Final OSED for Madrid TMA (Annex Safety Assessment)

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Abstract

This document contains the Safety Assessment for a typical application of the Optimized RNP Structures (02.01.01 OFA) in Full Implementation of P-RNAV in Madrid TMA (P05.07.04, WS1) operations. The report presents the assurance that the Safety Requirements for the V1-V3 phases are complete, correct and realistic, thereby providing all material to adequately inform the 02.01.01 OFA SPR.

The Safety Assessment Report refers to the Validation Exercise EXE-05.07.04-VP-142 carried out for Project 05.07.04, WS1.

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Executive summary

This document contains the Safety Assessment for Step 1 Project 05.07.04, Work String 1: Full Implementation of P-RNAV in Madrid TMA.

The key properties of the environment are described, as well as the proposed new mode of operations.

Then, SAfety Criteria (SAC) are settled in order to continue fulfilling the barriers of the relevant Accident Incident Model.

Relevant pre-existing Hazards are determined, and the ATM system services to address the hazards described. As a success approach, Safety Objectives under normal operations for those services are derived, in order to mitigate all the identified pre-existing hazards. This will comprise the safety benefits expected to be achieved by the new system.

On the other hand, a failure approach is carried out, determining the system-generated hazards and deriving safety objectives from them.

Finally, both safety objectives will be addressed by the determination of Safety Requirements, both for normal operations (success approach) and internal system failures (failure approach).

1 Introduction

1.1 Background

This operational concept describes the implementation of P-RNAV procedures in the Madrid-Barajas TMA in the context of step 1 of the SESAR V&V Storyboard.

The aim of project 05.07.4 is:

- To determine how to maximise the benefits of P-RNAV in TMA operations, thereby enhancing the business justification of any such future implementation.
- To determine feasibility of concepts, such as the sequencing legs, that build upon P-RNAV procedures to solve safety, capacity, complexity, environment or efficiency limitations in complex TMA's, based upon current deployment in low complexity TMAs .
- To build upon EUROCONTROL P-RNAV guidelines to enhance the potential benefits to air traffic.
- To determine feasibility & TMA design to address complex traffic management in multi-airport and mixed mode environments.
- To determine feasibility of concepts to address noise nuisance in transition from conventional to P-RNAV procedures.
- To optimise solutions for 2D P-RNAV operations to enable a solid foundation on which to build 3D and 4D RNAV operations to ATM Service Level 2 and beyond.
- To assess feasibility of implementing P-RNAV in complex TMAs and integrated with other advanced concepts like AMAN.

The generic issues covered by this project to full P-RNAV implementation are:

- 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 – Use of P-RNAV procedures to improve safety of manoeuvres in TMA where high terrain and bad weather conditions cause limitations to use of airspace.
- Controller Mode of Operation – MOPS change for adapting ATCOs to new P-RNAV procedures
- Route Spacing for P-RNAV – Investigation of solutions for optimum route spacing using P-RNAV.
- 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
- Reducing noise emissions in scenarios where early turns are required in departures (Guidance for early turn departures)
- Impact on preferential noise routes upon transition from conventional to P-RNAV procedures, due to the turning performance linked to each respectively.
- Impact on departure sequencing due to aircraft performance mix (climb rates, turn capability, etc), which creates different departure routes for different performance levels.
- Better traffic management in complex environment (Multiairport-TMA).

The project will not cover

- The integration of the new P-RNAV procedures with advanced separation modes and spacing techniques such as ASAS.
- Any relationship with 5.7.3 Controller Team Organisation, Roles and Responsibilities in a Trajectory Based Operation (including Multi-Sector Planner).

Madrid TMA will operate approach manoeuvres procedures based on P-RNAV with a new design which key features are a north/south symmetry for operations and a so called 'trombones' arrangement: the two approach traffic flows are channelled into two sequencing legs (one per each runway) that end in a set of transitions consisting in several parallel turns ending up in the final approach path.

It is a P-RNAV approach manoeuvres design with closed final transitions where, once the approach procedure is initiated, the transition to be followed is already assigned (and will not be changed except for contingency)

Departure procedures (SIDs) will be also redesigned, simplifying and reducing their number; initial segments of current procedures remain unchanged due to noise restrictions.

1.2 General Approach to Safety Assessment

1.2.1 A Broader approach

The Safety Assessment for Full Implementation of P-RNAV in Madrid TMA is conducted as per the SESAR Safety Reference Material (SRM) [1] which itself is based on a twofold approach:

- a success approach which is concerned with the safety of the Project title system in the absence of failure. It assesses how effective the new concepts and technologies would be when they are working as intended.
- a conventional failure approach which is concerned with the safety of Project title system in the event of failures. It assesses the ATM system generated risks.

This document presents the results of the safety assessment conducted by the project 05.07.04 (within OFA 02.01.01). The aim of this safety assessment is to demonstrate that Project title new system could be implemented safely considering a "baseline environment".

1.3 Scope of the Safety Assessment

The scope of this Safety Assessment includes:

- Description of the key properties of the environment
- Setting the Safety Criteria (SAC)
- Determination of pre-existing Hazards, their mitigations and related Safety Objectives
- Determination of the system-generated hazards, mitigations and related Safety Objectives
- Establishment of Safety Requirements for Normal Operations
- Establishment of Safety Requirements for System-Generated Failures

Although this Safety Assessment target was to cover the SRM methodology, the lack of resources and planning for the safety activities (common concern for other Working Projects in Release 1), has motivated a reduction in such issues as the in-depth design and the physical solution analysis.

1.4 Layout of the Document

This document contains the next sections:

- Section 1. Contains an introductory chapter, describing the safety assessment approach and its scope.
- Section 2. Contains the Safety Assessment at Operational Level, the lists of pre-existing hazards, the Safety Criteria, Safety Objectives (success and failure approach), and derived hazards.
- Section 3. Contains the Safety Assessment at SPR Level. It will demonstrate the system is safe under normal operations and system-generated failures.
- Section 4. It will be empty. This will address the Safety Assessment at Physical Level when the technical project produces technical specifications.
- Annex A. Contains the consolidated list of Safety Objectives.
- Annex B. Contains the consolidated list of Safety Requirements.
- Annex C. Contains the consolidated list of Assumptions

1.5 References

[1]. SESAR P16.06.01, Task T16.06.01-006, SESAR Safety Reference Material, Edition 00.02.02, 10th February 2012

[2]. SESAR P16.06.01, Task T16.06.01-006, Guidance to Apply the SESAR Safety Reference Material, Edition 00.01.02, 10th February 2012

[3]. SESAR P16.06.01, Task T16.06.01-007, OFA Safety Plan Template, Edition 00.01.02, 10th February 2012

[4]. SESAR P05.07.04, WS1, D02, Initial OSED – Madrid TMA

[5]. SESAR P05.07.04, WS1, D03, Validation Report (VALR)

2 Safety specifications at the OSED Level

2.1 Scope

Work String 1 of Project 05.07.04 refers to Full Implementation of P-RNAV in Madrid TMA. The project closes out completely at the end of Step 1.

2.2 Optimized RNP Structures (02.01.01 OFA) Operational Environment and Key Properties

The key properties and Operational Environment for full P-RNAV implementation in Madrid TMA relevant for the Safety Assessment are described in the chapters below.

2.2.1 Current Madrid Airspace Characteristics

	TMA Complexity Case
Environment Characteristic	**High Complexity**
High level characterisation	Maybe capacity constrained for only a short period during the day. At other times there is an environmental driver to provide optimised trajectory profiles where possible. Mainly capacity constrained for large periods throughout the day. May have environmental constraints during quieter periods (e.g. noise pollution during night time operations)
Separation minima (horizontal)	TMA: 3 Nm or wake turbulence separation criteria on approach
Separation minima (vertical)	TMA: 1000 ft E-TMA (or En-Route): 1000 ft at stabilised level
CNS/ATM capabilities	Primary VHF voice communication between ATC and aircraft. Radar controlled airspace. Navigational infrastructure supporting the requirements of the designed procedures.
Airport infrastructure	Multiple major airports within the TMA, at least one of which is operating a single or multiple runways in mixed or segregated mode and identified in the NOP and AIP as 4D operational
Route configuration & complexity	High deployment of RNAV-1 route structures alongside more conventional SID, STAR and Approach procedures. The route structure is optimized so as to structurally deconflict arrivals and departures to the maximum extent possible Route complexity is high to the degree that arrivals and departures can interact, as can the arrival streams inbound to different airports. Holding may still be used at peak times (albeit at reduced levels) to maintain runway pressure and avoid losing slots.
Sectorization	Highly sectorized as a result of previous TMA development to handle capacity. The sectors are small and typically have standing agreements to coordinate the presentation of traffic into and out of the sector

Table 1: Airspace Configuration Characteristics

TMA Characteristics

The Madrid TMA has been updated in order to allow independent parallel approaches, which limits are shown in the following figure:

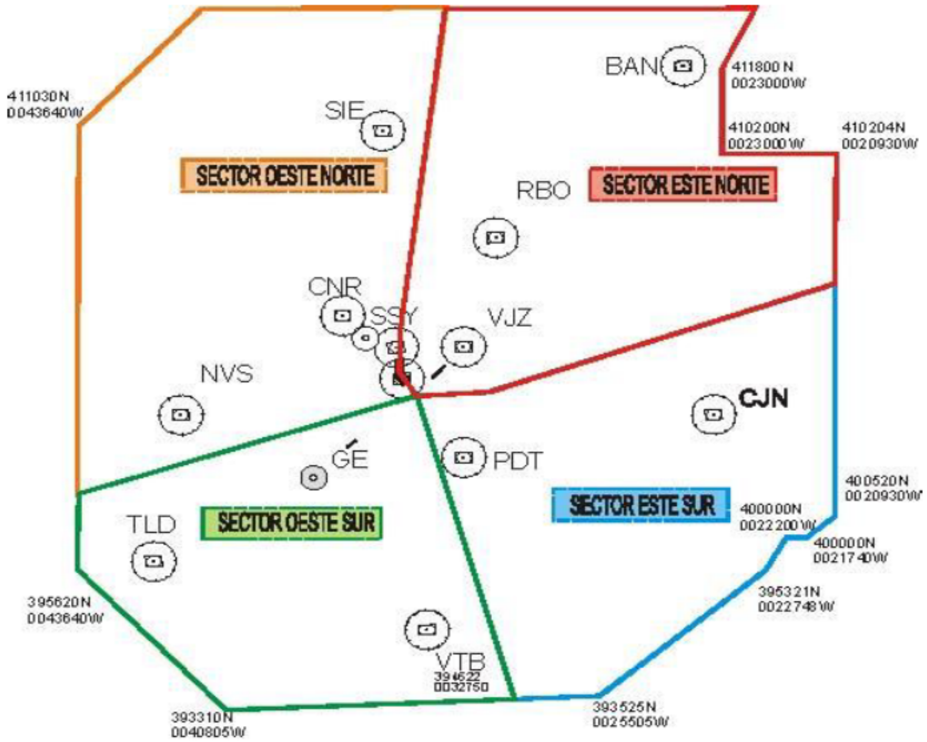

Figure 1: Current Madrid TMA

ATZ Characteristics

The air traffic control for the ATZ at Madrid –Barajas airport is provided through three air control towers giving service to the four RWYs.

The following figure shows the three control towers location in the Madrid airport.

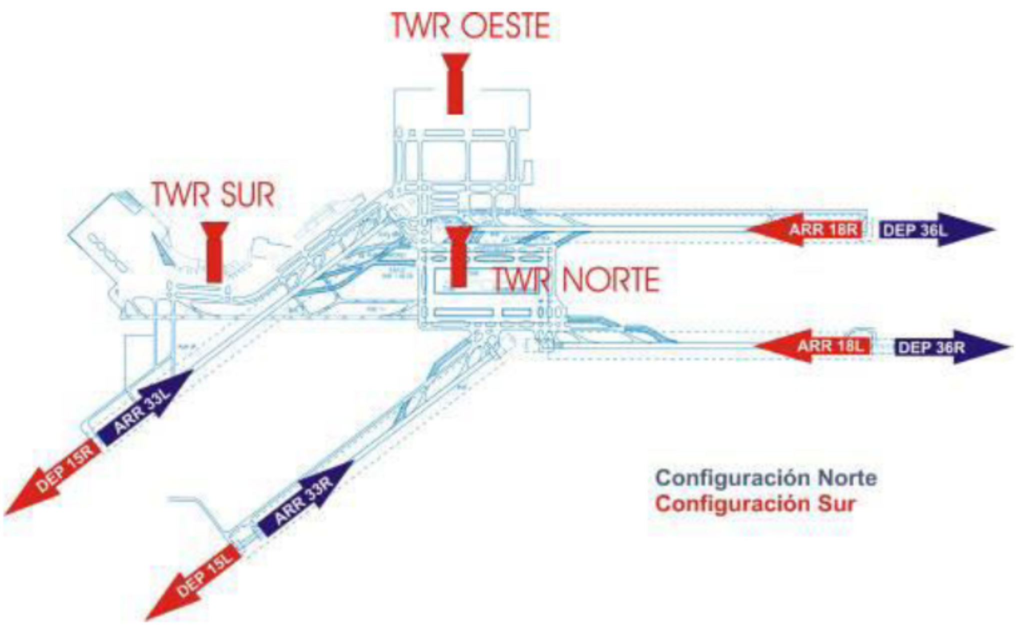

Figure 2: Madrid-Barajas airport layout and Control towers location

2.2.2 Environmental constraints

There are a lot of environmental problems around the Madrid-Barajas airport. A special noise monitoring system of the surrounding areas is used to monitor the excess of noise due to flight operations from Barajas airports. Microphones are placed in several locations to scan the noise performed by the airplanes. The figure below shows the locations of these microphones:

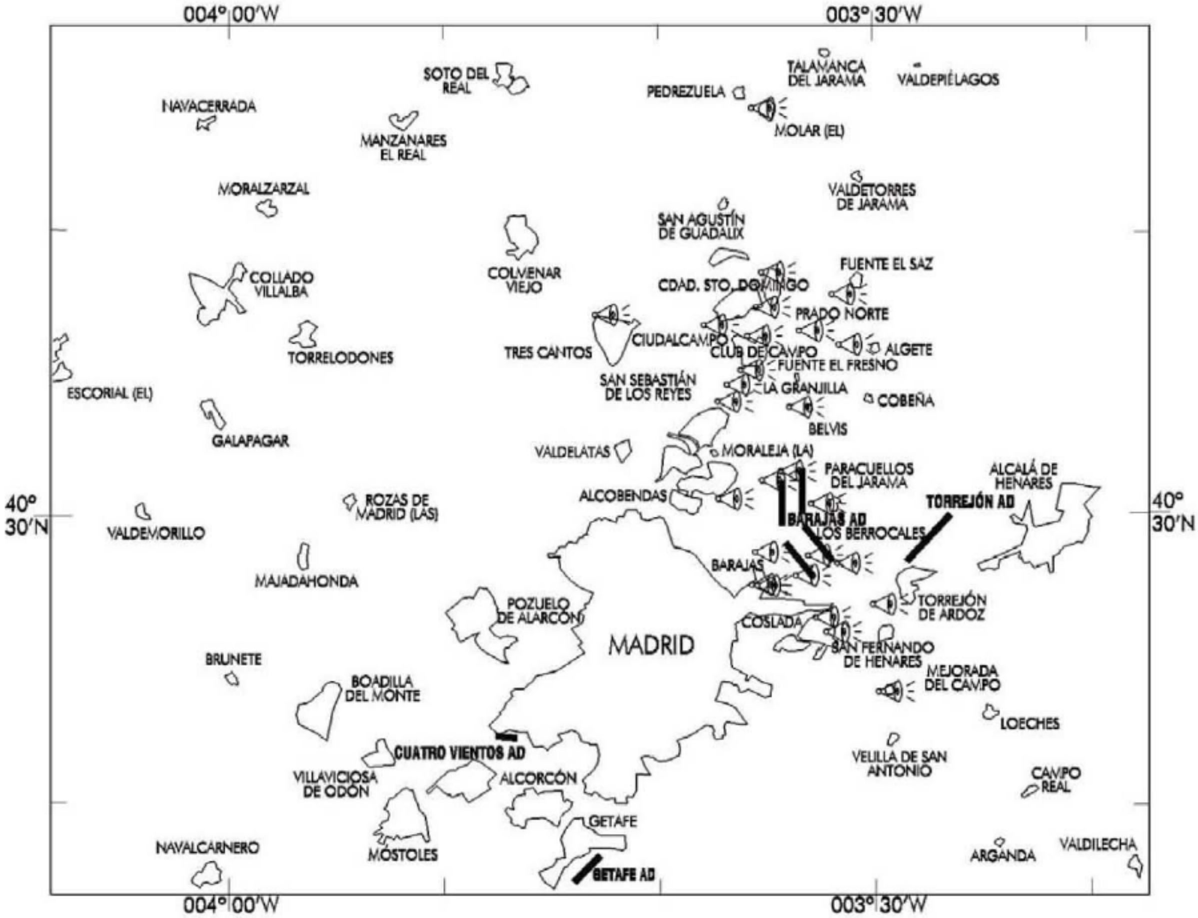

Figure 3: Location of noise sensor system

For this reason, the following **Noise abatement procedures** are put into force:

TAKE-OFF:

1. Up to 450 m (1500 ft) above aerodrome elevation:
- Take-off power
- Take-off flaps
- Climb maintaining V2 + 20 to 40 km/h (V2 + 10 to 20 kt) (or limited by fuselage angle).

2. At 450 m (1500 ft):
- Reduce power not less than ascent power.

3. From 450 m (1500 ft) to 900 m (3000 ft):
- Climb maintaining V2 + 20 to 40 km/h (V2 + 10 to 20 kt).

4. At 900 m (3000 ft):
- Accelerate gradually to reach climbing cruising speed with flaps retraction at the proper time.

LANDING:

1. The use of reverse thrust above from idle regime is forbidden at night time (2300-0700LT) except for safety reasons; in this case, it must be notified to TWR and the airport's Environment Deparment.

2. Landing and approach procedures on visual meteorological conditions will be performed with an angle equal to or higher than the ILS GP or PAPI of each runway.

2.2.3 Previous Operating Method

Nowadays there is a mix-mode operation, there are SIDs and STARs for both systems, Conventional and P-RNAV, but the approach procedures are open loops providing vectors to intercept the ILS localizer.

The main Characteristics of the airspace operating method are the following bellow:

- Radar controlled airspace.
- Separation minima (horizontal), TMA: 3 Nm or wake turbulence separation criteria on approach. Separation minima (vertical), TMA: 1000 ft.
- Mainly capacity constrained for large periods throughout the day. May have environmental constraints during quieter periods (e.g. noise pollution during night time operations)
- Multiple major airports within the TMA,
- Single airport, operating a single or multiple runways in mixed or segregated mode. The airport is published in the NOP and AIP as a 4D operational airport
- High deployment of RNAV-1 route structures alongside more conventional SID, STAR and Approach procedures.
- Route complexity is high to the degree that arrivals and departures can interact, as can the arrival streams inbound to different airports.
- Holding may still be used at peak times (albeit at reduced levels) to maintain runway pressure and avoid losing slots.
- Highly sectorized as a result of previous TMA development to handle capacity. The sectors are small and typically have standing agreements to coordinate the presentation of traffic into and out of the sector.
- CNS/ATM capabilities, Primary VHF voice communication between ATC and aircraft.
- Navigational infrastructure supporting the requirements of the designed procedures.

All these STAR procedures are shown in the next page figure:

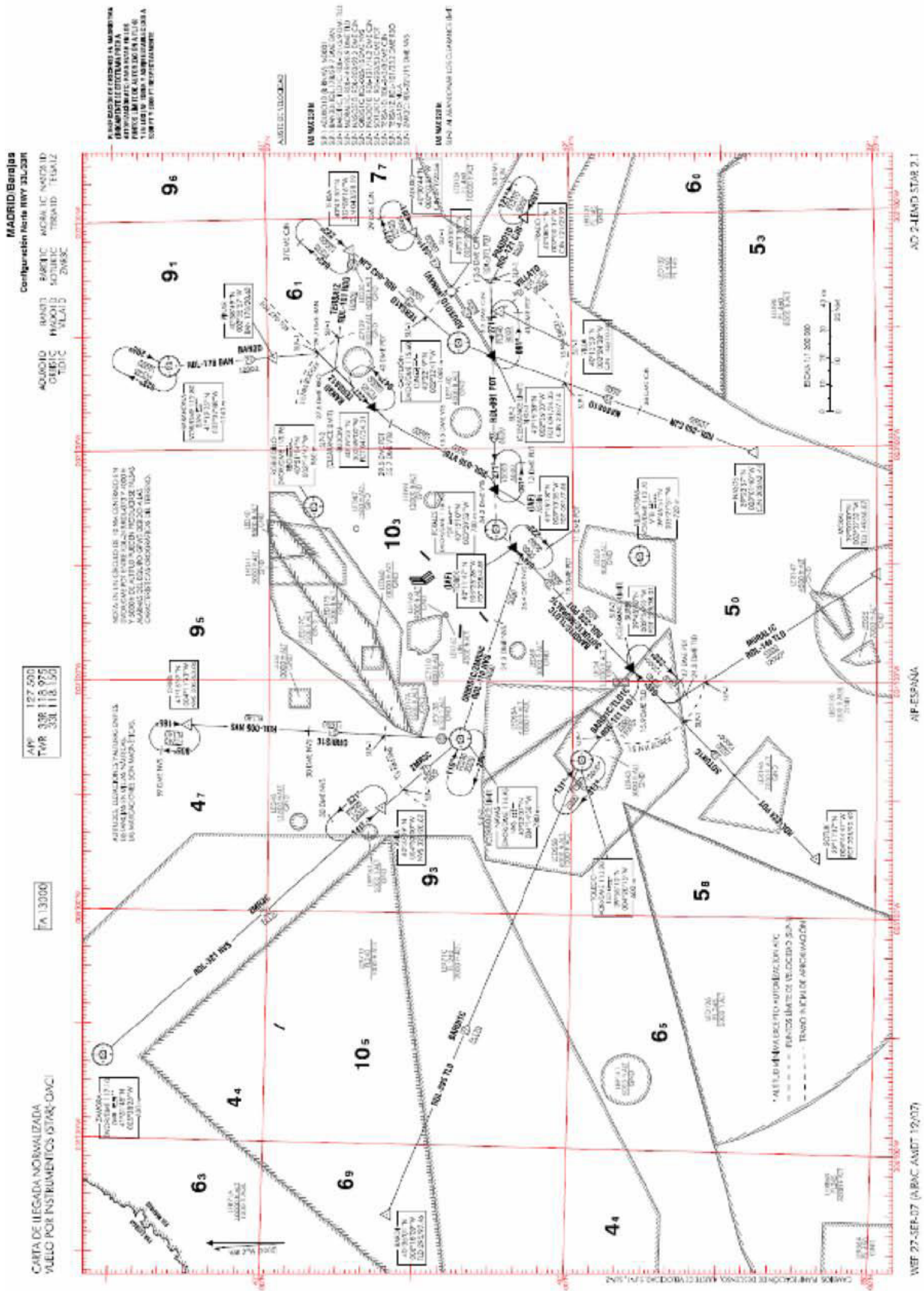

Figure 4: Madrid-Barajas STAR Chart, North Configuration

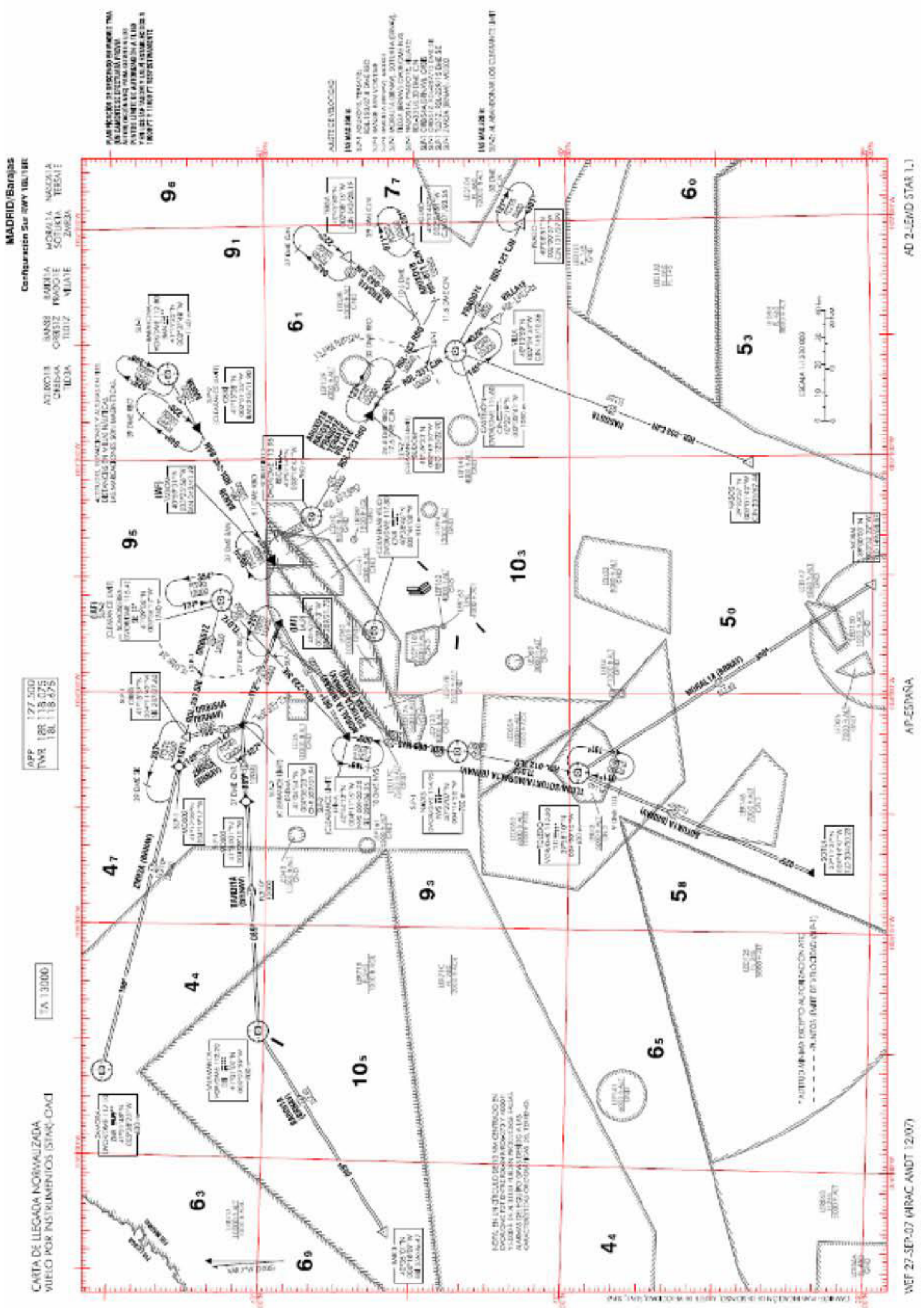

Figure 5: Madrid-Barajas STAR Chart, South Configuration

2.2.4 New SESAR Operating Method

The operation in the new Madrid TMA will be following the P-RNV criteria, including the developing of new SIDs and STARs compliant with P-RNAV procedures, as well as the introduction of P-RNAV transitions to the localizer from the IAFs until the interception of the localizer. All the airspace within the New TMA will be PNB offering more accurate navigation performances and also avoiding the dispersion of the trajectories in the SIDs procedures, thus making easier to design accurate trajectories able to compliant with noise abatement procedures, and in this way creating a better environment for the airport and the urban areas around it.

The principal operational and environmental improvement features in the new Airspace scenario will be:

Procedures, optional features in addition to the nominal features, required inputs and outputs:

- The main consideration to define the transitions to the ILS was the symmetry between north and south configuration.
- In the transitions to runway 18R, intermediate waypoints were introduced to establish in an accurate mode the altitude to overfly this points
- The distance flown between the IF and the first waypoint in the base leg are equal (25NM.). With the aim of reducing the operational complexity, having a common basic operational procedure for North / south configurations, thus reducing the impact of the runways changing making them faster and easier.
- Holding patterns must be convenient for P-RNAV and conventional traffic to facilitate the mix-mode operation. P-rnav regulations do not prescribe the obligation of defining a waypoint as a fix for the holding pattern.
- Holding patterns shall be located in the first feeders points and in the IAWP.
- The new dimension for the TMA Airspace will be based on the buffer area of the holding pattern as well as its orientation for conventional navigation in some cases.
- Respect to all the airspace users, civil, military and G.A. giving greater freedom to those who don't require separation service like General Aviation.
- Ensure general aviation needs are correctly captured.
- P-RNAV will permit the liberation of airspace for GA utilisation.
- (PI: Shared use of airspace and airports by different classes of airspace users)
- The flow of the departing traffic shall be implemented well separated from the feeders or overflying the lowest part of the transitions. The new P-RNAV SID will create different departure routes for different performance levels

Triggering events (including initiation):

- 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 – Use of P-RNAV procedures to improve safety of manoeuvres in TMA where high terrain and bad weather conditions cause limitations to use of airspace.
- Controller Mode of Operation – MOPS change for adapting ATCOs to new P-RNAV procedures.
- Route Spacing for P-RNAV – Investigation of solutions for optimum route spacing using P-RNAV.
- 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**
- Reducing noise emissions in scenarios where early turns are required in departures (Guidance for early turn departures)
- Impact on preferential noise routes upon transition from conventional to P-RNAV procedures, due to the turning performance linked to each respectively.
- Impact on departure sequencing due to aircraft performance mix (climb rates, turn capability, etc), which creates different departure routes for different performance levels.

Actors: operator and automatic actions:

- Air Traffic Controller, Executive Controller, Planning Controller, ATS Supervisor.
- Controller Mode of Operation, Route Spacing for P-RNAV and Mixed Mode Operation (PI: Separation minima infringement).
- Full P-RNAV implementation pursues the elimination of radar vectoring, thus avoiding open loop instructions, which will have a positive effect on safety and in Controller workload reduction through the use.
- Reduction of air-ground communications.
- reducing radar vectoring for traffic sequencing
- Flight Crew, Pilot,
- Exploitation of aircraft P-RNAV capabilities will optimize the placement of SIDs/STARS and instrument approach procedures.
- (PI: Increment in the hourly number of IFR flights able to enter the airspace volume)
- Full P-RNAV implementation pursues the elimination of radar vectoring based procedures by allowing the aircraft to fly defined precision SIDs and STARs, thus minimizing the variability of the deviation between the actually flown trajectories of aircraft in relationship to the RBT.

The criterion to define transitions to ILS was: Symmetry between North / South configuration

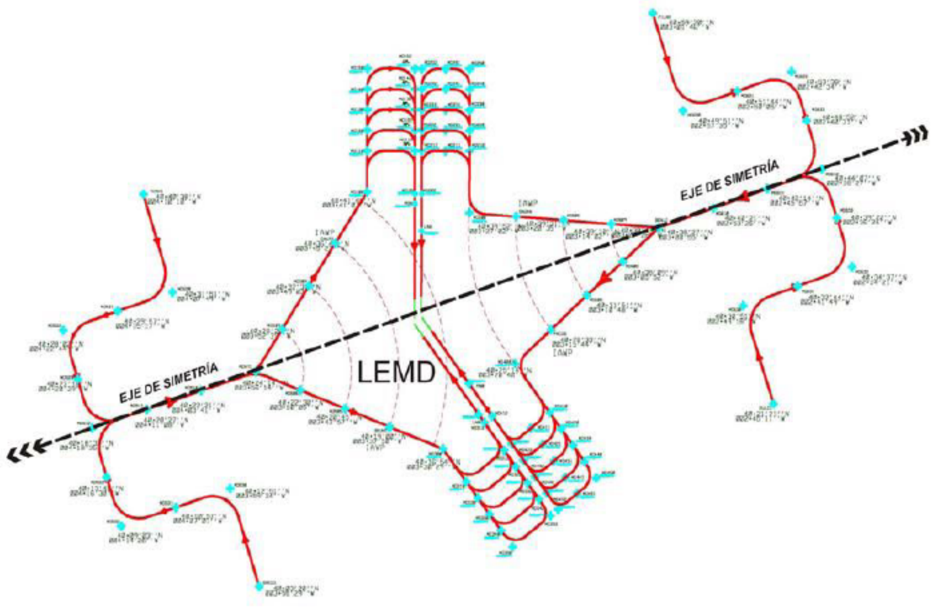

Figure 6: North/South configuration symmetry

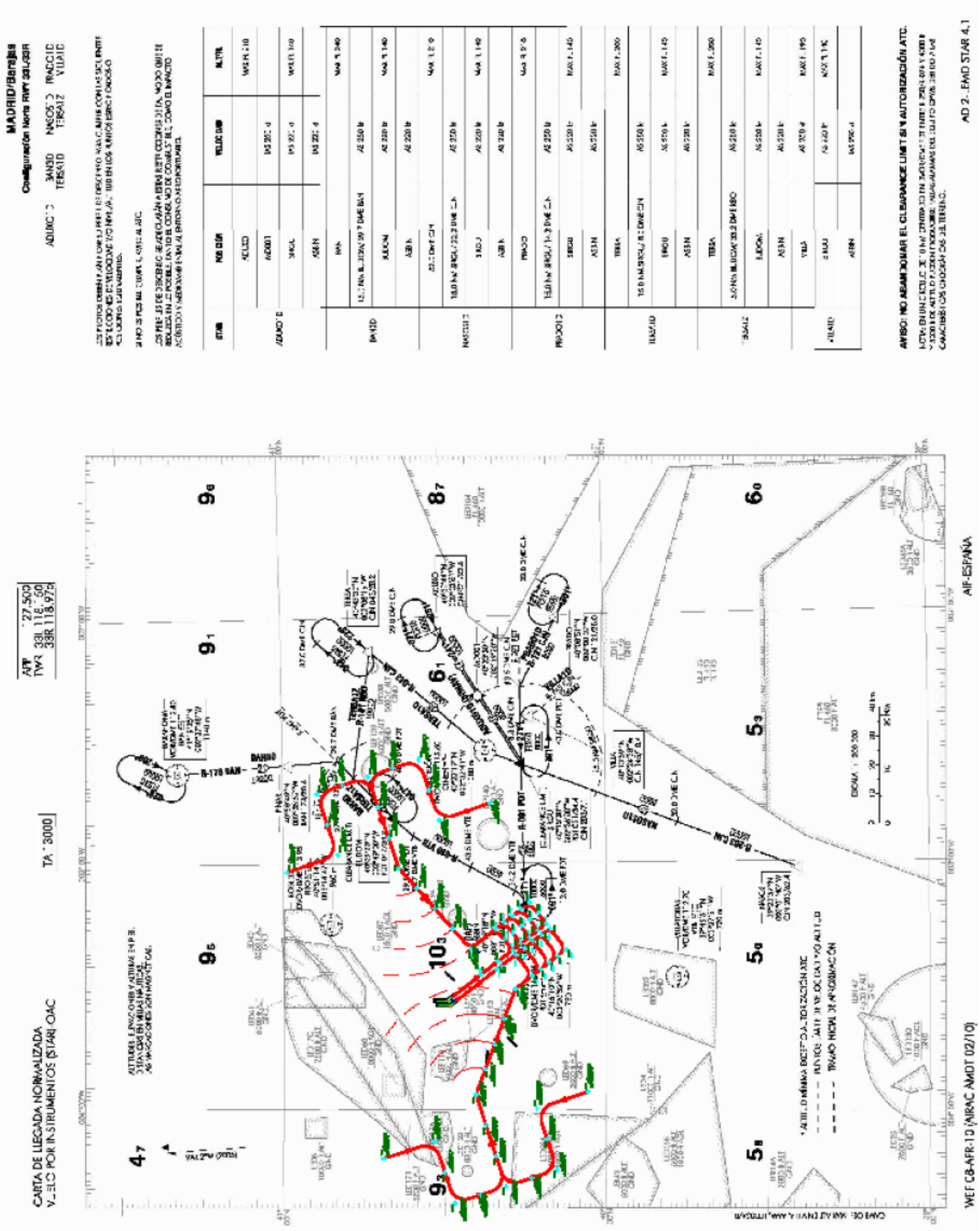

Figure 7: designed STAR chart

2.2.5 Differences between new and previous Operating Methods

Lack of effective P-RNAV operations across all European TMAs will affect arriving and departing aircraft, particularly commercial flights.

Consequential safety constraints may also have a knock-on effect to GA traffic to which the TMA is also providing a service. This may result in periods of high density, which introduces additional complexity to the operation. Also the growing environmental constraints will have a difficult solution without the implementation of P-RNAV operations.

Environmental constraints, especially those related to departure noise nuisance, are still an issue in most European airports. The opportunity to automatically fly departure profiles and tailored trajectories as early as possible can help tackle this issue.

Several airports are characterized by a seasonal demand (summer and holidays peaks), with an extremely wide range of aircraft with different navigation capabilities including a significant percentage that are not P-RNAV compliant.

Multiairport TMAs usually characterized by strong interacting traffic flows.

All European TMAs where the possibility still exists to achieve an improvement of current operations through the implementation of full P-RNAV scenarios including optimum design criteria and route separation.

Most of the problems mentioned above already exist at various European locations. The problem of complexity at some of the busier TMAs in Europe provides a safety and capacity constraint on further utilisation.

Although traffic levels are currently down on recent years, they are predicted to increase in the long-term. As the traffic levels in Europe increase, TMAs will have to improve their capability in order to meet SESAR objectives. In addition, implementing operational solutions in periods of low traffic demand is easier and will give the opportunity of testing without significant impact on capacity.

Although 3D and 4D RNAV are expected to be available in 2013, the solutions provided by this project will pave the way for the transition from 2D to 3D and 4D.

Furthermore based on the implementation of full P-RNAV, capacity problems in high density TMAs will be resolvable.

Generally speaking, the P-RNAV concept is quite mature (V5). Task 1 will take advantage of the methods and guidance available and will complete phase V3 by delivering a Full P-RNAV Implementation Plan in a complex TMA including all instrumental, legal and operational activities, and Safety, Business and Human Factor Cases, To reach this goal, there are some less mature elements (identified as limitations to practical full P-RNAV implementation, see section 1.3) which should be brought to the global maturity level, so that the concept is ready for full implementation in complex TMAs.

2.2.6 Airspace Organization Proposal

Holdings patterns proposal:

- Holding patterns shall meet P-RNAV conditions and also must fit conventional procedures.
- P-RNAV regulation does not consider the obligation of defining a “waypoint” as a holding fix.
- Holdings patterns must be located in the first points of the feeders, and also in the IAWPs.
- TMA shall contain, at least, the protection areas of the holding patterns, for R-NAV navigation as well as for conventional and also the primary areas of the transitions legs to the ILS.
- The new dimension of the TMA will be conditioned by the protection areas of the holding patterns and in some cases, by the orientation of those circuits for conventional navigation.

Lateral Limits of the TMA

It is necessary to widen the TMA, in order to include the protection areas of the holding pattern and a Minimum lateral separation of 5 NM from the Star´s.

Vertically the limits will be from the ground up to FL. 205.

En-route sectors will transfer the traffic before crossing the limits, en course to the “Clearance limits” TERES, GRECO, DULCI, o PILAR, descending to FL. 210.

It is shown in the following figure as a first draft.

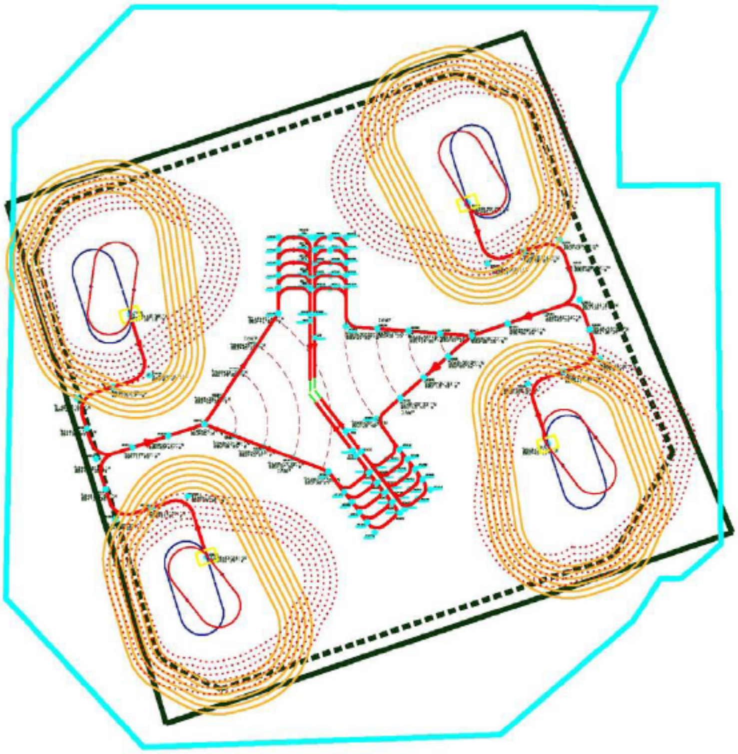

Figure 8: lateral limits of TMA and required holding protection areas

2.2.7 Aircraft approach by steps

- Separation between “turning base” legs to allow alternate between parallel runways.
- Five transitions at least, in order to have enough space to maneuver.
- 5 NM. Separation between “down wind” leg and the approach leg.

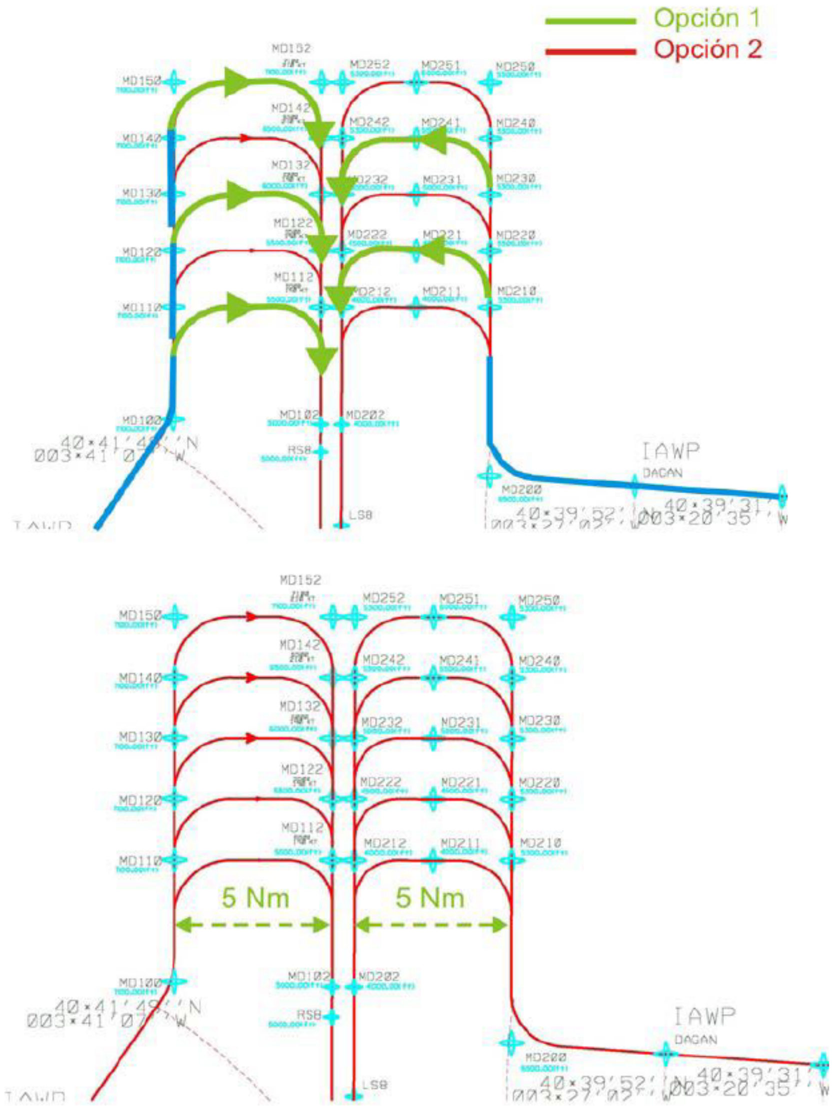

Figure 9: Transitions

In the transition to runway 18, it has been considered to introduce intermediate waypoints inside the turning base legs, to define (in a more accurate way) the passing altitudes over those points. The final establishment of those points is subject to the possibility of codifying them for the different types of aircraft and FMS, taking into account that the distances between consecutives waypoints could not be enough.

The distances flown between the bifurcation in the feeders and the first waypoint in the turning base leg are equal.

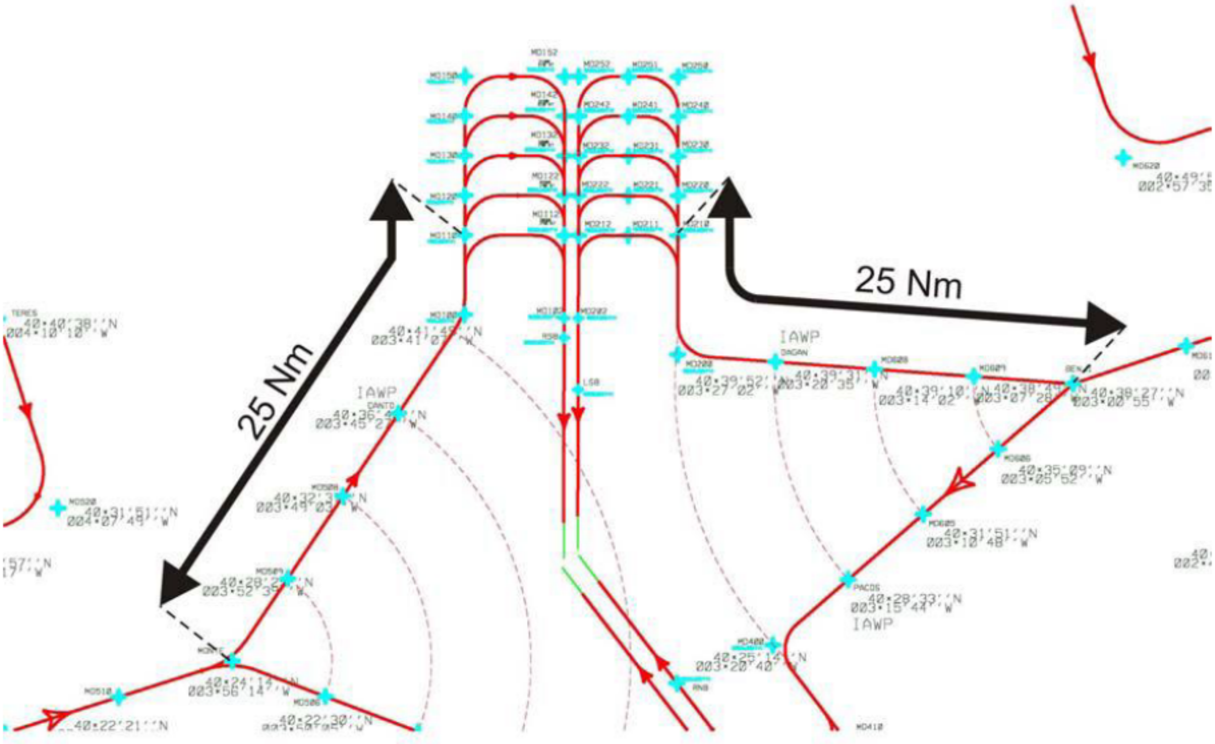

Figure 10: distances between IF and first waypoints

2.3 Airspace Users Requirements

Airspace user requirements are described at the Final OSED in Madrid TMA

2.4 SAfety Criteria

SAfety Criteria (SAC) have been derived in order to continue fulfilling the barriers of the relevant Accident Incident Model (AIM: Mid-Air Collision, CFIT and Wake induced accident), to support the ATM service through the introduction of this OFA.

SAC have been settled in coordination with P16.06.01.

<u>The Barrier Model (Service Level) – *Mid-Air Collision*</u>

SAC #1 – There shall be no increase in number of plan induced conflicts (MF5.1 in output of B9) arising from inadequate upstream planning (MB9.2.2.B) or inadequate co-ordination (MB9.3)

- Risk +: En-route Planner ATCO workload might increase due to conditions for traffic entry in TMA becoming more constraining in terms of traffic metering (assuming the metering of traffic is mandatory)

SAC #2 – There shall be no increase in number of plan induced conflicts (MF5.1 in output of B9) arising from inadequate arrival sequence management (MB9.B)

- Risk -: ATCO task for arrival sequence management is standardised (i.e. delivered via AMAN)
- Risk -: The trombones design offers different and flexible ways to entry into the final approach.
- Risk +: The instruction to follow the preferred trombone entry in the arrivals shall be given in a specific determined time window.

SAC #3 – There shall be no increase in number of plan induced conflicts (MF5.1 in output of B9) arising from inadequate departures sequence management (MB9.B)

- Risk -: ATCO tasks for departures sequence management is standardised
- Risk /-: There is an impact on departure sequencing due to aircraft performance mix (climb rates, turn capability, etc), different departure routes are needed for different performance levels
- Risk -: The new airspace design and ATCOs will separate different routes for departure. Environmental and noise restrictions make the routes to be similar to current ones..

SAC #4a – There shall be no increase in number of imminent infringements with other aircraft (MF5 in output of B5) arising from TMA and Approach ATC ineffective management of Plan induced tactical conflicts (MB5)

- Risk -: Less Approach ATCO workload with tactical de-confliction (standardised method where de-confliction is facilitated by dedicated P-RNAV route structure and stream having been delivered by TMA ATCO).
- Risk -: Less instructions (no vectoring), more monitoring. Less opportunity for wrong separation instructions.
- Risk +/-: Boredom involved by the routine with standardized method; however, Trombones will only be used in medium/busy periods with high volumes of traffic, requiring increased monitoring. In quiet times (where boredom could be a factor), vectors would be used.
- Risk +: More TMA ATCO workload with the preparation of the traffic entry conditions in the Trombones structure (at IAF), i.e. for traffic metering, for reaching prescribed level and speed (i.e. delivering the stream for Approach ATCO)

SAC #4b – There shall be no increase in number of imminent infringements with other aircraft (MF6 in output of B6) arising from TMA and Approach ATC ineffective management of Crew/aircraft induced tactical conflicts (MB6)

- Risk -: Less Approach ATCO workload with tactical de-confliction (standardised method where de-confliction is facilitated by dedicated P-RNAV route structure and stream having been delivered by TMA ATCO).
- Risk -: Less instructions (no vectoring), more monitoring. Less opportunity for wrong separation instructions.
- Risk -: Reduction in R/T communications leads to less opportunity for inadequate pilot response to ATC (i.e. ATCO more likely to clarify an inadequate response)
- Risk +/-: Boredom involved by the routine with standardized method; however, Trombones will only be used in medium/busy periods with high volumes of traffic, requiring increased monitoring. In quiet times (where boredom could be a factor), vectors would be used.
- Risk +: More TMA ATCO workload with the preparation of the traffic entry conditions in the Trombones structure (at IAF), i.e. for traffic metering, for reaching prescribed level and speed (i.e. delivering the stream for Approach ATCO)
- Risk +/-: Better trajectory predictability may, in the medium to long term, affect the controller's ability to detect and react to a deviation from instruction or route; however, there may be more time to detect due to increased monitoring and more time for Approach ATCO to react due to less workload
- Risk +: Mix of PRNAV and vectored operations may affect the controller's ability to detect and react to a deviation from instruction or route
- Risk +/-: The new design occupies more lateral airspace, however P-RNAV routes reduce the airspace required. Stacks require less vertical airspace. Therefore airspace should allow for de-confliction of routes and aircraft manoeuvring.

SAC #4c – There shall be no increase in number of imminent infringements with other aircraft (MF7 in output of B7) arising from TMA and Approach ATC ineffective management of ATC induced tactical conflicts (MB7)

- Risk -: Less Approach ATCO workload with tactical de-confliction (standardised method where de-confliction is facilitated by dedicated P-RNAV route structure and stream having been delivered by TMA ATCO).
- Risk -: Less instructions (no vectoring), more monitoring. Less opportunity for wrong separation instructions.

SAC #5 – There shall be no increase in number of ATC induced conflicts (MF7.1) arising from TMA and Approach ATC inducing new conflicts (MF7.1.1 to MF7.1.7) when managing the arrivals

- Risk -: Less Approach ATCO workload with tactical de-confliction due to standardised methods
- Risk +: More TMA ATCO workload with the preparation of the traffic entry conditions in the Trombones structure (at IAF)
- Risk +/-: Risk for wrong or untimely instruction to follow the preferred Trombone entry is no worse than today, assuming AMAN delivered via en-route ATCO and availability of stacks.

SAC #6 – There shall be no increase in number of ATC induced conflicts (MF7.1) arising from Tower and TMA ATC inducing new conflicts (MF7.1.1 to MF7.1.5 and MF7.1.7) when managing the departures.

- Risk -: Less ATCO workload with tactical de-confliction due to standardised methods.
- Risk +: ATC must take into account the different aircraft performances for continuous climb departures.

SAC #7 – There shall be no increase in number of Crew/aircraft induced conflicts (MF6.1) arising from conflict due to crew/aircraft deviation from instruction (MF6.1.2.1 to MF6.1.2.4)

- Risk -: Less instructions and R/T communications reduce the potential for pilot misunderstanding ATC instructions
- Risk +/-: Better trajectory predictability for pilot might incite him to take action in anticipation of ATCO instruction; however, this should be no different to today regarding leaving stacks without instruction (aircraft already fly stacks via FMS)
- Risk +: the number of aircraft induced conflicts might increase due to the increased aircraft autonomy with the continuous climb departures; additionally, there is a higher probability for the deviation from the cleared trajectory to induce conflict with other departing aircraft, due to aircraft performance mix (different climb rates, turn capability, etc) and higher complexity of SIDs, which creates different departure routes for different performance levels.

Note: For Guidance/Navigation errors based on GPS/Navaids, next ones are taken into account under SAC #7: MF6.3a (intended to cover errors of data -GPS/Navaid- used by the aircraft) and MF6.3c (intended to cover aircraft systems -autopilot, flight director, FMS, IPS...– errors)-.

SAC #8 – There shall be no increase in number of Crew/aircraft induced conflicts (MF6.1) arising from conflicts due to airspace infringement by MIL, VFR or CAT flights (MF6.1.1.2.1 to MF61.1.2.3)

- Risk -: The airspace design guides to a more static approach pattern, reducing the dynamic airspace to be used (radar vectoring is not so standardized).
- Risk +: An infringement in the new airspace design is more critical than in a radar vectoring airspace if a P-RNAV route is designed parallel to airspace boundary
- Risk +/-: Better trajectory predictability may, in the medium to long term, affect the controller's ability to detect and react to an airspace infringement; however, there may be more time to detect due to increased monitoring and more time for Approach ATCO to react due to less workload

<u>The Barrier Model (Service Level) – *CFIT*</u>

SAC #9 - There shall be no increase in number of Flights towards terrain commanded (CF5 in output of B5) arising from Pilot deviation from planned trajectory (CF5.1) during Arrivals

- Risk +/-: For arrivals post IAF, separation from terrain is different, because achieved through altitude constraints on P-RNAV routes instead of MVA associated to Vectoring

SAC #10 – There shall be no increase in number of Flights towards terrain commanded (CF5 in output of B5) arising from deviation due to onboard systems. Applies to both arrivals and departures.

- Risk +/-: Higher reliance on route conformance and hence reliance on systems to ensure aircraft conforms to route centre-line tolerances; however, there may be more time to detect due to increased monitoring and more time for Approach ATCO to react due to less workload
- Risk -: reduced reliance on human intervention (ATCO instructing headings and Pilot conforming to the instructions)

SAC #11 – There shall be no increase in number of Flights towards terrain commanded (CF5 in output of B5) arising from ATC trajectory command

- Risk +/-: The arrival vertical profile is changed with Trombones; however this is not a specific issue to Trombones arrivals.
- Risk -: Less Approach ATCO workload with terrain tactical de-confliction (standardised method where terrain de-confliction is strategic, ie facilitated by dedicated P-RNAV route structure, and stream has been delivered by TMA ATCO).
- Risk +: Mix of PRNAV and vectored operations may affect the controller's ability to detect and react to a deviation from instruction or route

SAC #12 – There shall be no increase in number of Flights towards terrain commanded (CF5 in output of B5) arising from lateral/vertical design of the routes and their publication, including MSA. Applies to both arrivals and departures.

- Risk +: "Direct To" instructions may contravene with minimum altitudes/ MSAs associated with terrain avoidance, especially when aircraft is in descent.
- Risk +/-: Departure routes: as actual departures routes are very constricted due to the environmental and noise restrictions, new ones would be similar to current ones.
- Risk - : CDAs defined with minimum altitudes and strategically placed waypoints associated with minimum clearances
- Risk - : PRNAV routes improve lateral conformance
- Risk + : Vectoring along PRNAV routes may contravene lateral limitations associated with terrain

SAC #13 – There shall be no increase in number of imminent CFITs (CF3 in output of B3) arising from failure of ATCO to identify and/or resolve conflict in time (CB3.2.2.1.2 and CB3.2.2.1.3 respectively)

- Risk +: More TMA ATCO workload with the preparation of the traffic entry conditions in the Trombones structure (at IAF)
- Risk -: Less Approach ATCO workload with tactical de-confliction (standardised method where de-confliction is facilitated by dedicated P-RNAV route structure).
- Risk +/-: Boredom involved by the routine with standardized method; however, Trombones will only be used in medium/busy periods with high volumes of traffic, requiring increased monitoring. In quiet times (where boredom could be a factor), vectors would be used.
- Risk +-: Better trajectory predictability may, in the medium to long term, affect the controller's ability to detect and react to a deviation from instruction or route; however, there may be more time to detect due to increased monitoring and more time for Approach ATCO to react due to less workload
- Risk +: Mix of PRNAV and vectored operations may affect the controller's ability to detect and react to a deviation from instruction or route

SAC #15 - There shall be no increase in number of Flights towards terrain commanded (CF5 in output of B5) arising from Pilot deviation from planned trajectory (CF5.1) during Departures

- Risk +/-: TBC

The Barrier Model (Service Level) – *Wake induced accident*

SAC #14 - There shall be no increase in number of Wake Vortex Encounters (WP4b in output of W4) arising from Approach ATC creating or maintaining insufficient separation (WF4.1.1.1 and WF4.1.1.2 respectively)

- Risk +/-: TBC

SAC #16 - There shall be no increase in number of Wake Vortex Encounters (WP4b in output of W4) arising from Sequencing Departures ATC creating or maintaining insufficient separation (WF4.1.1.1 and WF4.1.1.2 respectively)

- Risk +/-: TBC

2.5 Relevant Pre-existing Hazards

The purpose of most safety-related systems is to mitigate the hazards (and associated risks) that are pre-existing in the operational environment of the system concerned.

It should be taken into account that these hazards are, therefore, not caused by the system – rather, the main purpose of introducing the system is to eliminate those pre-existing hazards or at least maintain the associated risks at an acceptably low level.

The pre-existing hazards that the ATM Service / System have to mitigate in the Approach Airspace are as follows:

Hp#1 Conflicts between pairs of trajectories

Hp#2 Controlled flight towards terrain or obstacle

Hp#3 Aircraft entry into unauthorised areas

Hp#4 Aircraft encounters with severe weather conditions

Hp#5 Aircraft encounters with wake vortices

The service has to mitigate those hazards such that the Safety Criteria are satisfied. As a consequence, the relevant accident models of the AIM are MAC, CFIT, WVE.

2.6 Mitigation of the Pre-existing Risks – Normal Operations

2.6.1 Operational Services to Address the Pre-existing Hazards

The list of the ATM services related to the project, and the framework that will support the mitigations related to the pre-existing hazards is as follows:

ID	Service Objective	Pre-existing Hazards [Hp xx]
SP1	Maintain separation within the same arrival flow of the landing sequence	Hp#1, Hp#5
SP2	Create and maintain separation between the arrival flows of the landing sequence	Hp#1
SP3	Create and maintain spacing/separation between aircraft in converging arrival flows of the landing sequence	Hp#1
AFA	Facilitate acquisition of the Final approach path	Hp#1, Hp#5
SPT	Separate arrivals from terrain/obstacles	Hp#2
SPO	Separate arrivals from departures, transit flights, overflights and other arrivals (i.e. to other airports)	Hp#1
PUE	Prevent unauthorised entry of arrivals into restricted airspace	Hp#3
PAW	Prevent adverse weather encounters	Hp#4
SPD1	Maintain separation within same departing flow	Hp#1, Hp#5
SPD2	Maintain separation between departure flows (different RWYs)	Hp#1
SPOD	Separate departures from arrivals, other flows (other than departures and arrivals, multi-airport TMA)	Hp#1
SPTD	Separate departures from terrain/obstacles	Hp#2

PUED	Prevent unauthorized entry of departures into restricted airspace	Hp#3
PAWD	Prevent adverse-weather encounters for departures	Hp#4

Table 2: ATM and Pre-existing Hazards

2.6.2 Derivation of Safety Objectives (Functionality & Performance – success approach) for Normal Operations

Next table assigns safety objectives defined in order to mitigate the pre-existing risks under normal operations. The delivery of the ATM services and sub-services (if relevant) are described in relation to the Accident Incident Model (AIM) barriers (ATM layers).

Ref	Phase of Fight / Operational Service	Related AIM Barrier	Achieved by / Safety Objective [SO xx]
1	Phase 1 - Arrivals: CL limits to IAF Operational Services: - SP1 - Maintain separation within the same arrival flow of the landing sequence - SP2 - Create and maintain separation between the arrival flows of the landing sequence - SP3 - Create and maintain spacing/separation between aircraft in converging arrival flows of the landing sequence - SPO - Separate arrivals from departures, transit flights, overflights and other arrivals (i.e. to other airports) - PUE - Prevent unauthorised entry of arrivals into restricted airspace - PAW - Prevent adverse weather encounters	B9 - Traffic Planning and Synchronisation B5 - Plan Induced Conflict Management B6 - Externally Induced Conflict Management B7 - ATCo Induced Conflict Management W4 - Wake Spacing Management	SO#1 SO#2 SO#3 SO#4 SO#5
2	Phase 2 - Arrivals: IAF to IF Operational Services: - SP1 - Maintain separation within the same arrival flow of the landing sequence - SP2 - Create and maintain separation between the arrival flows of the landing sequence	B9 - Traffic Planning and Synchronisation B5 - Plan Induced Conflict Management B6 - Externally Induced Conflict Management B7 - ATCo Induced Conflict Management W4 - Wake Spacing Management	SO#6

Ref	Phase of Fight / Operational Service	Related AIM Barrier	Achieved by / Safety Objective [SO xx]
3	Phase 2 - Arrivals: IAF to IF Operational Services: - SP3 - Create and maintain spacing/separation between aircraft in converging arrival flows of the landing sequence - AFA - Facilitate acquisition of the Final approach path - SPO - Separate arrivals from departures, transit flights, overflights and other arrivals (i.e. to other airports) - PUE - Prevent unauthorised entry of arrivals into restricted airspace	B9 - Traffic Planning and Synchronisation B5 - Plan Induced Conflict Management B6 - Externally Induced Conflict Management B7 - ATCo Induced Conflict Management B3 - ATCO Warning B4 - Flight Crew Monitoring W4 - Wake Spacing Management	SO#7
4	Phase 2 - Arrivals: IAF to IF Operational Services: - SPT - Separate arrivals from terrain/obstacles - PAW - Prevent adverse weather encounters	B3 - ATCO Warning B4 - Flight Crew B6 - Externally Induced Conflict Management	SO#8
5	Phase 4 - Departures Operational Services: - SPD1 - Maintain separation within same departing flow - SPD2 - Maintain separation between departure flows (different RWYs) - SPOD - Separate departures from arrivals, other flows (other than departures and arrivals, multi-airport TMA) - SPTD - Separate departures from terrain/obstacles - PUED - Prevent unauthorized entry of departures into restricted airspace	B9 - Traffic Planning and Synchronisation B5 - Plan Induced Conflict Management B6 - Externally Induced Conflict Management B7 - ATCo Induced Conflict Management	SO#9 SO#10
6	Phase 4 - Departures Operational Services: - PAWD - Prevent adverse-weather encounters for departures	B6 - Externally Induced Conflict Management	SO#11 SO#12

Table 3: OFA Operational Services & Safety Objectives (success approach)

Next table describes those Safety Objectives defined to mitigate the pre-existing risks under normal operations.

ID	Description

ID	Description
Phase 1 - Arrivals: CL limits to IAF	
SO#1	Arrival traffic shall be metered according to TMA and holding capacity
SO#2	The required separation/spacing between aircraft shall be maintained through arrivals to IAF
SO#3	Emergency squawk aircraft shall be prioritized
SO#4	The required separation/spacing between aircraft in the event of severe weather shall be maintained through arrivals to IAF
SO#5	The required separation/spacing between aircraft in the event of one runway closure due to security reasons shall be maintained through arrivals to IAF
Phase 2 - Arrivals: IAF to IF	
SO#6	The required separation/spacing between aircraft shall be maintained on and between the transitions
SO#7	The required separation/spacing between aircraft shall be maintained in BENJI/MONTE arrival flows points
SO#8	Obstacle and terrain clearance for arrivals shall be provided
Phase 4 - Departures	
SO#9	Departure traffic shall be metered according to Runway throughput capacity
SO#10	The required separation/spacing between aircraft shall be maintained through departures
SO#11	The required separation/spacing between aircraft in the event of severe weather shall be maintained through departures
SO#12	The required separation/spacing between aircraft in the event of one runway closure due to security reasons shall be maintained through departures

Table 4: List of Safety Objectives (success approach) for Normal Operations

2.7 Optimized RNP Structures (02.01.01 OFA) Operations under Abnormal Conditions

No abnormal conditions (related to weather conditions) have been considered during the FHA or the validation exercises, airspace issues, as unauthorized entry into TSA, have been considered in the FHA, and have been included in the System Generated Risks chapter.

2.8 Mitigation of System-generated Risks (failure approach)

The Functional Hazard Assessment (FHA) performed resulted in the identification of several system-generated risks.

2.8.1 Identification and Analysis of System-generated Hazards

The following list contains the system-generated hazards identified during the Functional Hazard Assessment held in Madrid the 14th Jul 2011. For each hazard in the table are shown:

- the assessed immediate operational effect
- the possible mitigations of the safety consequence of the operational effect
- the assessed severity of the mitigated effects.

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 001	Deviation from the procedures induced by ATC. Related to errors in the use of P-RNAV phraseology P-RNAV capacity identification (if the aircraft is not P-RNAV equipped, a P-RNAV instruction will not be accepted).	SO#13 SO#14	- Slight reduction in the availability for traffic control - Increase in the ATCo workload (Slight increase in the aircraft-ATCo communications in a complex environment)	- Detection by flight monitoring by the ATCo - After the detection there is a chance to correct and the aircraft can keep flying P-RNAV	5
Hz 002	Deviation from the instrumental flight procedures induced by the aircraft. A lot of waypoints may require much time of processing and may be an error source. This data is pre- charged in the FMS. Current memory in equipment on board may cause a limitation in the number of procedures which can be stored. It's thought the disposal of current procedures will free enough memory for the new procedures. Deviation from the authorizations given by ATCo on the part of the crew (e.g: because of bad weather not informed to the ATCo)	SO#14 SO#15	- Increase in workload /complexity for the crew. - Increase in workload/complexity for ATCo. - Possible loss of separation - Reduction in time of reaction	- Detection by flight monitoring by the ATCo - Radar Vectoring. - Differences in severity taken into account the places where the deviations are detected, more severe in the turning leg (trombone), where the nominal separation in design may be lower than the separation minima - Chance of correcting by ATCo so that the aircraft can keep flying P-RNAV - ACAS warnings - Separation minima warnings - Detection by the surveillance of maps on board is possible	3

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 003	Presence of mixed traffic (P-RNAV/conventional) Limit in number of new conventional manoeuvres at the same time There will not be many mixed operations	SO#16 SO#17	- Increase in workload/complexity of ATCo.	- Conventional Approach procedures for conventional flights - No interaction between conventional and P-RNAV procedures - Conventional procedures keep holding areas. - Mixed mode of operations for low-load periods.	4
Hz 004	Potential risks related to the deviation from the authorizations of airspace use About dangerous or restricted areas activation/de-activation.	SO#18	- Incompatibility between some manoeuvre/procedures P-RNAV/conventional flight	- It has been considered in the design: Design of protections holding areas (inside TMA area).	5
Hz 005	Loss of P-RNAV service (DME/DME) (multiple aircraft).	SO#16 SO#19 SO#20	- P-RNAV (DME/DME) navigation is not available. - Increase in workload for ATCo. - Increase in workload for the crew.	- Radar vectoring and conventional procedures when the crew inform about the loss. For a single aircraft if P-RNAV capability is lost once the manoeuvre is initiated, and is below MVA (worst case), will be questioned about capability to finish the approach or reverted to a conventional approach. - DME/DME redundancy is enough in TMA scenario (SESAR). If it's detected the corruption of DME, DME will degrade and inform automatically.	3

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
Hz 006	Credible corruption of the P-RNAV capability.	SO#14 SO#19	- An aircraft without P-RNAV capability gets authorization to fly in a P-RNAV manoeuvre (e.g. because of flight plan information corruption)	- Detection by flight monitoring by the ATCo - The crew inform about the impossibility to fly in the P-RNAV manoeuvre.	5

Table 5: System-Generated Hazards and Analysis

Note: Also, the following hazards were identified, but disregarded by the participant experts:

- *Credible corruption of DME signal (multiple aircraft): considered not credible. Moved to Assumptions log*
- *VFR traffic incursion in IFR area: no additional risk compared to current operation.*

The list of Safety Objectives derived to mitigate the above described hazard is as follows:

ID	Description
SO#13	Aircraft deviation from procedures shall not be induced by ATC.
SO#14	Aircraft deviations from procedures shall be detected and corrected.
SO#15	P-RNAV procedures in TMA shall not exceed the FMS capability
SO#16	Conventional Approach procedures shall remain in place.
SO#17	Interference of conventional traffic with P-RNAV traffic shall be minimized
SO#18	There shall be no incompatibility between P-RNAV and conventional manoeuvres/procedures
SO#19	P-RNAV service loss shall derive in the use of conventional procedures
SO#20	Continuity and integrity of P-RNAV DME service shall be granted

Table 6: Additional Safety Objectives (functionality and performance) in the case of internal failures

2.9 Achievability of the SAfety Criteria

The Safety Criteria set in section 2.4 has been achieved through the specification of safety objectives (functional & performance and integrity) in sections 2.6 to 2.8.

2.10 Validation & Verification of the Safety Specification

Appendix A contains the consolidated list of Safety Objectives.

3 Safe Design at SPR Level

3.1 Scope

This Section addresses the following activities:

- derivation, from the Safety Objectives (Functionality and Performance) of section 2, of Safety Requirements for the SPR-level design
- derivation, from the Safety Objectives (integrity) of section 2, of Safety Requirements for the SPR-level design

3.2 The Optimized RNP Structures (02.01.01 OFA) Functional Model

No functional model has been described for P05.07.04, WS1.

3.3 The Optimized RNP Structures (02.01.01 OFA) SPR-level Model

Given the scope of Project, no SPR-level Model has been described. Description of procedures is found at the OSED and is assimilated to the SPR-model for the purpose of this analysis.

3.4 Analysis of the SPR-level Model – Normal Operational Conditions

3.4.1 Scenarios for Normal Operations

Scenarios for Normal Operations are defined at the Initial OSED, Chapter 5.

3.4.2 Thread Analysis of the SPR-level Model – Normal Operations

Thread Analysis has not been carried out.

3.4.3 Dynamic Analysis of the SPR-level Model – Normal Operational Conditions

Results of the Validation Exercise are described and analyzed at the Validation Report.

3.4.4 Additional Safety Requirements (functionality and performance) – Normal Operational Conditions

Safety requirements have been established in order to fulfil the Safety Objectives derived for Normal Operations.

ID	Description	Related Safety Objectives
Phase 1 - Arrivals: CL limits to IAF		
SR 001	Traffic metered in order to achieve max TMA sectors capacity commensurate with need to maintain separation/wake minima (5 and/or 3 NM)	SO#1
SR 002	conform to other entry criteria (external sectors): entry point, altitude, speed constraint, separation constraints (including for adverse meteorological conditions exercises)	SO#1
SR 003	Comply to a specified speed constraint at transitions IAF	SO#1
SR 004	May have direct-to clearances, e.g. to MONTE/BENJI or IAFs in medium/low density	SO#1
SR 005	May have direct-to clearances above 10000 ft, e.g. to BARAHONA	SO#1
SR 006	Changes to sequencing and spacing as necessary to improve delivery of traffic into the TMA and then to the IAF through speed control, vectoring, conformance to route options and holding	SO#2
SR 007	All non-P-RNAV arriving aircraft cleared along conventional routes to VOR/DME SOMOSIERRA or PERALES DE TAJUÑA whilst providing sufficient obstacle/terrain clearance	SO#2
SR 008	Conventional routes to be available separately for non-P-RNAV flight planned departing aircraft for handover to Area Control	SO#2
SR 009	Multiple arrival P-RNAV structures sharing the same airspace segregated so as to ensure lateral separation between the nearest points on the routes until, at least, longitudinal / vertical separation is necessarily applied as the routes converge (final approach and final departures segments)	SO#2
SR 010	Spacing between aircraft within converged flows maintained in accordance with longitudinal separation minima and landing constraints	SO#2
SR 011	Controllers continuously knowledgeable of aircraft P-RNAV capability in complex TMA (Either Flight Plans and/or A/G Communication)	SO#2 SO#6 SO#7
SR 012	Each aircraft to be monitored for conformance to its cleared route in complex TMA (or heading if vectored), assigned altitude, descent/departure profile and speed instructions. Deviations to be corrected, wherever possible, by means of timely, small corrections to course / altitude	SO#2 SO#6 SO#7
SR 013	Physical capacity for aircraft that have deviated, or been vectored, irretrievably from their cleared route / altitude to be re-inserted into the landing sequence or direct-to clearance provided in such a way as to avoid as far as possible propagating the need for the reversion to vectors for other aircraft in the landing sequence	SO#2 SO#4 SO#5 SO#6 SO#7

ID	Description	Related Safety Objectives
SR 014	Controller capacity for reversion to vectors to be maintained	SO#2 SO#4 SO#5 SO#6 SO#7
SR 015	P-RNAV structures shall be completely segregated from restricted airspace	SO#2
SR 016	Contingency lateral/vertical holding (as applicable) shall be available to accommodate unusual circumstances and emergencies: MONTE/BENJI (and CANTO, DAGAN, BRUNO and PACOS)	SO#2
SR 017	Mandate for P-RNAV in complex TMA	SO#2
SR 018	Aircraft given priority on shorter routes or to diversion airfield if required	SO#3
SR 019	Waypoints shall be defined to direct emergencies straight to Final Approach fix/ILS Intercept	SO#3
SR 020	Traffic held as necessary (in holds for arriving aircraft or on ground for departures)	SO#4 SO#5
SR 021	Speed constraints applied as necessary to maintain longitudinal spacing	SO#4 SO#5
SR 022	Exceeding traffic over degraded capacity will be transfer to Torrejón and Getafe airports in this order.	SO#5
Phase 2 - Arrivals: IAF to IF		
SR 023	Aircraft to be stable at the defined level/altitude for the transition assigned prior to transition entry	SO#6
SR 024	P-RNAV aircraft follow the assigned transition leg (non-P-RNAV aircraft vectored and follow assigned altitude)	SO#6
SR 025	Parallel sequencing legs shall be at a sufficient lateral distance such as to avoid clutter and facilitate visualization on radar screen: 5NM	SO#6
SR 026	Adjacent Sequencing Legs shall be horizontally separated, along their entire length, by at least the separation minima for P-RNAV: 1 NM + 1NM	SO#6
SR 027	Aircraft on the same Sequencing Leg spaced such that at least the minimum required horizontal separation is maintained between them whilst on the Sequencing Leg (by conformance to route and appropriate speed instructions), taking account of variability in aircraft turn performance	SO#6
SR 028	As each aircraft turns off the Sequencing Leg assigned towards the IF, horizontal separation shall be maintained between it and all aircraft on any adjacent sequencing leg(s) until lateral separation is established (and can be maintained) between them	SO#6
SR 029	Holdings shall be available on respectively IAFs	SO#6
SR 030	A spare level for each Leg (below or above)	SO#6
SR 031	Aircraft shall not proceed to any sequencing Leg (Direct-to or vectored) until it is spaced behind/ahead of the other aircraft in either the same sequence or adjacent sequencing leg sufficiently to ensure that at least the minimum horizontal separation is maintained	SO#7

ID	Description	Related Safety Objectives
SR 032	Aircraft shall not turn off the arrival procedure (Direct-to or vectored) towards the IAF Point until it is sufficiently spaced behind a preceding aircraft from its position and speed constraints	SO#7
SR 033	Between IAF and IF P-RNAV aircraft to follow the P-RNAV route and comply with associated altitude restrictions	SO#7
SR 034	Between IAF and IF non-P-RNAV aircraft to be cleared to descend subject to any altitude restrictions published for that route through radar vectoring	SO#7
SR 035	After exiting BENJI/MONTE aircraft shall be cleared precision Final Approach and transition Leg assigned	SO#7
SR 036	Spacing between aircraft within converged flows maintained in accordance with lateral separation minima and landing constraints	SO#7
SR 037	Vertical separation at intersections of (P-RNAV and convetional) STARs routes with SIDs and surrounding airports routes (Torrejón and Getafe) and MVA to be provided strategically by means of published level restrictions (or tactically by upstream Planning)	SO#7
SR 038	Multiple P-RNAV structures sharing the same airspace shall be segregated so as to ensure lateral separation between the nearest points on the routes	SO#7
SR 039	Holding patterns shall be available on MONTE/BENJI	SO#7
SR 040	Aircraft that have followed a missed approach to be re-inserted into the landing sequence in such a way as to avoid as far as possible propagating the need for reversion to vectors for other aircraft in the landing sequence	SO#7
SR 041	P-RNAV structures shall be completely segregated from restricted airspace	SO#7
SR 042	No direct-to IF instruction will be given when an aircraft reaches the end of a sequencing leg. Aircraft will follow the entire transition according to the procedure. In case it is necessary in order to give the controller the opportunity to manage the traffic flow (hold) as necessary, radar vectoring could be given or missed approach instructions.	SO#7
SR 043	An aircraft that is transitioned from the end of a sequencing leg for re-insertion into the landing sequence shall not impinge departing aircraft	SO#7
SR 044	Aircraft conformance to transition routes that are designed so as to satisfy the ICAO PANS-OPS 8168 obstacle clearance criteria and compliance to altitude restriction published for the routes	SO#8
SR 045	Minimum altitude shall be sufficient to provide vertical clearance from terrain/obstacle along the entire length of the procedure, taking account of minimum obstacle clearance (MOC) in accordance with ICAO PANS-OPS 8168	SO#8
SR 046	In South Configuration, controllers shall try to assign nearest transitions due to obstacle and terrain clearence. In turbulence or bad weather conditions, farest transitions WON'T be assigned due to obstacle existance (Mountain chain)	SO#8
Phase 4 - Departures		
SR 047	Traffic cleared in order to achieve max RWY throughput commensurate with need to maintain separation/wake minima (3 NM)	SO#9

ID	Description	Related Safety Objectives
SR 048	May have direct-to clearances above 10000 ft, e.g. to BARAHONA	SO#9
SR 049	Changes to queuing sequencing and clearences as necessary to improve delivery of traffic into the TMA and then to route conectors through speed control, vectoring, conformance to route options and holding	SO#10
SR 050	All non-P-RNAV departing aircraft cleared along conventional routes whilst providing sufficient obstacle/terrain clearance	SO#10
SR 051	Conventional routes to be available separately for non-P-RNAV flight planned departing aircraft for handover to Area Control	SO#10
SR 052	Multiple departures P-RNAV structures sharing the same airspace segregated so as to ensure lateral separation between the nearest points on the routes until, at least, longitudinal / vertical separation is necessarily applied as the routes converge (e.g. NAVAS DEL REY, SOMOSIERRA... etc.)	SO#10
SR 053	Spacing between aircraft within converged flows maintained in accordance with longitudinal separation minima and departure constraints (Noise restrictions)	SO#10
SR 054	Controllers continuously knowledgeable of aircraft P-RNAV capability in complex TMA (Either Flight Plans and/or A/G Communication)	SO#10
SR 055	Each aircraft to be monitored for conformance to its cleared departure route in complex TMA (or heading if vectored), assigned altitude, descent/departure profile and speed instructions. Deviations to be corrected, wherever possible, by means of timely, small corrections to course / altitude	SO#10
SR 056	Physical capacity for aircraft that have deviated, or been vectored, irretrievably from their cleared route / altitude to be re-inserted into the departure procedure assigned or direct-to clearance provided in such a way as to avoid as far as possible propagating the need for the reversion to vectors for other aircraft in the departure sequence	SO#10
SR 057	Controller capacity for reversion to vectors to be maintained	SO#10
SR 058	P-RNAV structures shall be completely segregated from restricted airspace	SO#10
SR 059	Mandate for P-RNAV in complex TMA	SO#10
SR 060	Traffic held as necessary (in TAXI waiting areas) until they are cleared (Bad weather delayed)	SO#11
SR 061	Speed constraints applied as necessary to maintain longitudinal spacing	SO#11 SO#12
SR 062	Physical capacity for aircraft that have deviated, or been vectored, irretrievably from their cleared route / altitude to be re-inserted into the departing procedure or direct-to clearance provided in such a way as to avoid as far as possible propagating the need for the reversion to vectors for other aircraft in the departing sequence	SO#11 SO#12
SR 063	Controller capacity for reversion to vectors to be maintained	SO#11 SO#12
SR 064	Traffic held as necessary (in TAXI waiting areas) until they are cleared (Degraded Capacity)	SO#12

Table 7: Additional Safety Requirements – Normal Operational Conditions

3.5 Analysis of the SPR-level Model – Abnormal Operational Conditions

No abnormal conditions have been considered during the FHA or the validation exercises.

3.6 Design Analysis – Case of Internal System Failures

At the FHA performed, mitigations for the identified system-generated hazards were proposed. Those mitigations are materialised into Safety Requirements to assure the fulfilment of the Safety Objectives.

3.6.1 Causal Analysis

A top-down identification of internal system failures has not been carried out.

3.6.2 Common Cause Analysis

N/A

3.6.3 Formalization of Mitigations

Mitigations for the system-generated hazards were derived at the FHA and are described in section 2.8.1.

3.6.4 Safety Requirements (integrity/reliability)

Safety requirements have been established in order to fulfil the Safety Objectives derived for system generated failures.

ID	Description	Related Safety Objectives
SR 065	ATC shall use the appropriate P-RNAV phraseology	SO#13
SR 066	P-RNAV instructions will not be accepted by non-P-RNAV equipped aircraft.	SO#13
SR 067	Continuous flight monitoring by ATC shall detect aircraft deviations.	SO#14
SR 068	ATC shall correct deviations in time (radar vectoring), allowing aircraft to keep flying P-RNAV routes when possible.	SO#14
SR 069	The number of waypoints required for the TMA shall be in accordance with FMS memory capability.	SO#15

ID	Description	Related Safety Objectives
SR 070	The number of waypoints required for the TMA procedures shall be in accordance with FMS processing capability.	SO#15
SR 071	Conventional Approach procedures shall remain in place.	SO#16
SR 072	There shall be no interaction between conventional and P-RNAV procedures	SO#17
SR 073	Conventional procedures shall keep holding areas	SO#17
SR 074	Mixed mode operations shall be used during low-load periods	SO#17
SR 075	Restricted areas incompatible with airspace design shall be removed.	SO#18
SR 076	Airspace design shall consider protection for all flight segments (e.g. holding areas)	SO#18
SR 077	Aircraft reporting P-RNAV loss once the manoeuvre is initiated shall be questioned about their capability to finish the approach.	SO#19
SR 078	Aircraft unable to finish the P-RNAV approach shall be reverted to conventional approach	SO#19
SR 079	DME/DME redundancy shall be provided	SO#20
SR 080	DME shall degrade and inform automatically in case of detected corruption.	SO#20

Table 8: Safety Requirements – System Generated Failures

3.7 Achievability of the SAfety Criteria

The Safety Criteria set in section 2.4 have been achieved through the specification of safety objectives (functional & performance and integrity) in sections 2.6 to 2.9 and then derived to the safety requirements.

3.8 Realism of the SPR-level Design

After Validation Exercises, results are limited for Release 1 as to demonstrate the feasibility of Safety Requirements, as well as the correctness of the assumptions.

3.8.1 Achievability of Safety Requirements / Assumptions

After Validation Exercises, results are limited for Release 1 as to demonstrate the fulfilment of Safety Requirements. Future evolution of the project will allow for the completion of SR verification.

3.8.2 "Testability" of Safety Requirements

After Validation Exercises, results are limited for Release 1 as to demonstrate the testability of Safety Requirements

3.9 Validation & Verification of the Safe Design at SPR Level

Appendix B contains the consolidated list of Safety Requirements.

4 Detailed Safe Design at Physical Level

This Section will address the Safety Assessment at Physical Level when the technical project produces technical specifications. For Release 1, detailed design at Physical Level is not yet available.

4.1 Scope

N/A

4.2 Description of the OFA Physical Model

N/A

4.3 Detailed Safety Requirements for the physical system design

N/A

4.4 Correct operation of the physical design

N/A

4.5 Adverse, Emergent Safety Properties

N/A

4.6 Proving the Safety Requirements

N/A

Appendix A Consolidated List of Safety Objectives

A.1 Safety Objectives (Functionality and Performance)

ID	Description
Phase 1 - Arrivals: CL limits to IAF	
SO#1	Arrival traffic shall be metered according to TMA and holding capacity
SO#2	The required separation/spacing between aircraft shall be maintained through arrivals to IAF
SO#3	Emergency squawk aircraft shall be prioritized
SO#4	The required separation/spacing between aircraft in the event of severe weather shall be maintained through arrivals to IAF
SO#5	The required separation/spacing between aircraft in the event of one runway closure due to security reasons shall be maintained through arrivals to IAF
Phase 2 - Arrivals: IAF to IF	
SO#6	The required separation/spacing between aircraft shall be maintained on and between the transitions
SO#7	The required separation/spacing between aircraft shall be maintained in BENJI/MONTE arrival flows points
SO#8	Obstacle and terrain clearance for arrivals shall be provided
Phase 4 - Departures	
SO#9	Departure traffic shall be metered according to Runway throughput capacity
SO#10	The required separation/spacing between aircraft shall be maintained through departures
SO#11	The required separation/spacing between aircraft in the event of severe weather shall be maintained through departures
SO#12	The required separation/spacing between aircraft in the event of one runway closure due to security reasons shall be maintained through departures

Table 9: List of Safety Objectives (success approach) for Normal Operations

A.2 Safety Objectives (Integrity)

ID	Description
SO#13	Aircraft deviation from procedures shall not be induced by ATC.
SO#14	Aircraft deviations from procedures shall be detected and corrected.
SO#15	P-RNAV procedures in TMA shall not exceed the FMS capability
SO#16	Conventional Approach procedures shall remain in place.
SO#17	Interference of conventional traffic with P-RNAV traffic shall be minimized
SO#18	There shall be no incompatibility between P-RNAV and conventional manoeuvres/procedures
SO#19	P-RNAV service loss shall derive in the use of conventional procedures
SO#20	Continuity and integrity of P-RNAV DME service shall be granted

Table 10: Additional Safety Objectives (functionality and performance) in the case of internal failures

Appendix B Consolidated List of Safety Requirements

B.1 Safety Requirements (Functionality and Performance)

ID	Description	Related Safety Objectives
Phase 1 - Arrivals: CL limits to IAF		
SR 001	Traffic metered in order to achieve max TMA sectors capacity commensurate with need to maintain separation/wake minima (5 and/or 3 NM)	SO#1
SR 002	conform to other entry criteria (external sectors): entry point, altitude, speed constraint, separation constraints (including for adverse meteorological conditions exercises)	SO#1
SR 003	Comply to a specified speed constraint at transitions IAF	SO#1
SR 004	May have direct-to clearances, e.g. to MONTE/BENJI or IAFs in medium/low density	SO#1
SR 005	May have direct-to clearances above 10000 ft, e.g. to BARAHONA	SO#1
SR 006	Changes to sequencing and spacing as necessary to improve delivery of traffic into the TMA and then to the IAF through speed control, vectoring, conformance to route options and holding	SO#2
SR 007	All non-P-RNAV arriving aircraft cleared along conventional routes to VOR/DME SOMOSIERRA or PERALES DE TAJUÑA whilst providing sufficient obstacle/terrain clearance	SO#2
SR 008	Conventional routes to be available separately for non-P-RNAV flight planned departing aircraft for handover to Area Control	SO#2
SR 009	Multiple arrival P-RNAV structures sharing the same airspace segregated so as to ensure lateral separation between the nearest points on the routes until, at least, longitudinal / vertical separation is necessarily applied as the routes converge (final approach and final departures segments)	SO#2
SR 010	Spacing between aircraft within converged flows maintained in accordance with longitudinal separation minima and landing constraints	SO#2
SR 011	Controllers continuously knowledgeable of aircraft P-RNAV capability in complex TMA (Either Flight Plans and/or A/G Communication)	SO#2 SO#6 SO#7
SR 012	Each aircraft to be monitored for conformance to its cleared route in complex TMA (or heading if vectored), assigned altitude, descent/departure profile and speed instructions. Deviations to be corrected, wherever possible, by means of timely, small corrections to course / altitude	SO#2 SO#6 SO#7
SR 013	Physical capacity for aircraft that have deviated, or been vectored, irretrievably from their cleared route / altitude to be re-inserted into the landing sequence or direct-to clearance provided in such a way as to avoid as far as possible propagating the need for the reversion to vectors for other aircraft in the landing sequence	SO#2 SO#4 SO#5 SO#6 SO#7

ID	Description	Related Safety Objectives
SR 014	Controller capacity for reversion to vectors to be maintained	SO#2 SO#4 SO#5 SO#6 SO#7
SR 015	P-RNAV structures shall be completely segregated from restricted airspace	SO#2
SR 016	Contingency lateral/vertical holding (as applicable) shall be available to accommodate unusual circumstances and emergencies: MONTE/BENJI (and CANTO, DAGAN, BRUNO and PACOS)	SO#2
SR 017	Mandate for P-RNAV in complex TMA	SO#2
SR 018	Aircraft given priority on shorter routes or to diversion airfield if required	SO#3
SR 019	Waypoints shall be defined to direct emergencies straight to Final Approach fix/ILS Intercept	SO#3
SR 020	Traffic held as necessary (in holds for arriving aircraft or on ground for departures)	SO#4 SO#5
SR 021	Speed constraints applied as necessary to maintain longitudinal spacing	SO#4 SO#5
SR 022	Exceeding traffic over degraded capacity will be transfer to Torrejón and Getafe airports in this order.	SO#5
Phase 2 - Arrivals: IAF to IF		
SR 023	Aircraft to be stable at the defined level/altitude for the transition assigned prior to transition entry	SO#6
SR 024	P-RNAV aircraft follow the assigned transition leg (non-P-RNAV aircraft vectored and follow assigned altitude)	SO#6
SR 025	Parallel sequencing legs shall be at a sufficient lateral distance such as to avoid clutter and facilitate visualization on radar screen: 5NM	SO#6
SR 026	Adjacent Sequencing Legs shall be horizontally separated, along their entire length, by at least the separation minima for P-RNAV: 1 NM + 1NM	SO#6
SR 027	Aircraft on the same Sequencing Leg spaced such that at least the minimum required horizontal separation is maintained between them whilst on the Sequencing Leg (by conformance to route and appropriate speed instructions), taking account of variability in aircraft turn performance	SO#6
SR 028	As each aircraft turns off the Sequencing Leg assigned towards the IF, horizontal separation shall be maintained between it and all aircraft on any adjacent sequencing leg(s) until lateral separation is established (and can be maintained) between them	SO#6
SR 029	Holdings shall be available on respectively IAFs	SO#6
SR 030	A spare level for each Leg (below or above)	SO#6

ID	Description	Related Safety Objectives
SR 031	Aircraft shall not proceed to any sequencing Leg (Direct-to or vectored) until it is spaced behind/ahead of the other aircraft in either the same sequence or adjacent sequencing leg sufficiently to ensure that at least the minimum horizontal separation is maintained	SO#7
SR 032	Aircraft shall not turn off the arrival procedure (Direct-to or vectored) towards the IAF Point until it is sufficiently spaced behind a preceding aircraft from its position and speed constraints	SO#7
SR 033	Between IAF and IF P-RNAV aircraft to follow the P-RNAV route and comply with associated altitude restrictions	SO#7
SR 034	Between IAF and IF non-P-RNAV aircraft to be cleared to descend subject to any altitude restrictions published for that route through radar vectoring	SO#7
SR 035	After exiting BENJI/MONTE aircraft shall be cleared precision Final Approach and transition Leg assigned	SO#7
SR 036	Spacing between aircraft within converged flows maintained in accordance with lateral separation minima and landing constraints	SO#7
SR 037	Vertical separation at intersections of (P-RNAV and convetional) STARs routes with SIDs and surrounding airports routes (Torrejón and Getafe) and MVA to be provided strategically by means of published level restrictions (or tactically by upstream Planning)	SO#7
SR 038	Multiple P-RNAV structures sharing the same airspace shall be segregated so as to ensure lateral separation between the nearest points on the routes	SO#7
SR 039	Holding patterns shall be available on MONTE/BENJI	SO#7
SR 040	Aircraft that have followed a missed approach to be re-inserted into the landing sequence in such a way as to avoid as far as possible propagating the need for reversion to vectors for other aircraft in the landing sequence	SO#7
SR 041	P-RNAV structures shall be completely segregated from restricted airspace	SO#7
SR 042	No direct-to IF instruction will be given when an aircraft reaches the end of a sequencing leg. Aircraft will follow the entire transition according to the procedure. In case it is necessary in order to give the controller the opportunity to manage the traffic flow (hold) as necessary, radar vectoring could be given or missed approach instructions.	SO#7
SR 043	An aircraft that is transitioned from the end of a sequencing leg for re-insertion into the landing sequence shall not impinge departing aircraft	SO#7
SR 044	Aircraft conformance to transition routes that are designed so as to satisfy the ICAO PANS-OPS 8168 obstacle clearance criteria and compliance to altitude restriction published for the routes	SO#8
SR 045	Minimum altitude shall be sufficient to provide vertical clearance from terrain/obstacle along the entire length of the procedure, taking account of minimum obstacle clearance (MOC) in accordance with ICAO PANS-OPS 8168	SO#8

ID	Description	Related Safety Objectives
SR 046	In South Configuration, controllers shall try to assign nearest transitions due to obstacle and terrain clearence. In turbulence or bad weather conditions, farest transitions WON'T be assigned due to obstacle existance (Mountain chain)	SO#8
Phase 4 - Departures		
SR 047	Traffic cleared in order to achieve max RWY throughput commensurate with need to maintain separation/wake minima (3 NM)	SO#9
SR 048	May have direct-to clearances above 10000 ft, e.g. to BARAHONA	SO#9
SR 049	Changes to queuing sequencing and clearences as necessary to improve delivery of traffic into the TMA and then to route conectors through speed control, vectoring, conformance to route options and holding	SO#10
SR 050	All non-P-RNAV departing aircraft cleared along conventional routes whilst providing sufficient obstacle/terrain clearance	SO#10
SR 051	Conventional routes to be available separately for non-P-RNAV flight planned departing aircraft for handover to Area Control	SO#10
SR 052	Multiple departures P-RNAV structures sharing the same airspace segregated so as to ensure lateral separation between the nearest points on the routes until, at least, longitudinal / vertical separation is necessarily applied as the routes converge (e.g. NAVAS DEL REY, SOMOSIERRA... etc.)	SO#10
SR 053	Spacing between aircraft within converged flows maintained in accordance with longitudinal separation minima and departure constraints (Noise restrictions)	SO#10
SR 054	Controllers continuously knowledgeable of aircraft P-RNAV capability in complex TMA (Either Flight Plans and/or A/G Communication)	SO#10
SR 055	Each aircraft to be monitored for conformance to its cleared departure route in complex TMA (or heading if vectored), assigned altitude, descent/departure profile and speed instructions. Deviations to be corrected, wherever possible, by means of timely, small corrections to course / altitude	SO#10
SR 056	Physical capacity for aircraft that have deviated, or been vectored, irretrievably from their cleared route / altitude to be re-inserted into the departure procedure assigned or direct-to clearance provided in such a way as to avoid as far as possible propagating the need for the reversion to vectors for other aircraft in the departure sequence	SO#10
SR 057	Controller capacity for reversion to vectors to be maintained	SO#10
SR 058	P-RNAV structures shall be completely segregated from restricted airspace	SO#10
SR 059	Mandate for P-RNAV in complex TMA	SO#10
SR 060	Traffic held as necessary (in TAXI waiting areas) until they are cleared (Bad weather delayed)	SO#11
SR 061	Speed constraints applied as necessary to maintain longitudinal spacing	SO#11 SO#12

ID	Description	Related Safety Objectives
SR 062	Physical capacity for aircraft that have deviated, or been vectored, irretrievably from their cleared route / altitude to be re-inserted into the departing procedure or direct-to clearance provided in such a way as to avoid as far as possible propagating the need for the reversion to vectors for other aircraft in the departing sequence	SO#11 SO#12
SR 063	Controller capacity for reversion to vectors to be maintained	SO#11 SO#12
SR 064	Traffic held as necessary (in TAXI waiting areas) until they are cleared (Degraded Capacity)	SO#12

Table 11: Additional Safety Requirements – Normal Operational Conditions

B.2 Safety Requirements (Integrity)

ID	Description	Related Safety Objectives
SR 065	ATC shall use the appropriate P-RNAV phraseology	SO#13
SR 066	P-RNAV instructions will not be accepted by non-P-RNAV equipped aircraft.	SO#13
SR 067	Continuous flight monitoring by ATC shall detect aircraft deviations.	SO#14
SR 068	ATC shall correct deviations in time (radar vectoring), allowing aircraft to keep flying P-RNAV routes when possible.	SO#14
SR 069	The number of waypoints required for the TMA shall be in accordance with FMS memory capability.	SO#15
SR 070	The number of waypoints required for the TMA procedures shall be in accordance with FMS processing capability.	SO#15
SR 071	Conventional Approach procedures shall remain in place.	SO#16
SR 072	There shall be no interaction between conventional and P-RNAV procedures	SO#17
SR 073	Conventional procedures shall keep holding areas	SO#17
SR 074	Mixed mode operations shall be used during low-load periods	SO#17
SR 075	Restricted areas incompatible with airspace design shall be removed.	SO#18
SR 076	Airspace design shall consider protection for all flight segments (e.g. holding areas)	SO#18
SR 077	Aircraft reporting P-RNAV loss once the manoeuvre is initiated shall be questioned about their capability to finish the approach.	SO#19
SR 078	Aircraft unable to finish the P-RNAV approach shall be reverted to conventional approach	SO#19
SR 079	DME/DME redundancy shall be provided	SO#20
SR 080	DME shall degrade and inform automatically in case of detected corruption.	SO#20

Appendix C Assumptions, Safety Issues & Limitations

C.1 Assumptions log

The following Assumptions were necessarily raised in deriving the above Functional and Performance Safety Requirements:

Ref	Assumption	Validation
A001	The current risk level associated with conventional departures and arrivals in terminal airspace is acceptable. Currently, although it's difficult to establish what the level risk is in the conventional procedures: o The ATM 2000+ strategy Safety Objectives establish the same hypothesis; o Every conventional departure and arrival operation and/or P-RNAV in current service has been approved (by means of acceptance or notification) by the national aeronautical authority. o The absence of a significant number of incidents involving risk in the Terminal Area allows assuming this assumption.	
A002	The current separation minima between aircraft, horizontal and vertical (which are 3 NM or 5 NM of radar separation) and 1000 ft, respectively, will be applicable to P-RNAV. o (Eurocontrol 2007). P-RNAV in Terminal Area doesn't seek the reduction of the current separation minima between aircraft or the criteria of minimum obstacle clearances and over-terrain. o Lateral protection area for navigation procedures in area are based in DME-DME and GNSS infrastructures.	
A003	Requirements about minimum obstacles clearance and over terrain in P-RNAV operation are similar to current ones specified in the ICAO document 8168 (PANS-OPS); in short: o Doc 8168: 984 ft of minimum obstacles clearance in STAR and initial approach. o For SID, gradient of 0,8% over Obstacles Identification Surface (OIS), which is usually equivalent to 2,5% from the runway edge (DER point). o Minimum obstacles lateral clearance for procedures based on the use of the conventional infrastructure depends on the navigation sensor used to (7.8º if it's VOR, 10.3º if it's NDB) as in the approach as in the departures. o Lateral protection area for navigation procedures in area based in DME-DME and GNSS infrastructures is also published (see Ref.8168 ICAO(PANS-OPS)).	
A004	There are navaids available in the terminal area, which offer conventional navigation solutions as reserve of P-RNAV procedures and allow an independent verification of the navigation information by the crew.	

Ref	Assumption	Validation
A005	There is available phraseology suitable for P-RNAV operations, and procedures to support this phraseology have been developed and published in the AIP	
A006	The system can take out and show the P-RNAV capacity of the aircraft to the ATCo; it can also show the P-RNAV procedures of TMA graphically. P-RNAV capacity is not information shared in oral communications, unless this equipment availability changes during the flight.	
A007	If the separation minima are reached or significant deviations from the planned path take place, or if the crew inform about the loss of the P-RNAV capability, controllers will indicate to the crew corrective actions, which may include the radar vectoring.	
A008	The ATS personal involved in P-RNAV operations has received specific training and information.	
A009	The on-board equipment involved in the operation (navigation sensors, RNAV computer, optional VNAV function, on-board data base, data display) is suitable for operation P-RNAV according to TGL-10 rev. 1. It's also included the capacity to keep into +/-1NM from the required path during 95% of the flight time.	
A010	Operational procedures and crew training fulfill the requirements established in TGL-10.	
A011	AIS supplier assures that AIS data contains the updated and validated P-RNAV procedures.	
A012	It is not credible that DME equipment gets deteriorated so that corruption of the signal DME takes place, so, this could not make the aircraft was guided by deceptive data of position.	
A013	The presence of visual flights (VFR) in the field o in the visual corridors already designed does not entail a change regarding current operation.	
A014	Traffic volumes will increase in terminal airspace in the future, according to previsions (4 possible scenarios) established in the CONSAVE, ACARE and IPC (Ref. OSED 5.7.4)	
A015	Current departure procedures in Madrid, with a design compliant with the current noise restrictions, will be reduced; those maintained (yet to be defined) will be similar (up to 10.000ft, limited by the noise abatement procedures) to some of the ones existing today.	
A016	Design of departure procedures keeps traffic flows separated from arrivals (trombones), as well as from obstacles/terrain.	
A017	Airspace design includes as an assumption the disappearance o those restricted areas that may prevent from the execution of designed manoeuvres, without possible alternative.	
A018	FMS equipment will support downloading P-RNAV procedures both by means of memory size and processing capability.	
A019	Corruption of the DME signal, affecting multiple aircraft, is not credible.	

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