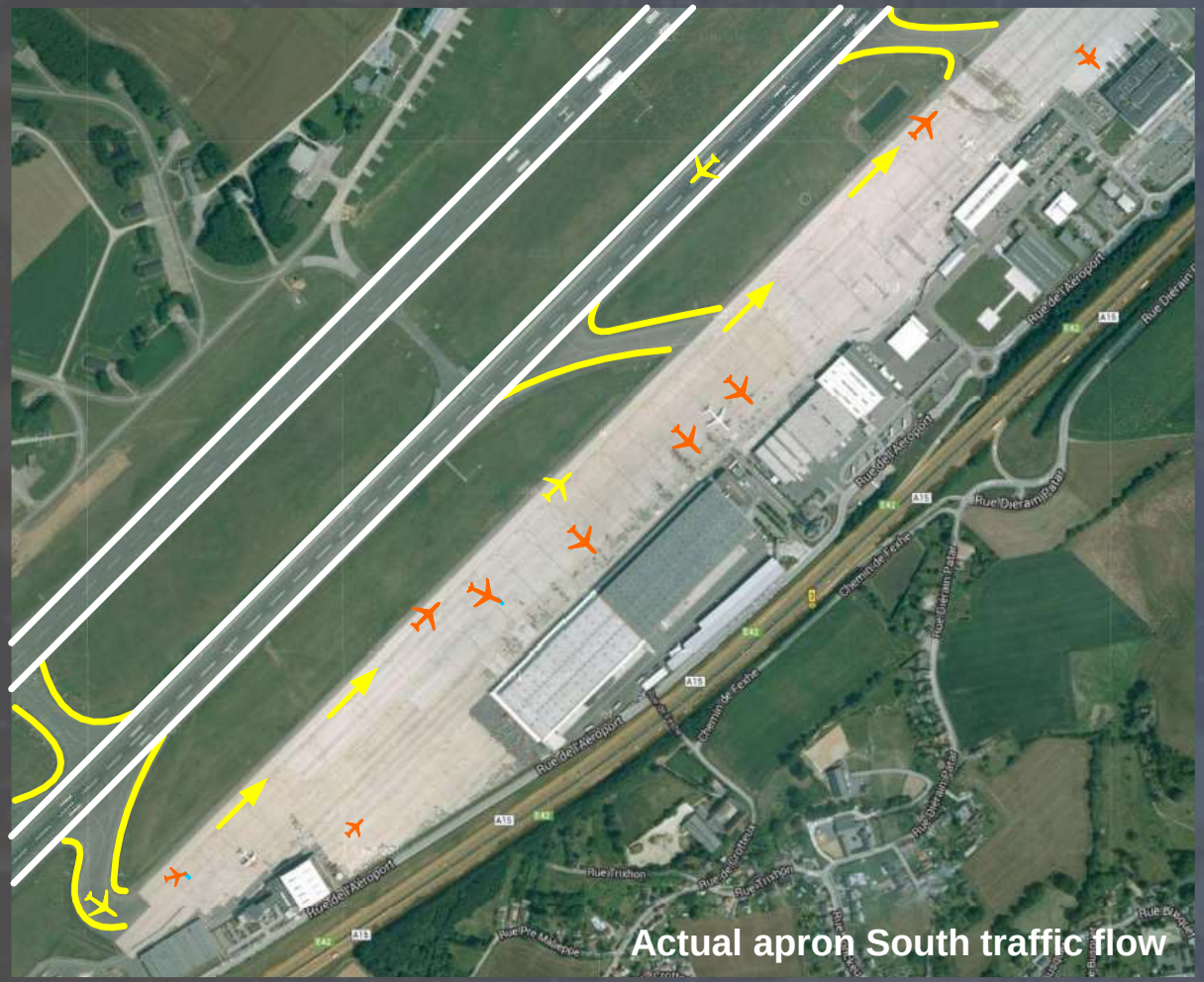
Targets	Status
Consistent A-A separation delivery to 5NM radar minimum for arrival pairs in a sequence to Runway XX 1.Facilitate separation 5NM separation delivery by APP control with supporting system and procedure enhancement - See **REC 2024-XXXX-01** 2.Enable further reduction of A-ROT average and distribution, for increased margin for clearance to land – See **REC 2024-XXXX-02** 3.Evolve ATC Tower control roles with introduction of 2nd executive controller, for either clearance delivery (DEL) and/or Ground (GND) control, relieving workload from the runway (RWY) / local (LOC) controller (consider feasibility of dual qualification of APP & TWR controller rating), and best practices for staffing and shift arrangements. Review procedures for the schedule and frequency of runway inspections, to align on best practices from other European airports - See **REC 2024-XXXX-09** 4.Implement a new intermediate parallel taxiway between the XX and YY, to allow landing traffic on XX to vacate, and have buffer area for holding before crossing departure runway YY, while clearing the runway exit See **REC 2024-XXXX-03**	
ACAP-2024-GMMN-02- Reducing arrival runway occupancy time on existing RWY 35L (and 17R) See **REC 2024-XXXX-02** and **REC-2024-XXXX-05** 1.Publish in AIP the recommendation to minimize runway occupancy time, with preferred / suggested exits for vacation after landing per category of aircraft and associated distance from landing threshold 2.Organize an awareness campaign for AO and Flight Crews, to tactically plan, prepare and execute safe and efficient braking to vacate the runway in most efficient manner 3.Implement a new RET between ZZ & WW, located such to minimize A-ROT for Medium category / Narrowbody jets (A320 family & B737 family), - or a displaced landing threshold such that WW distance is reduced to around 2000m, that can suit both code-C and code-E aircraft 4.Implement a new RET before QQ on RWY XX, located such to minimize A-ROT for Medium category/Narrowbodies	

Recommendation – Post-operations

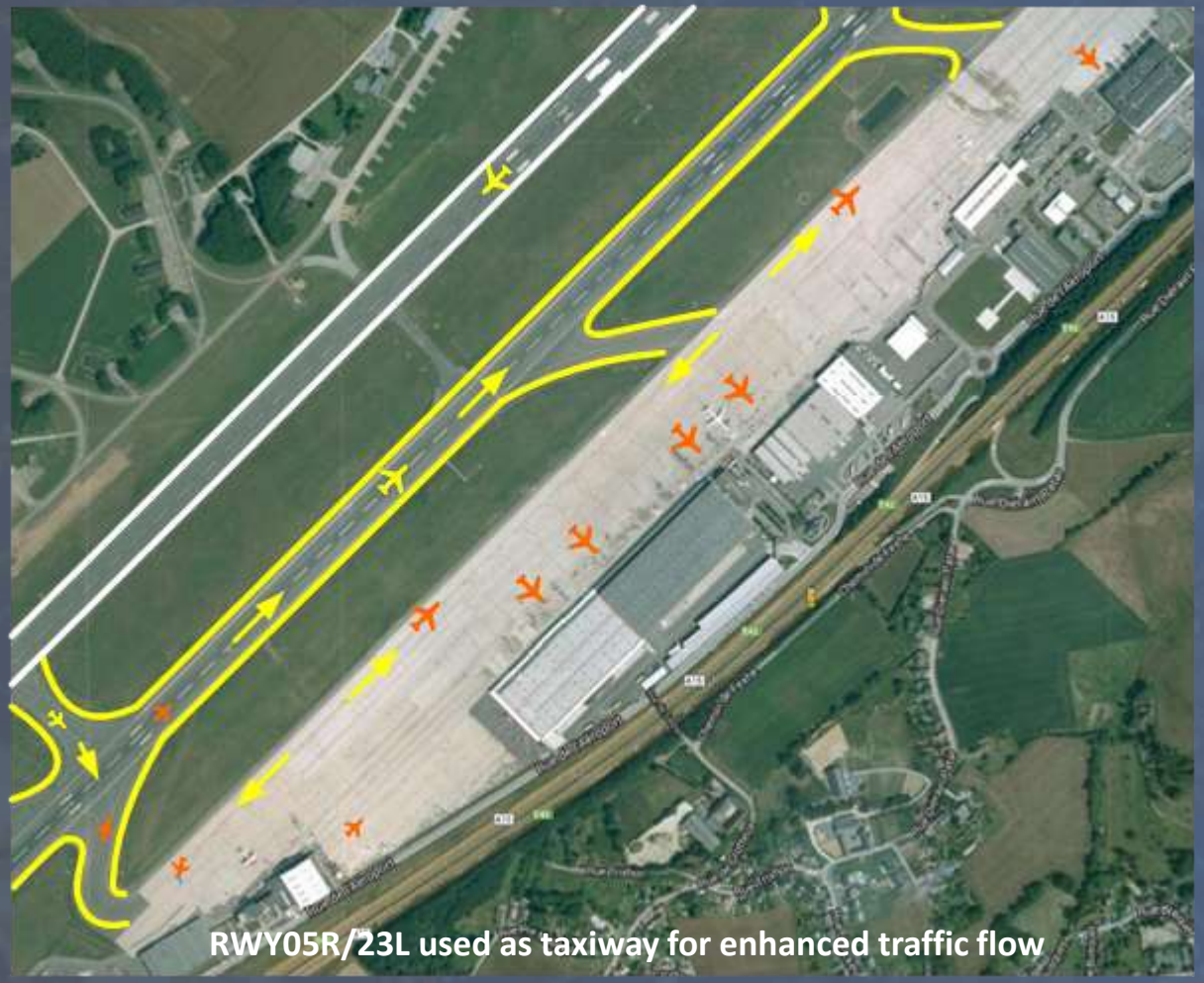
Targets	Status
REC-2024-XXXX-12- Runway and surface post-operations performance review using CCPM 1.Review periodically ROT-A per operator and communicate target occupancy. 2.Review periodically Taxi in and Out performance times per operator 3.Report cases, review, and communicate cases of slow reaction times by Flight deck crew. Rationale: See **OBS 2024-XXXX-18,** See ground traffic pressure analysis.	
REC-2024-XXXX-13- Airport-wide formal Capacity review process 1.Monitor traffic growth trends and conduct periodic assessments to ensure terminal processors continue to meet future demand. 2.As best practice from WASG (Worldwide Airport Scheduling Guidelines), formal capacity reviews every 2 years or ad-hoc with major change in processes, people, or infrastructure. Rationale: see **OBS 2024-XXXX-14**, **OBS 2024-XXXX-19**	
REC-2024-XXXX-14 - Landside Performance review process 1.Analyze transfer passenger flows to identify opportunities for optimizing turnaround times and enhancing transfer efficiency. Rationale: see **OBS 2024-GMMN-11; OBS 2024-GMMN-12, OBS 2024-GMMN-13, OBS 2024-GMMN-17**	

Operational Enhancements

Airport Infrastructure Use



Actual apron South traffic flow



RWY05R/23L used as taxiway for enhanced traffic flow

Minimising ROT

HIRO – AIP Publication

1.2.5.3 In order to ensure a minimum RWY occupancy time, it is recommended to name the expected high-speed turn-off during the approach briefing (Cockpit).

bevorzugte Abrollwege / **preferred** turn-offs

TYPE CLASS	RWY 07C	RWY 07R	RWY 25C	RWY 25L
HEAVY	L9	M13	L13	M21 (except A380)
Distance to turn-off	2500	2150	2100	2300
MEDIUM (JET)	L11	M15	L10	M17
Distance to turn-off	1800	1700	1850	1850
MEDIUM (PROP) LIGHT	L11	M15	L8	M11
Distance to turn-off	1800	1700	1150	1100

Alle Entfernungsangaben in Metern! – All distances in meters!

Entfernung zum Abrollen =Entfernung von der Schwelle der entsprechenden RWY zum Schnellabrollweg
Distance to turn-off = Distance from threshold of the respective RWY to turn-off intersection

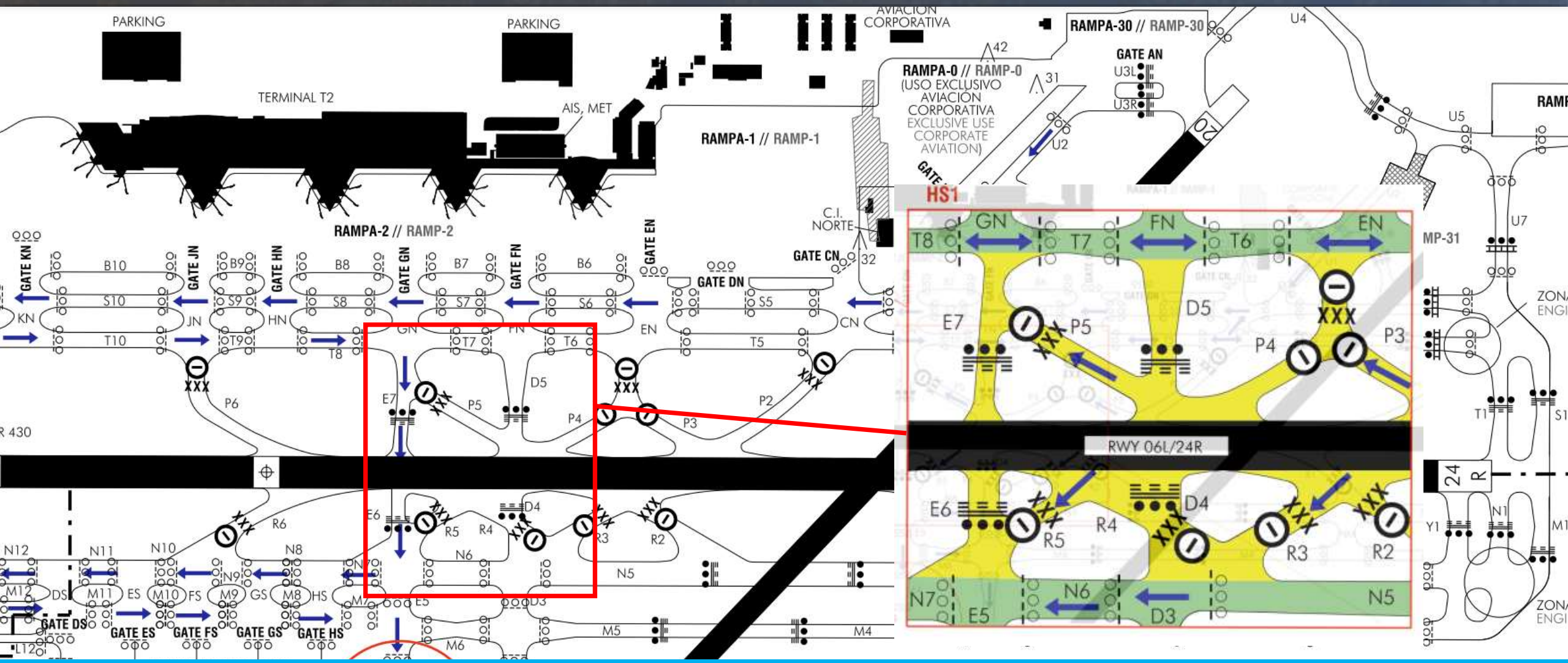
HIRO

- **Published in AIP**
- **Use of RETs**
- **RET distance per aircraft categories**

Example

CATEGORIA DE AERONAVE POR ESTELA TURBULENTA AIRCRAFT CATEGORY DUE TO WAKE TURBULENCE	RWY 24L DIST THR-RET	RWY 24R DIST THR-RET		RWY 06L DIST THR-RET		RWY 06R DIST THR-RET	RWY 02 DIST THR-EXIT
	DERECHA RIGHT	IZQUIERDA LEFT	DERECHA RIGHT	IZQUIERDA LEFT	DERECHA RIGHT	IZQUIERDA LEFT	IZQUIERDA LEFT
SUPER	G8 1703 m	R6 2053 m	P6 (1) 2112 m	P1 1864 m	R1 1661 m	G5 1703 m	UB 2039 m
PESADA HEAVY							
MEDIA (REACTORES) MEDIUM (JET)		R5 1703 m	P5 1617 m				
MEDIA (PROP) MEDIUM (PROP)	G7 1402 m	R3 1409	P3 1275 m	P2 1305 m	R2 1051 m	G6 1402 m	
LIGERA LIGHT	G7 1402 m			P4 945 m	R4 751 m		

Plan your exit and vacate as soon as possible



This will of course depend on the runway direction in-use, **P5/R5** should be the preferred ones in **westbound configurations** for medium jets

What Can I do?

ON APPROACH (briefing)

- check **current** runway conditions
- check the **airport briefing / AIP** for suitable exit(s)
- **plan the runway exit**
- **when possible, select optimum combination** of flaps and auto-brakes **settings**

ON LANDING:

- **VACATE AS SOON AS POSSIBLE and minimize runway occupancy time:**
  - **Use the first** runway exit **you can make,** rather than one you may miss
  - **Please do not use runway** to taxi closer **to your stand**
- USE **PROGRESSIVE BREAKING TECHNIQUES** TO REACH PLANNED EXIT

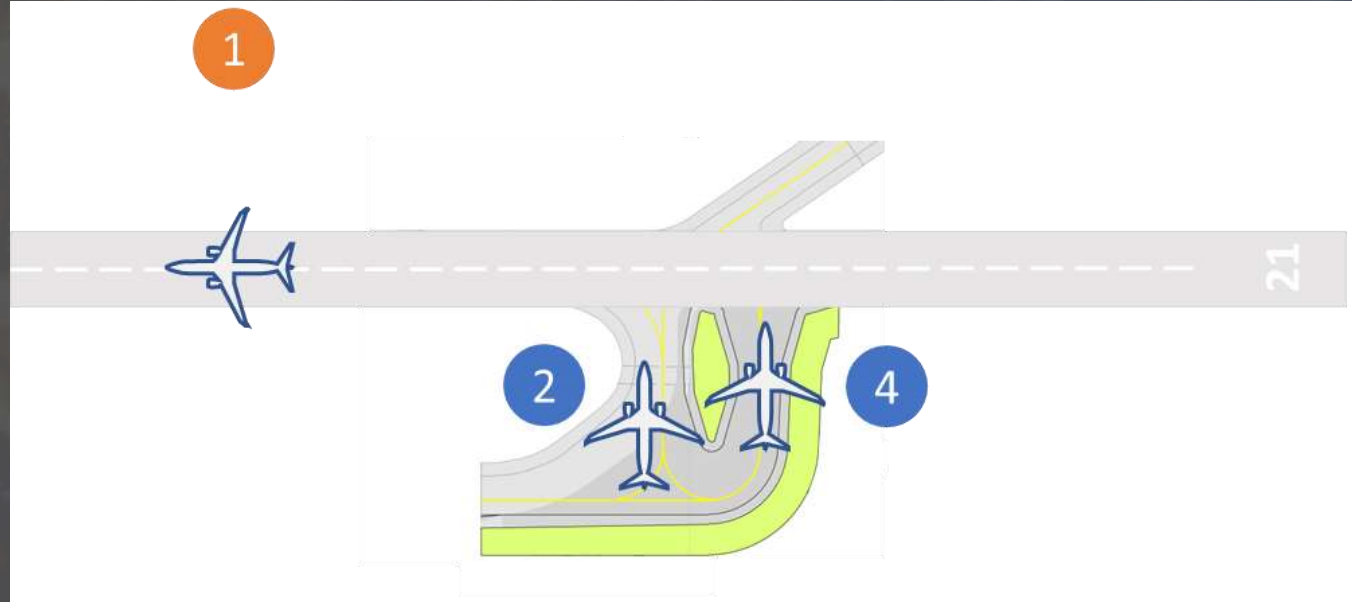
Collaborative Management

Local Runway Safety Team / Runway Performance Committee

- Airport
- ATSP
- Local airport home-based carriers / operators
- Pilot association

Runway Capacity – Enhancing Infrastructure

Airport Infrastructure – Dual RWY entry



1 Arrival

4 Departure

Note: Drawing not to scale. For illustration purposes only.

Is there an impact on the:

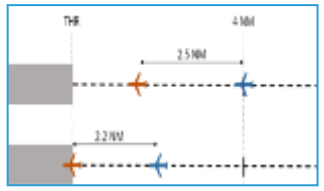
- RWY throughput?
- Departure Rate?

RET Positioning

Runway Throughput Enhancement – ATC solutions

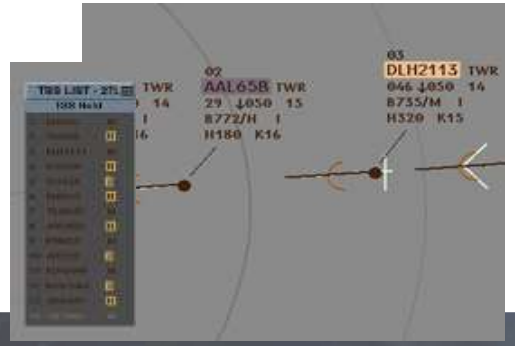
Runway Performance Package

	TBS and ORD tool	RECAT-EU / -PWS	ROCAT / Optimised ROT	Reduced MRS	Advanced Approaches support	Optimised Spacing on Departure (OSD)
Procedural						
Light Automation						
Advanced Automation						



Follower / Leader	Heavy	Medium (low ROT)	Medium (high ROT)	Light
Heavy	4 NM	5 NM	5 NM	6 NM
Medium (low ROT)	2.5 NM	2.5 NM	2.5 NM	5 NM
Medium (high ROT)	3 NM	3 NM	3 NM	5 NM
Light	3 NM	3 NM	3 NM	3 NM

	Heavy	A320	A319	B738	BCS3	E190	DH8D	...	Light
Heavy	4.0	5.0	5.0	5.0	5.0	5.0	5.0	...	6.0
A321	2.6	2.6	2.6	2.6	2.6	2.6	2.6	...	5.0
B738	2.7	2.7	2.7	2.7	2.7	2.7	2.7	...	5.0
A319	2.5	2.5	2.5	2.5	2.5	2.5	2.5	...	5.0
BCS3	2.6	2.6	2.6	2.6	2.6	2.6	2.6	...	5.0
GLF5	2.9	2.9	2.9	2.9	2.9	2.9	2.9	...	5.0
...	...	...	...	...	...	...	...	...	...
Light	3.0	3.0	3.0	3.0	3.0	3.0	3.0	...	3.0



Proposals for improving capacity (NATS example)

1. Sharing information across the airport
2. Better use of what you have
3. Balancing demand
4. Getting your sequence right
5. Being consistently consistent

Thank you!

- airport.optimisation@eurocontrol.int
  www.eurocontrol.int