Simulation of Air Traffic using Weather – based Climate Cost Functions – Feasibility Analysis

Green flights – Climate optimal flight trajectory
ECATS 2, November 2016, Athens, Greece

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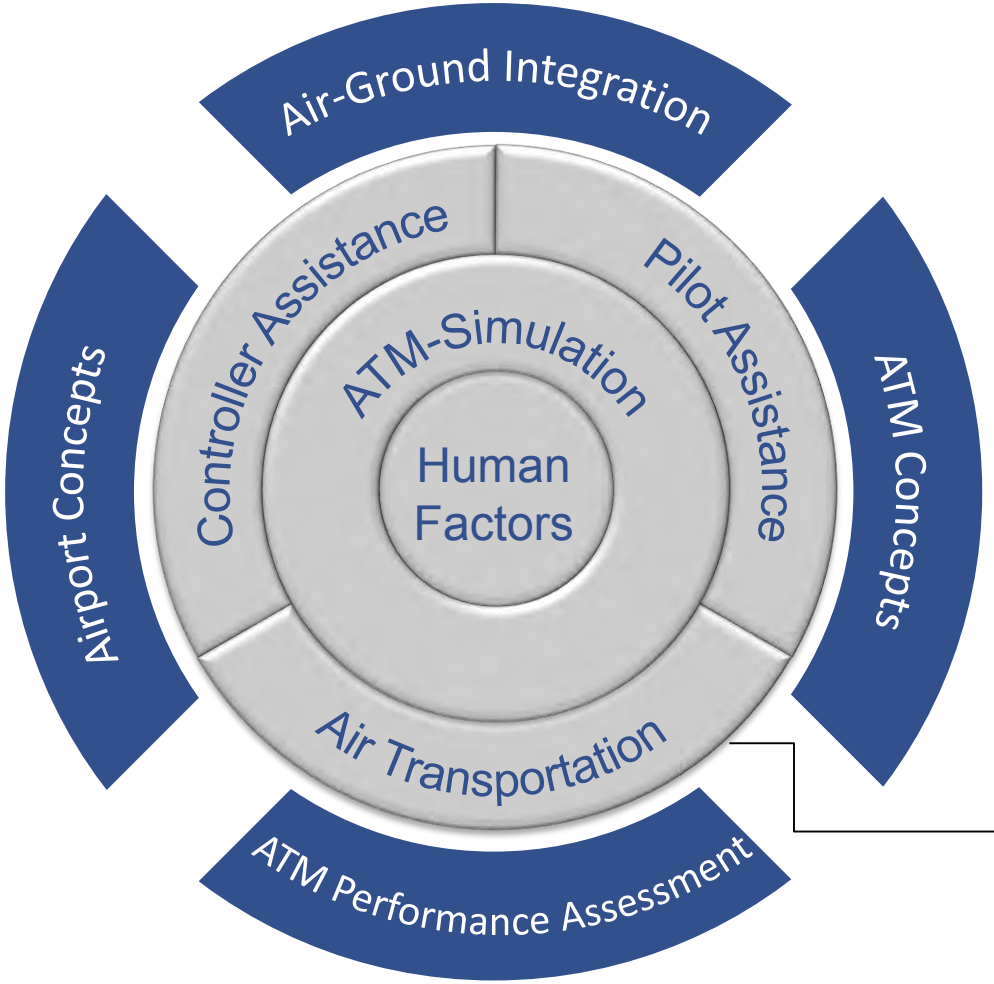
Structure

- Introduction and research motivation
- Background
- Methodology and simulation
- First results of simulation scenarios
- Outlook

Introduction and research motivation (1)



Research Topics - Air Transportation

1. Data-/modell-based ATM Performance Assessment
2. Integrated Airport Management (performance based - PBAM)
3. Advanced Concepts in ATM

Introduction and research motivation (2)

Topic: Model-based ATM Performance Assessment

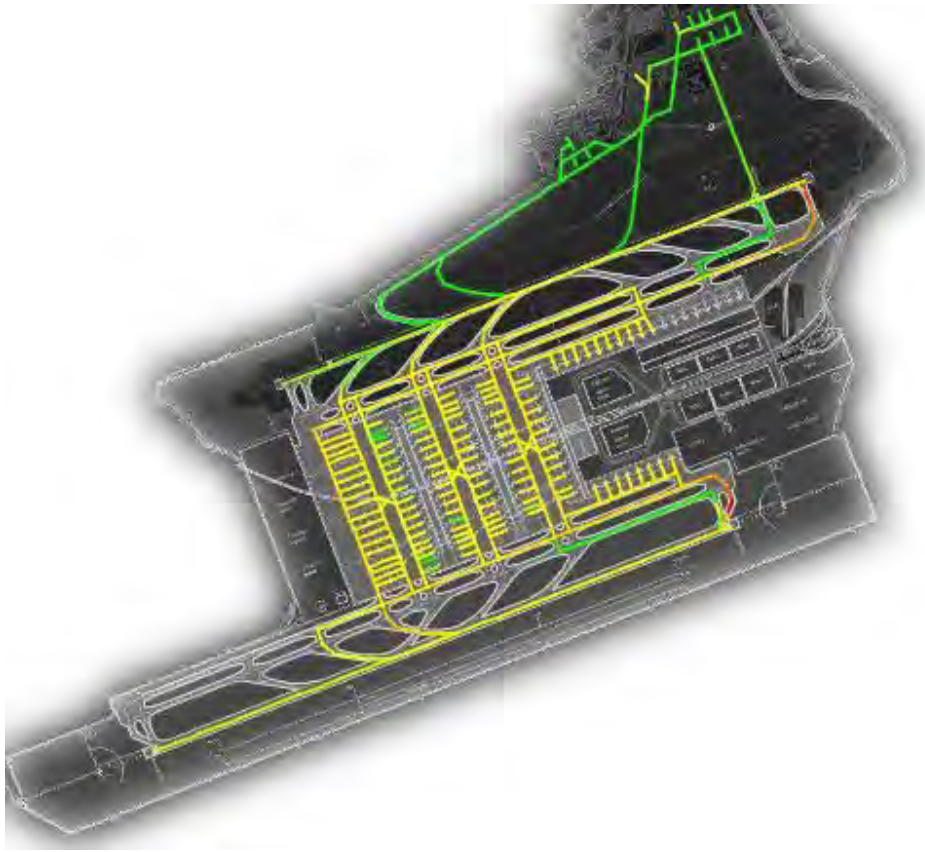
Key Performance Indicators: Emissions and Noise

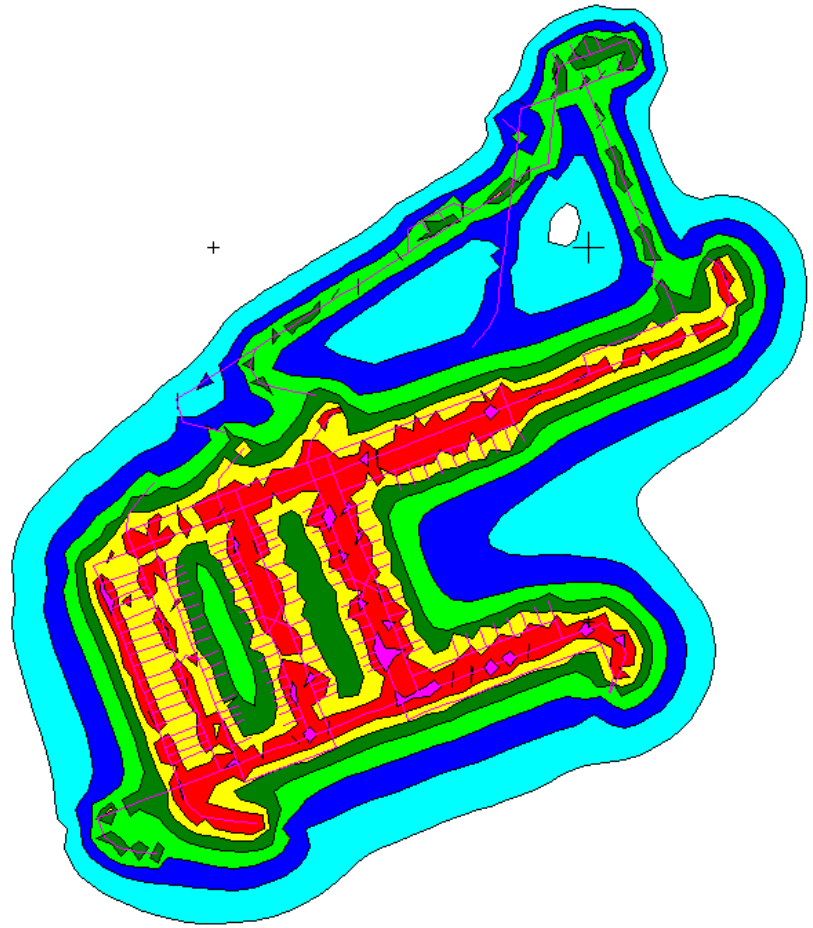
Electrical Taxiing

Evaluate noise and emission reduction potential at BER and FRA as proof of concept

Context:

SESAR CleanSky SGO





Introduction and research motivation (3)

Topic: Model-based ATM Performance Assessment

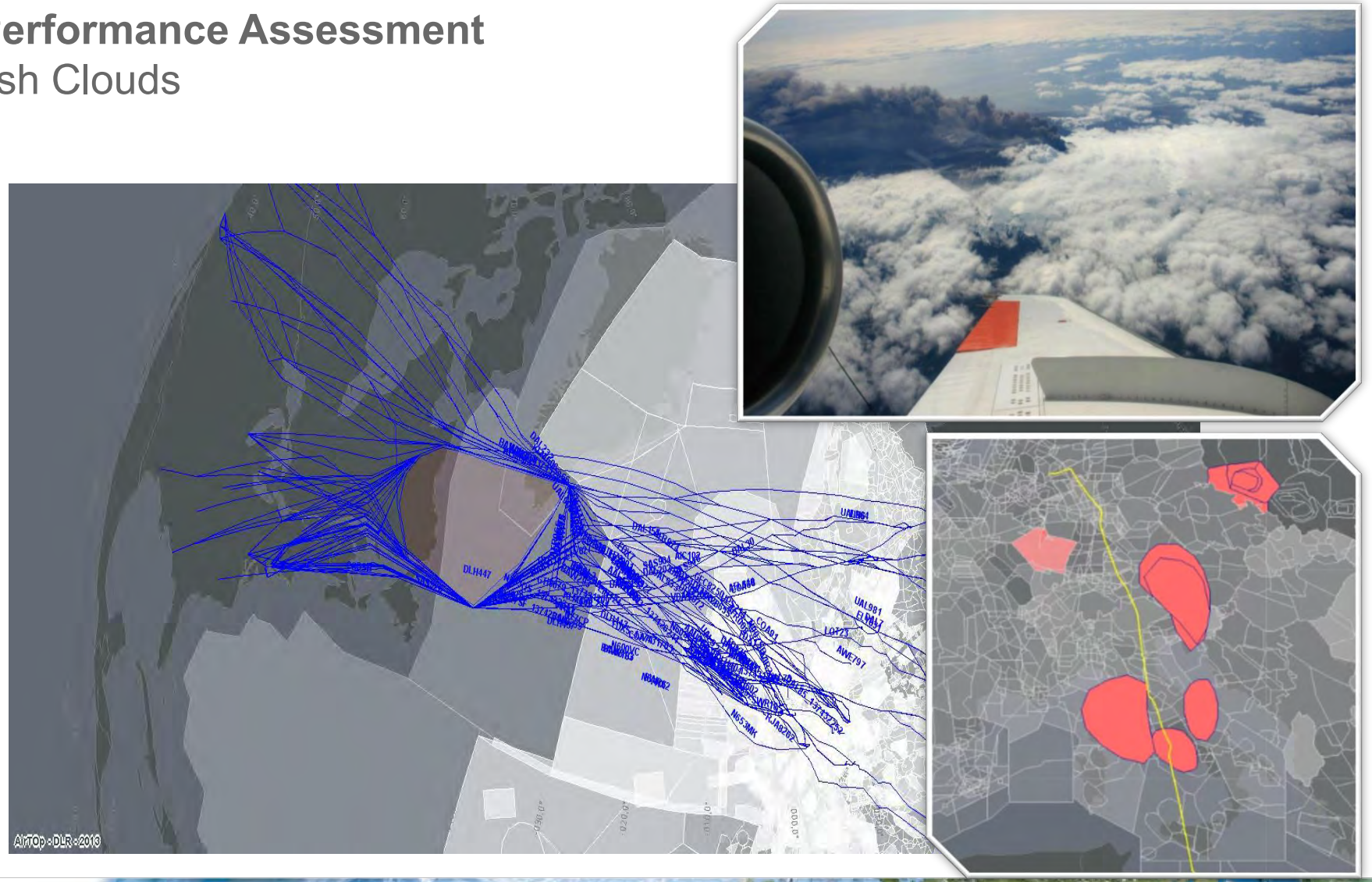
External Factors: Volcanic Ash Clouds

Task:

Assess the impact of volcanic ash avoidance scenarios on sector oriented

Context:

Internal Research



Introduction and research motivation (4)

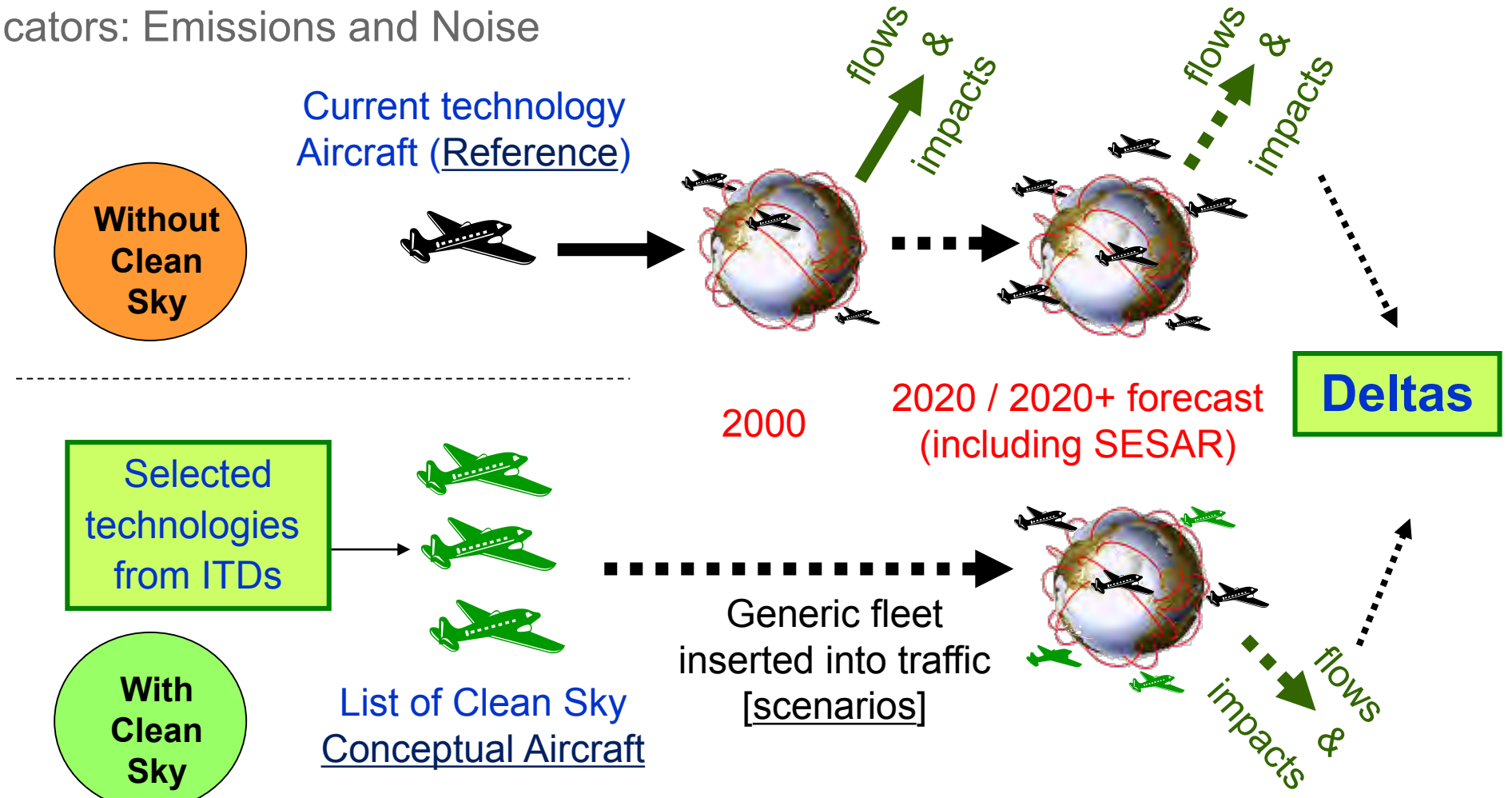
Topic: Model-based ATM Performance Assessment

Key Performance Indicators: Emissions and Noise

Assessment of environmental impacts (noise, emissions) of new technologies developed in Clean Sky's ITD's at Airport level

Context:

EU Project



Background

- Aviation related climate impact share today at about 5%
- How to reduce the climate impact not only in the area of non-CO2 components?
- Utilizing Weather information for Climate efficient and eco efficient future aviation - WeCare project
- The project focuses on three different areas:
  - Climate optimal routings
  - Cost benfit analysis of mitigation options
  - Demonstrable effects of air traffic
- Operational and technical measures considered to make air traffic more climate friendly

- **GOAL: to assess the operational measures by exploiting the effect that the climate optimized trajectories has on the existing ATM by means of fast time simulation**

Airport capacity

- Hourly throughput that an airport's runways are able to sustain during periods of high demand
- Runway configuration

Airspace capacity

- Air traffic controller workload i.e. the mental and physical work done by the controller to control traffic
- Geometric and temporal criteria based upon the performance characteristics of the aircraft in

Weather conditions

Operational conditions

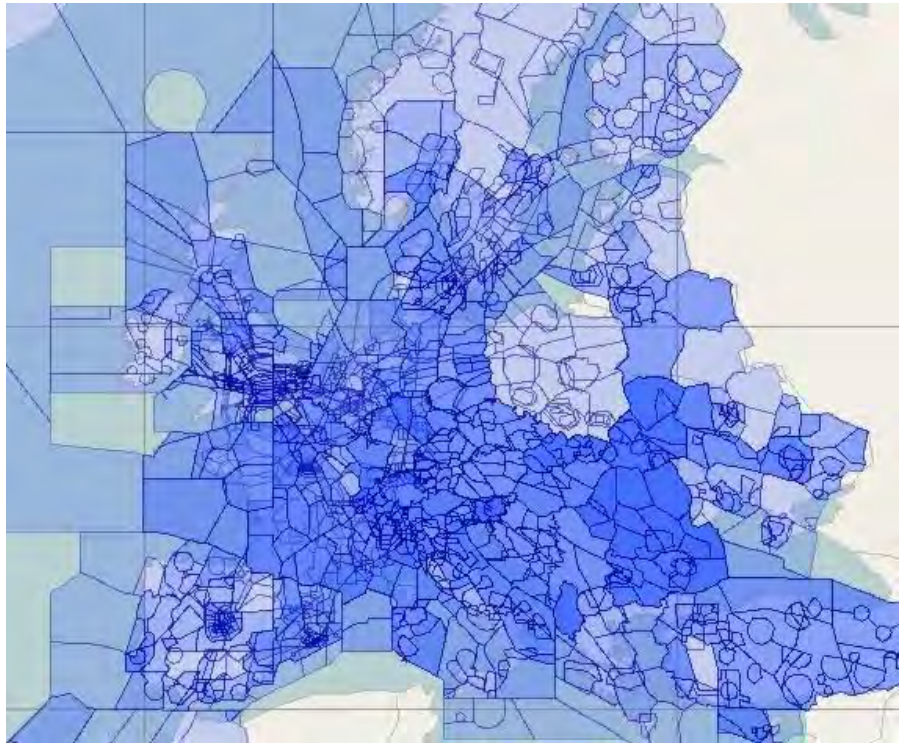
Methodology and simulation

- Analyzed day – extracted traffic North Atlantic operations only for 12/07/2012
- Optimized trajectories and air traffic data
  - Applied optimization:
    - Wind optimal (fuel)
    - Climate optimal agwp100 & atr20
  - Evaluation of the scenarios in fast time simulation tool includes:

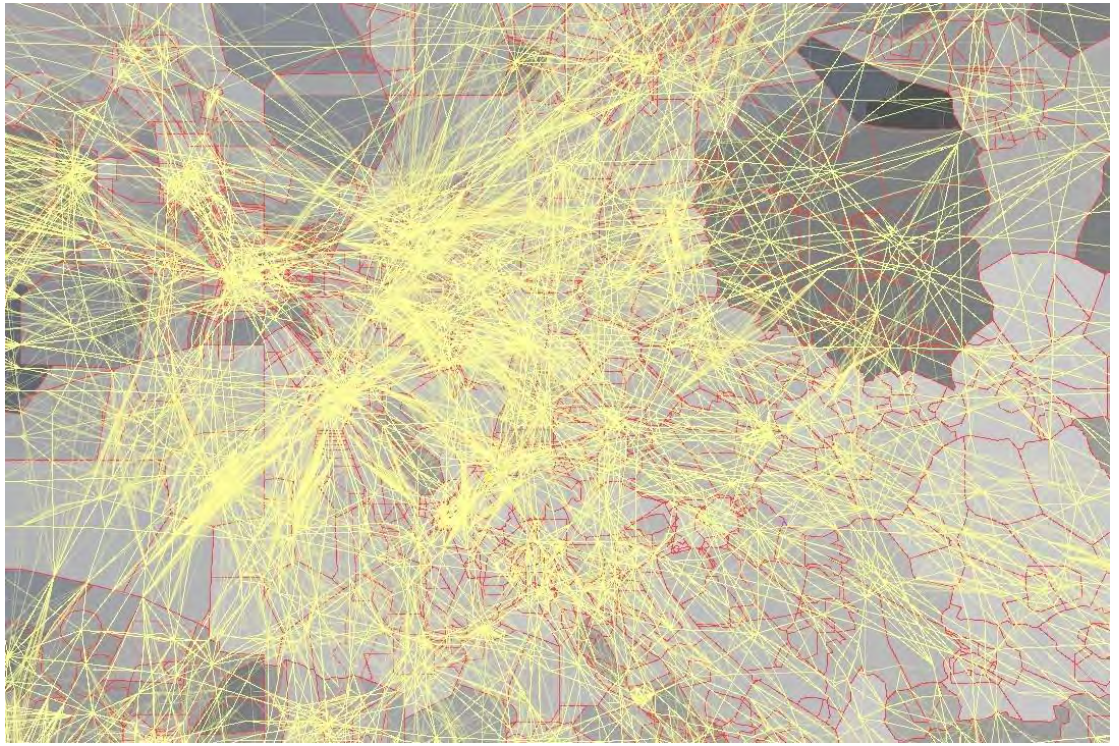
  - The EUROCONTROL provides 24 hours traffic data (for research purposes only) for the baseline scenario which is used to compare with the optimized traffic scenario
  - The optimized traffic scenarios are exported in so6 format which is then imported in AirTOp for the feasibility analysis

Methodology and simulation

- AirTOp, a fast time simulation tool, is a new generation of gate to gate fast-time simulation platforms
- Applied airspace model
- Model based on EUROCONTROL's DDR2 database and European AIS database (EAD)
- The model contains 1000 individual sector volumes including opening and closing schemes

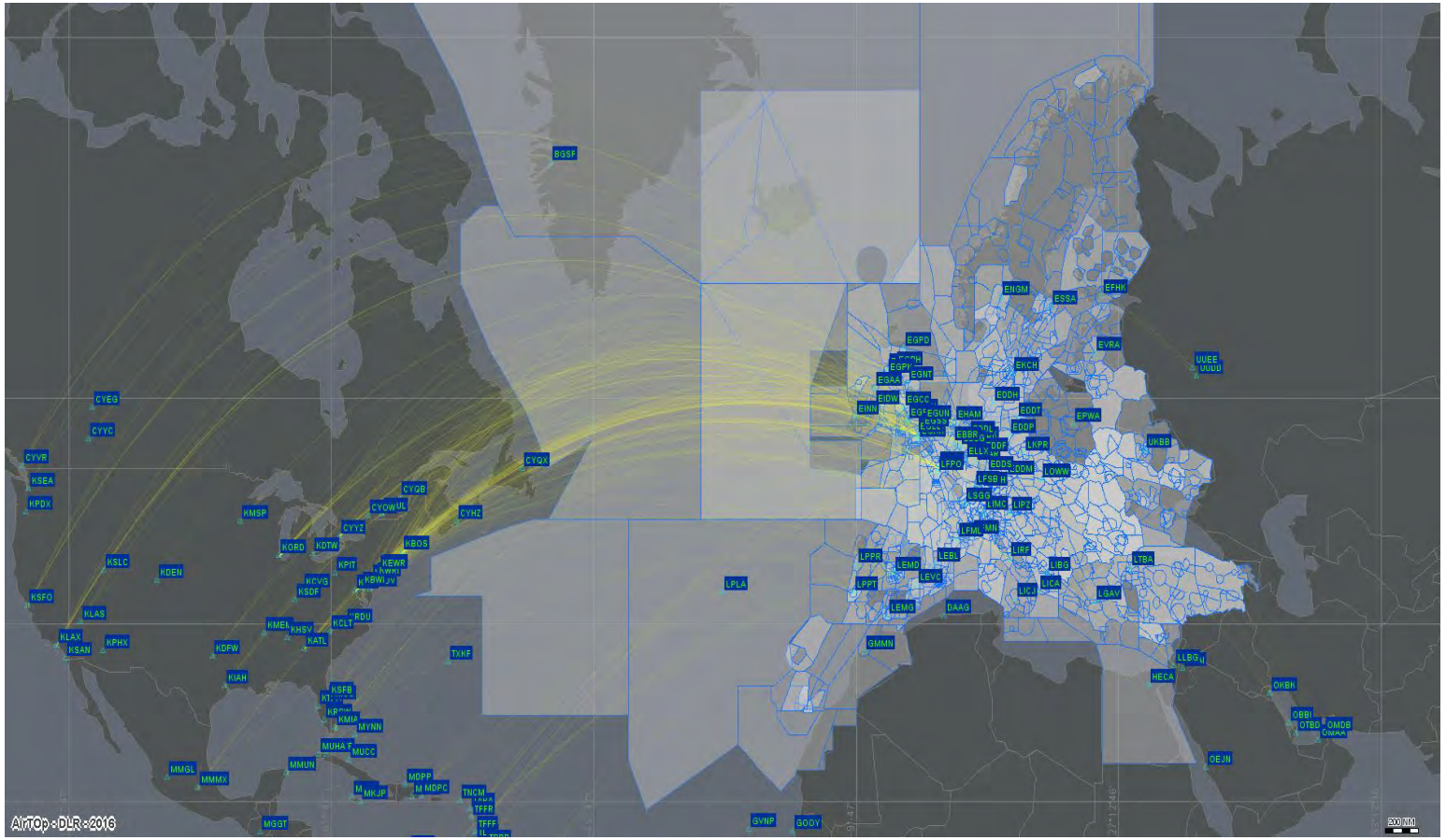


The European airspace structure represented in AirTOp



Twenty four hours simulation scenario in Europe

Methodology and simulation
North Atlantic airspace



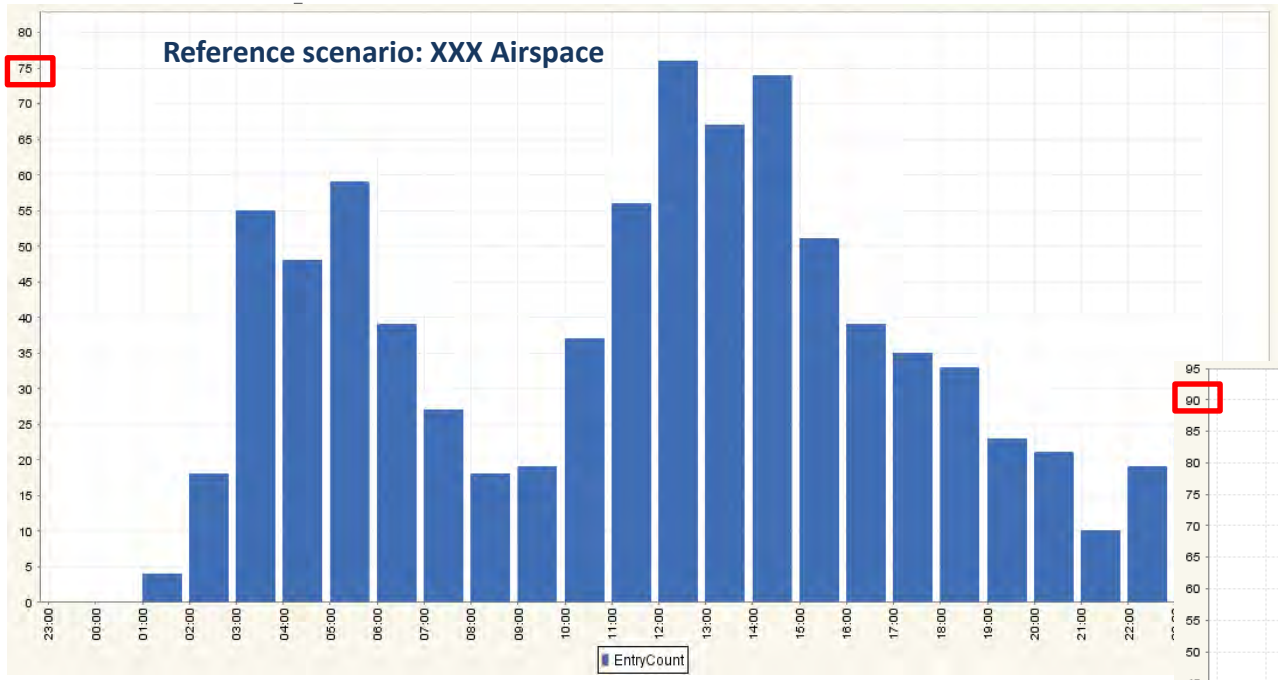
- Cooperation with NASA Ames regarding airspace
  - Oceanic airspace received in a working and not commercial form (differs from FIR)
  - East coast airspace not available (FAA)

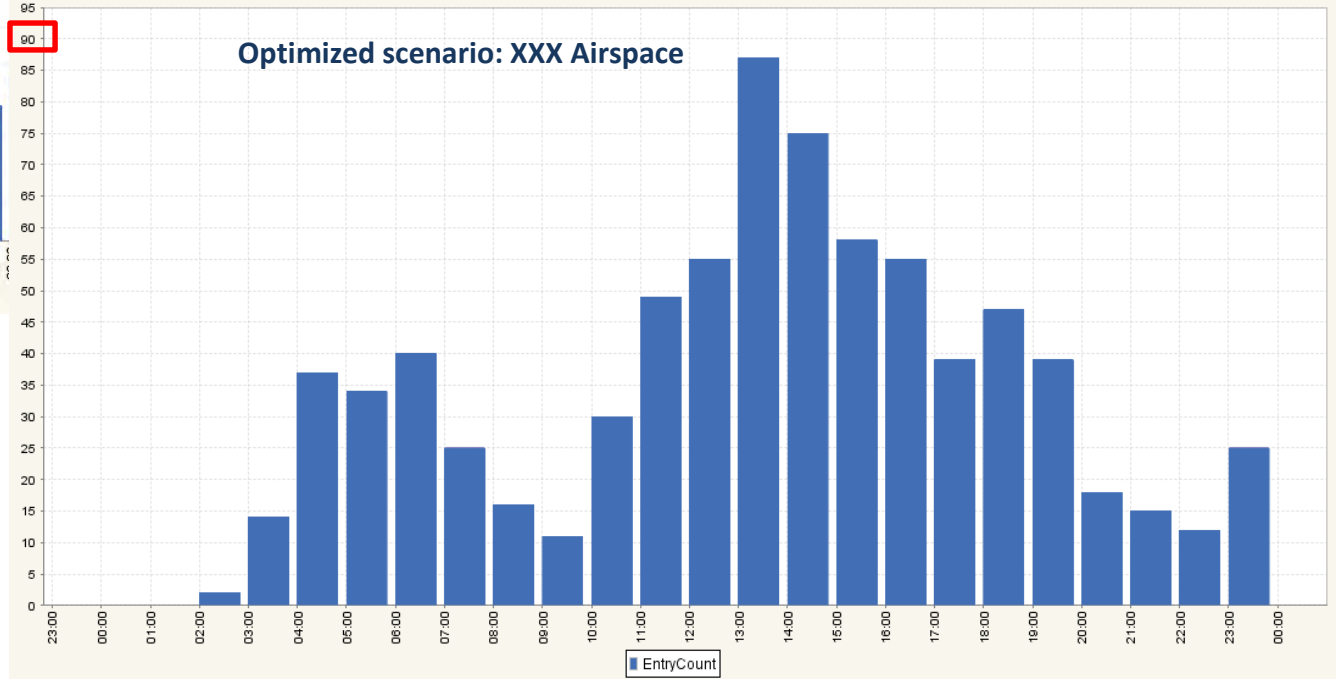
Methodology and simulation
Simulation scenarios and evaluation metrics

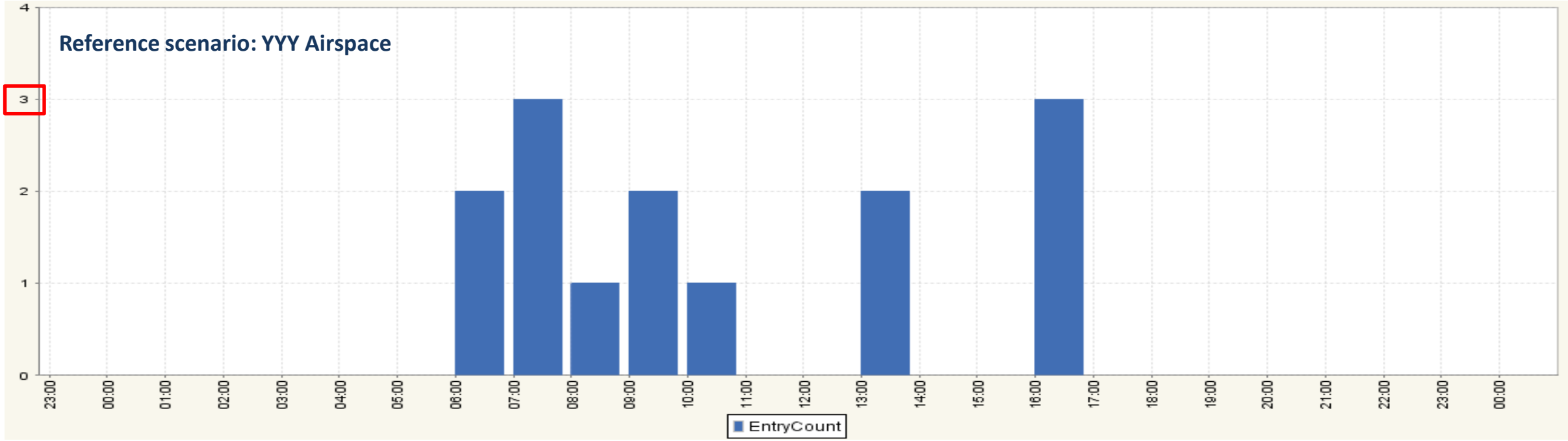
- Baseline scenario 1391 flights
- Optimized scenario for the prototype data
- Optimized scenario all weather climate cost functions

- The evaluation methodolody focuses on the following metrics from the performed fast-time simulation scenarios:
  - Traffic demand in different ATC sectors (only selected number of sectors will be evaluated for this project)
  - ATC sector capacities and controller taskload
  - Number of vertical movements in the ATC sectors
  - Flight duration and total distance flown (as important parameters when measuring the controller workload)

Draft results
Traffic demand in one ATC sector for the baseline and prototype data






Reference scenario: YYY Airspace
4
3
2
1
0
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
13:00
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16:00
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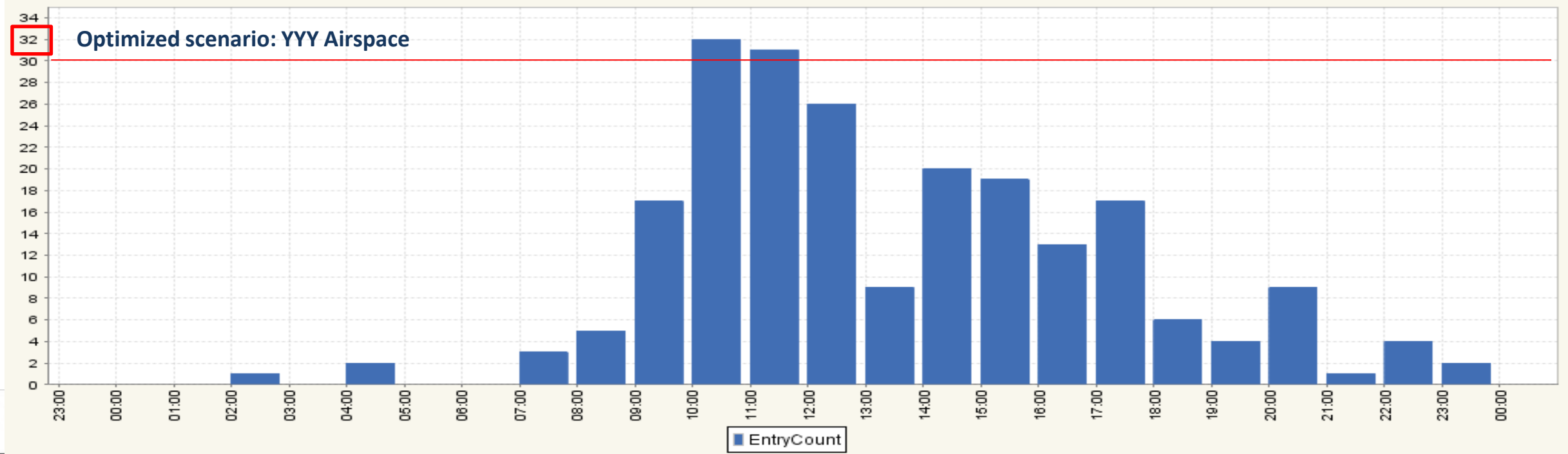
18:00
19:00
20:00
21:00
22:00
23:00
00:00
EntryCount


Optimized scenario: YYY Airspace
34
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
23:00
00:00
01:00
02:00
03:00
04:00
05:00
06:00
07:00
08:00
09:00
10:00
11:00
12:00
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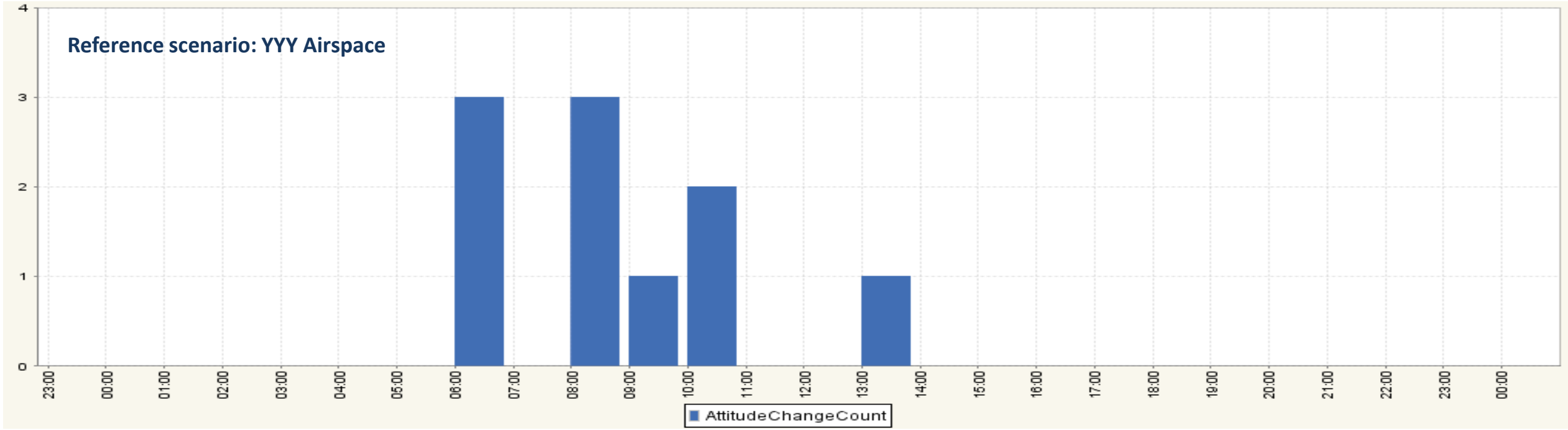
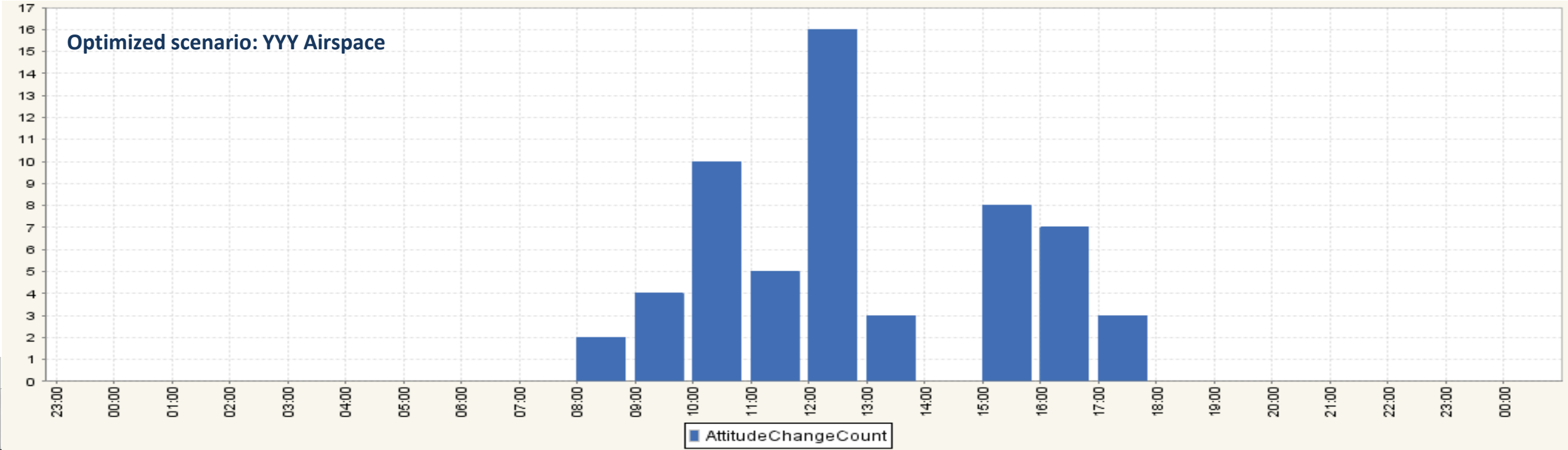
22:00
23:00
00:00
EntryCount

Reference scenario: YYY Airspace



Optimized scenario: YYY Airspace



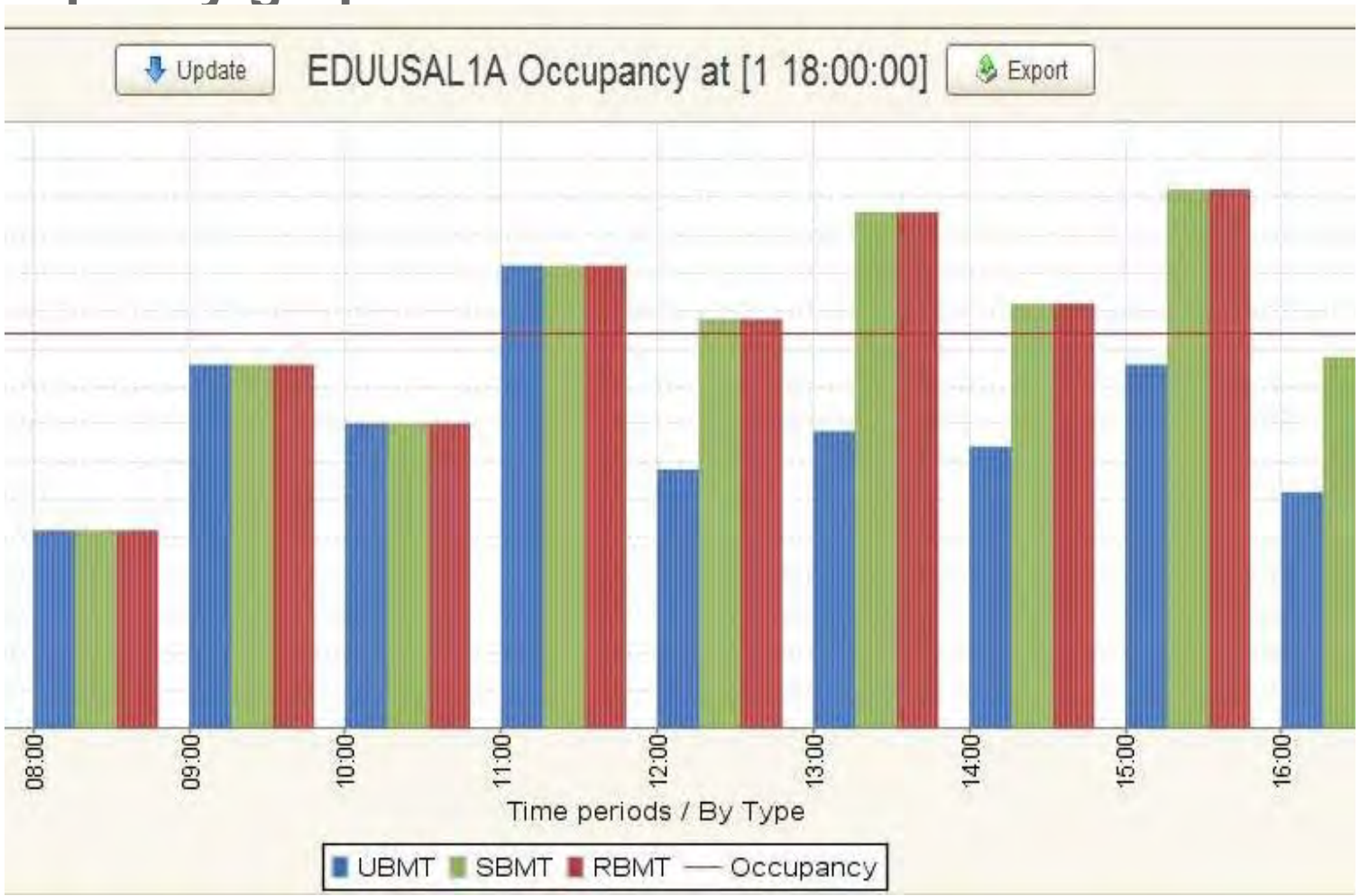
Reference scenario: YYY Airspace

Rolling Period	EntryCount	WorkLoad	WorkDuration	AttitudeChangeCount
00:00 - 01:00				
01:00 - 02:00				
02:00 - 03:00				
03:00 - 04:00				
04:00 - 05:00				
05:00 - 06:00				
06:00 - 07:00		2	3	00:02:05	3
07:00 - 08:00		3	9	00:05:06	
08:00 - 09:00		1	2	00:01:21	3
09:00 - 10:00		2	6	00:03:25	1
10:00 - 11:00		1	2	00:01:16	2
11:00 - 12:00					
12:00 - 13:00					
13:00 - 14:00		2	4	00:02:32	1
14:00 - 15:00					
15:00 - 16:00					
16:00 - 17:00		3	5	00:02:55	
17:00 - 18:00					
18:00 - 19:00					
19:00 - 20:00					
20:00 - 21:00					
21:00 - 22:00					
22:00 - 23:00					
23:00 - 00:00					

Optimized scenario: YYY Airspace

Rolling Period	EntryCount	WorkLoad	WorkDuration	AttitudeChangeCount
00:00 - 01:00				
01:00 - 02:00				
02:00 - 03:00		1	1	00:00:23	
03:00 - 04:00					
04:00 - 05:00		2	1	00:00:26	
05:00 - 06:00			1	00:00:37	
06:00 - 07:00					
07:00 - 08:00		3	5	00:02:50	
08:00 - 09:00		5	4	00:02:18	2
09:00 - 10:00		17	26	00:15:47	4
10:00 - 11:00		32	75	00:44:49	10
11:00 - 12:00		31	71	00:42:42	5
12:00 - 13:00		26	73	00:44:05	16
13:00 - 14:00		9	20	00:12:12	3
14:00 - 15:00		20	32	00:19:02	
15:00 - 16:00		19	31	00:18:21	8
16:00 - 17:00		13	22	00:12:55	7
17:00 - 18:00		17	30	00:18:03	3
18:00 - 19:00		6	11	00:06:26	
19:00 - 20:00		4	4	00:02:30	
20:00 - 21:00		9	14	00:08:38	
21:00 - 22:00		1	2	00:00:54	
22:00 - 23:00		4	6	00:03:42	
23:00 - 00:00		2	2	00:01:24	

An example of the results showing the fluctuation in traffic demand through ATC sector occupancy graph



Outlook and next steps

- The preliminary results have only included random sectors for the analysis
- The focus has been put on the change of the traffic demand and partly the workload/taskload
- The first results only include the optimized trajectories for the prototype data
- The scenarios with all weather optimized trajejectories will include a detailed assessment on the controller workload/taskload as well as analysis on the total distances and NM flown
- The ideas on future analysis include assessment at TMA and airport level

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