Final OSED for Madrid TMA (Annex Validation Report)

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Abstract

The main purpose is to assess the feasibility of the proposed P-RNAV scenario, mixed with conventional operations with a high traffic load in high complexity airspace. The aim is to deliver benefits to both, arrival and departure traffic. The methods used were fast-time and real time simulations.

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Executive summary

The main purpose is to assess the feasibility of:

- Mixed Mode Operations: Integration of P-RNAV & conventional routes used by a mix of P-RNAV-compliant and Conventional aircraft in high traffic density TMAs.
- High Terrain and bad weather
- Controller Mode of Operation: MOPS change
- Maximum capacity of P-RNAV Arrivals/Transitions/SIDs/STARs
- Suitable descent slope for P-RNAV Arrivals in all meteorological conditions.
- P-RNAV CDAs in high density traffic
- Continuous Climb Departures enabled by the enhanced horizontal performance of P-RNAV
- Impact on departure sequencing due to aircraft performance mix (climb rates, turn capability, etc), which creates different departure routes for different performance levels.

The main conclusions are:

- • Handling non-PRNAV traffic in the approach sequence with high traffic workload is difficult. A lot of coordination and attention paid to conventional traffic is needed between the final sector, director and feeders.
- • In general terms the arrival sequence is easier to carry out compared to the current TMA. The departures sequence doesn't change but departures can be monitored in their initial climb by the same controller so that a potential reaching is being observed and solved quickly.
- • The continuous climb departures are enabled by the enhanced horizontal performance of P-RNAV.
- • It will be interesting to study more SID's to facilitate the air traffic flow (e.g. traffic via DGO should proceed direct to DGO or RBO-DGO).
- • The delay times due to holding have been reduced.
- • It seems that these procedures make possible the increasing of traffic. However it hasn't been tested with a lot of traffic coming or going to LETO which would need more coordination.
- • When the runway in use in LETO is RWY23 for departures, either arrivals or departures to or from LEMD should be stopped.

1 Introduction

1.1 Purpose and scope of the document

This document provides the Validation Report for “Full implementation of P-RNAV in TMA” (05.07.04 project) and is involved within the Operational Focus Area (OFA) test case “Optimized RNP structures”. These are the results and conclusions of the simulation carried out to prove the feasibility of the implementation of P-RNAV in TMA operations. The project aims to extend the results to generic complex TMAs in Europe.

The project took the Madrid TMA as a reference test case.

Actors

The validation activities were carried out by 4 Air traffic controllers who worked in the design of the scenario (arrivals/departures) and exercises for the simulation.

In the simulation there were 10 Air traffic controllers and 9 pseudo-pilots who were in charge of performing the exercises.

4 people collecting NORVASE data. The objective of the Regulations for Sector Validation (NORVASE), compiled in the document “Regulations for Sector Validation Version 2.0” Code I-98ION-T01-1, is to establish criteria and standard procedures for the validation of the existing control sectors. As sectorisation has important operational and economic repercussions, the aforementioned criteria and procedures should be effective, homogeneous and provide optimum sectorisation.

Furthermore, the aim of NORVASE is that the analysis, evaluation, validation and creation of sectors be standardised and ordered, and guarantee the success and effectiveness of any and all sectors or ATC configuration.

Background

AENA

1.Works made for the new Madrid- Barajas TMA P-RNAV (20/11/2009)

2.P-RNAV Implementation in Spain. Analysis of the proposal and design for the new Palma de Mallorca TMA (08/04/2010)

3.Project TMA P-RNAV Madrid Document, Initial Study (13/08/08)

4.TMA Madrid PRNAV-“Transition codification North and South Configuration”

5.For the TMA Madrid PRNAV” (08/09/2008)

6.TMA Madrid PRNAV. Justification and proposal of Project development (12/02/89)

7.TMA Madrid 2008. Analysis of the new entry procedures (08/04/2008)

8.RETACDA.- Reduction of emissions in terminal areas by using continuous descent (30/09/09)

1.2 Intended audience

EURCONTROL and SJU are involved indirectly in all the activities of the projects. Indeed, SJU will determine what is acceptable or not during the whole lifecycle of the project.

Airspace Users

The utilization of P-RNAV based on transitions, will help airspace users to better predict and plan their trajectories.

The AU's are represented by the pilots / (pseudo-pilots) / AUs involved in the simulation.

Military Airspace Users

ATC

The display of the trajectories at the controller working position assists the controller in building and maintaining the traffic picture. This will give a better knowledge of the situation, adding a safety layer and a higher capacity. There also can be implemented with other ATC supporting tools (e.g. AMAN or Early detection systems).

Controllers participated in the sessions providing feedback and assessment of the operational procedures.

Military Airspace Managers

Ensure military aviation needs are correctly captured.

Airports

The airport and the surrounding areas are affected in this project due to the modification of TMA, STARs and SIDs that might affect Madrid-Barajas airport.

ANSPs AENA (NATS and ENAV as stakeholders)

They are directly involved in the structure and standardization working methods for the implementation of P-RNAV in the TMA.

They supervised the activities during the simulation.

Industry

There is no need of Industry involvement until the future implementation (out of the scope of this project) when it is going to be a necessity to demonstrate that these procedures are flyable in a real scenario (AIRBUS).

EASA

Regulator, Inspector

This Real-time simulation was performed in Madrid ACC.

There are also several projects that can be interested in this document:

Transversal projects:

5.2 - Consolidation of Operational Concept Definition and Validation

5.3 - Integrated and Pre-Operational Validation & Cross Validation

These project validation activities are going to be considered in the integration of AMAN in the procedures.

5.7 - TMA Trajectory and Separation Management

Operational projects:

4.7.3 - Use of Performance Based Navigation (PBN) for En Route Separation Purposes

5.6.2 - QM-2 – Improving Vertical Profile

5.6.3 - QM-3 – Approach Procedure with Vertical Guidance (APV)

5.6.4 - QM-4 – Tactical TMA and En-route Queue Management

1.3 Structure of the document

This document is composed of seven chapters:

- **Chapter 1** presents an introduction to the document, the purpose, scope, intended audience, background and a glossary of terms, acronyms and terminology.
- **Chapter 2** provides an overview on the context of the validation: summary of exercises, objectives, validation scenario and methods and techniques used.
- **Chapter 3** depicts detailed operational environment with details about analyses performed, exercises preparation, execution and deviation from planned activities.
- **Chapter 4** analyses the exercises results: capacity, complexity and workload
- **Chapter 5** includes the conclusions and recommendations.
- **Chapter 6** presents the validation reports.
- **Chapter 7** includes a list of applicable documents and reference documents.

1.4 Acronyms and Terminology

Term	Definition
ADD	Architecture Definition Document
ATM	Air Traffic Management
CDO	Continuous Descent Operations
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
E-OCVM	European Operational Concept Validation Methodology
GCA	Ground Control Approach
IRS	Interface Requirements Specification
INTEROP	Interoperability Requirements
MEA	Minimum En-Route Altitude
MVA	Minimum Vectoring Altitude
OFA	Operational Focus Areas
OI	Operational Improvement
OSED	Operational Service and Environment Definition
PAPO	Support Position
P-RNAV	Precision Radio Navigation

Term	Definition
RETACDA	Reduction of emissions in terminal areas by using continuous descent approaches
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SPR	Safety and Performance Requirements
SUA	Special Use of Airspace
SUT	System Under Test
TAD	Technical Architecture Description
TMA	Terminal Manoeuvring area
TS	Technical Specification
TWR	Tower
VALP	Validation Plan
VALR	Validation Report
VALS	Validation Strategy
VALP	Verification Plan
VR	Verification Report
VS	Verification Strategy

2 Context of the Validation

This document provides the Validation Report for Workstream 1 of Project 05.07.04 related to "Full implementation of P-RNAV procedures in complex TMAs" (Edition 00.00.01).

The Operational Service and Environment Definition (Initial OSED- Madrid TMA. D02. Edition 00.00.01) addresses the operational environment for PRNAV implementation in Madrid-Barajas TMA. It describes the operational procedures that are intended to support "the optimization of the RNP structures" with environmental sustainability.

Moreover, it addresses to the approach procedures with vertical guidance as well as to the departures. The document will collate and reference all the requirements which will serve as an input to be validated within the scheduled validation plan.

2.1 Concept Overview

Validation Exercise ID and Title	*EXE-05.07.04-VALP-142: Full Implementation of P-RNAV in Madrid TMA*
Leading organization	AENA
Validation exercise objectives	- Mixed Mode Operations: Integration of P-RNAV & conventional routes used by a mix of P-RNAV-compliant and Conventional aircraft in high traffic density TMAs. - High Terrain and bad weather - Controller Mode of Operation: MOPS change - Maximum capacity of P-RNAV Arrivals/Transitions/SIDs/STARs - Reduce both the pilot and controller workload. - P-RNAV CDAs in high density traffic - Continuous Climb Departures enabled by the enhanced horizontal performance of P-RNAV - Impact on departure sequencing due to aircraft performance mix (climb rates, turn capability, etc), which creates different departure routes for different performance levels. - Demonstrate that the delay times due to holding have been reduced - Demonstrate that the design is compatible with missed approach procedures. - Demonstrate that the possibility of runway closure doesn't affect the procedures.
Rationale	
Supporting DOD / Operational Scenario / Use Case	5.2 DOD / Madrid TMA
OI steps addressed	*AOM-0601 Terminal Airspace Organization Adapted through Use of Best practice, PRNAV and FUA (where suitable)* *AOM 0602 – Enhanced Terminal Airspace with Curved/Segmented Approaches and PRNAV Approaches (where suitable)* *AUO-0501 Visual Contact Approaches when Appropriate Visual Condition prevail* *AOM-0404 Optimized Route Network using advanced*

	RNP1 *AOM-0603 Enhanced Terminal Airspace for RNP-based Operations* *AO-0703 Aircraft Noise Management and Mitigation at and around Airports*
Enablers addressed	n/a
Applicable Operational Context	Optimized RNP structures in European Complex TMA
Expected results per KPA	- Environment (Fuel Burn per Flight)-0.03%TMA Arrival - Cost Effectiveness (Direct cost / flight)-0.06% TWR APP controller productivity / TWR APP Technology r. - Predictability (Flight duration variability) -0.04%TMA Departure - Airspace Capacity (Throughput / vol & time) +0.40%Improved Separation / Complexity Management TMA
Validation Technique	Real Time Simulation
Dependent Validation Exercises	*EXE-05.07.04-VALP-228* *EXE-05.07.04-VALP-229* *EXE-05.03-VALP-034*

Table 1: Concept Overview

2.2 Summary of Validation Exercise/s

2.2.1 Summary of Expected Exercise/s outcomes

EXPECTED EXERCISES OUTCOMES	RELEVANT STAKEHOLDERS
Integration of P-RNAV & conventional routes used by a mix of P-RNAV compliant and conventional aircraft in high density TMAs.	Airspace Users.- Companies, Civil and Military pilots(574.01) and Industry (574.05). As long as all aircraft are P-RNAV equipped, this mix mode operation allows the companies to gradually change the equipments.
The procedures are compliant with bad weather conditions: storms or hard wind.	Airspace Users.- Civil and Military pilots (574.01)
Demonstrate the success of the controller change mode of operation.	ATC (574.02) and ANSPs (AENA,574.04)
Provide the maximum capacity of P-RNAV arrivals/transitions/SIDs/STARs.	Airspace Users.- Companies, Civil and Military pilots and Industry. (574.01) Airports ?(574.03)
Reduce both the pilot and controller workload.	ATC (574.02) and ANSPs (AENA,574.04)
Continuous climb departures enabled by the enhanced horizontal performance of P-RNAV.	Airspace Users.- Civil and Military pilots (574.01), ATC (574.02) and ANSPs (AENA,574.04). Airports?(574.03)
Different departure routes for different performance levels.	Airspace Users.- Civil and Military pilots (574.01), ATC (574.02) and ANSPs (AENA,574.04). Airports? ?(574.03)
To reduce delay times due to holding .	Airspace Users.- Civil and Military pilots (574.01), ATC (574.02) and ANSPs (AENA,574.04).
Runway closure for any circumstance and night	Airports, ATC, Airspace Users and ANSPs (AENA 574.04)

configuration due to environmental impact.	
To test that the closed RNAV STARs help to minimise fuel burn.	Airports, ATC, Airspace Users and ANSPs (AENA 574.04)
To check what will be the change in the ATC mode of operation to the new procedures	Airports, ATC, Airspace Users and ANSPs (AENA 574.04)
Usage of PRNAV procedures to improve the manoeuvres safety in the TMA where there is a high terrain and where bad weather conditions makes a limited usage of airspace.	Airports, ATC, Airspace Users and ANSPs (AENA 574.04)
Look for solutions to optimize the separation between PRNAV aircrafts.	Airports, ATC, Airspace Users and ANSPs (AENA 574.04)
To reach the maximum capacity with PRNAV STARs and SIDs.	Airports, ATC, Airspace Users and ANSPs (AENA 574.04)
Suitable descent slope for PRNAV aircrafts in all weather conditions	Airports, ATC, Airspace Users and ANSPs (AENA 574.04)
Reduction of CO2 emissions and fuel consumption.	Airports, ATC, Airspace Users and ANSPs (AENA 574.04)
Identify the deficiencies in safety, efficiency and compatibility with capacity and human limitations	Airports, ATC, Airspace Users and ANSPs (AENA 574.04)
To guarantee that the new procedures have a margin error tolerance	Airports, ATC, Airspace Users and ANSPs (AENA 574.04)

Table 2: Summary of the expected results

2.2.2 Summary of Validation Objectives and success criteria

VALIDATION OBJECTIVES	SUCCESS CRITERIA	VALIDATION SCENARIO	OPERATIONAL PACKAGES
OBJ-05.07.04 VALP-0000.0001 Demonstrate feasibility of the integration of P-RNAV & conventional routes in high traffic density TMAs. Associated Operational Requirements New SIDs and STARs compliant with P-RNAV procedures along with conventional ones. Introduction of closed P-RNAV transitions to the localizer in order to avoid radar vectoring.	CRT-05.07.04 VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0004 The procedures are accepted by the controller, pilot and supervisor. The report provides evidence about the feasibility of the objective in terms of capacity, flexibility, efficiency and predictability ¿?	SCN-05.07.04 VALP-0000.0001 VALP-0000.0002 VALP-0000.0003 VALP-0000.0004 Madrid-(Barajas, Torrejón & Getafe). North and south configurations. High density traffic. Civil, GA and military. Sectors: Arrival 1 (Enroute-clearance limits) Arrival 2 (Clearance limits-BENJI/MONTE) Arrival 3 (BENJI_MONTE-FAP) Departure1 (airborne-7000ft) Departure2 (7000ft-13000ft) Departure3 (13000ft-FL200)	1.Operational package Efficient and green terminal airspace operations sub-package Improved Vertical profiles OFA Optimized RNP structures

OBJ-05.07.04 VALP-0000.0002 Demonstrate that the procedures are compliant with bad weather conditions: Storms and hard wind (coming from North-West)	CRT-05.07.04 VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0007 The procedures are accepted by the controller, pilot and supervisor. The final report provides evidence about the feasibility of P-RNAV procedures in bad weather procedures . ¿?	SCN-05.07.04 VALP-0000.0001 VALP-0000.0002 VALP-0000.0003 VALP-0000.0004 Madrid-(Barajas, Torrejón & Getafe). North or south configurations. High density traffic. Civil, GA and military. Sectors: Arrival 1 (Enroute-clearance limits) Arrival 2 (Clearance limits-BENJI/MONTE) Arrival 3 (BENJI_MONTE-FAP) Departure1 (airborne-7000ft) Departure2 (7000ft-13000ft) Departure3 (13000ft-FL200)	1.Operational package Efficient and green terminal airspace operations sub-package Improved Vertical profiles OFA Optimized RNP structures
OBJ-05.07.04 VALP-0000.0003 Demonstrate the success of the controller mode of operation. Associated Operational Requirements The "trombone" shaped STARs are the same for both configurations(north and south) until MONTE/BENJI. Reduction of the runway change impact.	CRT-05.07.04 VALP-0001.0008 VALP-0001.0002 VALP-0001.0009 VALP-0001.0010 The procedures are accepted by the controller, pilot and supervisor. A final report provides evidence about the feasibility of the MOPS change procedure (e.g.: the pre-advisory time for MOPS change has been reduced)	SCN-05.07.04 VALP-0000.0001 VALP-0000.0002 VALP-0000.0003 VALP-0000.0004 Change MOPS (from North to South Configuration) Madrid-(Barajas, Torrejón & Getafe). High density traffic. Civil,GA and military. Sectors: Arrival1 (Enroute-clearance limits) Arrival2 (Clearance limits-BENJI/MONTE) Arrival3 (BENJI_MONTE-FAP) Departure1 (airborne-7000ft) Departure2 (7000ft-13000ft) Departure3 (13000ft-FL200)	1.Operational package Moving from airspace to trajectory management sub-package Traffic Synchronization OFA Optimized RNP AMAN+Point Merge
OBJ-05.07.04 VALP-0000.0004 Provide the maximum capacity of P-RNAV arrivals/transitions/SIDs/STARs.	CRT-05.07.04 VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0011 The procedures are	SCN-05.07.04 VALP-0000.0003. Change MOPS (from South to North Configuration) Madrid-(Barajas, Torrejón & Getafe). High density traffic.	1.Operational package Moving from airspace to trajectory management sub-package Traffic Synchronization OFA Optimized RNP

Associated Operational Requirements New SIDs and STARs compliant with P-RNAV procedures along with conventional ones. Introduction of closed P-RNAV transitions to the localizer in order to avoid radar vectoring.	accepted by the controller, pilot and supervisor.	Sectors: Arrival1 (Enroute-clearance limits) Arrival2 (Clearance limits-BENJI/MONTE) Arrival3 (BENJI_MONTE-FAP) Departure1 (airborne-7000ft) Departure2 (7000ft-13000ft) Departure3 (13000ft-FL200)	AMAN+Point Merge 2.Operational package Integrated and collaborative Network Management. sub-package Demand and capacity balancing En-route OFA Environmental sustainability
OBJ-05.07.04 VALP-0000.0005 Reduce both the pilot and controller workload.	CRT-05.07.04 VALP-0001.0005 VALP-0001.0006 VALP-0001.0003 VALP-0001.0012	SCN-05.07.04 VALP-0000.0001 VALP-0000.0002 VALP-0000.0003 VALP-0000.0004	1.Operational package Moving from airspace to trajectory management sub-package Traffic Synchronization OFA Optimized RNP AMAN+Point Merge
OBJ-05.07.04 VALP-0000.0006 Demonstrate the feasibility of P-RNAV CDAs in high density traffic scenarios.	CRT-05.07.04 VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0013	SCN-05.07.04 VALP-0000.0001	1.Operational package Efficient and green terminal airspace operations sub-package Improved Vertical profiles OFA Optimized RNP structures
OBJ-05.07.04 VALP-0000.0007 Continuous climb departures enabled by the enhanced horizontal performance of P-RNAV.	CRT-05.07.04 VALP-0001.0005 VALP-0001.0006 VALP-0001.0003 VALP-0001.0014	SCN-05.07.04 VALP-0000.0001 VALP-0000.0002 VALP-0000.0003 VALP-0000.0004	1.Operational package Efficient and green terminal airspace operations sub-package Improved Vertical profiles OFA Optimized RNP structures
OBJ-05.07.04 VALP-0000.0008 Demonstrate the impact on departure sequencing due to aircraft performance mix, which creates different departure routes for different performance levels.	CRT-05.07.04 VALP-0001.0005 VALP-0001.0006 VALP-0001.0003 VALP-0001.0015	SCN-05.07.04 VALP-0000.0001 VALP-0000.0002 VALP-0000.0003 VALP-0000.0004	1.Operational package Efficient and green terminal airspace operations sub-package Improved Vertical profiles OFA Optimized RNP structures
OBJ-05.07.04 VALP-0000.0009 Demonstrate that the delay times due to holding have	CRT-05.07.04 VALP-0001.0005 VALP-0001.0006 VALP-0001.0003	SCN-05.07.04 VALP-0000.0001 VALP-0000.0002 VALP-0000.0003	1.Operational package Moving from airspace to trajectory management sub-package

been reduced.	VALP-0001.0016	VALP-0000.0004	Traffic Synchronization OFA Optimized RNP AMAN+Point Merge 2.Operational package Integrated and collaborative Network Management. sub-package Demand and capacity balancing En-route OFA Environmental sustainability 3.Operational package Efficient and green terminal airspace operations sub-package Improved Vertical profiles OFA Optimized RNP structures
OBJ-05.07.04 VALP-0000.0010 Demonstrate that the design is compatible with missed approach procedures.	CRT-05.07.04 VALP-0001.0005 VALP-0001.0006 VALP-0001.0003 VALP-0001.0017	SCN-05.07.04 VALP-0000.0001 VALP-0000.0002 VALP-0000.0003 VALP-0000.0004	
OBJ-05.07.04 VALP-0000.0011 Demonstrate that the possibility of runway closure doesn't affect the procedures.	CRT-05.07.04 VALP-0001.0005 VALP-0001.0006 VALP-0001.0003 VALP-0001.0018	SCN-05.07.04 VALP-0000.0003 VALP-0000.0004 VALP-0000.0005 VALP-0000.0006 Change MOPS Runway closure	1.Operational package Moving from airspace to trajectory management sub-package Traffic Synchronization OFA Optimized RNP AMAN+Point Merge

Table 3: Success Criteria

2.2.2.1 Choice of metrics and indicators

Here is the list of used Key Performance Indicators (KPIs) and metrics in 5.7.4 project:

KPIs and metrics	Linked to (project objectives)
Complexity	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006

	OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Complexity per movement	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Workload per movement	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Movement Workload	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Mean Flight Time (min)	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011

Percentage Time in Evolution (climb/descent)	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Number of Movements	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Max. Simultaneous Aircrafts	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Min. Simultaneous Aircrafts	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Actions in arrivals	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006

	OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Actions in departures	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Actions in over flight	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Actions	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Actions due to Movement	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011

Arrival separation or Sequencing Actions	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Departure separation or Sequencing Actions	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Overflight separation or Sequencing Actions	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Sep. Or Seq. Actions per Movement	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Number of vector per arrival	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006

	OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Number of vector per departure	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Number of vector per overflight	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Heading instructions due to movement	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Arrival monitoring	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011

Departure Monitoring	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Overflight Monitoring	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Monitoring due to movement	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Complexity (%) due to arrival	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Complexity (%) due to departure	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006

	OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Complexity (%) due to overflight	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Movement Complexity	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Workload (%) due to arrival	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
workload (%) due to departure	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011

workload (%) due to overflight	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Movement Workload	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Holdings	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Coordinations	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Percentage of time in evolution*	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006

	OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Number of arrivals	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Number of departures	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011
Number of Overflights	OBJ-05.07.04 VALP-0000.0001 OBJ-05.07.04 VALP-0000.0003 OBJ-05.07.04 VALP-0000.0004 OBJ-05.07.04 VALP-0000.0005 OBJ-05.07.04 VALP-0000.0006 OBJ-05.07.04 VALP-0000.0007 OBJ-05.07.04 VALP-0000.0008 OBJ-05.07.04 VALP-0000.0009 OBJ-05.07.04 VALP-0000.0010 OBJ-05.07.04 VALP-0000.0011

Table 4: List of KPIs and metrics

The Indicators and metrics should be selected from the list provided by the X.02 Validation Strategy in the Performance Framework Section but due to the lack of maturity of these metrics and KPIs the projects has used its own indicators and KPIs. The reason why the OBJ-05.07.04 VALP-0000.0002 is not appearing in the table above is because the simulator doesn't provide any evidence in terms of indicators related with the amount of wind introduced or turbulence in a bad weather situation.

2.2.3 Summary of Validation Scenarios

Airspace characteristics.- Madrid (Barajas, Getafe & Torrejón) TMA in high traffic density.

Involved Actors.- APP controllers, pilots, pseudo-pilots and supervisors.

SCN-05.07.04-VALP-0000.0001

Scenario.- North configuration. Maximum capacity.

Mixed mode operations.

High terrain and bad weather (storms) Descent slope. CDAs, CCDs. Aircraft performances. Delay times. Missed approaches. Single Runway.

Aircrafts profile.- Civil, GA and Military.

SCN-05.07.04-VALP-0000.0002

Scenario.- South configuration. Maximum capacity.

Mixed mode operations.

High terrain and bad weather. Descent slope. CDAs, CCDs. Aircraft performances. Delay times. Missed approaches. Single Runway.

Aircrafts profile.- Civil, GA and Military.

SCN-05.07.04-VALP-0000.0003

Scenario.- Change MOPS (from North to south configuration). Maximum capacity.

Mixed mode operations.

High terrain and bad weather. Descent slope. CDAs, CCDs. Aircraft performances. Delay times

Aircrafts profile.- Civil, GA and Military.

SCN-05.07.04-VALP-0000.0004

Scenario.- Change MOPS (from South to North configuration). Maximum capacity.

Mixed mode operations.

High terrain and bad weather. Descent slope. CDAs, CCDs. Aircraft performances. Delay times.

Aircrafts profile.- Civil, GA and Military.

SCN-05.07.04-VALP-0000.0005

Scenario.- Single Runway (North configuration).

SCN-05.07.04-VALP-0000.0006

Scenario.- Single Runway (South configuration).

2.2.4 Summary of Assumptions

ASS-05-07-04-VALP-0005-0001	Real traffic samples
ASS-05-07-04-VALP-0005-0002	Mixed aircraft types
ASS-05-07-04-VALP-0005-0003	Strong wind and crosswind during the simulation in both configurations
ASS-05-07-04-VALP-0005-0004	11 Operative sectors

ASS-05-07-04-VALP-0005-0005	Mixed mode Operations, both conventional and P-RNAV procedures
ASS-05-07-04-VALP-0005-0006	Hard meteorological Conditions (Storms)
ASS-05-07-04-VALP-0005-0007	Noise constraints
ASS-05-07-04-VALP-0005-0008	Airspace capacity

2.2.5 Choice of methods and techniques

This section briefly describes all methods and techniques used in the experiment to obtain the metrics and indicators.

Supported Metric / Indicator	Platform / Tool	Method or Technique
Sector Capacity	SACTA Simulator + NORVASE tool	NORVASE workload/capacity assessment
ATC Workload	SACTA Simulator + NORVASE tool	NORVASE workload/capacity assessment
Complexity	SACTA Simulator + NORVASE tool	NORVASE workload/capacity assessment
HF		Questionnaires
Environment (Fuel Consumption and gas emissions)	AEM3	Analysis of PALESTRA files
Environment	PALESTRA	Radar and flight plans information and updates recording

Table 5: Methods and Techniques

2.2.5.1Description of methods and techniques

2.2.5.1.1Initial Conditions

This section deals with all those criteria which were included in the NORVASE Report with the aim of providing more and better quality information. The intention is that said report be more easily understandable.
• With respect to the NORVASE indicators, a breakdown of the indicators which distinguish the flight phase of aircraft is given in the file for each sector included in the second section of the report. In this way the operational behaviour of the sector being studied may be fully analysed.
In the case of the final and feeder groups, the breakdown distinguishes between arrivals and departures, while for the evolution and route groups the breakdown distinguishes between aircraft in evolution and those in overflight.

NOTE: Throughout the document Evolution is used to mean “Traffic in Climb and Descent”.
There is a breakdown of the following NORVASE indicators: actions, coordinations, Radar Vector and complexity.

• The mean values of the NORVASE indicators given both in the second part of each section as well as in the executive summary of each of the groups refer to the historic mean values of the groups being studied. Included in the calculation of said mean values are data from sectors, of the same group, that reported in each of the last three years.

• With respect to workload, workload figures are calculated for each of the sectors bearing in mind that all available data over the last two years is used to determine the sector mean value (See Chapter 11.- NORVASE CAPACITY CALCULATION METHODOLOGY: MECANO). For sectors studied in P05.07.04 there is no historic information

2.2.5.1.2Sector Classification

2.2.5.1.2.1Groups

The aim of this preamble is to describe the different types of sector, both TMA and Route, based on their operational characteristics. The diagram below shows the sector groupings.

It is important to distinguish between sectors which generally deal with traffic in evolution (climbing or descending), and those which mainly handle overflight traffic. By looking at the chart "Percentage of Time in Overflight" it is possible to detect a big jump in the value of this variable. This jump enables us to distinguish between TMA Sectors and Route Sectors.

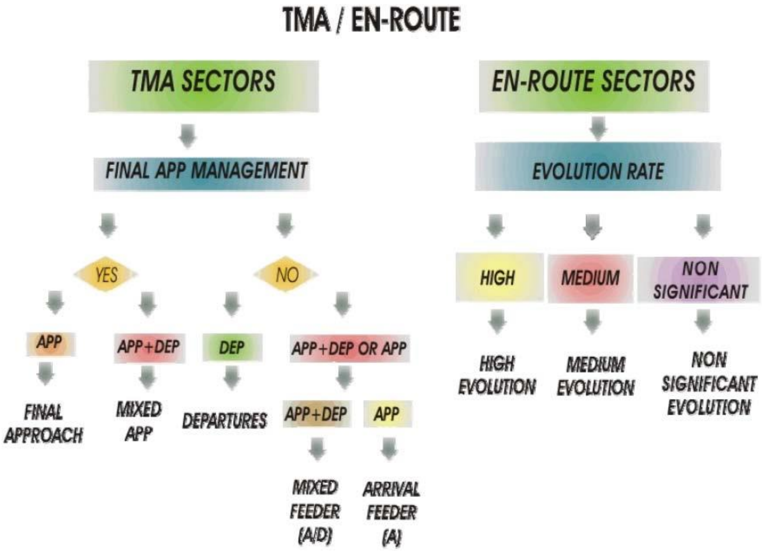


Figure 1: Groups

Within TMA Sectors the type of traffic handled varies according to whether the sector manages final approach or not. As such the classification is as follows:

2.2.5.1.2.1.1Group 1 (Final)

This group comprises all those sectors responsible for handling ARRIVALS in their final approach phase and Radar Vector towards ILS localizer interception. Once it is intercepted, the aircraft is transferred to TWR.

The main characteristics are:

•Sectors which exclusively or mainly handle arrivals.
•Sectors with a high degree of specialisation.

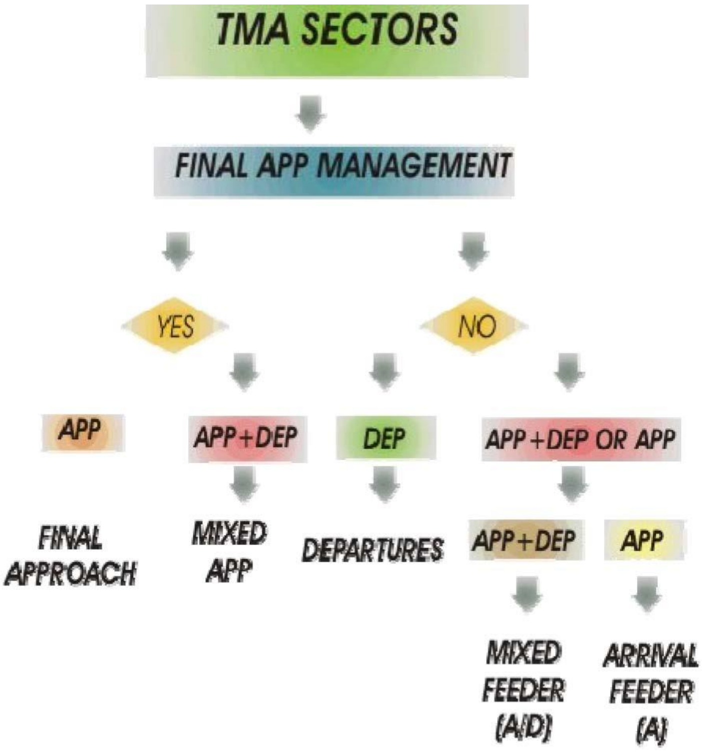


Figure 2: Final

2.2.5.1.2.1.2Group 2 (Mixed)

This group comprises all sectors responsible for handling ARRIVALS in their final approach phase which are Radar Vector towards TWR, as well as DEPARTURES coming from TWR.
The principal characteristics are:
•Sectors handling arrivals and departures transferred by TWR.
•TMA sectors with a low degree of specialisation.

2.2.5.1.2.1.3Group 3 (Departures)

Group comprising all sectors responsible for managing departures coming from TWR. The chief characteristics are:
•Sectors which mainly or exclusively manage departures.
•Sectors with a high degree of specialisation.

2.2.5.1.2.1.4Group 4 (A/D Feeder)

Group comprising all sectors responsible for handling ARRIVALS (final approach not included) that give Radar Vector towards final approach sectors, as well as managing DEPARTURES proceeding directly from TWR, or from a sector to which TWR has transferred departures.

The main characteristics are:

•TMA sectors which manage ascending and descending aircraft.
•TMA sectors with a high/medium level of specialisation.

2.2.5.1.2.1.5Group 5 (A Feeder)

Group comprising all sectors responsible for handling mainly ARRIVALS (final approach not included) that are Radar Vector towards final approach sectors. They differ from Group 4 due to the minor relevance of departures.
The Evolution Index is used to classify route sectors. It takes into account the time the aircraft spends in evolution (climb, descent) in the sector, the impact the evolution (climb, descent) has on controllers actions, and the complexity of these actions. The formula for the index is as follows:

ievolution = (%Tevol + %ActEvol + %CompEvol) / 3

Based on the intervals established by this index, the following groups may be identified.

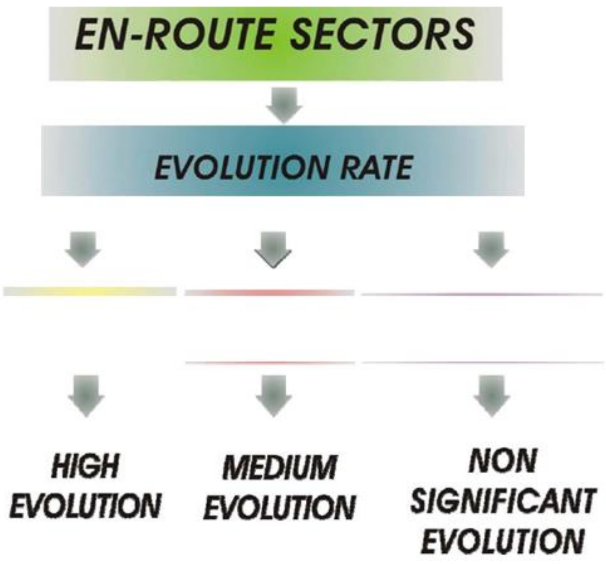


Figure 3: Feeder A

2.2.5.1.2.1.6Group 6 (High Evolution)

Sectors which show high evolution, being as they are route sectors. They are therefore transition sectors between pure TMA sectors and those which are more characteristically route sectors. Their Evolution Index given by the following expression: ievolution > 50

2.2.5.1.2.1.7Group 7 (Low Evolution)

Sector with low evolution but greater than that of pure route sectors. The value of their Evolution Index is: 15 < ievolution <50

2.2.5.1.2.1.8Group 8 (Route)

N/A

2.2.5.1.3Modulation

Once the sectors have been grouped, the workload and complexity of each sector can be calculated using the information provided by the data samples.

This section explains the process by which the workload of each control action is determined. This process includes data sampling and solving the equations.
Both in the system solving phase and in the later workload calculation process a new concept, Action Modulation, is required. The value assigned to the actions will be an initial value which will vary in line with variations in the operational situation in the sector.

The Complexity is modulated in the same way. It is modulated instantaneously based on the number of simultaneous aircraft in the mean flight time.

2.2.5.1.3.1Data Selection

Representative data is selected in different workload intervals, depending on the groupings being studied. Likewise, they will be statistical control of the actions in each group or interval. Data samples will be selected whose number of actions falls within the mean group values.

2.2.5.1.3.2Solving Equations

Once the data samples which make up the system of equations for each group have been selected, general restrictions are imposed on the actions, according to the group being studied.

As such we obtain results for the each kind of typical action. The remaining results are obtained by interpolation.

2.2.5.1.3.3Instant Modulation of All Actions

Given the difference in control difficulty, depending on the state of instantaneous saturation in each sector, we modulate the workload value registered every minute.

The instantaneous load in a given sector depends not only on the simultaneous aircraft (Asim) in the same, but also on the useful volume of said sector. By qualifying the number of simultaneous aircraft within a registered mean flight time (Tmv), one obtains a measure of the implicit difficulty in managing the aircraft present in the same without taking into account the dimensions of the sector.

The difficulty of traffic situations outside the low workload zone will vary in line with the number of communications that the controller makes until the saturation zone, in which, an increase in the communications will not resolve the existing complex traffic situation.
For this reason, the modulator factor is given by a function that relates simultaneous aircraft and the mean flight time.

The x-axis shows the Asim/Tmv variable, and the y-axis gives the Com10 variable.
To select the point of maximum complexity in an operation, for a given value of Asim/Tmv, it is best to choose that point with the maximum Com10 value. In that way the most complex situation for an operation recorded in the sector is obtained.

Afterwards, the graph of the series of data points is plotted, which may be exponential, polynomial, logarithmic or lineal; and the best fit is chosen, as long as it continually increases along the whole operation.
In this way we get the curve equation which is used to modulate the workload.

The modulation is assigned a reference value which will be the starting point. This value will be the midpoint of the curve (Xref= Asim /TMV), the mean value of Asim/TMV.

The first value of the variable Asim/TMV will be taken as the starting point for the modulation. Similarly the final value of the variable will be the last value of the modulation.

An intermediate point is chosen as the “no modulation” point. In this way modulation decreases the workload in zones below this point, and increases the workload in zones above this point.

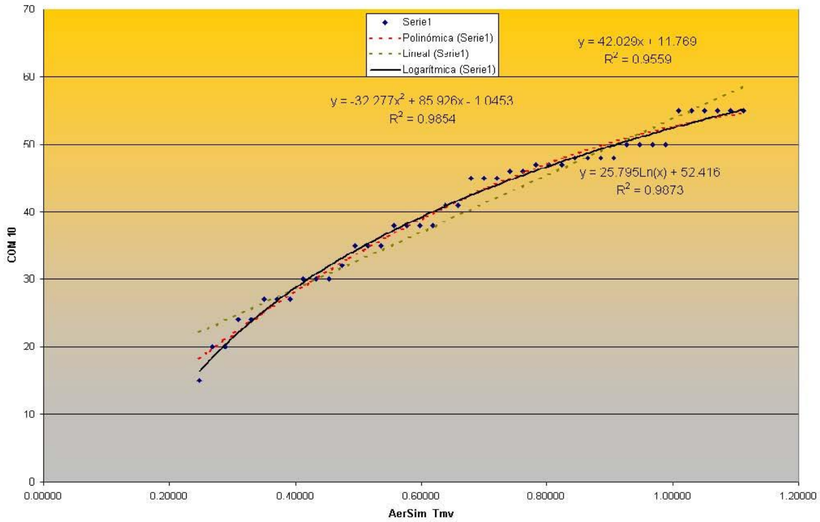


Figure 4: Instant Modulation of all actions

2.2.5.1.3.4 Workload Calculation

Once the initial workload for each control action has been determined, the workload for each data sample will be calculated in the opposite way, i.e. the corresponding minute-by-minute value for each action is substituted, modulating the workload according to the corresponding modulator value for that particular minute.

To avoid over-dimensioning when modulating, the maximum workload per sector is limited as explained below.
The number of communications is related to the number of actions, so that if we divide the communications made in a ten minute block by ten, we get a number which is representative of the actions carried out in one minute.
To calculate the workload that a minute of maximum difficulty would have, we assume that the maximum number (plus one) of actions registered in the sector are carried out and also, for safety reasons, that the actions carried out in that minute are those of greatest value for the group in question (*).
(*) This number of actions will be multiplied by the weighting of the highest value action which takes place in the type being considered. For sectors of Types 1, 2, 3, 4 or 5 the action to be considered is Radar Vector. In high and low evolution sectors (Types 6 or 7) the value of arrival-departure actions will be used. Finally for those where the evolution is not significant, Route (Type 8) the value of overfligh actions overflight will be used.
In this way, the maximum workload per minute is given by:

WLminmax = (Com10/10+1)*Selected Action
With this limitation the workload is not excessive. In those minutes where the modulated workload value exceeds WLminmax, the value WLminmax will be automatically assigned.

One of the advantages of calculating the workload in this way is that we can keep track of number of minutes in which a sector reaches the maximum (WLminmax), i.e. the number of minutes in which the sector has clearly been saturated can be known.

2.2.5.1.3.5Calculation of Norvase Indicators

Using CALCUNOR the data sampled in each sector is treated to give a series of indicators which enable us analyse the operational characteristics of the sector and thus evaluate its situation.
An explanation of how the most relevant NORVASE indicators are obtained is given below:

2.2.5.1.3.5.1Description of the indicators

Before we begin with a definition of the indicators that CALCUNOR calculates, we must clarify two things:
1. Although the duration of the data sample is an implicit value of the sample, it is decisive for CALCUNOR, therefore:

- If the data sample lasts more than one hour, only the hour with the greatest number of movements will be used. This means that the remainder of the data sample will be ruled out.
- Those data samples which last exactly 60 minutes are not modified.

2. The definitions which follow refer to a single data sample. In the case of more than one data sample, the result used will be the mean of the data samples in the sector, e.g. the sum of the indicators divided by the number of data samples.

As an aid to understanding this document the indicators have been classified as: Implicit Indicators which are those indicators calculated from the data recorded during sampling and Explicit Indicators which are calculated using a combination of implicit indicators.

2.2.5.1.3.5.2Implicit Indicators

An implicit indicator is an indicator which is obtained solely from the data recorded during sampling. The Guidelines for NORVASE Evaluation Teams (Data Sampling) Code I-05ION¬T06-2 details the aspects to be considered for each of the indicators mentioned below.

Actions is defined as the indicator that reflects all of the control actions carried out by the controller on the aircraft present in the data sample, be they IFR or VFR. This indicator gives the sum total of actions, separations, sequencing and Radar Vector.

Overflight Actions: Overflight Actions are those actions that are not unexpected and which are recorded for an aircraft in overflight phase, ruling out those actions which are noted after starting descent and adding those noted after starting overflight.

It must be stressed that start overflight is purely a milestone and is not considered to be an action, while start descent is considered to be an overflight action.

- Separation or Sequencing Actions (A) is the indicator which reflects the number of separation or sequencing actions carried out by the controller on all the aircraft present in the data sample, be they IFR or VFR.
- Arrival/Departure Separation/Sequencing Actions: separation or sequencing actions on Arrival/Departure are those actions which are noted for an aircraft in descent or climb phase, ruling out those which are noted after starting overflight and including those noted after a starting descent.
- Overflight Separation/Sequencing Actions: separation or sequencing actions on overflight are those actions which are noted for an aircraft in overflight phase, ruling out those which are noted after starting descent and including those noted after starting overflight.
- Radar Vector (S) is the indicator which reflects the number of times Radar Vector has been carried out by the controller on all of the aircraft present in the data sample, be they IFR or VFR.
- Unexpected Radar Vector (S): Unexpected Radar Vector is Radar Vector which is noted in the first three minutes of unexpected traffic entering a sector.
- Arrival/Departure Radar Vector (S): Arrival/Departure Radar Vector is Radar Vector which is not unexpected and is noted for an aircraft in descent or climb phase, ruling out Radar Vector after starting overflight and including those noted after starting descent.
- Departure Radar Vector (S): Departure Radar Vector is Radar Vector which is not unexpected and is noted for an aircraft in climb phase, ruling out Radar Vector noted after starting overflight and including Radar Vector noted after starting descent.
- Arrival Radar Vector (S): Arrival Radar Vector is Radar Vector which is not unexpected and is noted for an aircraft in descent phase, ruling out Radar Vector noted after starting overflight and including that Radar Vector noted after starting descent.
- Overflight Radar Vector (S): Overflight Radar Vector is Radar Vector which is not unexpected and is noted for an aircraft in overflight phase, ruling out Radar Vector which is noted after starting descent and including Radar Vector noted after starting overflight.

- Radar Vector (X) is the indicator that reflects the number of times standard Radar Vector has been carried out by the controller on all the aircraft in the data sample, be they IFR or VFR.
- Unexpected Radar Vector (X): Unexpected Radar Vector is Radar Vector that is noted in the first three minutes of unexpected traffic entering a sector.
- Arrival/Departure Radar Vector (X): Arrival/Departure Radar Vector is Radar Vector that is not unexpected and is noted for an aircraft in descent or climb phase, ruling out Radar Vector that is noted after starting overflight and including Radar Vector noted after starting descent.
- Departure Radar Vector (X): Departure Radar Vector is Radar Vector that is not unexpected and is noted for an aircraft in climb phase, ruling out Radar Vector that is noted after starting overflight and including Radar Vector noted after a starting descent.
- Arrival Radar Vector (X): Arrival Radar Vector is Radar Vector is Radar Vector that is not is not unexpected and is for an aircraft in descent phase, ruling out Radar Vector that is noted after starting overflight and including Radar Vector noted after a starting descent.
- Overflight Radar Vector (X): Overflight Radar Vector is Radar Vector that is not unexpected and is noted for an aircraft in overflight phase, ruling out Radar Vector that is noted after starting descent and including Radar Vector those noted after starting overflight.
- Surveillance is the indicator which reflects the work generated for the controller by aircraft simply being in communication. For this the duration of the aircraft in the data sample is analysed, be they IFR or VFR. To avoid exorbitant values, principally in the Route Group Sectors, it has been converted to a scalar (i.e. having no dimension), dividing the indicator by 60 minutes.
- Unexpected Surveillance: unexpected Surveillance is the total number of minutes of surveillance for unexpected traffic, i.e. during the first three minutes after unexpected traffic entering a sector.
- Arrival/Departure Surveillance: Arrival/Departure Surveillance is the total number of minutes of surveillance for aircraft in descent or climb phase, ruling out those departures that have begun overflight and including those in overflight that have begun descent.
- Overflight Surveillance: Overflight Surveillance is the total number of minutes of surveillance for aircraft in overflight phase, ruling out those which have begun descent and including those departures which have begun overflight.
- Coordinations: this is the indicator that gives the number of co-ordinations, not due to actions in the system, which the controller has carried out for all the aircraft present in the data sample, be they IFR or VFR.
- Coordinations in the System: gives the number of actions in the system that the controller has carried out for all the aircraft present in the data sample, be they IFR or VFR.
- Waits gives the number of waits that the controller has carried out for all the aircraft present in the data sample, be they IFR or VFR.
- No. of Visual Flights: number of visual movements to VFR aircraft with an entry time.
- No. of Movements – Data Sample: defined as the number of movements per data sample for IFR aircraft with an entry time.
- No. of Departures: number of aircraft with Departure flight group (D, U/D) of all aircraft considered to be data sample movement.
- No. of Arrivals: number of aircraft both with Arrival flight group (A, U/A) and those with Overflight flight group (O, U/O) but with a begin descent action, of all aircraft considered to be data sample movement.
- Actions due to Movements: quotient of the number of actions noted in data sample (Normal Actions to Unexpected Traffic + Arrival/Departure Actions + Overflight Actions) and the No. of Movements – Data Sample.
- Actions due to Departures: quotient of the number of actions noted as departures in the data sample and the Number of Departures.
- Actions due to Arrivals: quotient of the number of actions noted as arrivals in the data sample and the Number of Arrivals.
- Coordinations due to Movements: quotient of number of coordinations, be they due to actions in the system or not, and the No. of Movements – Data Sample.
- Coordinations due to Departures: quotient of the number of coordinations noted as Departures in the data sample, be they due to actions in the system or not, and the No. of Departures.
- Coordinations due to Arrivals: quotient of the number of coordinations noted as Arrivals in the data sample, be they due to actions in the system or not, and the No. of Arrivals.

2.2.5.1.3.5.3Explicit indicators

- Explicit Indicators are those indicators which are obtained by mathematical calculation using implicit indicators, obtained by direct observation, and assigned their corresponding value.
- Complexity: an indicator given by the following equation:

- Unexpected Actions * (Complexity Weighting) + Arrival/Departure Actions * (Complexity Weighting) + Overflight Actions * (Complexity Weighting) + Unexpected Surveillance * (Complexity Weighting) + Arrival/Departure Surveillance * (Complexity Weighting) + Overflight Surveillance * (Complexity Weighting) + Arrival/Departure Sep/Seq Act * (Extra Complexity Weighting) + Overflight Sep/Seq Act * (Extra Complexity Weighting) + (Coordinations + 2*General Coordinations) * (Complexity Weighting) + (System Coordinations) * (Complexity Weighting) + Unexpected Radar Vector * (Extra Complexity Weighting) + Arrival/Departure Radar Vector * (Extra Complexity Weighting) + Overflight Radar Vector * (Extra Complexity Weighting)
- Movement Complexity: quotient of the complexity of the data sample and the Num. of Movements – Data Sample.
- Arrival Complexity: quotient of complexity associated with aircraft in descent phase and number of arrivals.
- Departure Complexity: quotient of complexity associated with aircraft in climb phase and number of departures.
- Overflight Complexity: quotient of complexity associated with aircraft in overflight phase and number of overflights.
- Percentage of Time in Evolution (climb, descent): this indicator reflects the percentage of time of IFR movements with entry times that are in evolution phase with respect to the total time of those IFR movements with entry times that are in evolution phase in the sector.
- Percentage of Traffic in Evolution: this indicator reflects the percentage of IFR movements with entry times that are in evolution phase with respect to those IFR movements with entry times that are in evolution phase in the sector.
- Mean Flight Time: NORVASE considers that an aircraft enters the sector when it first establishes communication, and leaves the sector when it transfers to the following sector. The calculation consists of dividing the total minutes between the number of aircraft, taking into account all IFR aircraft with entry and exit times.
- Maximum Simultaneous Aircraft: NORVASE considers simultaneous aircraft to be all those that are IFR and are in communication in the same one minute period of the data sample. For a given data sample that minute where the maximum number of aircraft is recorded will be selected.
- Mean Simultaneous Aircraft: NORVASE considers simultaneous aircraft to be all those that are IFR and are in communication in the same one minute period of the data sample. The mean simultaneous aircraft is obtained by dividing the total simultaneous aircraft in each minute by the number of minutes of the data sample.
- Maximum Communications in 10 Minute Blocks: NORVASE considers any action or coordination carried out in the sector to be communication. 10 minute blocks are considered as the blocks that only last 10 minutes fixed with other pieces. To determine the maximum communication in 10 minute blocks the communications in the 10 minute blocks that comprise the data sample are analysed and that which has the maximum recorded number of communications is selected.
- Mean Communications in 10 Minute Blocks: NORVASE considers any action or coordination carried out in the sector to be communication. To determine the mean communication in 10 minute blocks the communications in the 10 minute blocks that comprise the data sample are analysed and the mean is calculated for each period.
- Workload: this is an indicator of the workload in seconds that the sector controller has during the data sample and is calculated as follows:
- Unexpected Actions * (Workload Weighting) + Arrival/Departure Actions * (Workload Weighting) + Overflight Actions * (Workload Weighting) + Unexpected Surveillance * (Workload Weighting) + Arrival/Departure Surveillance * (Workload Weighting) + Overflight Surveillance * (Workload Weighting) + Arrival/Departure Sep/Seq Action * (Extra Workload Weighting) + Overflight Sep/Seq Action * (Extra Workload Weighting) + Holdings * (Workload Weighting) + (Coordinations + 2 * General Coordinations) * (Workload Weighting) + (Actions in the System) * (Workload Weighting) + Unexpected Radar Vector * (Extra Workload Weighting) + Arrival/Departure Radar Vector * (Extra Workload Weighting) + Overflight Radar Vector * (Extra Workload Weighting)

2.2.5.1.3.6 NORVASE Capacity calculation methodology MECANO

2.2.5.1.3.6.1 Introduction

MECANO (MEtodología de cálculo de CApacidad NORVASE - NORVASE Capacity Calculation Methodology), MECANO, has defined an approach for determining the capacity of the control sectors, using the NORVASE data samples taken in each sector.

There were two principal issues:

•Giving the equivalent of the Workload, WL, in seconds.
•Obtaining the graph "workload / number of movements" for the sector, using all the data samples taken in said sector in the last 3 years (in such cases where the data is consistent with the current year's data samples).

2.2.5.1.3.6.2Giving the equivalent in sec

When evaluating the effort required to perform the activities carried out by air traffic controllers, the general aeronautical community has established the concept workload, which measures in seconds the time per hour a controller has been busy.

The maximum time a controller can work in one hour is 3,600 seconds. In fact, the limit is 2,520 seconds (70% of one hour). This gives a margin which guarantees safe control of aircraft and the permits the handling of momentary peaks in traffic which may lead to increased workload. It also takes into account the differing levels of expertise in air control personnel working in the same sector. This has been contemplated by NORVASE in the observation and data sampling procedure. The 70% limit is used to calculate Nominal Capacity.

This reference value has been accepted by the aeronautical community following different studies carried out by EUROCONTROL, DFS and NLR.

Taking as a reference the NORVASE weighting table, which scores the different events as per Table 1, the different NORVASE actions are assigned a weighting in seconds. This is done by developing a system of equations of the type:

200G + 300D + 1A + 61P + 51F = 2520

The first term represents a NORVASE data sample. The unknowns are the each of the NORVASE actions identified and the corresponding constant the number of times that the data sample was repeated.

Since 2004, the variables corresponding to the Separation or Sequencing Actions and the Actions in the System are included, as well as the variable corresponding to the Surveillance minutes of the data sample. Since 2006, the variable corresponding to standard Radar Vector has been included.
In the previous example:

200 G Two hundred Arrivals/Departures that required action
300 D 300 minutes of Arrival/Departure Surveillance
1 A One Coordination
61 P Sixty-one Arrival/Departure Radar Vector
51 F Fifty-one Arrival/Departure Sep/Seq Actions
The second term of the equation is the maximum workload per hour in a sector, i.e. 2520 seconds (70% of one hour).

Said system of equations has been mathematically solved using an optimisation algorithm (simulated annealing), which consists of varying the unknowns and automatically evaluating them until arriving at the values which give the best fit for each of the equations.
Furthermore, it should not be forgotten that the value of each action is modulated as explained in point 3.3. - MODULATION.

The quality of the data samples chosen greatly determines the validity of the results; as such a method has been established to enable the selection to be made in the most precise and objective way possible.
The steps are as follows:
1Variety in the workload intervals: representative data samples are chosen in different workload intervals, according to the group being studied.
2Statistical Control is carried out on the actions in each group and interval. Data samples are chosen whose action values are within the mean values of the group. The interval is increased starting from the mean value to ensure sufficient data samples.

3Representative sectors are chosen for each of the established sector groups (final, mixed, departures, A/D feeder, A feeder, high evolution, low evolution, route), hence their positions in the State Diagram is studied.
4We use the highest possible number of data samples, using those data samples which we know to have been carried out according to the correct NORVASE methodology. Furthermore, the data samples should satisfy the following:
•The NORVASE indicators are coherent.

•The number of movements (IFR only) is representative. Specifically, the number of movements of the data sample should be greater than or equal to the registered mean value of the sector for NORVASE data samples. Furthermore, the capacity and NORVASE percentile are taken into account.
•The number of actions, coordinations and complexity (including VFR ones) should be above the sector mean.
•The data samples have been carried out as and from 2004 by the NORVASE Local Team.

Once the data samples that make up the system of equations for each of the groups have been chosen, general restrictions are imposed on the actions depending on the group being studied. Said restrictions are imposed to ensure that any error obtained on applying them will be as small as possible.
After applying the algorithm we take the average of the 50 best solutions.
In this way we get the most representative actions for each type and the rest of the actions are obtained by interpolation.

2.2.5.1.3.6.3Instantaneous Modulation of all Actions

As the level of difficulty in control varies depending on the state of instantaneous saturation in each sector, we modulate the workload value recorded every minute.

The instantaneous load in a given sector depends not only on the simultaneous aircraft in the same but also on the useful volume of the sector. By qualifying the number of simultaneous aircraft within a registered mean flight time, one obtains a measure of the implicit difficulty in managing the aircraft present in the same without taking into account the dimensions of the sector.

The difficulty of traffic situations outside the low workload zone will vary in line with the number of communications that the controller makes until the saturation zone, in which, an increase in the communications will not resolve the existing complex traffic situation.

For this reason, the modulator factor is given by a function that relates simultaneous aircraft and the mean flight time, such that the workload for every minute, and consequently for every data sample will be given by the following expression:

MINUTE 1 WL MINUTE 1 = (n1*Act+n2*A+n3*S+n4*coord. +…) *f (Asim / TMV)
MINUTE 2 WL MINUTE 2 = (m1*Act+m2*A+m3*S+m4*coord. +…) * f (Asim / TMV) . . . .
. . . .
. . . . . .
. . .
MINUTE 60 WL MINUTE 60 = (p1*Act+p2*A+p3*S+p4*coord. +…) * f (Asim / TMV)
DATA SAMPLE WL = ∑ WL MINUTE i

The variables used in workload modulation are:

Asim: the average value of simultaneous aircraft corresponding to the 10 minute block that begins in that minute.
TMV: of the corresponding sector for the year studied.
Com10: Communications made by the controller in 10 minutes.
To determine the indicator we have taken into account the relationship between Asim and Com10.

The x-axis shows the Asim/Tmv variable, and the y-axis gives the Com10 variable.

To select the point of maximum complexity in an operation, for a given value of Asim/Tmv, it is best to choose that point with the maximum Com10 value. In that way the most complex situation for an operation recorded in the sector is obtained.
Afterwards, the graph of the series of data points is plotted, which may be exponential, polynomial, logarithmic or lineal; and the best fit is chosen, as long as it continually increases along the whole operation.

In this way we get the curve equation which is used to modulate the workload.

The modulation is assigned a reference value which will be the starting point. This value will be the midpoint of the curve (Xref= Asim /TMV), the mean value of Asim/TMV.

The first value of the variable Asim/TMV will be taken as the starting point for the modulation. Similarly the final value of the variable will be the last value of the modulation.

An intermediate point is chosen as the “no modulation” point. In this way modulation decreases the workload in zones below this point, and increases the workload in zones above this point.

The modulator expression will be of the form:

Mod=f(X)/f(Xref), the function being:

•Logarithmic: f(X)=C0+C1 lnX or
•Polynomial: f(X)= C0+ C1X+ C2X2 or
•Lineal: f(X)= C0+C1X

2.2.5.1.3.6.4Workload Calculation

Once the initial workload for each control action has been determined, the workload of each data sample will be calculated in the opposite way, i.e. the corresponding minute-by-minute value for each action is substituted, modulating the workload according to the corresponding modulator value for that particular minute. (Process explained in the previous section).

To avoid over-dimensioning when modulating, the maximum workload per sector is limited as follows.

The number of communications is related to the number of actions, so that if we divide the communications made in a ten minute block by ten, we get the number which is representative of the actions carried out in one minute.
To calculate the workload that a minute of maximum difficulty would have, we assume that the maximum number (plus one) of actions registered in the sector are carried out and also, for safety reasons, that the actions carried out in that minute are those of greatest value for the group in question (*).

(*) This number of actions will be multiplied by the weighting of the highest value action which takes place in the type being considered. For sectors of Types 1, 2, 3, 4 or 5 the action to be considered is Radar Vector. In high and low evolution sectors (Types 6 or 7) the value of arrival-departure actions will be used. Finally for those where the evolution is not significant, Route (Type 8) the value of overflight actions will be used.

In this way, the maximum workload per minute is given by:

WLminmax = (Com10/10+1)*Selected Action
With this limitation the workload is not excessive. In those minutes where the modulated workload value exceeds WLminmax, the value WLminmax will be automatically assigned.

One of the advantages of calculating the workload in this way is that we can keep track of number of minutes in which a sector reaches the maximum (WLminmax), i.e. when it is at its limit in terms of communications possible and as such at the limit of its capacity.

2.2.5.1.3.6.5Obtaining the calculated capacity

The nominal calculated capacity of the sector is the number of movements that corresponds to the maximum permitted workload of 2,520 seconds.

MECANO PLUS
The reference value of 70% occupation of controllers, 2,520 seconds per hour, is used. This gives sufficient margin and has been accepted and used in similar studies carried out by EUROCONTROL, DFS, NLR.

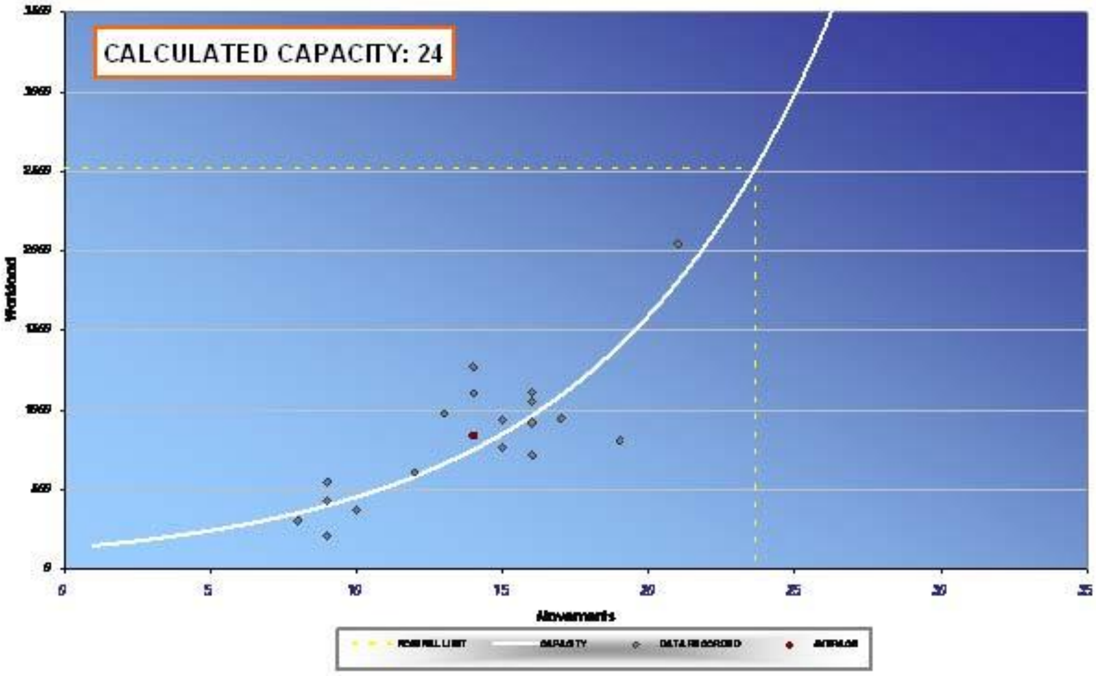


Figure 5: Calculated Capacity

2.2.5.1.3.7State Diagrams

State Diagrams illustrate the state of the sectors using a chart with four quadrants. These quadrants are delimited by the medians of absolute complexity and complexity per movement for every sector group in the last four years

2.2.5.1.3.7.1Quadrant 1

2.2.5.1.3.7.1.1Characteristics

Low Absolute Complexity Sectors, High Complexity / Movement Sectors, Sectors with a low number of movements per sample. High number of actions and coordinations per movement.

2.2.5.1.3.7.1.2Actions

Modification of Operating Procedures Suppression of coordinations by the modification of LoA's. Study Sector Design / Functions.

2.2.5.1.3.7.2Quadrant 2

2.2.5.1.3.7.2.1Characteristics

High Absolute Complexity Sectors, derived from a high number of movements and actions / coordinations. High Complexity / Movement Sectors, high number of actions and coordinations per movement. Sectors at the limit of their capacity.

2.2.5.1.3.7.2.2Actions

Modification of Operating Procedures (LoA's) Modification of Sector Design / Functions. Revision of Flows. If the previous is not possible, Re-sectorise.

2.2.5.1.3.7.3Quadrant 3

2.2.5.1.3.7.3.1Characteristics

Low Absolute Complexity Sectors, derived from a high number of movements. Sectors with Low Complexity / Movements. Sectors at the limit of their capacity and good utilisation.

2.2.5.1.3.7.3.2Actions

Ideal sector. Only if it does not absorb demand, re-sectorise or revise flows.

2.2.5.1.3.7.4Quadrant 4

2.2.5.1.3.7.4.1Characteristics

Low Absolute Complexity Sector. Sectors with Low Complexity / Movement. The further to the right of the quadrant, the better the utilisation. The higher in the quadrant, the greater the possibility of absorbing demand if the actions / coordinations are not acted upon.

2.2.5.1.3.7.4.2Actions

Revise the flows of other sectors to increase the demand (utilisation). Consider using part-time or integration with other sectors.

2.2.6 Validation Exercises List and dependencies

This section contains the list of validation exercises performed, providing details about the methodological approach undertaken as well as about the dependencies between the different exercises and between different experiment or runs:

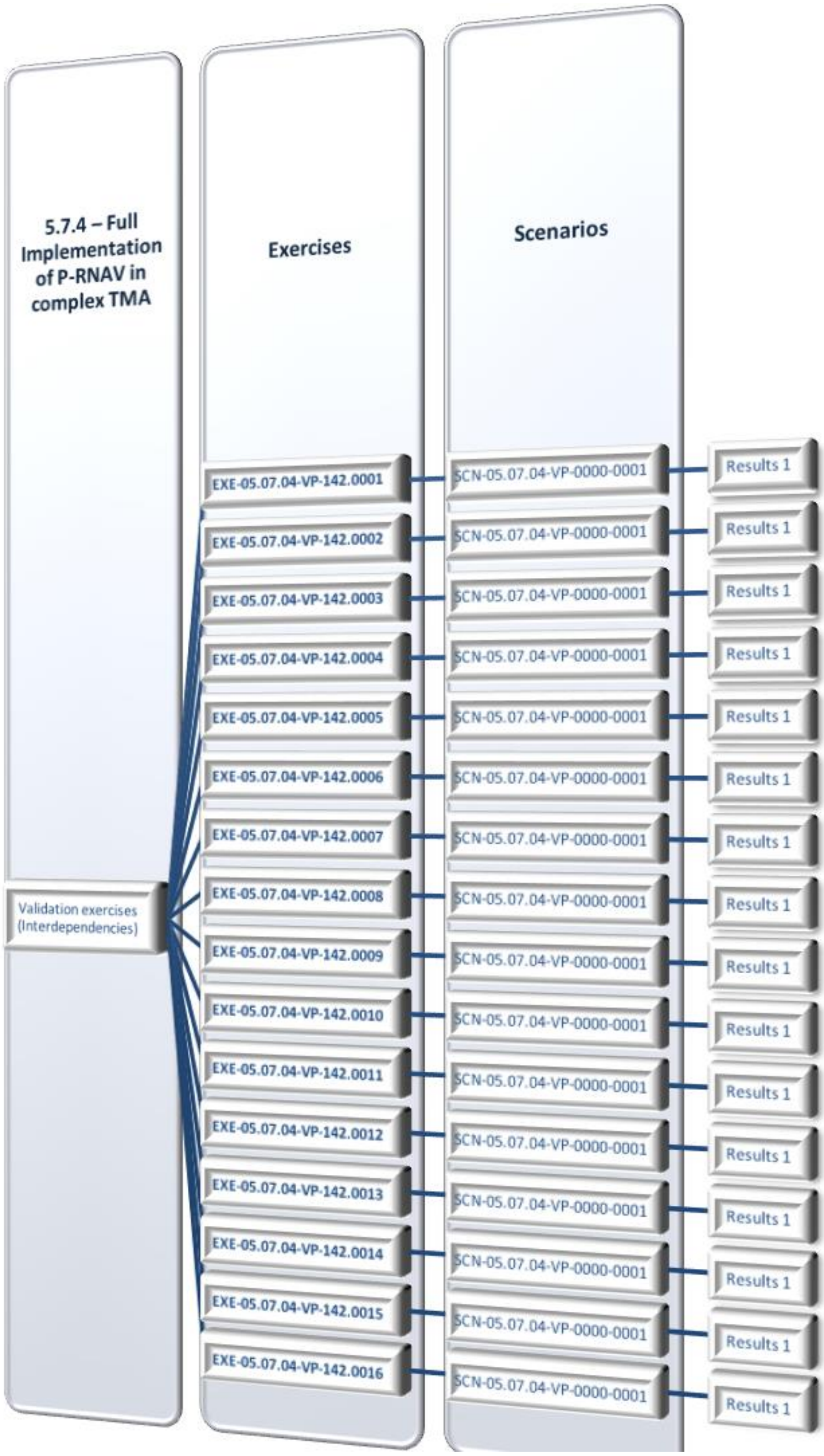


Figure 6: Validation Exercises List and dependencies (North Configuration)

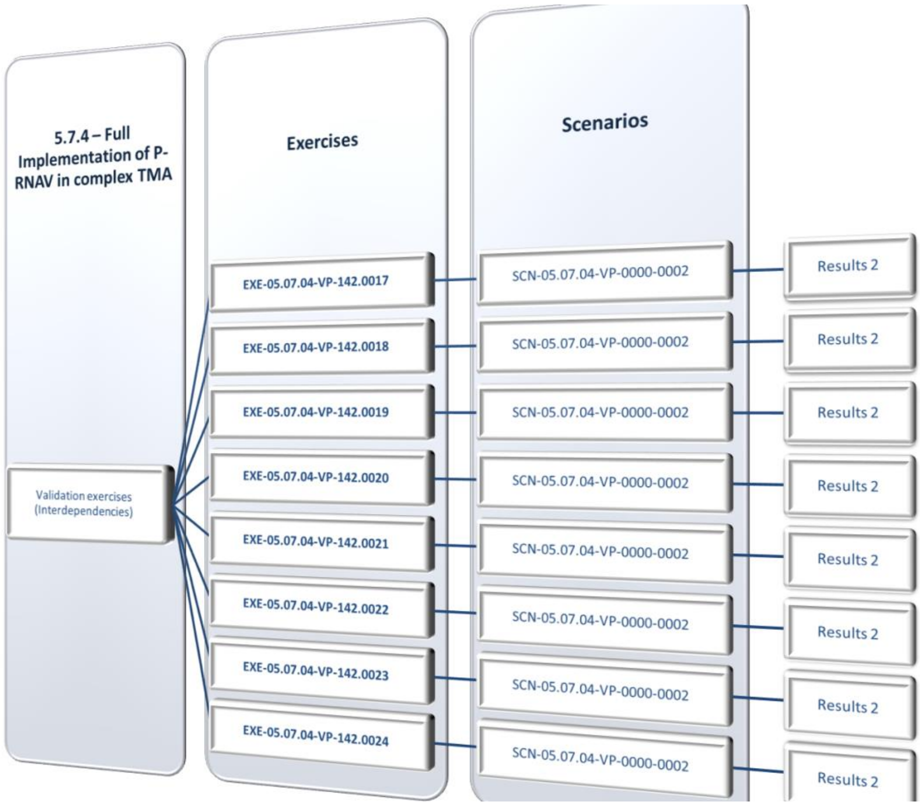


Figure 7: Validation Exercises List and dependencies (South Configuration)

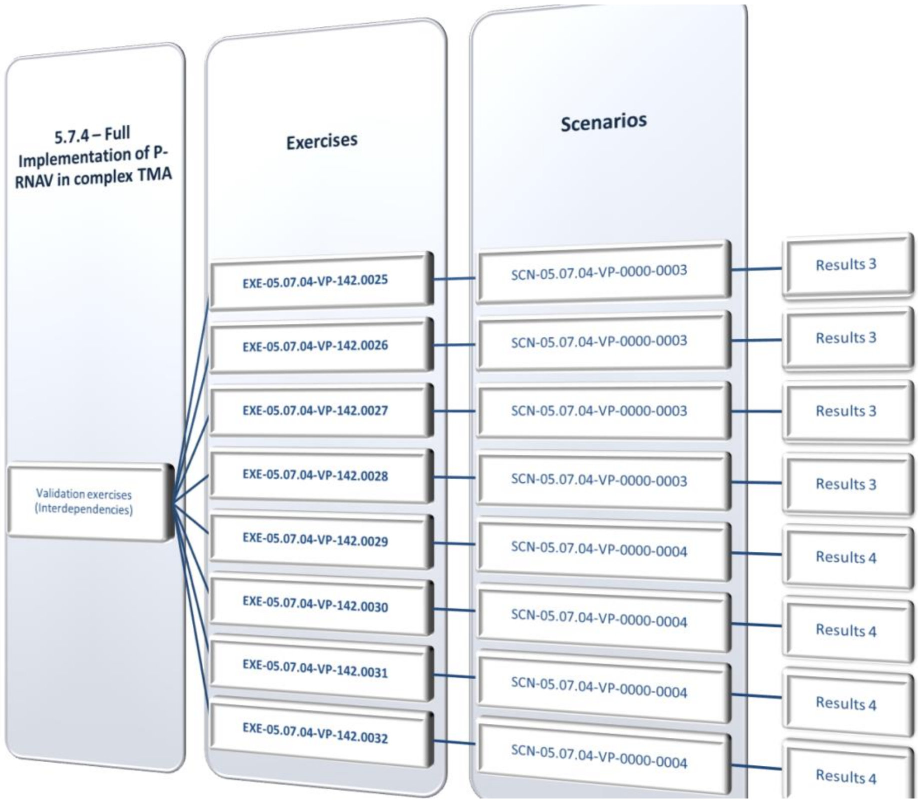


Figure 8: Validation Exercises List and dependencies (MOPS)

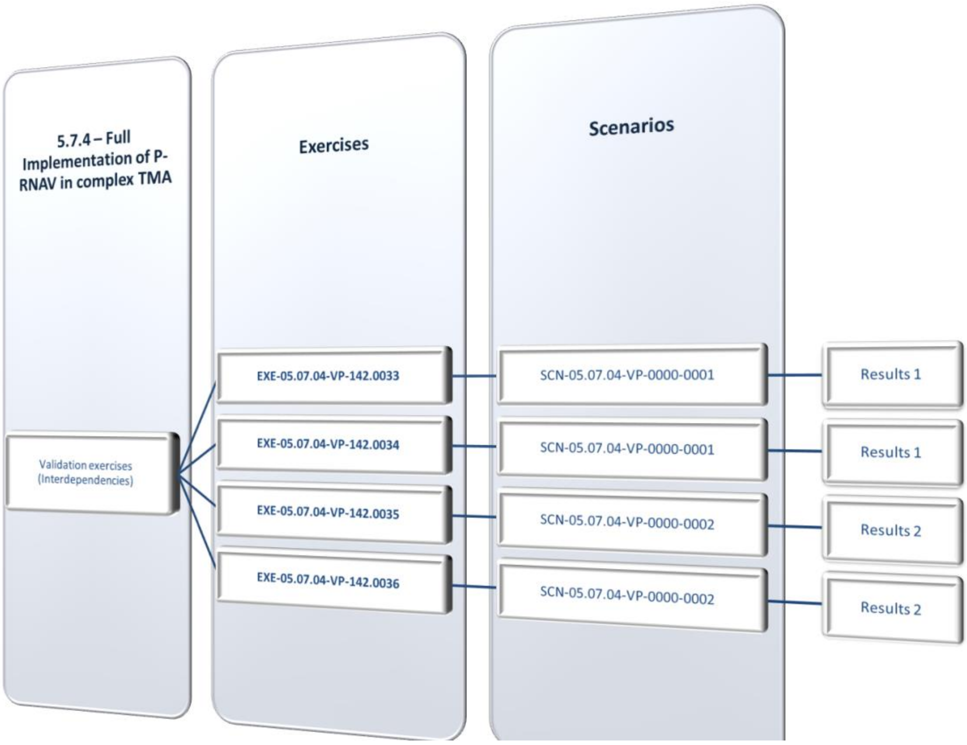


Figure 9: Validation Exercises List and dependencies (Sector Integration)

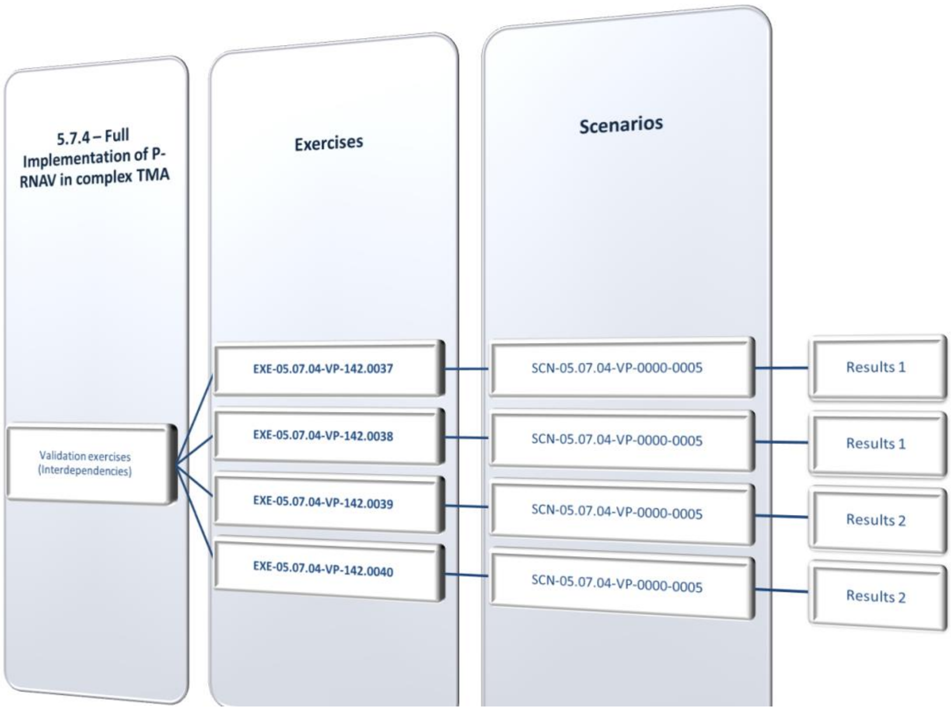


Figure 10: Validation Exercises List and dependencies (Single Runway)[1]

[1] EXE-05.07.04-VP-142.0039 and EXE-05.07.04-VP-142.0040 were simulated with SCN-05.07.04-VP-0000-0006

3 Conduct of Validation Exercises

3.1 Exercises Preparation

The exercises have been prepared according to the following activities performed (in order):

- Sectorization and procedures design
- Simulator preparation and technical acceptance criteria
- Database introduction according to the operative environment to execute the exercises
- Preparation of 40 exercises (1h of duration each one)
- 6 Sector Control Units
- 9 Pseudo-Pilots (9 PPL)
- 10 ATCOs
- Training
  - One week of training providing the necessary material for both controllers and pseudo-pilots

3.2 Exercises Execution

Here is listed the exercises executed during the 2 weeks of simulation with its corresponding dates:

Exercise ID	Exercise Title	Actual Exercise execution start date	Actual Exercise execution end date	Actual Exercise start analysis date	Actual Exercise end date
EXE-05.07.04-VALP-142.0001	Eastern Nucleus - NC (50% traffic sample)	-	-	-	-
EXE-05.07.04-VALP-142.0002	Eastern Nucleus - NC (50% + 30% traffic sample)	17/10/2011	28/10/2011	31/10/2011	30/12/2011
EXE-05.07.04-VALP-142.0003	Western Nucleus - NC (50% traffic sample)	-	-	-	-
EXE-05.07.04-VALP-142.0004	Western Nucleus - NC (50% traffic sample)	-	-	-	-
EXE-05.07.04-VALP-142.0005	Eastern Nucleus - NC (60% traffic sample + Hard Wind)	-	-	-	-
EXE-05.07.04-VALP-142.0006	Eastern Nucleus - NC (60% traffic sample + Hard Wind)	-	-	-	-
EXE-05.07.04-VALP-142.0007	Western Nucleus - NC (60% traffic sample + Hard Wind)	-	-	-	-
EXE-05.07.04-VALP-142.0008	Western Nucleus - NC (60% traffic sample + Hard Wind)	-	-	-	-
EXE-05.07.04-VALP-142.0009	Eastern Nucleus - NC (60% traffic sample + Storms at DULCI)	-	-	-	-
EXE-05.07.04-VALP-142.0010	Eastern Nucleus - NC (60% + 10% traffic sample + Storms at DULCI)	17/10/2011	28/10/2011	31/10/2011	30/12/2011
EXE-05.07.04-VALP-142.0011	Western Nucleus - NC (60% traffic sample + Storms at GRECO)	-	-	-	-
EXE-05.07.04-VALP-142.0012	Western Nucleus - NC (60% + 10% traffic sample + Storms at GRECO)	17/10/2011	28/10/2011	31/10/2011	30/12/2011
EXE-05.07.04-VALP-142.0013	Eastern Nucleus - NC (Maximum capacity)	-	-	-	-
EXE-05.07.04-VALP-142.0014	Eastern Nucleus - NC (Maximum capacity)	17/10/2011	28/10/2011	31/10/2011	30/12/2011
EXE-05.07.04-VALP-142.0015	Western Nucleus - NC (Maximum capacity)	17/10/2011	28/10/2011	31/10/2011	30/12/2011
EXE-05.07.04-VALP-142.0016	Western Nucleus - NC (Maximum capacity)	-	-	-	-
EXE-05.07.04-VALP-142.0017	Eastern Nucleus - SC (50% traffic sample + hard Wind)	-	-	-	-
EXE-05.07.04-VALP-142.0018	Eastern Nucleus - SC (60% traffic sample + hard Wind)	-	-	-	-
EXE-05.07.04-VALP-142.0019	Western Nucleus - SC (50% traffic sample + hard Wind)	-	-	-	-

EXE-05.07.04-VALP-142.0020	Western Nucleus - SC (60% traffic sample + hard Wind)	-	-	-	-
EXE-05.07.04-VALP-142.0021	Eastern Nucleus - SC (Maximum capacity)	-	-	-	-
EXE-05.07.04-VALP-142.0022	Eastern Nucleus - SC (Maximum capacity + Hard Wind)	-	-	-	-
EXE-05.07.04-VALP-142.0023	Western Nucleus - SC (Maximum capacity)	-	-	-	-
EXE-05.07.04-VALP-142.0024	Western Nucleus - SC (Maximum capacity + Hard Wind)	-	-	-	-
EXE-05.07.04-VALP-142.0025	Eastern Nucleus (MOPS NC to SC at 15' - Maximum Capacity)	-	-	-	-
EXE-05.07.04-VALP-142.0026	Eastern Nucleus (MOPS NC to SC at 15' - Maximum Capacity)	-	-	-	-
EXE-05.07.04-VALP-142.0027	Western Nucleus (MOPS NC to SC at 15' - Maximum Capacity)	17/10/2011	28/10/2011	31/10/2011	30/12/2011
EXE-05.07.04-VALP-142.0028	Western Nucleus (MOPS NC to SC at 20' - Maximum Capacity)	-	-	-	-
EXE-05.07.04-VALP-142.0029	Eastern Nucleus (MOPS SC to NC at 20' - Maximum Capacity)	17/10/2011	28/10/2011	31/10/2011	30/12/2011
EXE-05.07.04-VALP-142.0030	Eastern Nucleus (MOPS SC to NC at 20' - Maximum Capacity)	-	-	-	-
EXE-05.07.04-VALP-142.0031	Western Nucleus (MOPS SC to NC at 20' - Maximum Capacity)	-	-	-	-
EXE-05.07.04-VALP-142.0032	Western Nucleus (MOPS SC to NC at 20' - Maximum Capacity)	-	-	-	-
EXE-05.07.04-VALP-142.0033	Eastern and Western Nucleus - NC (60% traffic sample + Sectors integrated)	-	-	-	-
EXE-05.07.04-VALP-142.0034	Eastern and Western Nucleus - NC (Maximum capacity + Sectors integrated + Hard Wind)	17/10/2011	28/10/2011	31/10/2011	30/12/2011
EXE-05.07.04-VALP-142.0035	Eastern and Western Nucleus - SC (60% + 20% traffic sample + Sectors integrated)	17/10/2011	28/10/2011	31/10/2011	30/12/2011
EXE-05.07.04-VALP-142.0036	Eastern and Western Nucleus - SC (Maximum capacity + Sectors integrated + Hard Wind)	17/10/2011	28/10/2011	31/10/2011	30/12/2011
EXE-05.07.04-VALP-142.0037	Single Runway - NC (30% traffic sample + sectors integrated)	17/10/2011	28/10/2011	31/10/2011	30/12/2011
EXE-05.07.04-VALP-142.0038	Single Runway - NC (40% traffic sample + sectors integrated)	17/10/2011	28/10/2011	31/10/2011	30/12/2011
EXE-05.07.04-VALP-142.0039	Single Runway - SC (30% traffic sample + sectors integrated)	-	-	-	-
EXE-05.07.04-VALP-142.0040	Single Runway - SC (40% traffic sample + sectors integrated)	-	-	-	-

Table 6: Exercises execution/analysis dates

3.3 Deviations from the planned activities

There was no deviation from planned activities. At a exercise level there were some exercises that couldn't be simulated according to the validation plan and represented in the table above.

3.3.1 Deviations with respect to the Validation Strategy

5.7.4 EXE-142 is compliant with 5.2 Validation Strategy with no delays in planned activities.

3.3.2 Deviations with respect to the Validation Plan

During the integration of procedures in the simulator, in order to simulate the single runway exercises in both configurations, there was an inconvenient to try to introduce the transitions assigned from one runway to the other one. The quick solution was to carry out open arrivals after the IAF so the controller would be able to perform the sequence through radar vectoring to intercept the ILS localizer. The result was a scenario like is show in the following figure for North configuration (same for South Configuration):

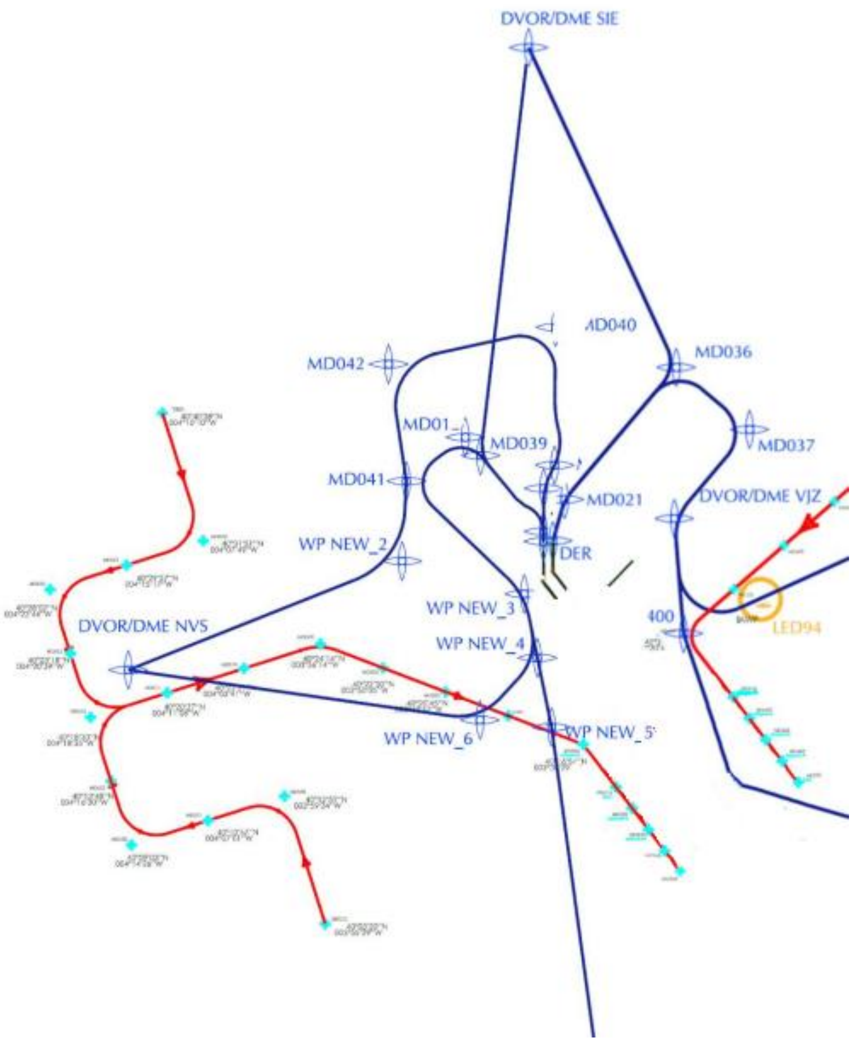


Figure 11: SCN-05.07.04-VALP-0000-0005

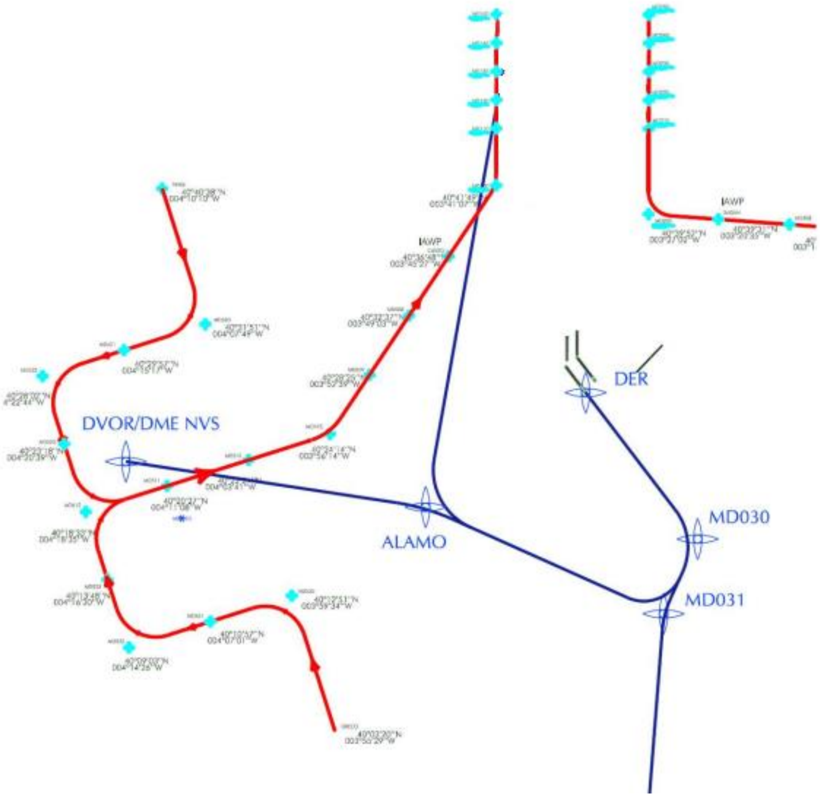


Figure 12: SCN-05.07.04-VALP-0000-0007

After the validation exercises, the recording session was generated and the commitment with Simulation Madrid ACC department was to generate PALESTRA files, to reproduce them in PC environment (what was seen on the radar screen during the simulation).

There were some exercises not simulated due to technical and time problems. The pseudo-pilots availability was too constrained and the validation activities were able to simulate until 2:00 PM. The constantly problems with communications (voice channel in sector control units) lead to cancel many exercises and had to be repeated. The schedule plan for the two weeks of simulation was to perform 4 exercises of 1 hour of duration each day.

It wasn't generated the corresponding flight plans exportation, vertical profiles traffic sample… etc. Sim Madrid ACC division doesn't have the infrastructure necessary to perform exportation process to PALESTRA. The only information available is .j01 files of the simulation days. J01 files are files which can be reproduced by PALESTRA like a session and it represents what was shown on the radar screen during the simulation activities.
The compromise to deliver an environmental case is not possible at this stage where the generated files only shows a 2D representation of the scenario and a quantitative study cannot be perform. The effort spend in the generation of j01 was too high and the resources are not available for 5.7.4 post-validation activities.[2]

[2] Palestra is one of the SACTA functions:
The support subsystem consists of a set of processors and *off line* applications for the generation of adaptation and configuration data of the GEODESYS (Geographical Operation Data System) and for the reduction and exploration of all the data recorded by the PALESTRA system.
GEODESYS: The Adaptation Database Manager enables the different SACTA subsystems to be configured to adjust to the geographical surroundings where they are installed and to the evolution of air space, as well as the different operative procedures for each one of them. It also makes maps that are viewed by the controllers in Control Positions. Furthermore, it is the tool that contains the technical parameterization.
Through this application, SACTA can operate in aeronautical environments as different as the Peninsula and the Balearic or Canary Islands. Likewise, reliable simulations have been made of air spaces in Germany, Hungry, Greece and the United Kingdom.
This tool has enhanced capabilities for information capture from external sources and information distribution to interested users.
Data analysis programmes: This is a group of applications used to operate and analyze the data recorded when the system is running. It allows for both the reproduction of past situations and the operational statistics for components, subsystems or traffic. Specific applications exist for surveillance, flight plans, supervision and weather and flight data.
The integration of all these tools is called PALESTRA.

4 Exercises Results

4.1 Summary of Exercises Results

Exercise ID	Exercise Title	Validation Objective ID	Validation Objective Title	Success Criterion	Exercise Results
EXE-05.07.04 VALP-142.00**02**	North Configuration (Eastern Nucleus). Missed approaches	OBJ-05.07.04-VALP-0000.**0001** OBJ-05.07.04-VALP-0000.**0003** OBJ-05.07.04-VALP-0000.**0005** OBJ-05.07.04-VALP-0000.**0007** OBJ-05.07.04-VALP-0000.**0008** OBJ-05.07.04-VALP-0000.**0009** OBJ-05.07.04-VALP-0000.**0010**	Mixed Mode Operations **MOPS change** Workload CCDs Aircraft performances Delay times Missed approaches	CRT-05.07.04- VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0004 VALP-0001.0003 VALP-0001.0004 VALP-0001.0005 VALP-0001.0006 VALP-0001.0008 VALP-0001.0009 VALP-0001.0010 VALP-0001.0012 VALP-0001.0014 VALP-0001.0015 VALP-0001.0016 VALP-0001.0017	See Norvase Results
EXE-05.07.04 VALP-142.00**10**	North Configuration (Eastern Nucleus) - Storms	OBJ-05.07.04-VALP-0000.**0001** OBJ-05.07.04-VALP-0000.**0003** OBJ-05.07.04-VALP-0000.**0005** OBJ-05.07.04-VALP-0000.**0007** OBJ-05.07.04-VALP-0000.**0008** OBJ-05.07.04-VALP-	Mixed Mode Operations **MOPS change** Workload CCDs Aircraft performances Delay times Missed approaches	CRT-05.07.04- VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0004 VALP-0001.0003 VALP-0001.0004 VALP-0001.0005 VALP-0001.0006 VALP-0001.0008 VALP-0001.0009 VALP-0001.0010 VALP-0001.0012 VALP-0001.0014 VALP-0001.0015 VALP-0001.0016 VALP-0001.0017	See Norvase Results

Exercise ID	Exercise Title	Validation Objective ID	Validation Objective Title	Success Criterion	Exercise Results
		0000.**0009** OBJ-05.07.04-VALP-0000.**0010**			
EXE-05.07.04 VALP-142.00**12**	Storms	OBJ-05.07.04-VALP-0000.**0001** OBJ-05.07.04-VALP-0000.**0002** OBJ-05.07.04-VALP-0000.**0003** OBJ-05.07.04-VALP-0000.**0005** OBJ-05.07.04-VALP-0000.**0007** OBJ-05.07.04-VALP-0000.**0008** OBJ-05.07.04-VALP-0000.**0009**	Mixed Mode Operations High Terrain and bad weather **MOPS change** Workload CCDs Aircraft performances Delay times	CRT-05.07.04- VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0004 VALP-0001.0005 VALP-0001.0006 VALP-0001.0007 VALP-0001.0008 VALP-0001.0009 VALP-0001.0010 VALP-0001.0012 VALP-0001.0014 VALP-0001.0015 VALP-0001.0016	See Norvase Results
EXE-05.07.04 VALP-142.00**14**	North Configuration (Eastern Nucleus) - Max. Capacity	OBJ-05.07.04-VALP-0000.**0001** OBJ-05.07.04-VALP-0000.**0003** OBJ-05.07.04-VALP-0000.**0005** OBJ-05.07.04-VALP-0000.**0007** OBJ-05.07.04-VALP-0000.**0008** OBJ-05.07.04-VALP-0000.**0009** OBJ-05.07.04-	Mixed Mode Operations **MOPS change** Workload CCDs Aircraft performances Delay times Missed approaches	CRT-05.07.04- VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0004 VALP-0001.0003 VALP-0001.0004 VALP-0001.0005 VALP-0001.0006 VALP-0001.0008 VALP-0001.0009 VALP-0001.0010 VALP-0001.0012 VALP-0001.0014 VALP-0001.0015 VALP-0001.0016 VALP-0001.0017	See Norvase Results

Exercise ID	Exercise Title	Validation Objective ID	Validation Objective Title	Success Criterion	Exercise Results
		VALP-0000.**0010**			
EXE-05.07.04 VALP-142.00**15**	Maximum capacity	OBJ-05.07.04-VALP-0000.**0001** OBJ-05.07.04-VALP-0000.**0004** OBJ-05.07.04-VALP-0000.**0005** OBJ-05.07.04-VALP-0000.**0007** OBJ-05.07.04-VALP-0000.**0008** OBJ-05.07.04-VALP-0000.**0009** OBJ-05.07.04-VALP-0000.**0010**	Mixed Mode Operations Maximum capacity Workload CCDs Aircraft performances Delay times Missed approaches	CRT-05.07.04- VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0004 VALP-0001.0005 VALP-0001.0006 VALP-0001.0011 VALP-0001.0012 VALP-0001.0014 VALP-0001.0015 VALP-0001.0016 VALP-0001.0017	See Norvase Results
EXE-05.07.04 VALP-142.00**27**	Maximum capacity Eastern sectors. North configuration	OBJ-05.07.04-VALP-0000.**0001** OBJ-05.07.04-VALP-0000.**0003** OBJ-05.07.04-VALP-0000.**0004** OBJ-05.07.04-VALP-0000.**0005** OBJ-05.07.04-VALP-0000.**0007** OBJ-05.07.04-VALP-0000.**0008** OBJ-05.07.04-VALP-0000.**0009**	Mixed Mode Operations **MOPS change** Maximum capacity Workload CCDs Aircraft performances Delay times	CRT-05.07.04- VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0004 VALP-0001.0005 VALP-0001.0006 VALP-0001.0008 VALP-0001.0009 VALP-0001.0010 VALP-0001.0011 VALP-0001.0012 VALP-0001.0014 VALP-0001.0015 VALP-0001.0016	See Norvase Results
EXE-05.07.04 VALP-142.00**27**	Configuration (Eastern	OBJ-05.07.04-VALP-	Mixed Mode	CRT-05.07.04-	See Norvase Results

Exercise ID	Exercise Title	Validation Objective ID	Validation Objective Title	Success Criterion	Exercise Results
	Nucleus) - Max. Capacity	0000.**0001** OBJ-05.07.04-VALP-0000.**0003** OBJ-05.07.04-VALP-0000.**0004** OBJ-05.07.04-VALP-0000.**0005** OBJ-05.07.04-VALP-0000.**0007** OBJ-05.07.04-VALP-0000.**0008** OBJ-05.07.04-VALP-0000.**0009**	Operations **MOPS change** Maximum capacity Workload CCDs Aircraft performances Delay times	VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0004 VALP-0001.0005 VALP-0001.0006 VALP-0001.0008 VALP-0001.0009 VALP-0001.0010 VALP-0001.0011 VALP-0001.0012 VALP-0001.0014 VALP-0001.0015 VALP-0001.0016	
EXE-05.07.04 VALP-142.00**34**	Maximum capacity Western sectors. North configuration	OBJ-05.07.04-VALP-0000.**0001** OBJ-05.07.04-VALP-0000.**0003** OBJ-05.07.04-VALP-0000.**0004** OBJ-05.07.04-VALP-0000.**0005** OBJ-05.07.04-VALP-0000.**0007** OBJ-05.07.04-VALP-0000.**0008** OBJ-05.07.04-VALP-0000.**0009**	Mixed Mode Operations **MOPS change** Maximum capacity Workload CCDs Aircraft performances Delay times	CRT-05.07.04- VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0004 VALP-0001.0005 VALP-0001.0006 VALP-0001.0008 VALP-0001.0009 VALP-0001.0010 VALP-0001.0011 VALP-0001.0012 VALP-0001.0014 VALP-0001.0015 VALP-0001.0016	See Norvase Results
EXE-05.07.04 VALP-142.00**35**	South configuration (Eastern & western nucleus) **Final approach sectors**	OBJ-05.07.04-VALP-0000.**0001** OBJ-05.07.04-VALP-0000.**0003** OBJ-05.07.04-VALP-	Mixed Mode Operations **MOPS change** Workload CCDs	CRT-05.07.04- VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0004 VALP-0001.0005 VALP-0001.0006 VALP-0001.0008 VALP-0001.0009	

Exercise ID	Exercise Title	Validation Objective ID	Validation Objective Title	Success Criterion	Exercise Results
		0000.**0005** OBJ-05.07.04-VALP-0000.**0007** OBJ-05.07.04-VALP-0000.**0008** OBJ-05.07.04-VALP-0000.**0009** OBJ-05.07.04-VALP-0000.**0010**	Aircraft performances Delay times Missed approaches	VALP-0001.0010 VALP-0001.0012 VALP-0001.0014 VALP-0001.0015 VALP-0001.0016 VALP-0001.0017	
EXE-05.07.04 VALP-142.00**36**	South configuration (Eastern & western nucleus) **Final approach sectors.** Maximum capacity	OBJ-05.07.04-VALP-0000.**0001** OBJ-05.07.04-VALP-0000.**0003** OBJ-05.07.04-VALP-0000.**0004** OBJ-05.07.04-VALP-0000.**0005** OBJ-05.07.04-VALP-0000.**0007** OBJ-05.07.04-VALP-0000.**0008** OBJ-05.07.04-VALP-0000.**0009** OBJ-05.07.04-VALP-0000.**0010**	Mixed Mode Operations **MOPS change** Maximum capacity Workload CCDs Aircraft performances Delay times Missed approaches	CRT-05.07.04- VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0004 VALP-0001.0005 VALP-0001.0006 VALP-0001.0008 VALP-0001.0009 VALP-0001.0010 VALP-0001.0011 VALP-0001.0012 VALP-0001.0014 VALP-0001.0015 VALP-0001.0016 VALP-0001.0017	See Norvase Results
EXE-05.07.04 VALP-142.00**37**	North configuration (Eastern & western nucleus). Single runway	OBJ-05.07.04-VALP-0000.**0001** OBJ-05.07.04-VALP-0000.**0003** OBJ-05.07.04-VALP-0000.**0005** OBJ-05.07.04-	Mixed Mode Operations **MOPS change** Workload CCDs	CRT-05.07.04- VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0004 VALP-0001.0003 VALP-0001.0004 VALP-0001.0005 VALP-0001.0006 VALP-0001.0008 VALP-0001.0009 VALP-0001.0010	See Norvase Results

Exercise ID	Exercise Title	Validation Objective ID	Validation Objective Title	Success Criterion	Exercise Results
		VALP-0000.**0007** OBJ-05.07.04-VALP-0000.**0008** OBJ-05.07.04-VALP-0000.**0009** OBJ-05.07.04-VALP-0000.**0011**	Aircraft performances Delay times **Single runway as contingency procedure**	VALP-0001.0012 VALP-0001.0014 VALP-0001.0015 VALP-0001.0016 VALP-0001.0018	
EXE-05.07.04 VALP-142.00**38**	North configuration (Eastern & western nucleus). Single runway Maximum capacity	OBJ-05.07.04-VALP-0000.**0001** OBJ-05.07.04-VALP-0000.**0003** OBJ-05.07.04-VALP-0000.**0005** OBJ-05.07.04-VALP-0000.**0007** OBJ-05.07.04-VALP-0000.**0008** OBJ-05.07.04-VALP-0000.**0009** OBJ-05.07.04-VALP-0000.**0011**	Mixed Mode Operations **MOPS change** Workload CCDs Aircraft performances Delay times **Single runway as contingency procedure**	CRT-05.07.04- VALP-0001.0001 VALP-0001.0002 VALP-0001.0003 VALP-0001.0004 VALP-0001.0003 VALP-0001.0004 VALP-0001.0005 VALP-0001.0006 VALP-0001.0008 VALP-0001.0009 VALP-0001.0010 VALP-0001.0012 VALP-0001.0014 VALP-0001.0015 VALP-0001.0016 VALP-0001.0018	See Norvase Results

Table 7: Summary of Validation Exercises Results

4.1.1 Results on concept clarification

It didn’t require any concept clarification.

4.1.2 Results per KPA

Here is listed the results per KPA

4.1.2.1Capacity, Complexity and Workload

4.1.2.1.1Sectors ENN, ESN, WNN & WSN (P-RNAV North Configuration)

With a vertical limit of FL 205, these sectors are in charge of the traffic coming into and going out of TMA boundaries.

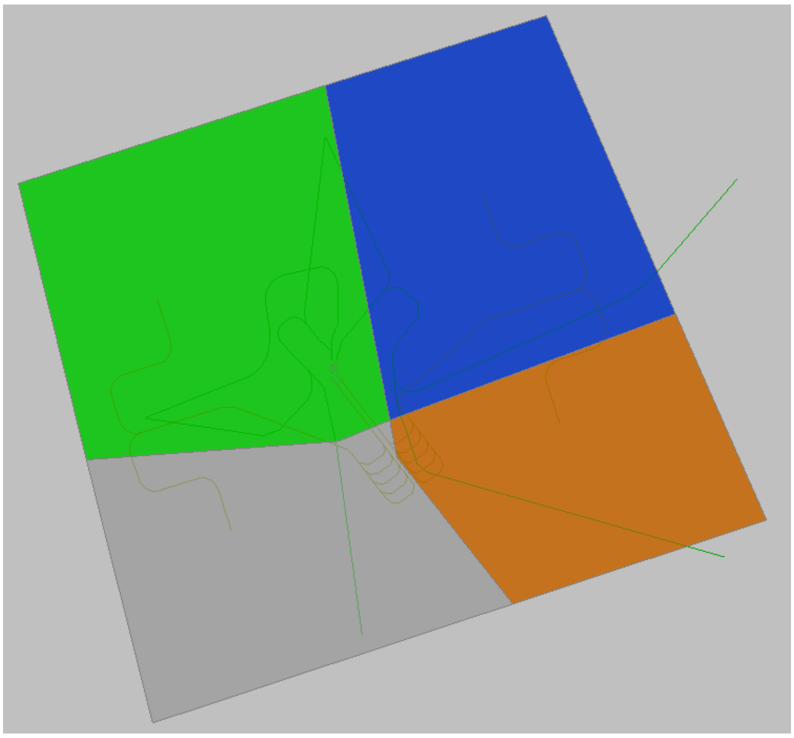


Figure 13: External Sectors for North Configuration

They are also in charge of over-flying traffic below 205 FL. The indicated airspeed in this airspace is 250kts at the clearance limits. The horizontal separation is adjusted to 5-7 NM (3NM of radar separation minima). The controllers in charge of these feeder sectors transfer the traffic to the director sectors.

4.1.2.1.2Sectors REN &RWN (P-RNAV)

With a vertical limit of FL145, these sectors are in charge of the traffic proceeding from external sectors and in charge of Torrejón and Getafe.

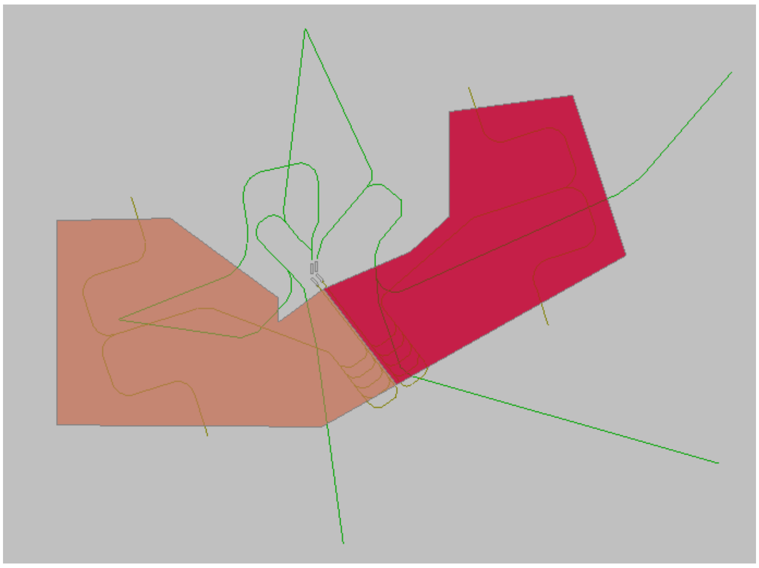


Figure 14: Director Sectors for North Configuration

The indicated airspeed in this airspace area is 230kts at BENJI or MONTE. The horizontal separation is adjusted to 5 NM (3NM of radar separation minima). The controllers in charge of these director sectors transfer the traffic to the final approach sectors after sequencing it and before reaching the respective IAF.

4.1.2.1.2.1Sector REN results (P-RNAV)

This sector manages the external East trombone of the approach to RWY 33 R
It also manages approaches to RWY 23 of Torrejón Air Base
The sector is included in the GROUP 1 (Arrival Sectors).
The sector will be managed from Madrid ACC.
Vertical limits are from GND to 14500 ft.
Evolution time in the sector is 100%

DEPENDENCY	LECM	YEAR OF STUDY:	2011
SECTOR	LEMDREN		

					Med.	Máx.
Complexity	1612	Workload	2156	Simultaneous aircrafts	3,8	8,0
Time in evolution (%)	100			Communications / 10 min.	28,5	39,2
Mean flight time (min)	6					

	1ª	2ª	3ª	4ª	5ª	6ª	7ª	8ª	9ª	10ª	11ª	12ª	13ª	14ª	15ª	Media
Incidents actions	0	0	0	0	0	0	0	0	0	0	0	0	0			0,0
Departures/Arrivals actions	231	140	148	148	132	211	201	122	67	167	98	190	191			157,4
Over-flights actions	0	0	0	0	0	0	0	0	0	0	0	0	0			0,0
Incidents surveillance	0	0	0	0	0	0	0	0	0	0	0	0	0			0,0
Departures/Arrivals surveillance	341	198	169	204	196	355	283	147	93	296	185	266	263			230,5
Over-flights surveillance	0	0	0	0	0	0	0	0	0	0	0	0	0			0,0
Arrivals/Departures Sep/Seq act	134	49	42	55	61	66	127	11	27	74	33	105	49			64,1
Over-flights Sep/Seq actions	0	0	0	0	0	0	0	0	0	0	0	0	0			0,0
Holdings	0	0	0	2	0	2	0	0	1	0	0	0	0			0,4
Number of visual flights	0	0	0	0	1	1	1	0	0	0	0	1	1			0,4
Shared Traffic	0	0	0	0	1	1	1	0	0	0	0	1	1			0,4
Coordination	4	4	13	3	9	3	6	27	4	13	13	9	4			8,6
System Coordination	0	0	0	0	0	0	0	0	0	0	0	0	0			0,0
Incident radar vectoring	0	0	0	0	0	0	0	0	0	0	0	0	0			0,0
Departure/Arrivals radar vectori	1	0	0	1	1	0	0	1	0	9	0	3	1			1,3
Over-flights radar vectoring	0	0	0	0	0	0	0	0	0	0	0	0	0			0,0
Standar radar vectoring (X)	0	0	0	0	0	0	0	0	0	0	0	0	1			0,1
Movements per test run (IFR)	44	30	31	39	35	40	38	31	18	40	29	41	42			35

Run date	OC17	OC19	OC19	OC20	OC20	OC21	OC24	OC24	OC25	OC26	OC26	OC27	OC28
Day	L	X	X	J	J	V	L	L	M	X	X	J	V
Hour	12:38	9:20	11:20	11:46	13:05	9:30	9:20	10:50	10:55	11:00	13:00	9:55	9:15

Departures	0,08	Arrivals	35,15	Number of movements - Run	35
Actions per departure	0,46	Actions per arrival	4,40	Actions per movement	4,40
Coordinations per departure	0,08	Coordinations per arrival	0,26	Coordinations per movement	0,26
Radar Vectoring per departure	0,15	Radar Vectoring per arrival	0,03	Radar Vectoring per movement	0,03
Complexity per departure	7,54	Complexity per arrival	43,84	Complexity per movement	43,92

Figure 15: REN spreadsheet runs

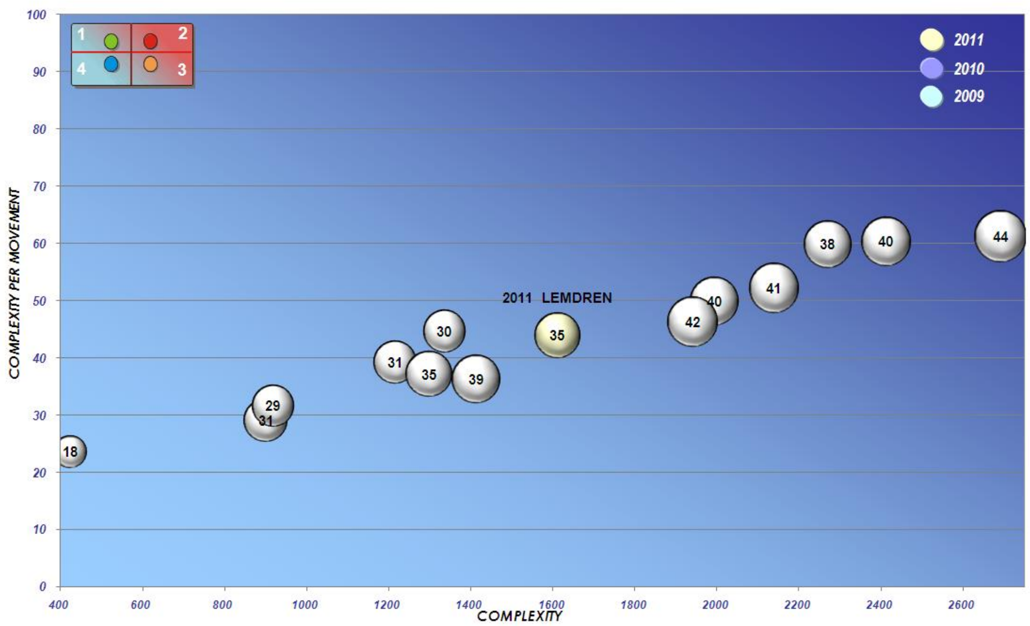


Figure 16: REN Status

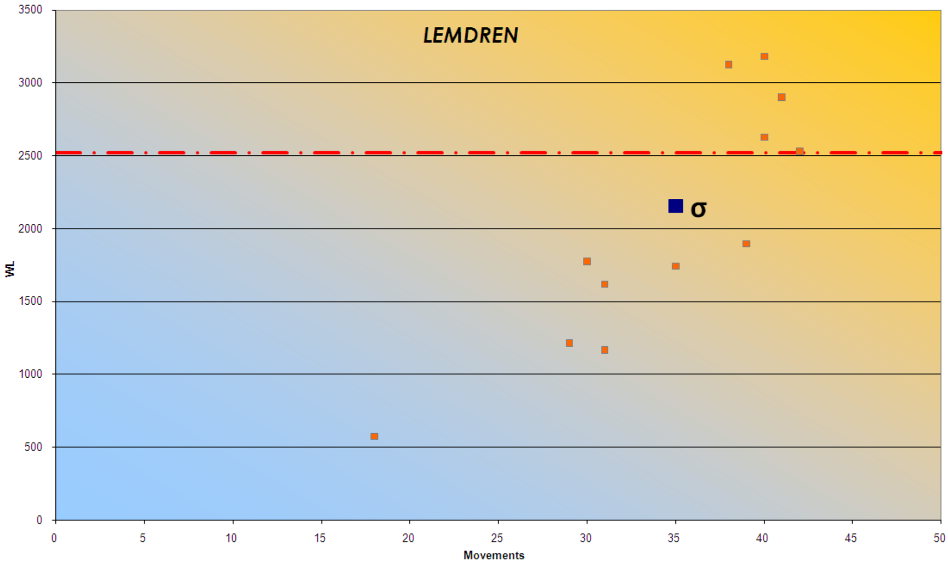


Figure 17: REN Workload

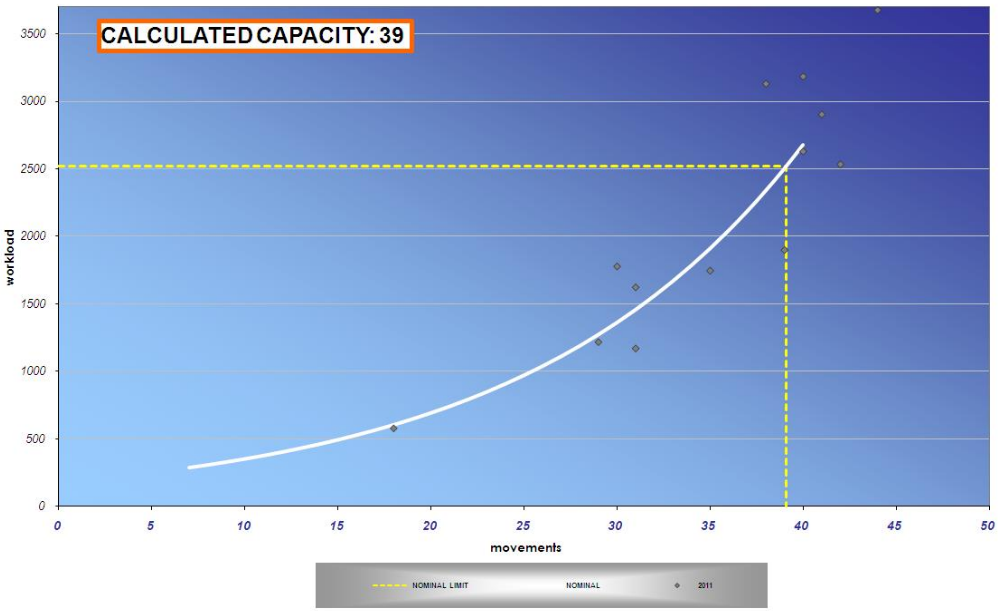


Figure 18: REN calculated capacity

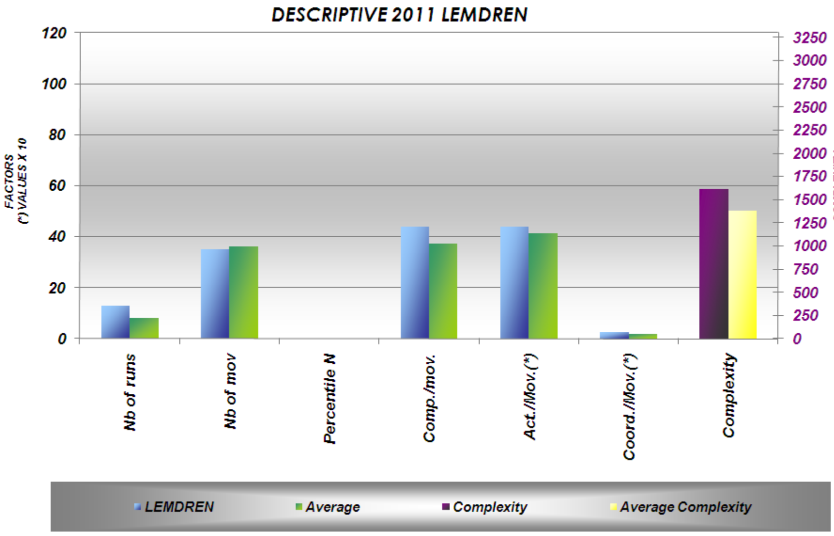


Figure 19: REN descriptive 2011

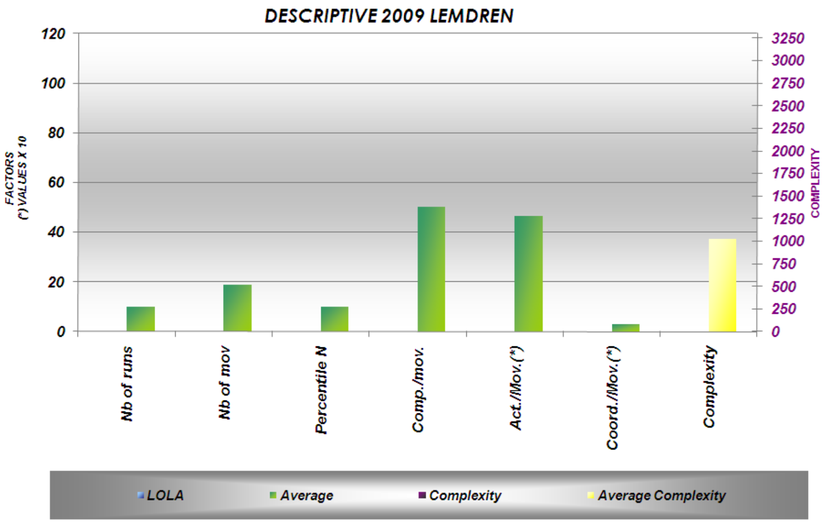


Figure 20: REN descriptive 2009

The State Diagram shows a sector whose general complexity increases in direct proportion to the traffic growth. This probably is due to the amount of time that the traffic remains under the responsibility of the sector.

The increment is much less in individual complexity per movement which depicts a sector able to handle amounts of traffic around the calculated capacity (49 Movs/hour).

For higher traffic loads some procedural changes will be needed, above all in the relationship with external feeders, to reduce the number of coordinations.

The number of ATC interventions is high, since these sectors are responsible of sequencing the traffic for the approach; nevertheless, the radar vectoring is very low. This fact reduces also significantly the complexity per movement.

4.1.2.1.2.2Sector RWN results (P-RNAV)

This sector manages the external West trombone of the approach to RWY 33L

It also manages approaches to Getafe Air Base
The sector is included in the GROUP 1 (Arrival Sectors).
The sector will be managed from Madrid ACC.
Vertical limits are from GND to 14500 ft.
Evolution time in the sector is 100%

Aena

DEPENDENCY	LECM		YEAR OF STUDY:	2011	
SECTOR	LEMDRWN				
				Med.	Máx.
Complexity	1405	Workload 1868	Simultaneous aircrafts	4,3	12,0
Time in evolution (%)	100		Communications / 10 min.	28,0	36,4
Mean flight time (min)	7				

	1ª	2ª	3ª	4ª	5ª	6ª	7ª	8ª	9ª	10ª	11ª	12ª	13ª	14ª	15ª	Media
Incidents actions	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Departures/Arrivals actions	135	153	166	119	165	208	179	78	187	115	162	236				158,6
Over-flights actions	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Incidents surveillance	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Departures/Arrivals surveillance	273	266	334	174	223	358	329	117	232	164	252	361				256,9
Over-flights surveillance	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Arrivals/Departures Sep/Seq act	35	58	79	27	55	98	94	30	75	49	81	137				68,2
Over-flights Sep/Seq actions	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Holdings	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Number of visual flights	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Shared Traffic	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Coordination	0	8	1	1	2	2	0	15	2	12	0	2				3,8
System Coordination	0	1	0	0	0	0	0	0	0	0	0	0				0,1
Incident radar vectoring	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Departure/Arrivals radar vectori	0	0	0	0	0	12	0	0	0	1	0	2				1,3
Over-flights radar vectoring	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Standar radar vectoring (X)	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Movements per test run (IFR)	35	41	40	31	42	49	41	20	39	33	40	45				38

Run date	OC18	OC18	OC18	OC19	OC19	OC20	OC21	OC25	OC26	OC26	OC27	OC28
Day	M	M	M	X	X	J	V	M	X	X	J	V
Hour	9:24	11:16	12:38	9:20	11:20	10:10	9:32	11:00	11:00	12:55	9:50	10:30

Departures	0,08	Arrivals	37,92	Number of movements - Run	38
Actions per departure	0,17	Actions per arrival	4,14	Actions per movement	4,13
Coordinations per departure	0,08	Coordinations per arrival	0,13	Coordinations per movement	0,13
Radar Vectoring per departure	0,00	Radar Vectoring per arrival	0,03	Radar Vectoring per movement	0,03
Complexity per departure	1,83	Complexity per arrival	35,53	Complexity per movement	35,50

Figure 21: RWN spreadsheet runs

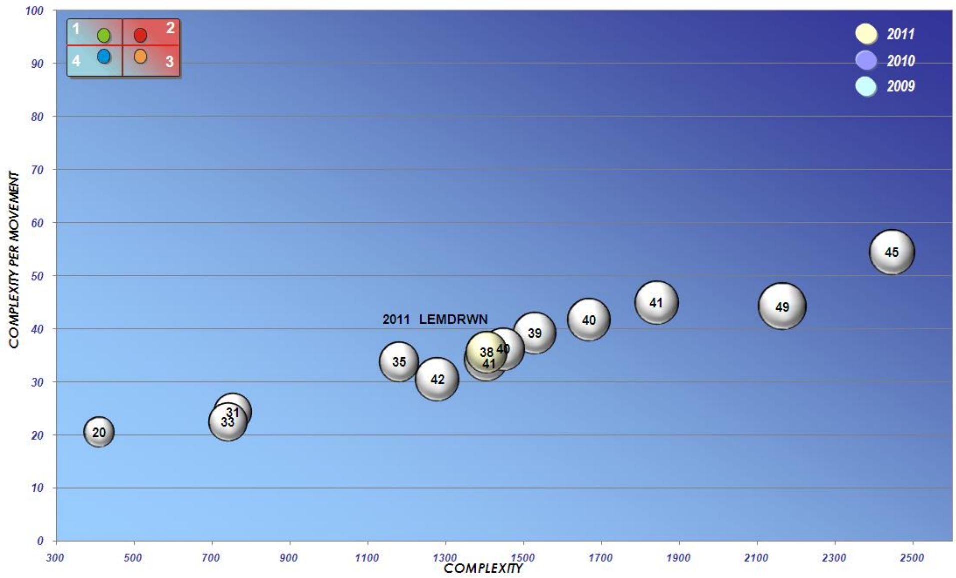


Figure 22: RWN Status

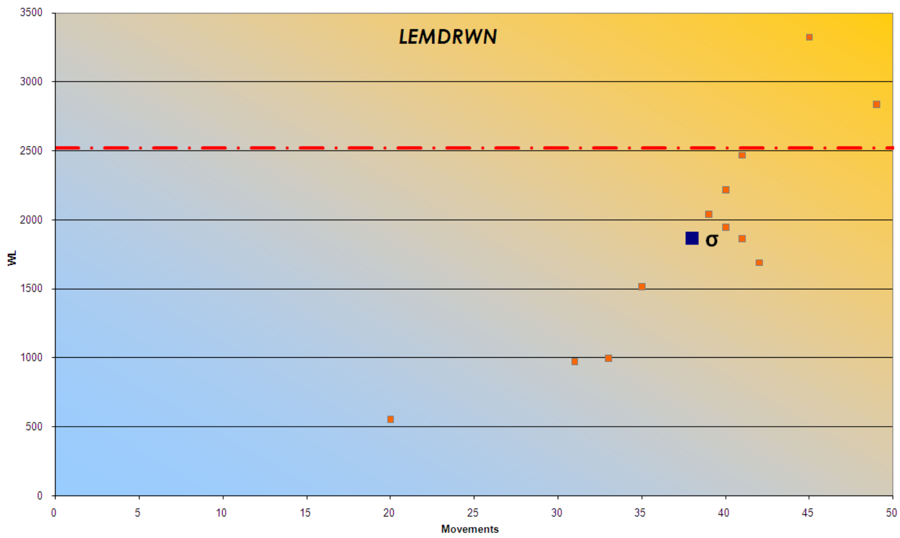


Figure 23: RWN Workload

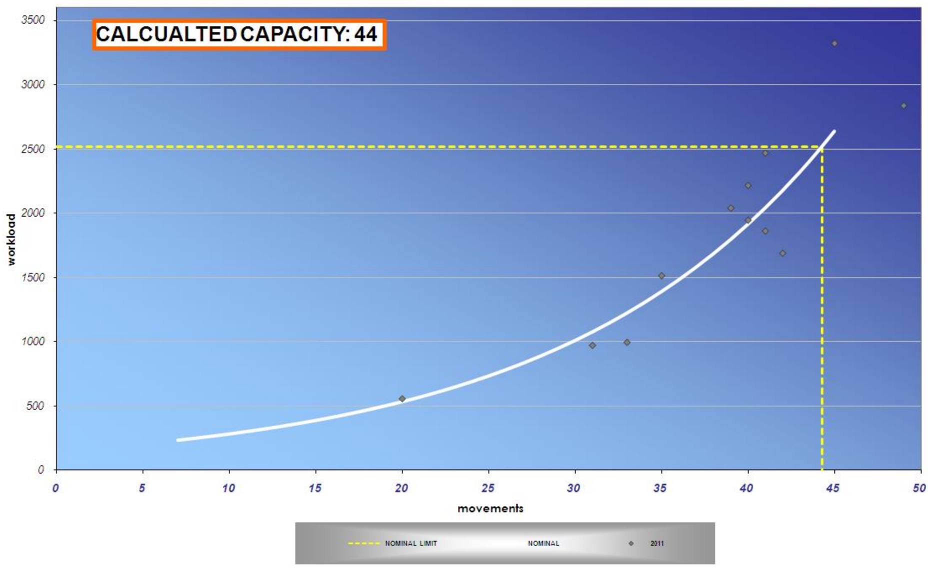


Figure 24: RWN calculated capacity

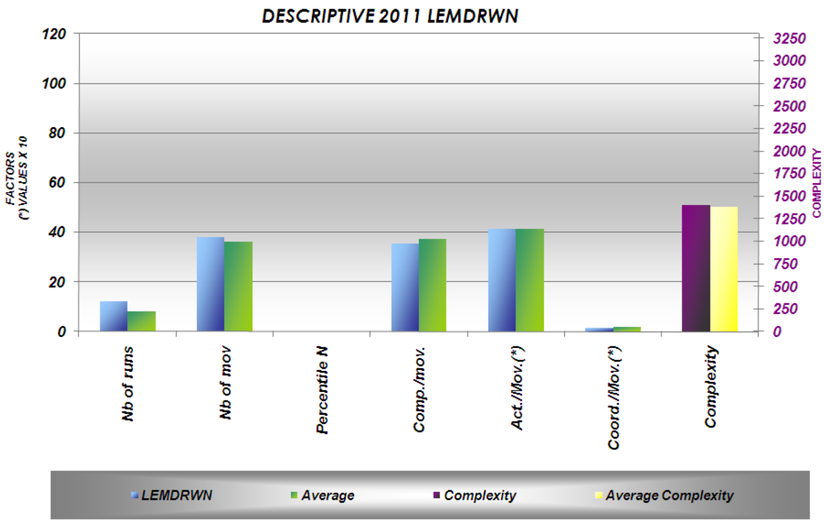


Figure 25: RWN descriptive 2011

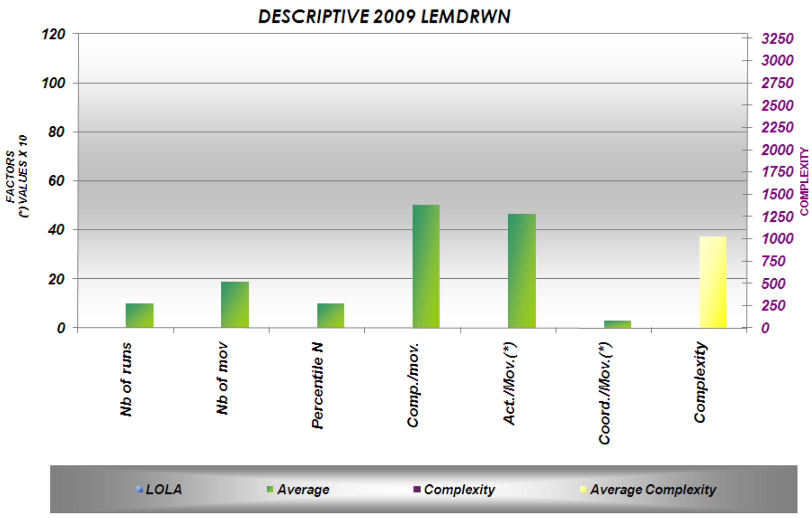


Figure 26: RWN descriptive 2009

As their homonym for east RWY's, the complexity per movement remains low as the traffic increases. This shows a situation in which the controllers work load is a direct consequence of the amount of time dedicated to radar surveillance, whilst the number of interventions to handle individual traffic remains very similar.

The sector improves the actual situation in Madrid, with a calculated capacity of 44 Movs/hour versus 36Movs/hour which is the actual situation.

The situation in the state diagram also shows the necessity of improving coordination procedures with feeder to be able to handle a higher amount of traffic.

4.1.2.1.3Sectors AFEN &AFWN (P-RNAV)

The vertical limit is FL105. These sectors are in charge of the final sequencing of the traffic proceeding from director sectors.

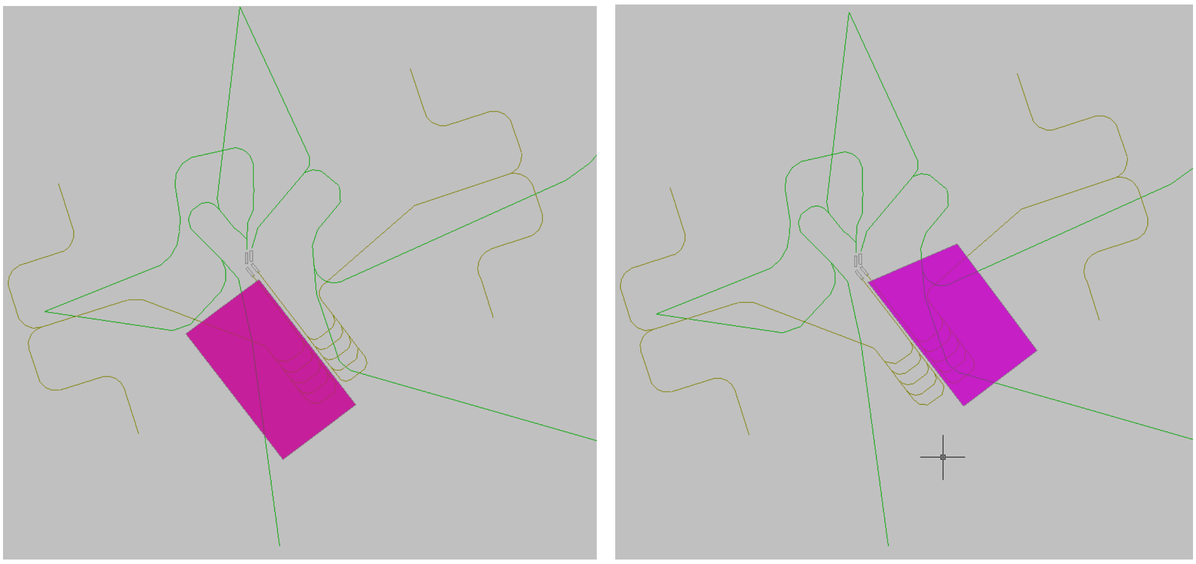


Figure 27: AFEN and AFWN for North Configuration

The indicated airspeed in this area is between 180kts and 210kts. The horizontal separation is adjusted to 3 NM or higher depending on the wake turbulence. The controllers in charge decide the transition that the aircraft has to follow to intercept the ILS localizer. When established in the localizer, they transfer the traffic to the tower (TWR).

4.1.2.1.3.1Sector AFEN results (P-RNAV)

This is the sector in charge of the grid and final approach to RWY 33R in Barajas.
The sector is included in the GROUP 1 (Final Approach Sectors).
The sector will be managed from Madrid ACC.
Vertical limits are from GND to 10500 ft.
Evolution time in sector LEMDAFEN is 100%

DEPENDENCY	LECM		YEAR OF STUDY:	2011	
SECTOR	LEMDAFEN				
				Med.	Máx.
Complexity	1207	Workload 806	Simultaneous aircrafts	5,5	11,0
Time in evolution (%)	100		Communications / 10 min.	20,9	34,0
Mean flight time (min)	10				

	1º	2º	3º	4º	5º	6º	7º	8º	9º	10º	11º	12º	13º	14º	15º	Media
Incidents actions	0	0	0	0	0	0	0	0	0							0,0
Departures/Arrivals actions	132	127	78	131	120	117	106	153	112							119,6
Over-flights actions	0	0	0	0	0	0	0	0	0							0,0
Incidents surveillance	0	0	0	0	0	0	0	0	0							0,0
Departures/Arrivals surveillance	349	259	292	437	380	304	348	250	336							328,3
Over-flights surveillance	0	0	0	0	0	0	0	0	0							0,0
Arrivals/Departures Sep/Seq act	37	46	14	44	33	13	30	59	30							34,0
Over-flights Sep/Seq actions	0	0	0	0	0	0	0	0	0							0,0
Holdings	0	0	2	0	2	0	0	0	0							0,4
Number of visual flights	0	0	0	0	0	0	0	0	0							0,0
Shared Traffic	0	0	0	0	0	0	0	0	0							0,0
Coordination	0	4	11	5	2	2	2	3	4							3,7
System Coordination	0	0	0	0	0	0	0	0	0							0,0
Incident radar vectoring	0	0	0	0	0	0	0	0	0							0,0
Departure/Arrivals radar vectori	6	6	3	1	7	4	4	7	3							4,6
Over-flights radar vectoring	0	0	0	0	0	0	0	0	0							0,0
Standar radar vectoring (X)	0	0	0	0	0	0	0	0	0							0,0
Movements per test run (IFR)	40	27	30	40	38	37	34	27	37							34

Run date	OC17	OC19	OC19	OC20	OC21	OC24	OC26	OC26	OC27
Day	L	X	X	J	V	L	X	X	J
Hour	12:38	9:20	11:20	11:46	9:30	9:20	11:00	12:55	9:55

Departures	0,00	Arrivals	34,44	Number of movements - Run	34
Actions per departure	0,00	Actions per arrival	3,56	Actions per movement	3,56
Coordinations per departure	0,00	Coordinations per arrival	0,11	Coordinations per movement	0,11
Radar Vectoring per departure	0,00	Radar Vectoring per arrival	0,14	Radar Vectoring per movement	0,14
Complexity per departure	0,00	Complexity per arrival	35,56	Complexity per movement	35,56

Figure 28: AFEN spreadsheet runs

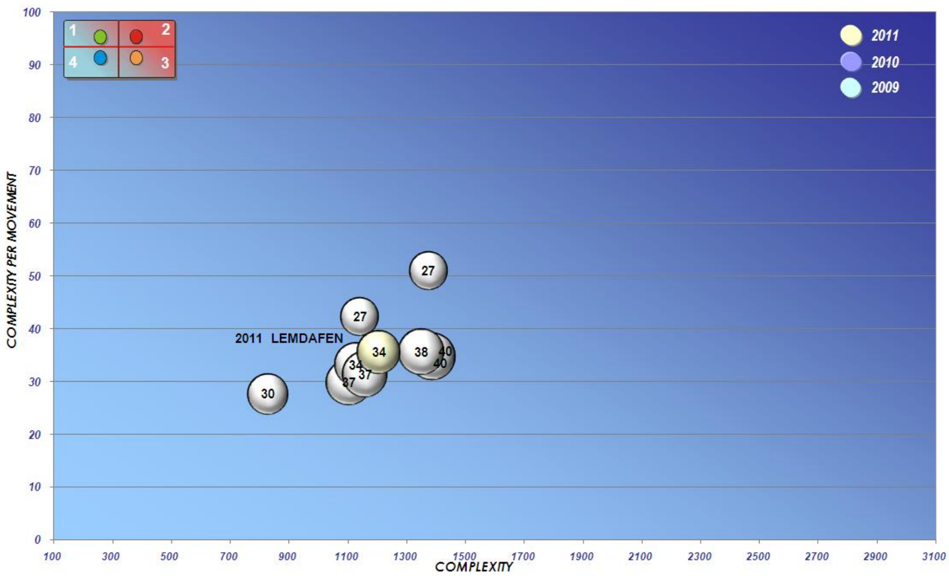


Figure 29: AFEN Status

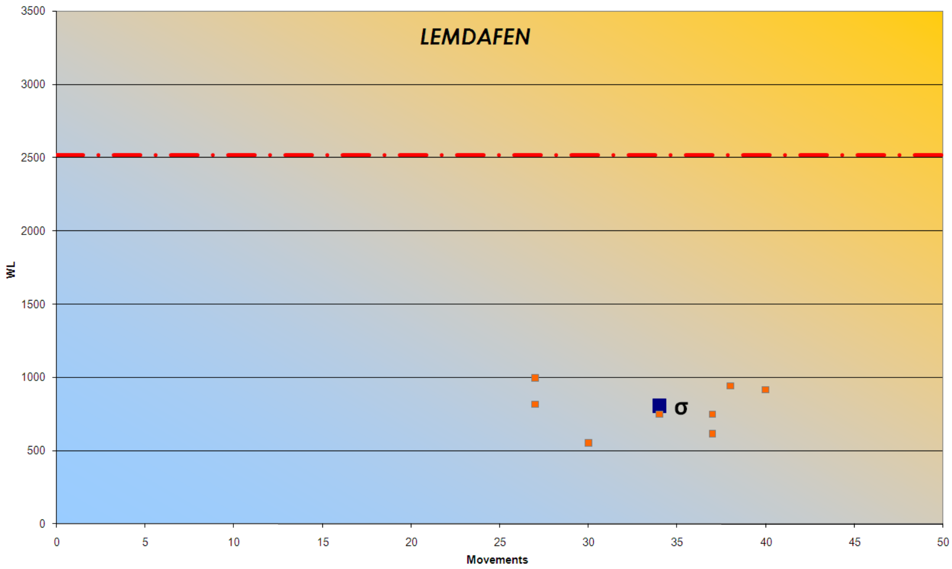


Figure 30: AFEN Workload

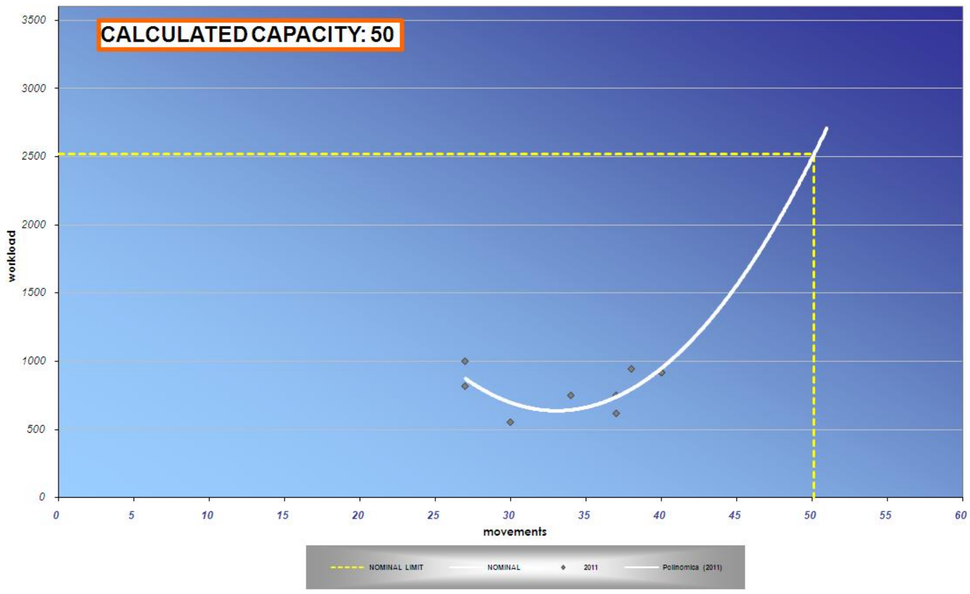


Figure 31: AFEN calculated capacity

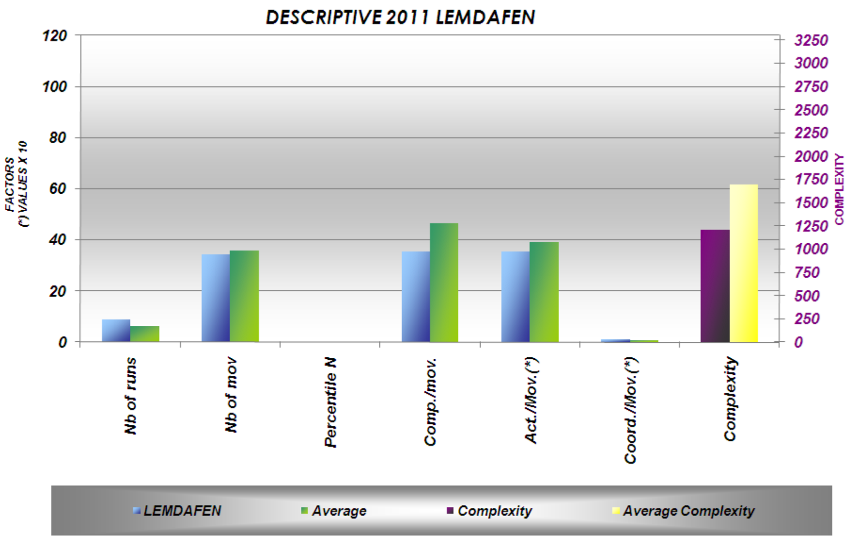


Figure 32: AFEN descriptive 2011

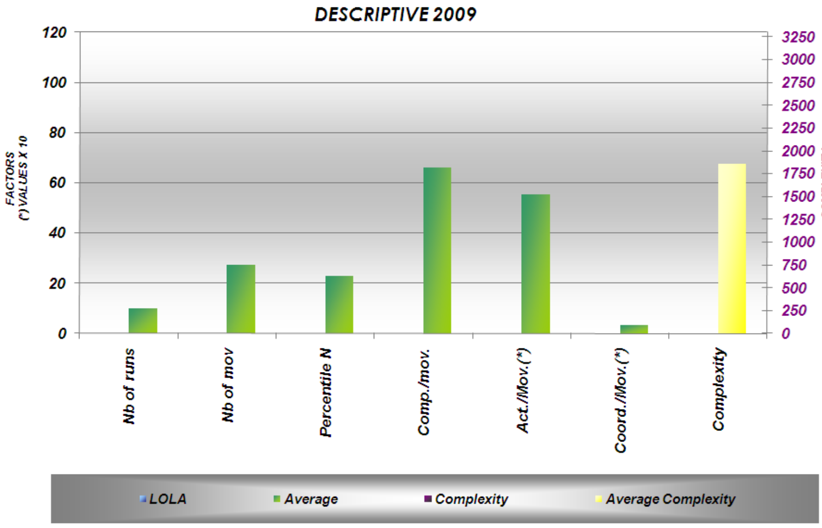


Figure 33: AFEN descriptive 2009

The sector complexity shows a low value (1207) compared with the mean of sectors of this group (1700) calculated upon the data pick-up carried out along 2011.

Also sector Work-load is very low (806) compared with the actual approach sector in LEMD (1847).

The resulting overall picture shows a very well balanced sector, with operational procedures adapted to the traffic performance and to the route structure.

The calculated capacity value (50) reflects the reduced need of intervention of ATCO as a consequence of the very few radar vectoring registered.

It is also noted in the data pick up the progress experimented in controller's skills as the simulation advanced, this is reflected in the reduction of interventions, well in accordance with the amount of traffic simulated, except in the 2nd register corresponding to the 19th of October in which the increment in coordinations is a consequence of the injection of a higher number of non-P-RNAV equipped aircrafts.

4.1.2.1.3.2Sector AFWN results (P-RNAV)

This sector manages the grid and final approach to RWY 33L
The sector is included in the GROUP 1 (Final Approach Sectors).
The sector will be managed from Madrid ACC.
Vertical limits are from GND to 10500 ft.
Evolution time in the sector is 100%

DEPENDENCY	LECM	YEAR OF STUDY:	2011
SECTOR	LEMDAFWN		

					Med.	Máx.
Complexity	1476	Workload	979	Simultaneous aircrafts	5,8	11,0
Time in evolution (%)	100			Communications / 10 min.	19,0	29,2
Mean flight time (min)	10					

	1ª	2ª	3ª	4ª	5ª	6ª	7ª	8ª	9ª	10ª	11ª	12ª	13ª	14ª	15ª	Media
Incidents actions	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Departures/Arrivals actions	101	144	134	66	108	154	147	111	114	127	60	59				110,4
Over-flights actions	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Incidents surveillance	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Departures/Arrivals surveillance	438	430	398	289	336	420	451	280	351	365	260	164				348,5
Over-flights surveillance	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Arrivals/Departures Sep/Seq act	18	63	43	9	24	60	58	26	44	53	0	13				34,3
Over-flights Sep/Seq actions	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Holdings	0	0	1	0	0	0	0	0	0	0	0	0				0,1
Number of visual flights	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Shared Traffic	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Coordination	2	3	0	0	1	2	5	0	3	1	0	0				1,4
System Coordination	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Incident radar vectoring	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Departure/Arrivals radar vectori	0	3	4	2	3	0	1	0	3	0	1	0				1,4
Over-flights radar vectoring	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Standar radar vectoring (X)	0	0	0	0	0	0	0	0	0	0	0	0				0,0
Movements per test run (IFR)	38	41	38	28	40	42	37	36	36	38	29	22				35

Run date	OC18	OC18	OC18	OC19	OC19	OC20	OC24	OC25	OC26	OC26	OC26	OC28
Day	M	M	M	X	X	J	L	M	X	X	X	V
Hour	9:21	11:15	12:33	9:20	11:20	10:10	9:20	9:11	9:15	11:00	12:55	10:30

Departures	0,25	Arrivals	35,17	Number of movements - Run	35
Actions per departure	0,19	Actions per arrival	3,07	Actions per movement	3,06
Coordinations per departure	0,00	Coordinations per arrival	0,04	Coordinations per movement	0,04
Radar Vectoring per departure	0,00	Radar Vectoring per arrival	0,04	Radar Vectoring per movement	0,04
Complexity per departure	1,89	Complexity per arrival	40,03	Complexity per movement	40,05

Figure 34: AFWN spreadsheet runs

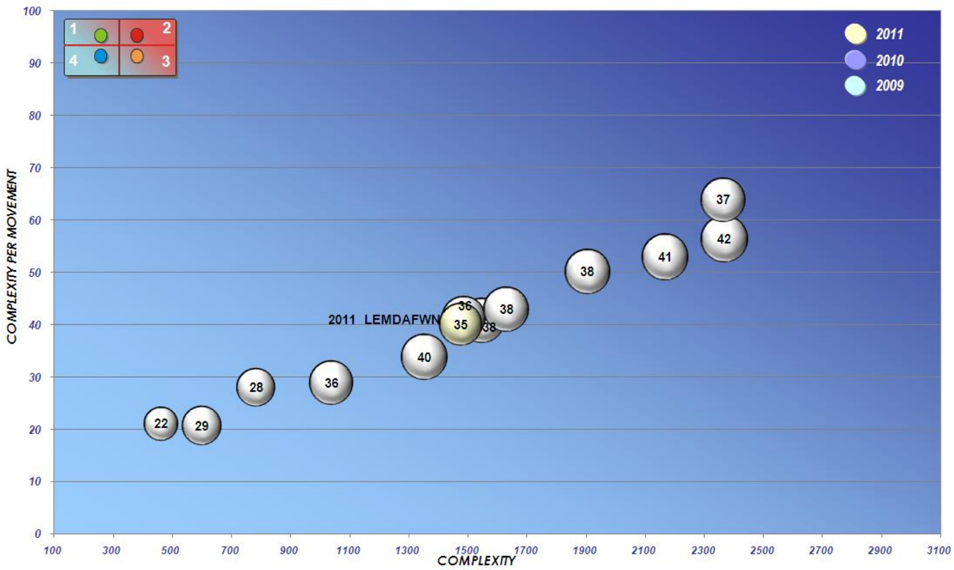


Figure 35: AFWN Status

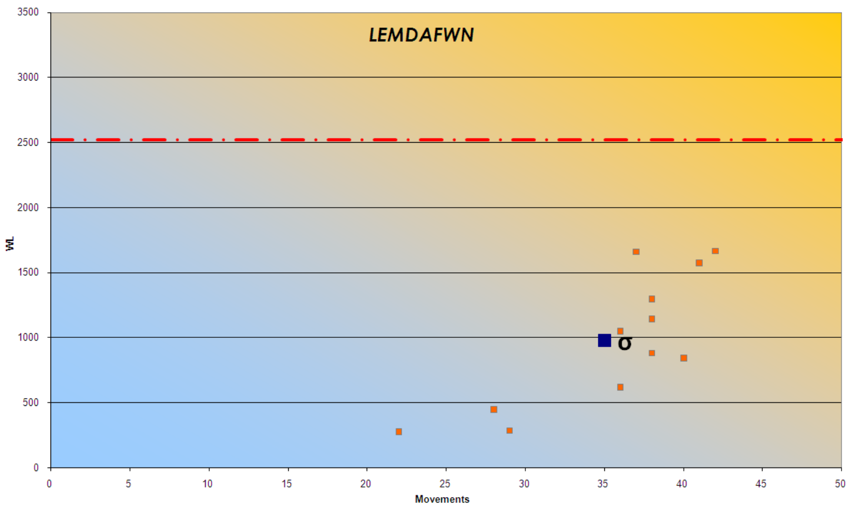


Figure 36: AFWN Workload

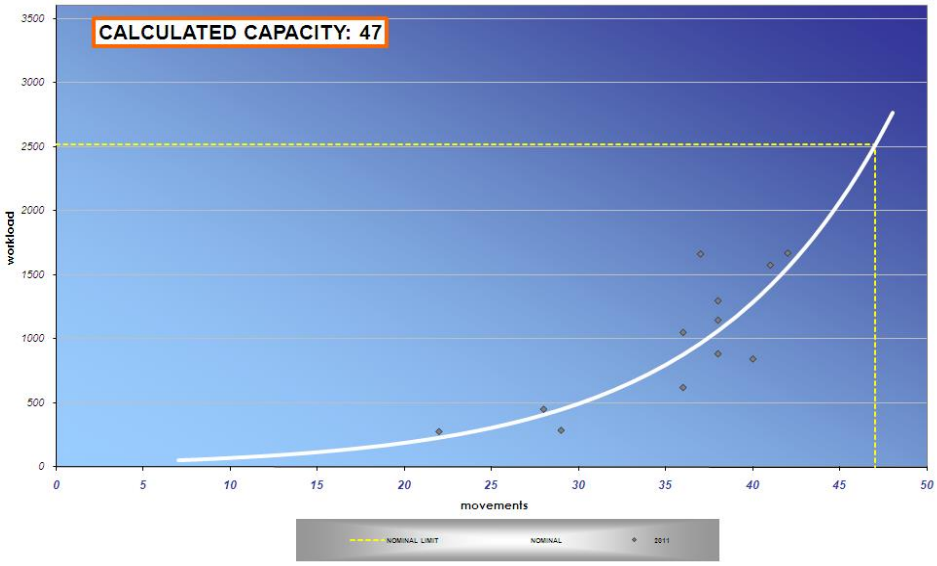


Figure 37: AFWN calculated capacity

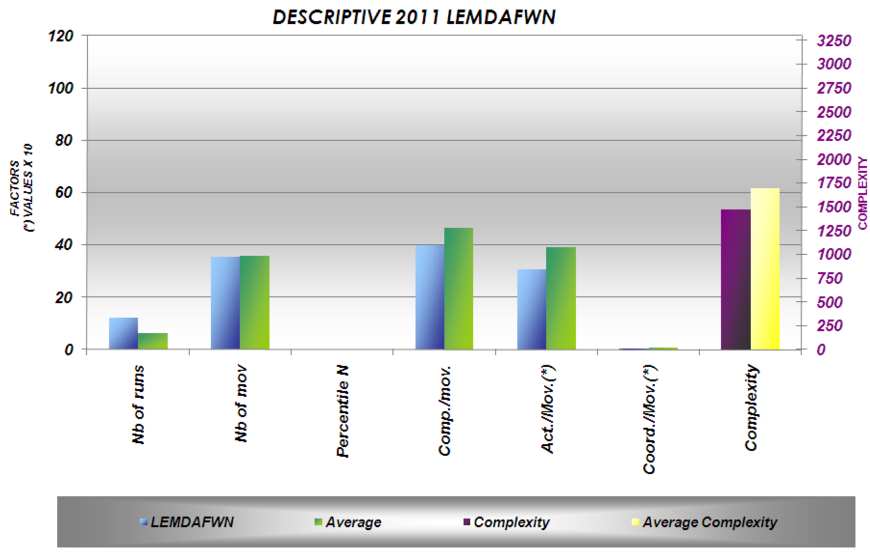


Figure 38: AFWN descriptive 2011

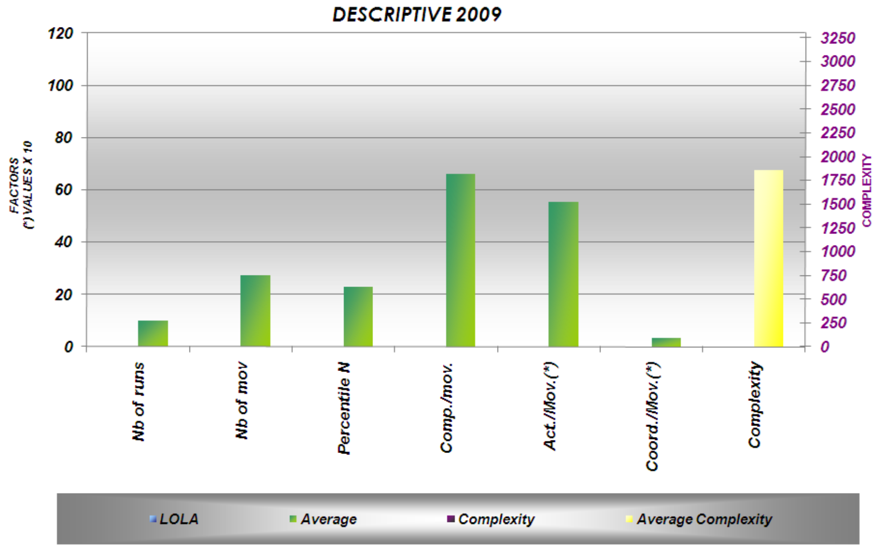


Figure 39: AFWN descriptive 2009

The sector performance is satisfactory. Three of the four samples placed in the second quadrant of the state diagram where picked up the 18th which was the first day of formal operation of the sector. Later on we find samples with similar traffic load and with less complexity per movement.

The traffic sample of 32 movements was affected by a greater number of non P-RNAV equipped traffic, to test procedures. Is due to this that the number of coordinations (5) and controller's interventions (58) is high and thus the complexity.

In the comparative graphic we can appreciate that the sector complexity is below the mean of Group 1 sectors studied with NORVASE during 2011.

4.1.2.1.4Sector DIN

This sector manages the initial departure paths from RWY 36 R and L
The sector is included in the GROUP 3 (Departure Sectors).
The sector will be managed from Madrid ACC.
Vertical limits are from GND to 7500 ft.
Evolution time in the sector is 100%

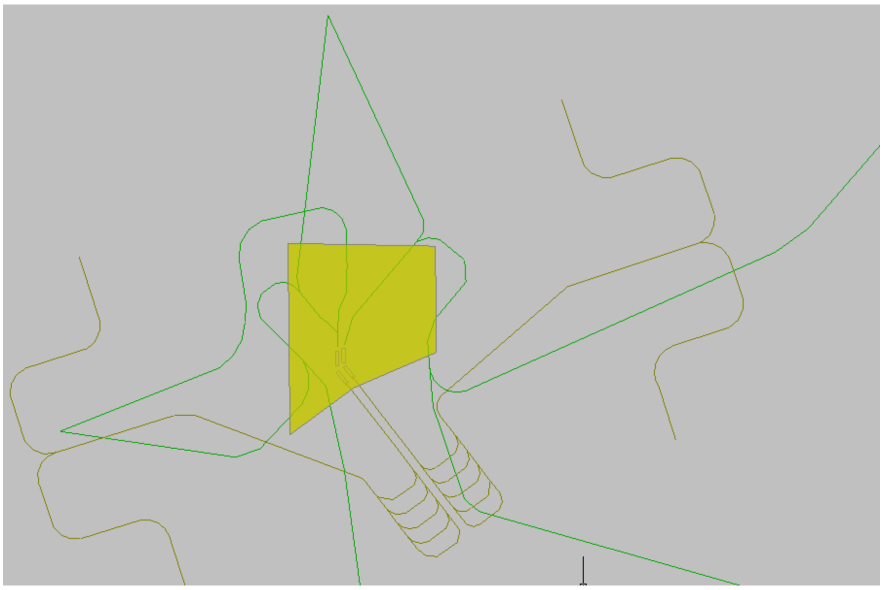


Figure 40: DIN Sector

4.1.2.1.4.1Sector DIN results (P-RNAV)

Aena

DEPENDENCY	LECM		YEAR OF STUDY:	2011
SECTOR	LEMDDIN			

				Med.	Máx.
Complexity	462	Workload 592	Simultaneous aircrafts	1,9	6,0
Time in evolution (%)	100		Communications / 10 min.	8,9	16,0
Mean flight time (min)	3				

	1ª	2ª	3ª	4ª	5ª	6ª	7ª	8ª	9ª	10ª	11ª	12ª	13ª	14ª	15ª	σ
Incidents actions	0	0	0	0												0,0
Departures/Arrivals actions	61	39	36	67												50,8
Over-flights actions	0	0	0	0												0,0
Incidents surveillance	0	0	0	0												0,0
Departures/Arrivals surveillance	97	105	99	156												114,3
Over-flights surveillance	0	0	0	0												0,0
Arrivals/Departures Sep/Seq act	1	0	0	0												0,3
Over-flights Sep/Seq actions	0	0	0	0												0,0
Holdings	0	0	0	0												0,0
Number of visual flights	0	0	0	0												0,0
Shared Traffic	0	0	0	0												0,0
Coordination	4	0	0	0												1,0
System Coordination	0	0	0	0												0,0
Incident radar vectoring	0	0	0	0												0,0
Departure/Arrivals radar vectori	0	0	0	0												0,0
Over-flights radar vectoring	0	0	0	0												0,0
Standar radar vectoring (X)	0	0	0	0												0,0
Movements per test run (IFR)	32	38	36	33												35

Run date	OC17	OC18	OC18	OC18
Day	L	M	M	M
Hour	12:38	9:23	11:14	12:33

Departures	34,75	Arrivals	0,00	Number of movements - Run	35
Actions per departure	1,49	Actions per arrival	0,00	Actions per movement	1,49
Coordinations per departure	0,03	Coordinations per arrival	0,00	Coordinations per movement	0,03
Radar Vectoring per departure	0,00	Radar Vectoring per arrival	0,00	Radar Vectoring per movement	0,00
Complexity per departure	13,56	Complexity per arrival	0,00	Complexity per movement	13,56

Figure 41: DIN spreadsheet runs

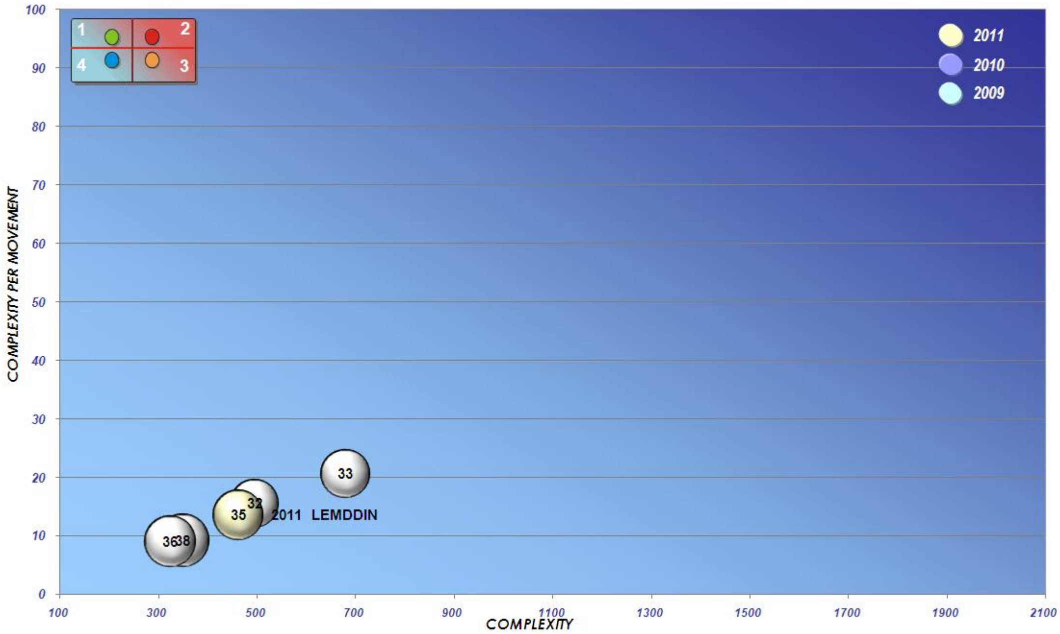


Figure 42: DIN Status

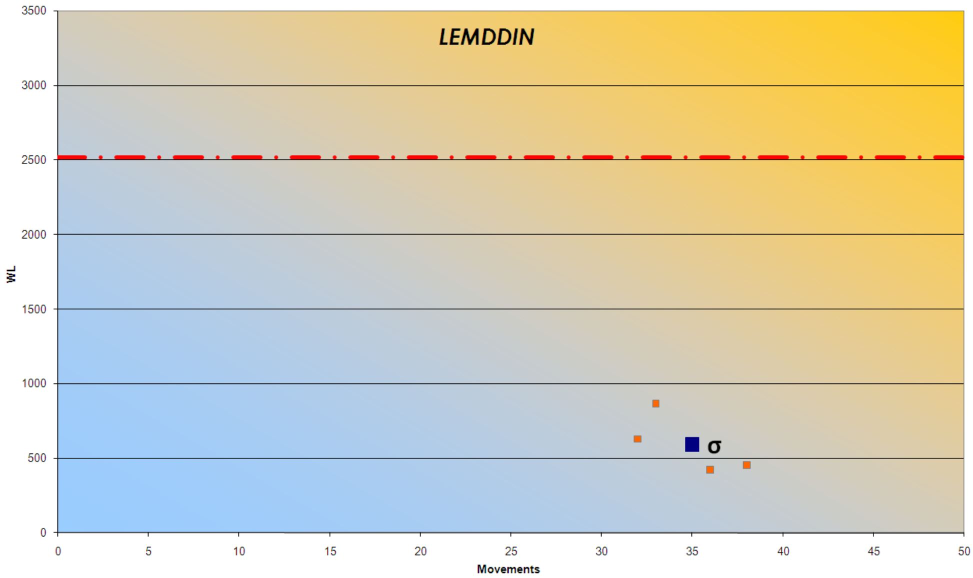


Figure 43: DIN Workload

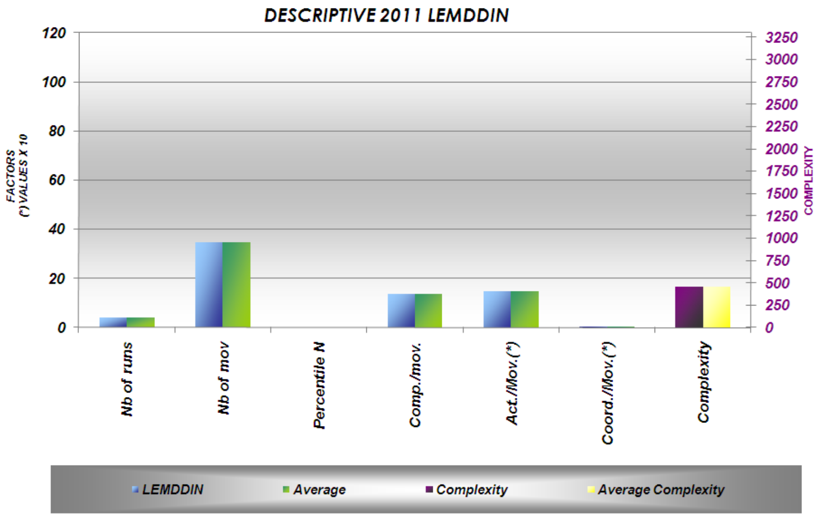


Figure 44: DIN descriptive 2011

With the observation of the sector during the four samples picked up, and the situation of this samples very low in the 4th quadrant of the state diagram, we can affirm that the sector is able to manage an amount of traffic well above the airport departure RWY's throughput.

This observation was repeated for the south configuration with exactly the same result.

Departures are completely deconflicted with arrivals, so these sectors only have to monitor possible deviations from the nominal departure trajectory with minimum intervention by ATC.

4.1.2.1.5 Sectors ENS, ESS, WNS & WSS (P-RNAV South Configuration)

With a vertical limit of FL205, these sectors are in charge of the traffic coming into and going out of TMA boundaries.

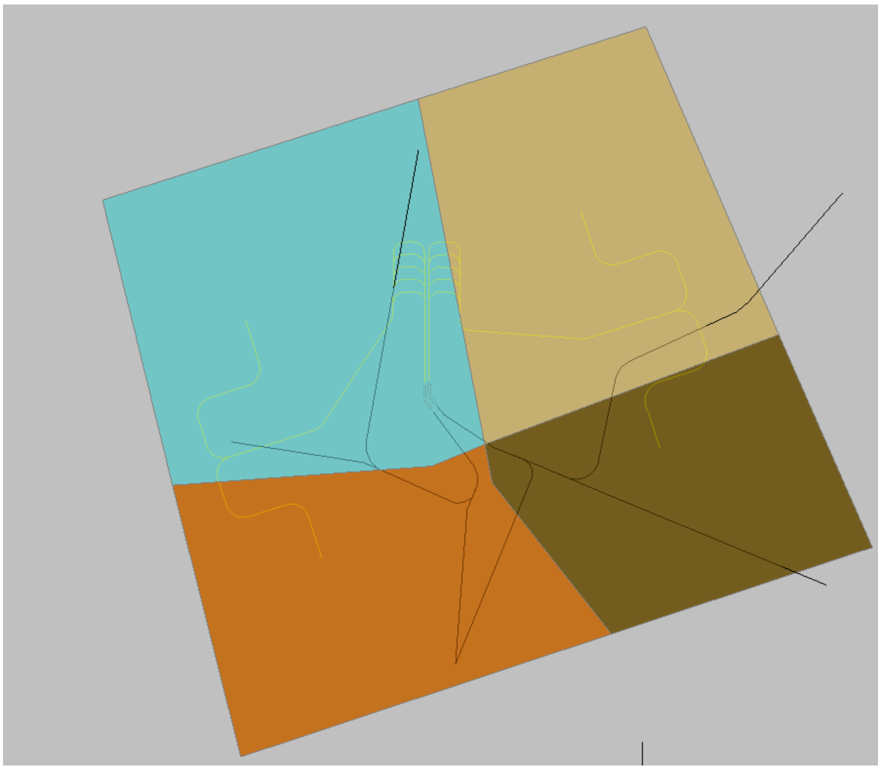


Figure 45: External Sectors for South Configuration

They are also in charge of over-flying traffic below 205 FL. The indicated airspeed in this airspace is 250 kts at the clearance limits. The horizontal separation is adjusted to 5-7 NM with 3NM of radar separation minima. The controllers in charge of these feeder sectors transfer the traffic to the director sectors.

The sample is not representative enough to calculate the sectors capacity. We have used the same North configuration capacity data.

4.1.2.1.6Sectors RES & RWS

With a vertical limit of FL145, these sectors are in charge of the merging traffic coming from external sectors and in charge of Torrejón and Getafe airbases.

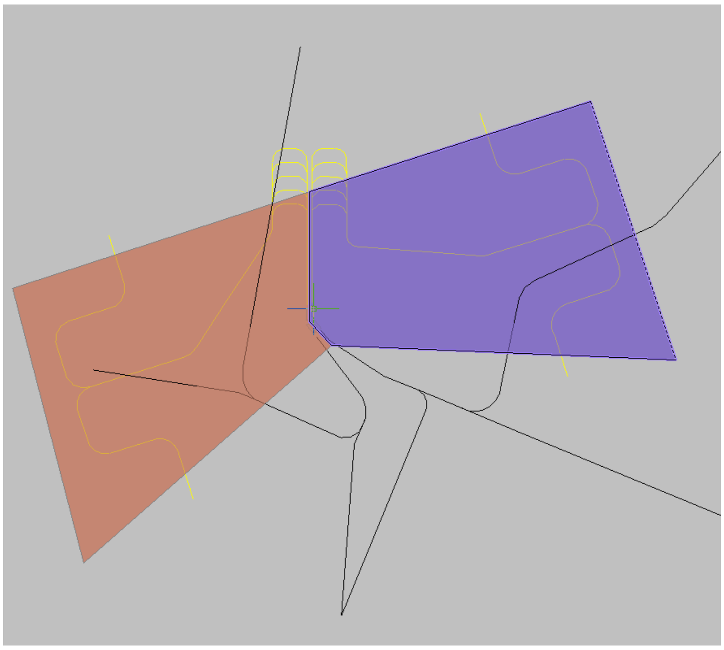


Figure 46: Director Sectors for South Configuration

The indicated airspeed in this area is about 230 kts at BENJI and MONTE. The horizontal separation is adjusted to 5 NM (3NM of radar separation minima). The controllers in charge of these director sectors transfer the traffic to the final approach sectors after sequencing it and before reaching the respective IAF.

4.1.2.1.6.1Sector RES results (P-RNAV)

This sector manages the external East trombone of the approach to RWY 18 L
It also manages approaches to RWY 23 of Torrejón Air Base
The sector is included in the GROUP 1 (Arrival Sectors).
The sector will be managed from Madrid ACC.
Vertical limits are from GND to 14500 ft.
Evolution time in the sector is 100%

Aena

DEPENDENCY	LECM		YEAR OF STUDY:	2011	
SECTOR	LEMDRES				
				Med.	Máx.
Complexity	1215	Workload 1615	Simultaneous aircrafts	3,0	7,0
Time in evolution (%)	100		Communications / 10 min.	23,4	35,5
Mean flight time (min)	5				

	1ª	2ª	3ª	4ª	5ª	6ª	7ª	8ª	9ª	10ª	11ª	12ª	13ª	14ª	15ª	Media
Incidents actions	0	0	0	0												0,0
Departures/Arrivals actions	108	150	143	125												131,5
Over-flights actions	0	0	0	0												0,0
Incidents surveillance	0	3	0	0												0,8
Departures/Arrivals surveillance	156	249	184	137												181,5
Over-flights surveillance	0	0	0	0												0,0
Arrivals/Departures Sep/Seq act	39	80	41	20												45,0
Over-flights Sep/Seq actions	0	0	0	0												0,0
Holdings	0	0	0	0												0,0
Number of visual flights	0	0	0	0												0,0
Shared Traffic	0	0	0	0												0,0
Coordination	17	6	9	9												10,3
System Coordination	0	0	1	0												0,3
Incident radar vectoring	0	0	0	0												0,0
Departure/Arrivals radar vectori	0	1	2	0												0,8
Over-flights radar vectoring	0	0	0	0												0,0
Standar radar vectoring (X)	0	0	0	0												0,0
Movements per test run (IFR)	30	34	34	33												33
Run date	OC19	OC25	OC26	OC27												
Day	X	M	X	J												
Hour	13:00	12:35	9:15	11:30												

Departures	0,00	Arrivals	32,75	Number of movements - Run	33
Actions per departure	0,00	Actions per arrival	4,00	Actions per movement	4,00
Coordinations per departure	0,00	Coordinations per arrival	0,32	Coordinations per movement	0,33
Radar Vectoring per departure	0,00	Radar Vectoring per arrival	0,02	Radar Vectoring per movement	0,02
Complexity per departure	0,00	Complexity per arrival	36,69	Complexity per movement	36,90

Figure 47: RES spreadsheet runs

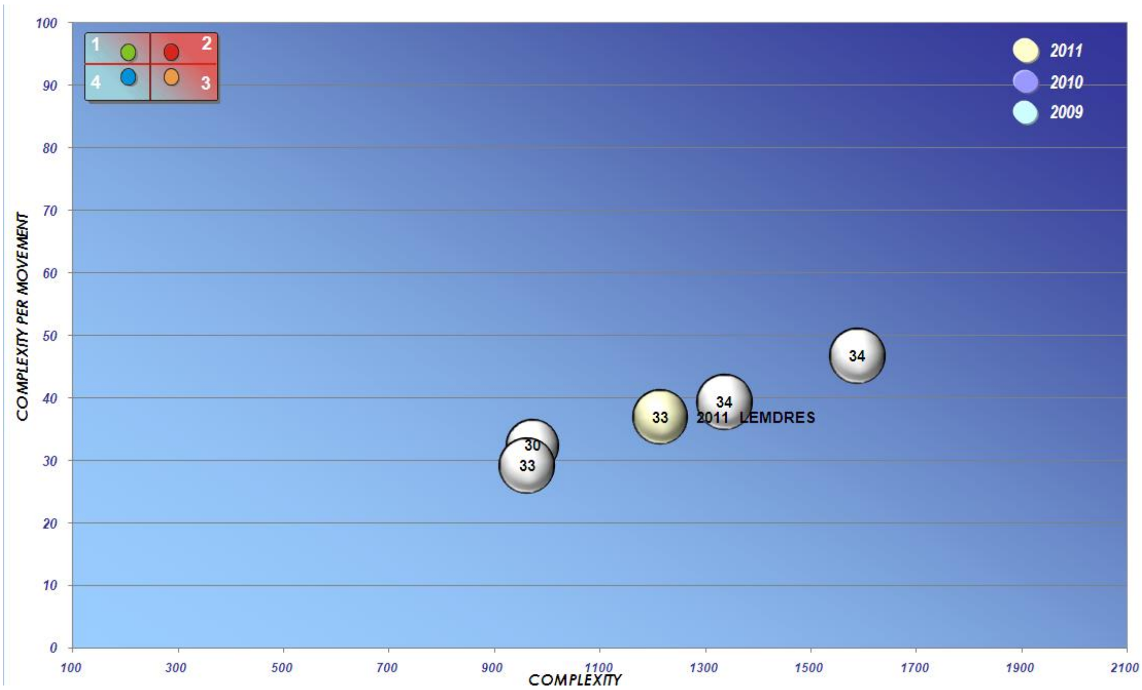


Figure 48: RES Status

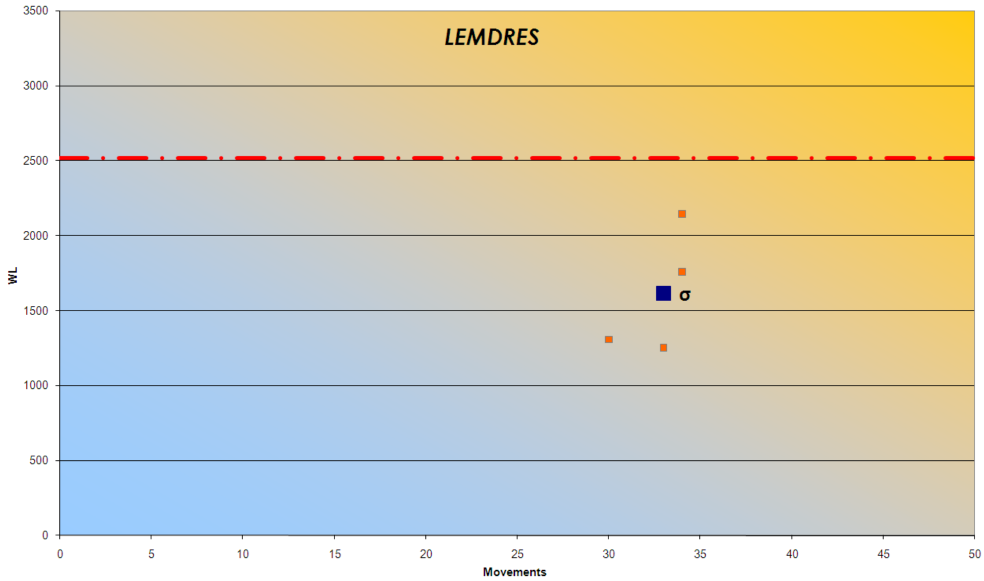


Figure 49: RES Workload

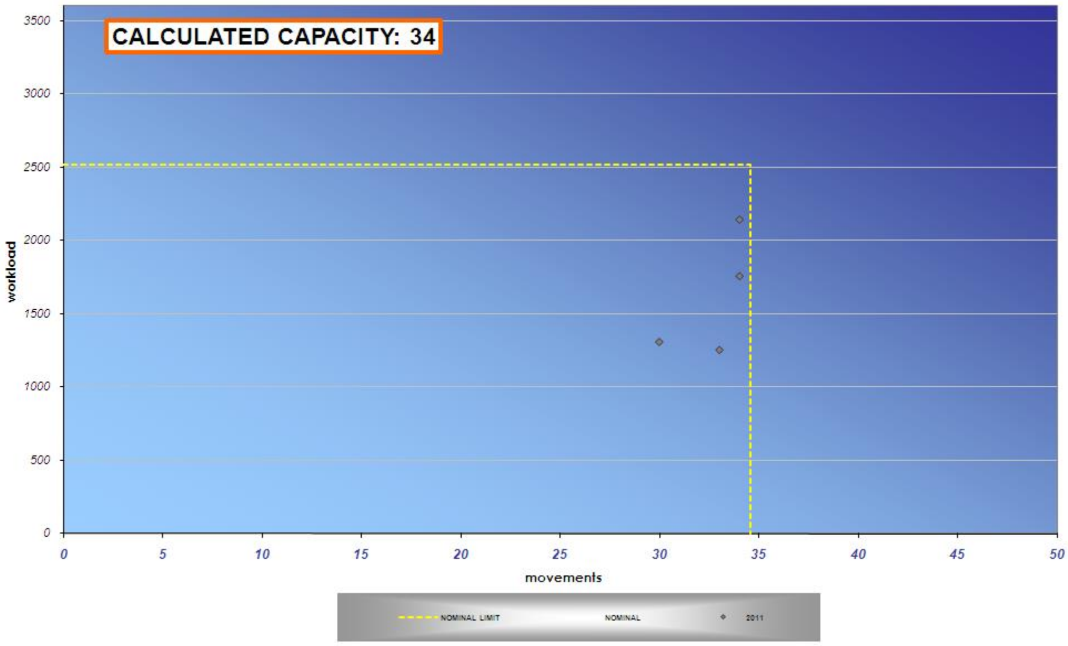


Figure 50: RES calculated capacity

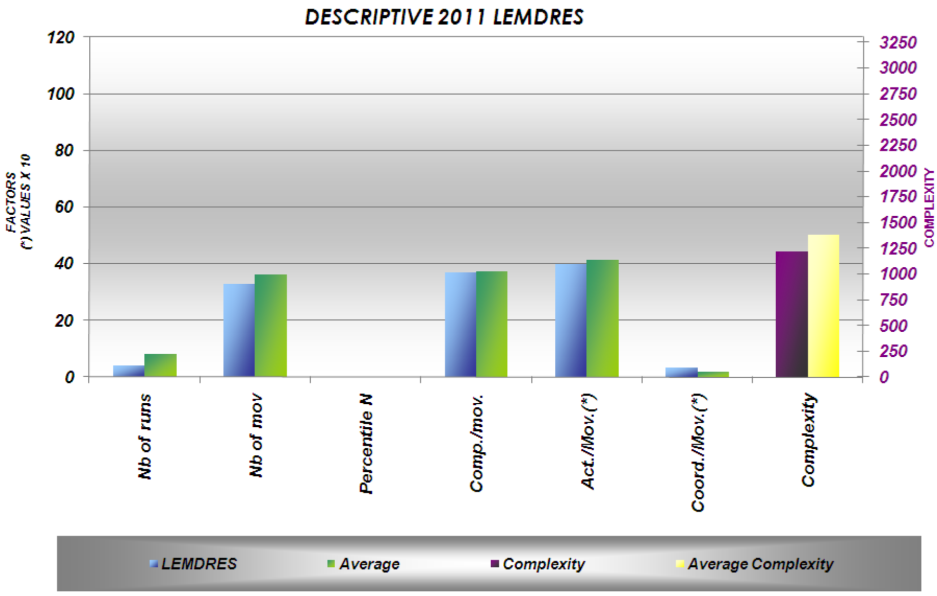


Figure 51: RES descriptive 2011

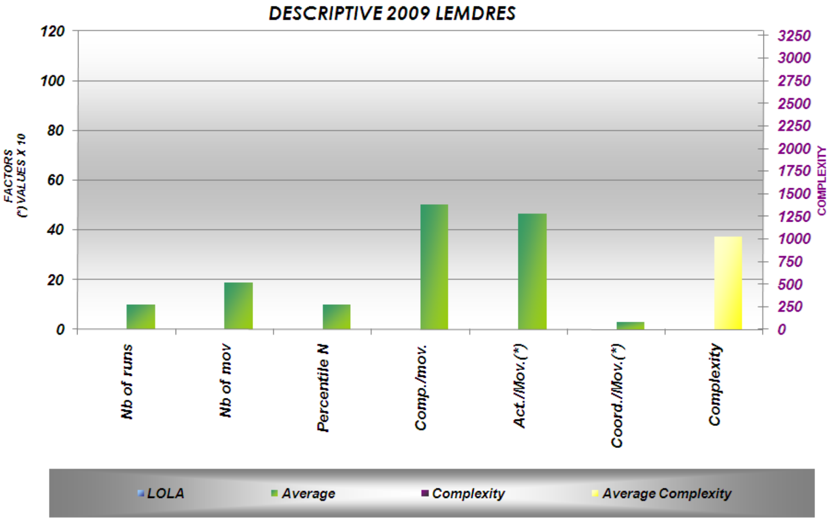


Figure 52: RES descriptive 2009

The behavior of the sector is very similar to LEMDREN. In fact is the same sector but serving south configuration.

Bad weather situations with strong wind conditions have been simulated with this configuration and it has showed the necessity to increase separation between traffics under these conditions.

As for the north configuration, a need to improve procedures to reduce coordinations will be needed for higher amounts of traffic.

4.1.2.1.6.2Sector RWS results (P-RNAV)

This sector manages the external West trombone of the approach to RWY 18 R
It also manages approaches to Getafe Air Base
The sector is included in the GROUP 1 (Arrival Sectors).
The sector will be managed from Madrid ACC.
Vertical limits are from GND to 14500 ft.
Evolution time in the sector is 100%

DEPENDENCY	LECM	YEAR OF STUDY:	2011
SECTOR	LEMDRWS		

					Med.	Máx.
Complexity	1288	Workload	1698	Simultaneous aircrafts	3,9	9,0
Time in evolution (%)	100			Communications / 10 min.	26,8	37,0
Mean flight time (min)	6					

	1ª	2ª	3ª	4ª	5ª	6ª	7ª	8ª	9ª	10ª	11ª	12ª	13ª	14ª	15ª	Media
Incidents actions	0	0	0													0,0
Departures/Arrivals actions	152	130	180													154,0
Over-flights actions	0	0	0													0,0
Incidents surveillance	0	0	0													0,0
Departures/Arrivals surveillance	300	208	201													236,3
Over-flights surveillance	0	0	0													0,0
Arrivals/Departures Sep/Seq act	52	46	88													62,0
Over-flights Sep/Seq actions	0	0	0													0,0
Holdings	0	0	0													0,0
Number of visual flights	0	0	0													0,0
Shared Traffic	0	0	0													0,0
Coordination	0	2	1													1,0
System Coordination	0	0	0													0,0
Incident radar vectoring	0	0	0													0,0
Departure/Arrivals radar vectori	0	7	3													3,3
Over-flights radar vectoring	0	0	0													0,0
Standar radar vectoring (X)	0	0	0													0,0
Movements per test run (IFR)	42	35	40													39

Run date	OC19	OC26	OC27
Day	X	X	J
Hour	13:00	9:15	11:30

Departures	0,00	Arrivals	39,00	Number of movements - Run	39
Actions per departure	0,00	Actions per arrival	3,94	Actions per movement	3,94
Coordinations per departure	0,00	Coordinations per arrival	0,03	Coordinations per movement	0,03
Radar Vectoring per departure	0,00	Radar Vectoring per arrival	0,09	Radar Vectoring per movement	0,09
Complexity per departure	0,00	Complexity per arrival	32,96	Complexity per movement	32,96

Figure 53: RWS spreadsheet runs

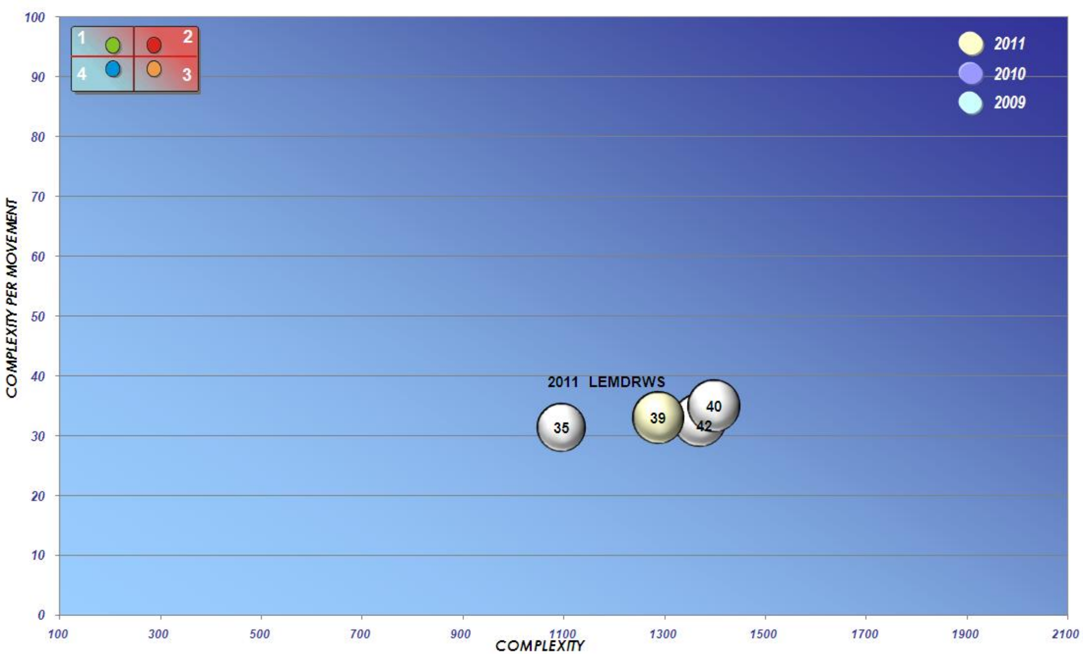


Figure 54: RWS Status

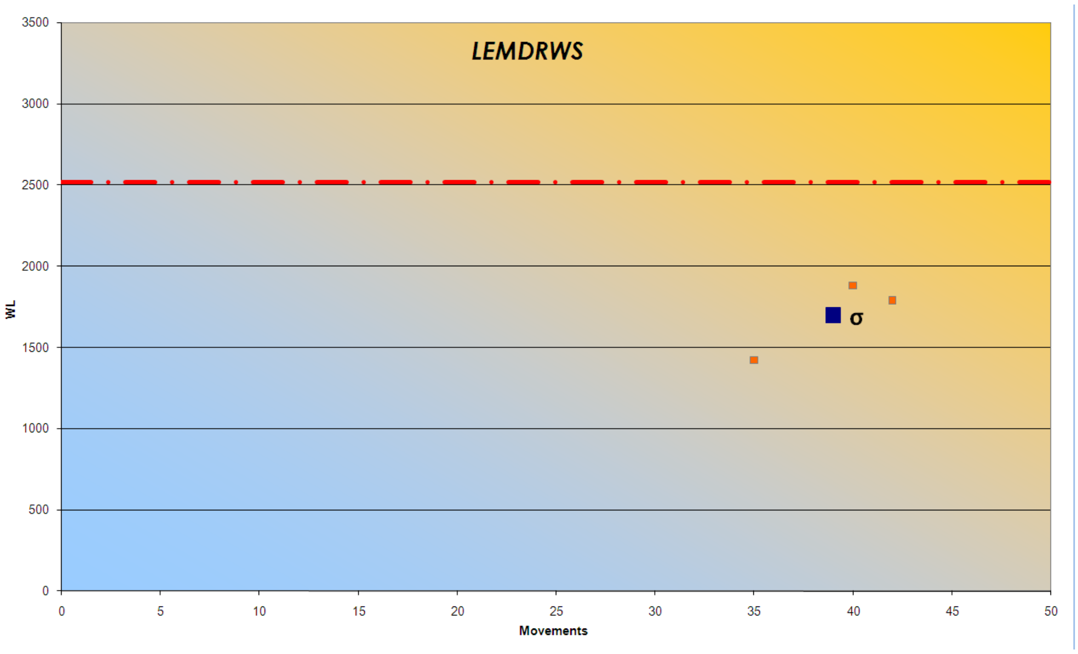


Figure 55: RWS Workload

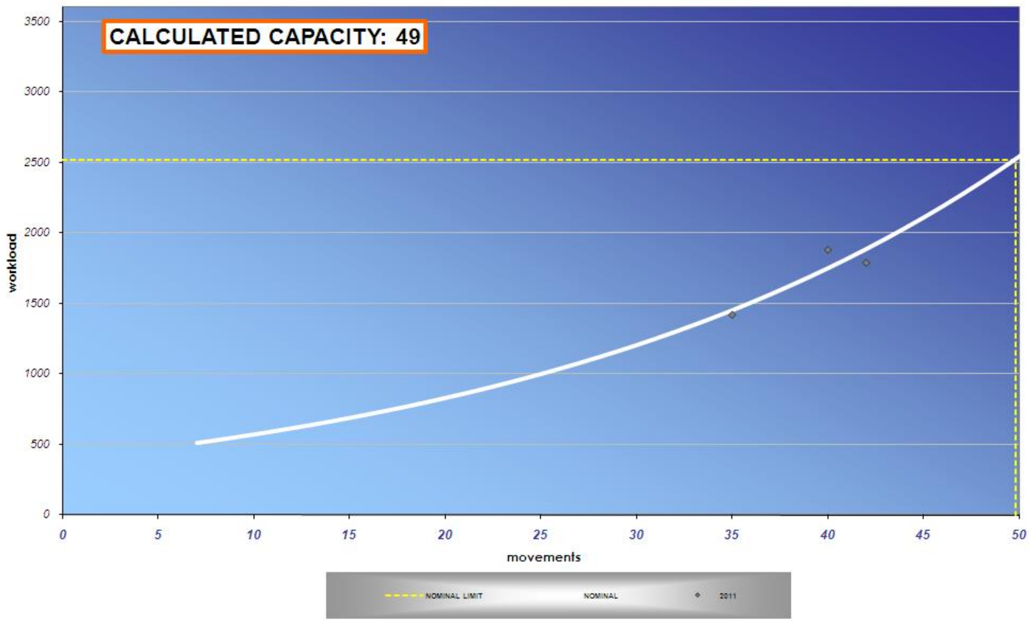


Figure 56: RWS calculated capacity

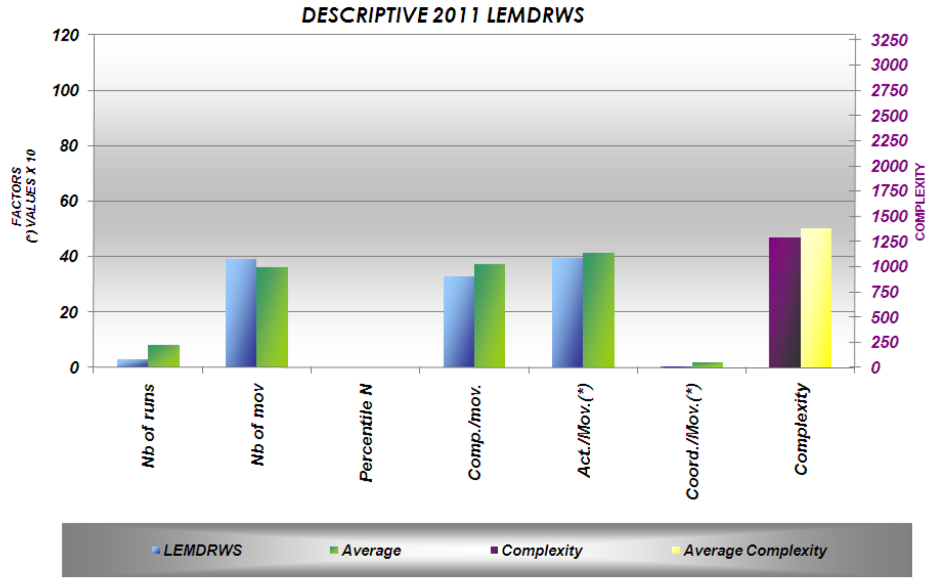


Figure 57: RWS descriptive 2011

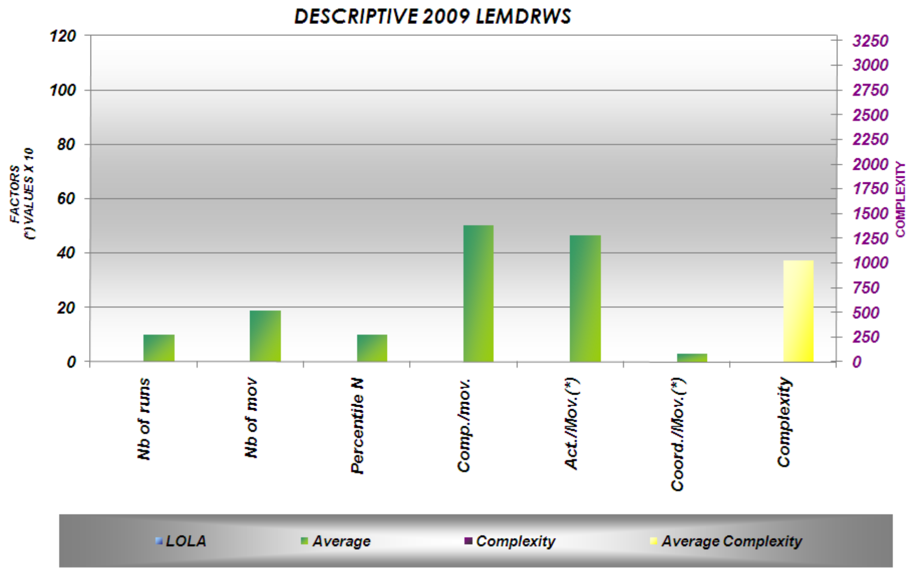


Figure 58: RWS descriptive 2009

The sector is exactly the same as for the north configuration.

The higher capacity value for this sector is based upon a limited number of samples due to simulator failure. This value needs to be modulated with a higher number of data pick-up, and probably will trend towards a value near 44 Movs/hour.

This sector is particularly affected by bad weather conditions in the final approach to RWY 18R, since it has to transfer the traffic to the final approach sector with an increased separation.

Compared with the actual sector in Madrid, the management of traffic improves, as it is conducted more towards south and thus farther from high terrain.

The capacity of the actual equivalent sector is 32 Movs/hour.

4.1.2.1.7Sectors AFES & AFWS (P-RNAV)

With a vertical limit of 11500ft. these sectors are in charge of the final sequencing of the traffic coming from the director sectors. The indicated airspeed in this area is between 180kts and 210kts. The horizontal separation is adjusted to 3NM (radar separation minima) or depending on the wake turbulence existing at that moment.

4.1.2.1.7.1Sector AFES results (P-RNAV)

This sector manages the grid and final approach to RWY 18L
The sector is included in the GROUP 1 (Final Approach Sectors).
The sector will be managed from Madrid ACC.
Vertical limits are from GND to 11500 ft.
Evolution time in the sector is 100%

Aena

DEPENDENCY	LECM	YEAR OF STUDY:	2011		
SECTOR	LEMDAFES				
				Med.	Máx.
Complexity	996	Workload 585	Simultaneous aircrafts	5,0	10,0
Time in evolution (%)	100		Communications / 10 min.	18,9	28,8
Mean flight time (min)	10				

	1ª	2ª	3ª	4ª	5ª	6ª	7ª	8ª	9ª	10ª	11ª	12ª	13ª	14ª	15ª	Media
Incidents actions	0	0	0	3	0	0										0,5
Departures/Arrivals actions	118	103	118	102	130	80										108,5
Over-flights actions	0	0	0	4	0	0										0,7
Incidents surveillance	0	0	0	3	0	0										0,5
Departures/Arrivals surveillance	322	341	296	295	288	260										300,3
Over-flights surveillance	0	0	0	0	0	0										0,0
Arrivals/Departures Sep/Seq act	22	27	17	12	34	24										22,7
Over-flights Sep/Seq actions	0	0	0	1	0	0										0,2
Holdings	0	0	0	0	0	0										0,0
Number of visual flights	0	0	1	0	0	1										0,3
Shared Traffic	0	0	1	0	0	1										0,3
Coordination	1	1	4	0	0	2										1,3
System Coordination	0	0	0	0	0	0										0,0
Incident radar vectoring	0	0	0	0	0	0										0,0
Departure/Arrivals radar vectori	2	0	0	0	0	0										0,3
Over-flights radar vectoring	0	0	0	0	0	0										0,0
Standar radar vectoring (X)	0	0	0	0	0	0										0,0
Movements per test run (IFR)	31	34	32	32	32	30										32

Run date	OC19	OC20	OC24	OC25	OC26	OC27
Day	X	J	L	M	X	J
Hour	13:00	13:05	10:50	12:35	9:15	11:30

Departures	0,17	Arrivals	31,83	Number of movements - Run	32
Actions per departure	0,00	Actions per arrival	3,41	Actions per movement	3,44
Coordinations per departure	0,00	Coordinations per arrival	0,04	Coordinations per movement	0,04
Radar Vectoring per departure	0,00	Radar Vectoring per arrival	0,01	Radar Vectoring per movement	0,01
Complexity per departure	0,00	Complexity per arrival	30,93	Complexity per movement	31,26

Figure 59: AFES spreadsheet runs

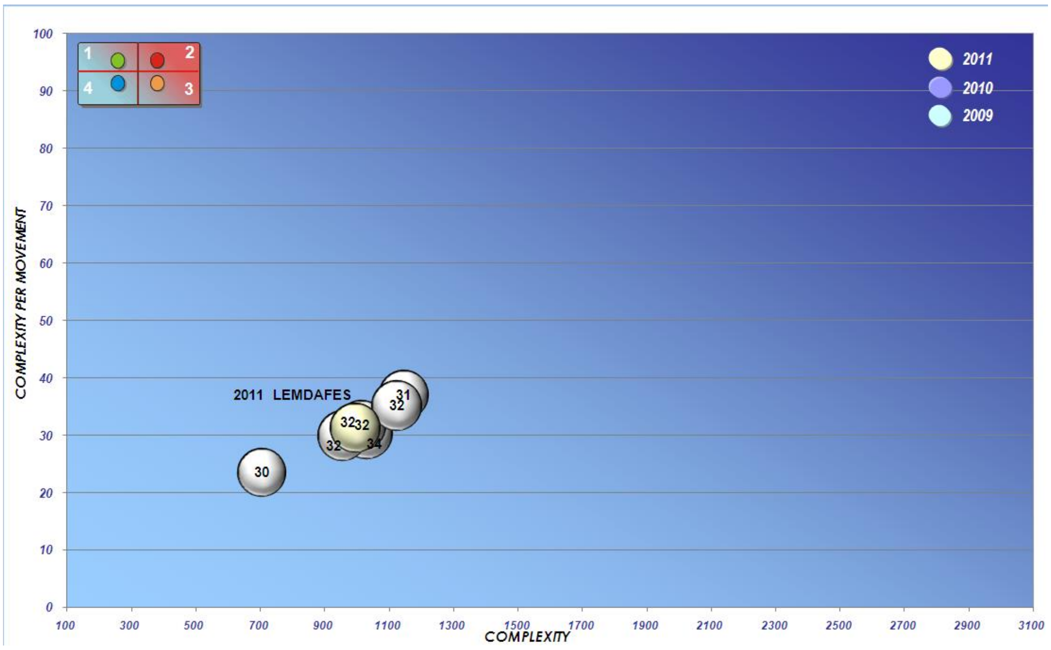


Figure 60: AFES Status

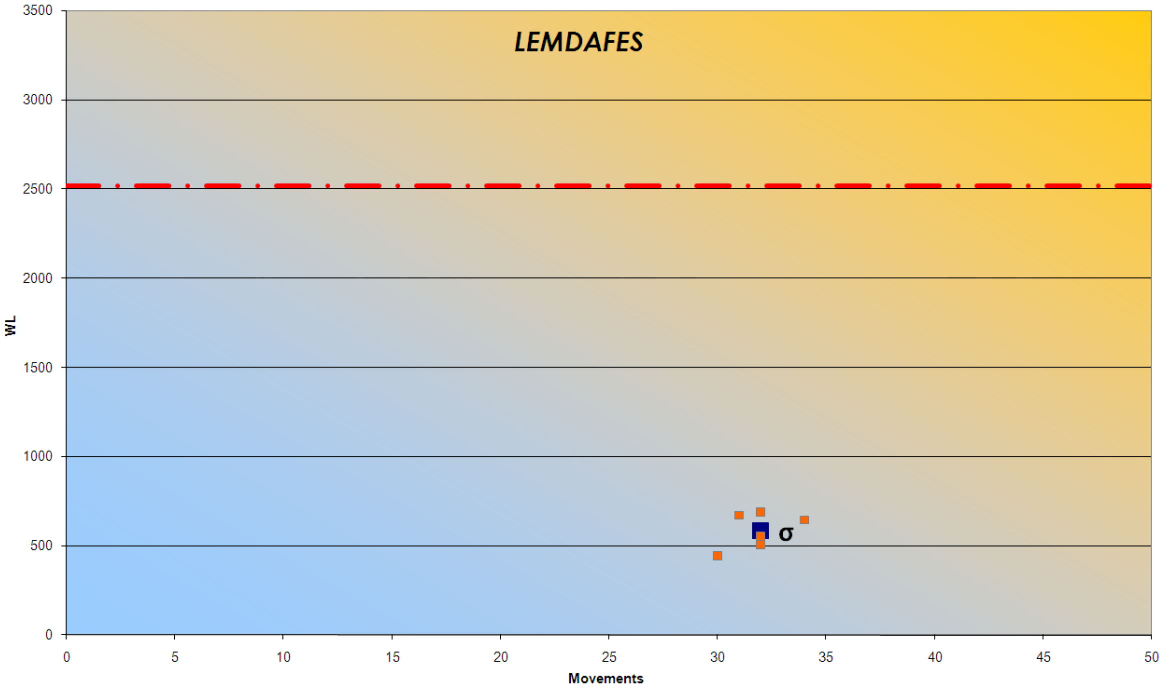


Figure 61: AFES Workload

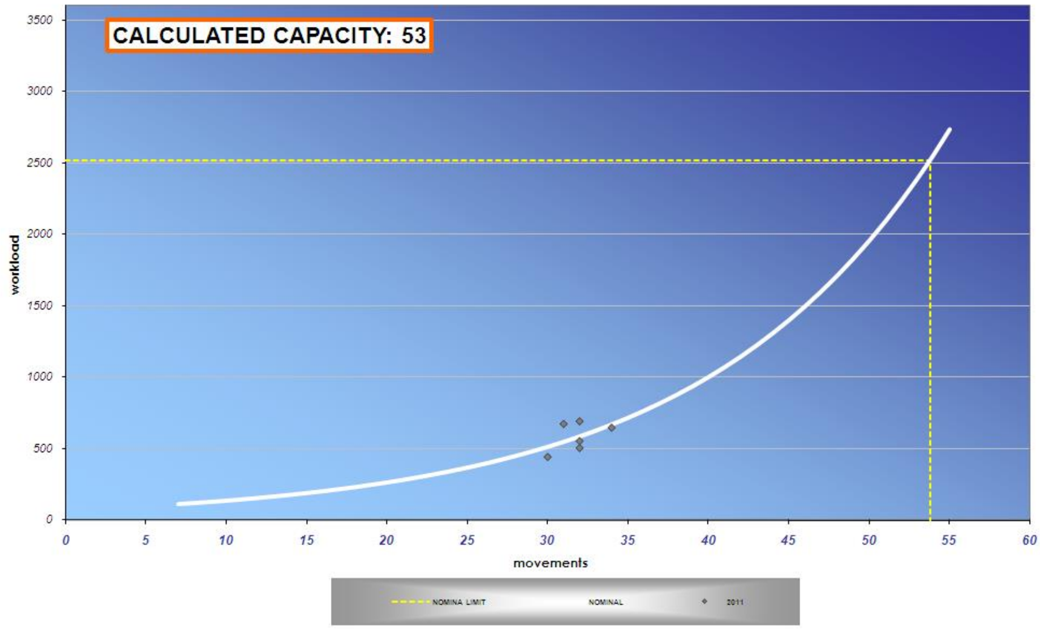


Figure 62: AFES calculated capacity

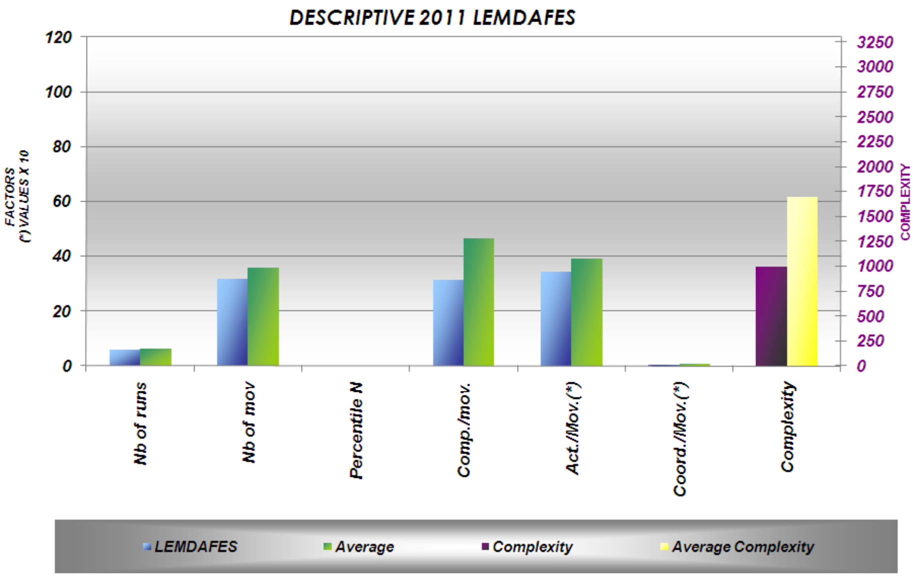


Figure 63: AFES descriptive 2011

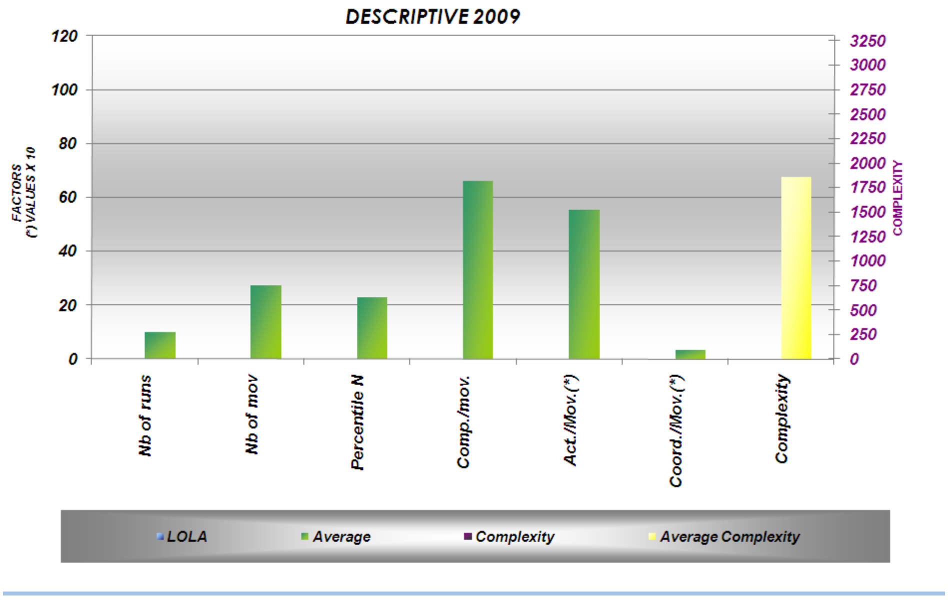


Figure 64: AFES descriptive 2009

This is the best resolver sector of the entire TMA scenario. This is clearly shown by the concentration of NORVASE samples in the Work Load and Capacity diagrams that present a very similar work load for different traffic loads.

The position of the different samples in the fourth quadrant of the state diagram represents a sector with a capacity limited by the RWY throughput and, in many cases for the increased separation to prevent wake turbulence effects.

The coordination with collateral sectors is almost unnecessary which is an indication of the good adaptation of the operational procedures applied.

The number of controller's intervention per movement (3.44) explains the low complexity value (996) of the sector.

4.1.2.1.7.2Sector AFWS results (P-RNAV)

This sector manages the grid and final approach to RWY 18R
The sector is included in the GROUP 1 (Final Approach Sectors).
The sector will be managed from Madrid ACC.
Vertical limits are from GND to 11500 ft.
Evolution time in the sector is 100%

DEPENDENCY	LECM	YEAR OF STUDY:	2011
SECTOR	LEMDAFWS		

					Med.	Máx.
Complexity	1894	Workload	1302	Simultaneous aircrafts	7,1	11,0
Time in evolution (%)	100			Communications / 10 min.	26,2	39,0
Mean flight time (min)	11					

	1ª	2ª	3ª	4ª	5ª	6ª	7ª	8ª	9ª	10ª	11ª	12ª	13ª	14ª	15ª	Media
Incidents actions	0	0	0													0,0
Departures/Arrivals actions	146	176	125													149,0
Over-flights actions	0	0	0													0,0
Incidents surveillance	0	0	0													0,0
Departures/Arrivals surveillance	449	448	382													426,3
Over-flights surveillance	0	0	0													0,0
Arrivals/Departures Sep/Seq act	34	80	49													54,3
Over-flights Sep/Seq actions	0	0	0													0,0
Holdings	0	0	0													0,0
Number of visual flights	0	0	0													0,0
Shared Traffic	0	0	0													0,0
Coordination	0	0	0													0,0
System Coordination	0	0	0													0,0
Incident radar vectoring	0	0	0													0,0
Departure/Arrivals radar vectori	0	3	2													1,7
Over-flights radar vectoring	0	0	0													0,0
Standar radar vectoring (X)	0	0	0													0,0
Movements per test run (IFR)	43	41	36													40

Run date	OC19	OC24	OC25
Day	X	L	M
Hour	13:00	10:50	12:35

Departures	0,00	Arrivals	40,00	Number of movements - Run	40
Actions per departure	0,00	Actions per arrival	3,72	Actions per movement	3,72
Coordinations per departure	0,00	Coordinations per arrival	0,00	Coordinations per movement	0,00
Radar Vectoring per departure	0,00	Radar Vectoring per arrival	0,04	Radar Vectoring per movement	0,04
Complexity per departure	0,00	Complexity per arrival	47,10	Complexity per movement	47,10

Figure 65: AFWS spreadsheet runs

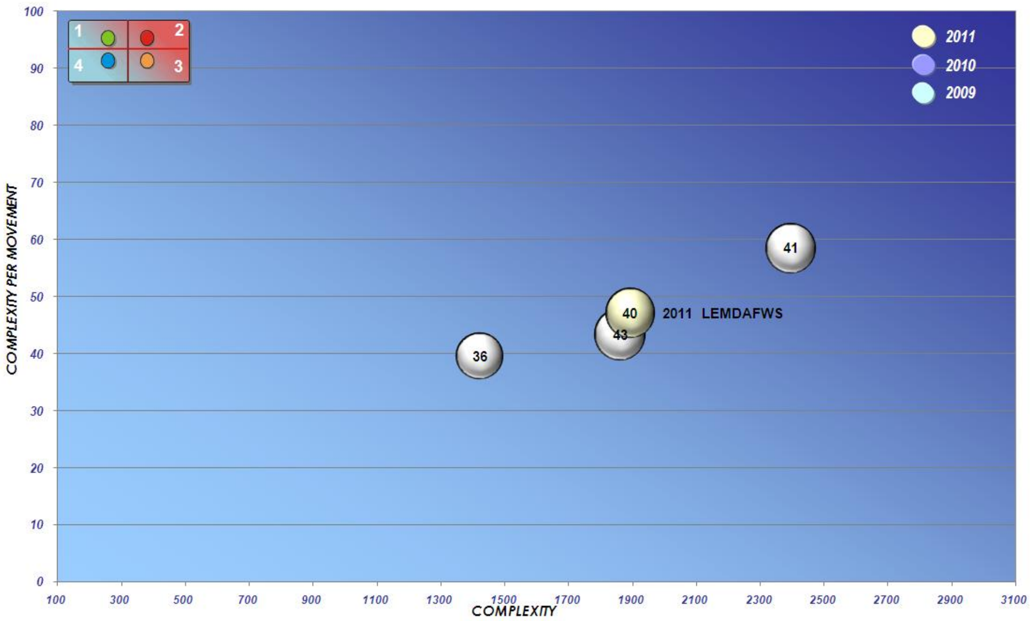


Figure 66: AFWS Status

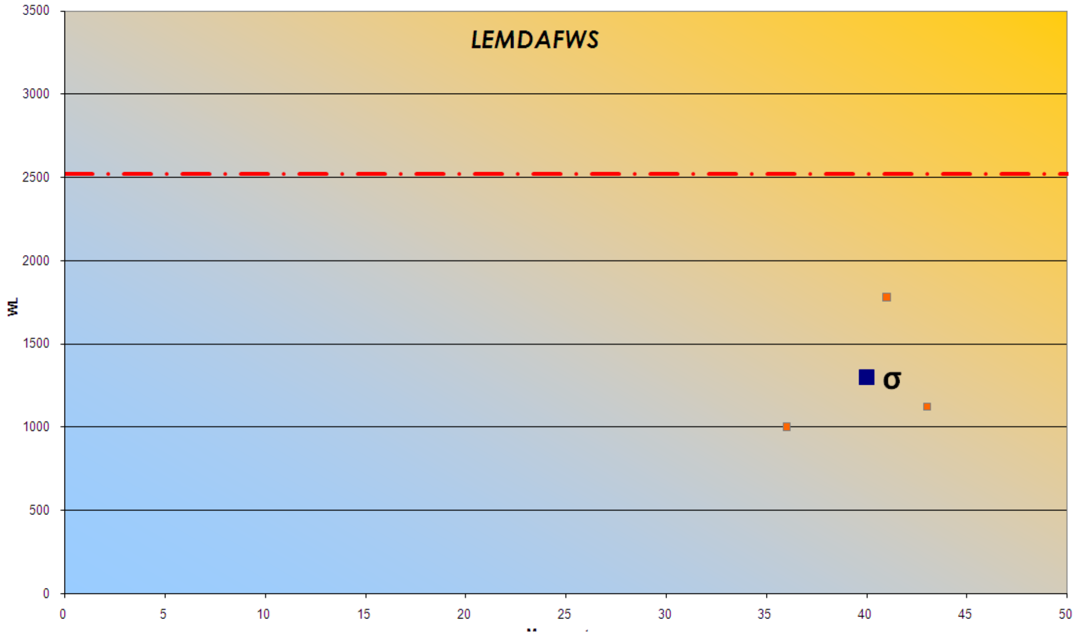


Figure 67: AFWS Workload

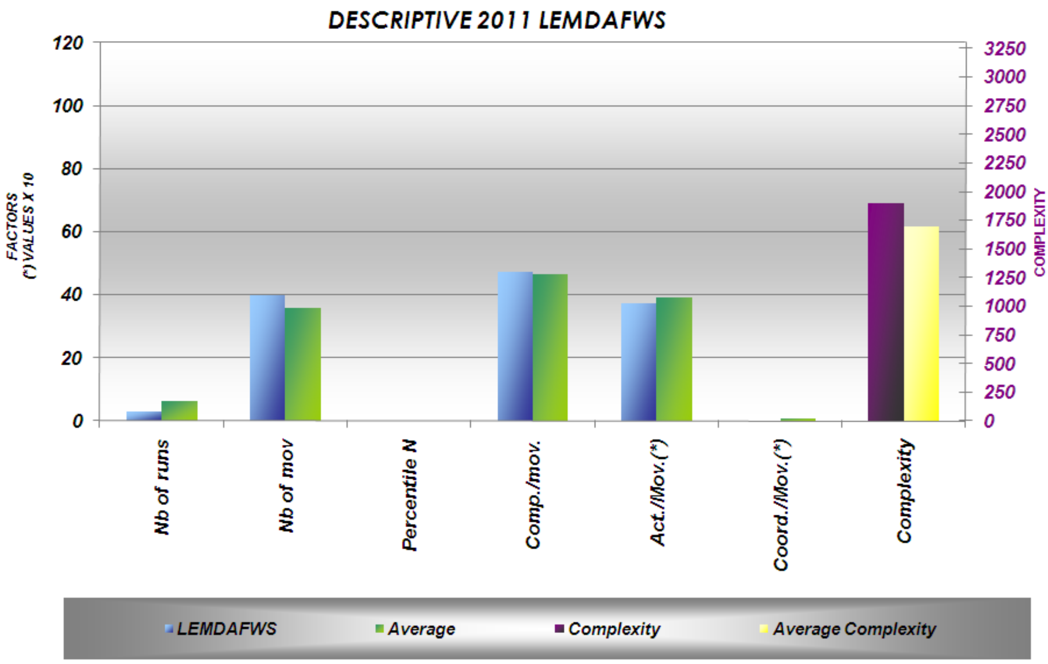


Figure 68: AFWS descriptive 2011

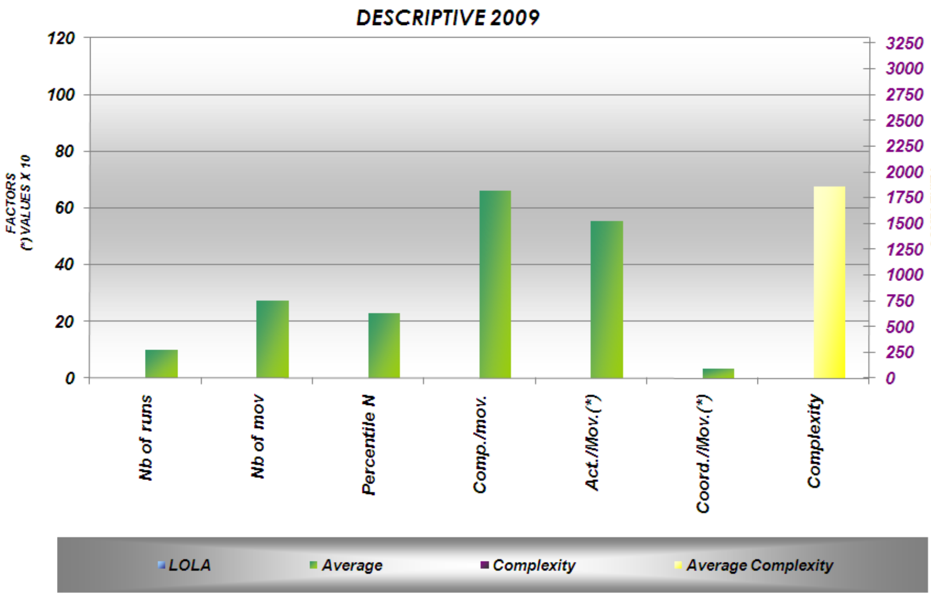


Figure 69: AFWS descriptive 2009

Due to a simulator failure the number of samples available for this sector does not allow the calculation of a capacity value.

Comparing this sector with the actual final approach sector to RWY 18 in Madrid, the complexity and WL values obtained are significantly lower (1894complexity and 1302WL for LEMDFWS versus 2469 complexity and 1878 WL for actual sector).

Taking this into account and the position of the samples in the state diagram, we can think on a capacity between 45 and 50 Movs/hour

4.1.2.1.8Sector DIS (P-RNAV)

This sector is in charge of the departures from both runways until 7 000 ft.

Figure 70: DIS Sector (with final approach sectors)

Due to technical limitations and the lack of Control Sector Units (UCS) it wasn't able to collect enough data to be representative of the sector capacity. Same is applicable to DES and DWS sectors:

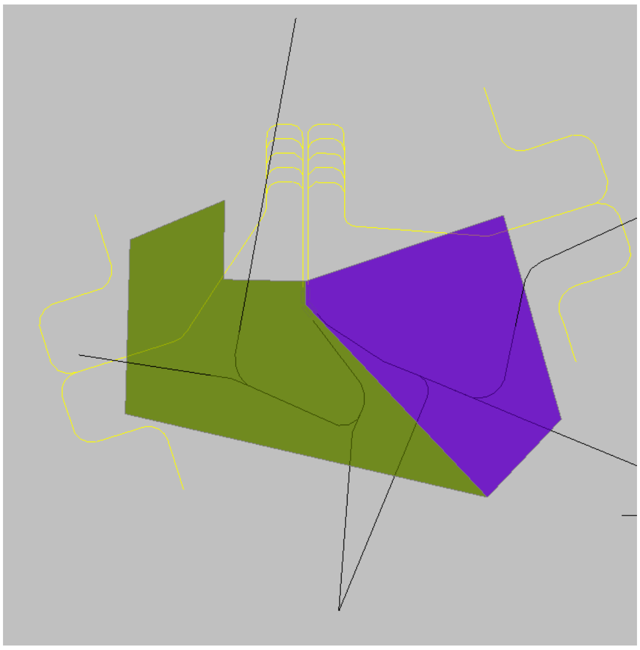


Figure 71: DES and DWS Sectors

4.1.3 Results impacting regulation and standardisation initiatives

The simulated scenario is fully compliant with P-RNAV procedures design standards and regulations.

4.2 Analysis of Exercises Results

It has been compared the P-RNAV sectors with the actual Madrid TMA sectors data, provided by the NORVASE (report year availability) because is the most similar source to compare with.

CONFIGURACIÓN NORTE		
SECTOR P-RNAV	SECTOR	INFORME NORVASE
LEMDAFEN	LEMDAIN	2008
LEMDAFIN		
LEMDAFWN		
LEMDDIN	LECMDEN	2006
LEMDREN	LEMDREN	2008
LEMDRWN	LEMDRWN	2008
LEMDENN	LECMENN	2006
LEMDESN	LECMESN	2006
LEMDWNN	LECMWNN	2006
LEMDWSN	LEMDWSN	Sin informe

CONFIGURACIÓN SUR		
SECTOR P-RNAV	SECTOR	INFORME NORVASE
LEMAFES	LEMDAIS	2008
LEMDAFWS		
LEMDRES	LEMDRES	2008
LEMDRWS	LEMDRWS	2008
LEMDENS	LEMDENS	Sin informe
LEMDESS	LEMDESS	Sin informe

Figure 72: Future and current comparing sectors

4.2.1 Actual sector ENN

East North Sector in North Configuration.The ATC service for this sector is provided from LECM (Air Traffic Control Centre of Madrid):

- TMA sector (FL 245 / GND)
- Declared capacity: 45 mov/hour
- Traffic in evolution (time): 95%

Hereby are listed the results obtained from 2006 report corresponding to this sector:

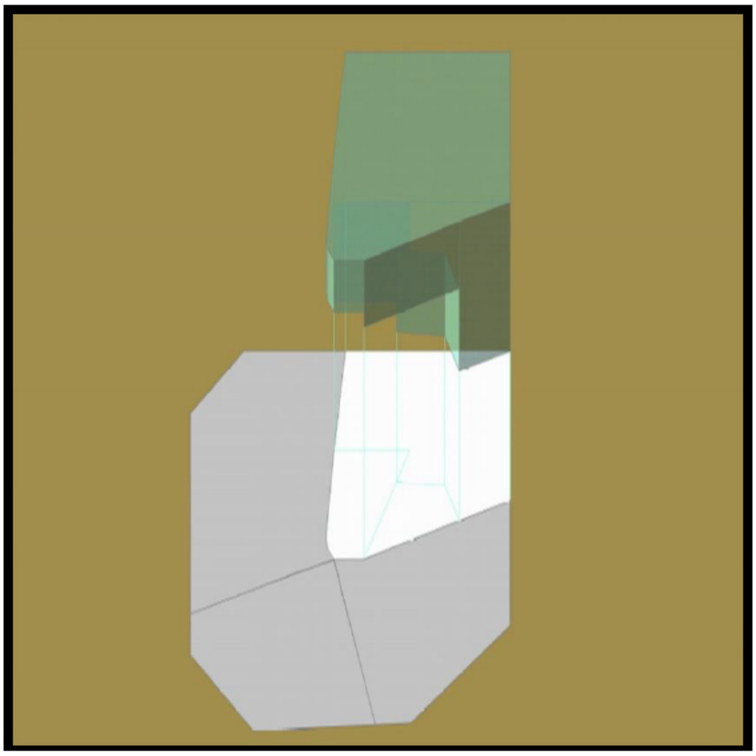


Figure 73: LECMENN graphical representation

DEPENDENCIA	LECM		AÑO DE ESTUDIO:	2006
SECTOR	LECMENN			

					Med.	Máx.
Complejidad	699	Workload 1098		Aeronaves simultáneas	2.3	7.0
Tiempo en evolución (%)	95			Comunicaciones / 10 min.	15.0	27.8
Tiempo Medio de Vuelo (min)	7					

CAMPOS	1ª	2ª	3ª	4ª	5ª	6ª	7ª	8ª	9ª	10ª	11ª	12ª	13ª	14ª	15ª	Media
Actuaciones en imprevistos	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.0
Actuaciones en Salidas/Llegada	82	81	59	57	101	50	100	50	76	115	86	56	60	40		72.4
Actuaciones en Sobrevuelos	2	0	4	6	15	0	0	0	7	1	1	1	0	0		2.6
Vigilancia de Imprevistos	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.0
Vigilancia de Salidas/LLegadas	145	141	93	128	163	85	135	101	103	183	161	111	120	81		125.0
Vigilancia de Sobrevuelos	11	0	64	25	51	0	0	0	17	6	2	7	0	0		13.1
Act.sep/sec salidas/llegadas	3	4	1	0	16	5	32	8	7	19	6	5	8	4		8.4
Act.sep/sec sobrevuelos	0	0	0	0	5	0	0	0	0	0	0	0	0	0		0.4
Esperas	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.0
Nº de vuelos visuales	0	0	1	0	0	0	0	0	0	0	0	1	0	0		0.1
Coordinación	9	16	6	14	12	10	11	7	5	14	9	7	12	11		10 2
Coordinación en sistema	1	17	3	0	5	0	4	1	2	3	3	0	1	0		2.9
Guia Vectorial Imprevisto	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.0
Guía Vectorial Salida/LLegada	1	0	1	0	7	0	1	0	3	3	1	0	1	2		1.4
Guía Vectorial Sobrevuelo	0	0	0	0	2	0	0	0	0	0	0	0	0	0		0.1
Guia Vectorial Estándar (X)	0	0	0	0	2	0	0	0	0	0	0	0	0	0		0.1
Movimientos por Toma (IFR)	22	24	17	19	28	15	22	11	19	30	27	20	16	11		20 0
Fecha Toma	OC06	OC06	OC06	OC06	OC09	OC09	OC09	OC09	OC09	OC09	OC11	OC11	OC11	OC11		
Día	V	V	V	V	L	L	L	L	L	L	X	X	X	X		
Hora	06:32	07:34	09:18	10:18	06:47	07:47	09:44	10:45	14:00	15:00	06:47	07:48	09:25	10:24		

Salidas	9.2	LLegadas	10.5	Nº Movimientos-Toma	20
Actuaciones por salida	3.09	Actuaciones por llegada	4.23	Actuaciones por Movimiento	3.75
Coordinaciones por salida	0.64	Coordinaciones por llegada	0.67	Coordinaciones por Movimiento	0.67
Guía Vectorial por salida	0.07	Guía Vectorial por llegada	0.05	Guía Vectorial por movimiento	0.07
Complejidad por salida	28.8	Complejidad por llegada	37.4	Complejidad por movimiento	34.1

Figure 74: LECMENN Spreadsheet runs

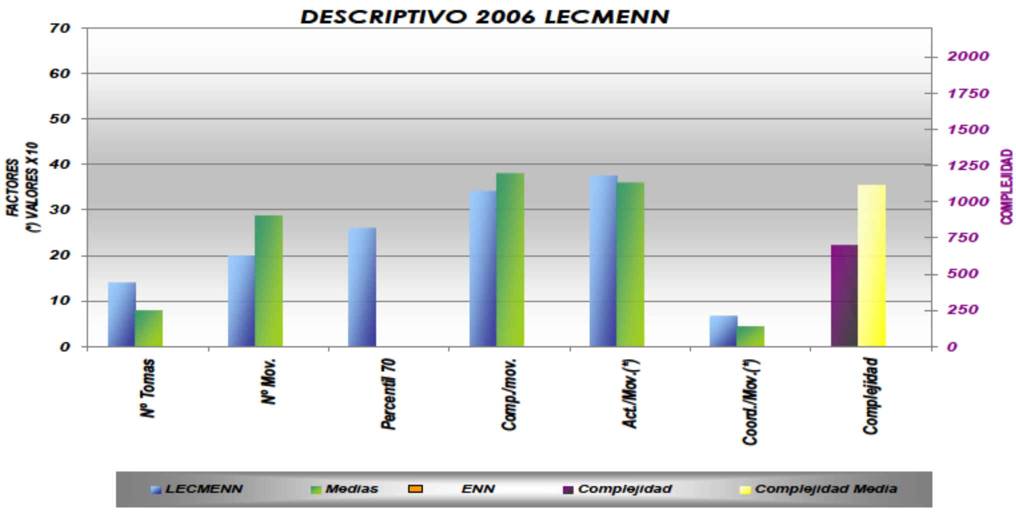


Figure 75: LECMENN Descriptive 2006

Here is shown the status diagram with the sector evolution till 2006. The average figures corresponds to the last 4 years runs:

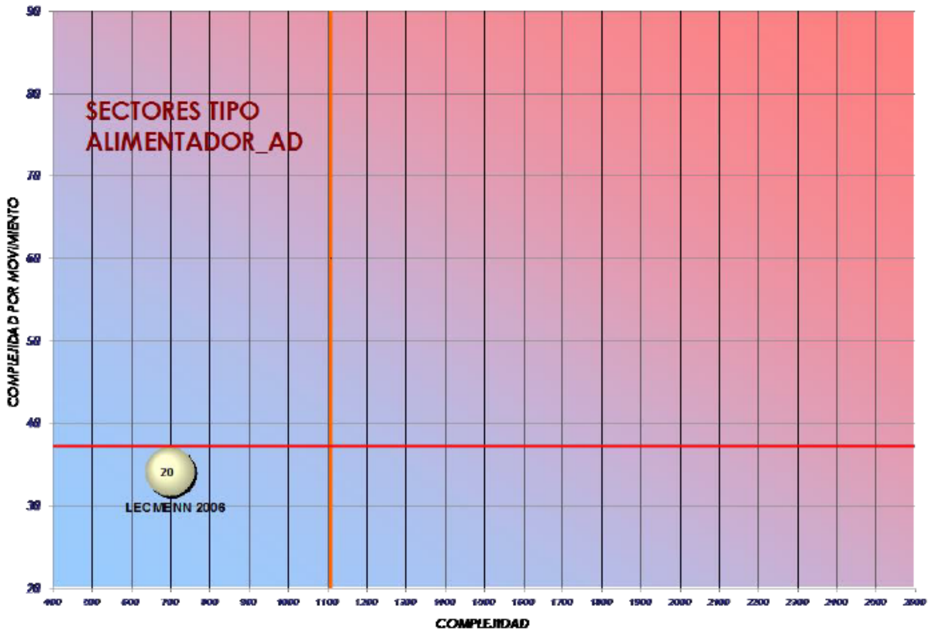


Figure 76: LECMENN Status

Finally, it is shown the calculated capacity of this sector where it can be noticed the tendency curve of the corresponding sector.

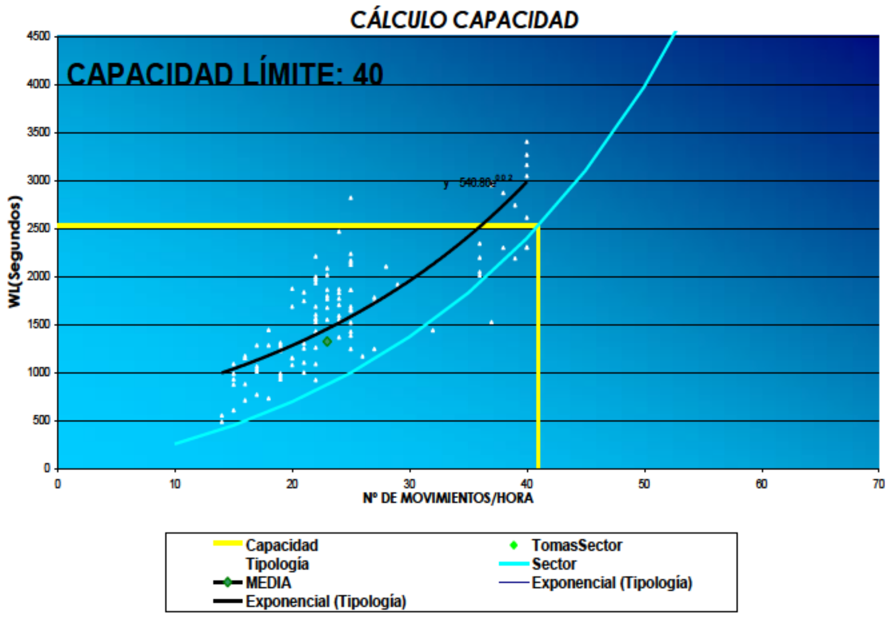


Figure 77: LECMENN Calculated capacity

Here are the results comparing the new situation with the previous one regarding LECMENN sector:

YEAR	2006	2011	Comparison results
SECTOR	LECMENN	ENN	
GROUP	Feeder	Feeder	
COMPLEXITY 	698,6	579	-17%
COMPLEXITY/MOV 	34,09	33,04	-3%
CORRDINATIONS/MOV 	0,67	0,06	-91%
ACTIONS/MOV	3,75	3,6	-4%

			
RADAR VECTORING/MOV 	0,07	0	Reduced to cero
WORKLOAD 	1098	933	-15%
PERCENTILE 70	26		
Nb OF MOV	20	18	-10%
CALCULATED CAPACITY	40[3]	25	-38%
DECLARED[4] - CALCULATED	5		

Table 8: ENN comparison results

The number of runs regarding LEMDENN is very low (only two) so the calculated capacity (25) is not representative and it doesn't assure that the capacity of this sector has been reduced. It is necessary to establish in a future a deeper number of runs within these external sectors. However, here are listed the main results comparison:

- The complexity **has been reduced in a 17%** compared with 2006 situation.
- The complexity per movement within this airspace **has been reduced in a 3%** compared with 2006.
- The coordination actions per movements **have been reduced in a 91%** compared to 2006.
- The actions per movements **have been reduced** within this airspace jurisdiction in a **4%.**
- The usage of radar vectoring **has been reduced to zero.**
- The workload **has been reduced in a 15%** compared to 2006 within external sectors jurisdiction.
- The number of movements **has been reduced in a 10%.**[5]
- The calculated capacity **has been reduced in a 38%** compared to 2006.[6]

4.2.2 Actual sector REN

[3] Declared capacity value as used: 45
[4] Group limit capacity
[5] This is a bad result and it's due to the lack of traffic sample in the exercise runs. That is the reason why the runs have to be increased in number during exercises with higher traffic samples.
[6] It is the same here. The number of runs is too low to establish a very well fitted extrapolation to calculate a decent capacity. This result is not relevant

East Director Sector in North Configuration.The ATC service for this sector is provided from LECM (Air Traffic Control Centre of Madrid):

- TMA sector (FL 135 / GND)
- Declared capacity: 43 mov/hour
- Traffic in evolution (time): 100%

Hereby are listed the results obtained from 2008 report corresponding to this sector:

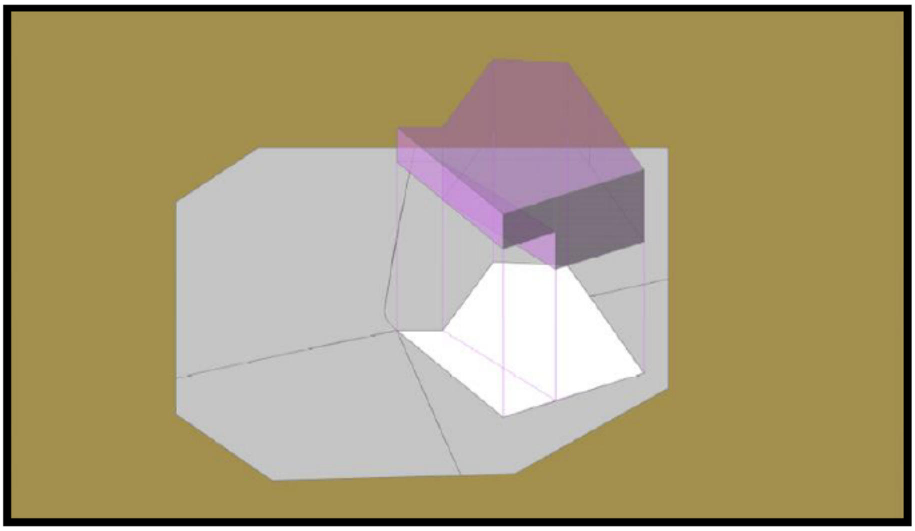


Figure 78: LEMDREN graphical representation

DEPENDENCIA	LECM		AÑO DE ESTUDIO:	2008	
SECTOR	LEMDREN				
				Med.	Máx.
Complejidad	1255	Workload 1610	Aeronaves simultáneas	2.5	6.0
Tiempo en evolución (%)	100		Comunicaciones / 10 min.	20.4	34.6
Tiempo Medio de Vuelo (min)	7				

	1ª	2ª	3ª	4ª	5ª	6ª	7ª	8ª	9ª	10ª	11ª	12ª	13ª	14ª	15ª	Media
Actuaciones en imprevistos	0	0	0	0	0	0	0	0								0.0
Actuaciones en Salidas/Llegada	120	96	79	75	112	139	128	111								107.5
Actuaciones en Sobrevuelos	0	0	0	0	0	0	0	0								0.0
Vigilancia de Imprevistos	0	0	0	0	0	0	0	0								0.0
Vigilancia de Salidas/LLegadas	147	128	121	120	149	196	161	178								150.0
Vigilancia de Sobrevuelos	0	0	0	0	0	0	1	0								0.1
Act.sep/sec salidas/llegadas	43	29	25	22	33	49	44	16								32.6
Act.sep/sec sobrevuelos	0	0	0	0	0	0	0	0								0.0
Esperas	0	1	0	0	0	0	0	1								0.3
Nº de vuelos visuales	0	0	0	0	0	0	0	0								0.0
Coordinación	10	10	8	3	8	18	17	11								10.6
Coordinación en sistema	0	0	0	0	0	0	0	0								0.0
Guía Vectorial Imprevisto	0	0	0	0	0	0	0	0								0.0
Guía Vectorial Salida/LLegada	9	7	2	4	7	11	11	13								8.0
Guía Vectorial Sobrevuelo	0	0	0	0	0	0	0	0								0.0
Guía Vectorial Estándar (X)	0	0	0	0	0	0	0	0								0.0
Movimientos por Toma (IFR)	23	18	16	16	24	26	23	24								21.3

Fecha Toma	AB11	AB11	AB11	AB11	AB15	AB15	AB15	AB17
Día	V	V	V	V	M	M	M	J
Hora	07:30	08:30	10:01	11:01	07:41	08:41	09:52	08:58

Salidas	0.63	Llegadas	20.50	Nº Movimientos-Toma	21
Actuaciones por salida	0.50	Actuaciones por llegada	5.19	Actuaciones por Movimiento	5.05
Coordinaciones por salida	0.88	Coordinaciones por llegada	0.46	Coordinaciones por Movimiento	0.49
Guía Vectorial por salida	0.00	Guía Vectorial por llegada	0.38	Guía Vectorial por movimiento	0.36
Complejidad por salida	6.38	Complejidad por llegada	59.59	Complejidad por movimiento	57.91

Figure 79: LEMDREN Spreadsheet runs

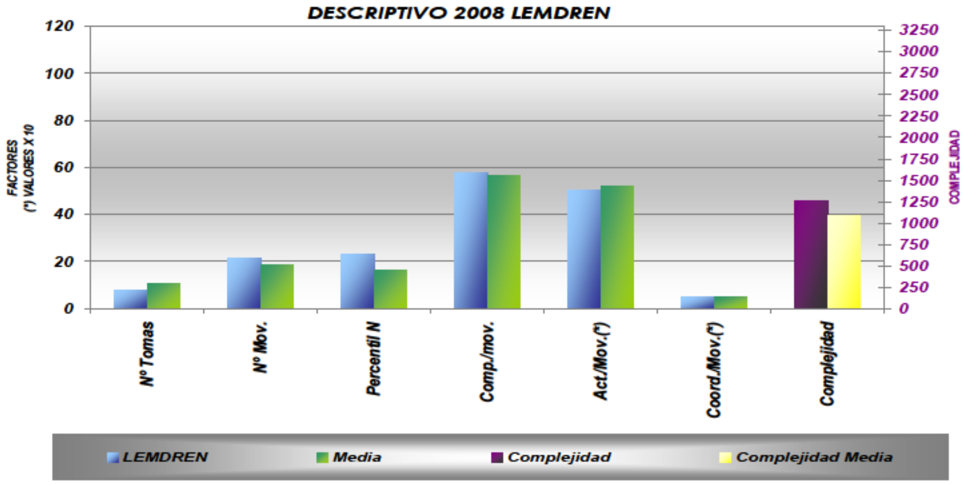


Figure 80: LEMDREN Descriptive 2008

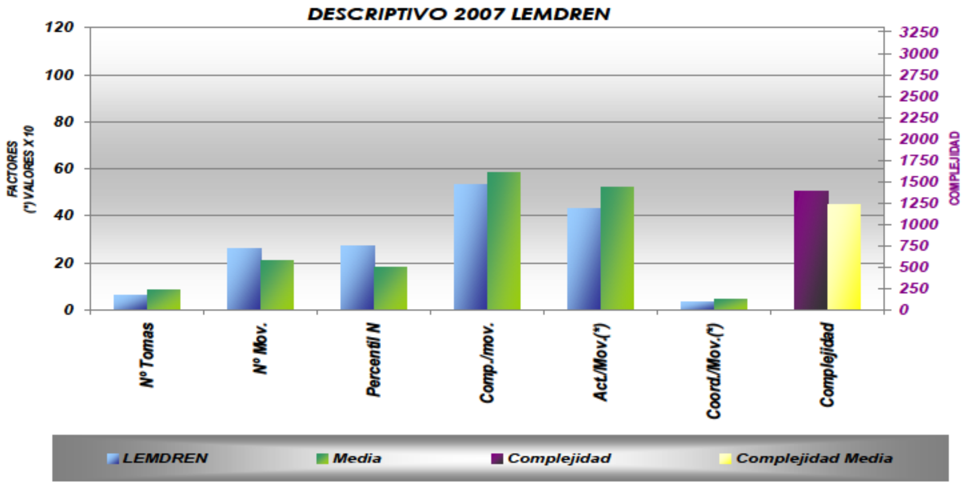


Figure 81: LEMDREN Descriptive 2007

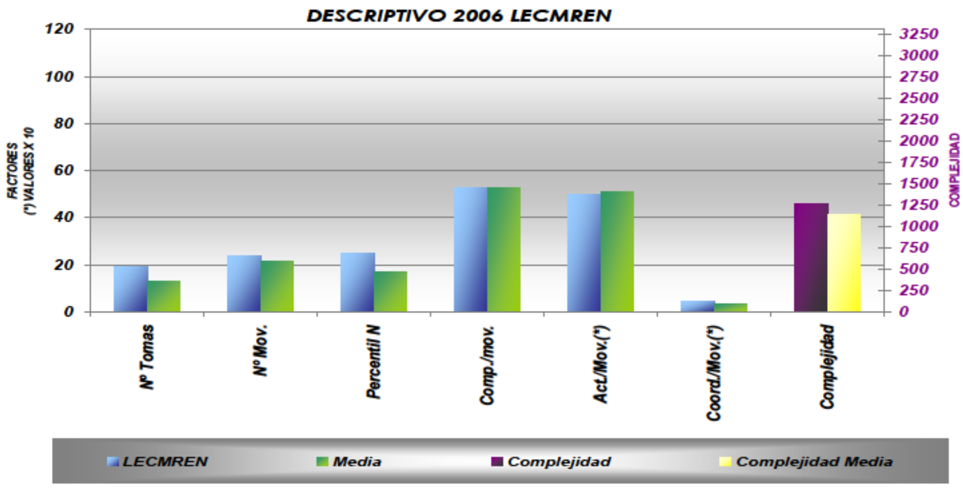


Figure 82: LEMDREN Descriptive 2006

Here is shown the status diagram with the sector evolution till 2008. The average figures corresponds to the last 4 years runs:

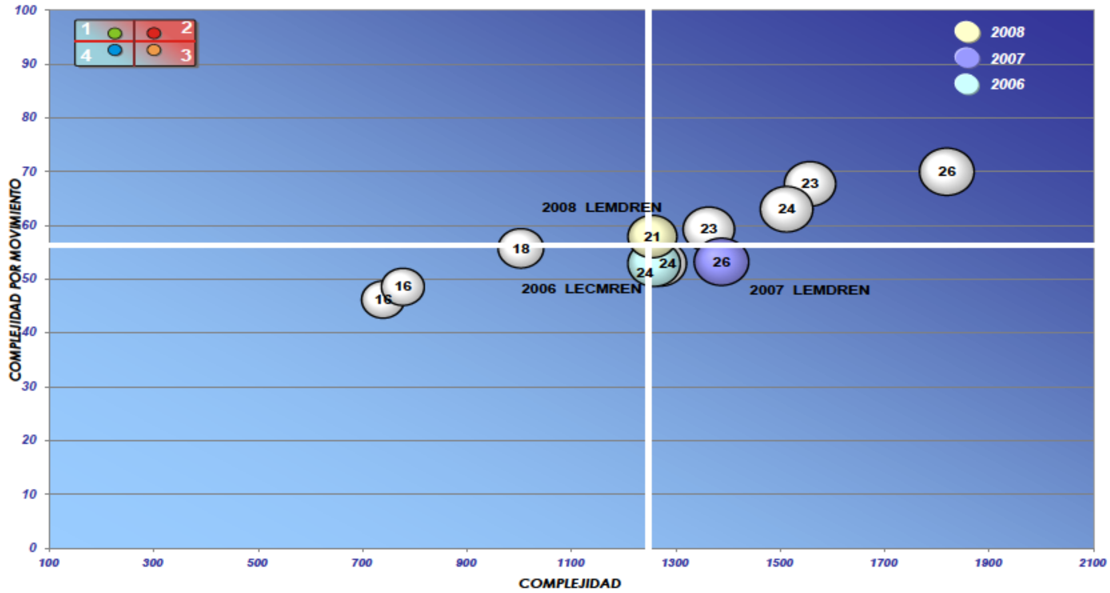


Figure 83: LEMDREN Status

Finally, it is shown the calculated capacity of this sector where it can be noticed the tendency curve of the corresponding sector.

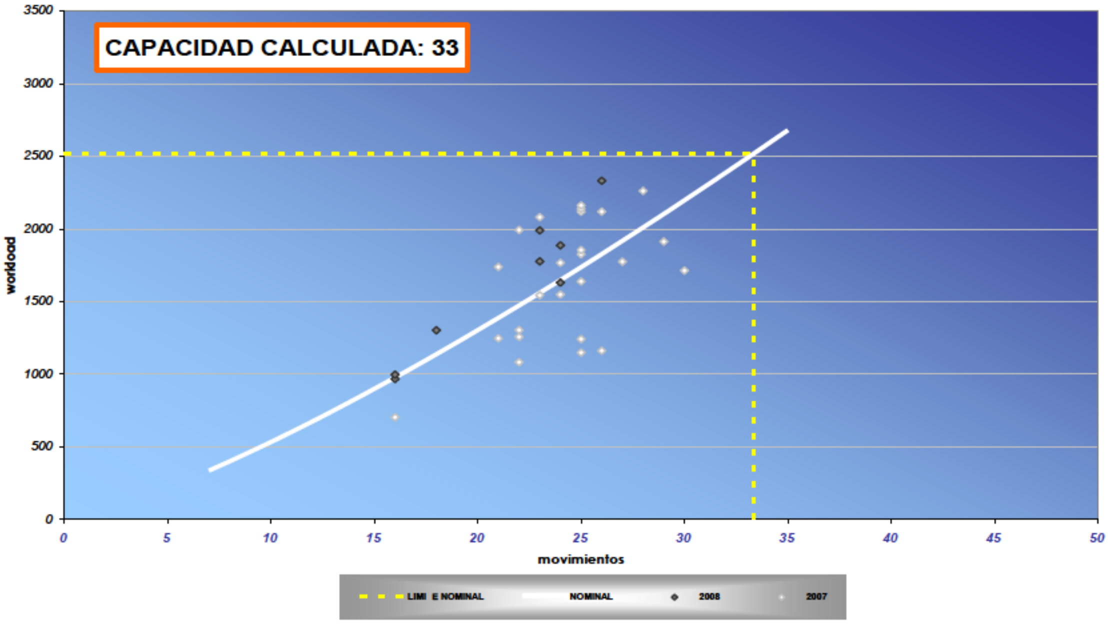


Figure 84: LEMDREN Calculated capacity

Here are the results comparing the new situation with the previous one regarding LEMDREN sector:

YEAR	2008	2011	Comparison results
SECTOR	LEMDREN	REN	
GROUP	Feeder A	Director	
COMPLEXITY 	1255	1612	28%
COMPLEXITY/MOV 	57,91	43,92	-24%
CORRDINATIONS/MOV 	0,49	0,26	-47%
ACTIONS/MOV 	5,05	4,40	-13%
RADAR VECTORING/MOV 	0,36	0,03	-92%
WORKLOAD 	1610	2156	34%
PERCENTILE 70	23		
Nb OF MOV	21	35	67%
CALCULATED CAPACITY	33[7]	39	18%
DECLARED - CALCULATED	10		

Table 9: LEMDREN comparison results

[7] Declared capacity value as used: 43

The number of runs regarding LEMDREN is quite representative in order to establish a feasible capacity (39). Here are listed the main results comparison:

- The complexity **has been increased in 28%** compared with 2008 situation. This result in reasonable taking into account the existence of conventional and P-RNAV procedures, Getafe and Torrejón procedures as well cohabiting in the same airspace.
- The complexity per movement within this airspace **has been reduced in a 24%** compared with 2008. This is a good figure knowing that the procedures designs are simpler and more intuitive.
- The coordination actions per movements **have been reduced in 47%** compared to 2008. This shows that with this new scenarios there is no much need in coordinate with collateral sectors, being at every moment situational aware of what is going on in the scenario
- The actions per movements **have been reduced** within this airspace jurisdiction in a **13%.** This is one of the most important figures now that in the critical area known as director, the number of actions that ATCs have to performed have been reduced
- The usage of radar vectoring **has been reduced in a 92%.** One of the main goals of the project was to reduce radar vectoring but maintaining it in case of emergency. This figure shows that even though the ATCs have to back up with radar vectoring usage, it has been reduced in over 90/ of them.
- The workload **has been increased in a 34%** compared to 2008 within external sectors jurisdiction. This is a comprehensive number due to the increase of complexity in the sector and the incremental capacity. This is a critical sector where the workload will be increased
- The number of movements **has been increased in a 34%**
- The calculated capacity **has been increased in 18%** compared to 2008.

4.2.3 Actual sector RWN

West Director Sector in North Configuration. The ATC service for this sector is provided from LECM (Air Traffic Control Centre of Madrid):

- TMA sector (FL 135 / GND)
- Declared capacity: 43 mov/hour
- Traffic in evolution (time): 100%

Hereby are listed the results obtained from 2008 report corresponding to this sector:

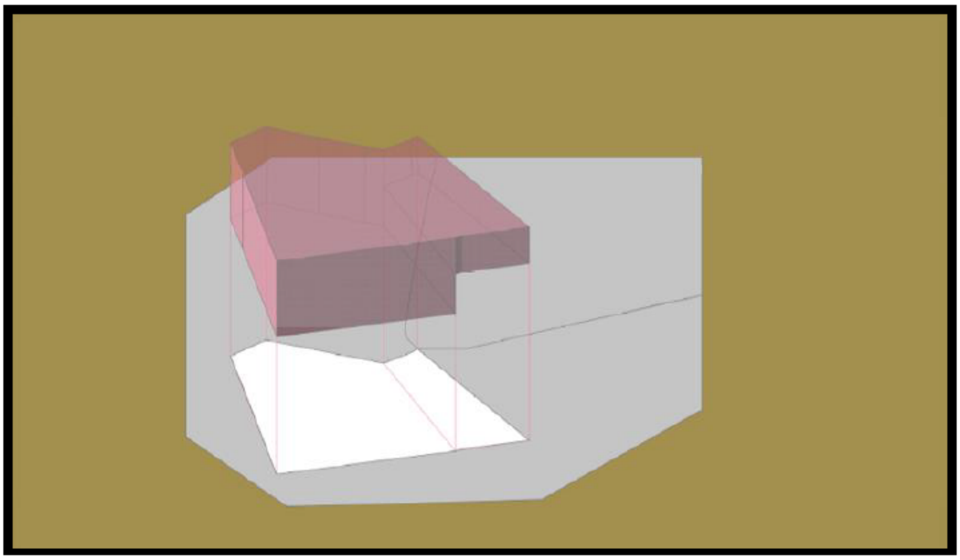


Figure 85: LEMDRWN graphical representation

DEPENDENCIA	LECM	AÑO DE ESTUDIO:	2008
SECTOR	LEMDRWN		

					Med.	Máx.
Complejidad	1232	Workload	1536	Aeronaves simultáneas	2.9	7.0
Tiempo en evolución (%)	100			Comunicaciones / 10 min.	19.2	36.4
Tiempo Medio de Vuelo (min)	8					

	1ª	2ª	3ª	4ª	5ª	6ª	7ª	8ª	9ª	10ª	11ª	12ª	13ª	14ª	15ª	Media
Actuaciones en imprevistos	0	0	0	0	0	0	0	0	0							0.0
Actuaciones en Salidas/Llegada	99	131	127	104	93	161	84	62	66							103.0
Actuaciones en Sobrevuelos	0	0	0	0	0	0	0	0	0							0.0
Vigilancia de Imprevistos	0	0	0	0	0	0	0	0	0							0.0
Vigilancia de Salidas/LLegadas	174	208	204	176	131	219	133	181	147							174.8
Vigilancia de Sobrevuelos	0	0	0	0	0	0	0	0	0							0.0
Act.sep/sec salidas/llegadas	14	21	13	14	15	24	19	9	21							16.7
Act.sep/sec sobrevuelos	0	0	0	0	0	0	0	0	0							0.0
Esperas	0	0	0	0	0	0	0	0	0							0.0
Nº de vuelos visuales	0	0	0	0	0	0	0	1	1							0.2
Coordinación	5	7	2	4	9	8	2	7	12							6.2
Coordinación en sistema	4	0	30	11	2	26	1	2	0							8.4
Guía Vectorial Imprevisto	0	0	0	0	0	0	0	0	0							0.0
Guía Vectorial Salida/LLegada	9	19	9	10	10	22	5	5	13							11.3
Guía Vectorial Sobrevuelo	0	0	0	0	0	0	0	0	0							0.0
Guía Vectorial Estándar (X)	1	1	3	1	0	0	1	0	0							0.8
Movimientos por Toma (IFR)	22	24	26	19	19	29	24	23	13							22.1

Fecha Toma	AB11	AB11	AB15	AB15	AB17	AB17	AG05	DI19	OC15
Día	V	V	M	M	J	J	M	V	X
Hora	07:33	11:01	07:35	08:36	08:58	10:18	09:40	10:26	10:37

Salidas	0.89	Llegadas	21.22	Nº Movimientos-Toma	22
Actuaciones por salida	2.15	Actuaciones por llegada	4.68	Actuaciones por Movimiento	4.67
Coordinaciones por salida	0.70	Coordinaciones por llegada	0.60	Coordinaciones por Movimiento	0.66
Guía Vectorial por salida	0.30	Guía Vectorial por llegada	0.56	Guía Vectorial por movimiento	0.56
Complejidad por salida	28.80	Complejidad por llegada	55.45	Complejidad por movimiento	55.66

Figure 86: LEMDRWN Spreadsheet runs

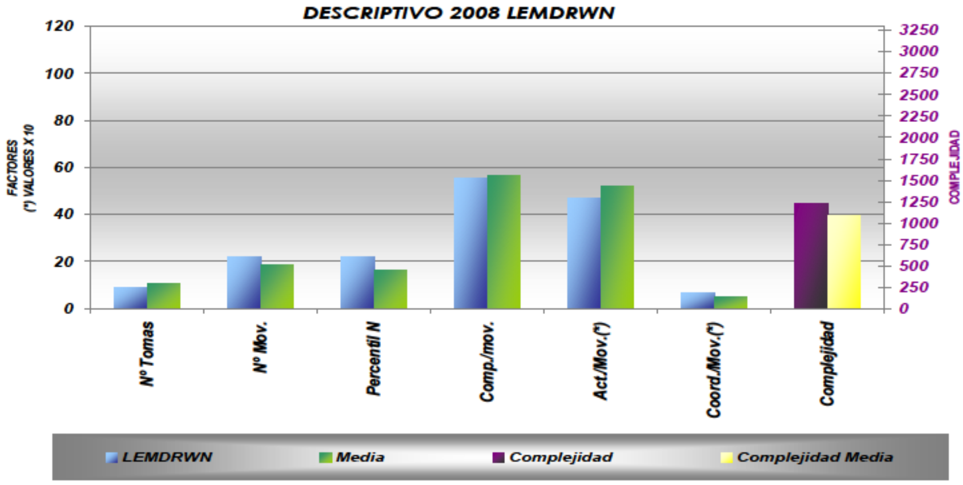


Figure 87: LEMDRWN Descriptive 2008

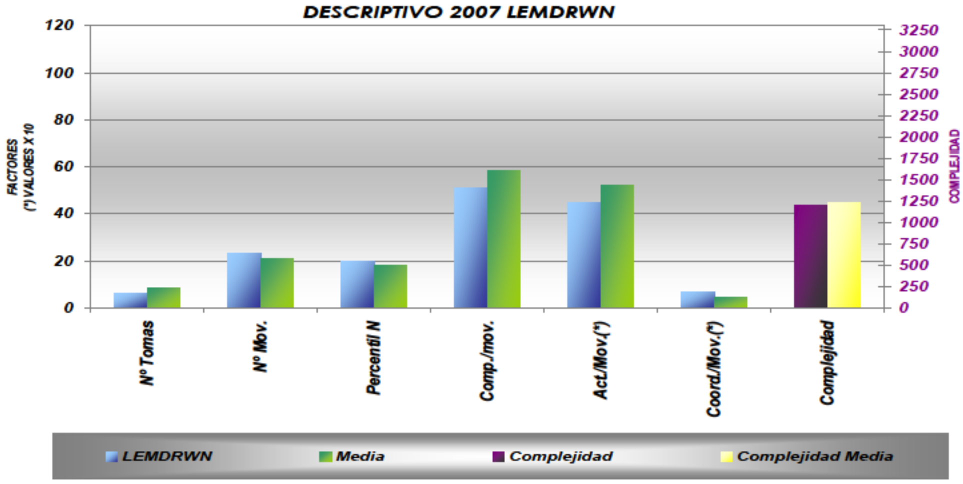


Figure 88: LEMDRWN Descriptive 2007

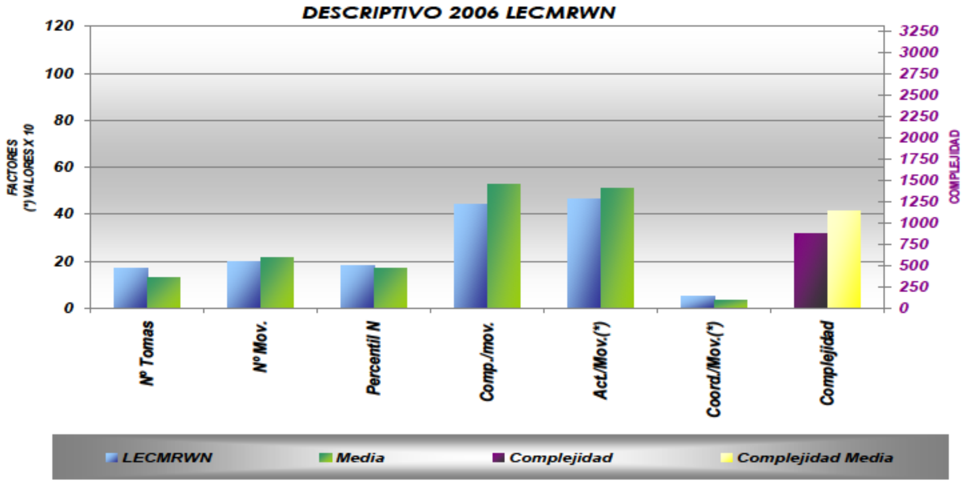


Figure 89: LEMDRWN Descriptive 2006

Here is shown the status diagram with the sector evolution till 2008. The average figures corresponds to the last 4 years runs:

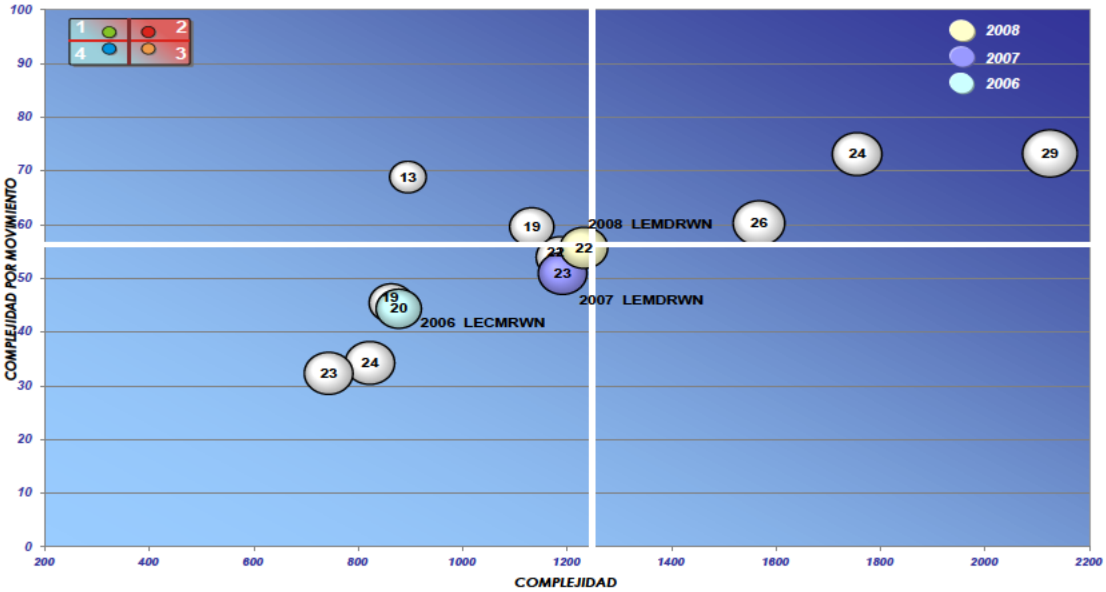


Figure 90: LEMDRWN Status

Finally, it is shown the calculated capacity of this sector where it can be noticed the tendency curve of the corresponding sector.

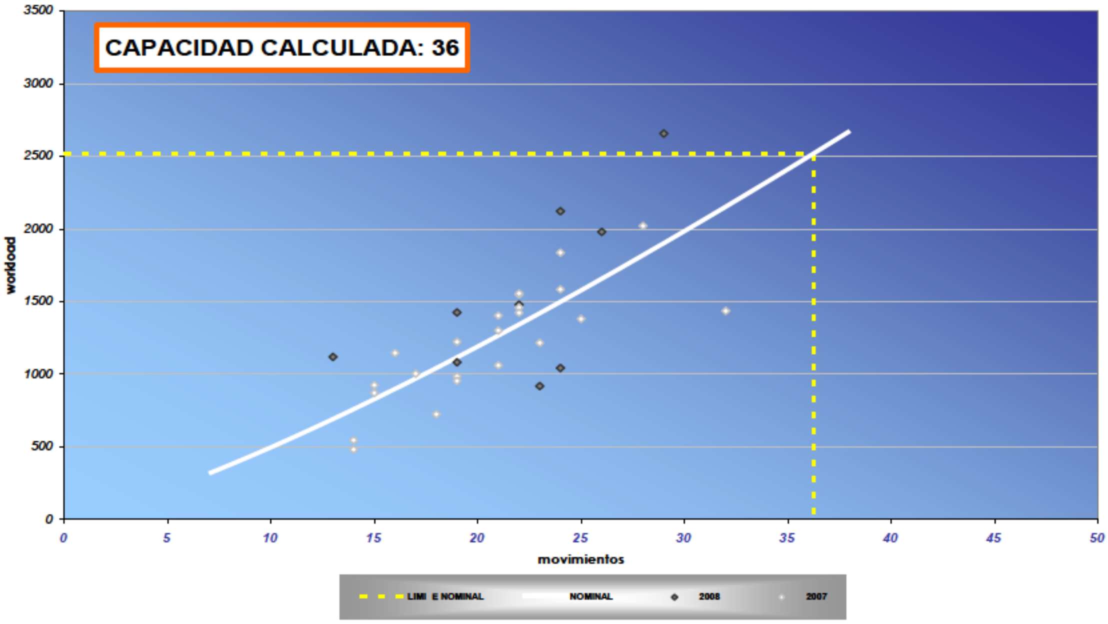


Figure 91: LEMDRWN Calculated capacity

Here are the results comparing the new situation with the previous one regarding LEMDRWN sector:

YEAR	2008	2011	Comparison results
SECTOR	LEMDRWN	REN	
GROUP	Feeder A	Director	
COMPLEXITY 	1231,9	1405	14%
COMPLEXITY/MOV 	55,66	35,50	-36%
CORRDINATIONS/MOV 	0,66	0,13	-80%
ACTIONS/MOV 	4,67	4,13	-12%
RADAR VECTORING/MOV 	0,56	0,03	-95%
WORKLOAD 	1536	1868	22%
PERCENTILE 70	22		
Nb OF MOV	22	38	73%
CALCULATED CAPACITY	36[8]	44	22%
DECLARED - CALCULATED	7		

Table 10: LEMDRWN comparison results

[8] Declared capacity value as used: 43

The number of runs regarding LEMDREN is quite representative in order to establish a feasible capacity (39). Here are listed the main results comparison:

- The complexity **has been increased in 14%** compared with 2008 situation. This result in reasonable taking into account the existence of conventional and P-RNAV procedures, Getafe and Torrejón procedures as well cohabiting in the same airspace.
- The complexity per movement within this airspace **has been reduced in a 36%** compared with 2008. This is a good figure knowing that the procedures designs are simpler and more intuitive.
- The coordination actions per movements **have been reduced in 80%** compared to 2008. This shows that with this new scenarios there is no much need in coordinate with collateral sectors, being at every moment situational aware of what is going on in the scenario
- The actions per movements **have been reduced** within this airspace jurisdiction in a **12%.** This is one of the most important figures now that in the critical area known as director, the number of actions that ATCs have to performed have been reduced
- The usage of radar vectoring **has been reduced in a 95%.** One of the main goals of the project was to reduce radar vectoring but maintaining it in case of emergency. This figure shows that even though the ATCs have to back up with radar vectoring usage, it has been reduced in over 90/ of them.
- The workload **has been increased in a 22%** compared to 2008 within external sectors jurisdiction. This is a comprehensive number due to the increase of complexity in the sector and the incremental capacity. This is a critical sector where the workload will be increased
- The number of movements **has been increased in a 73%**
- The calculated capacity **has been increased in 22%** compared to 2008.
- The results are basically the same compared with REN. Complexity is increased due to the different procedures in the sector (P-RNAV, conventional, military, etc).

4.2.4 Actual sector AIN

Initial Approach Sector in North Configuration. The ATC service for this sector is provided from LECM (Air Traffic Control Centre of Madrid):

- TMA sector (FL 70 / GND)
- Declared capacity: 48 mov/hour
- Traffic in evolution (time): 100%

Hereby are listed the results obtained from the 2008 report corresponding to this sector (compared also with 2007 and 2006 descriptive figures). This is one of the most difficult sectors to compare to. Nowadays, the current arrivals in Madrid-Barajas are segregated, implying a unique single sector of Initial Approach for both runways. Now, 5.7.4 wants to implement independent parallel runways, with one final approach sector for each runway (AFEN & AFWN). There is a need to establish the NTZ (NO transgression zone) in order to assure the safety of the independent arrivals.

The only scenario where we could compare KPIs is when one runway is declared closed and there is a need to integrate both initial approach sectors (SCN-005).

Here is where the main difference in cost-benefit from ANSP perspective will be, when ANSP has to decide between ATC hour cost and number of movement benefit. Here is presented how the initial approach sector integrated and its figures is:

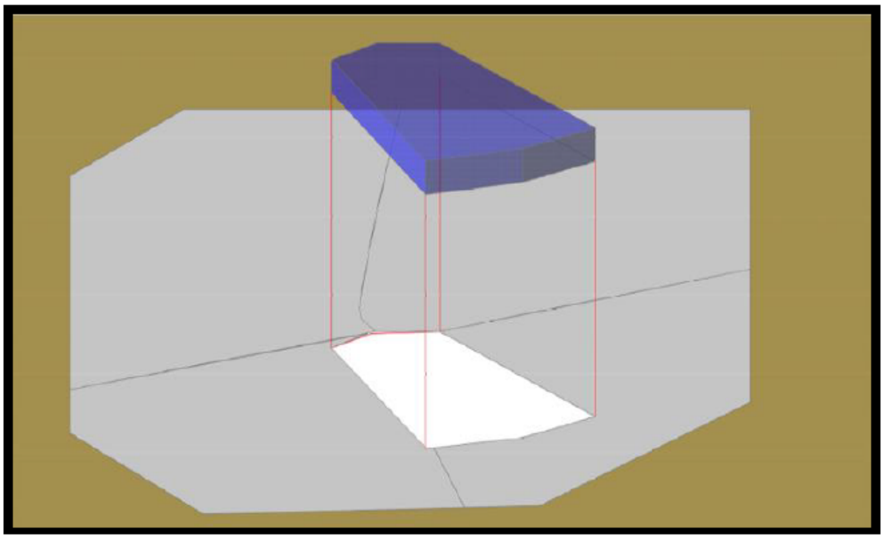


Figure 92: LEMDAIN graphical representation

DEPENDENCIA	LECM		AÑO DE ESTUDIO:	2008	
SECTOR	LEMDAIN				
				Med.	Máx.
Complejidad	2253	Workload 1847	Aeronaves simultáneas	2.9	6.0
Tiempo en evolución (%)	100		Comunicaciones / 10 min.	27.9	42.4
Tiempo Medio de Vuelo (min)	5				

	1ª	2ª	3ª	4ª	5ª	6ª	7ª	8ª	9ª	10ª	11ª	12ª	13ª	14ª	15ª	Media
Actuaciones en imprevistos	0	0	0	0	0	0	0	0	0							0.0
Actuaciones en Salidas/Llegada	219	163	189	205	118	86	130	161	169							160.0
Actuaciones en Sobrevuelos	0	0	0	0	0	0	0	0	0							0.0
Vigilancia de Imprevistos	0	0	0	0	0	0	0	0	0							0.0
Vigilancia de Salidas/LLegadas	226	178	196	241	127	108	186	137	169							174.2
Vigilancia de Sobrevuelos	0	0	0	0	0	0	0	0	0							0.0
Act.sep/sec salidas/llegadas	0	0	0	60	17	12	20	8	19							15.1
Act.sep/sec sobrevuelos	0	0	0	0	0	0	0	0	0							0.0
Esperas	0	0	0	0	0	0	0	0	0							0.0
Nº de vuelos visuales	0	0	0	0	0	0	0	0	0							0.0
Coordinación	1	0	0	3	0	0	1	2	2							1.0
Coordinación en sistema	0	6	4	1	20	0	2	15	9							6.3
Guía Vectorial Imprevisto	0	0	0	0	0	0	0	0	0							0.0
Guía Vectorial Salida/LLegada	76	42	58	32	22	13	20	55	46							40.4
Guía Vectorial Sobrevuelo	0	0	0	0	0	0	0	0	0							0.0
Guía Vectorial Estándar (X)	46	39	44	53	28	11	26	31	34							34.7
Movimientos por Toma (IFR)	47	41	44	52	29	21	28	29	36							36.3

Fecha Toma	AB15	AB15	AB15	AG07	AG31	OC11	OC12	OC15	OC16
Día	M	M	M	J	D	S	D	X	J
Hora	07:50	08:50	09:50	07:49	09:35	13:50	10:08	10:51	08:45

Salidas	0.00	Llegadas	36.33	Nº Movimientos-Toma	36
Actuaciones por salida	0.00	Actuaciones por llegada	4.44	Actuaciones por Movimiento	4.44
Coordinaciones por salida	0.00	Coordinaciones por llegada	0.22	Coordinaciones por Movimiento	0.22
Guía Vectorial por salida	0.00	Guía Vectorial por llegada	2.02	Guía Vectorial por movimiento	2.02
Complejidad por salida	0.00	Complejidad por llegada	61.06	Complejidad por movimiento	61.06

Figure 93: LEMDAIN Spreadsheet runs

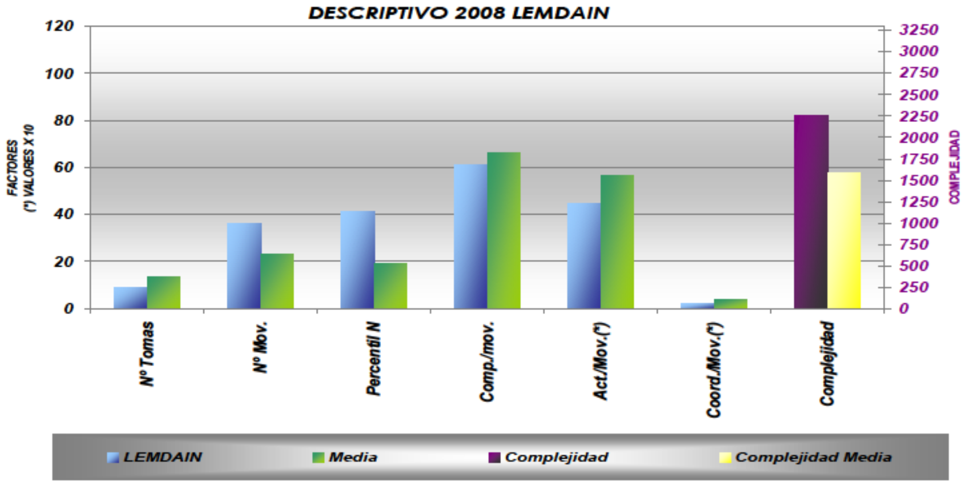


Figure 94: LEMDAIN Descriptive 2008

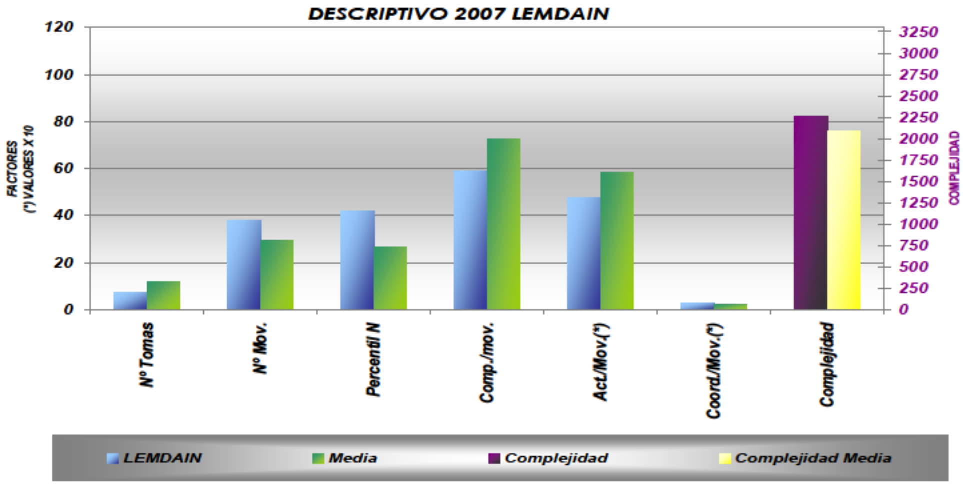


Figure 95: LEMDAIN Descriptive 2007

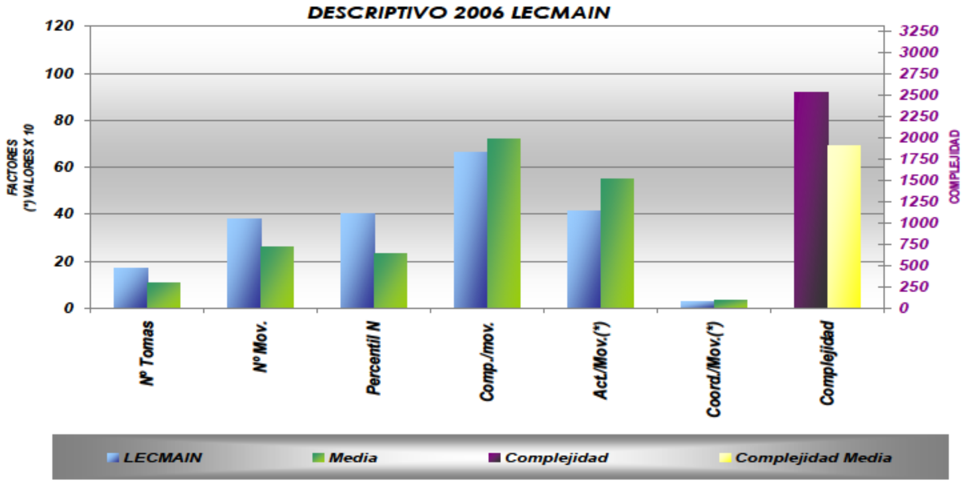


Figure 96: LEMDAIN Descriptive 2006

Here is shown the status diagram with the sector evolution till 2008. The average figures corresponds to the last 4 years runs:

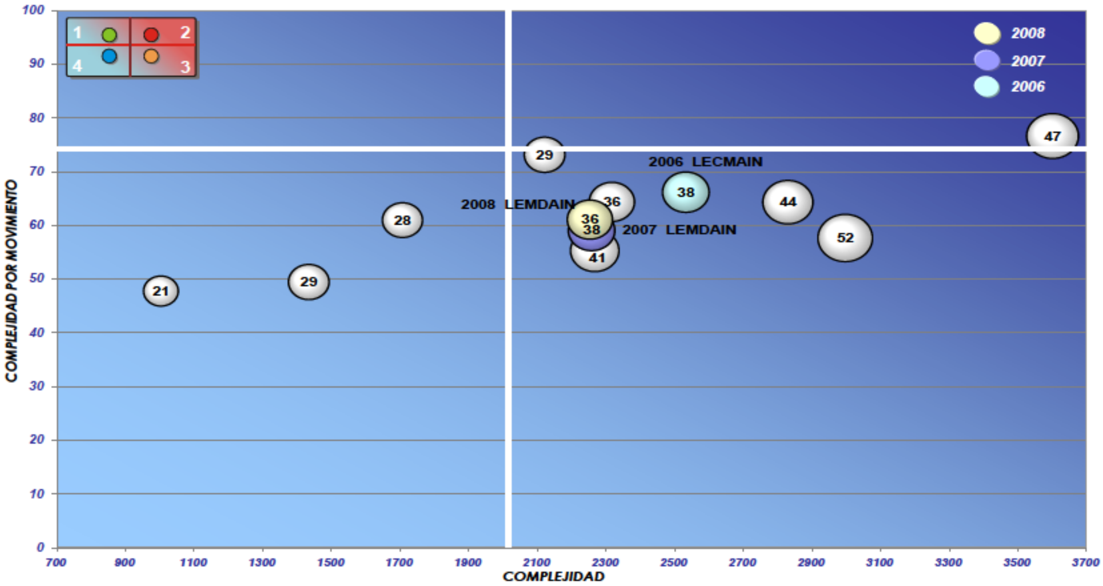


Figure 97: LEMDAIN Status

Finally, it is shown the calculated capacity of this sector where it can be noticed the tendency curve of the corresponding sector.

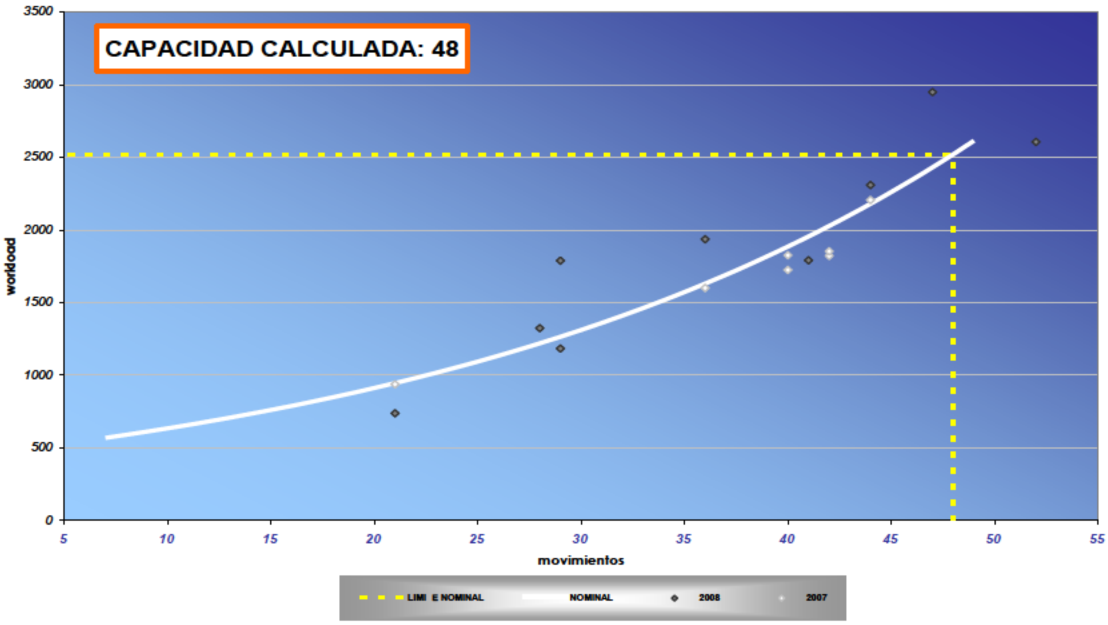


Figure 98: LEMDAIN Calculated capacity

During the validation exercises there were some of the exercises related with one single runway operations where the final approach sectors were integrated in one single controlling position. The difficulty arrives when there were not enough runs to establish a feasible declared capacity. It is impossible to compare KPIs because they are completely different configurations: 2 dependent parallel runways with one single initial approach sector and one single final approach sector; and 2 independent parallel runways with two initial approach sectors and one NTZ sector:

YEAR	2008	2011	2011	2011
SECTOR	LEMDAIN	AFEN	AFWN	NTZ
RUNWAYS	33R/33L	33R	33L	33R/33L
GROUP	Final	Final	Final	N/A
COMPLEXITY 	2253	1207	1476	N/A
COMPLEXITY/MOV 	61,06	35,56	40,05	N/A
CORRDINATIONS/MOV 	0,22	0,11	0,04	N/A
ACTIONS/MOV 	4,44	3,56	3,06	N/A
RADAR VECTORING/MOV 	2,02	0,14	0,04	N/A
WORKLOAD 	1847	806	979	N/A
PERCENTILE 70	41			N/A
Nb OF MOV	36	34	35	N/A
CALCULATED CAPACITY	48[9]	50	47	N/A
DECLARED - CALCULATED	0			N/A

Table 11: LEMDAIN, AFEN & AFWN results

[9] Declared capacity value as used: 48

The number of runs regarding LEMDREN is quite representative in order to establish a feasible capacity (39). Here are listed the main results comparison:

- The usage of radar vectoring per movement **has been reduced to 0,04 – 0,14.**
- The workload **has been decreased in 47 - 57%. The number of ATCs has been changed from one single initial approach position and one final approach position (executive + planner) to 2 final approach positions (executive + planner) and 1 NTZ controller.**
- The number of movements **has been increased from 36 (2 Dependent PARALLEL RUNWAYS) to 34 + 35 (2 Independent PARALLEL RUNWAYS)**
- The calculated capacity **has been increased from 48 (2 Dependent PARALLEL RUNWAYS) to 50 + 47 (2 Independent PARALLEL RUNWAYS)**
- The results are incomparable and the adding expression has to be taking as a mathematical complex operation and not the basic adding operation.

4.2.5 Sector LECMDEN

East Departures in North Configuration. The ATC service for this sector is provided from LECM (Air Traffic Control Centre of Madrid):

- TMA sector (FL 160 / GND)
- Declared capacity: 49 mov/hour
- Traffic in evolution (time): 98%

Hereby are listed the results obtained from 2006 report corresponding to this sector:

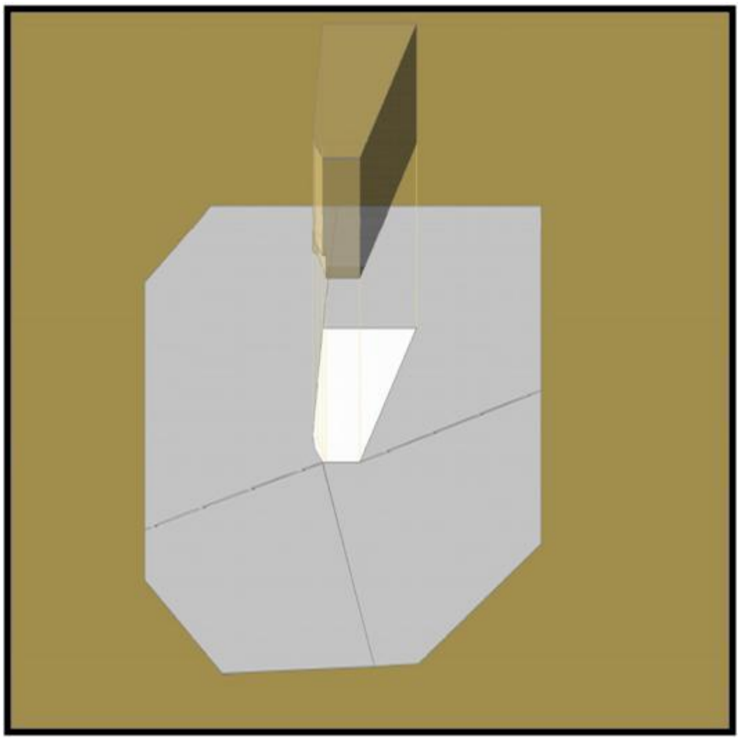


Figure 99: LECMDEN graphical representation

DEPENDENCIA	LECM		AÑO DE ESTUDIO:	2006	
SECTOR	LECMDEN			Med.	Max.
Complejidad	645	Workload 851	Aeronaves simultáneas	1.9	6.0
Tiempo en evolución (%)	98		Comunicaciones / 10 min.	13.8	28.0
Tiempo Medio de Vuelo (min)	5				

CAMPOS	1ª	2ª	3ª	4ª	5ª	6ª	7ª	8ª	9ª	10ª	11ª	12ª	13ª	14ª	15ª	Media
Actuaciones en imprevistos	0	0	0	0	0	0	0	0	0	0						0.0
Actuaciones en Salidas/Llegada	48	84	44	59	58	50	80	86	71	70						65 0
Actuaciones en Sobrevuelos	0	0	0	0	0	2	0	0	0	0						0.2
Vigilancia de Imprevistos	0	0	0	0	0	0	0	0	0	0						0.0
Vigilancia de Salidas/LLegadas	73	142	87	113	109	93	99	112	146	142						111.6
Vigilancia de Sobrevuelos	0	0	0	0	0	24	0	0	0	0						2.4
Act.sep/sec salidas/llegadas	4	8	2	8	2	2	5	4	3	1						3.9
Act.sep/sec sobrevuelos	0	0	0	0	0	0	0	0	0	0						0.0
Esperas	0	0	0	0	0	0	2	0	0	0						0.2
Nº de vuelos visuales	0	0	0	0	0	0	0	0	0	0						0.0
Coordinación	9	8	7	10	11	6	27	21	17	27						14 3
Coordinación en sistema	1	1	0	0	3	2	3	0	0	0						1.0
Guia Vectorial Imprevisto	0	0	0	0	0	0	0	0	0	0						0.0
Guía Vectorial Salida/LLegada	1	6	0	0	0	0	9	8	3	2						2.9
Guía Vectorial Sobrevuelo	0	0	0	0	0	1	0	0	0	0						0.1
Guia Vectorial Estándar (X)	0	0	0	0	0	1	0	0	0	0						0.1
Movimientos por Toma (IFR)	15	29	18	22	26	23	22	25	23	21						22 0
Fecha Toma	OC06	OC06	OC06	OC06	OC09	OC09	OC09	OC09	OC09	OC09						
Día	V	V	V	V	L	L	L	L	L	L						
Hora	06:33	07:33	09:19	10:19	06:47	07:48	09:43	10:44	14:00	15:00						

Salidas	20.6	LLegadas	1.8	Nº Movimientos-Toma	22
Actuaciones por salida	2.79	Actuaciones por llegada	2.77	Actuaciones por Movimiento	2.92
Coordinaciones por salida	0.46	Coordinaciones por llegada	2.16	Coordinaciones por Movimiento	0.69
Guía Vectorial por salida	0.11	Guía Vectorial por llegada	0.14	Guía Vectorial por movimiento	0.13
Complejidad por salida	27.0	Complejidad por llegada	28.1	Complejidad por movimiento	28.7

Figure 100: LECMDEN Spreadsheet runs

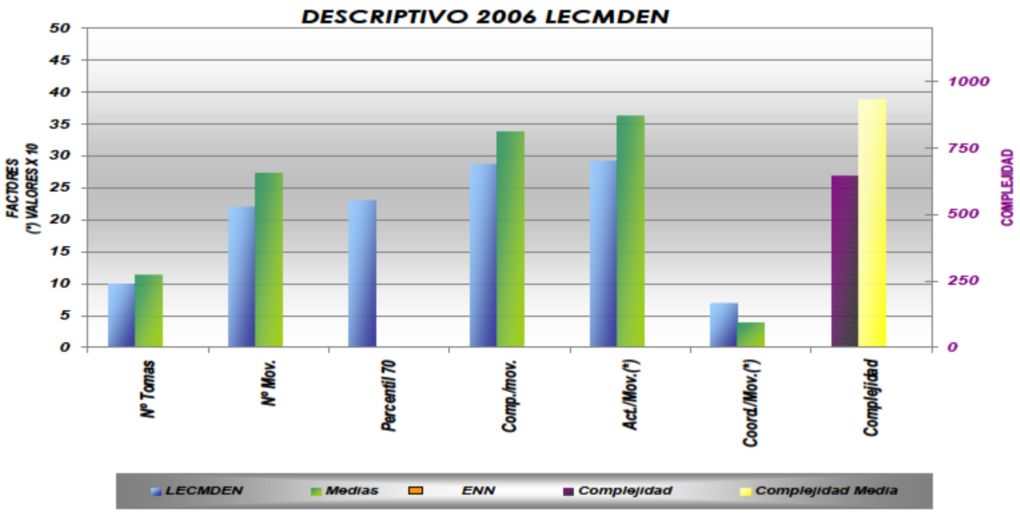


Figure 101: LEMDRWN Descriptive 2006

Here is shown the status diagram with the sector evolution till 2008. The average figures corresponds to the last 4 years runs:

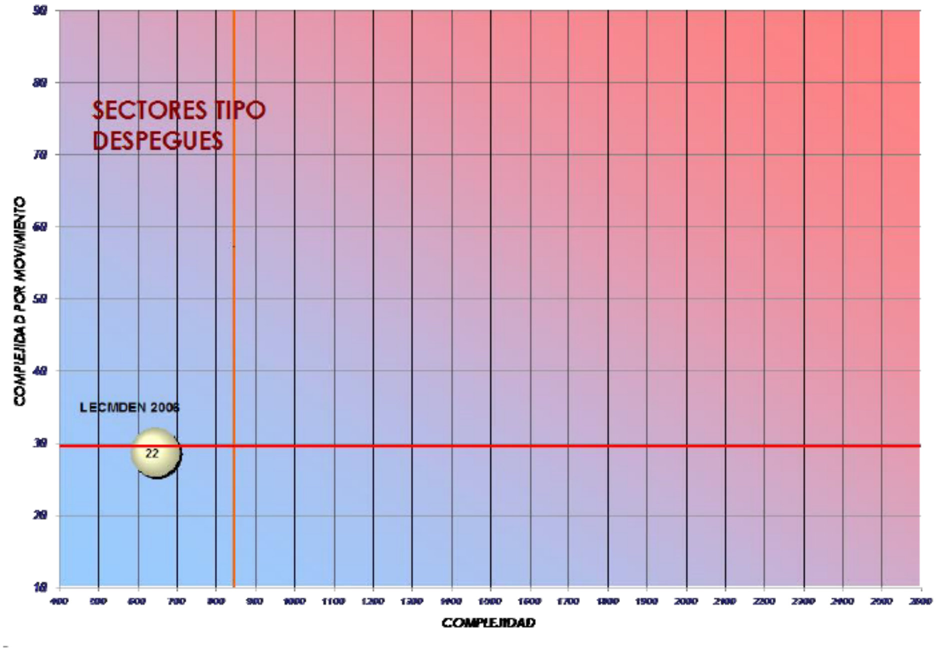


Figure 102: LECMDEN Status

Finally, it is shown the calculated capacity of this sector where it can be noticed the tendency curve of the corresponding sector.

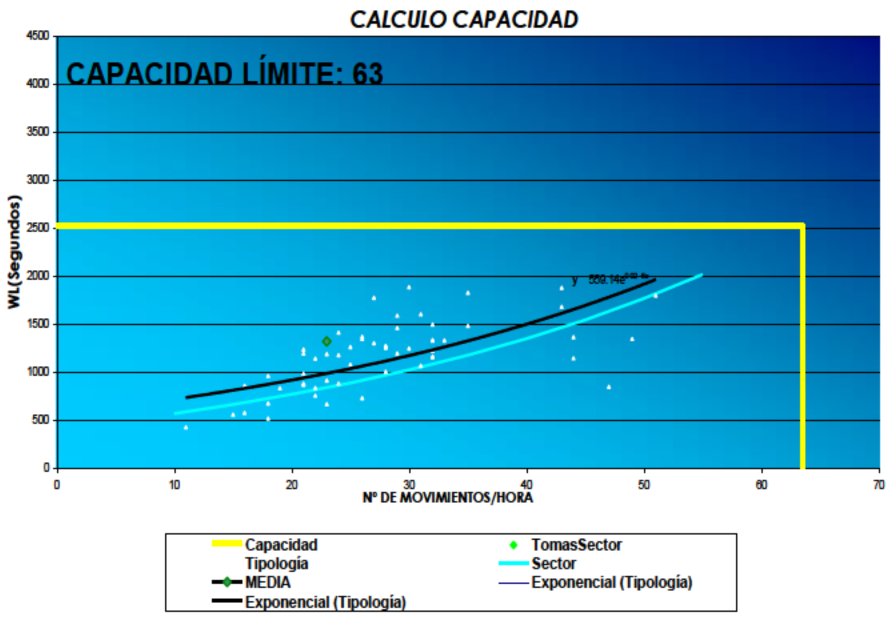


Figure 103: LECMDEN Calculated capacity

Here are the results comparing the new situation with the previous one regarding LECMDEN sector:

YEAR	2006	2011	Comparison results
SECTOR	LECMDEN	DIN	
GROUP	Departures	Departures	
COMPLEXITY 	644,5	462	-28%
COMPLEXITY/MOV 	28,65	13,56	-53%
CORRDINATIONS/MOV 	0,69	0,03	-96%
ACTIONS/MOV 	2,92	1,49	-49%
RADAR VECTORING/MOV 	0,13	0	Reduction to zero
WORKLOAD 	851	592	-30%
PERCENTILE 70	23		
Nb OF MOV	22	35	
CALCULATED CAPACITY	63[10]		
DECLARED - CALCULATED	-13		

Table 12: DIN comparison results

[10] Declared capacity value as used: 49

The number of runs regarding LEMDREN is quite representative in order to establish a feasible capacity (39). Here are listed the main results comparison:

- The complexity **has been decreased in 28%** compared with 2006 situation.
- The complexity per movement within this airspace **has been reduced in a 53%** compared with 2006. This is a good figure knowing that the procedures designs are simpler and more intuitive.
- The coordination actions per movements **have been reduced in 96%** compared to 2006. This shows that with these new scenarios there is no much need in coordinating with collateral sectors.
- The actions per movements **have been reduced** within this airspace jurisdiction in a **49%.**
- The usage of radar vectoring **has been reduced to zero.**
- The workload **has been decreased in a 30%** compared to 2008 within external sectors jurisdiction. This is a comprehensive number due to the increase of complexity in the sector and the incremental capacity. This is a critical sector where the workload will be increased
- The runs are not good enough in number to establish a feasible calculated capacity. It is recommended to re-run the NORVASE data pick-up of this sector.

Here is represented the comparative figures in graphical terms where it can be observed the difference in volumetric terms, geometry, location and sector configuration and how this affect to the final results of the validation:

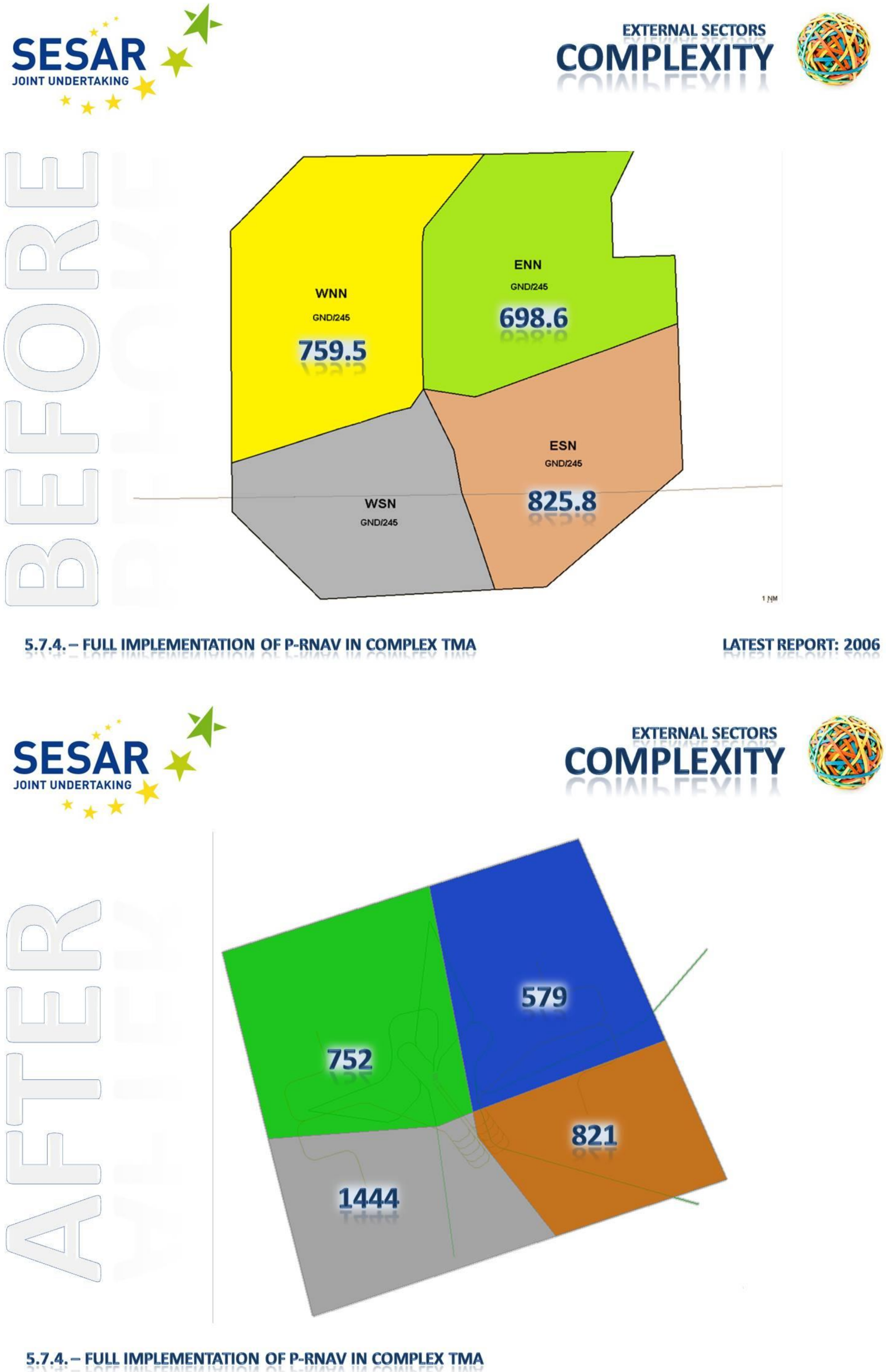
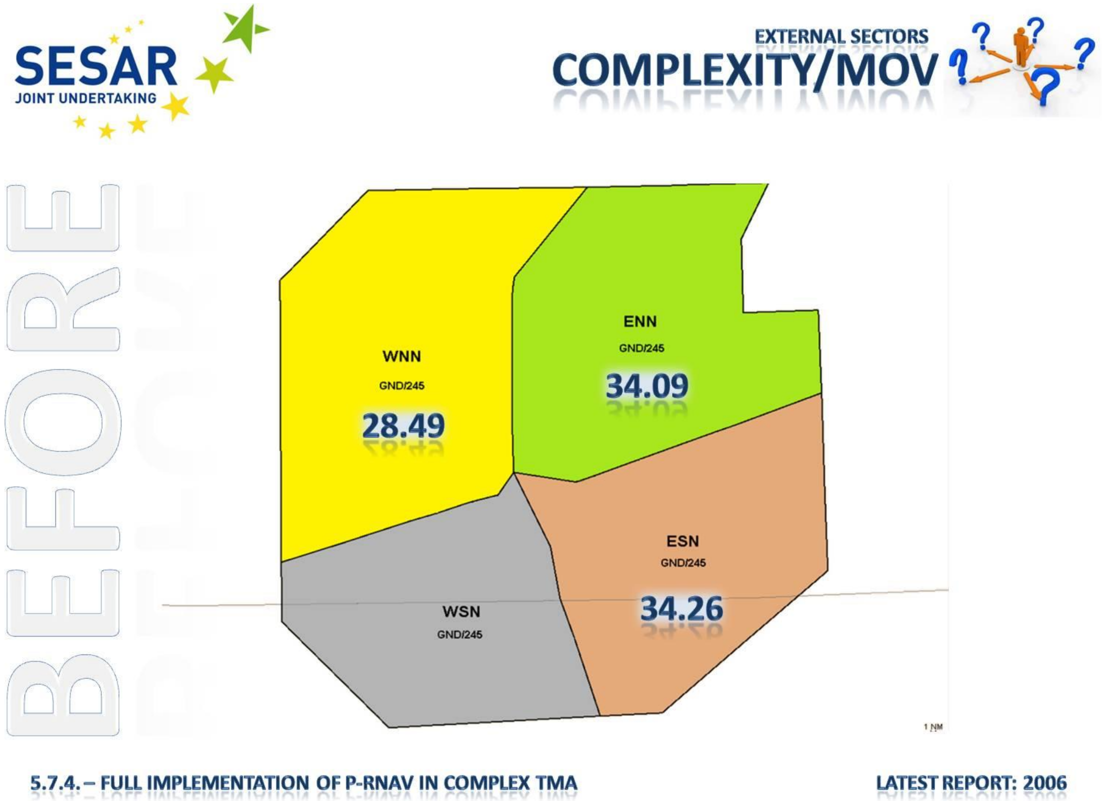


Figure 104: Complexity comparative results – External sectors



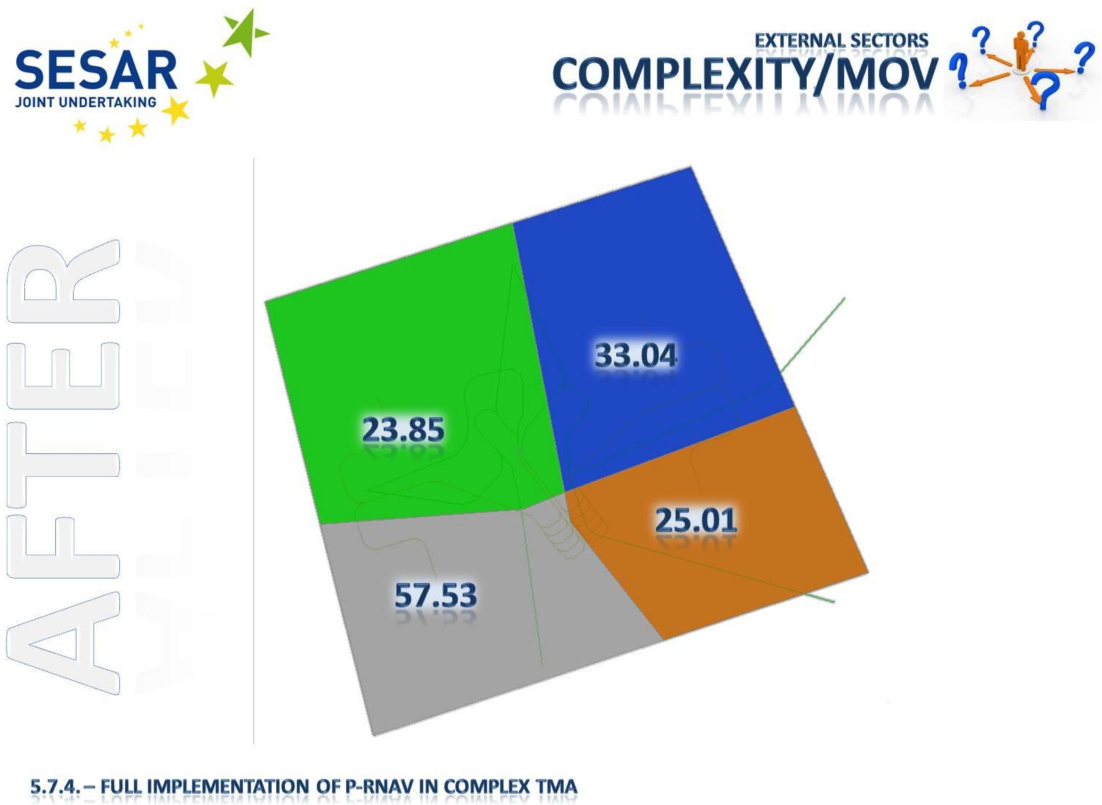
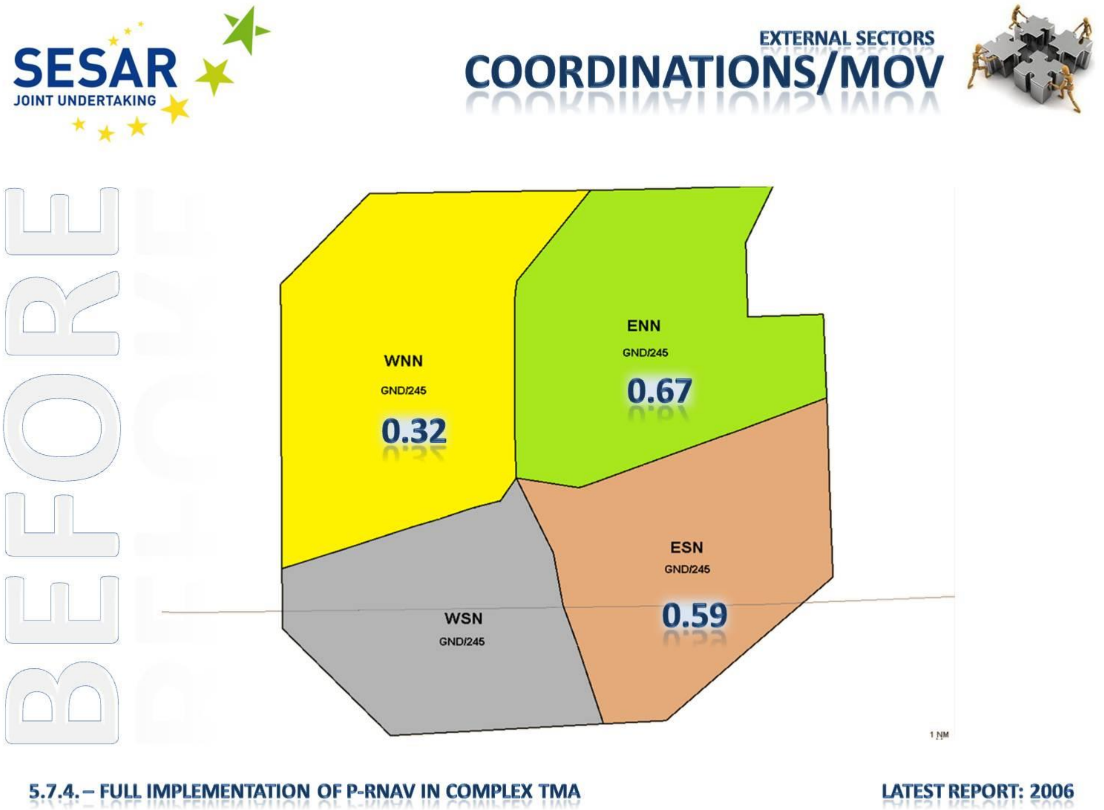


Figure 105: Complexity/mov comparative results – External sectors



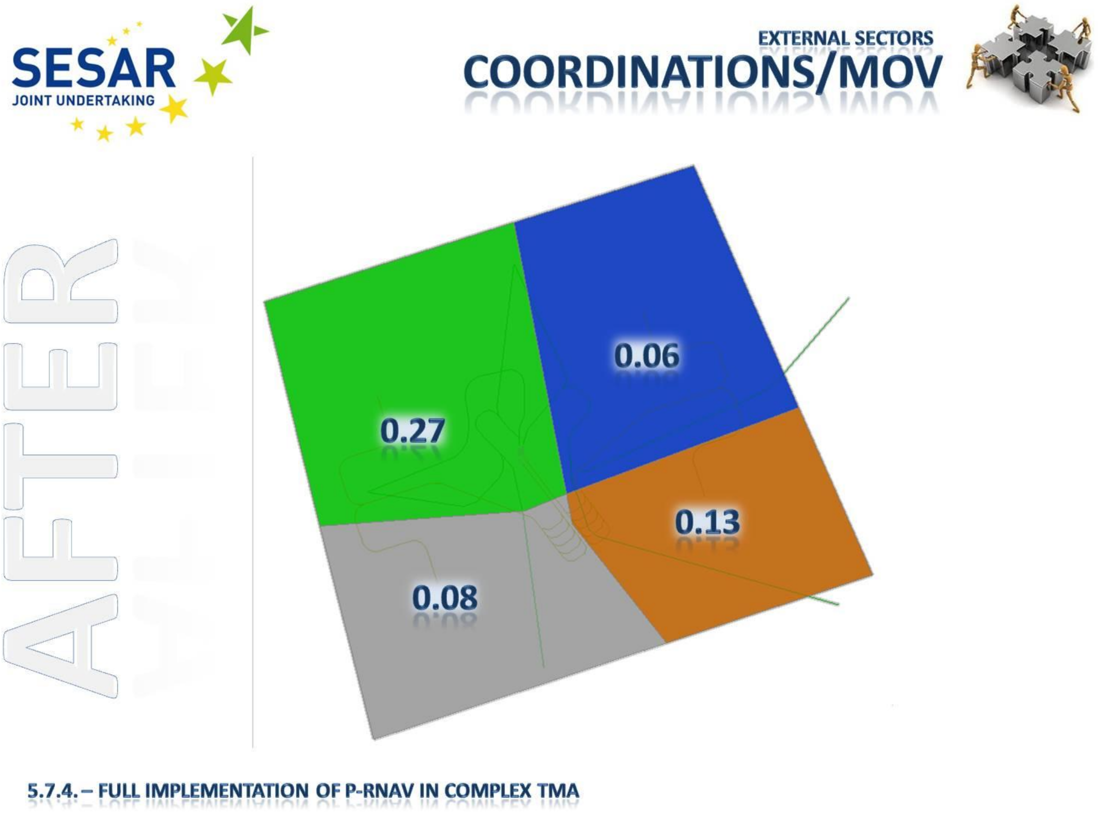
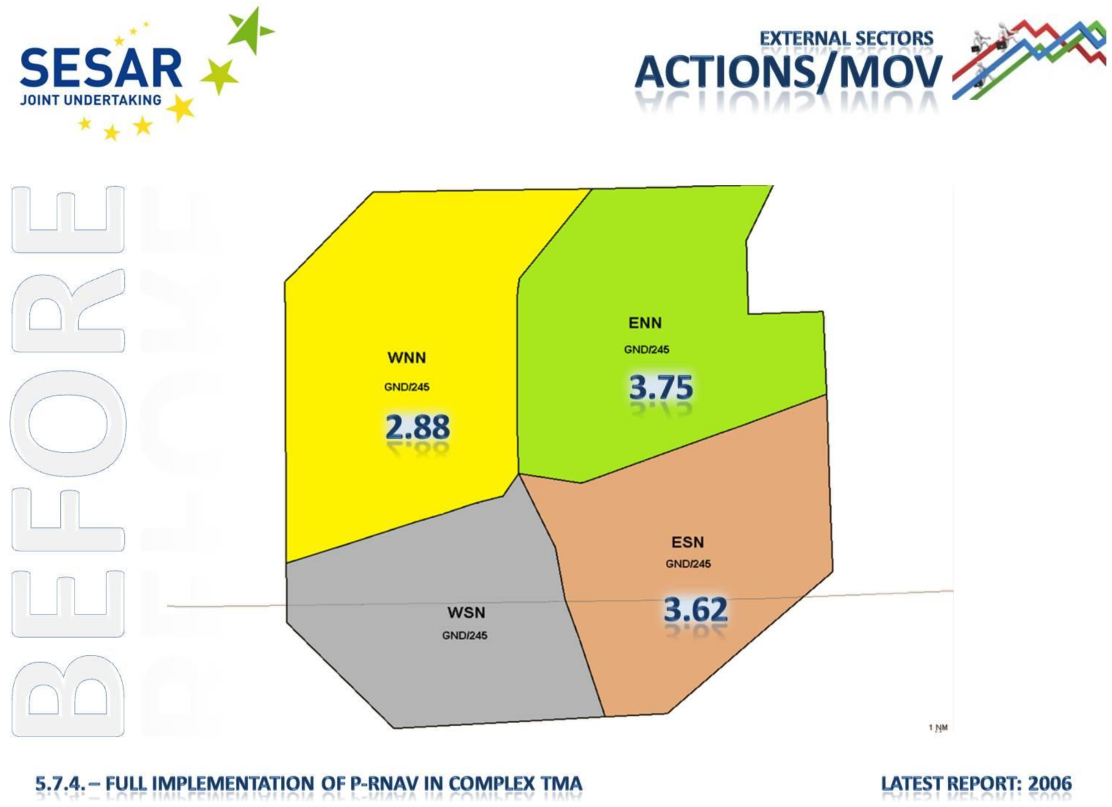


Figure 106: Coordinations/mov comparative results – External sectors



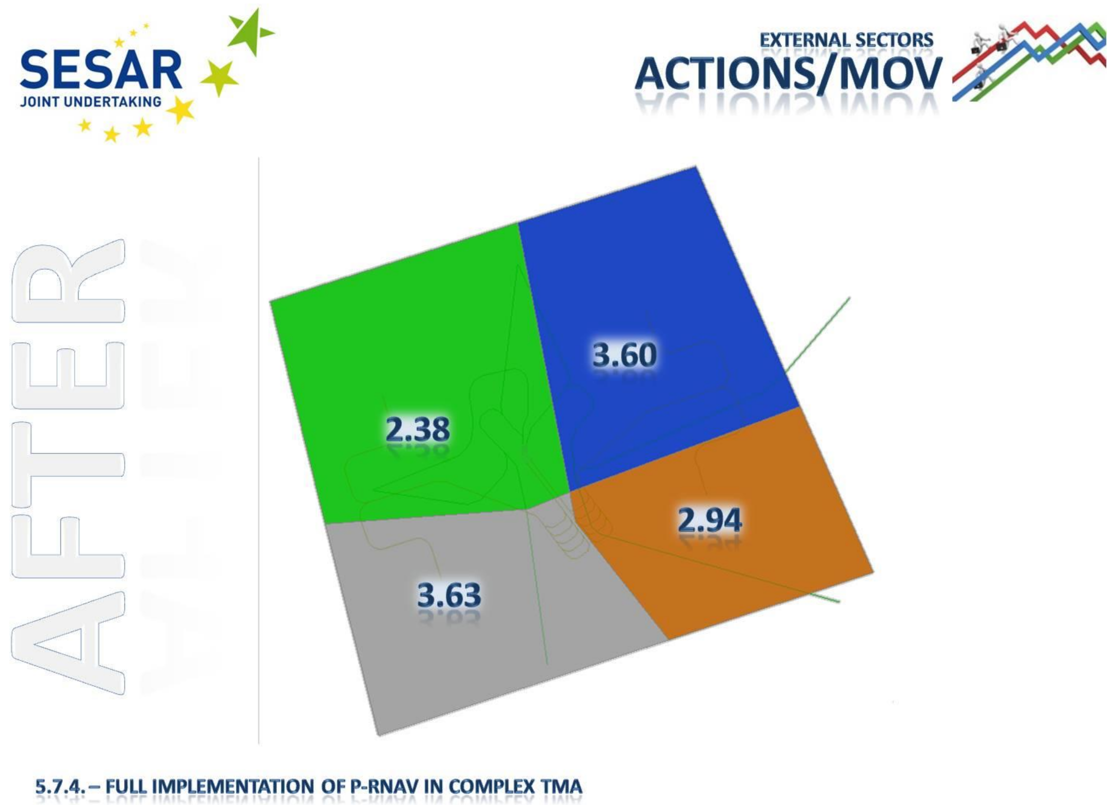
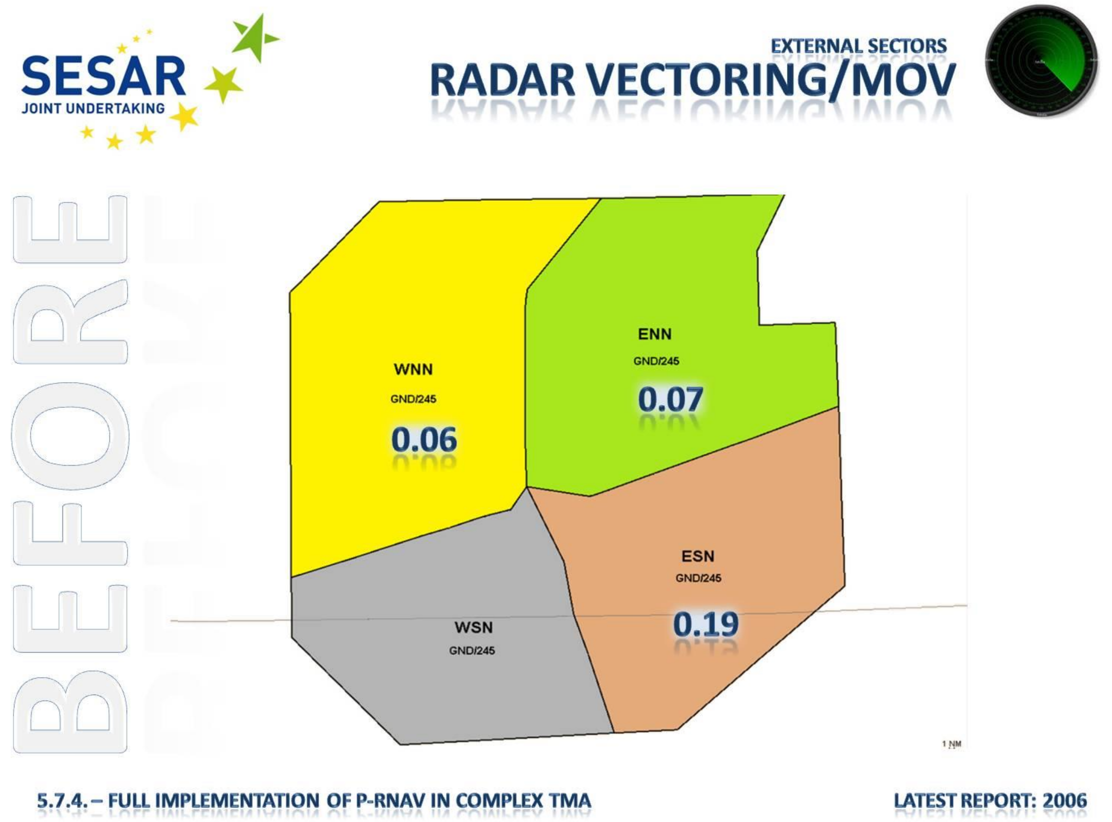


Figure 107: Actions/mov comparative results – External sectors



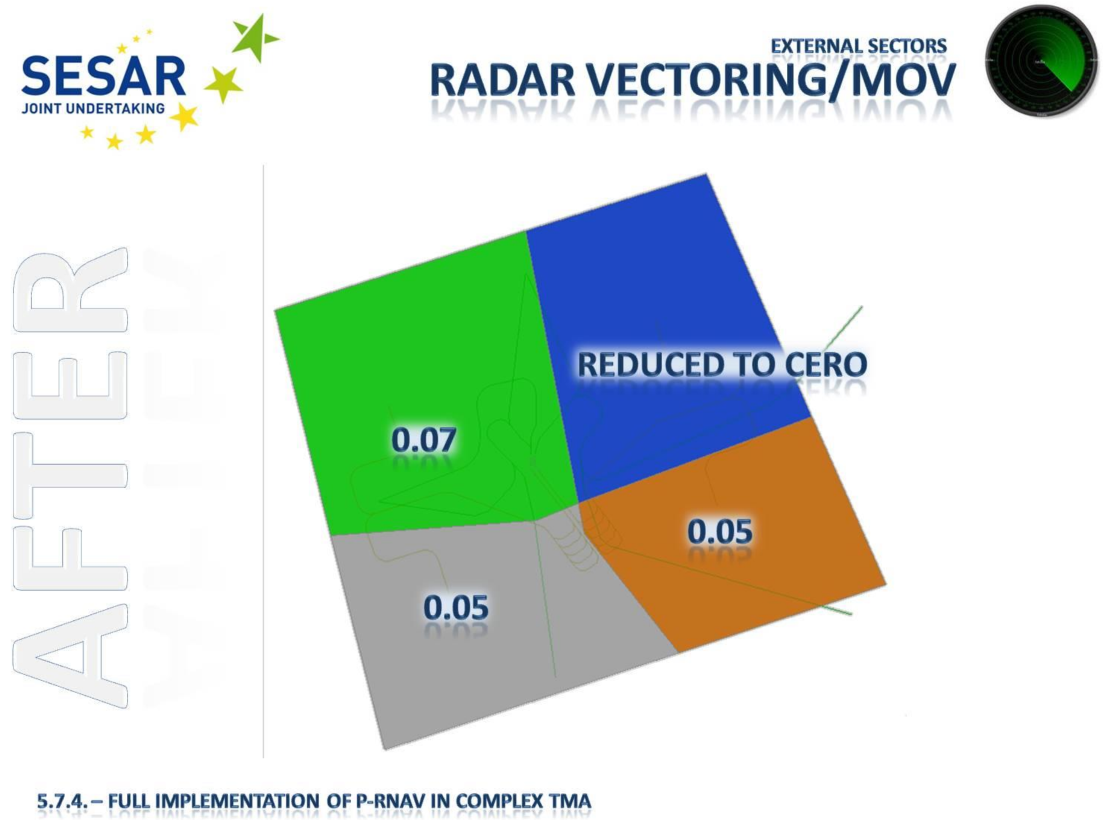
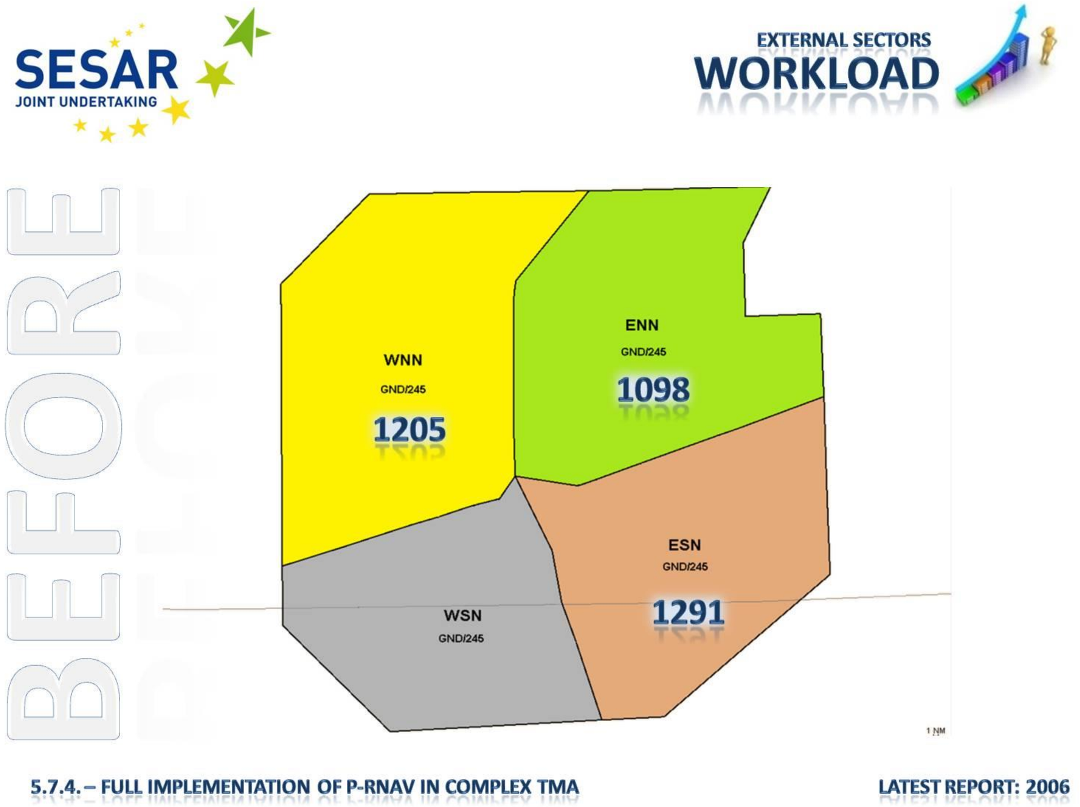


Figure 108: Radar vectoring/mov comparative results – External sectors



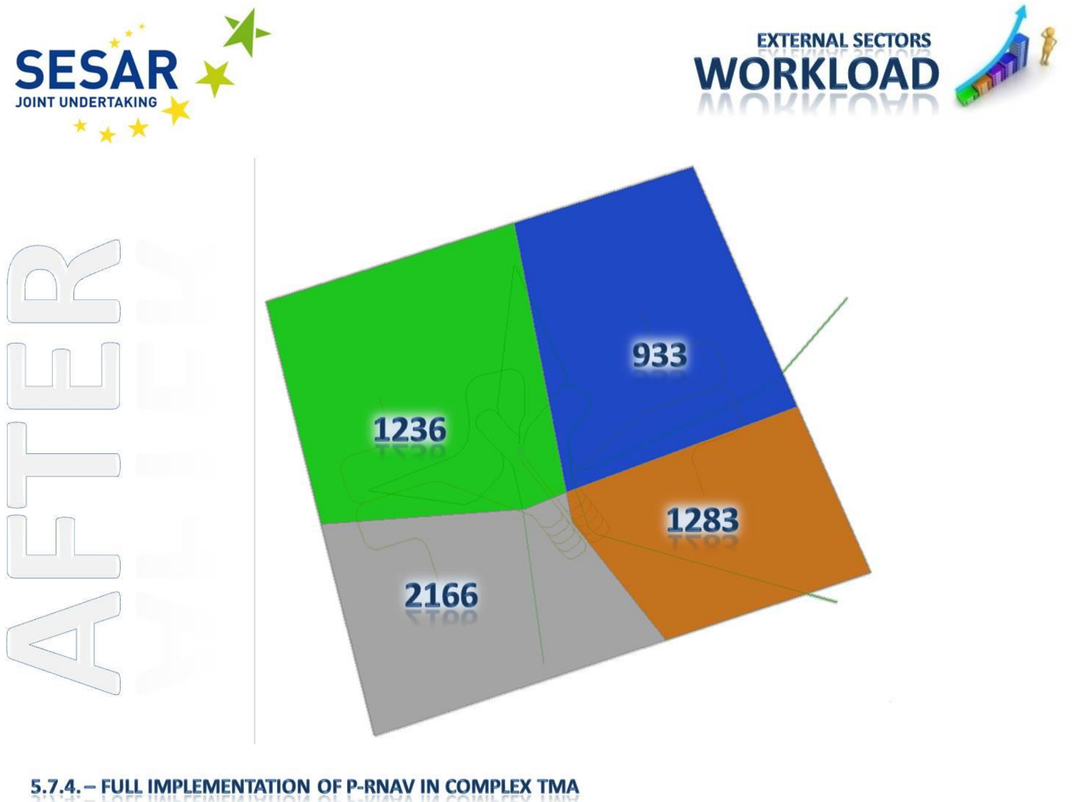
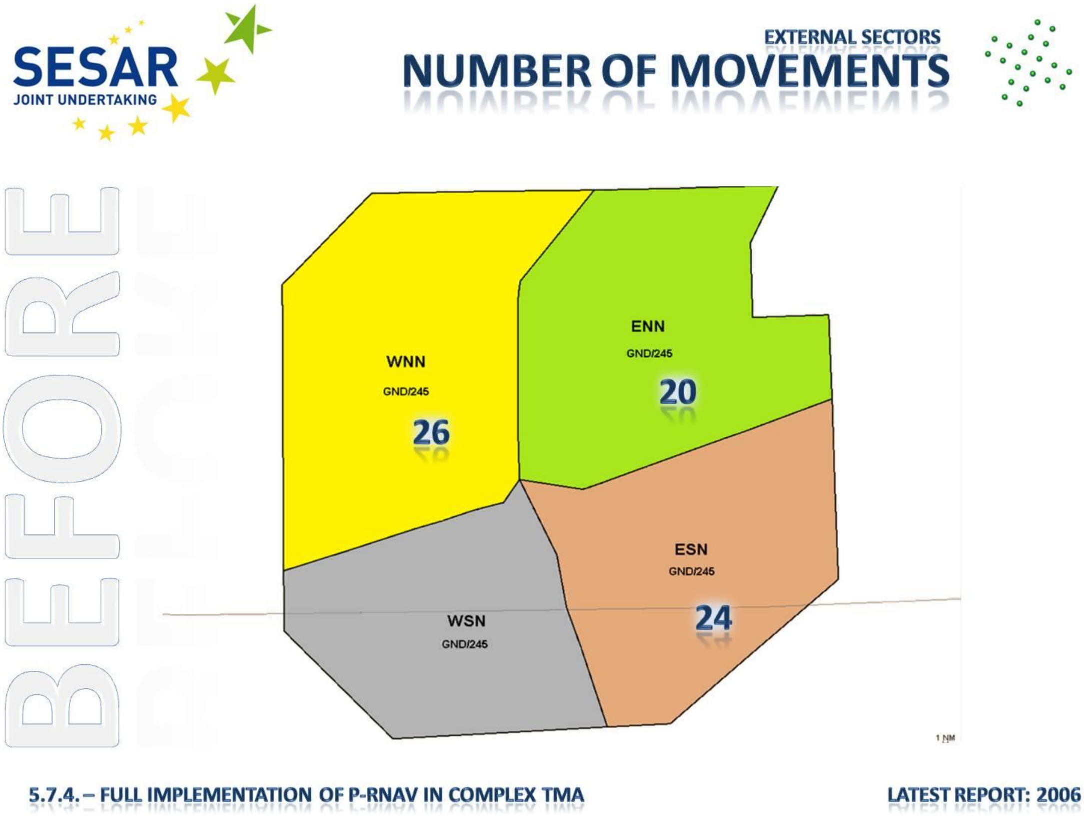


Figure 109: Workload comparative results – External sectors



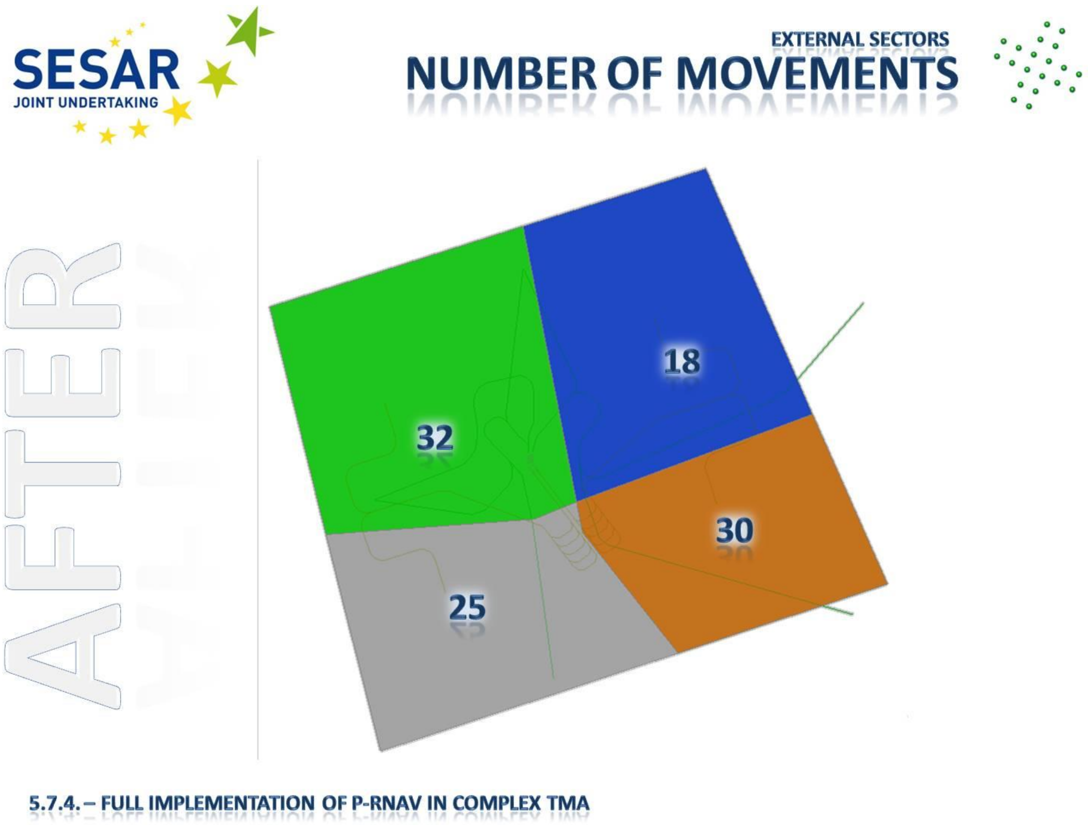


Figure 110: Nb of movements comparative results – External sectors

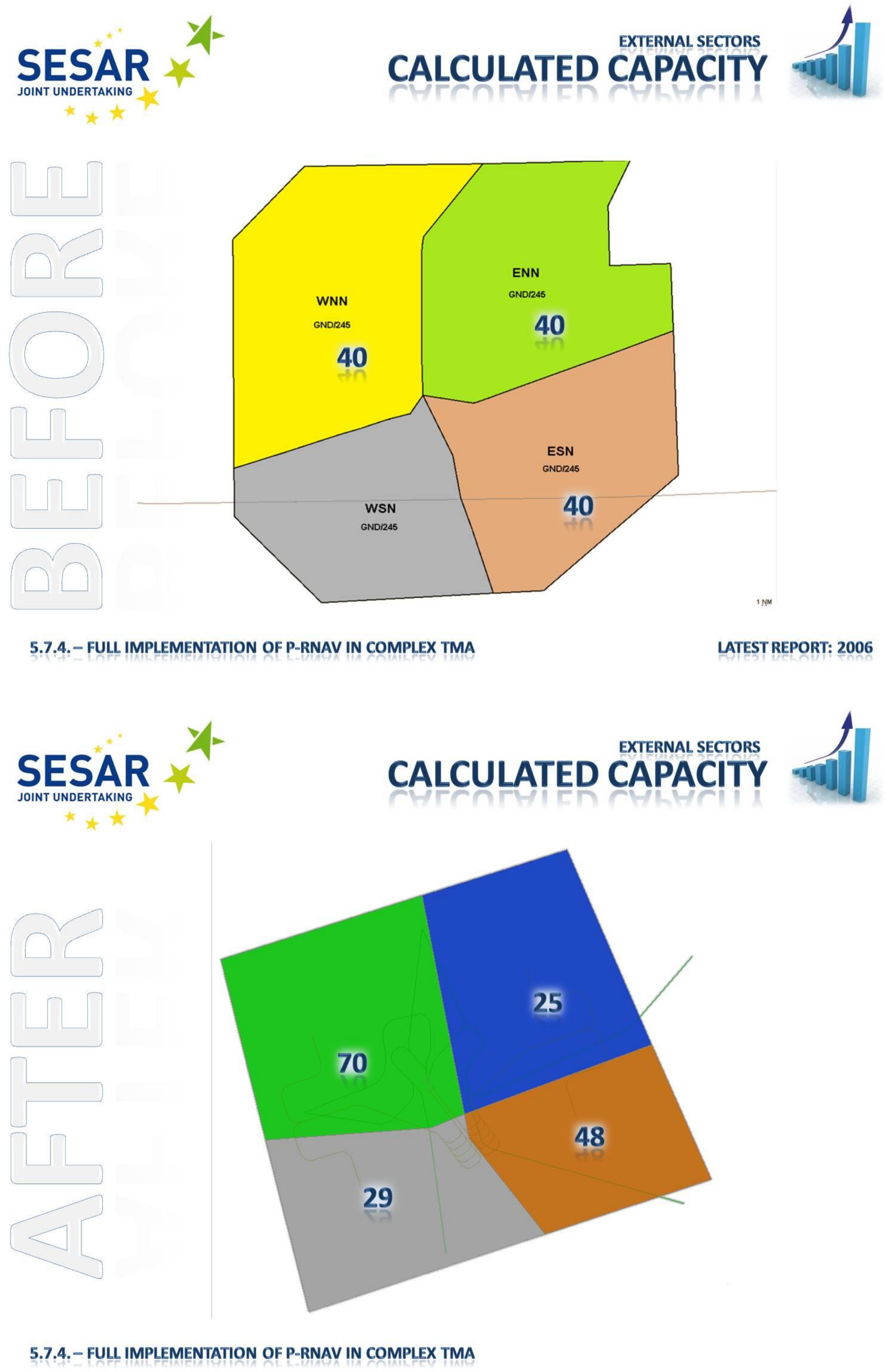


Figure 111: Calculated capacity comparative results – External sectors

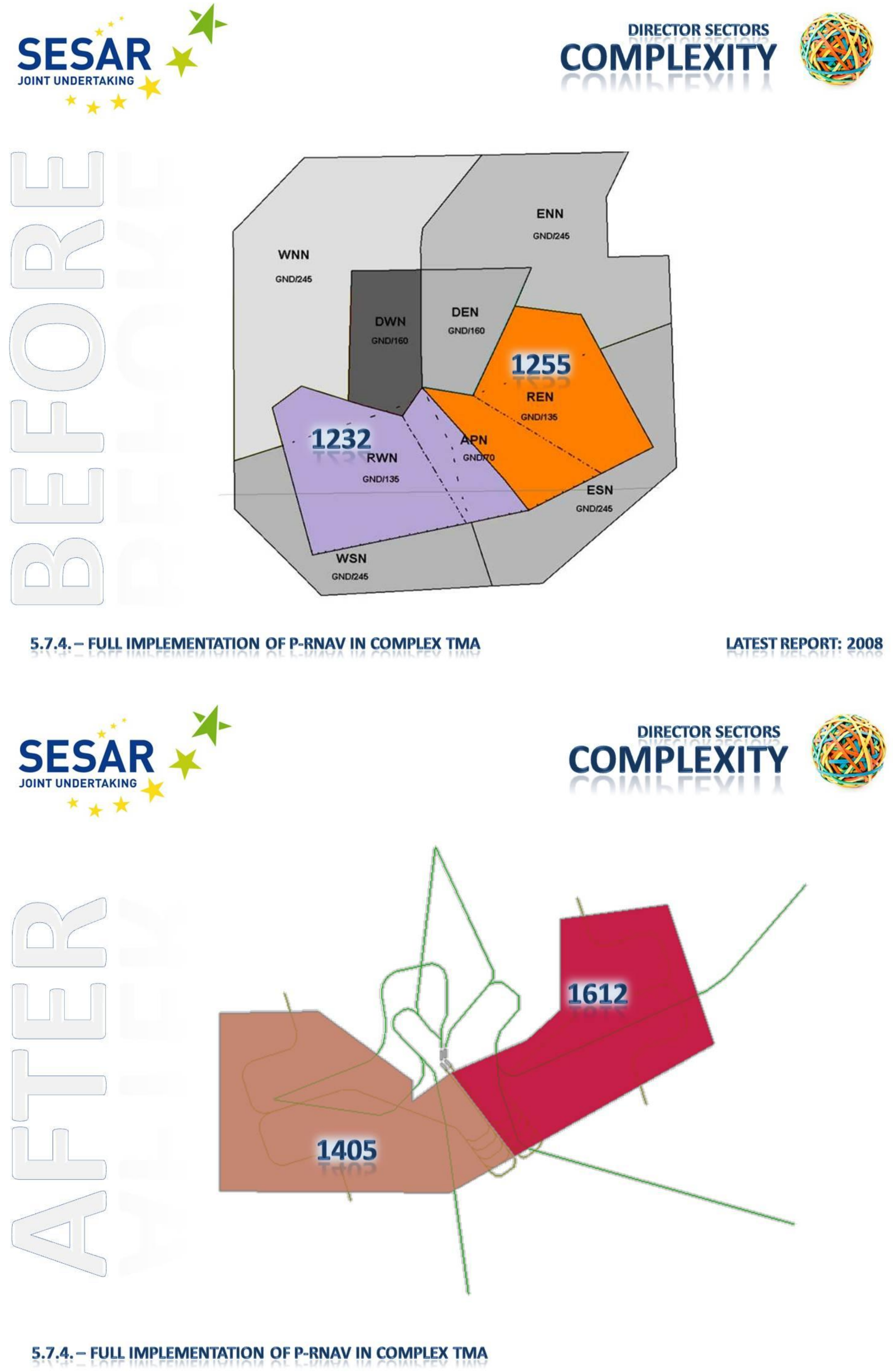
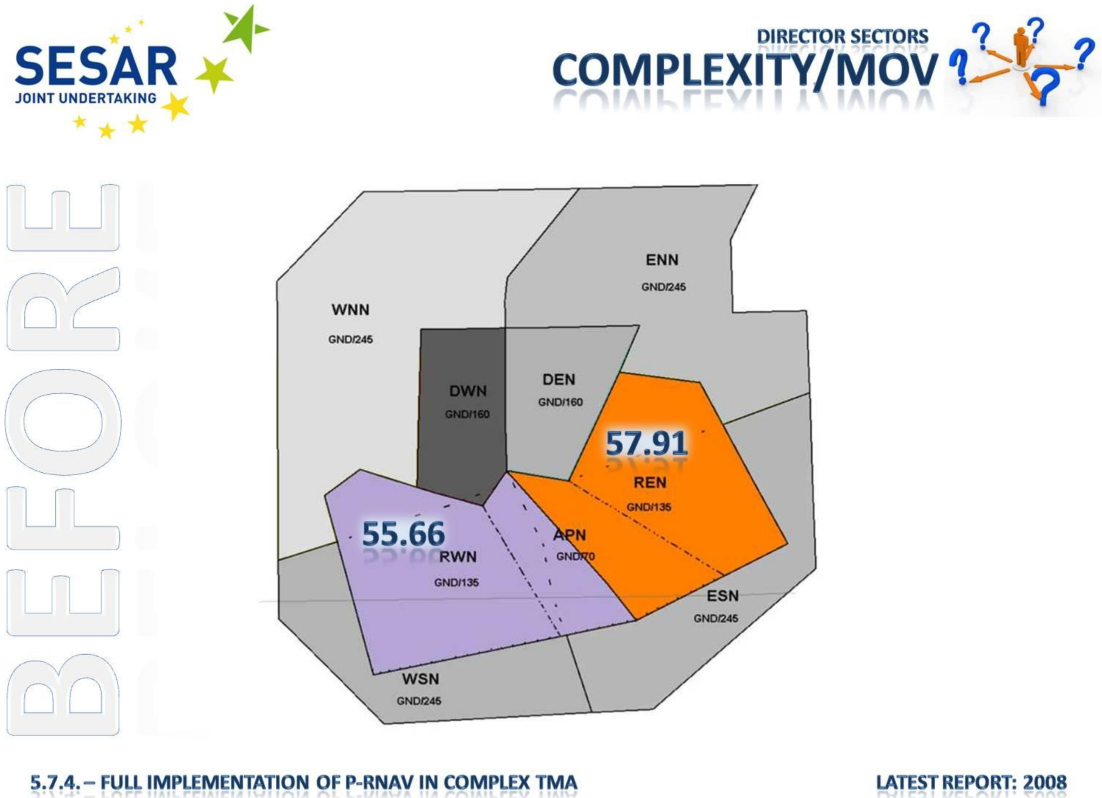


Figure 112: Complexity comparative results –Director sectors



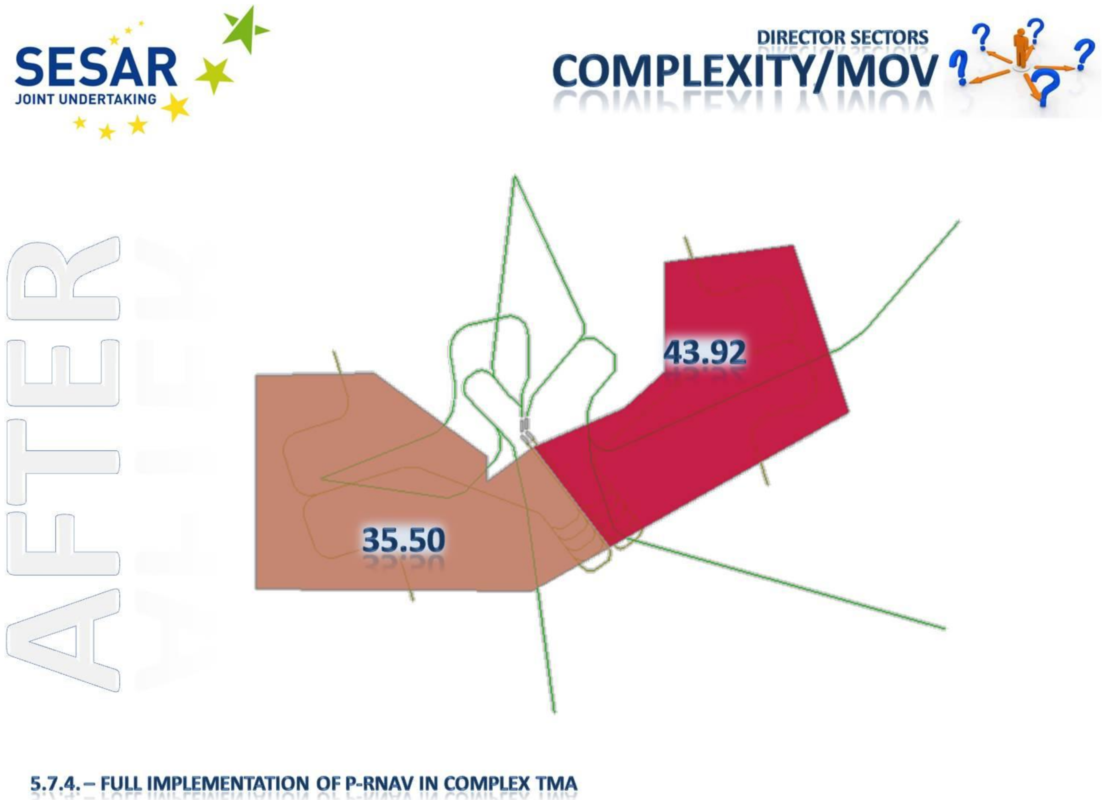


Figure 113: Complexity/mov comparative results – Director sectors

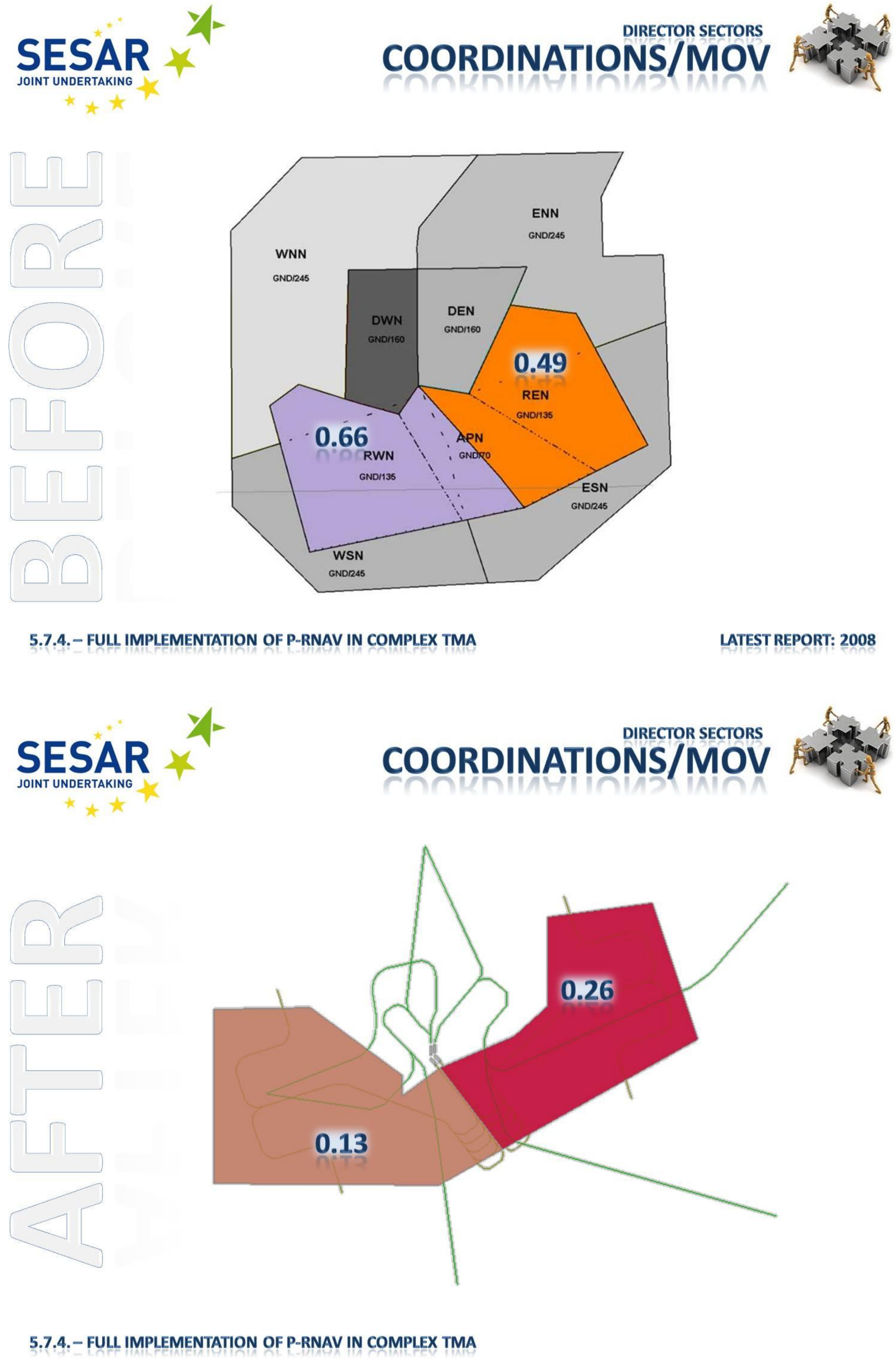


Figure 114: Coordinations/mov comparative results – Director sectors

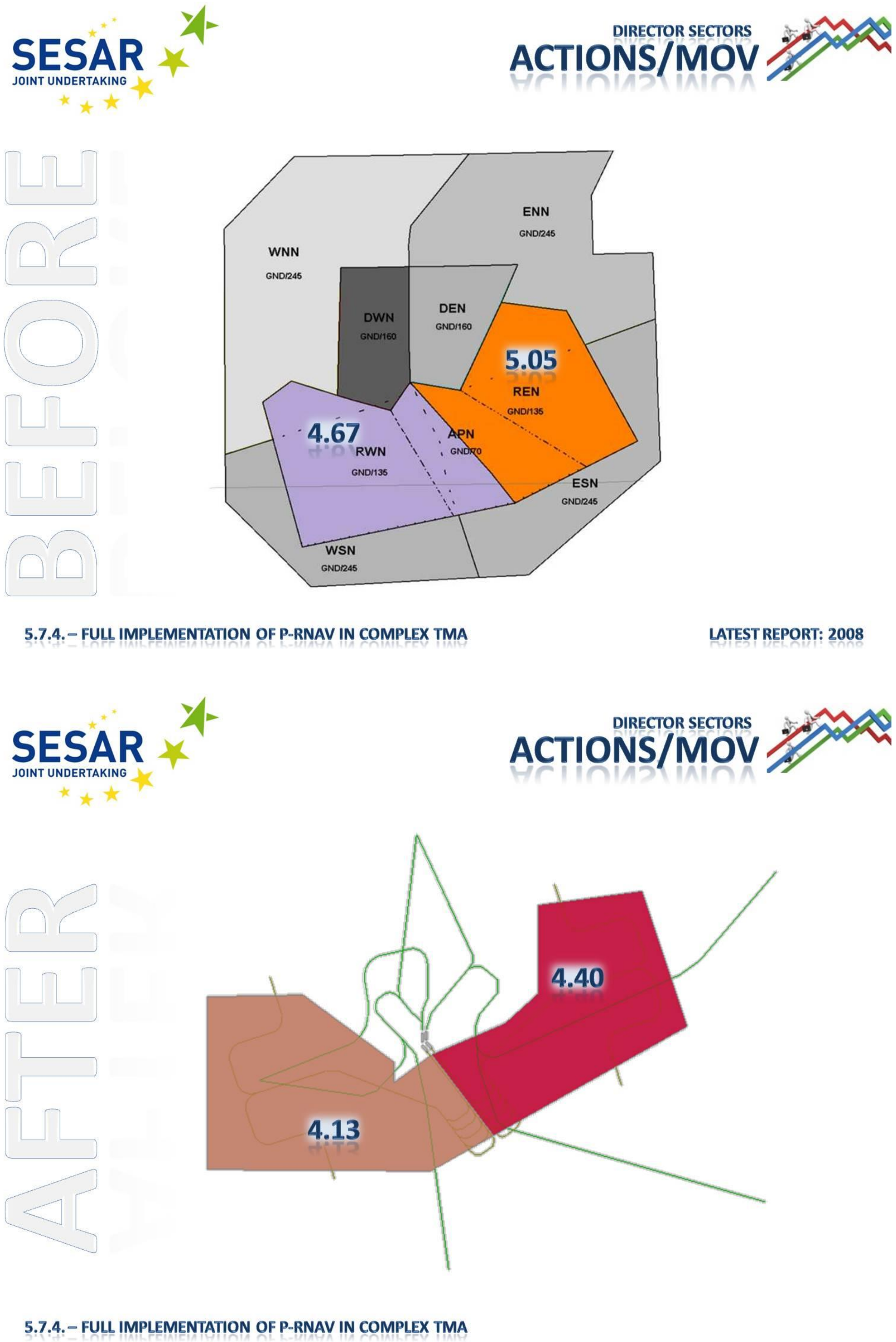
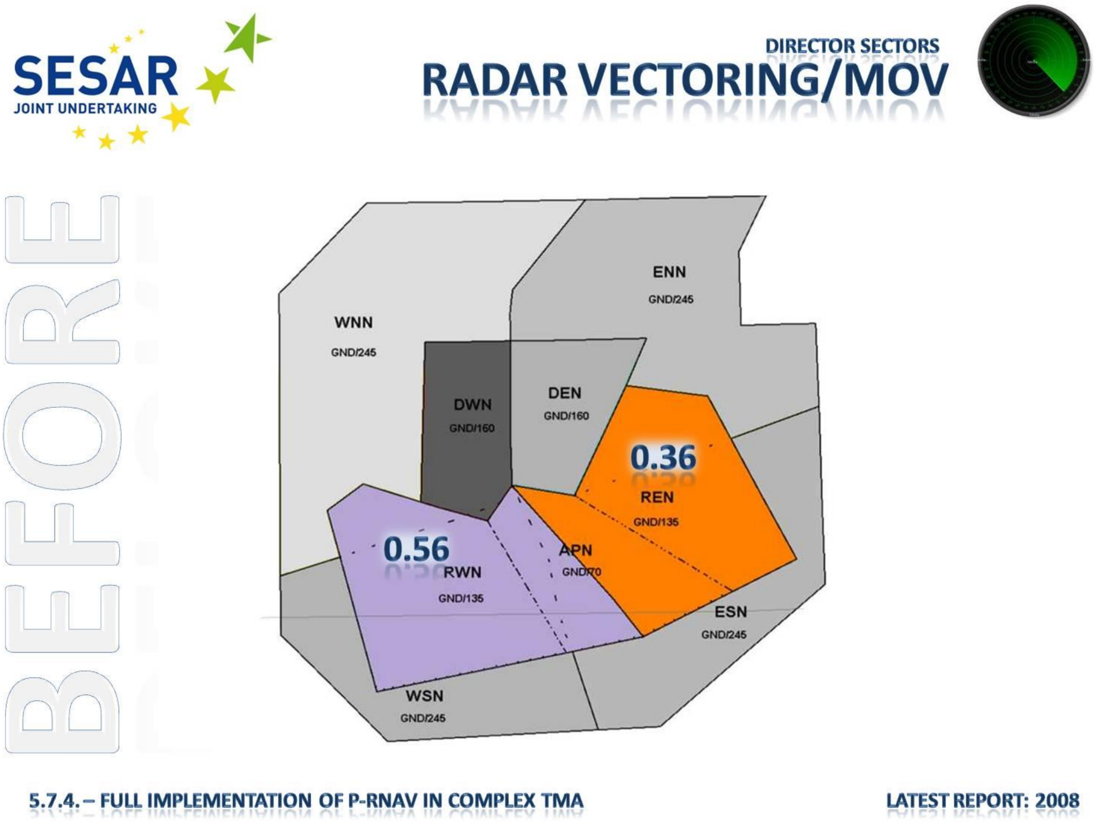


Figure 115: Actions/mov comparative results – Director sectors



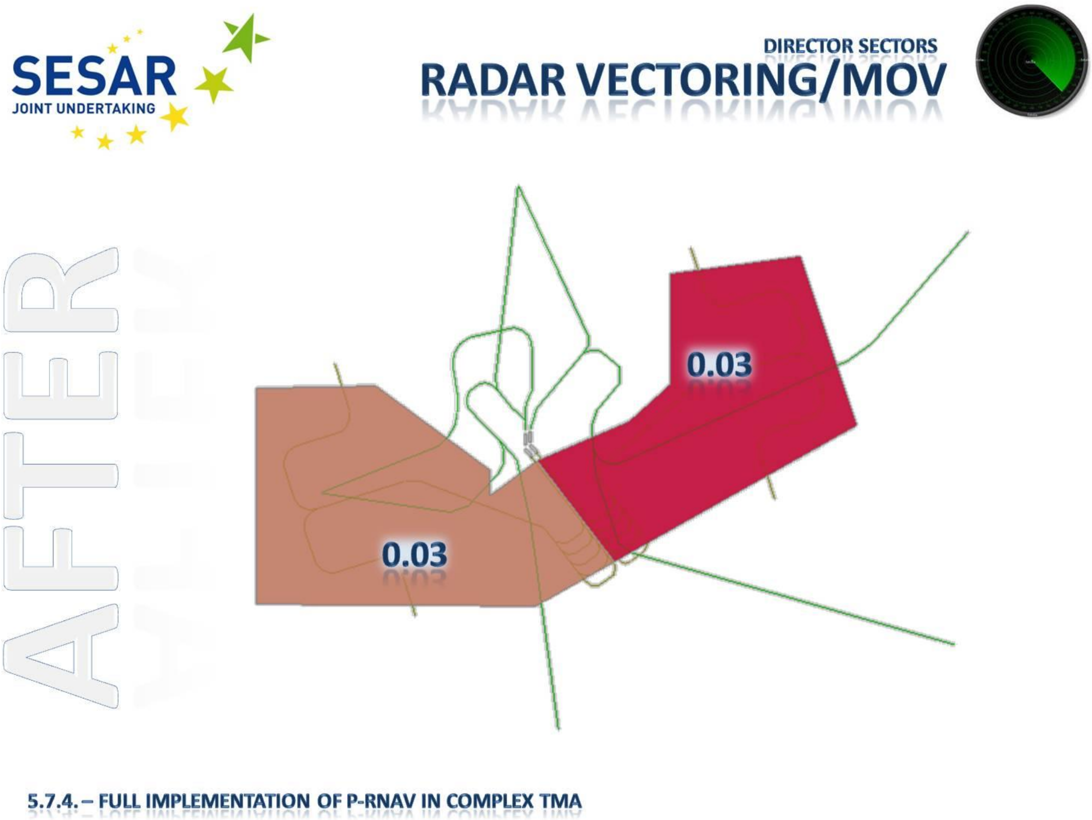
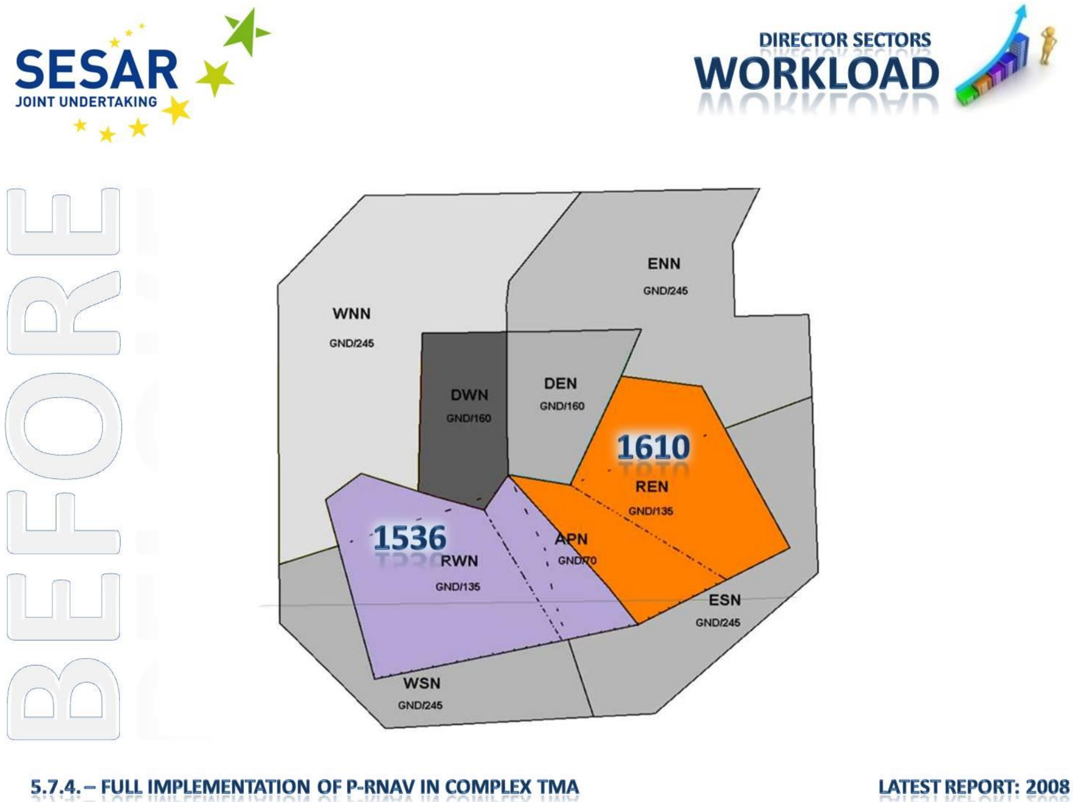


Figure 116: Radar vectoring/mov comparative results – Director sectors



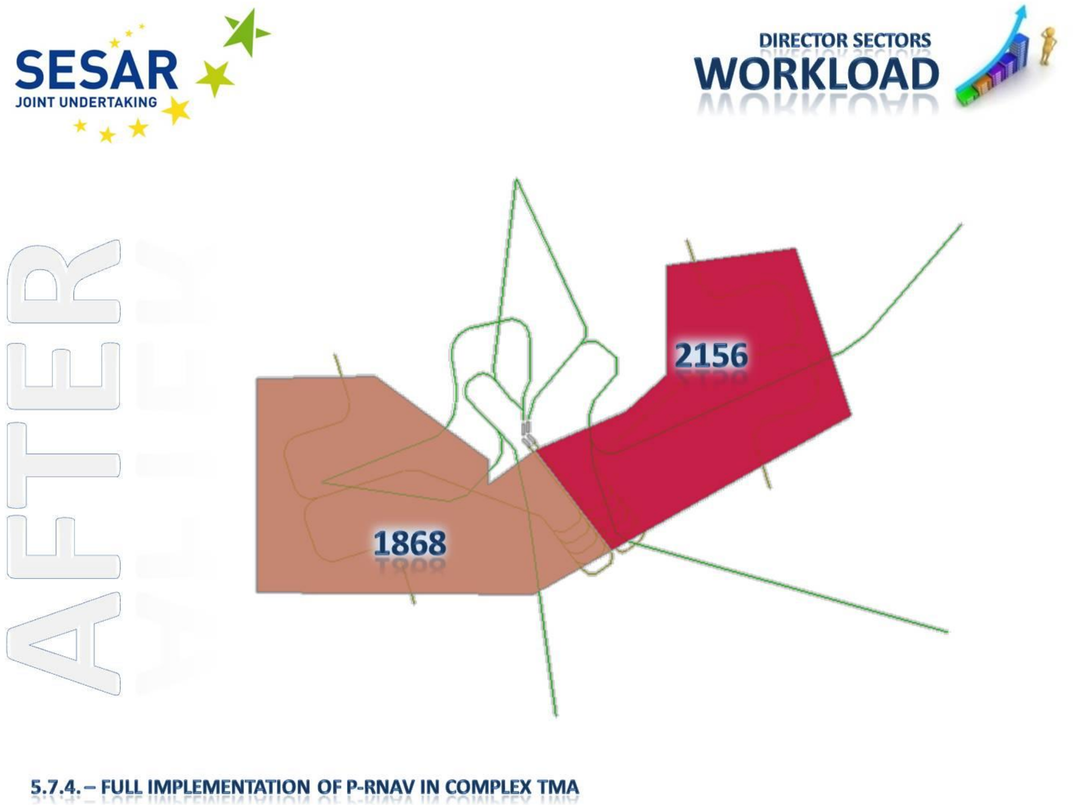
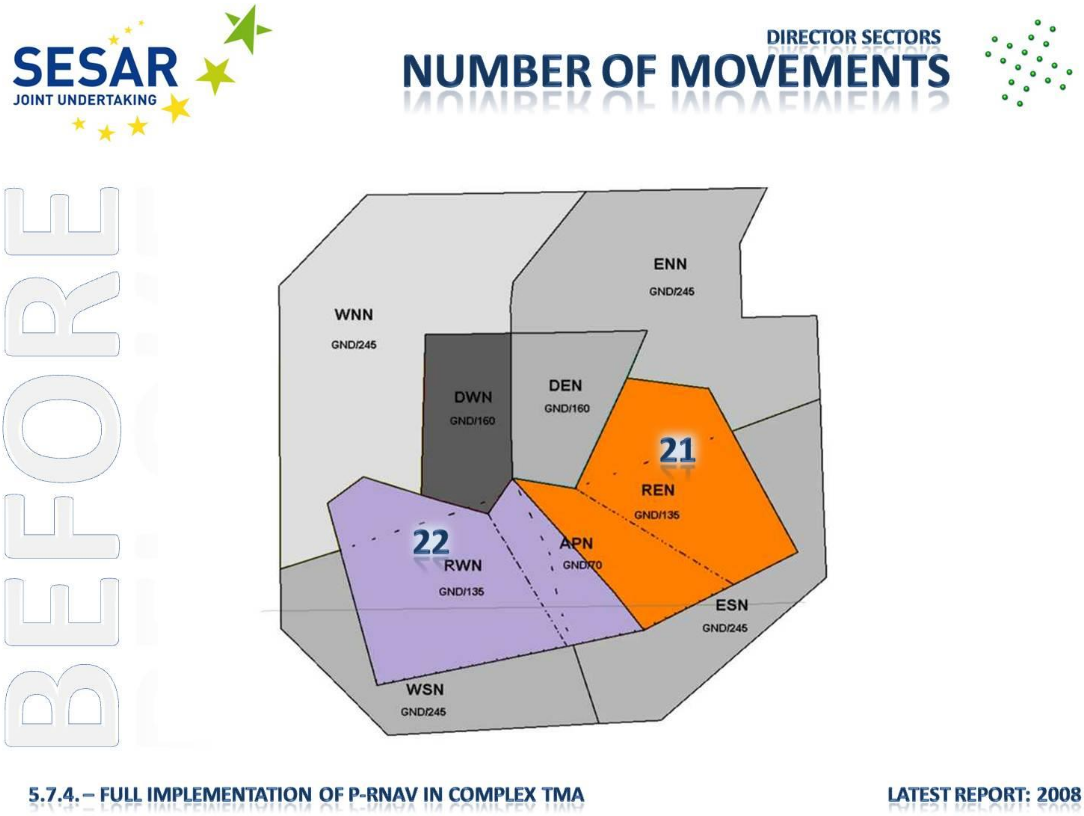


Figure 117: Workload comparative results – Director sectors



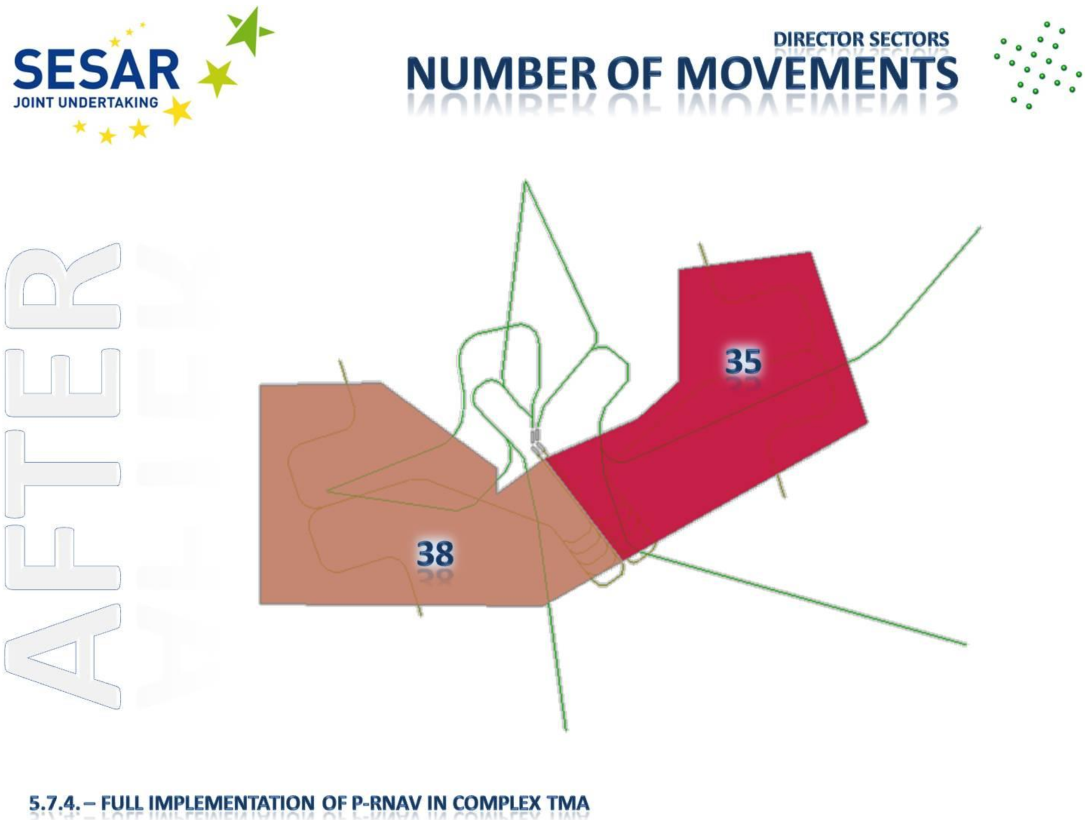
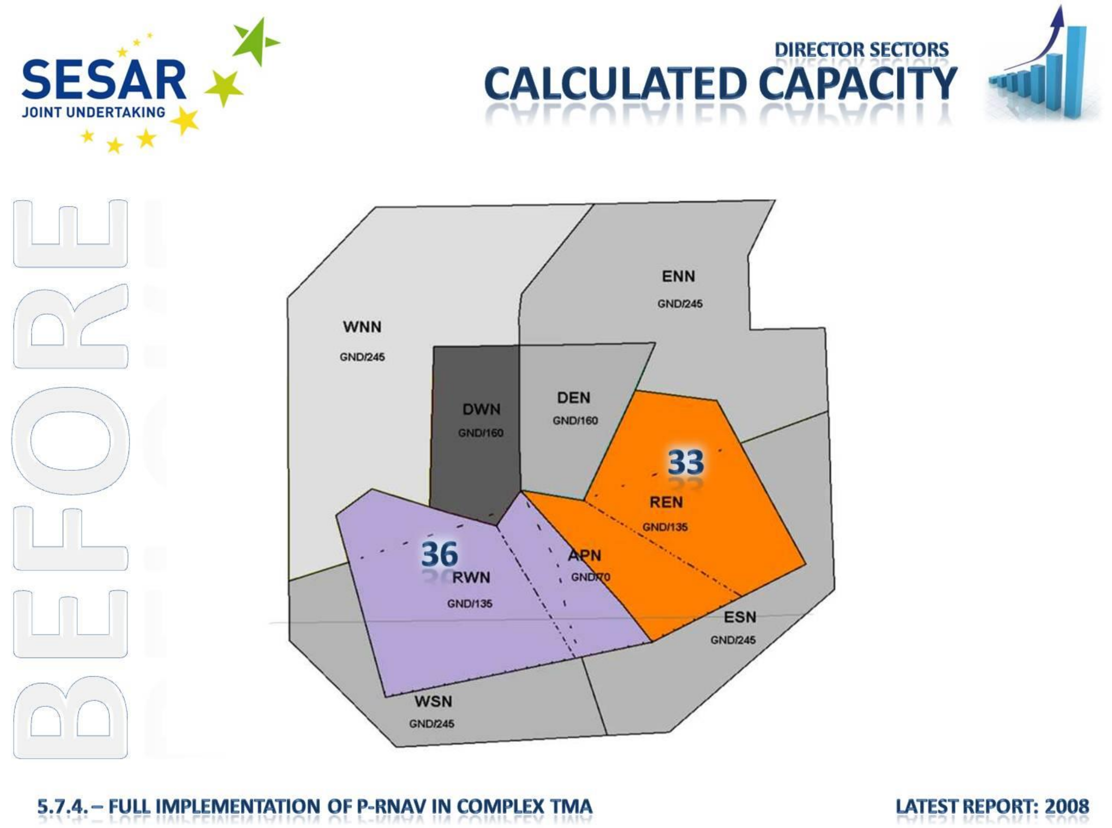


Figure 118: Nb of movements comparative results – Director sectors



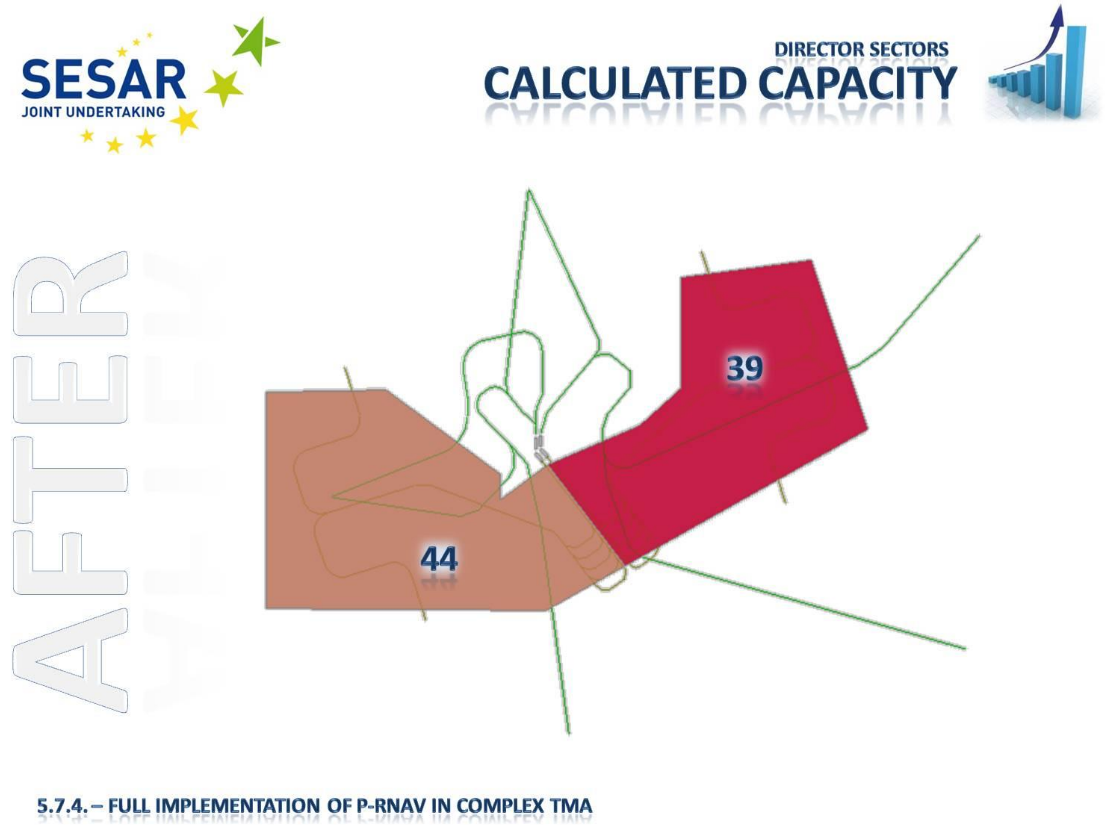
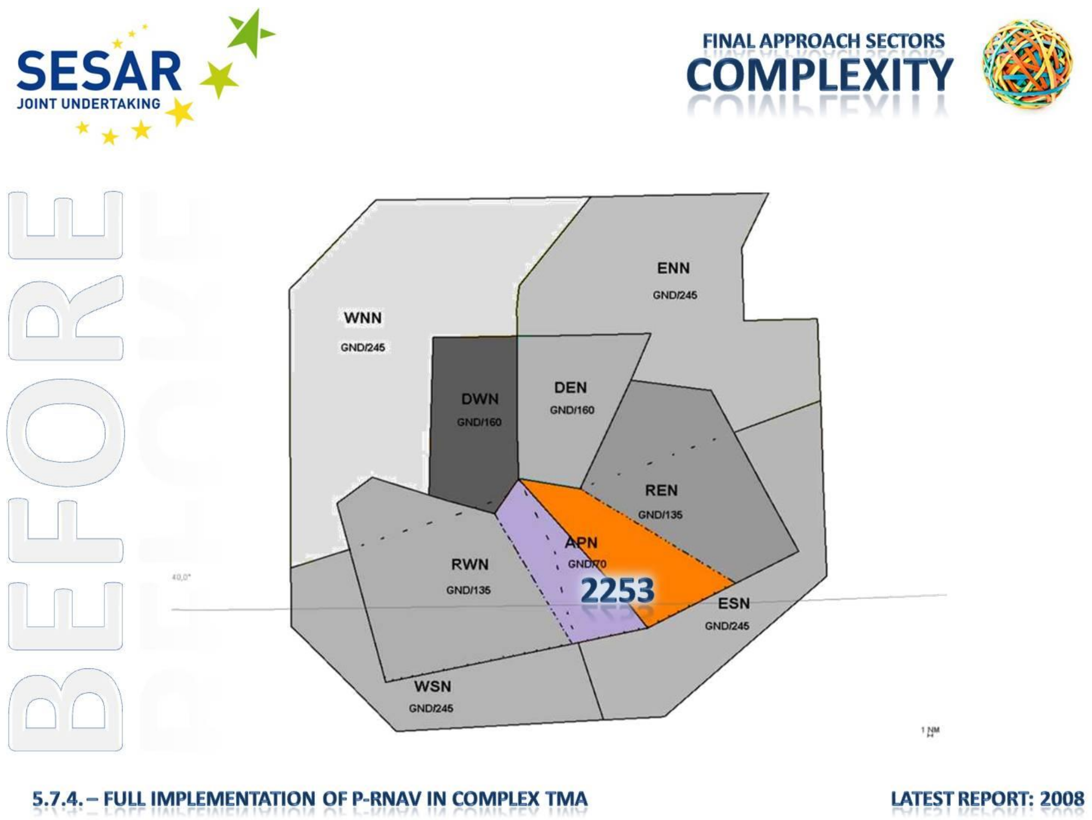


Figure 119: Calculated capacity comparative results – Director sectors



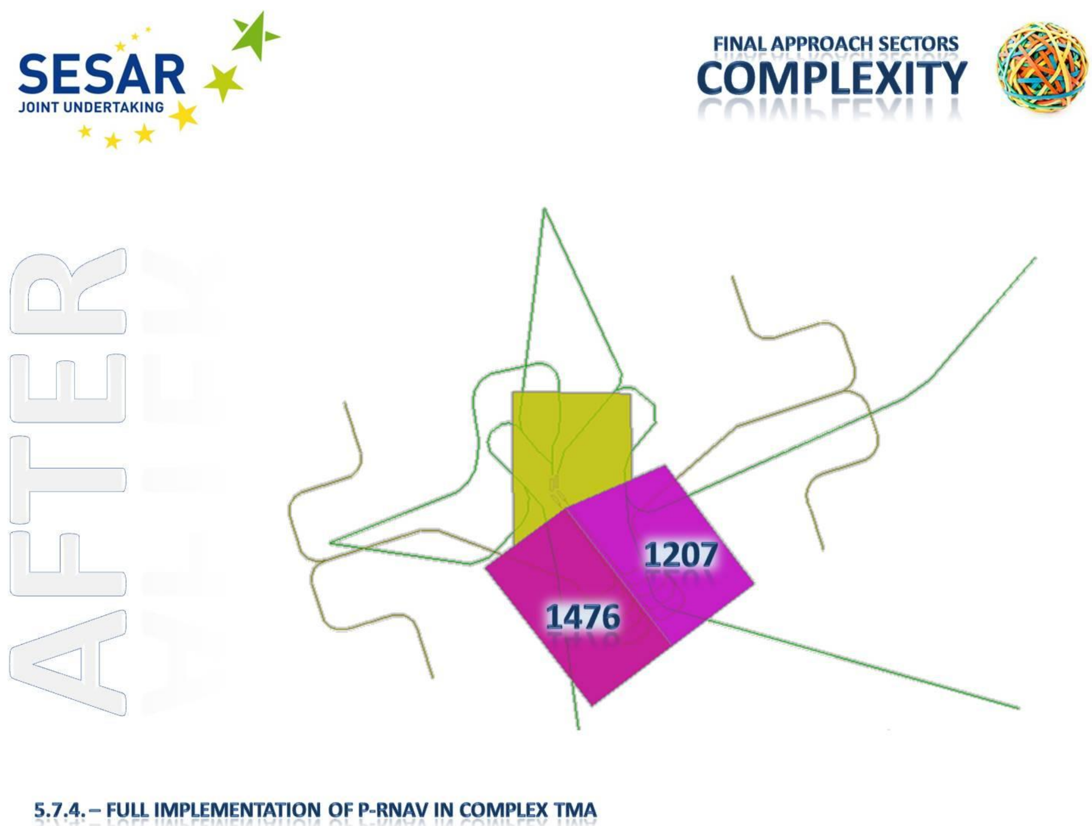
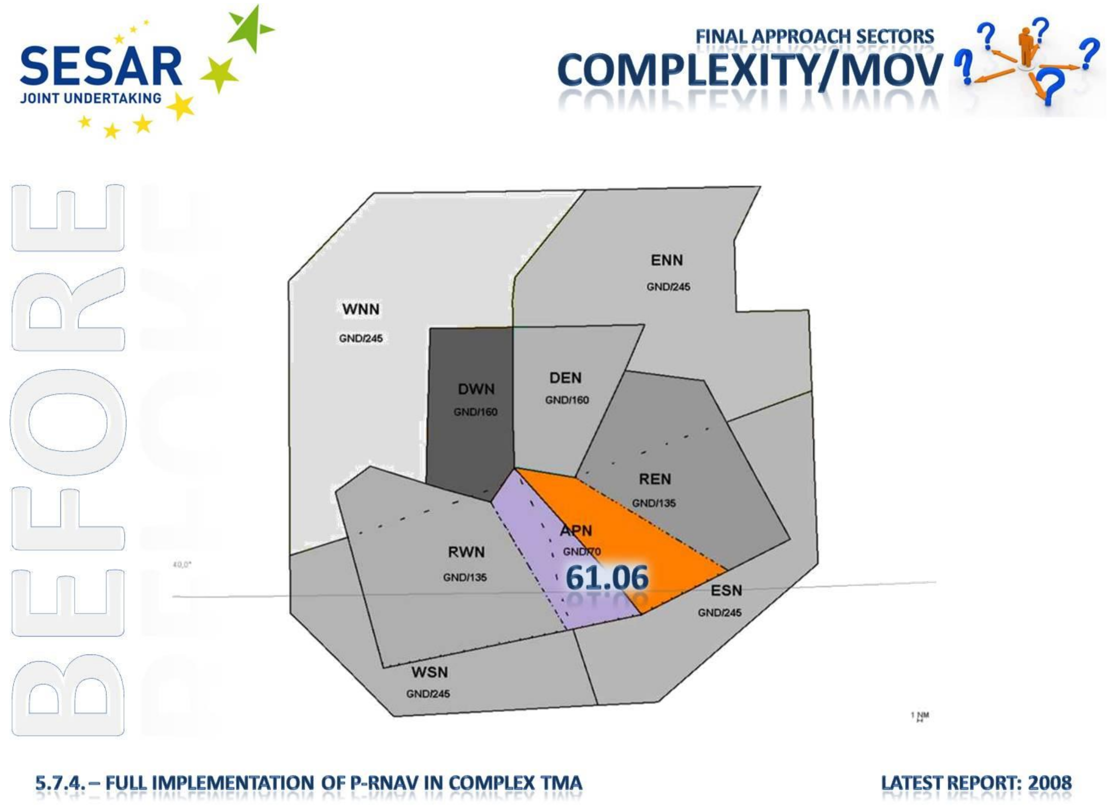


Figure 120: Complexity comparative results – Final approach sectors



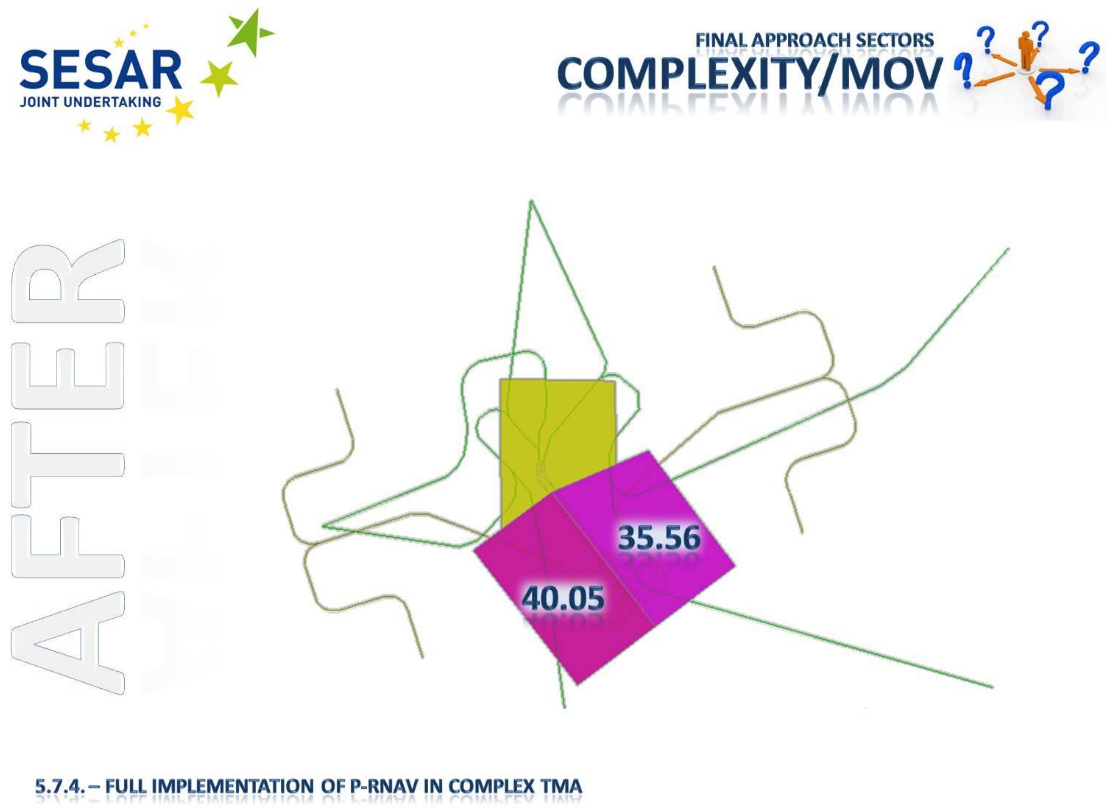
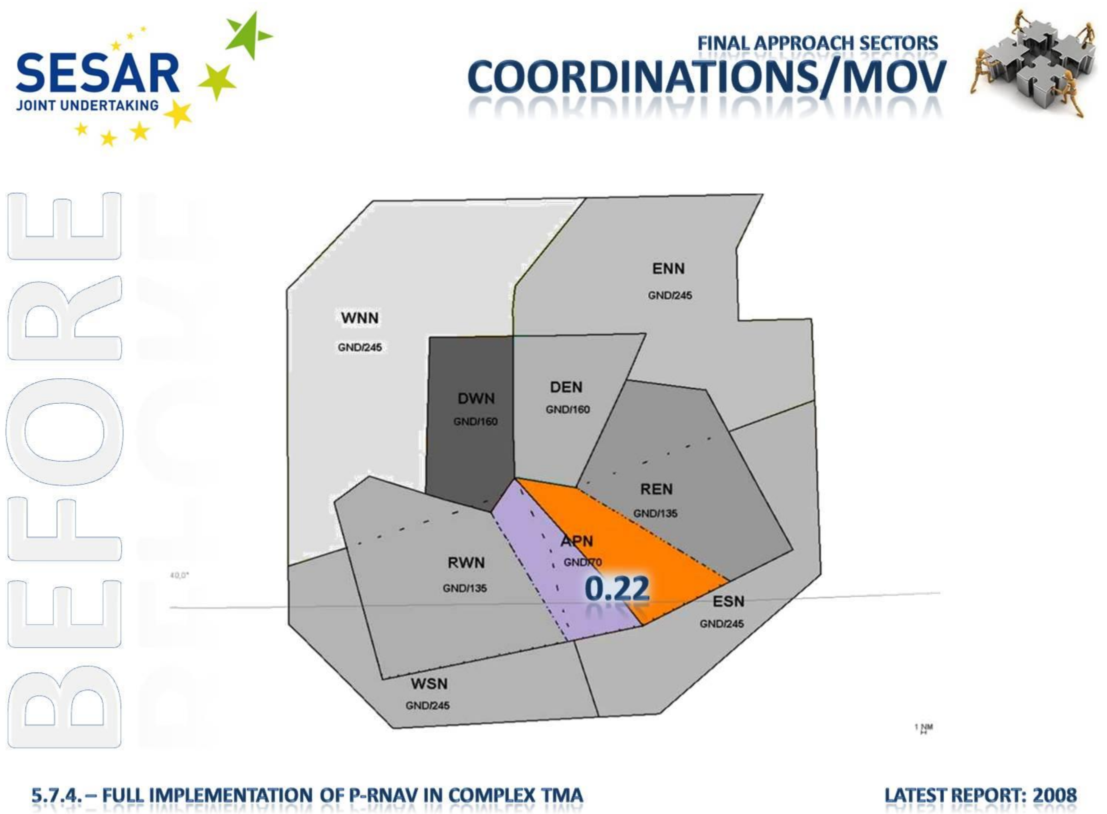


Figure 121: Complexity/mov comparative results – Final approach sectors



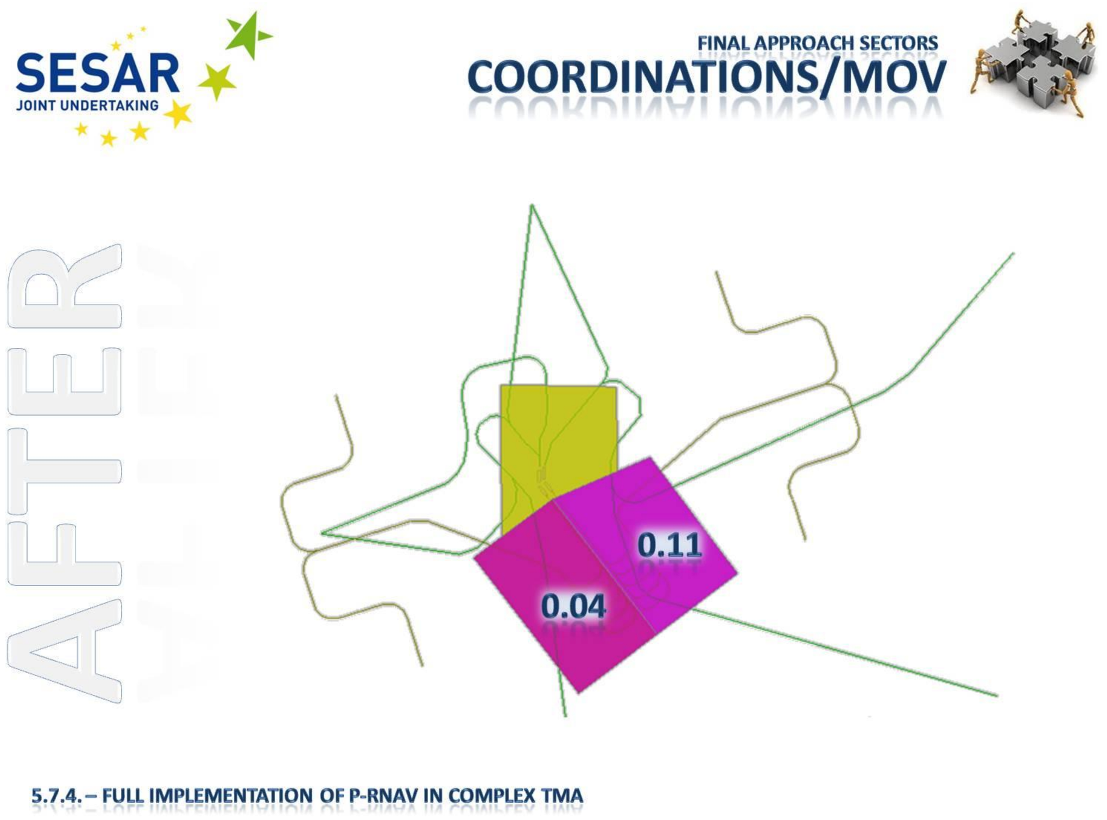


Figure 122: Coordinations/mov comparative results – Final approach sectors

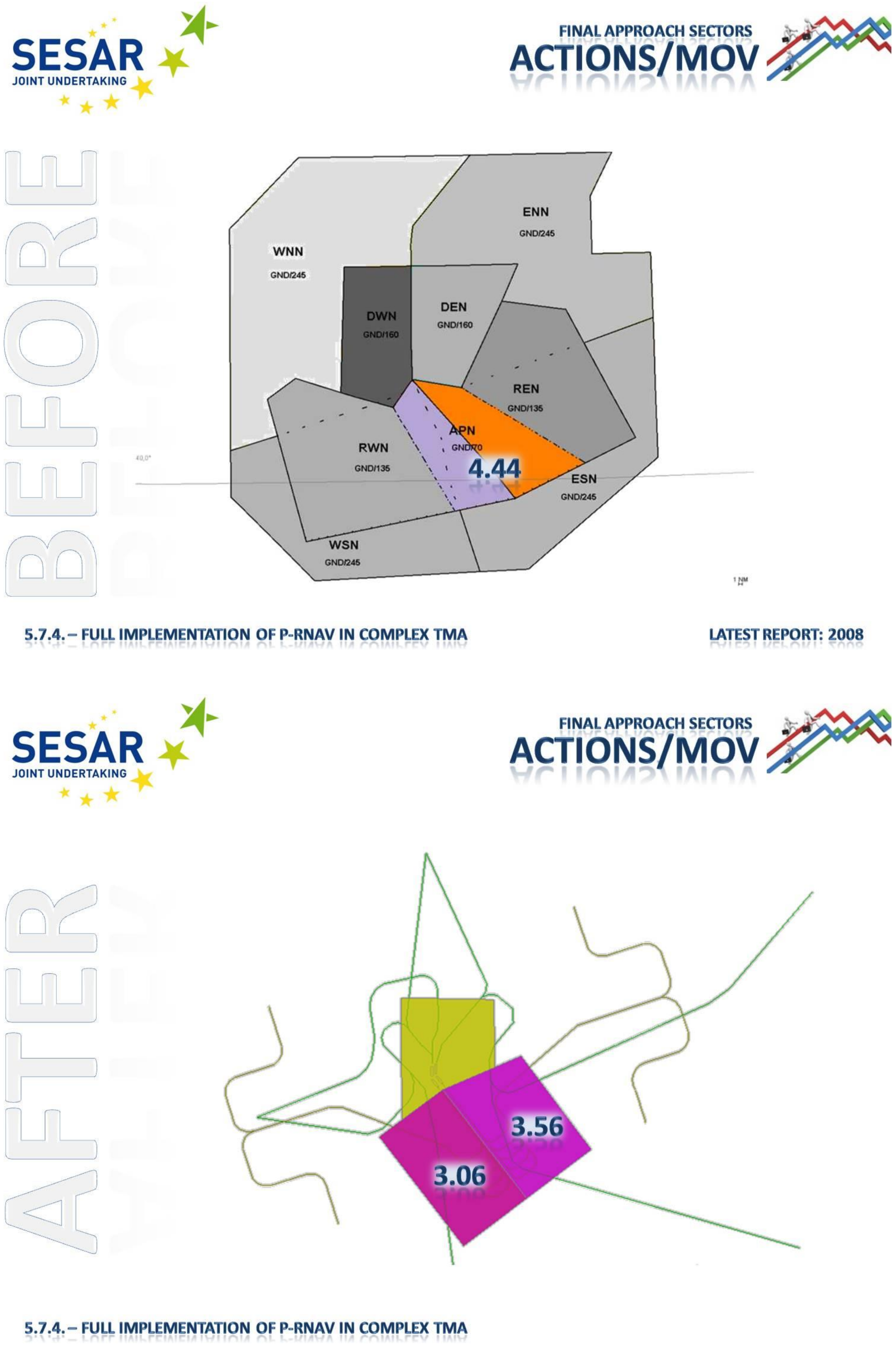
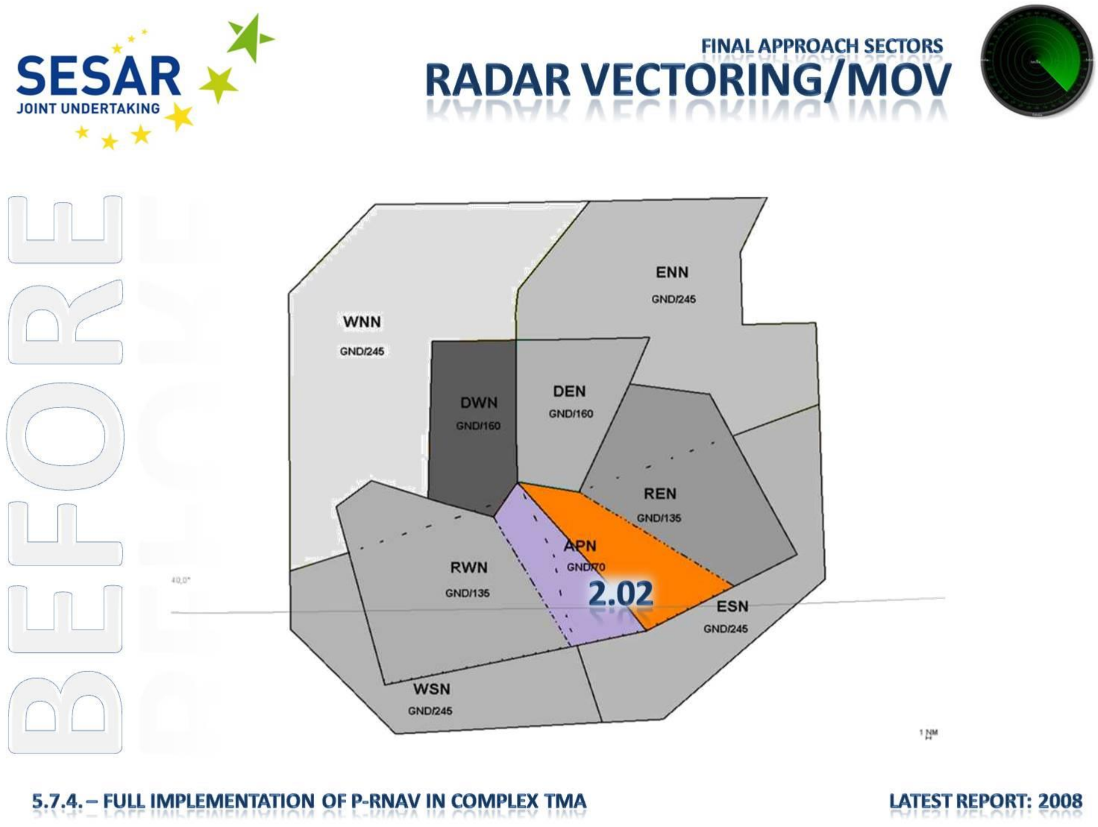


Figure 123: Actions/mov comparative results – Final approach sectors



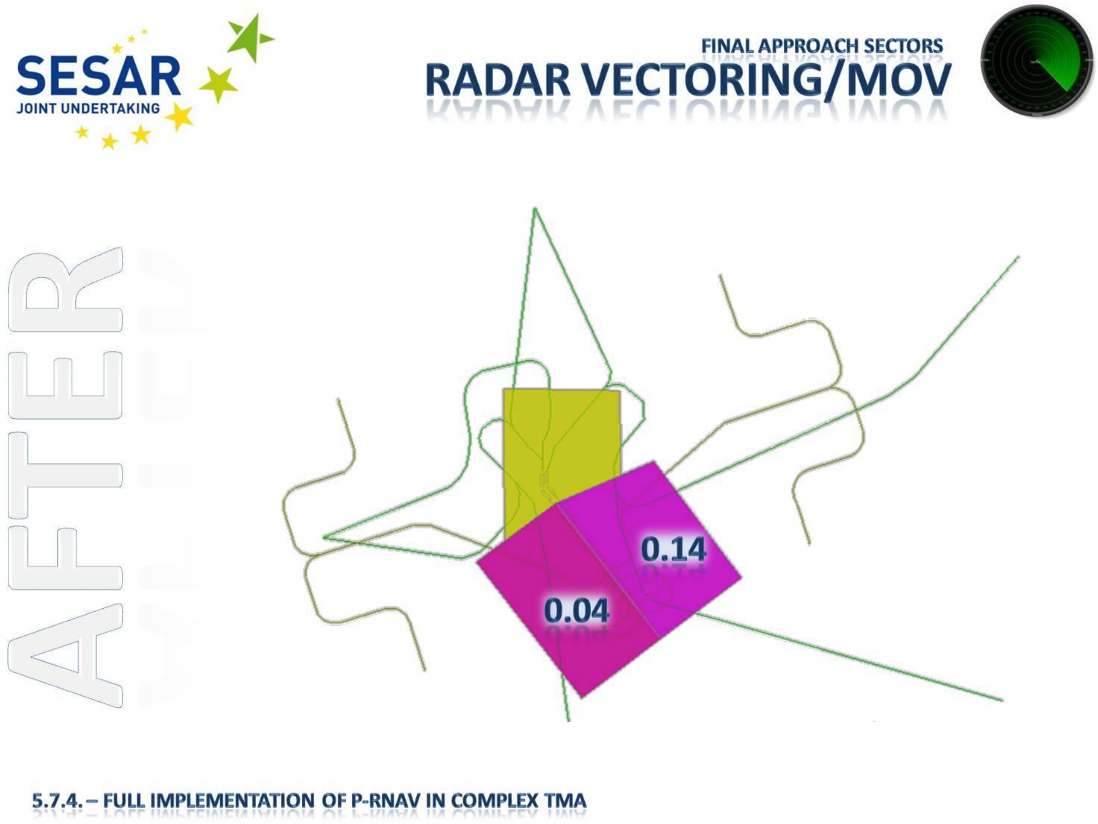


Figure 124: Radar vectoring comparative results – Final approach sectors

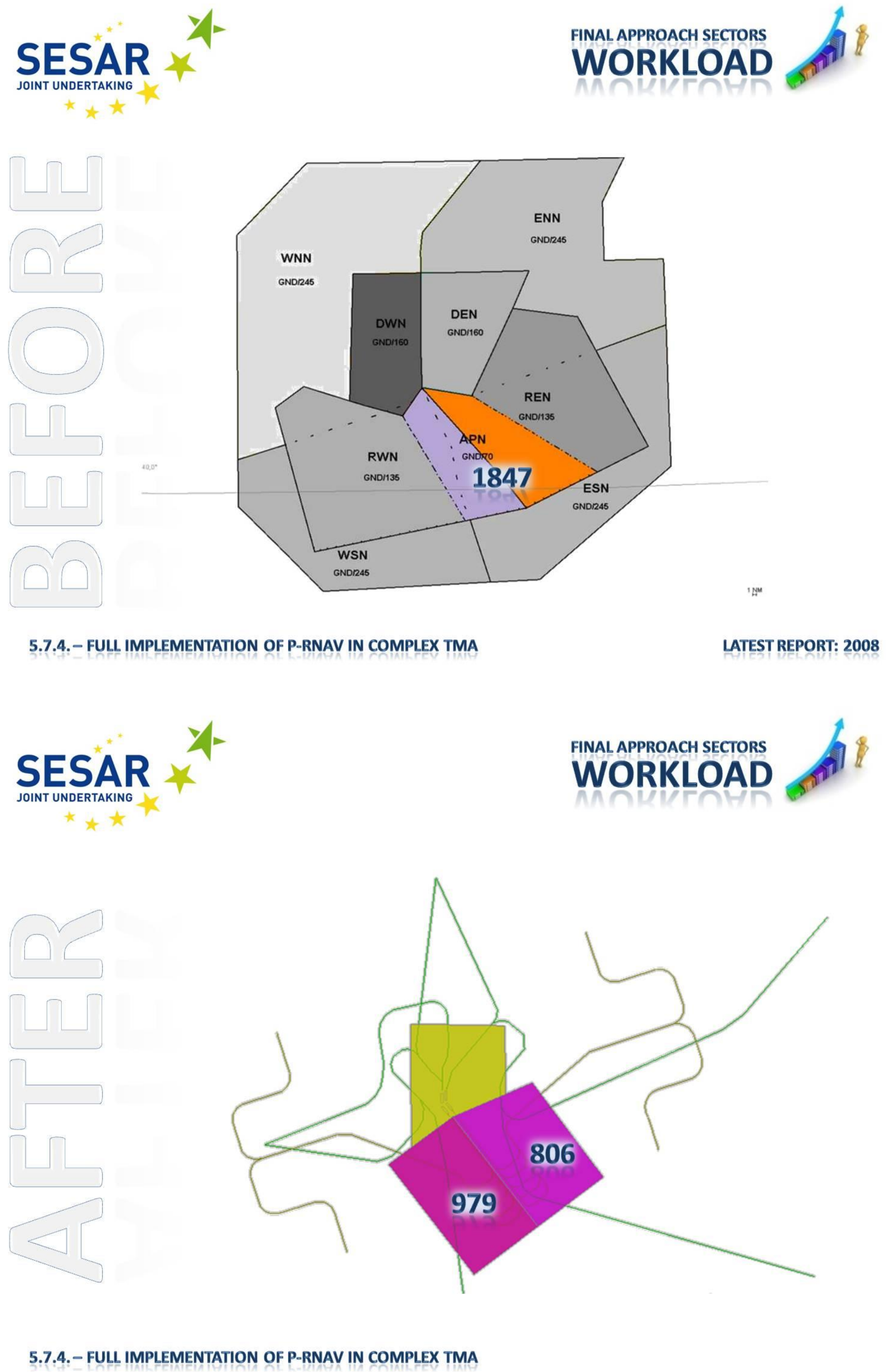
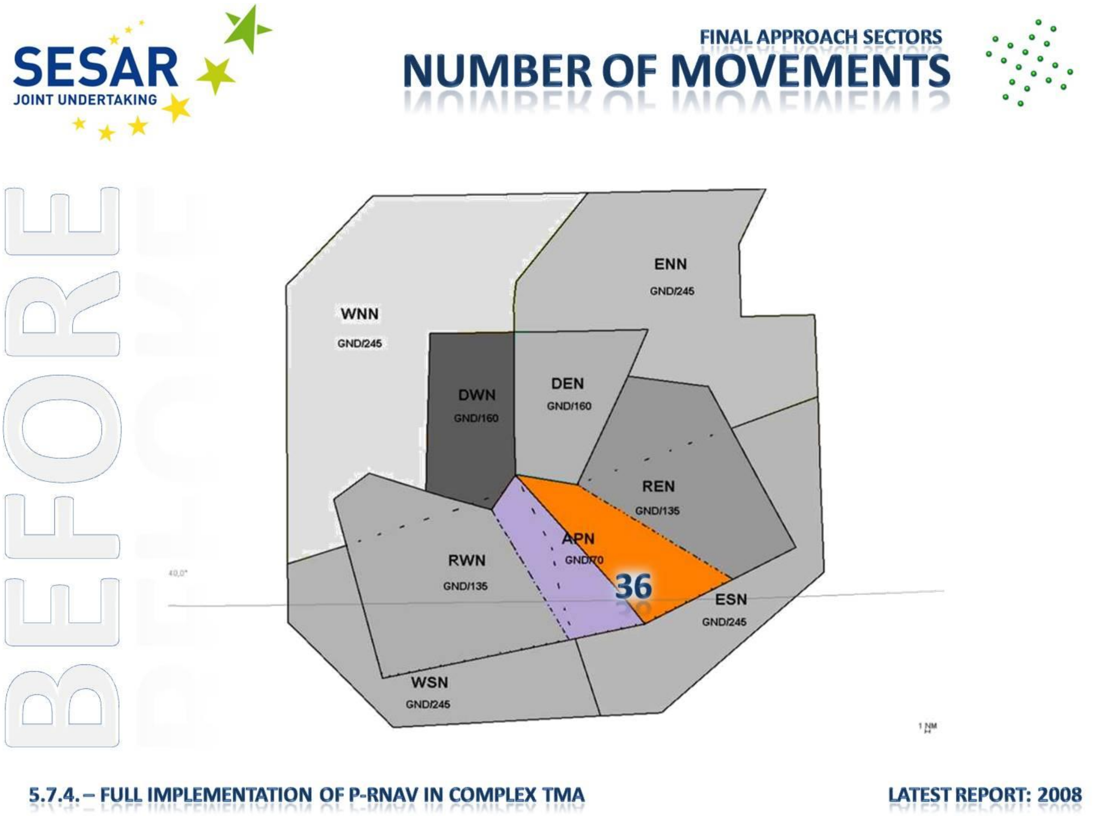


Figure 125: Workload comparative results – Final approach sectors



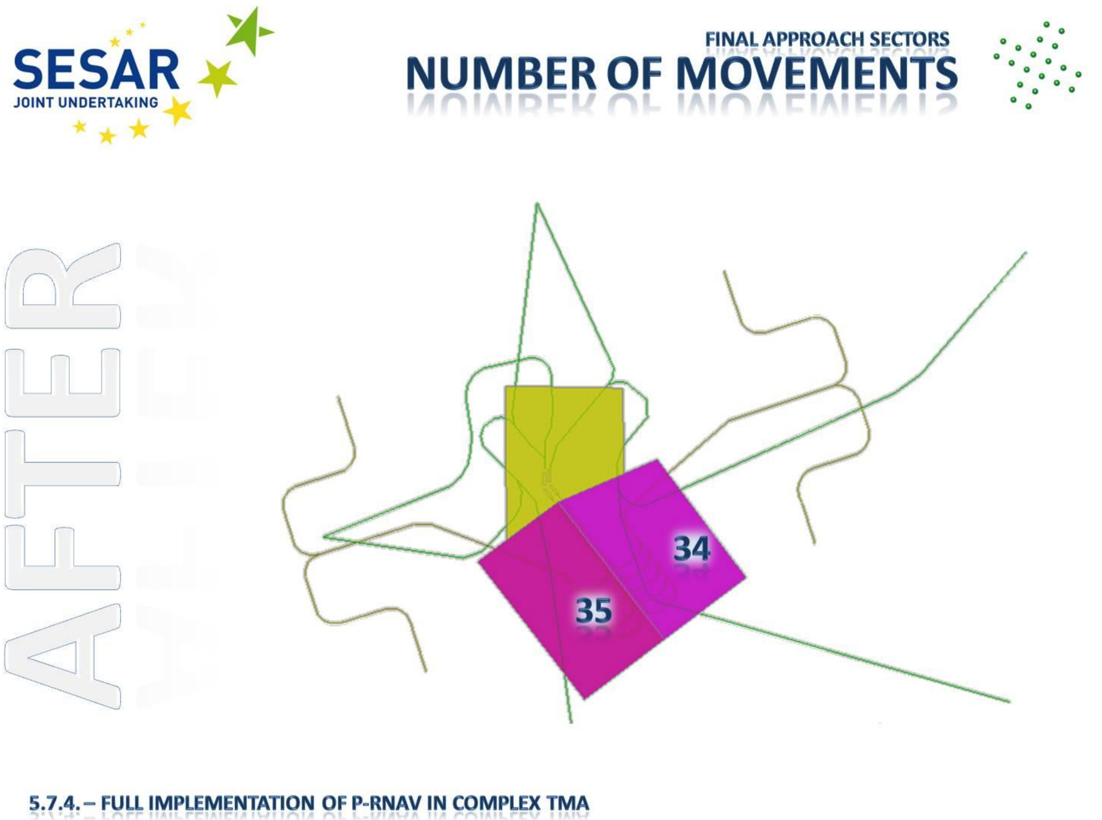
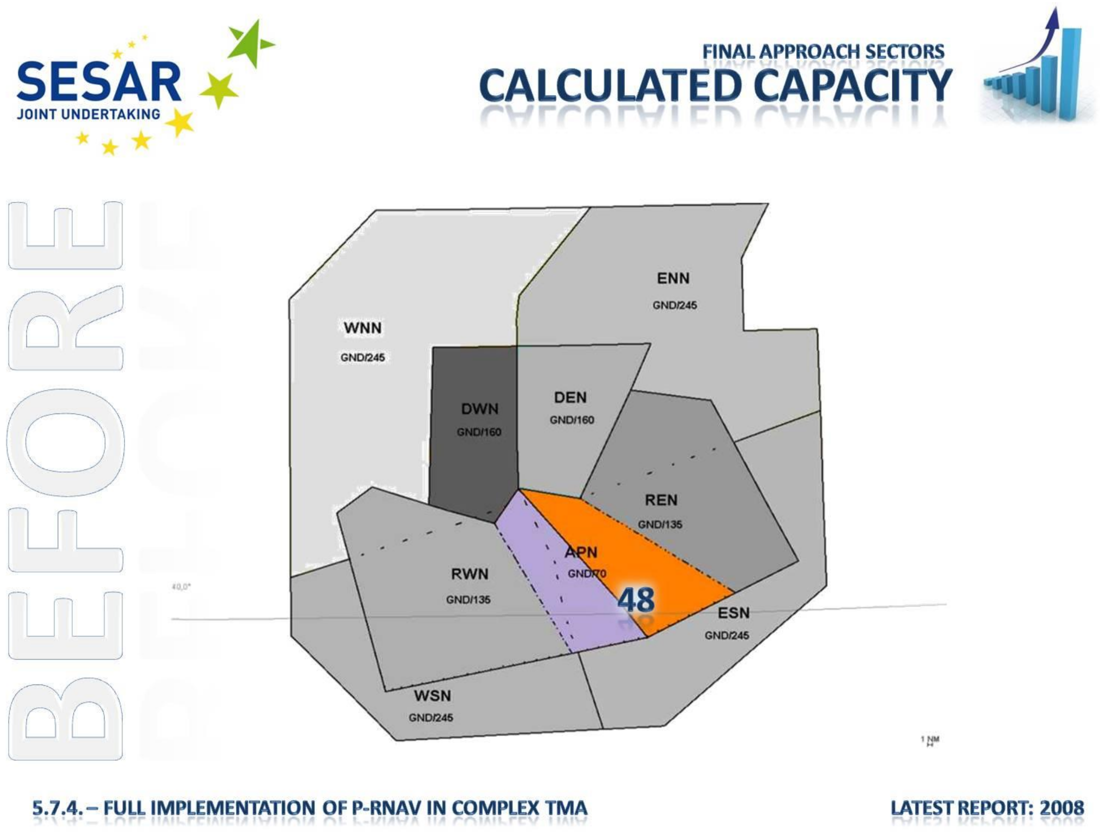


Figure 126: Nb of movements comparative results – Final approach sectors



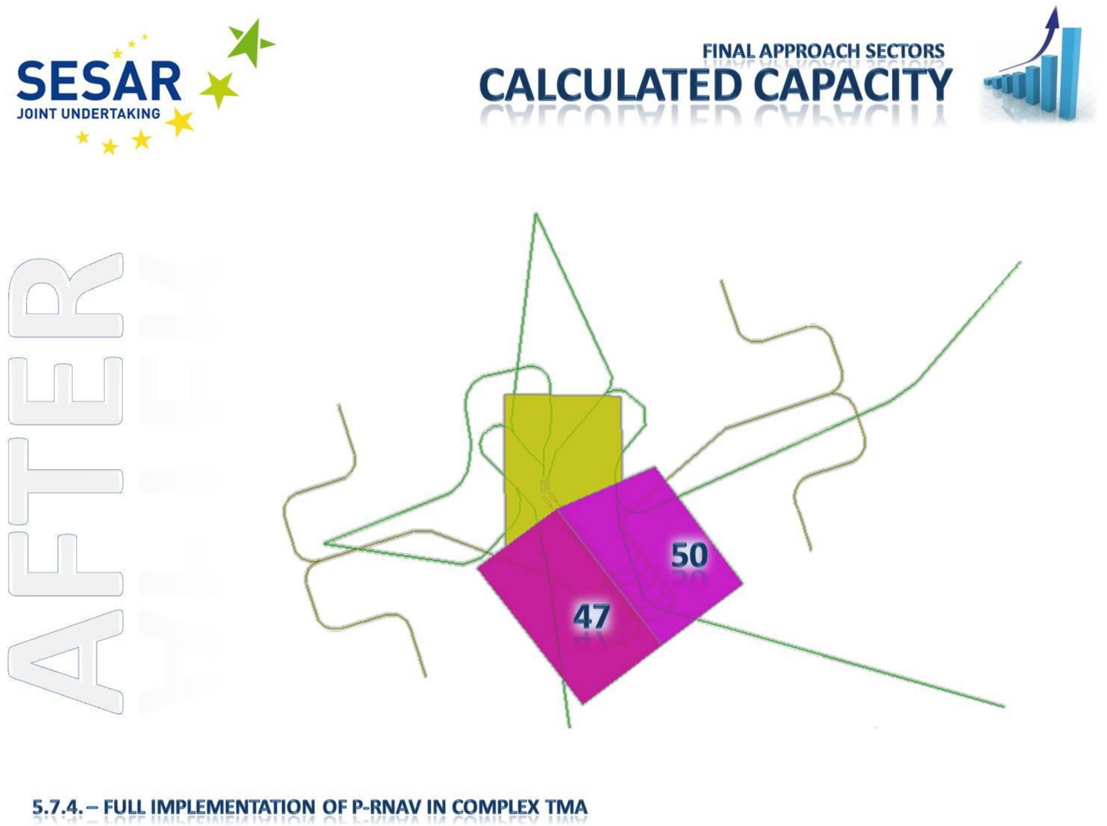
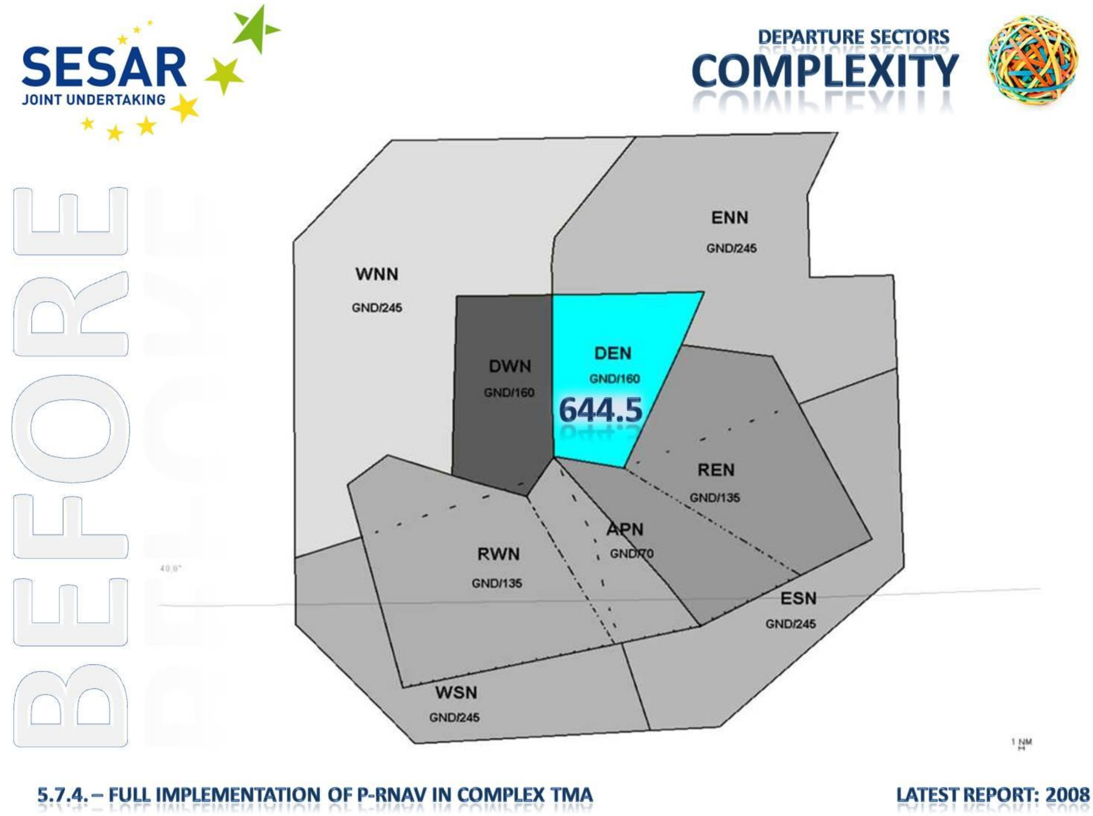


Figure 127: Calculated capacity comparative results – Final approach sectors



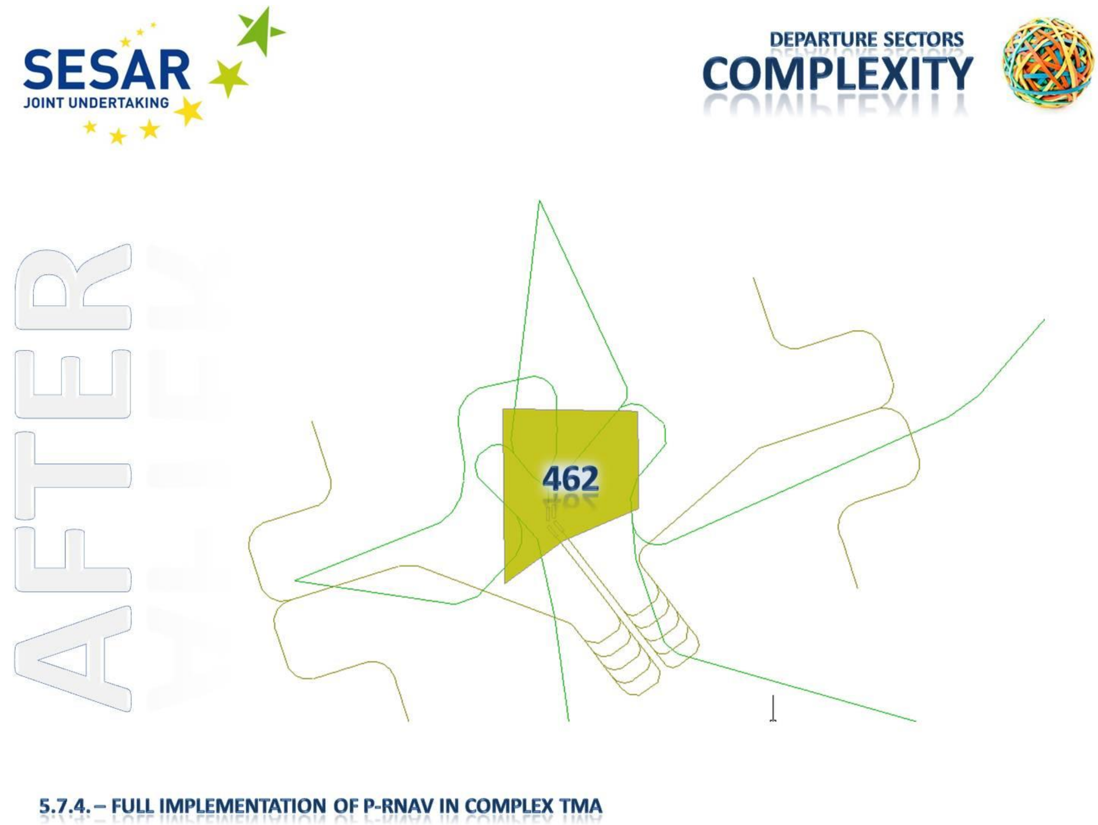


Figure 128: Complexity comparative results – Departure sectors

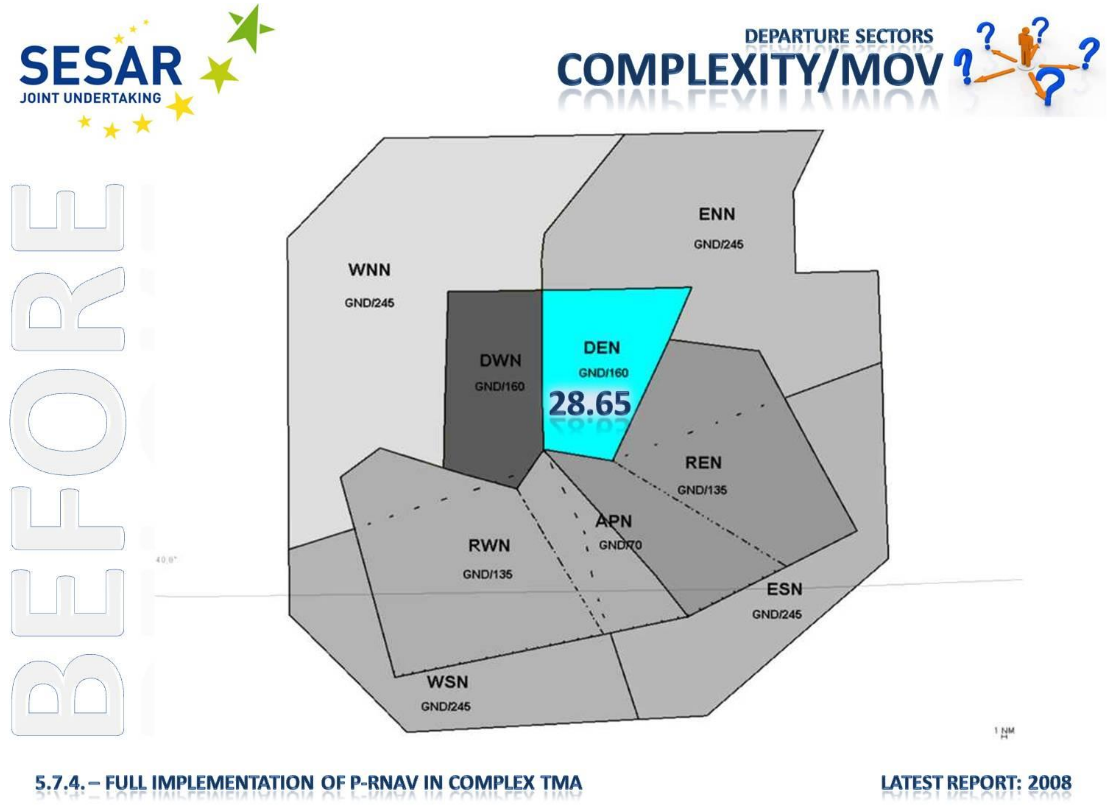
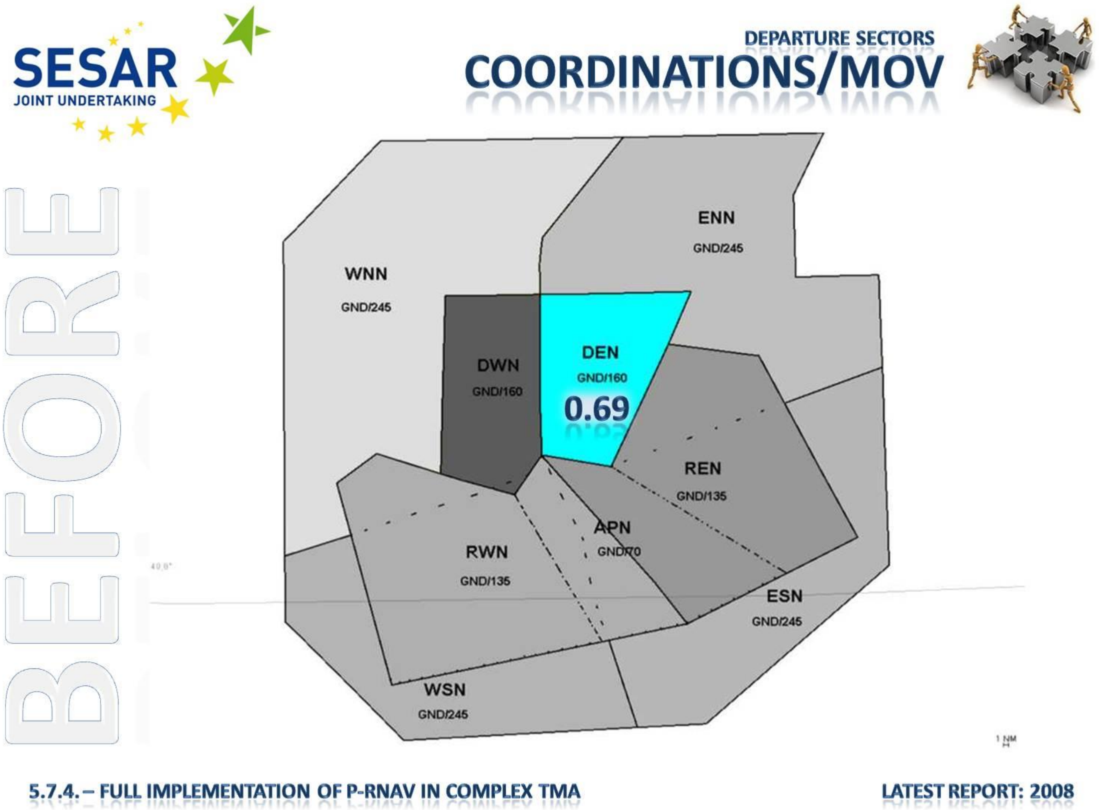


Figure 129: Complexity comparative results – External sectors



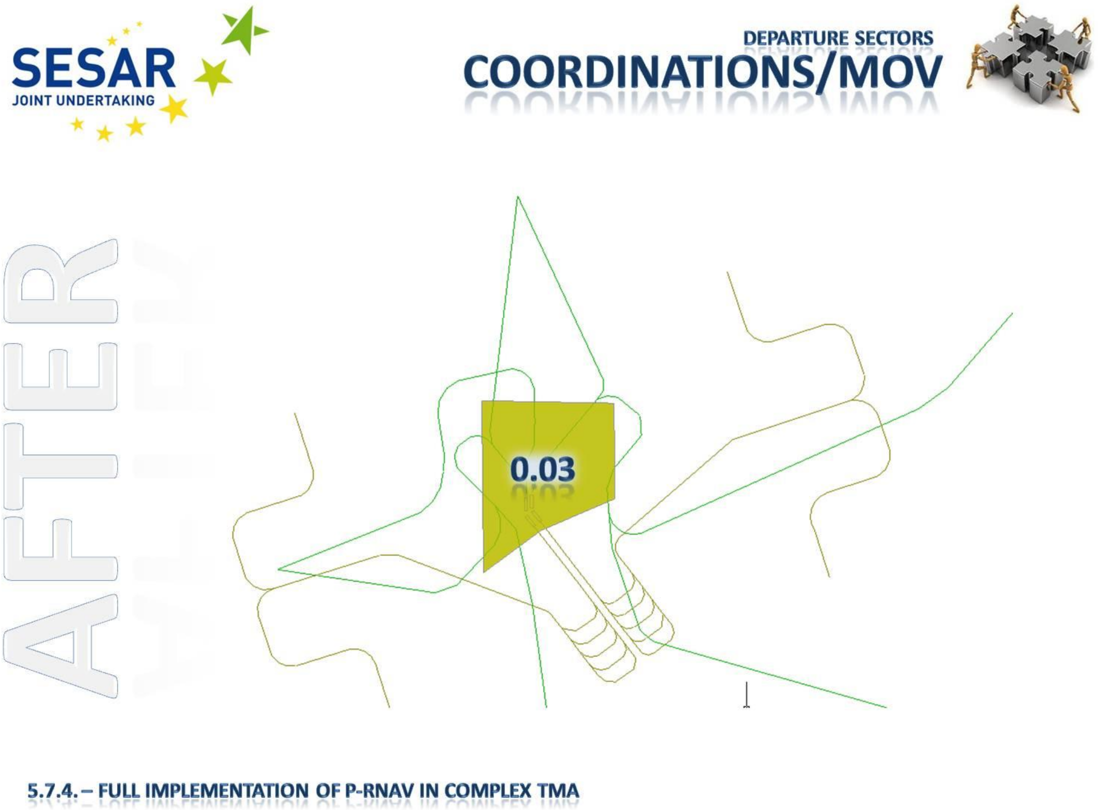
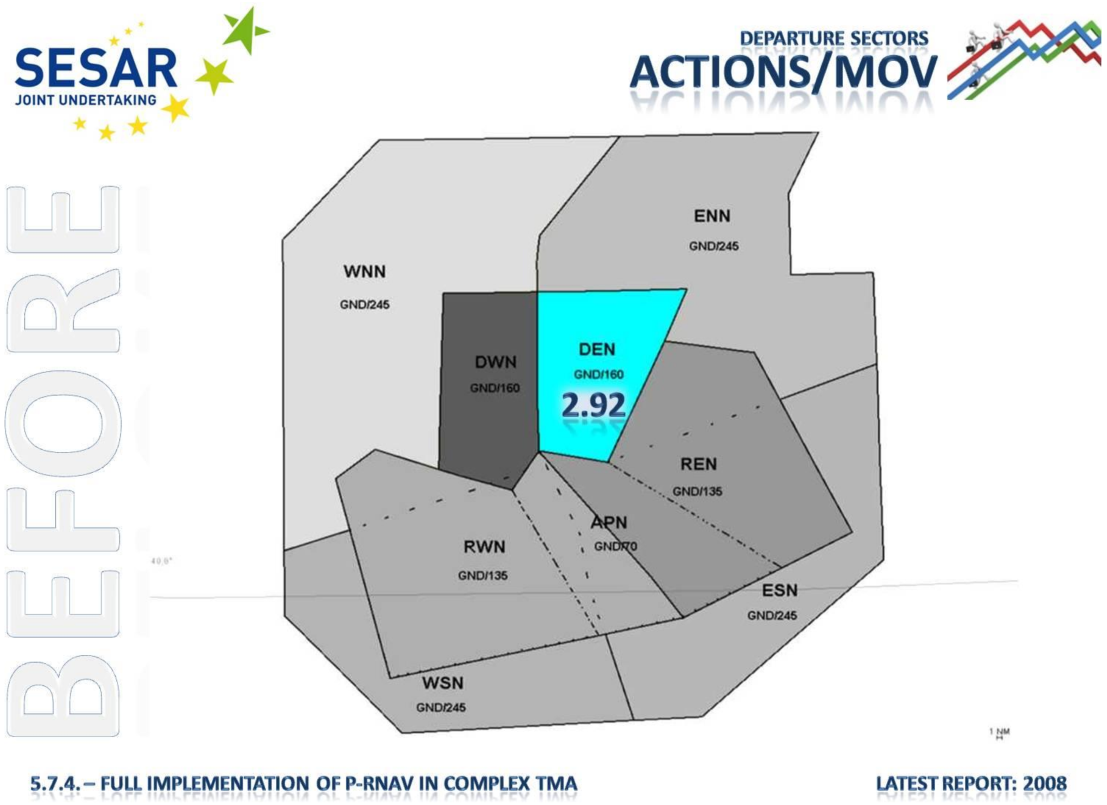


Figure 130: Complexity comparative results – External sectors



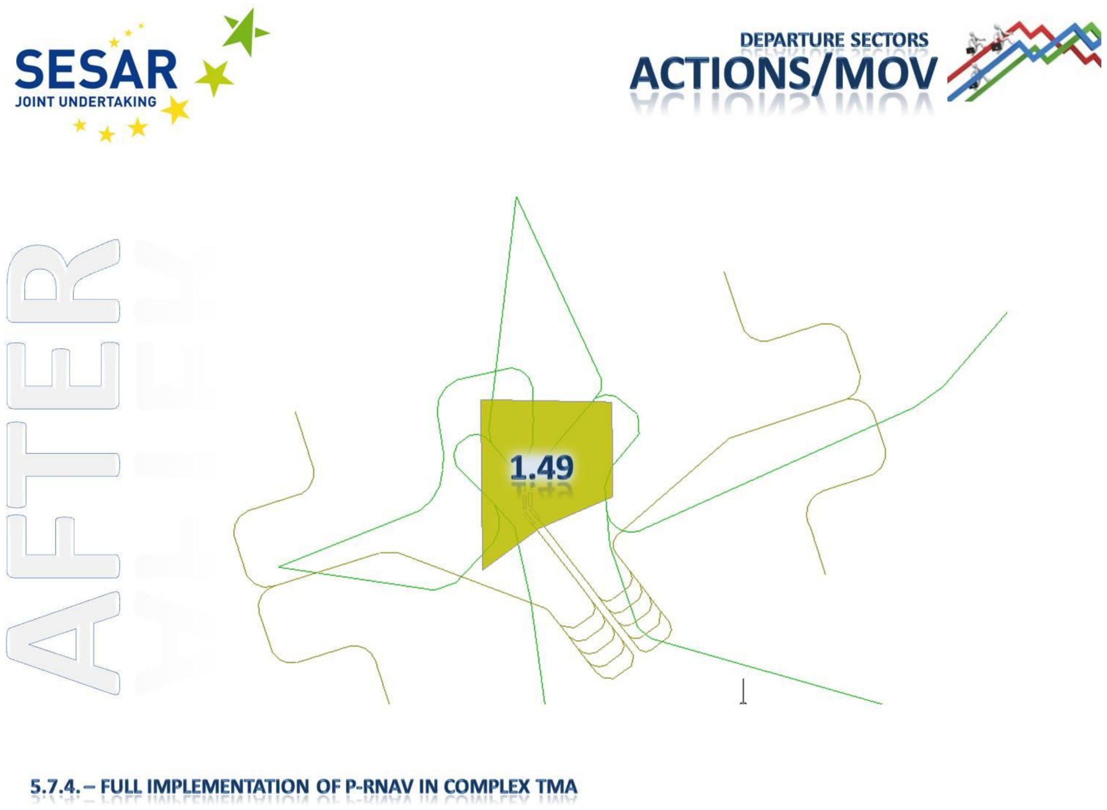
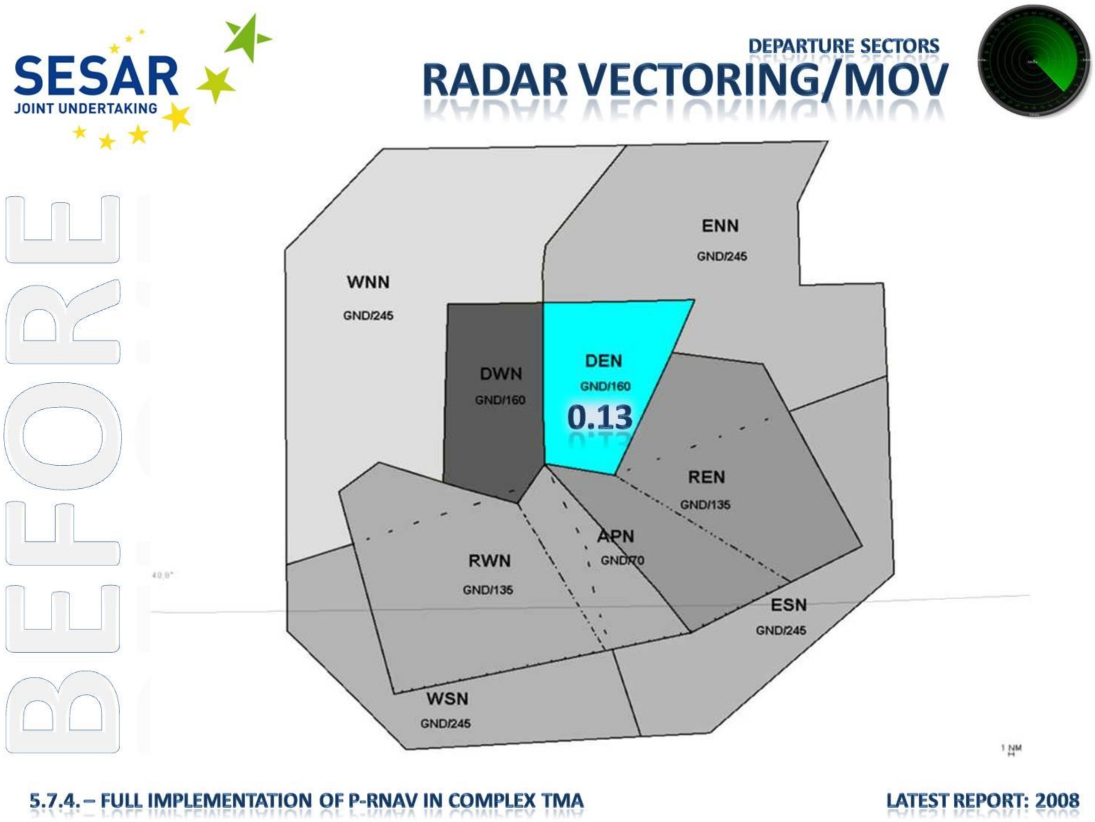


Figure 131: Complexity/mov comparative results – Departure sectors



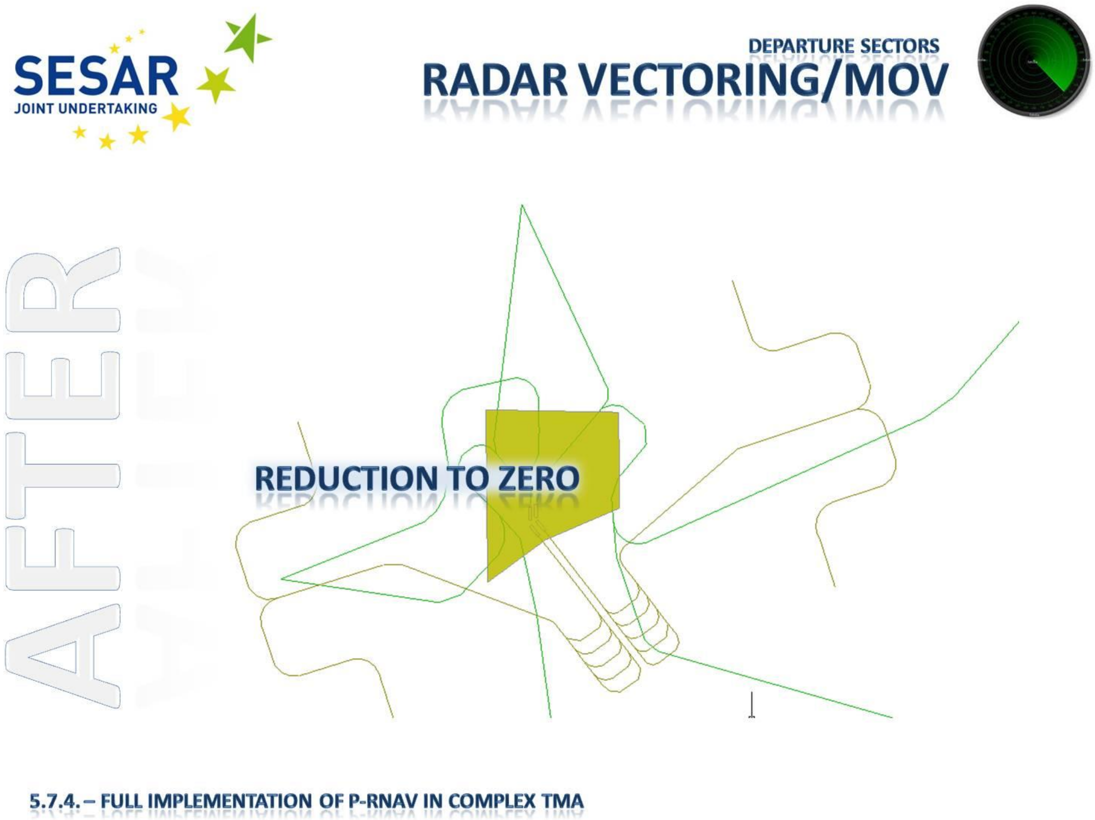
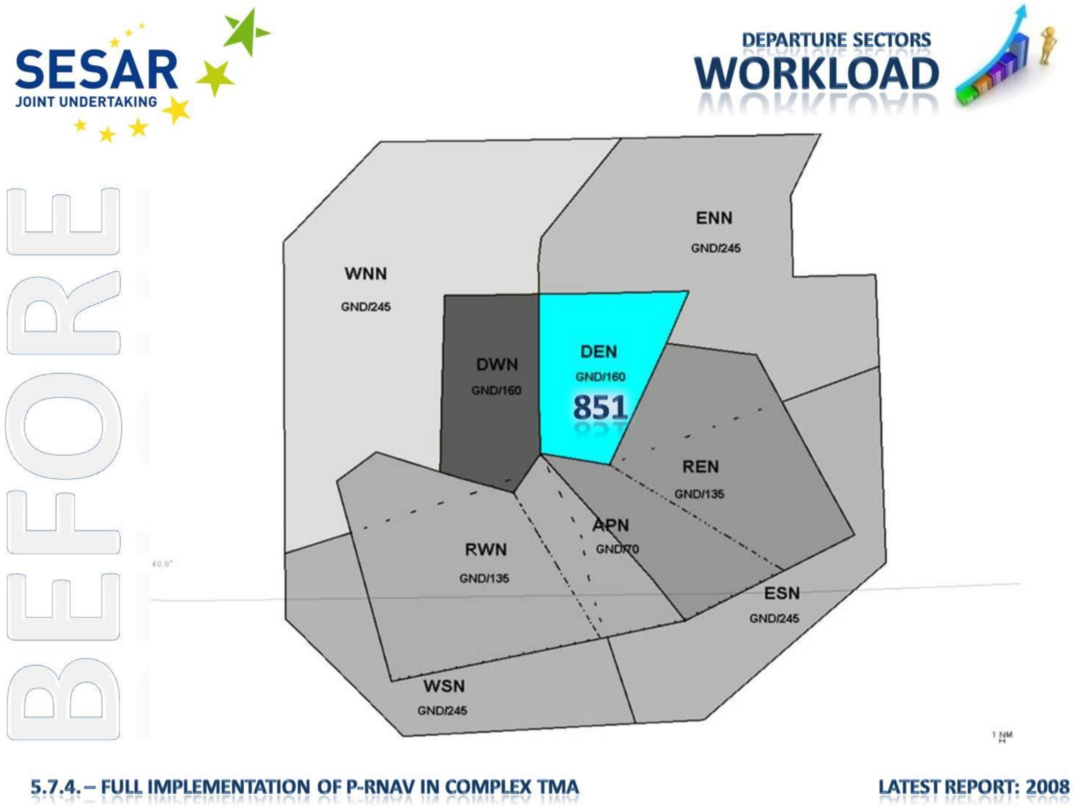


Figure 132: Radar vectoring comparative results – Departure sectors



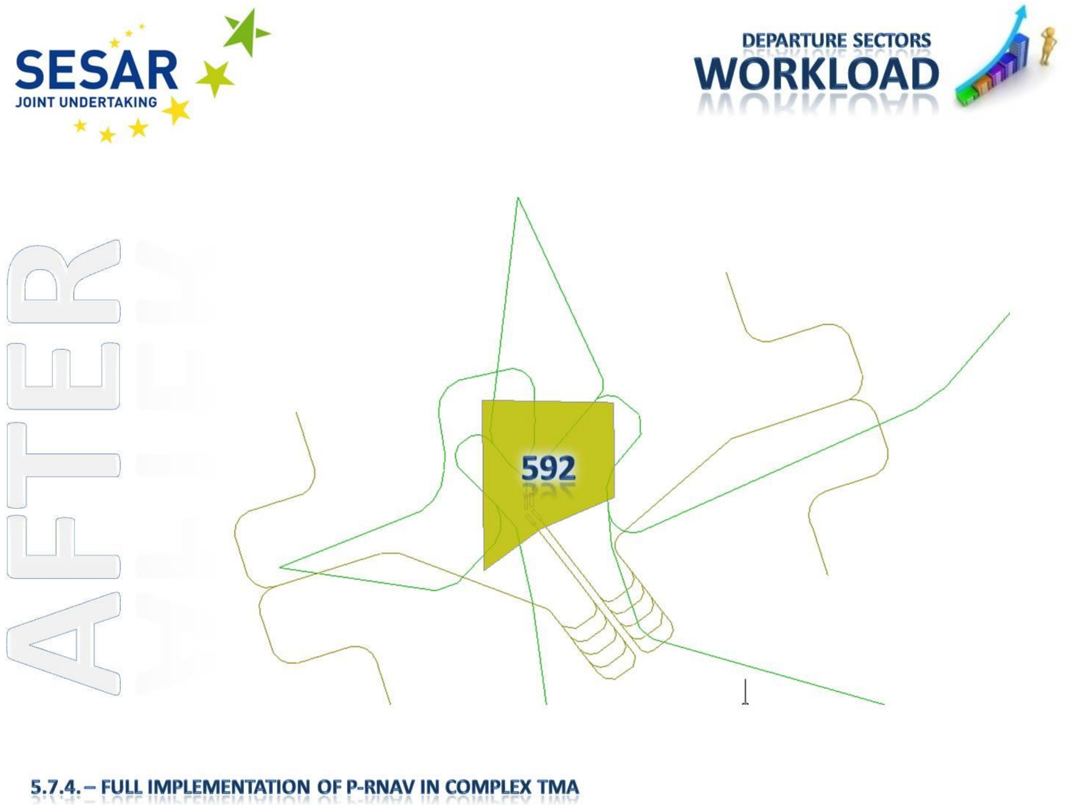
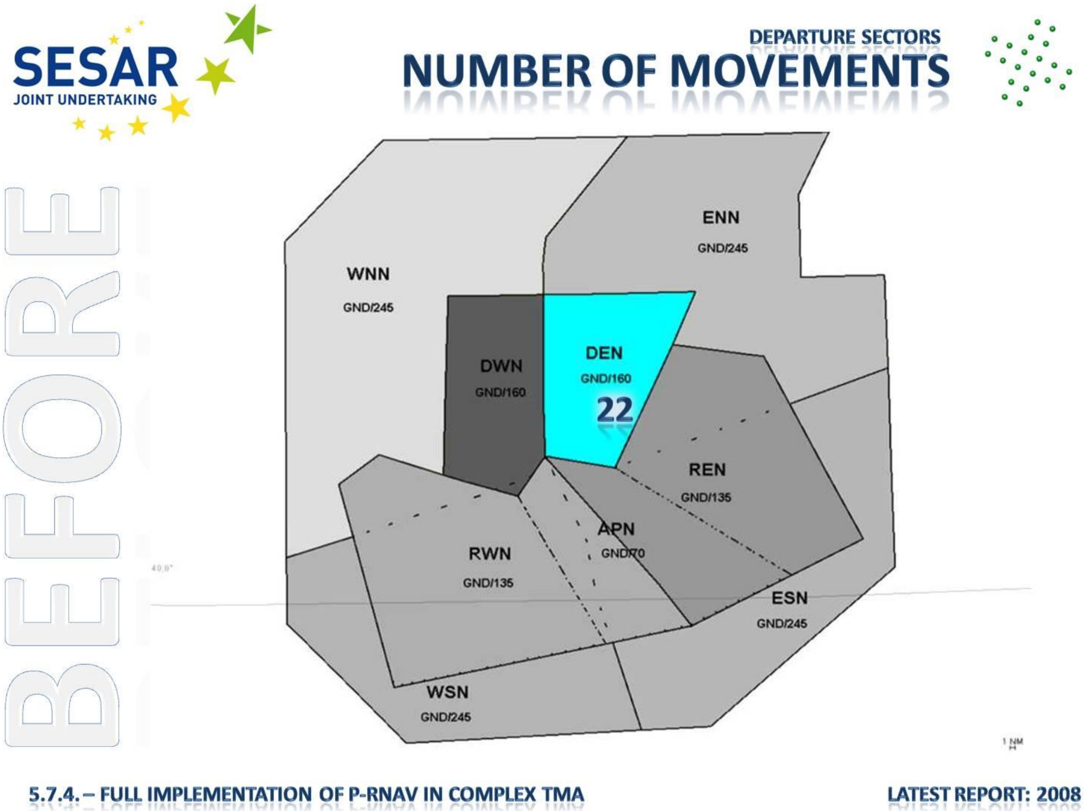


Figure 133: Workload comparative results – Departure sectors



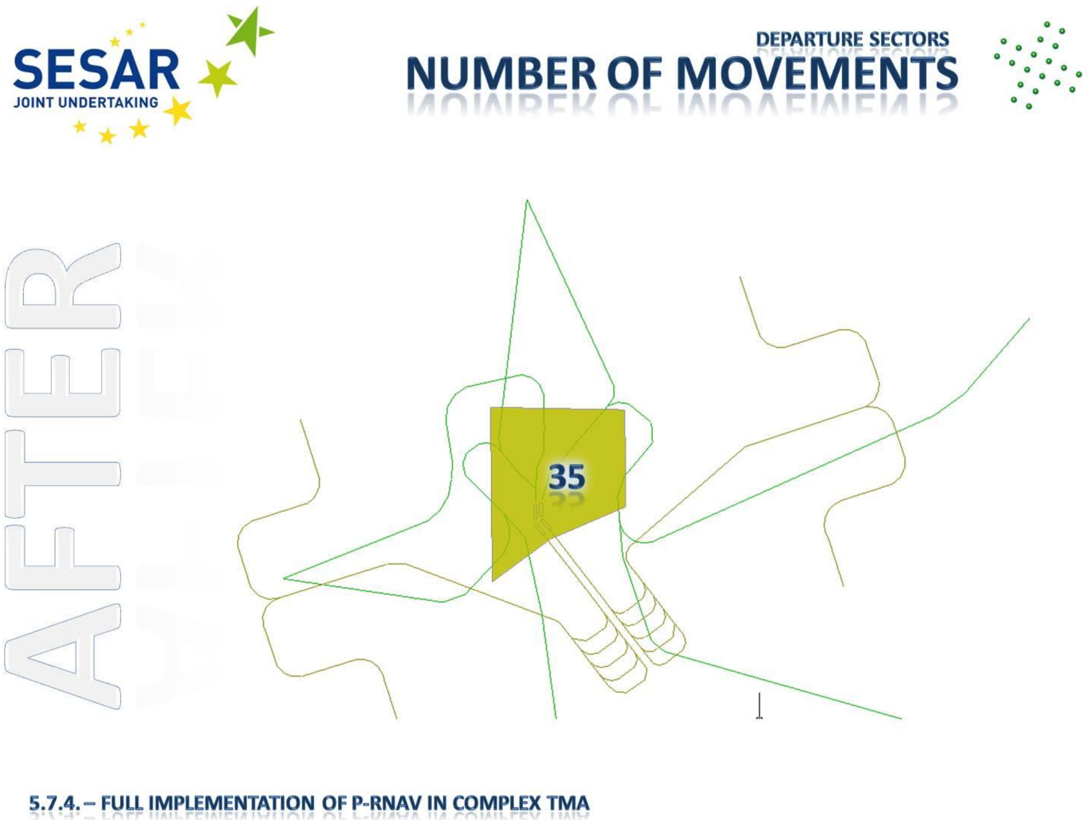
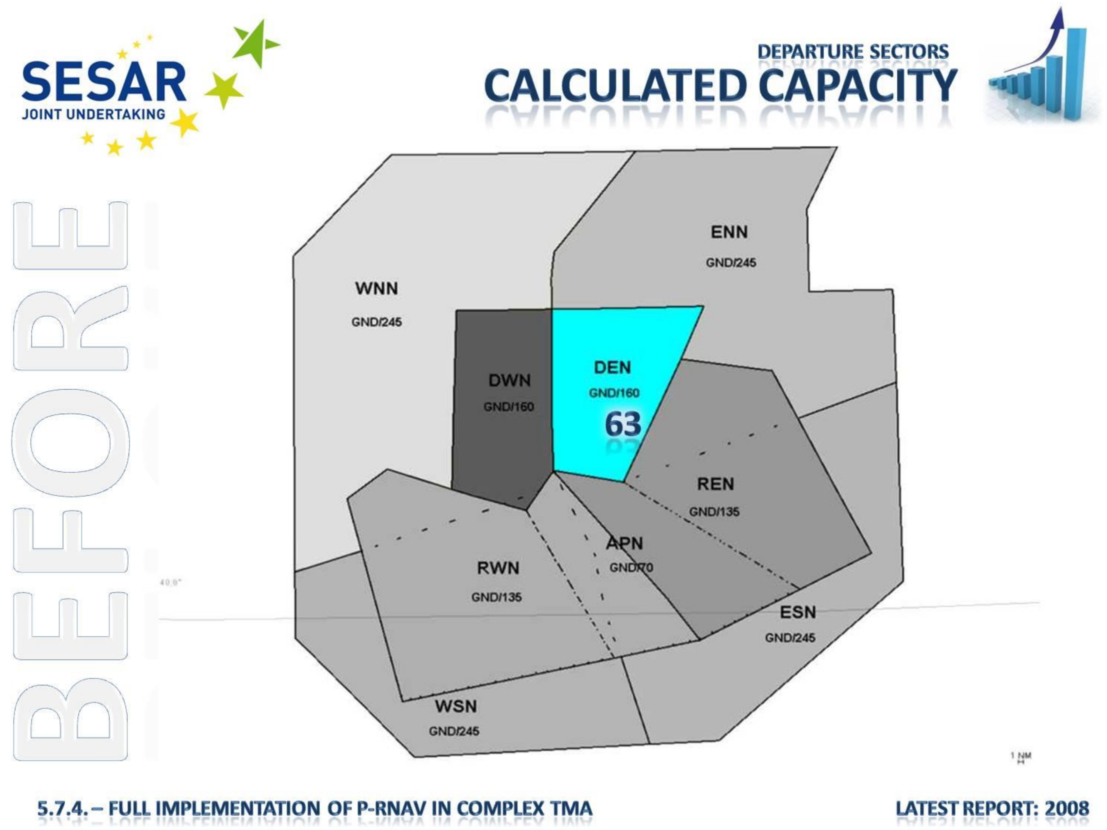


Figure 134: Nb of movements comparative results – Departure sectors



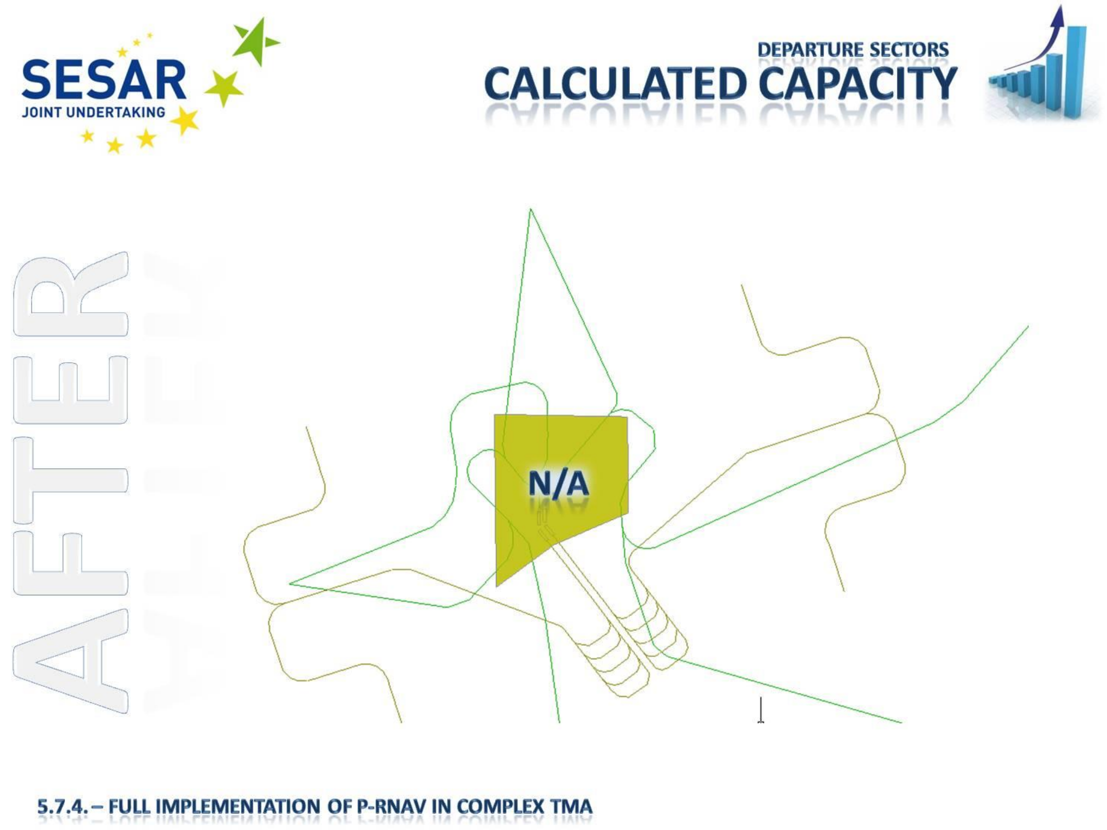


Figure 135: Calculated capacity comparative results – Departure sectors

Validation Objective ID	Validation Objective Title	Exercise ID	Exercise Title	Success Criteria[11]	Exercise Results	Validation Objective Analysis Status per exercise	Validation Objective Analysis Status
Obj #1	Mixed Mode Operations: Integration of P-RNAV & conventional routes used by a mix of P-RNAV-compliant and Conventional aircraft in high traffic density TMAs.	*EXE-05.07.04-VALP-142*	Full Implementation of P-RNAV in Madrid TMA	New procedures have been accepted by controllers and it has been demonstrated the feasibility of P-RNAV and conventional procedures compliance.	Conventional traffic increases workload significantly. A better support from system is needed to reduce coordinations	OK	OK
Obj #2	High Terrain and bad weather	*EXE-05.07.04-VALP-142*	Full Implementation of P-RNAV in Madrid TMA	New procedures have been accepted by controllers and it has been demonstrated the feasibility of P-RNAV and conventional procedures with high terrain and bad weather	The 5th transition in South configuration (18R) should be avoided due to high terrain in bad weather conditions	OK	OK
Obj #3	Maximum capacity of P-RNAV Arrivals/Transitions/SIDs/STARs	*EXE-05.07.04-VALP-142*	Full Implementation of P-RNAV in Madrid TMA	Increase Capacity compared to previous mode of operations	See exercises results per KPA (Capacity) – 4.1.2	OK	OK
Obj #4	Suitable descent slope for P-RNAV Arrivals in all meteorological conditions	*EXE-05.07.04-VALP-142*	Full Implementation of P-RNAV in Madrid TMA				
Obj #5	P-RNAV CDAs in high density traffic	*EXE-05.07.04-VALP-142*	Full Implementation of P-RNAV in Madrid TMA	New procedures have been accepted by controllers and it has been demonstrat	The CDAs proposal are suitable with the new TMA design	NON TESTED	NON TESTED

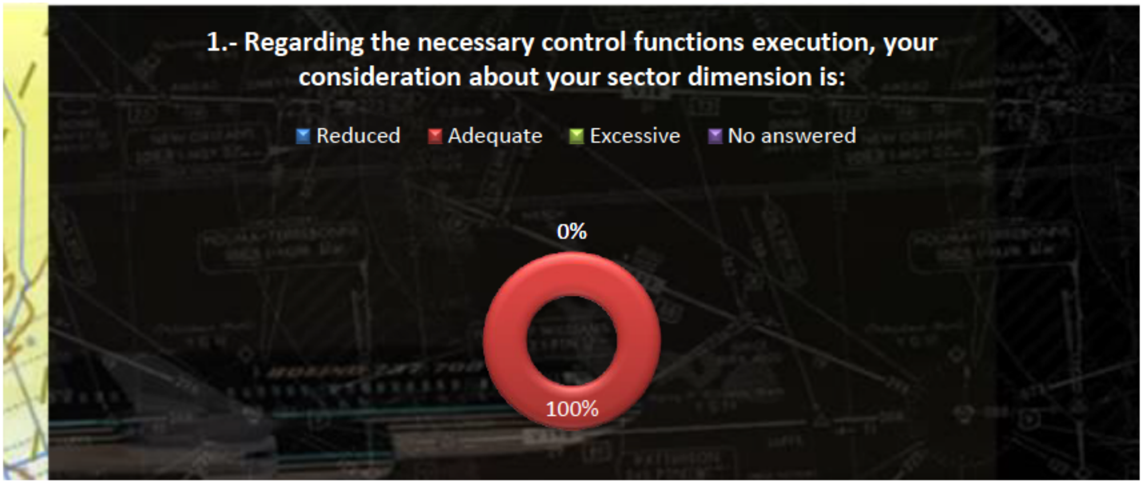
[11] Note that a validation objective can have more than 1 success criterion, please make them appear in the same cell.

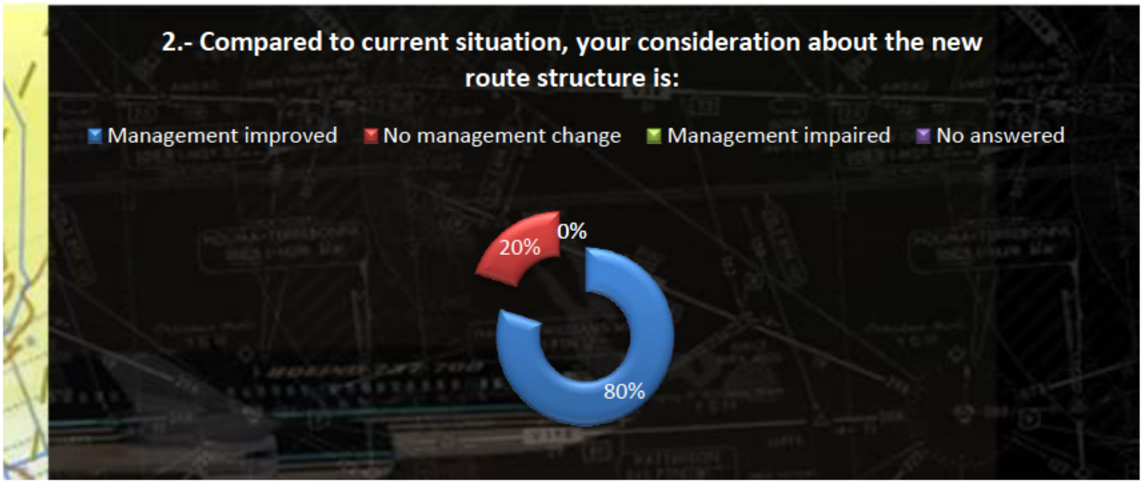
Validation Objective ID	Validation Objective Title	Exercise ID	Exercise Title	Success Criteria[11]	Exercise Results	Validation Objective Analysis Status per exercise	Validation Objective Analysis Status
				ed the feasibility of CDAs in the new scenario			
Obj #6	Continuous Climb Departures enabled by the enhanced horizontal performance of P-RNAV	*EXE-05.07.04-VALP-142*	Full Implementation of P-RNAV in Madrid TMA	New departure procedures have been accepted by controllers and it has been demonstrated the integration of these new procedures with arrivals and Torrejon and Getafe ones	It would be interesting to study more SID's to facilitate the air traffic flow (e.g. heading North direct to DGO or via RBO-DGO).	OK	OK
Obj #7	Impact on departure sequencing due to aircraft performance mix (climb rates, turn capability, etc), which creates different departure routes for different performance levels	*EXE-05.07.04-VALP-142*	Full Implementation of P-RNAV in Madrid TMA	New departure procedures have been accepted by controllers and Demonstrate that the new scenario holds different departures procedures depending on aircraft performance	The different departures (e.g. NVS and NVS long) fulfil with aircraft performance requirements	OK	OK

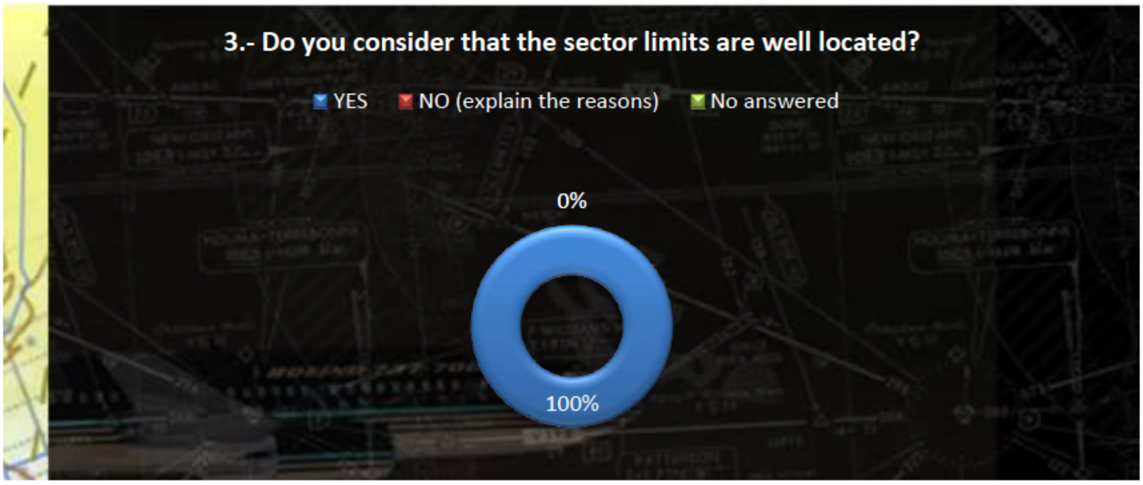
Table 13: Overview: Validation Objectives, Exercises Results and Validation Objectives Analysis Status

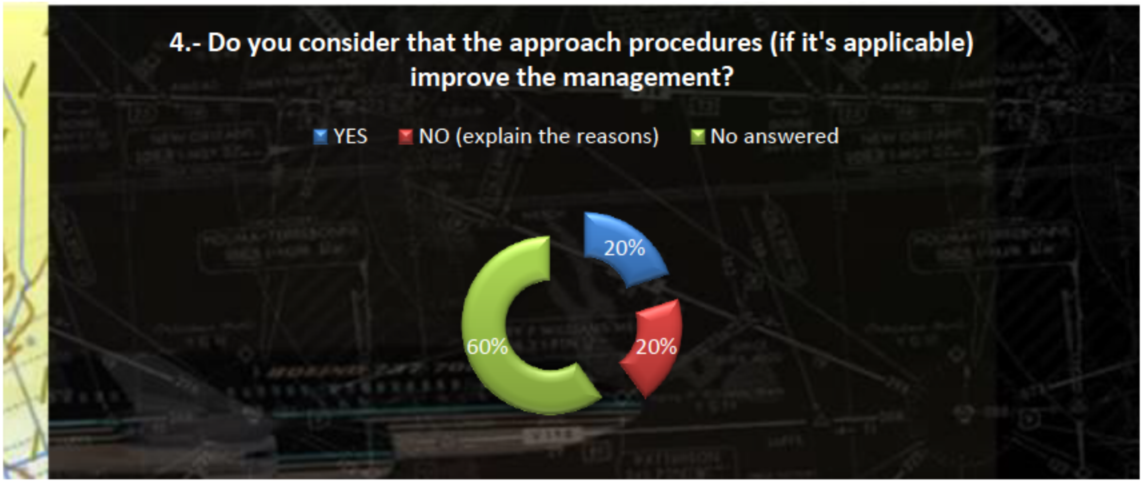
The impact of conventional traffic is significant and increases workload due to the need of coordination between controllers. Procedures have been accepted, but in order to reduce workload, it has been recommended by controllers to have a support from system. This support basically consists in an advice through the radar label about the condition of conventional traffic. This can be done by adding an extra symbol to the label of traffic or by using a different colour in the presentation of this label. CDA procedures have been analyzed for inclusion in the scenario. They have not been simulated due to the impossibility of the simulator to offer realistic traffic behaviour when performing a CDA. Nevertheless we are convinced that CDA procedures are feasible in the P-RNAV scenario, but only with med/low traffic demand. The status in the table has been changed to "Non Tested"

4.2.6 Analysis of Airspace

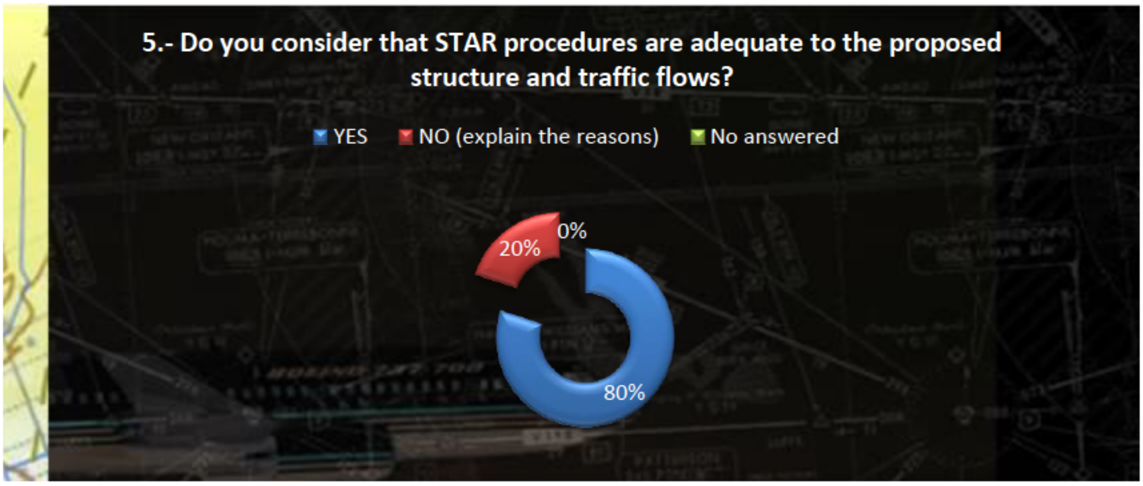




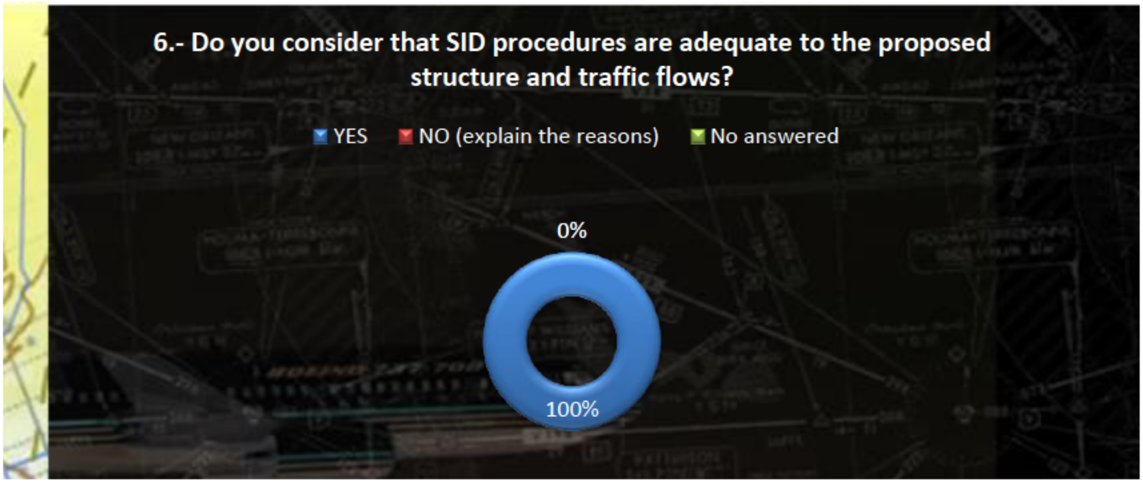


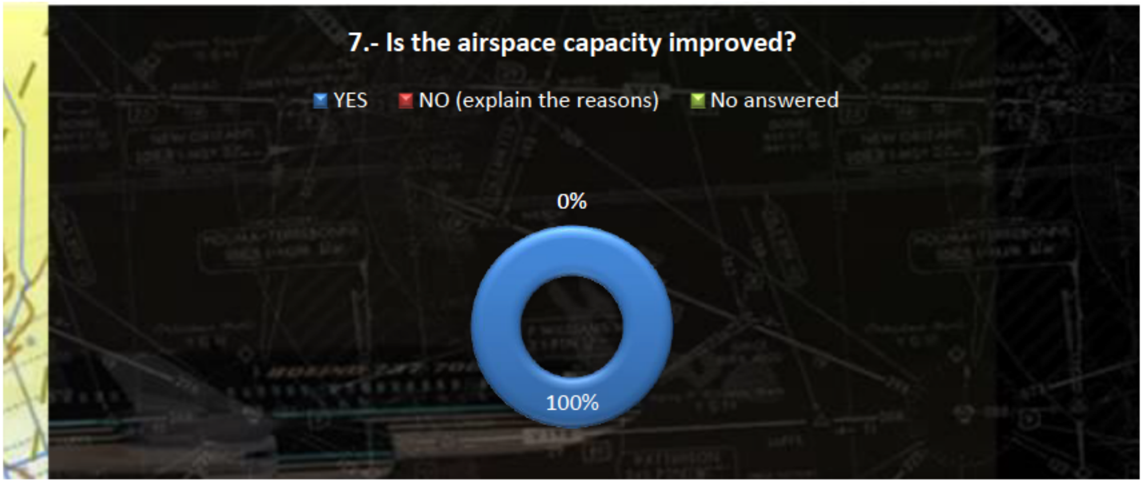


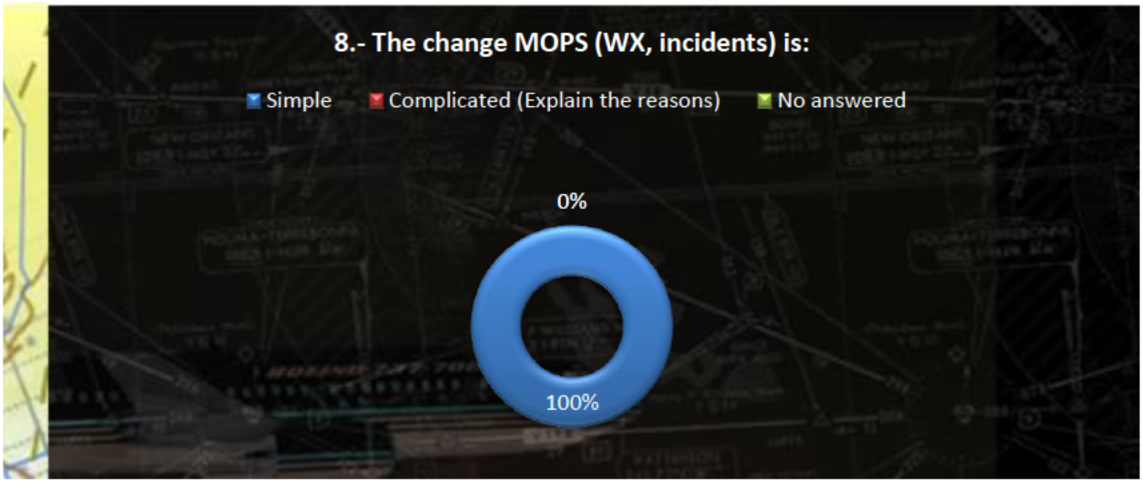
Comments:
"The approach procedures are impaired regarding the operations for a single runway"



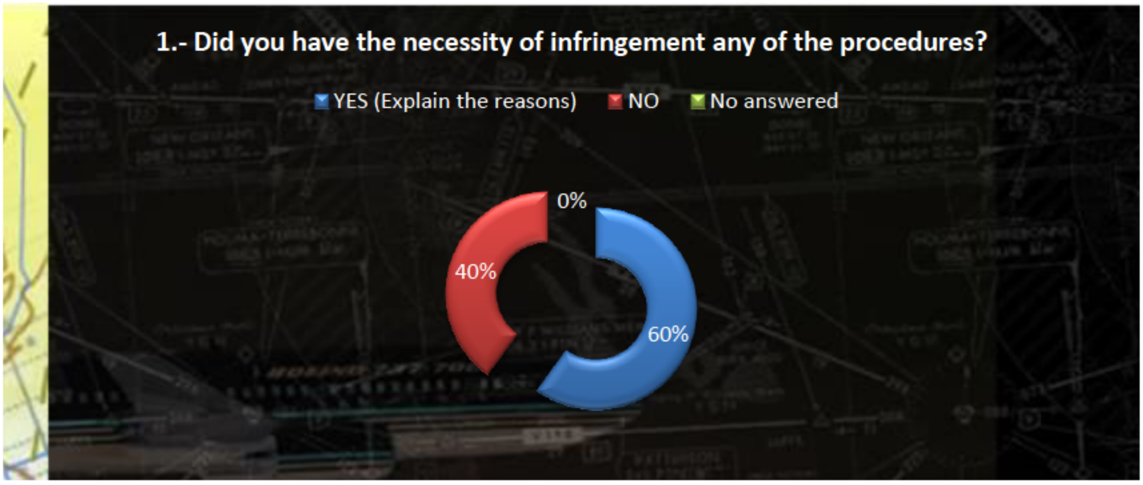
Comments:
"It is necessary to analyze and improve the connecting points with ACC"



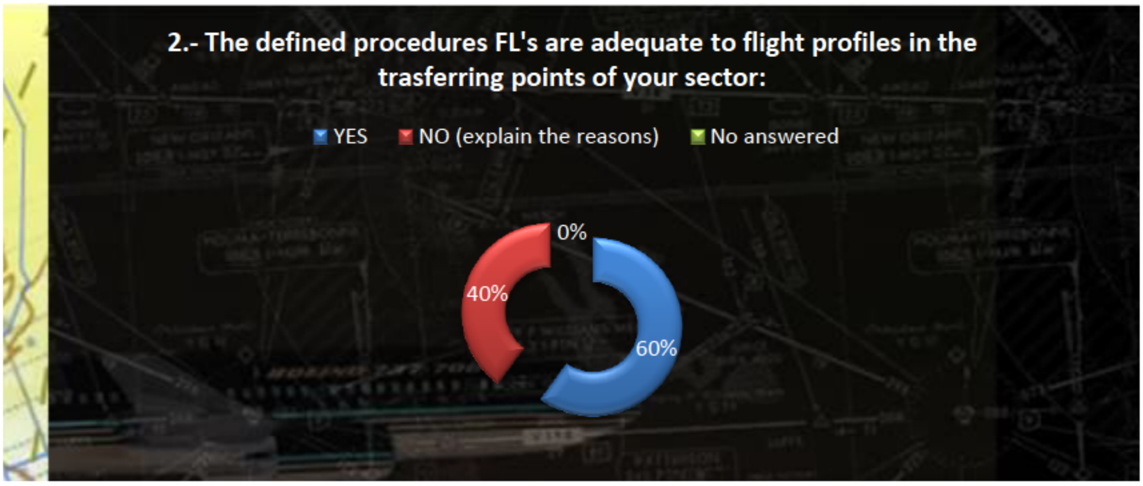

7.- Is the airspace capacity improved?
YES
NO (explain the reasons)
No answered
0%
100%


8.- The change MOPS (WX, incidents) is:
Simple
Complicated (Explain the reasons)
No answered
0%
100%

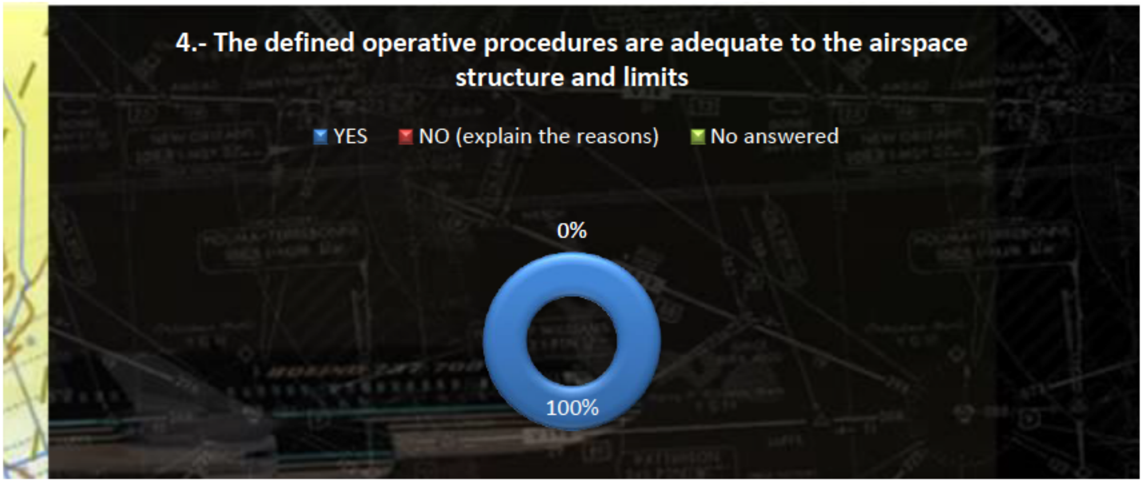
4.2.7 Analysis of Procedures

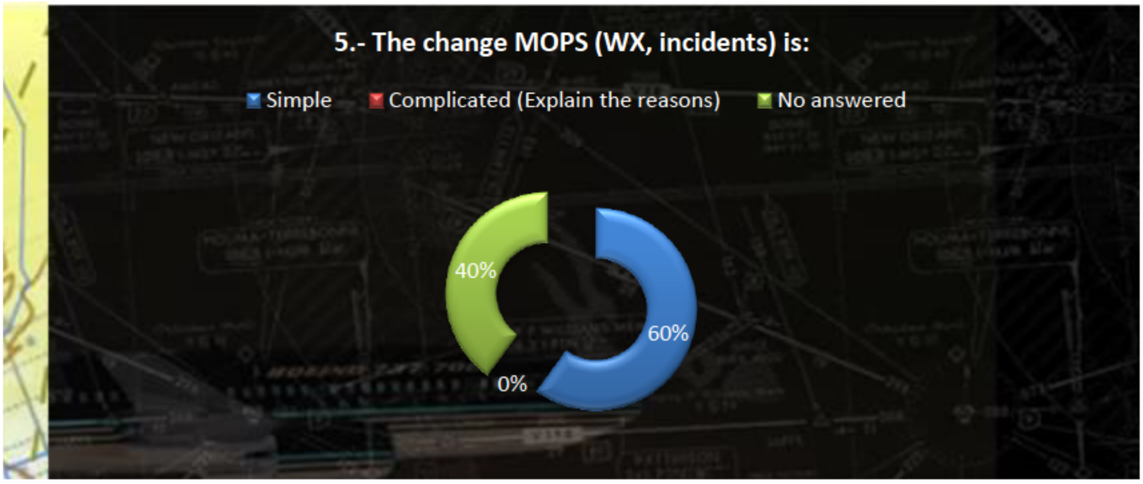


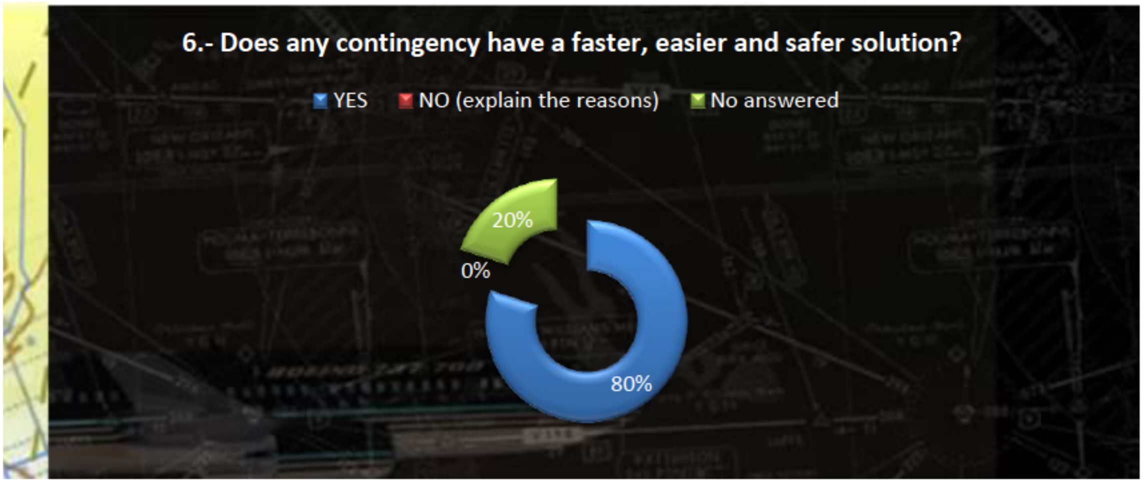
Comments
"Trajectories shortcut and ask for lower flight levels for some traffic"
"Longitudinal separation due o inbound traffic coming too close from preceding sectors"



Comments
"The traffic is flying very low with a huge amount of miles flown"
"The defined FLs for arrivals are excessively low"

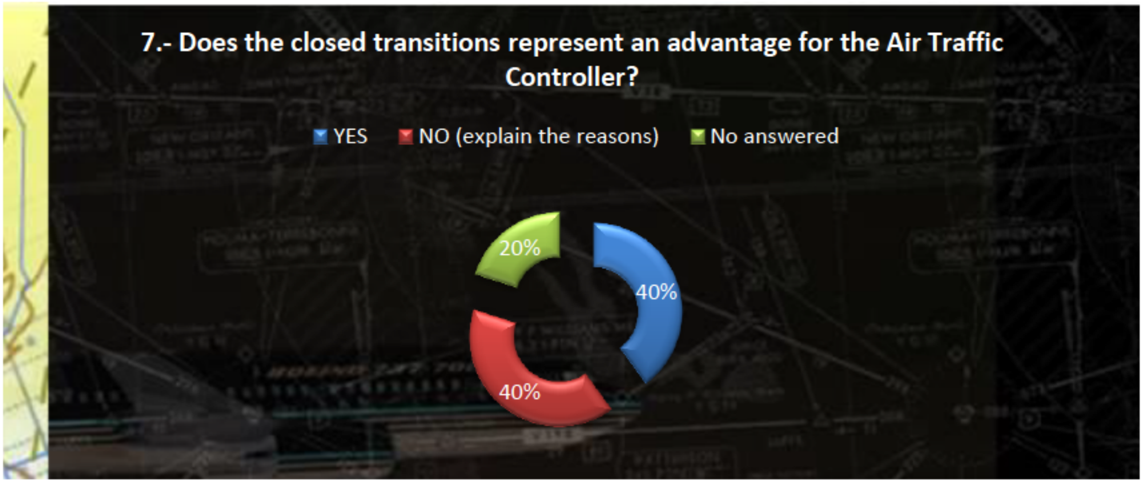






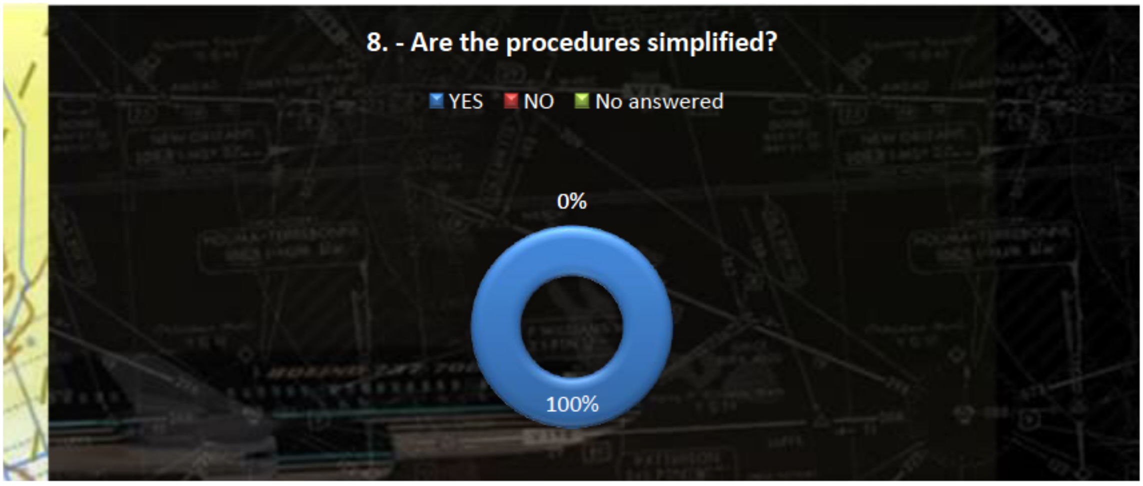
Comments

"It is necessary to test it"

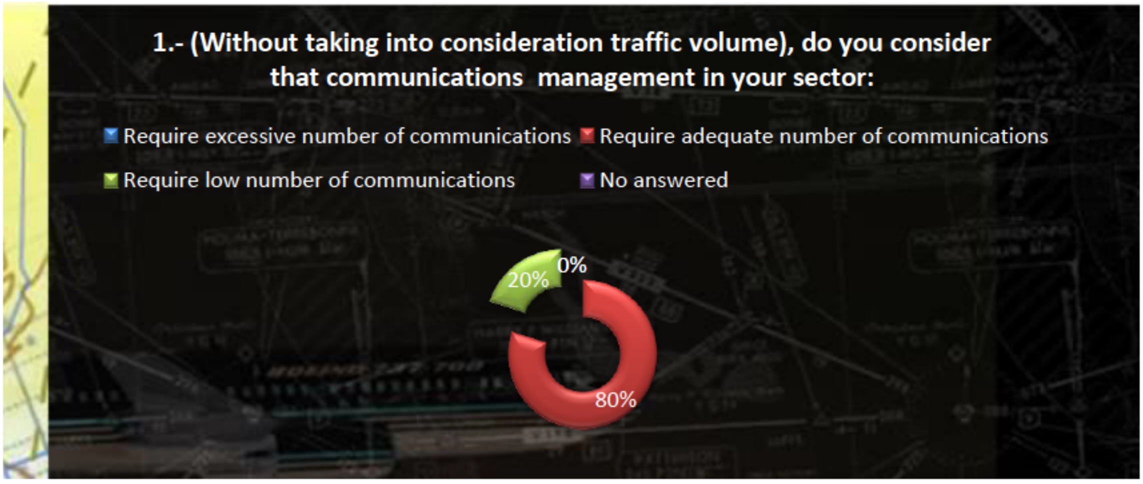


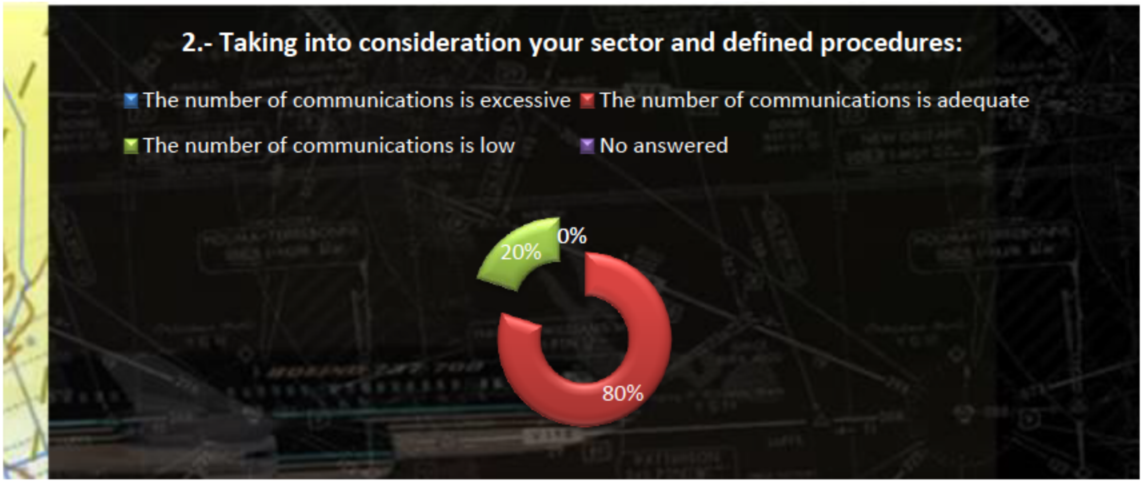
Comments

"It seems to be that in a single runway operations the closed transitions aren't effective"
"Flexibility is reduced compared to radar vectoring (test it)"

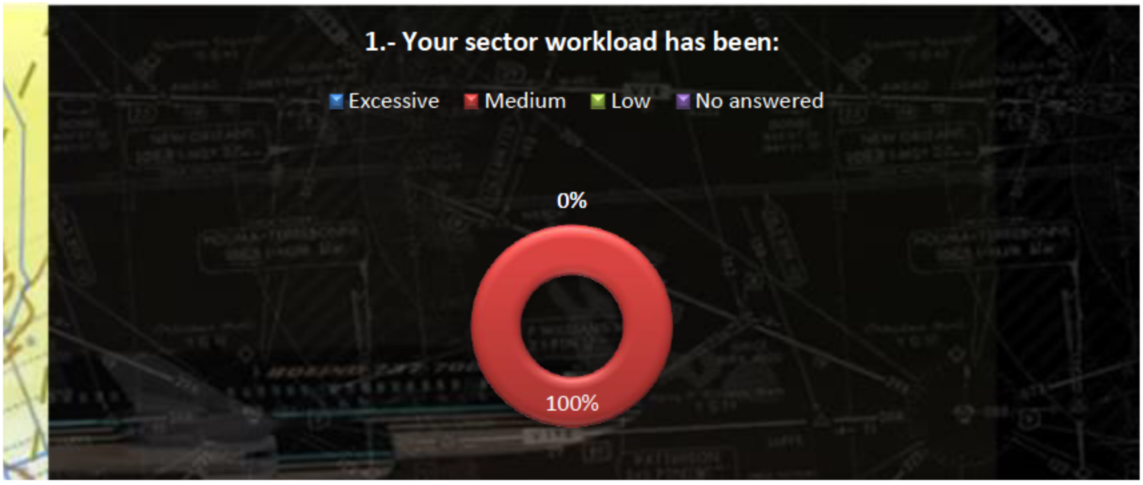


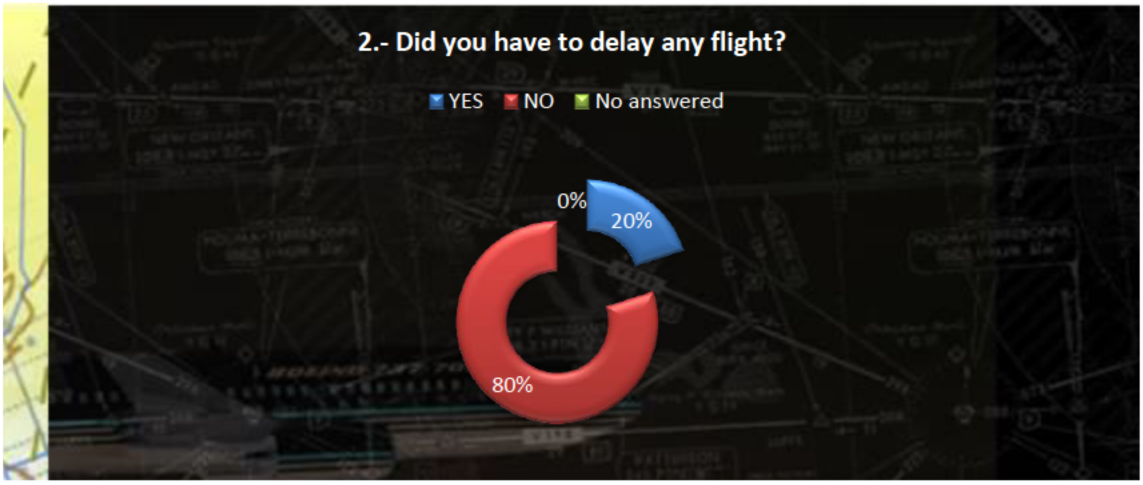
4.2.8 Analysis of Communications





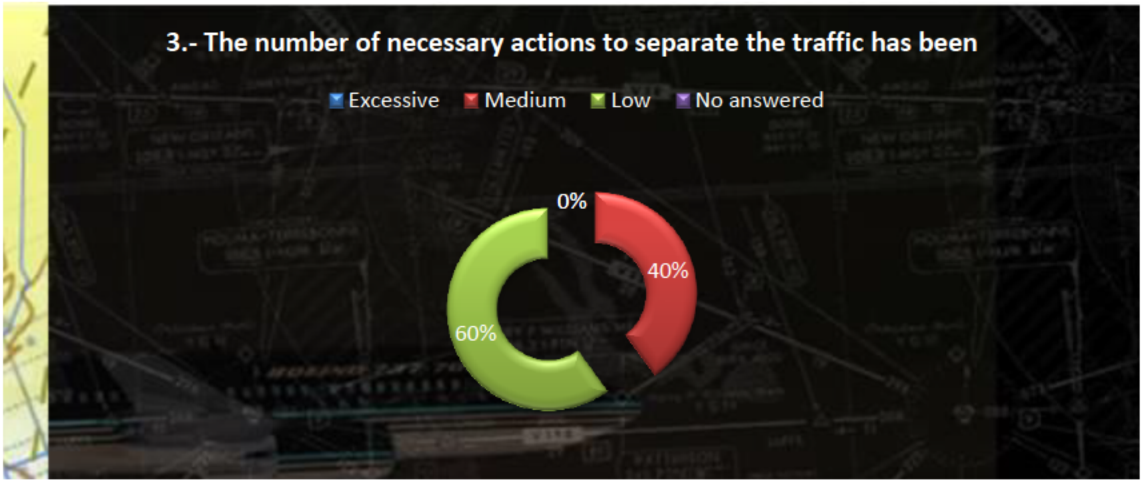
4.2.9 Analysis of Tasks

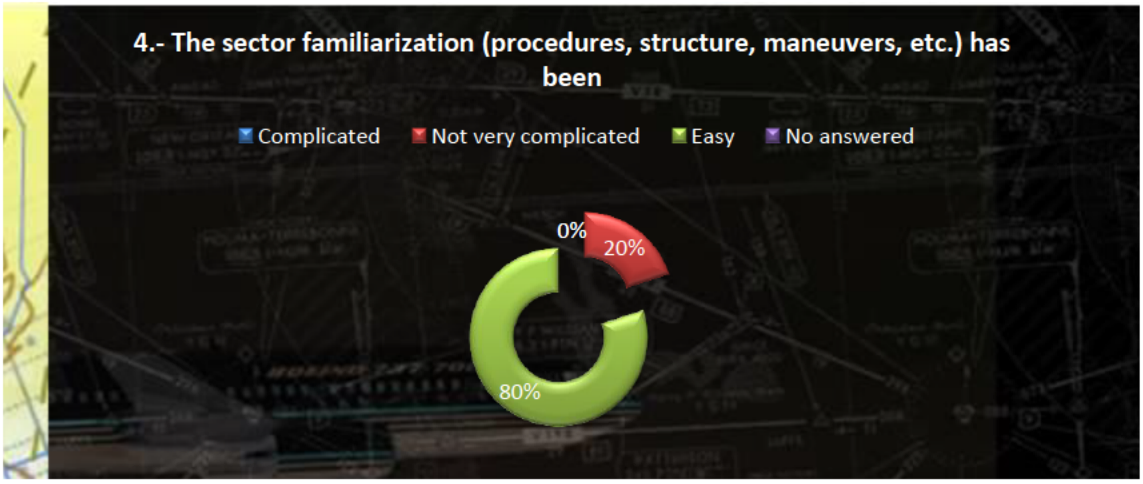


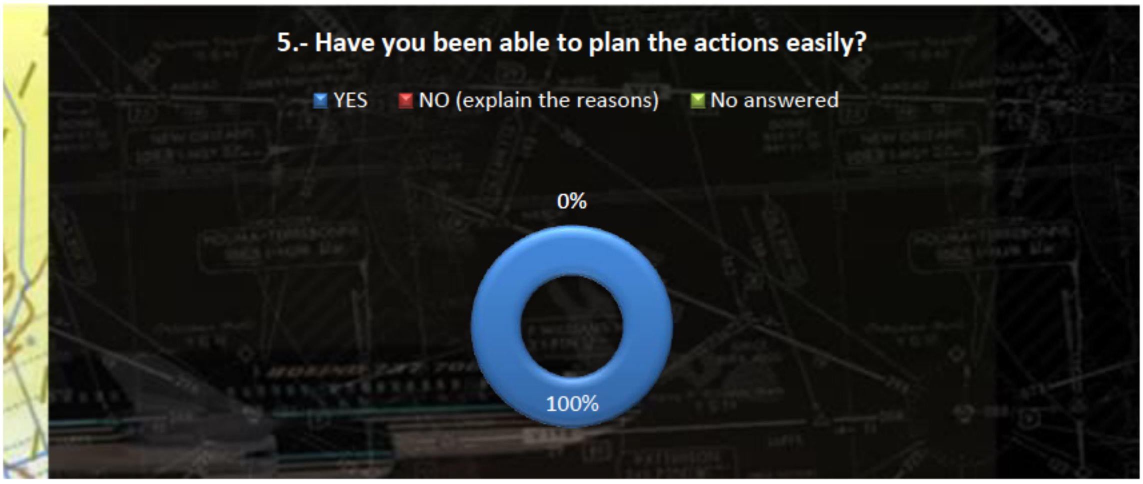


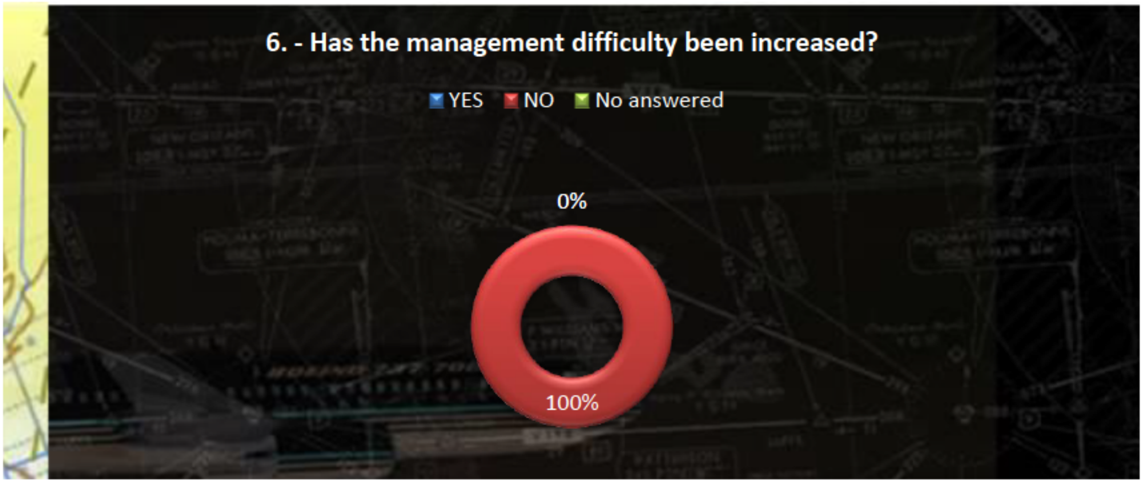
Comments

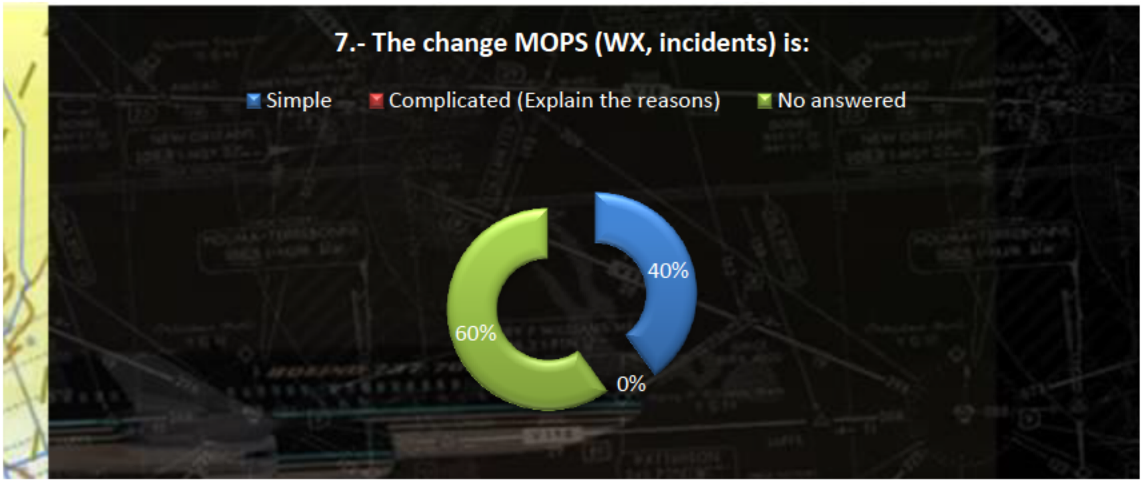
"Due to lack of final approach sector capacity some traffic had to be put on hold"

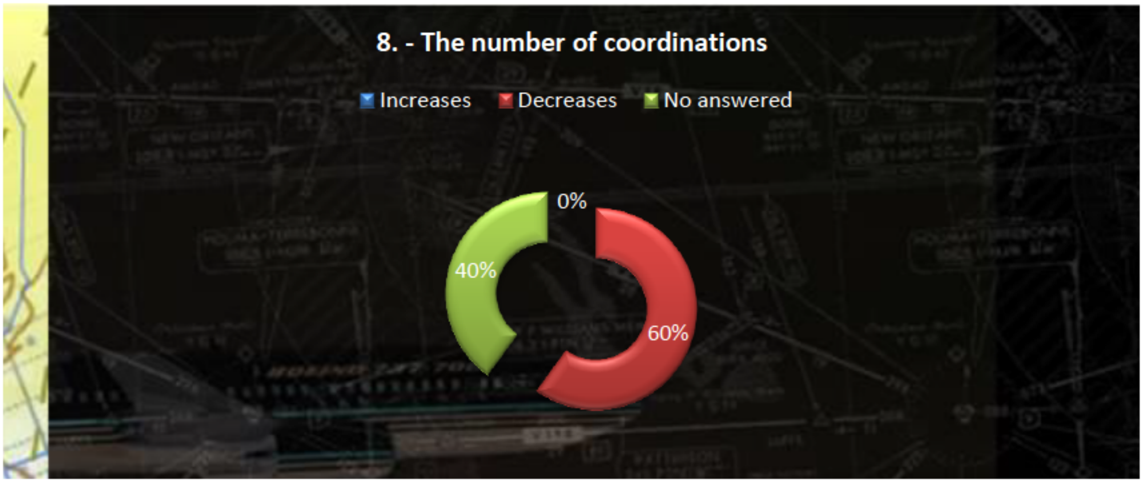

3.- The number of necessary actions to separate the traffic has been
Excessive
Medium
Low
No answered
0%
40%
60%


4.- The sector familiarization (procedures, structure, maneuvers, etc.) has been
Complicated
Not very complicated
Easy
No answered
0%
20%
80%

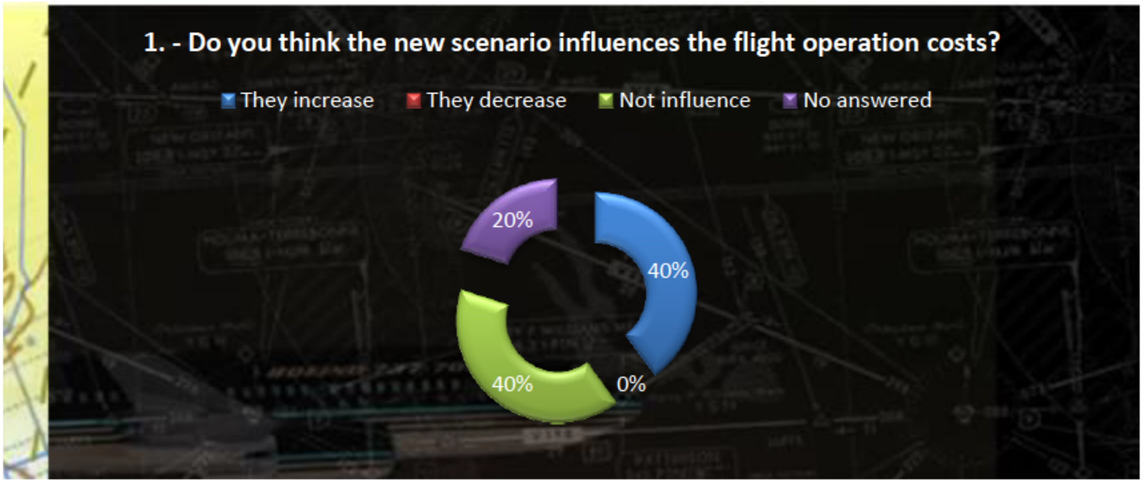

5.- Have you been able to plan the actions easily?
YES
NO (explain the reasons)
No answered
0%
100%

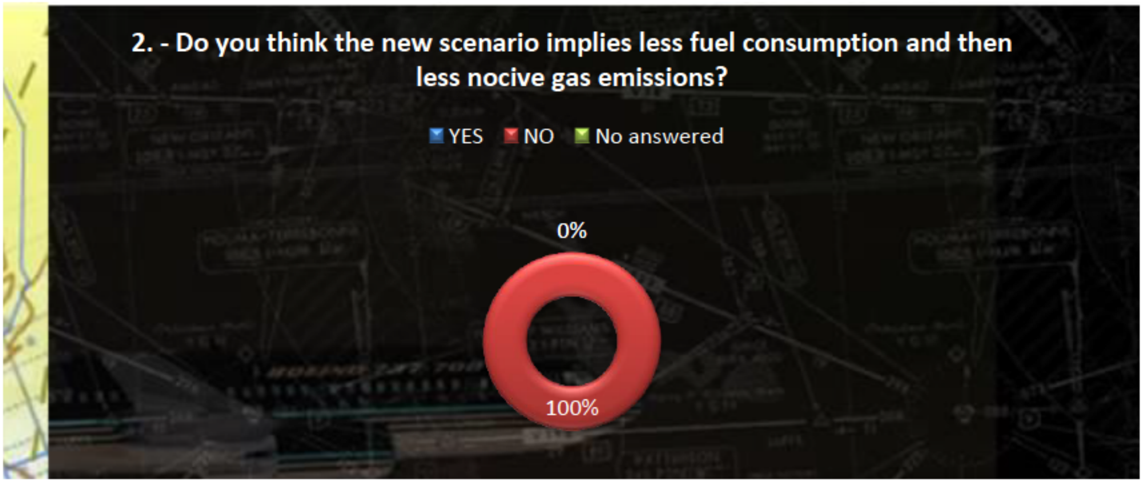






4.2.10 Analysis of Cost-Benefit & Environment





Comments
"It is necessary to demonstrate if the increase of miles flown worth"
"FLs too low for too long routes, companies should evaluate if it is worthy"

4.2.11 Unexpected Behaviours/Results

Here is the list of the problems identified in the context of 5.7.4 WS1 validation exercises preparation, execution and analysis:

- All the exercises could not be performed as planned because of lack of simulator availability (Madrid ACC was able to schedule 2 weeks for 5.7.4 simulation activities). The lack of training sessions for controllers (derived from simulator availability to perform training sessions) led to exercises repeated and delayed. Moreover, the problems with communications channel between controllers and pseudo-pilots led to exercises cancellation and delays.

- There were no sufficient results for some sectors due to the lack of NORVASE data pick-up. The limited number of runs made necessary to exclude the less significant sectors of the total scenario (external feeders).

- The exported files from the simulation to PALESTRA didn't contain enough information (only 2D reproduction of what was shown in the radar screen) to provide a quantitative environmental case.

4.3 Confidence in Results of Validation Exercises

4.3.1 Quality of Validation Exercises Results

Some factors have to be taken into account to evaluate quality of results:

- Insufficient time of training for controllers and pilots
- Lack of Sector Control Units availability
- Lack of resources (controllers, pseudo-pilots and NORVASE data pick-up experts)
- The recorded files resulting from the validation activities are limited
- Lack of export data options in simulator units and PAPOs (support positions)
- Frequent communication failures

4.3.2 Significance of Validation Exercises Results

Some factors have to be taken into account to evaluate significance of results:

- The impacts in some current restricted areas haven't been taken into account due to current negotiation process.
- Coordination and influence of Torrejon GCA have not been simulated

5 Conclusions and recommendations

5.1 Conclusions

- System should be able to pre-advice, by automated means to final approach controller about the arrival of non P-RNAV equipped aircrafts, as well as to the initial approach controller. This will avoid extra coordinations between both controllers, to ask the initial approach controller to open a gap between two P-RNAV equipped traffic, to allow final controller to put in sequence the non equipped aircraft.

- Feeder sectors should pre-sequence traffic to facilitate management of initial approach sectors.

- Silent coordination procedures supported by the system should be implemented to reduce coordinations between feeders and initial approach sectors.

- For high traffic demands as simulated in the higher traffic samples, the support of tools such as AMAN is needed to help pre-sequencing traffic to feeder sectors.

- In strong wind conditions, the separation between traffics at the deliverance from initial to final approach sectors needs to be increased from seven to ten miles to prevent overtaking in the final approach path.

- For single RWY operation closed transitions have been observed as non manageable by NORVASE specialists and also by controllers. Open transitions and radar vectoring to localizer has conducted all right, always accompanied by a reduction in capacity.

- If at a given time it is necessary to change a pre-assigned transition to localizer, once the aircraft has passed the IAF, it is recommended to instruct the traffic to turn to localizer by using radar vectors better than assigning a new transition, since pilot may not be able to introduce the change in the FMS.

5.2 Recommendations

This section contains recommendations for close out of V3 and looking forward to future projects and implementation phases. Here are listed the main recommendations for P-RNAV Madrid TMA:

- Possibility to elevate of superior TMA limits till FL245
- To study the possibility of traffic coming at higher levels from clearance limits (e.g. FL 210) due to the distance left to IAWP's.
- To change the procedures so that departure sectors could climb the traffic before transferring it to en-route sectors (e.g.FL200)
- To carry out a deeper study of missed approach procedures in order to send them to the IAWP.
- In South Configuration, MEA's in the final grids are below MVA. Alternative procedures should be studied for the event of need of radar vectoring.
- To handle non-PRNAV traffic in the approach sequence with high traffic workload is difficult.
- Incidences of departing traffic from Torrejon and Getafe in the departure sectors should be further analysed.
- Redesign sector limits and its jurisdictions in order to well include in them the corresponding aerodromes in their space.

- It would be interesting to study more SID's to facilitate the air traffic flow (e.g. heading North direct to DGO or via RBO-DGO).
- It is suggested that director sectors receive the traffic from external feeders sectors at FL 150 via TERES and PILAR; and FL 160 via GRECO and DULCI.
- Sequencing tools (AMAN) are needed for the scenario to accommodate high traffic loads without increasing workload or provoking delays.
- Solutions for specific CDO manoeuvres have been analysed, although not tested. CDO in high traffic periods seems to be not feasible.

6 References

6.1 Applicable Documents

[1] V&V Plan Latest version

[2] SESAR V&V Strategy Latest version

[3] Template Toolbox 02.00.00

[4] Requirements and V&V Guidelines 02.00.00

[5] Toolbox User Manual 02.00.00

[6] European Operational Concept Validation Methodology (E-OCVM) - 2.0 [March 2007]

[7] 05.07.04 - D003 – Madrid OSED

[8] 5.2. - DOD

6.2 Reference Documents

The following documents provide input/guidance/further information/other:

[9] 5.7.4 – Validation Plan

[10]5.7.4 – Updated OSED for Madrid TMA

[11]5.7.4 – Benefit Mechanisms

- END OF DOCUMENT -