P 05.07.04- Final Business Case and Transition Feasibility Report

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Abstract

This report illustrates all results and conclusions of the project that will be structured focused in providing a stakeholders' decision support tool for implementing P-RNAV in complex TMAs.

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Table of Contents

List of tables

List of figures

Executive summary

This report illustrates all results and conclusions of the project that will be structured focused in providing a stakeholders' decision support tool for implementing P-RNAV in complex TMAs. For all the reasons exposed below, the Project 5.7.4 WS1 and WS 2 are considered ready to implement and head to V4. This conclusion is based on SEMP transition feasibility criteria including validation and maturity assessment aspects.

1 Introduction

1.1 Purpose of the document

This document presents a resume of the different business cases analysed after the validation processes carried out in the frame of Project 05.07.04.The complete information related to the different assessments is published in other project deliverables, such as OSEDs and Validation Reports.
The document addresses also an assessment of the Transition Feasibility of the two options studied, through the completion of a Checklist for Assessment of ATM Service Maturity.

1.2 Intended readership

The intended readership is SJU to establish conclusions and recommendations in implementation process of P-RNAV in complex TMAs.
This document also provides targeted feedback to the transversal performance projects SWP16.6 and B.5.
Other projects, parties or countries under the umbrella of SESAR Programme or any other P-RNAV implementation initiative could be interested in reading this documentation but no implications in their goals, objectives, scopes or any other approach that the projects should take.

1.3 Inputs from other projects

No inputs from any other projects are expected

1.4 Acronyms and Terminology

Term	Definition
ACAS	Airborne Collision Avoidance System
ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
AMAN	Arrival Manager
ANSP	Air Navigation Service Provider
AOC	Aircraft Operations Centre
ASAS	Airborne Separation Assistance Systems
ASEP	Airborne Separation
ASPA	Airborne Spacing
APV	Approach Procedure with Vertical guidance
APW	Air Proximity Warning
ATC	Air Traffic Control

Term	Definition
ATFCM	Air Traffic Flow and Capacity Management
ATM	Air Traffic Management
ATOW	Actual Take Off Weight
ATSU	Air Traffic Service Unit
CCD	Continuous Climb Departure
CBA	Cost Benefit Analysis
CDA	Continuous Descent Arrival
CDM	Collaborative Decision Making
CFIT	Controlled Flight Into Terrain
CDTI	Cockpit Display of Traffic Information
CIDEFO	Spanish acronym of Inter Ministerial Committee between Ministry of Defense and Transportation
CTA	Controlled Time of Arrival
CWP	Controller Working Position
DCT	Direct routing
DMAN	Departure Manager
ENR	Enroute
FIR	Flight Information Region
FMS	Flight Management System
FUA	Flexible Use of Airspace
GNSS	Global Navigation Surveillance System
GPWS	Ground Proximity Warning System
i4D	Initial 4-Dimension trajectory
IFR	Instrument Flight Rules
MAC	Mid-Air Collision
MSAW	Minimum Safe Altitude Warning
NOP	Network Operations Plan
NPA	Non-Precision Approach

Term	Definition
OFA	Operational Focus Area
PBN	Performance Based Navigation
PSR	Primary Surveillance Radar
RB/MT	Reference Business/Mission Trajectory
RNAV	Area Navigation
RNP	Required Navigation Performance
R/T	Radio Telephone (or Radio Telephony)
SB/MT	Shared Business/Mission Trajectory
SID	Standard Instrument Departure
SSR	Secondary Surveillance Radar
STAR	Standard Arrival Route
TCT	Tactical Controller Tools
TMA	Terminal Manoeuvring Area
TP	Trajectory Prediction
VFR	Visual Flight Rules

2 Common Operative Conclusions and Recommendations at OSP level

2.1 Common Conclusions

Which procedure should be put forward: Point Merge or Trombones, depends on local circumstances and airspace availability.
Typically, Trombone procedures can apply Sequencing & Merging closer to final approach than Point Merge Systems. However, in the Madrid Trombone design, the merging occurs far upstream with the turn onto Final Approach facilitated by a 'P-RNAV grid'; the Point Merge System in London provided base leg turns onto Final Approach for some airfield approaches. These test cases demonstrate a P-RNAV route structured TMA can be designed to mitigate against constraints when sufficient consideration is given to design around the local conditions.
Trombones are more similar to 'current day' vectoring operation meaning that it is relatively comfortable for controllers and pilots to adjust to this systemised procedure.
Point Merge Systems provide a higher degree of structure and standardisation, allowing them to become homogenous designs that can be applied to multiple airports. This provides potential benefits in transferability of skills. The simplicity of operation of the Point Merge System means that it is intuitive for controllers to use, i.e. simple for a new trainee controller to pick up the technique. However, the procedure is less intuitive for the pilot, placing an increased importance on the controller informing the pilot of expected route, constraints and 'time on leg' prior to entering the STAR.

- In strong wind conditions, the separation between traffics at the deliverance from initial to final approach sectors needs to be increased to prevent overtaking in the final approach path.
- Solutions for specific CDO manoeuvres have been analysed, although not tested. CDO in high traffic periods seems to be not feasible.
- CCD have been carried out for the majority of departures.
- Adaptation of ATCOS participating in the validation sessions to the new procedures has been easy and quick.
- In bad weather conditions the reversion to a radar vectoring environment has proven to be feasible, if absolutely necessary, although increasing significantly the work-load.
- Important improvements in the overall TMA capacity values have been obtained.
- Overall flying times have been reduced in P-RNAV scenarios.
- Safety levels have been kept in acceptable margins.
- RWY configuration changes management has been improved.
- Aircraft holdings have been reduced.
- Application of P-RNAV procedures has enabled the design of de-conflicted SIDs and STARs

2.2 Common 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:

- Non P-RNAV equipped aircraft should be clearly identified in the radar and flight plan data presentation to minimize the need for tactical coordination.
- External sectors should be able to pre-sequence traffic to facilitate management of initial approach sectors.
- Silent coordination procedures supported by the system should be improved to minimize the need for coordination
- For high traffic demands as simulated in the higher traffic samples, the support of tools such as AMAN should be helpful for pre-sequencing traffic to external sectors.
- Altitudes in the STARS should be well adapted to aircraft performances.
- Vertical limits of sectors should be adapted so as to enable CCD

3 WS1 Business case conclusions

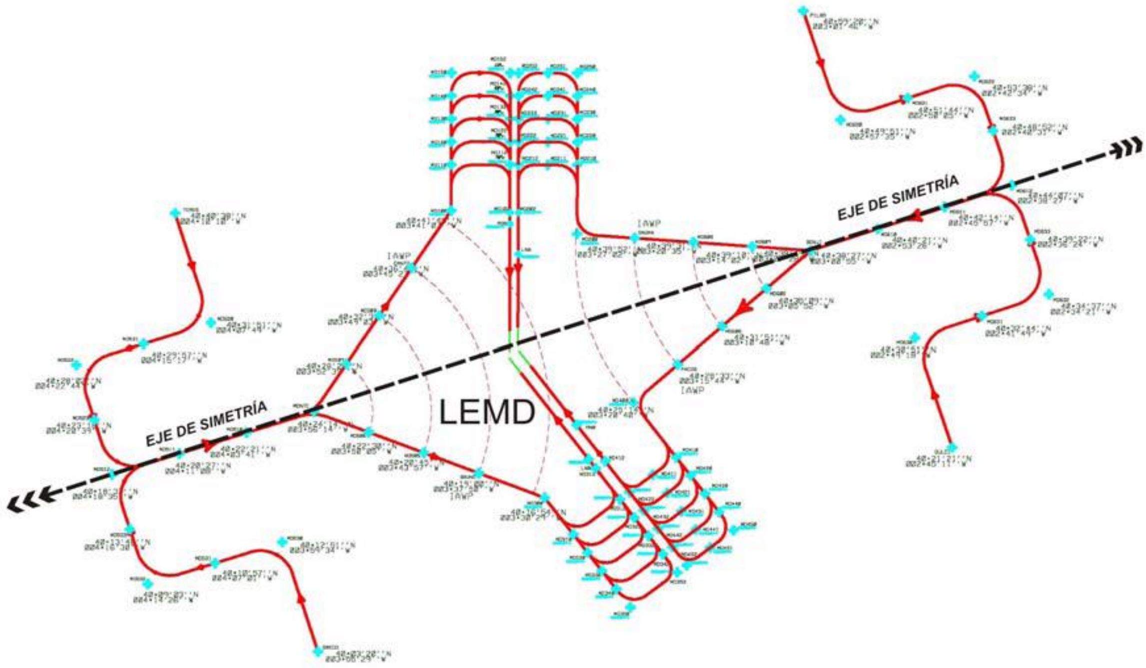


Figure 1: New Madrid TMA project

3.1 Benefit Mechanisms (WS1)

3.1.1 Positive and Negative Impacts

Positive Impact	Primary or Secondary	Rank (1 = most important)	Order of Magnitude
Improve Arrival/Departure sequencing	Primary	1	N/A
Permits segregated arrival and departures streams	Secondary	1	N/A

Reduce the need of radar vector usage	Primary	2	N/A
Reduce both pilot and controller workload	Primary	2	N/A
SAF11 O1: Ensure that the numbers of ATM induced accidents and serious or risk bearing incidents (includes those with direct and indirect ATM contribution) do not increase and, where possible, decrease (SESAR)	Primary	1	≥ 1 (est. 2005)
SAF21 O1: All ANSPs and regulators are expected to achieve agreed maturity levels	Primary	2	N/A
ENV111 O1: Achieve emission improvements as an automatic consequence of the reduction of excess fuel consumption addressed in the KPA Efficiency[1]	Primary	1	
ENV112 O1: Minimize other adverse atmospheric effects (e.g. contrails) to the extent possible (SESAR)	Secondary	2	
ENV211 O1: Improve the role of ATM in developing environmental rules (SESAR)	Secondary	3	
CEF2 O1: Reduce the cost of military training missions	Secondary	1	
CEF21 O1: Reduce the cost of mission transit time from the airbase to the training areas and back.	Secondary	2	
CEF111 O1: Limit Airspace User investments related to increased role in ATM	Secondary	4	
CEF112 O1 Reduce the gate-to-gate air navigation cost (average cost per flight)	Primary	1	
CEF11221 O1: Reduce terminal ATM/CNS cost	Primary	2	
CEF11222 O1: Reduce terminal MET and regulatory costs	Primary	3	
CEF121 O1: Reduce cost of ATM inefficiencies to the level determined by the QoS targets	Secondary	5	
CEF1211 O1: Reduce indirect cost by meeting Flight Efficiency targets	Secondary	6	
CEF1212 O1: Reduce indirect cost by meeting Flexibility targets	Secondary	7	
CEF1213 O1: Reduce indirect cost by meeting Predictability targets	Secondary	8	

[1] This positive impact is as an automatic consequence of the reduction of fuel consumption at a local level that affects the reduction of G2G fuel consumption.

CAP11 O1: Increase the network capacity to support the annual flights	Secondary	2	
CAP12 O1: Increase the network capacity to support the daily flights	Secondary	3	
CAP2 O1: Increase local airspace capacity in line with growing traffic demand (Capacity x3 where required)	Primary	1	
EFF111 O1: Improve departure punctuality	Primary	1	
EFF111 O1: Improve departure punctuality	Primary	2	
EFF112 O1: Improve adherence to planned gate-to-gate flight duration	Primary	3	
EFF112 O1: Improve adherence to planned gate-to-gate flight duration	Primary	4	
EFF11221 O1: Reduce airborne queuing (time spent in holding patterns)	Primary	6	
EFF12 O1: Improve Fuel Consumption	Secondary	9	
EFF1211 O1: Reduce fuel penalties resulting from non-optimum TMA and taxi operations	Secondary	10	
EFF1212 O1: Reduce Fuel Penalties resulting from route extensions (non-optimum route)	Primary	8	
EFF122 O1: Reduce Fuel Penalties resulting from non-optimum flight profile	Secondary	11	
EFF21 O1: improve the impact that SUA location and dimensions have on mission effectiveness	Secondary	12	
EFF3 O1: Improve the efficiency of airspace utilization for military training, both in terms of booking and actual usage	Secondary	13	
FLX111 O1: Accommodate more non-scheduled IFR flights can depart on time as requested	Secondary	3	
FLX112 O1: Accommodate more VFR-IFR change requests accommodated as requested	Secondary	4	
FLX121 O1: Accommodate more time/speed change requests without imposing penalties	Primary	1	
FLX122 O1: Accommodate more route/vertical profile change requests without imposing penalties	Primary	2	
FLX21 O1: Apply the FUA concept to a larger position of SUA	Secondary	5	

FLX22 O1: improve the release of airspace for civil use on cancellation of military use, at various time horizons prior to the scheduled start of training	Secondary	6	
FL3 O1: Improve ANSP ability to respond to the need of services in airspace at airports where previously no service was available	Secondary	7	
PRD1111 O1: Improve G2G Variability	Secondary	2	
PRD1112 O1: Improve arrival punctuality	Primary	1	
PRD1121 O1: Reduce Reactionary delays	Secondary	3	
PRD11212 O1: Reduce Reactionary cancellations	Secondary	4	
PRD112 O1: Reduce Degraded Conditions	Secondary	5	
PRD113 O1: Improve Disrupted Conditions	Secondary	6	
PRD11311 O1: Improve Service Disruption Delays	Secondary	7	
PRD11312 O1: Service Disruption Diversion	Secondary	8	
PRD11313 O1: Service Disruption cancellations	Secondary	9	

Table 1: Positive Impacts

Negative Impact [2]	**Primary or Secondary**	**Rank** (1 = most important)	**Order of Magnitude**
Reduce of C02 emissions	Primary	1	N/A
Reduce of fuel burning	Primary	1	N/A
Shorter and more directly routes	Primary	2	N/A

Table 2: Negative Impacts

[2] These Negative impacts are as example because each of the positive impacts can turn into negative if the simulation results show negative results.

3.1.2 KPAs covered by Area

Here is listed all the KPAs covered by the Initial Baseline Performance framework (edition 0) until now (28th of February 2011). As a checklist the project has identified the KPAs that are going to affect indirectly or directly. Also, it has been identified the ones which are going to be measured and assess as so:

KPA	Main Focus Area	Qualitative Performance objectives	Affected	Assessed
SAF	ATM-related Safety Outcome	Ensure that the numbers of ATM induced accidents and serious or risk bearing incidents do not increase and, where possible, decrease (SESAR)	√	√[3]
	Safety Management Practices and Safety Culture	All ANSPs and regulators are expected to achieve agreed maturity levels	√	√
ENV	Environmental Sustainability Outcome	Climate Related Effects, Noise Emissions & Noise Impact	√	√
	Environmental Management Operations	Existing Environmental Constraints & Proposed New Environmental Constraints	√	√
CEF	ATM Effectiveness (Direct & Indirect Costs)	Limit Airspace User investments related to increased role in ATM; Flexibility & Predictability targets Reduce the gate-to-gate air navigation cost	√	√
	Mission Effectiveness	Mission transit time from the airbase to the training areas and back.	√	√
CAP	Network Capacity	Increase European daily & annual IFR throughput in line with growing traffic demand	√	
	Local Airspace Capacity	Increase local airspace capacity in line with growing traffic demand	√	√
	Airport Best-In-Class Capacity	Single-runway airports, Parallel-dependent-runway airports & Parallel-independent-runway airports		
EFF	Flight Efficiency	Improve departure punctuality, adherence to planned G2G flight duration & fuel consumption	√	
	Mission Efficiency by Training inside SUA (TrS)	Improve the impact of SUA location and dimensions Improve the efficiency of airspace utilisation for military training	√	
	Airspace Efficiency	No	√	√
FLX	Business Trajectory Flexibility	Late Filing, Air Filing, Time/Speed Changes & Route/Vertical Trajectory Changes	√	√
	Flexible Civil/Military Use of Airspace (FUA)	Apply the FUA concept to a larger portion of SUA; Improve the release of airspace for civil use on cancellation of military use, at various time horizons prior to the scheduled start of training	√	
	Service Location Flexibility	Improve ANSP ability to respond to the need for services in airspace and at airports where previously no service was available	√	√
PRD	Business Trajectory Predictability	On-time Operation, Knock-on Effect, Reduce the occurrence of degraded conditions by reducing the impact of their causes on capacity & Prevent and mitigate service disruption to the greatest extent	√	
AEQ	Access	Shared used & Alternatives to Shared Use	√	√
	Equity	Under shared use conditions, improve management of access priority based on class of airspace user;	√	√
PRT	Stakeholders involved during Performance Management	Definition, Performance Review, Regulation, Assesment & Data Reporting for Objectives, Targets, Metrics & KPIs	√	√

[3] This KPA is going to be assessed at a local level not at a Network level

	Stakeholders involved during Operations	Participation during Planning (Equal opportunity, @ the appropriate time) & Tactical Operations (Timely transfer, appropriate time frame & acceptable)limits of safety - cost effectiveness)	√	√
	Stakeholders involved during Deployment	Should take into account individual stakeholder needs (planning of deployment of new equipment, procedures or systems)	√	√
	Stakeholders involved during Design	All stakeholders shall have the opportunity to be involved in the R&D process	√	√
	Stakeholders involved during Regulation	During development of new regulations, stakeholders shall be involved in the consultation phase avoiding conflicts of interest	√	

Table 3: 5.7.4 KPAs affected and assessed.

In the following sub-points it has been identified the KPAs that are going to be covered/affected and assessed by this project by shading its row in GREEN, the ones that are going to be covered/affected but not assessed in BLUE (out of the scope) and finally in RED the one that are not going to be covered/affected nor assessed by 5.7.4. The following figure representing a scope illustrates better this reasoning:

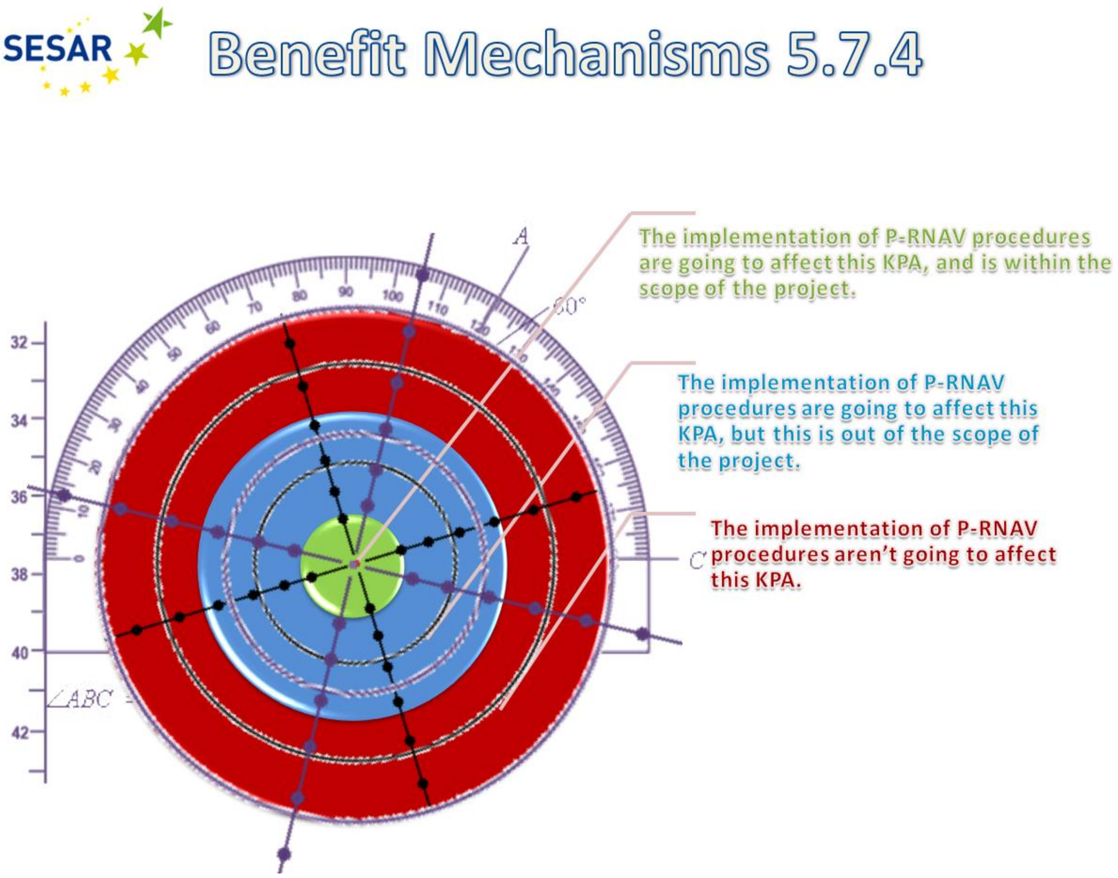


Figure 2: Benefits Mechanisms in 5.7.4

In this document is listed also a first approach to the KPIs that are going to be measured within this project and validation exercises. It has been shaded in LIGHT GREEN the ones who are going to be used as an input for the assessment. Shade in LIGH BLUE the ones that could be an input for the assessment but are out of the scope of the project. Finally, in LIGHT RED the ones that are not to be used nor assessed as an input. Adding up all the possibilities here is explained the main ones:

KPA	KPI	Explanation
GREEN	LIGH GREEN	The KPI is going to be produced, used and assessed affecting the associated KPA (e.g.: the new procedures increase the number of flight able to enter in the airspace increasing the capacity of the local airspace area)
GREEN	LIGH BLUE	KPI as an input from an external source and assessed affecting the associated KPA (e g.: the number of accidents have been reduced in the local area so the safety has increased)
GREEN	LIGH RED	The KPI is not going to be used but the associated KPA is going to be assessed (e g.: the traffic flows structure change in other countries are going to affect the capacity of the local airspace)
BLUE	LIGH GREEN	The KPI is going to be produced, used but not assessed (out of the scope); (e.g. the number of incidents in the local area affects the safety at a network level)
BLUE	LIGH BLUE	KPI as an input from an external source but not assessed affecting the associated KPA (e.g.: the NOx emission are going to be reduced with the new procedures and affects the reduction of environmental impact)
BLUE	LIGH RED	The KPI is not going to be used but the associated KPA is not going to be assessed (e.g. the time spent in coordinate an unexpected SUA affects the capacity and flexibility of the use of airspace)
RED	LIGH GREEN	The KPI is going to be produced but the project do not affect the associated KPA (e.g.: the number of departures with the new procedures are not going to affect the runway throughput capacity)
RED	LIGH BLUE	KPI as an input from an external source but the project do not affect the associated KPA (e.g. the reduction of en-route flight time do not affect the flight efficiency in the local area)
RED	LIGH RED	The KPI is not going to be used and the project do not affect the associated KPA (e.g. the departures punctuality do not affect the mission effectiveness)

Table 4: 5.7.4 KPAs vs. KPIs.

The target associated to each KPI are extracted from ATM Master Plan objectives and this project is contributing as a part of the whole target (e.g.: the new procedures have reduced the probability of an accident occurrence at a local area and this contributes to the whole probability of an accident occurrence in the European airspace).

3.1.2.1Safety KPA

- Stakeholders: Community and States
- Grouping: High External Visibility - Effects are societal and of political nature

Main Focus Area	1st Lower Level Focus Area	2nd Lower Level Focus Area	3th Lower Level Focus Area	4th Lower Level Focus Area	KPI	Target
SAF1 - ATM-related Safety Outcome	SAF11 - ATM Induced Accidents and Incidents				SAF11 O1 I1 : Accident probability per operation (flight) relative to the 2005 baseline	SAF11 O1 I1 T1: Considering the anticipated increase in the European annual traffic volume, the implication of the initial safety performance objective is that the overall safety level would gradually have to improve, so as to reach an improvement factor of 3 in order to meet the safety objective in 2020 and a factor 10 for the design goal (based on the assumption that safety needs to improve with the square of traffic volume increase). This could be translated into a reduction of 66% in the ratio accidents/flight
SAF1 - ATM-related Safety Outcome	SAF11 - ATM Induced Accidents and Incidents				SAF11 O1 I2: Annual European wide absolute number of ATM induced accidents	SAF11 O1 I2 T1: No increase and if possible, a decrease. Taking as baseline 1997-2008: 7 accidents in 12 years (ratio accidents/year =0.58) (source: PRC) 2020 Target: no increase (ratio ≤ 0.58)
SAF1 - ATM-related Safety Outcome	SAF11 - ATM Induced Accidents and Incidents				SAF11 O1 I3: Annual European wide absolute number of ATM induced serious or risk bearing incidents	SAF11 O1 I3 T1: 2020: no increase
SAF2 - Safety Mgt Practices and Safety Culture	SAF21 - Maturity Level of Organizations					

Table 5: 5.7.4 Safety KPA.

3.1.2.2Environment KPA

- Stakeholders: Airlines, ANSPs, Community & States
- Grouping: High External Visibility - Effects are societal and of political nature

Main Focus Area	1st Lower Level Focus Area	2nd Lower Level Focus Area	3th Lower Level Focus Area	4th Lower Level Focus Area	KPI	Target
ENV1 - Environmental Sustainability Outcome	ENV11 - Atmospheric Effects	ENV111 - Gaseous Emissions			ENV111 O1 I1: Average fuel consumption per flight as a result of ATM improvements	ENV111 O1 I1 T1: -10%
ENV1 - Environmental Sustainability Outcome	ENV11 - Atmospheric Effects	ENV111 - Gaseous Emissions			ENV111 O1 I2: Average CO2 emission per flight as a result of ATM improvements	ENV111 O1 I2 T1: -10%
ENV1 - Environmental Sustainability Outcome	ENV11 - Atmospheric Effects	ENV111 - Gaseous Emissions			ENV111 O1 I3:: Amount of NOx emissions which is attributable to inefficiencies in ATM service provision	No targets documented
ENV1 - Environmental Sustainability Outcome	ENV11 - Atmospheric Effects	ENV111 - Gaseous Emissions			ENV111 O1 I4: Amount of H2O emissions which is attributable to inefficiencies in ATM service provision	No targets documented
ENV1 - Environmental Sustainability Outcome	ENV11 - Atmospheric Effects	ENV111 - Gaseous Emissions			ENV111 O1 I5: Amount of particulate emissions which is attributable to inefficiencies in ATM service provision	No targets documented
ENV1 - Environmental Sustainability Outcome	ENV11 - Atmospheric Effects	ENV112 - Other Adverse Atmospheric Effects				
ENV1 - Environmental Sustainability Outcome	ENV12 - Noise Effects	ENV121 - Noise Emissions			ENV121 O1 I1: Total Area of the noise footprint	
ENV1 - Environmental Sustainability Outcome	ENV12 - Noise Effects	ENV122 - Noise Impact			ENV122 O1 I1: Impact Area of the particular noise level	
ENV2 - Environmental Management Operations	ENV21 - Environmental Constraint Management	ENV211 - Address Existing Constraints				
ENV2 - Environmental Management Operations	ENV21 - Environmental Constraint Management	ENV212 - Address Proposed New Constraints				

Table 6: 5.7.4 Environment KPA.

3.1.2.3Cost-Effectiveness KPA

- Stakeholders: ANSPs, Military and Airlines
- Grouping: Medium External Visibility - Effects are business-level, on users and operators

Main Focus Area	1st Lower Level Focus Area	2nd Lower Level Focus Area	3th Lower Level Focus Area	4th Lower Level Focus Area	KPI	Target
CEF1 - ATM Cost Effectiveness	CEF11 - Direct cost of G2G ATM	CEF111 - Airspace User Costs				
CEF1 - ATM Cost Effectiveness	CEF11 - Direct cost of G2G ATM	CEF112 - G2G ANS costs			CEF112 O1 I1: Total annual en route and terminal ANS cost in Europe, €/flight	CEF112 O1 I1 T1: 2020: €400 (2005) / Flight
CEF1 - ATM Cost Effectiveness	CEF11 - Direct cost of G2G ATM	CEF112 - G2G ANS costs	CEF1121 En-route ANS Costs	CEF11211 En-route ATM/CNS Costs		
CEF1 - ATM Cost Effectiveness	CEF11 - Direct cost of G2G ATM	CEF112 - G2G ANS costs	CEF1121 En-route ANS Costs	CEF11212 Other En-route Costs		
CEF1 - ATM Cost Effectiveness	CEF11 - Direct cost of G2G ATM	CEF112 - G2G ANS costs	CEF1122 Terminal ANS Costs	CEF11221 Terminal ATM/CNS Costs		
CEF1 - ATM Cost Effectiveness	CEF11 - Direct cost of G2G ATM	CEF112 - G2G ANS costs	CEF1122 Terminal ANS Costs	CEF11222 Other Terminal Costs		
CEF1 - ATM Cost Effectiveness	CEF12 - Indirect cost of G2G ATM	CEF121 - Airspace User Costs				
CEF1 - ATM Cost Effectiveness	CEF12 - Indirect cost of G2G ATM	CEF121 - Airspace User Costs	CEF1211 Flight Efficiency Impact			
CEF1 - ATM Cost Effectiveness	CEF12 - Indirect cost of G2G ATM	CEF121 - Airspace User Costs	CEF1212 Flexibility Impact			
CEF1 - ATM Cost Effectiveness	CEF12 - Indirect cost of G2G ATM	CEF121 - Airspace User Costs	CEF1213 Predictability Impact			
CEF2 - Mission Cost Effectiveness	CEF21 - Training Costs					
CEF2 - Mission Cost Effectiveness	CEF22 - Transit Costs					

Table 7: 5.7.4 Cost-Effectiveness KPA.

3.1.2.4Capacity KPA

- Stakeholders: ANSPs, Military and Airlines
- Grouping: Medium External Visibility - Effects are business-level, on users and operators

Main Focus Area	1st Lower Level Focus Area	2nd Lower Level Focus Area	3th Lower Level Focus Area	4th Lower Level Focus Area	KPI	Target
CAP1 - Network Capacity	CAP11 - Annual IFR Throughput				CAP11 O1 I1: Flights/year	CAP11 O1 I1 T1: 16 Million flights/year
CAP1 - Network Capacity	CAP12 - Daily IFR Throughput				CAP12 O1 I1: Flights/day	CAP12 O1 I1 T1: 50000 flights/day
CAP2 - Local Airspace Capacity					CAP2 O1 I1: Hourly number of IFR flights able to enter the airspace volume	CAP2 O1 I1 T1: 2020 target: busiest en-route airspace volumes, typical busy hour demand would grow 70-80% between 2005 and 2020. For the busiest/largest terminal airspace volumes, typical busy

					hour demand would grow only 40-50% between 2005 and 2020
CAP2 - Local Airspace Capacity				CAP2 O1 I2: Annual number of IFR flights able to enter the airspace volume	CAP2 O1 I2 T1: Annual demand same growth rates as the typical busy hour requirement. For the busiest/largest terminal airspace volumes, annual demand grows somewhat more than the typical busy hour demand. For the smaller terminal airspace volumes, annual demand grows somewhat less than the typical busy hour demand.
CAP2 - Local Airspace Capacity	CAP21 - ACC/FIR Capacity			CAP2 O1 I1: Hourly number of IFR flights able to enter the airspace volume	CAP2 O1 I1 T1: 2020 target: busiest en-route airspace volumes, typical busy hour demand would grow 70-80% between 2005 and 2020. For the busiest/largest terminal airspace volumes, typical busy hour demand would grow only 40-50% between 2005 and 2020
CAP2 - Local Airspace Capacity	CAP21 - ACC/FIR Capacity			CAP2 O1 I2: Annual number of IFR flights able to enter the airspace volume	CAP2 O1 I2 T1: Annual demand same growth rates as the typical busy hour requirement. For the busiest/largest terminal airspace volumes, annual demand grows somewhat more than the typical busy hour demand. For the smaller terminal airspace volumes, annual demand grows somewhat less than the typical busy hour demand.
CAP2 - Local Airspace Capacity	CAP22 - APP/TMA capacity			CAP2 O1 I1: Hourly number of IFR flights able to enter the airspace volume	CAP2 O1 I1 T1: 2020 target: busiest en-route airspace volumes, typical busy hour demand would grow 70-80% between 2005 and 2020. For the busiest/largest terminal airspace volumes, typical busy hour demand would grow only 40-50% between 2005 and 2020
CAP2 - Local Airspace Capacity	CAP22 - APP/TMA capacity			CAP2 O1 I2: Annual number of IFR flights able to enter the airspace volume	CAP2 O1 I2 T1: Annual demand same growth rates as the typical busy hour requirement. For the busiest/largest terminal airspace volumes, annual demand grows somewhat more than the typical busy hour demand. For the smaller terminal airspace volumes, annual demand grows somewhat less than the typical busy hour demand.
CAP2 - Local Airspace Capacity	CAP23 - Sector capacity			CAP2 O1 I1: Hourly number of IFR flights able to enter the airspace volume	CAP2 O1 I1 T1: 2020 target: busiest en-route airspace volumes, typical busy hour demand would grow 70-80% between 2005 and 2020. For the busiest/largest terminal airspace volumes, typical busy hour demand would grow only 40-50% between 2005 and 2020
CAP2 - Local Airspace Capacity	CAP23 - Sector capacity			CAP2 O1 I2: Annual number of IFR flights able to enter the airspace volume	CAP2 O1 I2 T1: Annual demand same growth rates as the typical busy hour requirement. For the busiest/largest terminal airspace volumes, annual demand grows somewhat more than the typical busy hour demand. For the smaller terminal airspace volumes, annual demand grows somewhat less than the typical busy hour demand.
CAP2 - Local Airspace Capacity	CAP24 - SUA capacity	CAP241 - Designed SUA capacity (DSC)			
CAP2 - Local Airspace Capacity	CAP24 - SUA capacity	CAP242 - Utilized SUA capacity (USC)			
CAP2 - Local Airspace Capacity	CAP24 - SUA capacity	CAP243 - Utilized FIR/UIR Capacity			
CAP3 - Airport capacity				CAP3 O1 I1: Hourly number of IFR movements (departures plus arrivals)	
CAP3 - Airport capacity				CAP3 O1 I2: Daily number of IFR movements (departures plus arrivals)	
CAP3 -	CAP31 - BIC	CAP 311 - Single		CAP311 O1 I1: Best In	CAP311 O1 I1 T1: 2020: 60 mov/h

Airport capacity	capacity in VMC	RWY Airport capacity in VMC			Class (BIC) declared airport capacity in VMC (1 RWY), mov/hr	
CAP3 - Airport capacity	CAP31 - BIC capacity in VMC	CAP 312 - Parallel dependent RWY Airport capacity in VMC			CAP312 O1 I1: Best In Class (BIC) declared airport capacity in VMC (2 parallel dependent RWYs), mov/h	CAP312 O1 I1 T1: 2020:90 mov/h
CAP3 - Airport capacity	CAP31 - BIC capacity in VMC	CAP 313 - Parallel independent RWY Airport capacity in VMC			CAP313 O1 I1: Best In Class (BIC) declared airport capacity in VMC (2 parallel independent RWYs), mov/h	CAP313 O1 I1 T1: 2020: 120 mov/h
CAP3 - Airport capacity	CAP32 - BIC capacity in IMC	CAP 321 - Single RWY Airport capacity in IMC			CAP321 O1 I1: Best In Class (BIC) declared airport capacity in IMC (1 RWY), mov/hr	CAP321 O1 I1 T1: 2020:48 mov/h
CAP3 - Airport capacity	CAP32 - BIC capacity in IMC	CAP 322 - Parallel dependent RWY Airport capacity in IMC			CAP322 O1 I1: Best In Class (BIC) declared airport capacity in IMC (2 parallel dependent RWYs), mov/h	CAP322 O1 I1 T1: 2020:72 mov/h
CAP3 - Airport capacity	CAP32 - BIC capacity in IMC	CAP 323 - Parallel independent RWY Airport capacity in IMC			CAP323 O1 I1: Best In Class (BIC) declared airport capacity in IMC (2 parallel independent RWYs), mov/h	CAP323 O1 I1 T1: 2020: 96 mov/h

Table 8: 5.7.4 Capacity KPA.

3.1.2.5Efficiency KPA

- Stakeholders: ANSPs, Military and Airlines
- Grouping: Medium External Visibility - Effects are business-level, on users and operators

Main Focus Area	1st Lower Level Focus Area	2nd Lower Level Focus Area	3th Lower Level Focus Area	4th Lower Level Focus Area	KPI	Target
EFF1 - Flight Efficiency	EFF11 - Temporal efficiency	EFF111 - Departure Punctuality			EFF111 O1 I1:Number of scheduled flights departing on time (as planned);	EFF111 O1 I1 T1: 2020: 98% flights on time
EFF1 - Flight Efficiency	EFF11 - Temporal efficiency	EFF111 - Departure Punctuality			EFF111 O1 I2:Average delay of delayed scheduled flights (departing not as planned)	EFF111 O1 I2 T1: 2020: Average departure delay<10 min
EFF1 - Flight Efficiency	EFF11 - Temporal efficiency	EFF112 - G2G Flight Duration			EFF112 O1 I1:Number of flights with block to block time as planned;	EFF112 O1 I1 T1:2020: 95% flights as planned
EFF1 - Flight Efficiency	EFF11 - Temporal efficiency	EFF112 - G2G Flight Duration			EFF112 O1 I2: Average block to block time extension of the flights with time longer than planned	EFF112 O1 I2 T1: 2020: average block-to-block time extension <10 minutes
EFF1 - Flight Efficiency	EFF11 - Temporal efficiency	EFF112 - G2G Flight Duration	EFF1121 - Taxi Time		No KPIs or Targets defined by SESAR	No KPIs or Targets defined by SESAR
EFF1 - Flight Efficiency	EFF11 - Temporal efficiency	EFF112 - G2G Flight Duration	EFF1122 - Airborne Time		No KPIs or Targets defined by SESAR	No KPIs or Targets defined by SESAR
EFF1 - Flight Efficiency	EFF11 - Temporal efficiency	EFF112 - G2G Flight Duration	EFF1122 - Airborne Time		EFF11222 O1 I1: Horizontal en-route efficiency (excess distance flown per flight)	EFF11222 O1 I1 T1: annual reduction of route extension by 2 km/flight/year; PC target valid until 2013
EFF1 - Flight Efficiency	EFF12 - G2G Fuel				EFF12 O1 I1: Number of flights have fuel	EFF12 O1 I1 T1: 2020: 95% flights as planned

	Efficiency				consumption as planned	
EFF1 - Flight Efficiency	EFF12 - G2G Fuel Efficiency	EFF121 - Impact of G2G Flight Duration	EFF1211 - TMA + Taxi efficiency			
EFF1 - Flight Efficiency	EFF12 - G2G Fuel Efficiency	EFF121 - Impact of G2G Flight Duration	EFF1212 - Horizontal En-Route Efficiency			
EFF1 - Flight Efficiency	EFF12 - G2G Fuel Efficiency	EFF122 - Vertical Efficiency				
EFF2 - Mission Effectiveness (Military)	EFF21 - Training inside SUA					

Table 9: 5.7.4 Efficiency KPA.

3.1.2.6Flexibility KPA

- Stakeholders: ANSPs, Military and Airlines
- Grouping: Medium External Visibility - Effects are business-level, on users and operators

Main Focus Area	1st Lower Level Focus Area	2nd Lower Level Focus Area	3th Lower Level Focus Area	4th Lower Level Focus Area	KPI	Target
FLX1 - Business trajectory Flexibility	FLX11 - Unscheduled Traffic	FLX111 - Late Filing			FLX111 O1 I1: Number of accommodated non-scheduled IFR flights departed on time as requested	FLX111 O1 I1 T1: 2020: 98% of non-scheduled IFR flights departed on time as requested
FLX1 - Business trajectory Flexibility	FLX11 - Unscheduled Traffic	FLX112 - Air Filing			FLX112 O1 I1: number of accommodated VFR-IFR change requests as requested	FLX112 O1 I1 T1: 2020: 98% of the VFR-IFR change requests as requested
FLX1 - Business trajectory Flexibility	FLX12 - Trajectory Modifications	FLX121 - Time/Speed Changes			FLX121 O1 I1: Number of scheduled flights with departure time as requested (after change request)	FLX121 O1 I1 T1: 2020: 98% of departure change requests accommodated as requested
FLX1 - Business trajectory Flexibility	FLX12 - Trajectory Modifications	FLX121 - Time/Speed Changes			FLX121 O1 I2: (Average delay of delayed scheduled flights (after change request))	FLX121 O1 I2 T1: 2020: average delay< 5 min
FLX1 - Business trajectory Flexibility	FLX12 - Trajectory Modifications	FLX121 - Time/Speed Changes			FLX121 O1 I3: Flexibility demand: % Flights requesting time translation from initial Reference Business Trajectory (FLX.1.OBJ1.IND3)	No target defined by SESAR
FLX1 - Business trajectory Flexibility	FLX12 - Trajectory Modifications	FLX122 - Route/Vertical Changes			FLX122 O1 I1: Percentage of route/vertical change requests accommodated	FLX122 O1 I1 T1: 2020: 95% of route/vertical profile change requests accommodated
FLX1 - Business trajectory Flexibility	FLX12 - Trajectory Modifications	FLX122 - Route/Vertical Changes			FLX122 O1 I2: Percentage of route/vertical change requests accommodated without imposing delay	FLX122 O1 I2 T1: 2020: 90% of route/vertical profile/change requests accommodated as requested
FLX1 - Business trajectory Flexibility	FLX12 - Trajectory Modifications	FLX122 - Route/Vertical Changes			FLX122 O1 I3: Average delay of flights delayed as a consequence of route / vertical change request	FLX122 O1 I3 T1: 2020: <5 minutes per flight

FLX2 - Flexible Use of Airspace	FLX21 - FUA Application					
FLX2 - Flexible Use of Airspace	FLX22 - SUA Management					
FLX3 - Service Local Flexibility						

Table 10: 5.7.4 Flexibility KPA.

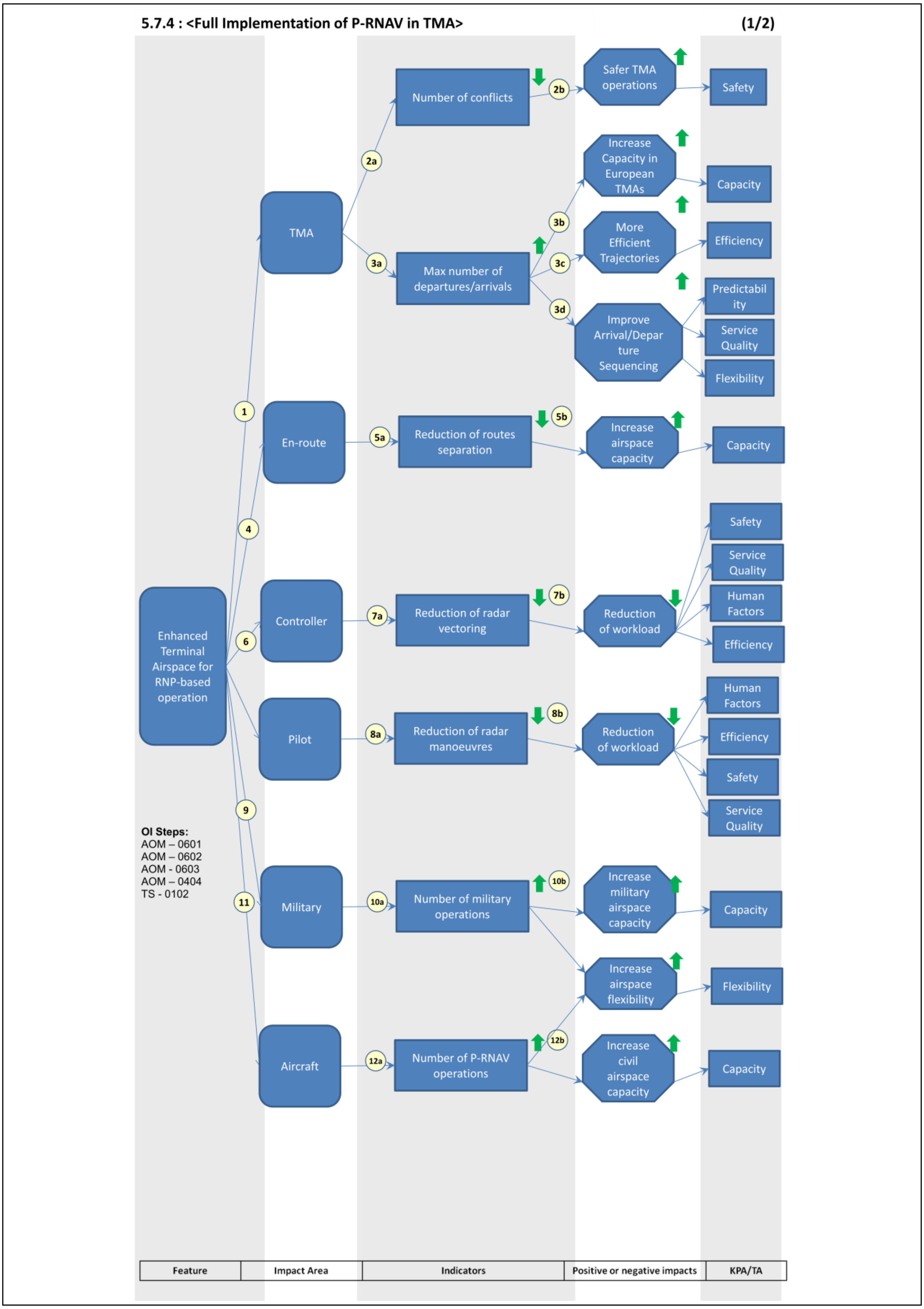
3.1.2.7Predictability KPA

- Stakeholders: ANSPs, Military and Airlines
- Grouping: Medium External Visibility - Effects are business-level, on users and operators

Main Focus Area	1st Lower Level Focus Area	2nd Lower Level Focus Area	3th Lower Level Focus Area	4th Lower Level Focus Area	KPI	Target
PRD1 - Business Trajectory Predictability	PRD11 - Nominal conditions	PRD111 - On-Time Operations	PRD1111 - G2G Variability		PRD1112 O1 I1: Coefficient of flight duration variation	PRD1111 O1 I1 T1: 2020: At the regional level, the variability of flight duration (off-block to on-block) shall have a coefficient of variation of maximum 0.015 (standard deviation divided by the mean value)
PRD1 - Business Trajectory Predictability	PRD11 - Nominal conditions	PRD111 - On-Time Operations	PRD1112 - Arrival Punctuality		PRD1112 O1 I1: Number of flights arriving on time (as planned)	PRD1112 O1 I1 T1: 95% of flights arriving on time (as planned)
PRD1 - Business Trajectory Predictability	PRD11 - Nominal conditions	PRD111 - On-Time Operations	PRD1112 - Arrival Punctuality		PRD1112 O1 I2: Average arrival delay of the flights with delayed arrival	PRD1112 O1 I1 T1: 2020: 95% avg arrival delay<10 minutes
PRD1 - Business Trajectory Predictability	PRD11 - Nominal conditions	PRD112 - Knock-on effect	PRD1121 - Reactionary delays		PRD1121 O1 I1: Reactionary delay	PRD1121 O1 I1 T1: 2020: 50% reduction of total reactionary delay compared to 2010
PRD1 - Business Trajectory Predictability	PRD11 - Nominal conditions	PRD112 - Knock-on effect	PRD11212 - Reactionary cancellations		PRD1122 O1 I1: Reactionary flight cancellation rate	PRD1122 O1 I1 T1: 2020: 50% reduction of reactionary flight cancellation rate compared to 2010
PRD1 - Business Trajectory Predictability	PRD112 - Degraded Conditions					
PRD1 - Business Trajectory Predictability	PRD113 - Disrupted Conditions					
PRD1 - Business Trajectory Predictability	PRD113 - Disrupted Conditions	PRD1131 - Service Disruption Effect	PRD11311 - Service Disruption Delays		PRD11311 O1 I1: Delay (min) due to the service disruption	PRD11311 O1 I1 T1: 2020: 50% reduction of total service disruption delay compared to 2010
PRD1 - Business Trajectory Predictability	PRD113 - Disrupted Conditions	PRD1131 - Service Disruption Effect	PRD1132 - Service Disruption Diversion		PRD11312 O1 I1: Flight diversion rate due to service disruption compared to 2010	PRD11312 O1 I1 T1: 2020: 50% reduction of service disruption flight diversion rate compared to 2010
PRD1 - Business Trajectory Predictability	PRD113 - Disrupted Conditions	PRD1131 - Service Disruption Effect	PRD11313 - Service Disruption cancellations		PRD11313 O1 I1: Flight cancellation rate due to the service disruption	PRD11313 O1 I1 T1: 2020: 50% reduction of service disruption flight cancellation rate compared to 2010

Table 11: 5.7.4 Predictability KPA.

3.1.2.8Benefit Mechanisms (WS1)



Feature Description: *<fuller description of the feature>*

Mechanisms

(1) *<how the feature will bring changes in the 'impact area'>*

(2a) *<how the 'impact area' will bring about changes in the 'indicator'>*
+ *<how the indicator will be measured – metric description>*

(2b) *<what change is seen in the 'positive' or 'negative impacts' when the indicator(s) change and which KPA[4](s) this links to>*

(..) *<continues for other numbered mechanisms>*

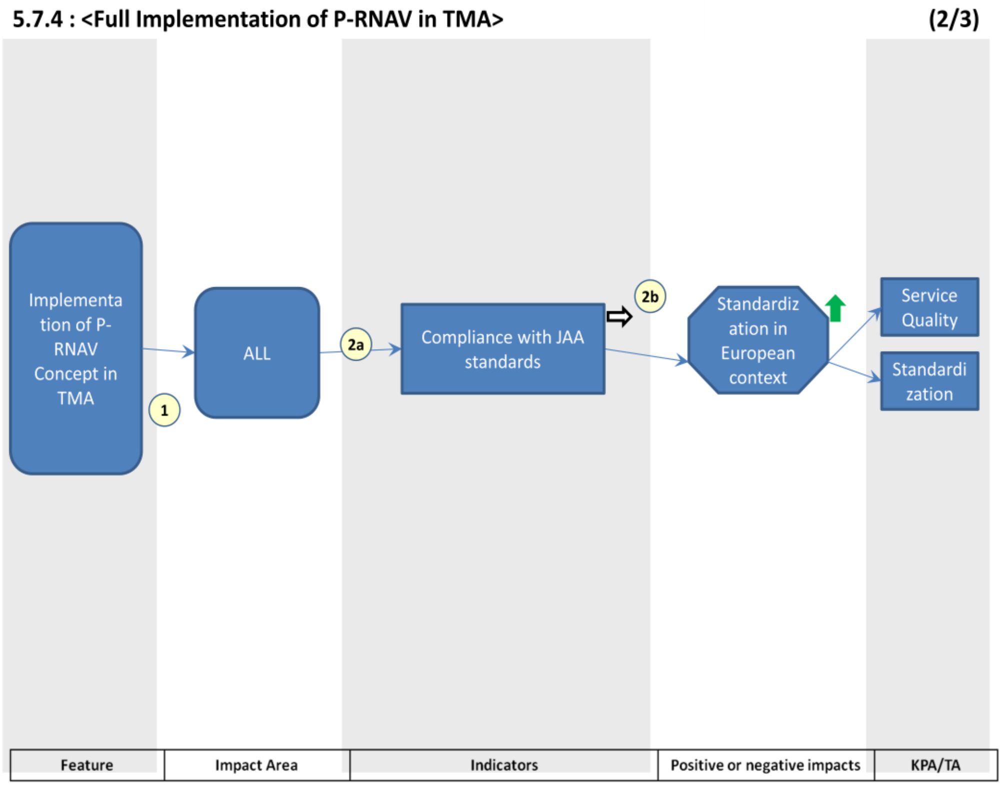
Impacted Stakeholders

Positive Impact 1	*<which stakeholders will be impacted>*
Negative Impact …	*<which stakeholders will be impacted>*

Data Sources

Indicator A	*<where can the data to measure the indicator come from>*
Indicator …	*<where can the data to measure the indicator come from>*

Table 12: Benefit Mechanism 001



[4] In the next version of the guidelines, projects will be asked to link to Strategic Targets and Influencing Factors, see Ref **Error! Reference source not found.**, which are at a lower level than KPAs. If projects are already familiar with these then they are encouraged to use them.

Feature Description: *<fuller description of the feature>*

Mechanisms

(1) *<how the feature will bring changes in the 'impact area'>*

(2a) *<how the 'impact area' will bring about changes in the 'indicator'>*
+ <how the indicator will be measured – metric description>

(2b) *<what change is seen in the 'positive' or 'negative impacts' when the indicator(s) change and which KPA[5](s) this links to>*

(..) *<continues for other numbered mechanisms>*

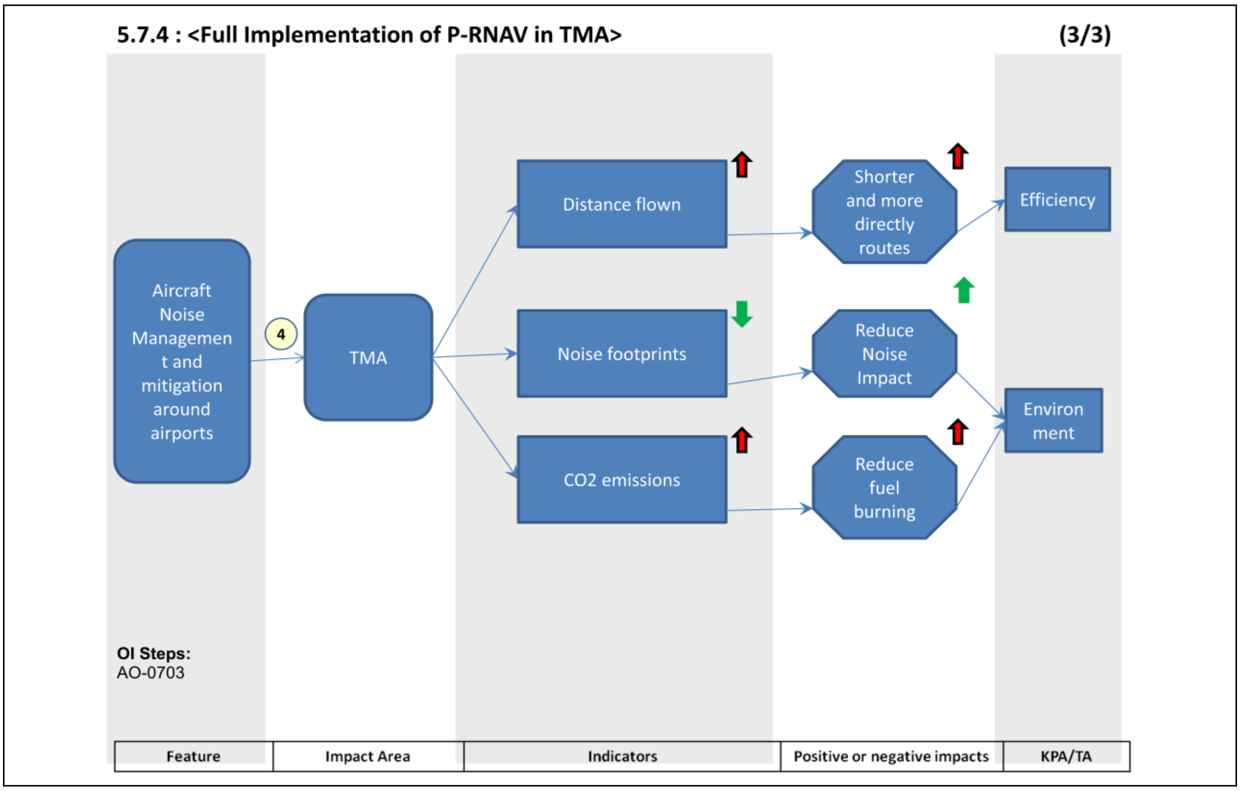
Impacted Stakeholders

Positive Impact 1	*<which stakeholders will be impacted>*
Negative Impact …	*<which stakeholders will be impacted>*

Data Sources

Indicator A	*<where can the data to measure the indicator come from>*
Indicator …	*<where can the data to measure the indicator come from>*

Table 13: Benefit Mechanism 002



[5] In the next version of the guidelines, projects will be asked to link to Strategic Targets and Influencing Factors, which are at a lower level than KPAs. If projects are already familiar with these then they are encouraged to use them.

Feature Description: *<fuller description of the feature>*

Mechanisms

(1) *<how the feature will bring changes in the 'impact area'>*

(2a) *<how the 'impact area' will bring about changes in the 'indicator'>*
+ *<how the indicator will be measured – metric description>*

(2b) *<what change is seen in the 'positive' or 'negative impacts' when the indicator(s) change and which KPA[6](s) this links to>*

(..) *<continues for other numbered mechanisms>*

Impacted Stakeholders

Positive Impact 1	*<which stakeholders will be impacted>*
Negative Impact …	*<which stakeholders will be impacted>*

Data Sources

Indicator A	*<where can the data to measure the indicator come from>*
Indicator …	*<where can the data to measure the indicator come from>*

Table 14: Benefit Mechanism 003

3.1.2.9Legend

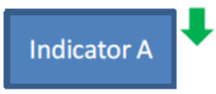
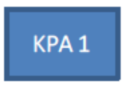
Column Title	Box Shape	Column Description
Feature		Introduces one of the new features that the project is bringing to the world of ATM
Impact Area		Sub categories used to group indicators and positive/negative impacts to help orient the reader (may not always be necessary)
Indicators		Aspects which can be measured (or calculated from other metrics) to identify if the expected positive and negative impacts are actually realised. These need to be measured in the validation exercises
Positive or Negative Impacts		Describes the expected positive or negative impacts
KPA		KPAs linked to the positive or negative impacts

Table 15: Benefit Mechanism Syntax - Columns

The boxes in these columns are linked by numbered arrows which represent the mechanisms.

[6] In the next version of the guidelines, projects will be asked to link to Strategic Targets and Influencing Factors, see Ref **Error! Reference source not found.**, which are at a lower level than KPAs. If projects are already familiar with these then they are encouraged to use them.

1	The numbers provide links to the mechanism descriptions in the text.

Table 16: Benefit Mechanism Syntax - Mechanisms

The arrows associated with the Indicators and the Positive or Negative Impacts are:

	A beneficial decrease e.g. a reduction in CO_2 emissions (indicator) or a reduction in controller workload (positive impact)
	A detrimental increase e.g. an increase in CO_2 emissions (indicator) or an increase in controller workload (negative impact)
	A beneficial increase e.g. an increase in no. of movements (indicator) or an increase in safety (positive impact)
	A detrimental decrease e.g. a reduction in no. of movements (indicator) or a reduction in safety (negative impact)
	A change in the indicator, a positive or negative impact is expected but with current knowledge the direction is still not clear. Can be coloured to show the main expectation. It is preferable to use a direction arrow, however this is provided as a 'last resort', for example where input from a TA expert is required.

Table 17: Benefit Mechanism Syntax – Coloured Arrows

3.2 Complexity/Capacity/Workload Assessment

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	25	-38%
DECLARED - CALCULATED	5		

Table 18: LEMDENN comparison results

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	39	18%
DECLARED - CALCULATED	10		

Table 19: LEMDREN comparison results

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	44	22%
DECLARED - CALCULATED	7		

Table 20: LEMDRWN comparison results

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	50	47	N/A
DECLARED - CALCULATED	0			N/A

Table 21: LEMDAIN, AFEN & AFWN results

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		
Nr. OF MOV	22	35	
CALCULATED CAPACITY	63		
DECLARED - CALCULATED	-13		

Table 22: DIN comparison results

3.3 Environmental Conclusions

The Environmental assessment can only conclude that **qualitatively** the P-RNAV procedures in the Madrid's TMA (with all the limits and recommendations coming from the RTS and FTS validation exercises) can deliver reductions in Fuel burn and Emissions mainly by reducing:

- the holdings and obviously the delays related to them;
- by allowing CCDs;
- and not hindering the performance of CDOs (although not in heavy traffic).

However, quantitatively there was no possibility of comparing the data sources provided since it would have been like: "mixing apples and oranges[7]". **Thus the quantitative analysis is inconclusive**.

For the future it is advisable to simulate (as was the case) both a baseline scenario and a P-RNAV scenario on the same RTS platform. And (which was not the case) be able to extract data from the RTS exercises in a format usable by any analytical software for later analysis and comparison.

Again the same as above should be said for the simulation of both a baseline scenario and a P-RNAV scenario on the same FTS platform.

These conclusions do not invalidate either the RTS or the FTS, since they were used for the objectives they were built for. These conclusions highlight the difficulty of trying to extrapolate answers and numbers from different sources without having for each platform a baseline scenario to compare it with.

3.4 Safety Conclusions

Traffic metered in order to achieve max TMA sectors capacity commensurate with need to maintain separation/wake minima (5 and/or 3 NM)
conform to other entry criteria (external sectors): entry point, altitude, speed constraint, separation constraints (including for adverse meteorological conditions exercises)
Comply to a specified speed constraint at transitions IAF
May have direct-to clearances
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
All non-P-RNAV arriving aircraft cleared along conventional routes whilst providing sufficient obstacle/terrain clearance
Conventional routes to be available separately for non-P-RNAV flight planned departing aircraft for handover to Area Control
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)
Spacing between aircraft within converged flows maintained in accordance with longitudinal

[7] English expression.

separation minima and landing constraints
Controllers continuously knowledgeable of aircraft P-RNAV capability in complex TMA (Either Flight Plans and/or A/G Communication)
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
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/departing sequence
Controller capacity for reversion to vectors to be maintained
P-RNAV structures shall be completely segregated from restricted airspace
Contingency lateral/vertical holding (as applicable) shall be available to accommodate unusual circumstances and emergencies.
Aircraft given priority on shorter routes or to diversion airfield if required
Waypoints shall be defined to direct emergencies straight to Final Approach fix/ILS Intercept
Traffic held as necessary (in holds for arriving aircraft or on ground for departures) Speed constraints applied as necessary to maintain longitudinal spacing Exceeding traffic over degraded capacity will be transfer to Torrejón and Getafe airports in this order.
Aircraft to be stable at the defined level/altitude for the transition assigned prior to transition entry
P-RNAV aircraft follow the assigned transition leg (non-P-RNAV aircraft vectored and follow assigned altitude)
Parallel sequencing legs shall be at a sufficient lateral distance such as to avoid clutter and facilitate visualization on radar screen: 5NM
Adjacent Sequencing Legs shall be horizontally separated, along their entire length, by at least the separation minima for P-RNAV: 1 NM + 1NM
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
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
Holdings shall be available on respectively IAFs
A spare level for each Leg (below or above)

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
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
Between IAF and IF P-RNAV aircraft to follow the P-RNAV route and comply with associated altitude restrictions
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
After exiting BENJI/MONTE aircraft shall be cleared for Final Approach and transition Leg assigned Vertical separation at intersections of (P-RNAV and conventional) 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)
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 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.
An aircraft that is transitioned from the end of a sequencing leg for re-insertion into the landing sequence shall not impinge departing aircraft
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
Traffic cleared in order to achieve max RWY throughput commensurate with need to maintain separation/wake minima (3 NM)
May have direct-to clearances above 10000 ft
Changes to queuing sequencing and clearances as necessary to improve delivery of traffic into the TMA and then to route connectors through speed control, vectoring, conformance to route options and holding Spacing between aircraft within converged flows maintained in accordance with longitudinal separation minima and departure constraints (Noise restrictions)
Traffic held as necessary (in TAXI waiting areas) until they are cleared (Degraded Capacity)

Table 23: Safety Conclusions

3.5 Security Conclusions

The conclusions are:

1. It is NOT necessary to perform a detailed security assessment in P5.7.4 work stream 1 due to its purely operational nature.
2. It has been demonstrated that the project has NO relevant impact on ATM Security. Only two minor risks have been identified in the preliminary security risk assessment and the corresponding treatment actions have been defined. Such risks are related with the following assets: runway and staff.
3. Several 'security related assets' have been identified in the context of the system addressed by the project. However all of them fall outside its scope). Among the assets identified, the most critical one concerning the operation in the TMA is the radar, namely the radar service not being available for any cause.

3.6 Human Factors Conclusions

1. HF experts involve from the inception of Validation Plan.
2. Scenario elaboration should fit for all TA assessment purposes.
3. Metrics should not be limited to Qualitative questionnaires with SMEs
4. HF experts must have a "say" in the decision making process of elaboration of exercises.
5. Baseline is needed
6. Assessment techniques / tools should be recognized by HF experts or at least HF experts fully informed of alternative techniques that are not in the reference material.
7. When technical problem in the simulator arise, scenario data must be rejected.
8. Traffic forecast must be realistic and following B.5 and TA recommendations on common baseline and assumptions
9. Simulations must reflect future actual operations.

3.7 Cost-Benefit Analysis

3.7.1 Cost Benefit Methodology

The Cost-Benefit study presents three main phases where a number of steps can be allocated:

- A first phase where definition and hypothesis of the project are undertaken. It is necessary to examine needs, consider constraints and state the point of view from which costs and benefits will be assessed (base line).
- Identification of affected areas and classification of variables from an economic point of view, i.e. setting out the costs and benefits over time. Identification is done according to company's accountancy, and the estimation may be carried out by amounts of money and milestones or by indicators and unit costs. It is necessary to analyze incremental effects respect to a base line and gather data about costs and benefits, expressing them in a valid standard unit of measurement (Euros).
- The last phase consists of model building and result analysis, conducting a deterministic estimation of net present value (NPV) and its deterministic model and a sensitivity analysis to determine which variables appear to have the most influence on the NPV.

The base line is an alternative situation in which the system continues at present situation, i.e. it consists of doing all the required activities to keep operative the present system, extending it up to its theoretical capability.

Definition and hypothesis Phase:

The recommended steps in this phase are:

- Project definition formulating objectives and targets for instance increasing capacity or reducing costs. Moreover it is necessary to set the period of project evaluation and in the case of several alternatives in the project the same period should be considered.
- Assumed hypothesis to establish the study. There may be hypothesis for the complete project as well for each alternative.
- Identification of alternatives or different possibilities of executing a project.

According to technical features, the investments that may arise due to project are allocated to the following areas:

- Tools
- Infrastructure

- Navigation
- Surveillance
- Communication
- Aeronautical Services
- Automation
- Information Technology
- Headquarters

Identification and Classification Phase:

It is necessary to identify the variations in benefits, the positive results when undertaking an investment and costs, the consumption of resources to carry out a project.

- Identification of benefits and costs
- Estimation of benefits and costs

At this point some differences may be noted between EUROCONTROL's general view of cost-benefit analysis as presented in meetings and present analysis.

EUROCONTROL's general structure of costs in a project of investment is identified according to the project phases:

R+D Research and Development: from the beginning of the project, some costs associated to improvements or new services and research arises.

Processing: in this period project presentation and approval of the proposal are carry out, as well as drafting and processing of specifications.

Project Implementation: this phase covers time from contract signing to the point the whole new system is in operation. It could be divided into Infrastructure, Equipment and Transition periods.

Operating phase: it covers from the point new system is commissioned as the main system to the end of the study. Replacement of some elements could be required in this phase. In general benefits begin at commissioning.

On the contrary, in our study the Cost-Benefit Analysis is tackled in an company-management approach, the core business is highlighted and thus company's costs relating to technical and human resources necessary to undertake the project such as Amortization Cost or Staff Cost are drawn firstly. Other operating costs associated to service provision are considered as Exploitation costs.

Models are considered for the main stakeholders reflecting the project analysis: ANS Provider and Airline Users. Environment is not dealt with due the difficulty in reaching a quantitative result.

The cost-benefit analysis is based on the income and costs accounts implied in a particular project and not on the moment and phase where all these incomes and costs appear.

Modeling and Analysis Phase:

- Economic evaluation of alternatives. Benefits and costs must be allocated in time.
- Analysis and interpretation of results. The economic result could be assessed by some criteria as well as deterministic and probabilistic analysis:
- NPV (net present value):
- Benefit-Cost ratio
- IRR (internal return ratio)
- Pay-back period.

P-RNAV case:

In particular, as PRNAV project is considered, the main costs for ANSPs and Airlines models from a EUROCONTROL point of view are:

ANSPs:

- Pre-implementation Costs, which contain Training costs in respect of PRNAV procedures for ATCOs and Administrative costs arisen in design of new operating procedures and ATCO certification.
- Implementation and commissioning costs such as coexistence between new and out-mode systems.
- Calibrating costs as testing costs.

Airlines:
- Training costs in respect of PRNAV procedures for pilots.
- Management costs for the project
- Administrative costs due to new operating procedures.
- Implementation and commissioning costs due to new equipment required for PRNAV operations.

The study comprises two main models that reflect the project analysis for the two main stakeholders: ANS Provider and Airline Users.

Two main areas of investment might be considered in this project for ANS Provider model: Navigation and Automation. Navigation Cost contains investment due to new requirement in equipment (i.e. DME/DME) while the investment due to new technologies (i.e. SACTA evolutions) is considered under Automation Cost.

Aligned with these investments, there are two Amortization Costs: in Navigation and in Automation derived from the loss of value link to the pass of time, technical progress and obsolescence.
Costs that arise from the operation of the system can be divided into Staff Cost and Exploitation Cost. Staff Cost has been extracted from exploitation costs to receive a differentiated study.

Staff Cost can be distributed into Service Provision Costs due to the operation of the new system respect to base line and Transition Costs, due to training to new system.

As far as Exploitation Cost is concerned two types of costs can be found: Administrative Cost including costs due to Certification and Calibration amongst others and Maintenance Cost.
Benefits are the difference between global income for ANSP and global cost. It is assumed that there are no incremental incomes due to project.

In a parallel way, Airlines model presents two main types of Amortization Cost: Training Cost and Exploitation Cost that reflects the effectiveness of the system performance. Exploitation Cost contains the effects of the inefficiency in delay, tactical and strategically, inefficiency in flight, accommodated diversions and cancelations cost.

Users incomes mainly come from incremental accommodated demand. Benefits are the difference between global income and global cost for User.

3.7.2 Project

1. Project — **Implementation of PRNAV procedures in Madrid TMA**

Geographical Area

FIR	_
TMA	X
Airport	_

Description

Implementation of PRNAV procedures (SID and STAR) in Madrid TMA

Service Provided

Airspace Design	X
Capacity/Demand Management	_
ATC (Route/Approach/Airport)	_
CNS	_
AIS	_
Others	_

Alternatives

Alternative 1

PRNAV Procedures in Madrid TMA

Alternative 2

_

Key Performance Area

Safety	X
Cost_Efficiency	X
Capacity	X
Productivity	X
Flight Efficiency	X
Environment	X

Baseline

Conventional Procedures in Madrid TMA

Investment

Infrastructure	_
Navigation	_
Communication	_
Surveillance	_
Automation	_
Tool	_
Others	_

Remarks

Alternative 1 an 2 are compared with regard to Baseline (Incremental)

Calendar

Current Year	2012
Final Year	2021
Operational Year	2012

Collaboration

Dirección de Operaciones
División de Planificación y Control. Gabinete N.A.

3.7.3 Assumptions

2. Assumptions
Economic Assumptions
The models calculate cash-flow using project's current year prices (real value or without inflation)
For the effect of NPV´s calculation, it has been considered a discount factor of 4% on the Service Providers´ model, 4% on the Airlines´ Model and 4% on the Externalities´ model
Net Present Value is the sum of the discounted annual cash flow
Economic impact on Safety has not been assesed, despite the fact that these concepts are otherwise crucial to comply with.
Unit Cots have been calculated with regard to the current situation. For calculation purposes, typical values from EUROCONTROL Standard Inputs document regarding delay, flight time inefficiencies, and pollutant emissions unit costs are used.
In order to interpret values of the Net Present Value (NPV) of the projects, it should be remarked that the Cost-Benefit Analysis is calculated with incremental values and therefore NPV in positive means "additional benefits" while NPV in negative means "additional costs".
Operational Assumptions
Capacity is restricted as airline´s profitability remains null, that is, while delay costs remain higher than net benefits per flight. Therefore there is a maximum rate of delay@gate
In relation with the overall minutes of delay @ gate, a proportion corresponds to delays higher than 15 minutes and the rest associated with delays lower than 15 minutes.
An en-route average speed of 450NM/h, calibration flight speed of 170 NM/h and a landing speed of 280NM/h are used
It has been considered that annual Nautical Miles savings and annual CO2 savings change with IFR movements´ variation
Particular Assumptions
There is no need of aditional investment for Aena in the navigation system to support the PRNAV procedures in TMA Madid, not in Automation due to the changes in the airspace design
There is no need of additional on board equipment investemet for the Airspace Users
Flight leves don't change with the new procedures, so the flight efficiency it is not affected
CTA working hours decreased by the project because although the sectorization change (2 to 3 sectors), the sectors have less complexity and therefore the hours used to manage them decrease (4 to 3 CTAs)
Sector Capacity for the TMA Madrid increases due to the new PRNAV procedures in TMA Madrid, so the ATC Capacity delay in the Madrid TMA is reduced to cero
Flight time increased from 21,60 minutes with current arrival procedures to 22,86 minutes with PRNAV arrival procedures in the Madrid TMA, and flight time decreased from 7,5 minutes with current departures procedures to 6 minutes with PRNAV departure procedures in the Madrid TMA
Due to the project, tactical on board delay disappears (3,2 flights per hour during six hours per day and 365 per annum with 3,75 minutes of tactical on board delay per flight)

3.7.4 Economic Evaluation

3. Financial and Economic Evaluation

FINANCIAL ASSESSMENT

	Alternative 1 (Incremental BL)	Alternative 2 (Incremental BL)	Baseline
Financial Net Present Value vs Capital	11.940.333 €	- €	- €
Financial Net Present Value vs Inversión	11.940.333 €	- €	- €

ECONOMIC ASSESSMENT

	Alternative 1 (Incremental BL)	Alternative 2 (Incremental BL)	Baseline
Economic Net Present Value vs Capital	82.582.184 €	- €	- €
Airspace Users	70.641.851 €	- €	- €
Externalities	- €	- €	- €
Economic Net Present Value vs Investment	82.582.184 €	- €	- €
Airspace Users	70.641.851 €	- €	- €
Externalities	- €	- €	- €

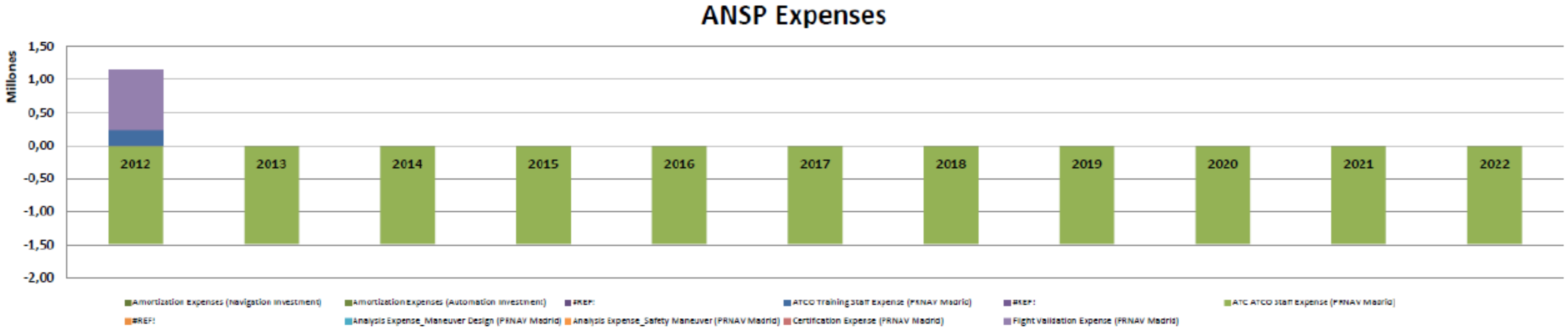
Comments

The studied alternative means benefits for all the Stakehoders: ANSP and Airspace Users

3.7.5 Change of ANSP expenses

4. Time Series

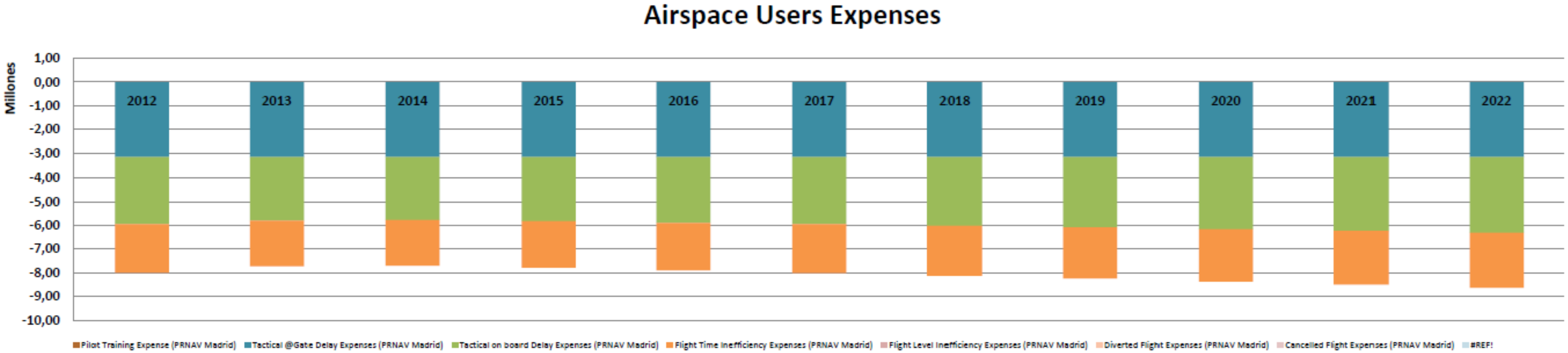
Alternative 1	***PRNAV Procedures in Madrid TMA***											
ANSP (€)	**NPV**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Investment	-	-	-	-	-	-	-	-	-	-	-	-
Navigation Investment	-	-	-	-	-	-	-	-	-	-	-	-
Automation Investment	-	-	-	-	-	-	-	-	-	-	-	-
Amortization Expenses (Investment)	-	-	-	-	-	-	-	-	-	-	-	-
Amortization Expenses (Navigation Investment)	-	-	-	-	-	-	-	-	-	-	-	-
Amortization Expenses (Automation Investment)	-	-	-	-	-	-	-	-	-	-	-	-
Anticipated Amortization Expenses	-	-	-	-	-	-	-	-	-	-	-	-
Pre_Operational Staff Expenses	240.385	250.000	-	-	-	-	-	-	-	-	-	-
ATCO Training Staff Expense (PRNAV Madrid)	240.385	250.000	-	-	-	-	-	-	-	-	-	-
Operational Staff Expenses	-13.046.102	-1.489.200	-1.489.200	-1.489.200	-1.489.200	-1.489.200	-1.489.200	-1.489.200	-1.489.200	-1.489.200	-1.489.200	-1.489.200
ATC ATCO Staff Expense (PRNAV Madrid)	-13.046.102	-1.489.200	-1.489.200	-1.489.200	-1.489.200	-1.489.200	-1.489.200	-1.489.200	-1.489.200	-1.489.200	-1.489.200	-1.489.200
Pre_Operational Expenses	865.385	900.000	-	-	-	-	-	-	-	-	-	-
Analysis Expense_Maneuver Design (PRNAV Madrid)	-	-	-	-	-	-	-	-	-	-	-	-
Analysis Expense_Safety Maneuver (PRNAV Madrid)	-	-	-	-	-	-	-	-	-	-	-	-
Certification Expense (PRNAV Madrid)	-	-	-	-	-	-	-	-	-	-	-	-
Flight Validation Expense (PRNAV Madrid)	865.385	900.000	-	-	-	-	-	-	-	-	-	-
Operational Expenses	-	-	-	-	-	-	-	-	-	-	-	-
Income	-	-	-	-	-	-	-	-	-	-	-	-
Capital Financial Performance	11.940.333	339.200	1.489.200	1.489.200	1.489.200	1.489.200	1.489.200	1.489.200	1.489.200	1.489.200	1.489.200	1.489.200
Investment Finacial Performance	11.940.333	339.200	1.489.200	1.489.200	1.489.200	1.489.200	1.489.200	1.489.200	1.489.200	1.489.200	1.489.200	1.489.200



3.7.6 Change of AUs expenses

4. Time Series

Alternative 1	***PRNAV Procedures in Madrid TMA***											
AIRSPACE USERS (€)	**NPV**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Investment	-	-	-	-	-	-	-	-	-	-	-	-
Amortization Expenses (Investment)	-	-	-	-	-	-	-	-	-	-	-	-
Pre_Operational Expenses	-	-	-	-	-	-	-	-	-	-	-	-
Pilot Training Expense (PRNAV Madrid)	-	-	-	-	-	-	-	-	-	-	-	-
Operational Expenses	-70.579.195	-7.994.688	-7.724.467	-7.701.691	-7.787.807	-7.898.650	-8.012.154	-8.128.382	-8.247.400	-8.369.274	-8.494.073	-8.621.867
Tactical @Gate Delay Expenses (PRNAV Madrid)	-27.764.736	-3.169.318	-3.169.318	-3.169.318	-3.169.318	-3.169.318	-3.169.318	-3.169.318	-3.169.318	-3.169.318	-3.169.318	-3.169.318
Tactical on board Delay Expenses (PRNAV Madrid)	-24.653.309	-2.778.532	-2.622.934	-2.609.819	-2.659.406	-2.723.232	-2.788.589	-2.855.515	-2.924.048	-2.994.225	-3.066.086	-3.139.672
Flight Time Inefficiency Expenses (PRNAV Madrid)	-18.161.151	-2.046.838	-1.932.215	-1.922.554	-1.959.083	-2.006.101	-2.054.247	-2.103.549	-2.154.034	-2.205.731	-2.258.669	-2.312.877
Flight Level Inefficiency Expenses (PRNAV Madrid)	-	-	-	-	-	-	-	-	-	-	-	-
Diverted Flight Expenses (PRNAV Madrid)	-	-	-	-	-	-	-	-	-	-	-	-
Cancelled Flight Expenses (PRNAV Madrid)	-	-	-	-	-	-	-	-	-	-	-	-
Income	62.656	7.062	6.666	6.633	6.759	6.921	7.087	7.257	7.431	7.610	7.792	7.979
C02 Emissions Incentives (PRNAV Madrid)	62.656	7.062	6.666	6.633	6.759	6.921	7.087	7.257	7.431	7.610	7.792	7.979
Capital Financial Performance	70.641.851	8.001.750	7.731.133	7.708.324	7.794.565	7.905.571	8.019.241	8.135.640	8.254.831	8.376.884	8.501.865	8.629.846
Investment Finacial Performance	70.641.851	8.001.750	7.731.133	7.708.324	7.794.565	7.905.571	8.019.241	8.135.640	8.254.831	8.376.884	8.501.865	8.629.846



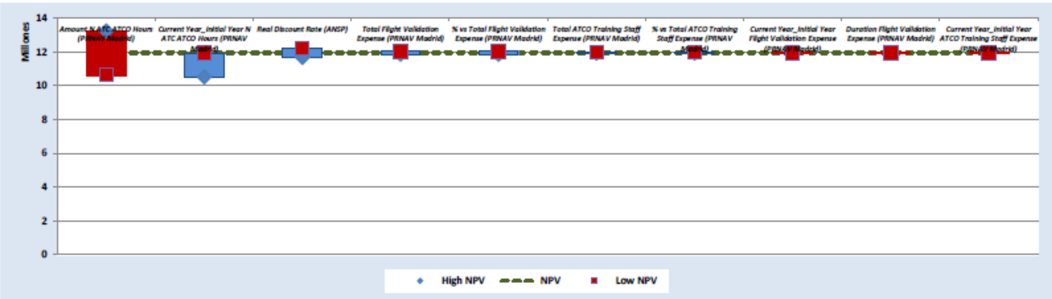
3.7.7 Time Series Externalities Investment

TBC

3.7.8 Sensitivity Analysis

Sensitivity Analysis refers to the impact one given input to the model has on the overall NPV. Different NPV values are calculated by varying this one given input between its low and high value (10%-10%),while keeping all other inputs as constants

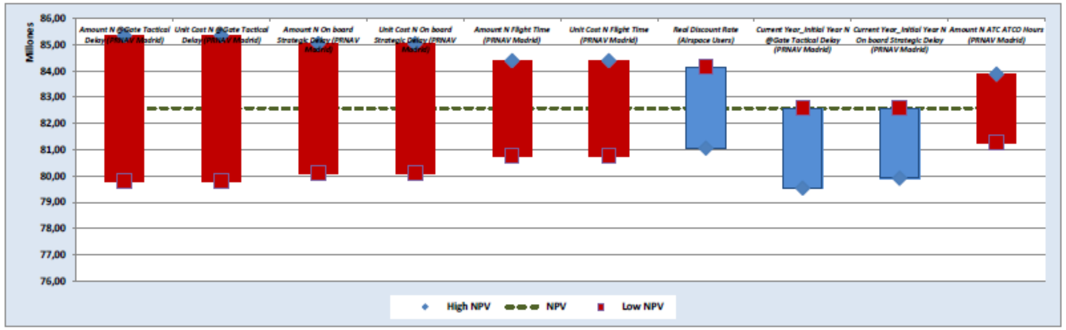
Financial Analysis. Alternative 1 ***PRNAV Procedures in Madrid TMA***



Comments

The assessment of the relative importance of variables:

1. Amount N ATC ATCO Hours (PRNAV Madrid)
2. Current Year_Initial Year N ATC ATCO Hours (PRNAV Madrid)
3. Real Discount Rate (ANSP)
4. Total Flight Validation Expense (PRNAV Madrid)
5. % vs Total Flight Validation Expense (PRNAV Madrid)



Comments

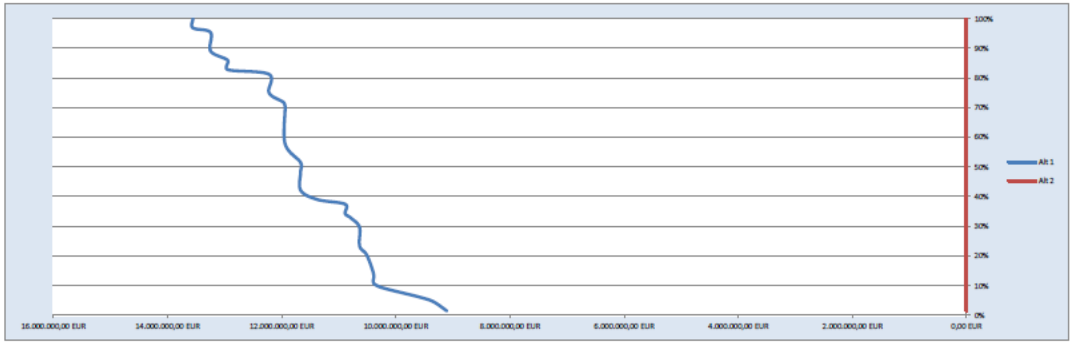
The assessment of the relative importance of variables:

1. Amount N @Gate Tactical Delay (PRNAV Madrid)
2. Unit Cost N @Gate Tactical Delay (PRNAV Madrid)
3. Amount N On board Strategic Delay (PRNAV Madrid)
4. Unit Cost N On board Strategic Delay (PRNAV Madrid)
5. Amount N Flight Time (PRNAV Madrid)

3.7.9 Probabilistic Analysis

NPV Risk Analysis is the range of values the NPV of the project might have with the probabilities attached to the different NPV values. We calcule low, base and high value of the NPV usisng low, base and high values of the inputs

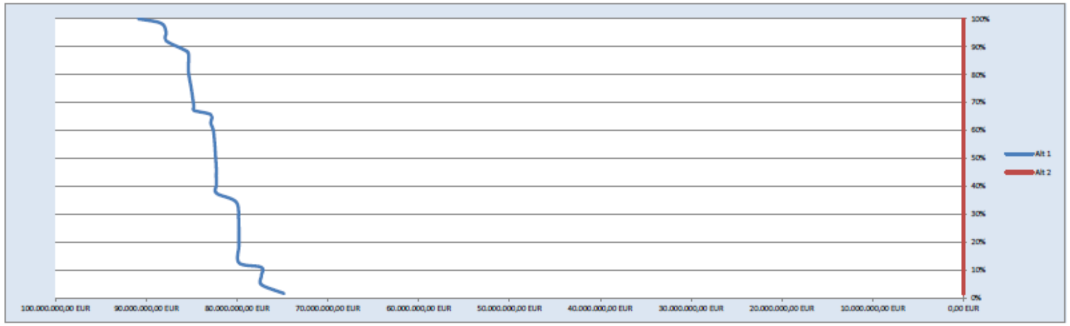
Financial Analysis



Comments

On the side of ANSP profitability, the risk level is low because a variability in the main variables implies a few variability in the economic result

Economic Analysis



Comments

On the side of Arilines profitability, the risk level is low because a variability in the main variables implies a few variability in the economic result

3.7.10 Conclusions

Conclusions

The main parameter to take into account in the implementation of the PRNAV in Madrid TMA on the ANSP side is the decrease in ATCO ATC hours. Others are the calibration costs and training costs and the starting year of the project

Airspace Users will have cost savings due to the implementation of PRNAV procedures in Madrid TMA in terms of: delay on the capacity area (tactical @ gate and tactical on board delay) and flight time on the flight efficiency area (increase in nautical miles on the arrival procedures but decrease on departures procedures). Besides, the Airspace Users will have incentives in terms of CO2 emission reduction on the environmental area

ANNEX I. Performance Indicators

Alternative 1 ***PRNAV Procedures in Madrid TMA***

CAPACITY	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
@Gate Tactical Delay (PRNAV Madrid) (min)	- 38.983	- 38.983	- 38.983	- 38.983	- 38.983	- 38.983	- 38.983	- 38.983	- 38.983	- 38.983	- 38.983
On board Strategic Delay (PRNAV Madrid) (min)	- 24.808	- 23.419	- 23.302	- 23.745	- 24.315	- 24.898	- 25.496	- 26.108	- 26.734	- 27.376	- 28.033
Diverted Flights (PRNAV Madrid) (Flights)	-	-	-	-	-	-	-	-	-	-	-
Cancelled Flights (PRNAV Madrid) (Flights)	-	-	-	-	-	-	-	-	-	-	-
FLIGHT EFFICIENCY	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Flight Time (PRNAV Madrid) (min)	- 51.171	- 48.305	- 48.064	- 48.977	- 50.153	- 51.356	- 52.589	- 53.851	- 55.143	- 56.467	- 57.822
Flight Level Fuel (PRNAV Madrid) (Tm)	-	-	-	-	-	-	-	-	-	-	-
ENVIRONMENT	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
CO2 Emissions Reduction (PRNAV Madrid) (kg)	1.176.932	1.111.024	1.105.469	1.126.473	1.153.508	1.181.192	1.209.541	1.238.570	1.268.295	1.298.734	1.329.904

ANNEX II. Key input data

GENERAL	Alternative 1	Alternative 2	Base Line
Real Interest Rate	0,03	0,03	0,03
Real Discount Rate (ANSP)	0,04	0,04	0,04
Real Discount Rate (Airspace Users)	0,04	0,04	0,04
Current Year	2.012	2.012	2.012

MOVEMENTS	Alternative 1			Alternative 2			Base Line		
	2012	2017	2022	2012	2017	2022	2012	2017	2022
Spain IFR Flights	1.680.319	1.811.494	2.003.957	1.680.319	1.811.494	2.003.957	1.680.319	1.811.494	2.003.957

TOTAL EXPENSE	Alternative 1			Alternative 2			Base Line		
	Total (€)	Milestone (years)	Duration (years)	Total (€)	Milestone (years)	Duration (years)	Total (€)	Milestone (years)	Duration (years)
Analysis Expense_Maneuver Design (PRNAV Madrid)	0	0	0	0	0	0	0	0	0
Analysis Expense_Safety Maneuver (PRNAV Madrid)	0	0	0	0	0	0	0	0	0
Certification Expense (PRNAV Madrid)	0	0	0	0	0	0	0	0	0
Flight Validation Expense (PRNAV Madrid)	900.000	0	1	0	0	0	0	0	0
Pilot Training Expense (PRNAV Madrid)	0	0	0	0	0	0	0	0	0

PERFORMANCE INDICATORS CAPACITY	Alternative 1			Alternative 2			Base Line		
	New	Milestone (years)	Duration (years)	New	Milestone (years)	Duration (years)	New	Milestone (years)	Duration (years)
N @Gate Tactical Delay (PRNAV Madrid) (min)	-38.983	0	20	0	0	0	0	0	0
N Diverted Flights (PRNAV Madrid) (Flights)	0	0	0	0	0	0	0	0	0
N Cancelled Flights (PRNAV Madrid) (Flights)	0	0	0	0	0	0	0	0	0

PERFORMANCE INDICATORS FLIGHT EFFICIENCY	Alternative 1			Alternative 2			Base Line		
	New	Milestone (years)	Duration (years)	New	Milestone (years)	Duration (years)	New	Milestone (years)	Duration (years)
N Flight Time (PRNAV Madrid) (min)	-54.207	0	20	0	0	0	0	0	0
N Flight Level Fuel (PRNAV Madrid) (Tm)	0	0	20	0	0	0	0	0	0

PERFORMANCE INDICATORS ENVIRONMENT	Alternative 1			Alternative 2			Base Line		
	New	Milestone (years)	Duration (years)	New	Milestone (years)	Duration (years)	New	Milestone (years)	Duration (years)
N CO2 Emissions Reduction (PRNAV Madrid) (kg)	1.246.750	0	20	0	0	0	0	0	0

UNIT COST. CAPACITY	Value	Unit
Tactical @Gate Delay Expenses (PRNAV Madrid)	81,30	€/min
Tactical on board Delay Expenses (PRNAV Madrid)	112,00	€/min
Diverted Flight Expenses (PRNAV Madrid)	7.000,00	€/Flights
Cancelled Flight Expenses (PRNAV Madrid)	20.000,00	€/Flights

UNIT COST. FLIGHT EFFICIENCY	Value	Unit
Flight Time Inefficiency Expenses (PRNAV Madrid)	40,00	€/min
Flight Level Inefficiency Expenses (PRNAV Madrid)	740,00	€/Tm
CO2 Emissions Incentives (PRNAV Madrid)	0,01	€/kg

4 WS2 Business case conclusions

Work Stream 2 of project 5.7.4 developed an operational concept for the Operational Focus Area (OFA) 02.01.02 of **Point Merge in Complex TMA**.

The activities conducted to support validation of this concept in the used two test cases: London TMA and Milan TMA.

This section provides the conclusions of the aforementioned validations for each transversal area of performance assessment. It is sub-divided as per the transversal performance projects so as to provide targeted feedback.

1. Complexity/Capacity/Workload Conclusions – a fundamental influencing factor for many KPAs.
2. Environment Conclusions – as per guidance from P16.6.3
3. Safety Conclusions – as per guidance from P16.6.1.
4. Security Conclusions – as per guidance from P16.6.2.
5. Human Factors Conclusions - as per guidance from P16.6.5.
6. Assessment of Cost & Benefit - as per guidance from P16.6.6.
7. Summary of Performance Assessment - the output of validations, per KPI, as per guidance from B4.1/B.5.

4.1 Complexity/Capacity/Workload Assessment

The output of the Real Time Simulations were analysed via a mix of the following:

- End-of-run self-reported Bedford Workload Scale
- End-of-simulation questionnaire
- Debrief and questionnaire comments
- Number of Tactical Instructions
- R/T Occupancy
- Number of Aircraft on Frequency

TMA Planning controllers and Executive controllers using the P-RNAV system experience reduced workload/stress, improved situation awareness and reduced R/T – even in high traffic situations. Fewer tactical instructions are needed than in current day operations. This provides spare capacity which allows the controller to dedicate more time in managing traffic along the sequencing leg and establish a correct inbound sequence; it also improves controller capability to deal with a range non-nominal scenarios.

The OSED [16] describes the changes Complexity/Capacity/Workload in more detail.

4.2 Environmental Conclusions

The output of the Real Time Simulations were analysed via a mix of the following:

- Advanced Emissions Model (AEM3) analysis of Fuel/CO_2 [8]
- Integrated Noise Model (INM) analysis of Noise footprint [9]
- Debrief and questionnaire comments

[8] As per guidance from P16.6.3
[9] As per guidance from P16.6.3

The use of the Point Merge System reduces the reliance on stack holding; holding time is reduced overall.

An increase in the track miles for Arrivals is likely to be needed to accommodate the route taking in the Point Merge Systems. However, vertical profiles can be greatly improved for Arrivals and Departures. For Arrivals, the only level constraint may be due to the Sequencing Legs; where constraints allow, the possibility to handle descending traffic inside PMS leg structure may enable a continuous descent operation from the Top of Descent whilst also helping to relieve pressure from feeding sectors without having the need to increase track miles. For Departures, the structured routes and well-defined (closed loop) operations for Arrivals allows departing aircraft an unrestricted initial climb phase of flight.

Aircraft which experience zero holding on the sequencing leg could have a continuous descent from the TMA boundary to the “At level [FL/altitude] by” restriction if facilitated by the P-RNAV route. This provides the potential for a CDA from the Top of Descent (ToD).

The vertical profiles improvements are expected to provide a corresponding reduction to Noise impact.

The OSED [16] describes the environmental impacts in more detail.

4.3 Safety Conclusions

The output of the Real Time Simulations were analysed via a mix of the following:

- The Safety Integrated Risk Picture (IRP) [10]
- Assessment of Non-nominal scenarios [11]
- Debrief and questionnaire comments

The introduction of Point Merge procedures are known to have an impact upon the Approach and TMA controller tasks and responsibilities and are anticipated to deliver Safety benefits in the form of significantly reduced controller workload, improved situational awareness and reduced R/T when compared to the current operation.

Confirmation of the Point Merge system design at the SPR Level was achieved through a series of Real Time Simulations and limited cockpit simulations using London TMA as a test case. During the Real Time Simulations a range of scenarios were tested (including normal and abnormal conditions) with Controller feedbacks being sought during de-brief sessions and detailed Controller questionnaires. The output of these sessions, including conclusions and recommendations was documented in the Validation Report, which concluded that Approach Controllers reported reduced workload, improved situational awareness and reduced R/T, which in turn provided additional capacity for dealing with non-nominal scenarios.

Achievability of the Safety Acceptance Criteria, Functional & Performance Safety Objectives, and Safety Requirements was also demonstrated. Partial achievability was demonstrated for the Integrity Safety Objectives, with additional analysis being required during V3/V4 phases of the project

Due to the nature of the OFA having only one operational project within it, it was considered inappropriate for the project to populate the ‘physical level’ of the SAR. Since there is no system project in the OFA, the development of those sections intended to cover the conformance monitoring tools identified during the hazard analysis will therefore need to be undertaken during V4.

Moreover, the implementation of such a structure allows for a better and more predictable management of contingency situations, providing for a high situational awareness both for ATCOs and pilots, due to the possibility to design holding patterns separated from each other until an established flight level.

The Safety Assessment Report [18] describes the impact to safety in more detail.

[10] As per guidance from P16.6.1
[11] As per guidance from P16.6.1

4.4 Security Conclusions

Security is covered as part of the Safety Assessment process (See Section 4.3). Security aspects can be considered in a very similar manner to the way in which safety has been considered. All Security aspects were determined to fit as part of the Safety aspects.

The OSED [16] describes the security impacts in more detail.

4.5 Human Factors Conclusions

In addition to the Complexity/Capacity/Workload assessment (See Section 4.1), which directly relates to Human Factors, the output of the Real Time Simulations were analysed via a mix of the following:

- China Lakes Situation Awareness Scale
- User Confidence measures
- NATS Picture Dimensions Scale (proprietary)
- NATS Confidence Diamond (proprietary)
- Debrief and questionnaire comments

As a legal foundation, the controller is responsible for maintaining the minimum prescribed separation between aircraft. With the introduction of Point Merge in Complex TMA, fundamental responsibilities will not change. However, due to the introduction of new procedures, tasks and operating methods will change.
The Point Merge System changes the method of operations for Approach Controllers. It is more passive, and monitoring of aircraft behaviour becomes a more important factor. Speed control becomes the principal method of separation assurance and the use of the Mode-S down-linked IAS value was found to support the controller task. Level constraints may need to be applied to manage separation, for example, level-offs prior to entry to the sequencing legs, while for Milan Malpensa the design allowed for descending aircraft inside the sequencing legs, leaving the feeding sectors the only task to horizontal pre-sequencing of traffic.

As a consequence of the change in the working method, a crucial aspect would be the need to provide for the maintenance of the appropriate skill in tactical traffic management via Recurrent Training activities.

The OSED [16] describes the changes to Roles & Responsibilities in more detail.

4.6 Assessment of Cost & Benefit

A full Assessment of Costs & Benefits can be found in Annex 30. [12]

4.6.1 Costs

4.6.1.1 Costs to Airspace Users

The cost to the Airspace Users is considered to be **Low**. The key reasons for this are as follows:

- The P-RNAV concept is mature: regulations exist and many aircraft are already equipped.
- The concept assumes that 100% of aircraft are B-RNAV capable. Aircraft with B-RNAV capability are able to use the P-RNAV route structure, albeit to a lesser degree of accuracy than P-RNAV capable aircraft.

[12] As per guidance from P16.6.6.

- P-RNAV route structures can be designed to accommodate low performance commercial & business aircraft.

4.6.1.2 Costs to Air Navigation Service Providers

The cost to the Air Navigation Services Provider is considered to be **High** for one key reason:

- This concept can only be implemented as part of a complete TMA redesign, which is an intensive and extensive process.

Note that a complete TMA redesign will consolidate costs & benefits from multiple initiatives so this 'High' cost cannot be considered against this concept alone.

4.6.2 Benefits

4.6.2.1 Benefits to Airspace Users - Equipped

The benefit to the Equipped Airspace User is considered to be **Medium** in the following categories:

- Fuel Cost Saving
- CO2 Cost Saving
- Un-accommodated traffic avoidance

4.6.2.2 Benefits to Airspace Users – Unequipped

The benefit to the Unequipped Airspace User is considered to be similar to that of Equipped Airspace Users because Equipped an Unequipped are treated equally. However the level of accuracy that non P-RNAV equipped aircraft can adhere to the routes is reduced so the Environmental benefits will be correspondingly reduced.

4.6.2.3 Benefits to Air Navigation Service Providers

The benefits to the Air Navigation Services Providers are considered to be **Medium** the following categories:

- ACC ATCO Productivity Increase
- APP+TWR ATCO Productivity Increase

4.6.2.4 Benefits to Airports

The benefits to Airports are considered to be **Low** the following categories:

- Un-accommodated traffic avoidance

4.6.2.5 Benefits to Local Communities

The benefits to communities local to the affected Airports are considered to be **Low** the following categories:

- Noise Impact

4.7 Summary of Performance Assessment

The Key Performance Areas (KPAs), as defined for the SESAR Programme, that the concept OFA is expected to impact are as follows:

> Safety
> Environment
> Local Airspace Capacity

> Airport Capacity

> ATM Cost Effectiveness

Results of the P5.7.4 validation exercises per KPA, for the TMA overall, are displayed in the final two columns of the table below to provide an indication of potential benefits.

FOCUS AREAS	Lower level Focus Areas		KPIs	London TMA	Milano TMA
SAF1 ATM-related safety outcome	**SAF11** ATM Induced accidents and incidents		**SAF11 O1 I1**: Safety level: Accident probability per operation (flight) relative to the 2005 baseline	Impact upon the Approach and TMA controller tasks and responsibilities are anticipated to deliver Safety benefits [18]	TMA Safety levels maintained at current day levels and improved
ENV1 Environmental Sustainability Outcome	**ENV11** Atmospheric Effects	**ENV1111** Gaseous Emissions	**ENV1111 O1 I1:** Average fuel consumption per flight as a result of ATM improvements	35 kg per flight	Vertical profile improvements. Estimate minimal change to track miles
			ENV1111 O1 I2: Average CO2 emission per flight as a result of ATM improvements	109 kg per flight	Vertical profile improvements. Estimate minimal change to track miles
CAP2 Local airspace capacity	**CAP2** Local airspace capacity		**CAP2 O1 I1**: Hourly number of IFR flights able to enter the airspace volume	16% reduction in controller Workload*	20% increase in number of handled traffic per hour
CAP3 Airport capacity	**CAP31** BIC capacity in VMC[13]	**CAP 311** Single RWY Airport capacity in VMC	**CAP311 O1 I1**: Best In Class (BIC) declared airport capacity in VMC (1 RWY), mov/hr	+2 mov/hr increase	Increase in runway throughput potentially achievable
		CAP 312 Parallel dependent RWY Airport capacity in VMC	**CAP312 O1 I1**: Best In Class (BIC) declared airport capacity in VMC (2 parallel dependent RWYs), mov/h	*Not assessed*	Increase in runway throughput potentially achievable
CEF1 ATM Cost Effectiveness	**CEF11** Direct cost of G2G ATM	**CEF112** G2G ANS costs	**CEF112 O1 I1**: Total annual en route and terminal ANS cost in Europe, €/flight	16% reduction in controller Workload* Enabled by homogenous design	20-25% reduction in controller Workload* Enabled by homogenous design

Table 24: SESAR KPIs impacted by the 'Point Merge in Complex TMA' OFA

(*) Controller workload can have an impact on Safety, Capacity and/or Cost Effectiveness. If workload is too high or too low then this can affect controller concentration and effectiveness, therefore impacting Safety. If controller workload is reduced per flight handled then the controller has the potential to manage a greater number of flights over a set period, so the potential Capacity and Cost Effectiveness is increased (e.g. if a new runway opened in the TMA, this could be accommodated without increase in delay or the need for additional working hours or staff).

The 16% reduction in controller Workload indicates a potential increase in Local Airspace Capacity of a similar order of magnitude only if the following is considered as valid:

"Hourly number of flights able to enter airspace volume", as per the B4.1-defined KPI [19] was not considered an appropriate metric for the London TMA validation exercises because the traffic loading for the validation was a 'constant'. The 'variable' was the level of controller workload experienced under the constant traffic loading per airspace design or scenario. Controller workload is also the most capacity-constraining factor in a Complex TMA, so a change in controller workload can be assumed to be representative of a change in local airspace capacity.

A reduction in 'Noise impact' to communities local to the affected Airports is also expected, but not quantified.

[13] Visual Meteorological Conditions

5 References

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

[1] 05.07.04 – Initial OSED 00.00.01

[2] PIR part 1 and 2 02.02.00

[3] B4.3 Architecture Description Document

[4] ICAO Document 9694

[5] B4.1 [Initial] Baseline Performance Framework (Edition 0) D12.

[6] Aena. TRABAJOS REALIZADOS PARA EL FUTURO TMA PRNAV DE MADRID-BARAJAS. 20/11/09

[7] Aena. P-RNAV IMPLEMENTATION IN SPAIN. ANÁLISIS DE LA PROPUESTA DE DISEÑO DEL NUEVO TMA DE PALMA. 08/04/2010

[8] Aena. DOCUMENTO DE PROYECTO DE NUEVO TMA P-RNAV MADRID: ESTUDIO INICIAL. 13/08/08

[9] Aena -TMA MADRID PRNAV-"CODIFICACIÓN DE LAS TRANSICIONES EN CONF. NORTE Y SUR PARA EL NUEVO TMA MADRID PRNAV". 08/09/2008

[10] Aena. PROYECTO: NUEVO TMA DE MADRID PRNAV. JUSTIFICACIÓN Y PROPUESTA DE DESARROLLO DEL PROYECTO. 12/02/08

[11] Aena. TMA MADRID 2008. ANÁLISIS DE NUEVOS. PROCEDIMIENTOS DE ENTRADA 08/04/2008

[12] RETACDA: REDUCTION OF EMISSIONS IN TERMINAL AREAS USING CONTINUOUS DESCENT APPROACHES 30/09/09

[13] 5.2. D04 DOD

[14] SESAR P05.07.04 WS2 Validation Plan; Edition 00.02.00, April 2012

[15] SESAR P05.07.04 WS2 Validation Report (VALR) , Edition 00.02.00, June 2012

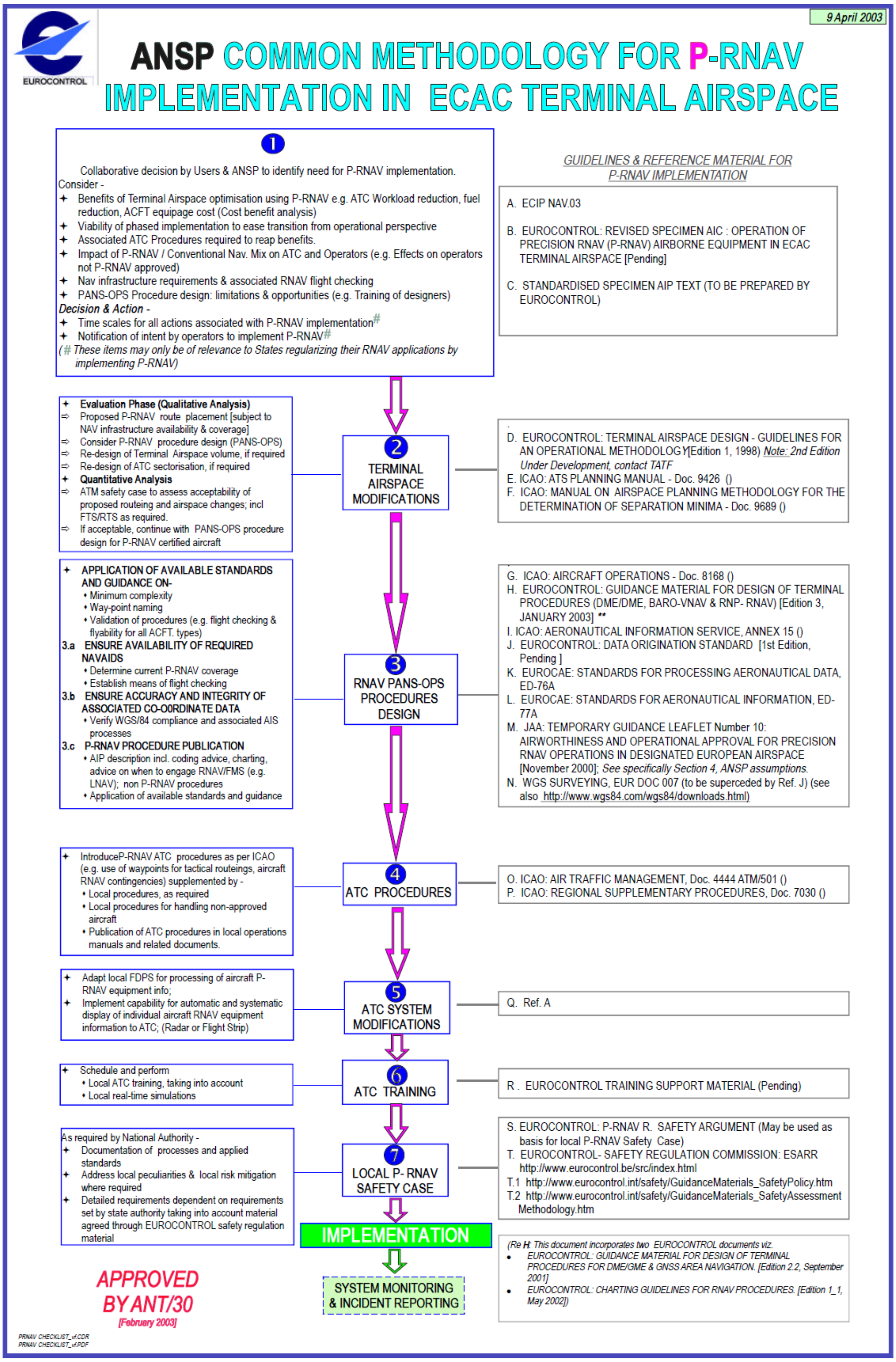
[16] Operational Service and Environment Definition (OSED) for Point Merge in Complex TMA, 00.01.00, July 2012

[17] Safety & Performance Requirements (SPR) for Point Merge in Complex TMA, Edition 00.01.00, July 2012

[18] SESAR P.05.07.04 Point Merge in Complex TMA – London & Milan (OFA) Safety Assessment Report (SAR), Edition 00.01.00, March 2012

[19] B4.1 Methodology for Allocating Targets and Performance Requirements at the Appropriate Levels, Edition 00.01.00, July 2010 (KPI Definition)

Annex 1 – Steps to be follow to implement P-RNAV in similar TMAs



Annex 2 – Airworthiness certifications and Operational Approval

The JAA Temporary Guidance Leaflet (TGL) 10, Airworthiness and Operational Approval for Precision RNAV Operations in Designated European Airspace, is applicable to all aircraft flying RNAV SIDs, STARs and Approaches up to the FAF. It requires a lateral track keeping accuracy of at least 1NM for 95% of flight time. This should not be confused with RNP1 (as defined in ED75 - the RNP MASPS), which has specific requirements for integrity, availability and continuity, including annunciation of the estimated navigation performance to the pilot, and may also be predicated on aircraft being capable of flying fixed radius turns. The protection provided by the criteria applicable to the worst case infrastructure available in a terminal area, be it DME/DME or Basic GNSS, is considered to be adequate for P-RNAV systems**33**.

The TGL also makes the following assumptions:

a) All terminal P-RNAV procedures:

i) are consistent with the relevant parts of ICAO Doc 8168 PANS OPS;

ii) are designed following the guidelines of EUROCONTROL document NAV.ET1.ST10 'Guidance Material for the Design of Procedures for DME/DME and GNSS Area Navigation', as amended, or equivalent material; and

iii) Take account of the functional and performance capabilities of RNAV systems and their safety levels as detailed in the leaflet.

iv) take account of the lack of a mandate for vertical navigation by ensuring that traditional means of vertical navigation can continue to be used;

v) Support integrity checking by the flight crew by including, on the charts, fix data (e.g. range and bearing to navigational aids) from selected waypoints.

b) All routes/procedures are based upon WGS 84 co-ordinates.

c) The design of a procedure and the supporting navigation infrastructure (including consideration for the need of redundant aids) have been assessed and validated to the satisfaction of the responsible airspace authority demonstrating aircraft compatibility and adequate performance for the entire procedure. This assessment includes flight checking where appropriate

d) If the procedure allows a choice of navigation infrastructure, e.g. DME/DME or GNSS, the obstacle clearance assessment has been based upon the infrastructure giving the poorest precision.

e) The required navigation aids critical to the operation of a specific procedure, if any, i.e. those which must be available for the required performance, are identified in the AIP and on the relevant charts. Navigation aids that must be excluded from the operation of a specific procedure, if any, are identified in the AIP and on the relevant charts. *Note: This may include required VOR/DME beacons.*

f) Barometric altitude compensation for temperature effects is accounted for in accordance with current approved operating practices. (Temperature compensation is not addressed as a special P-RNAV consideration).

g) The supporting navigation infrastructure, including the GNSS space segment, is monitored and maintained and timely warnings (NOTAM) are issued for non-availability of a P-RNAV procedure if navigational aids, identified in the AIP as critical for a specific P-RNAV procedure, are not available.

h) For procedures which rely on GNSS, the acceptability of the risk of loss of P-RNAV capability for multiple aircraft due to satellite failure or RAIM holes, has been considered by the responsible airspace authority. Similarly, the risk has been considered where a single DME supports multiple P-RNAV procedures.

i) The particular hazards of a terminal area and the feasibility of contingency procedures following loss of P-RNAV capability have been assessed and, where considered necessary, a requirement for the carriage of dual P-RNAV systems has been identified in the AIP for specific terminal P-RNAV procedures, e.g. procedures where radar performance is inadequate for the purposes of supporting P-RNAV. *Note: Airspace authorities may need to amend their national legal code to establish the power to require that P-RNAV or dual PRNAV systems be carried in airspace notified for the purposes of these requirements.*

j) Where reliance is placed on the use of radar to assist contingency procedures, its performance has been shown to be adequate for that purpose, and the requirement for a radar service is identified in the AIP.

k) RT phraseology appropriate to P-RNAV operations has been promulgated.

l) Navigation aids, including TACAN, not compliant with ICAO Annex 10 are excluded from the AIP.34

It is the responsibility of the pilot to ensure that the RNAV system uses inputs from at least one of the nominated infrastructures and maintains the required navigation accuracy.

Annex 3 – Full Assessment of Costs & Benefits for Point Merge in Complex TMA

The attached file contains the full Assessment of Costs & Benefits for Work Stream 2 of the Project.

ACB - Point Merge in Complex TMA

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