Operational Service and Environment Definition (OSED) for Point Merge in Complex TMA

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Abstract

This OSED details the operational concept for the Operational Focus Area (OFA) 02.01.02 of "Point Merge in Complex TMA". It builds on previous concept development and implementation by further developing it to cater for a Point Merge centric P-RNAV route structure and operating method for Very High Capacity (VHC) or High Capacity (HC) needs TMAs. The key developments are as follows:

- An invariant Point Merge design is used, i.e. the Point Merge Systems and STARs do not change whether Easterly or Westerly runways are in use.
- The Point Merge System(s) constitutes a set of Transition options after the end of the STAR (at the Initial Approach Fix), where the options pertain the landing runway.
- Shorter, more efficient, arrival routes that bypass the Point Merge System are defined as alternative routes in the published procedures of the Airspace Users.

The concept is expected to deliver improvements in Human Performance, Safety, and environmental efficiency.

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Executive summary

An OSED addresses a set of operational concept elements, whose corresponding requirements are described in the Safety and Performance Requirements (SPR) document. This OSED details the operational concept for the Operational Focus Area (OFA) 02.01.02 of “Point Merge in Complex TMA”.

Lack of effective P-RNAV operations across all European TMAs affects arriving and departing aircraft, particularly commercial flights, due to the increasing complexity in such environments. In addition, the increasing environmental needs will be difficult to implement without the use of P-RNAV operations.

Point Merge is an innovative method developed by the EUROCONTROL Experimental Centre (EEC); it enables the merging of traffic flows, whilst incorporating the predictability of P-RNAV routes, but affording Controllers a degree of flexibility in the way they manage aircraft associated with traditional ATM.

The introduction of Point Merge procedures has an impact upon the Approach and TMA controller tasks and responsibilities. These changes are mainly likely to result in potential benefits (e.g. reduced communication and workload and more predictability). The changes may also present a risk of some negative impact in terms of vigilance issues, deskilling and job satisfaction.

This OSED builds on previous concept development and implementation by further developing it to cater for a Point Merge centric P-RNAV route structure and operating method for Very High Capacity (VHC) or High Capacity (HC) needs TMAs. The key developments are as follows:

- For a ‘Airspace Constrained’ TMAs with ‘Airfield Interaction’ constraints, it is recommended that an invariant Point Merge design is used, i.e. the Point Merge Systems and STARs do not change whether Easterly or Westerly runways are in use, only the Transitions to runway (Approach Via) change.
- The Point Merge System(s) constitutes a set of Transition options after the end of the STAR (at the Initial Approach Fix), where the options pertain the landing runway. The flight crew should be notified of the expected Transition and distance to fly on sequencing legs, as soon as possible in advance - ideally at, or before, clearance for the STAR - so as to allow suitable time to update the FMS for fuel planning /management considerations.
- Shorter, more efficient, arrival routes that bypass the Point Merge System are defined as alternative routes in the published procedures of the Airspace Users. These are used during periods of low density traffic (e.g. night time),

The concept was evaluated by Fast-Time Simulation, Real-Time Simulation and limited Cockpit Simulation using the London TMA as test case and via two Real Time simulations using Milan TMA as test case.

The concept is expected to deliver significantly reduced controller workload, improved situational awareness and reduced R/T. This enables safety improvements and also enables effective delivery of traffic to meet airport capacity requirements, i.e. making best use of available airport capacity.
Aircraft are expected to spend less time holding but there is likely to be a slight increase in the distance flown, and therefore fuel burnt, for arrivals. However, departing aircraft are expected to have far more efficient climb profiles (lateral & vertical), which reduces fuel burnt and noise pollution.

It is expected that the increased systemisation may make the P-RNAV implementation marginally less resilient to some abnormal events, but more resilient to other abnormal events. The validations did not prove conclusive on this point, for example the London TMA Test Case found that the P-RNAV implementation was less resilient to a Runway Closure event whereas the Milan TMA test case found that it was more resilient.

However, it all cases P-RNAV provided a better situational awareness when compared with baseline situation, due to the possibility to provide for holding patterns inside the Point Merge structure.

1 Introduction

1.1 Purpose of the document

The Operational Service and Environment Definition (OSED) describes the operational concept defined in the Detailed Operational Description (DOD) in the scope of its Operational Focus Area (OFA).

It defines the operational services, their environment, scenarios and use cases and requirements.

The OSED is used as the basis for assessing and establishing operational, safety, performance and interoperability requirements for the related systems further detailed in the Safety and Performance Requirements (SPR) document. The OSED identifies the operational services supported by several entities within the ATM community and includes the operational expectations of the related systems.

This OSED is a top-down refinement of the TMA DOD[1] produced by the federating OPS SWP5.2 project. It also contains additional information which should be consolidated back into the higher level SESAR concepts using a “bottom up” approach.

The figure below presents the location of the OSED within the hierarchy of SESAR concept documents, together with the SESAR Work Package or Project responsible for their maintenance.

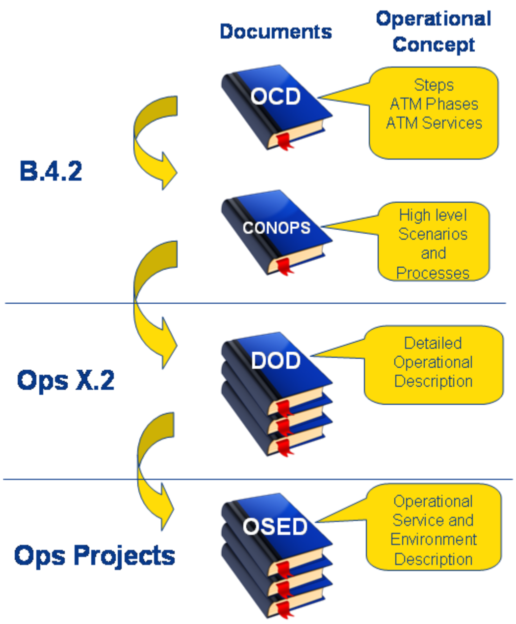

Figure 1: The 4 types of SESAR Operational Concept documents

It is expected that many updates to this OSED will be produced during the lifecycle of the 5.7.4 project

1.2 Scope

This OSED details the operational concept for the Operational Focus Area (OFA) 02.01.02 of **Point Merge in Complex TMA**.

Operational Package	**Operational Sub-Package**	**Operational Focus Area (OFA)**
PAC02 – Efficient and Green Terminal Airspace Operations	Enhanced Route Structures	Point Merge in Complex TMA

This OSED develops a Point Merge centric P-RNAV route structure and operating method for a complex TMA. Therefore, the concept is centred on Point Merge procedures but also incorporates

[1] At the time of writing, a complete baseline SWP5.2 DOD was not available. Therefore, many references have been made instead to applicable high level documents delivered by B.4.2.

aspects of P-RNAV route structures for Arrivals & Departures so that a fully effective concept for TMA airspace is developed.

Only Project 5.7.4 contributes to this OFA.

Project 5.7.4 is also developing the OSED that describes the operational concept for the OFA of Optimised **RNP Structures** (not included in this document). These two OFAs form the Operational Sub-Package of **Enhanced Route Structures**. As defined in the Operational Focus Area Programme Guidance [15], 5.7.4 is the only project contributing this Sub-Package.

SESAR SWP5.3 is expected to perform integrated validation of the project 5.7.4 and project 5.6.4 (Arrival Management) concepts. The outcome of this validation may provide a new iteration of this document on the basis of the integrated validation findings. This OSED captures expected performance in accordance with the performance framework by WPB4.1.

This OSED develops the scenarios and use cases.

The OSED defines the Operational Requirements, based on the expected performance, scenarios and use cases.

1.3 Intended audience

- Primary projects;
  - P 5.6.4 for compatibility with queue management concept
  - P5.6.7 for compatibility with Integrated Sequence Building/Optimisation of Queues
  - P5.9 for HMI needs/requirements
  - WP8 for Information needs/requirements
- Federating projects:
  - SWP 5.2 for Consolidation;
  - SWP 5.3 for cross-WP integrated validation
- Transversal project:
  - WP B for architecture and performance modelling
- ANSPs with Complex TMAs, who are considering development of a P-RNAV route structure using Point Merge

1.4 Structure of the document

The context and scope of the document is provided in Section 1.

Section 2 provides a summary of the Operational Concept from the DOD. This includes mapping of the concept developed in this OSED to the relevant elements in the TMA DOD. It also includes details of the affected KPAs and the Benefit Mechanisms.

Section 3 provides a detailed description of the concept "Point Merge in Complex TMA", divided by flight phase.

Section 4 provides the operational, human and constraining factors of the Operational Environment into which the concept delivers.

A set of Use Cases is detailed in Section 5.

Section 6 is the container of the requirements collected from sections 3 & 5. This section feeds the Safety & Performance Requirements (SPR) document.

Section 7 lists applicable and reference documents.

1.5 Background

The Increasing level of air traffic travelling through UK and European airspace presents ANSPs with additional complexity in the task of efficient Air Traffic Management (ATM). In particular the task of handling arrivals traffic is becoming increasingly controller intensive as traffic is routed using numerous tactical instructions to sequence traffic in preparation for final approach.

The use of existing technology present in Precision Area Navigation (P-RNAV) equipped aircraft provides the opportunity to improve the way in which arrivals traffic is managed, through the implementation of innovative airspace designs, extensive use of an aircraft's in-built Flight Management System (FMS), and a reduction in the number of tactical instructions issued by the controller. However, it should also be noted that although P-RNAV as a concept improves the predictability of aircraft behaviour/performance (position and heading), it also reduces the options available to the Controller while managing traffic (i.e. less flexibility), and so it is desirable to incorporate into the airspace design some features that may reinstate a degree of flexibility when required.

The Point Merge concept enables the merging of arrival flows, whilst incorporating the predictability of P-RNAV routes, but affording Controllers a degree of flexibility in the way they manage aircraft associated with traditional ATM.

Lack of effective P-RNAV operations across all European TMAs will affect arriving and departing aircraft, particularly commercial flights. Consequential safety constraints may also have a knock-on effect to GA traffic to which the TMA is also providing a service. This may result in periods of high density, which introduces additional complexity to the operation. Also the growing environmental constraints will have a difficult solution without the implementation of P-RNAV operations.

Point Merge is an innovative method developed by the EUROCONTROL Experimental Centre (EEC) for merging arrival flows with existing technology including precision area navigation (P-RNAV). It is designed to enable extensive use of the flight management system and continuous descents, even under high traffic load. Point Merge formally corresponds to a P-RNAV application usable in high, medium or low density terminal airspace

Point Merge has already been studied and found feasible and beneficial in various 'generic' environments in Approach (two, three or four entry points; one or two runways; and different TMA sizes). Under this generic validation thread, activities carried out so far (2005-2008) include ground prototyping sessions using real-time human-in-the-loop simulations, initial flight deck real time simulations, and model-based simulations. A 'Point Merge Procedure Design and Coding Assessment' has also been conducted, involving a verification of conformance of the Point Merge procedure to existing international standards, and identification of areas where there may be issues. Support to implementation of Point Merge so far includes:

- EUROCONTROL developed an Operational Services and Environment Definition (OSED) for "Point Merge", an innovative technique developed by the EUROCONTROL Experimental Centre, and designed to improve and harmonise arrival operations in terminal airspace with a pan-European perspective. [14]
- AVINOR (Oslo Gardermoen, planned implementation date: 2011). A large scale assessment carried out successfully for Oslo in 2008/2009 through fast time simulations at the EUROCONTROL Central European Research, Development and Simulation Centre (CRDS), and controllers' real time simulations at the EUROCONTROL Experimental Centre (EEC). [14]
- IAA (Dublin, considered implementation date: 2012). An initial real-time simulation conducted at the EEC for Dublin in 2007, followed by a second simulation in 2010 looking at the expected Dublin TMA 2012 environment including Point Merge and CDAs. [14]
- ENAV (implementation considered in Rome Fiumicino). An initial real-time simulation conducted at the Rome ACC in 2008 and focusing on the TMA, followed by larger scale simulations involving ACC sectors and arrival manager, conducted at ENAV premises in 2009. [14]
- DSNA (Paris ACC). A study undertaken with EUROCONTROL, consisting of a series of small scale Real-Time Simulations and workshops in 2009/2010. Investigated the potential applicability, benefits and limitations of Point Merge for ACC Arrivals, [14] This now constitutes a basis for the exercise 427 of project 5.6.7
- NATS (London Heathrow). Fast Time Simulations undertaken for the Environmentally Responsible Air Transport (ERAT) project in 2010, to analyse the feasibility of CDAs into Heathrow Airport whilst using Point Merge Procedures to maintain landing runway throughput.

While Point Merge can be considered as previously mature (V3) for medium complexity TMAs, the application to multi-airport and highly complex/constrained TMA is developed in this document.

1.6 Glossary of terms

Term	Definition	Source
Actor	An implementation independent unit of responsibility that performs an action to achieve an effect that contributes to a desired end state.	ATM Lexicon
Airspace	A defined three dimensional region of space relevant to air traffic.	ATM Lexicon
Arrival Manager	A planning system to improve arrival flows at one or more airports by calculating the optimised approach / landing sequence and Target Landing Times (TLDT) and, where needed, times for specific fixes for each flight, taking multiple constraints and preferences into account.	ATM Lexicon
Closed Loop Clearance	A clearance resulting in a revision of one portion of the Reference Business Trajectory (RBT), e.g. a direct route from a point of the original RBT to another point of the original RBT.	ATM Lexicon
Complexity	In the ATM context, complexity refers to the number of simultaneous or near- simultaneous interactions of trajectories in a given volume of airspace.	ATM Lexicon
Constraint	Any restriction brought to the preferred trajectory of an aircraft, being either a tactical constraint such as ATCO instruction, or a strategic constraint derived from the operations of the network	ATM Lexicon
Continuous Descent Operation	An operation, enabled by airspace design, procedure design and ATC facilitation, in which an arriving aircraft descends continuously, to the greatest possible extent, by employing minimum engine thrust, ideally in a low drag configuration, prior to the final approach fix /final approach point.	ATM Lexicon
Intermediate Approach	The downwind, base and intercept approach path segments for positioning and turning on to merge on to final approach ending at the interception of the final approach localiser and glideslope.	ATM Lexicon
Level	A generic term relating to the vertical position of an aircraft in flight and meaning variously, height, altitude or flight level.	ATM Lexicon
Level Constraint	The constraint defined by an objective to set the cleared flight level (CFL) for the flight.	ATM Lexicon
Level Off	To maneuver an aircraft into a flight attitude that is parallel to the surface of the earth after gaining or losing altitude.	ATM Lexicon
Managed Airspace	Airspace in which all traffic is known to the Air Traffic System	ATM Lexicon
Open Loop Clearance	An ATC clearance that does not include a specified or implied point where the restriction on the trajectory ends.	ATM Lexicon
Operational Concept	A proposed system in terms of the user needs it will fulfil, its relationship to existing systems or procedures and the ways it will be used. It is used to obtain consensus among the acquirer, developer, support, and user agencies on the operational concept of a proposed system.	ATM Lexicon
Operational Focus Area	A limited set of dependent operational and technical improvements related to an Operational sub-package, comprising specific interrelated OIs designed to meet specific performance expectations of the ATM Performance Partnership.	ATM Lexicon
Operational Improvement	The result of any operational measure or action taken through time in order to improve the performance of the ATM system.	ATM Lexicon
Operational Package	1. A deployment focused grouping of performance driven operational changes and associated technical and procedural enablers. 2. A (very) high level grouping of (related) Operational Improvement Steps for the purpose of (very) high level communication.	ATM Lexicon
Operational Sub-Package	A sub-grouping of connected operational and technical improvements related to the Operational Package with closely related operational focus, designed to meet performance expectations of the ATM Performance Partnership.	ATM Lexicon
Operating Environment	An environment with a consistent type of flight operations.	ATM Lexicon

Term	Definition	Source
Performance-Based Navigation	Area navigation based on performance requirements for aircraft operating along an ATS route, on an instrument approach procedure or in a designated airspace.	ATM Lexicon
Primary Project	Projects that develop and perform validation on aspects of the operational concept and the system	ATM Lexicon
Queue Management	The tactical establishment and maintenance of a safe, orderly and efficient flow of traffic.	ATM Lexicon
Required Navigation Performance	A statement of the navigation performance necessary for operation within a defined airspace.	ATM Lexicon
Separation Constraint	The separation to keep aircraft operating safely on final approach. Examples are minimum radar separation to keep risk of collision to an acceptable safe level and wake turbulence radar separation to keep the risk of an adverse wake turbulence encounter to an acceptable safe level.	ATM Lexicon
Spacing Constraint	The spacing required to be set on final approach for runway operations in the prevailing meteorological conditions. Examples are VIS2 spacing, LVP spacing, runway surface inspection spacing and non-nominal runway occupancy spacing.	ATM Lexicon

1.7 Acronyms and Terminology

Term	Definition
ACARS	Aircraft Communications Addressing and Reporting System
ADD	Architecture Definition Document
ANSP	Air Navigation Service Provider
ATM	Air Traffic Management
ATS	Air Traffic Services
AU	Airspace User
CAT B	Category B (flights)
DOD	Detailed Operational Description
E-ATMS	European Air Traffic Management System
FAF	Final Approach Fix
FIN	Final Approach Director
FMS	Flight Management System
FUA	Flexible Use of Airspace
GA	General Aviation
GS	Ground Speed
IAF	Initial Approach Fix
INT	Intermediate Approach Director
INTEROP	Interoperability Requirements
IRS	Interface Requirements Specification
KPA	Key Performance Area
MAC-TMA	Mid-Air Collision - Terminal Manoeuvring Area (*part of the SESAR Safety model*)
MAP	Missed Approach Procedure
OFA	Operational Focus Area
OSED	Operational Service and Environment Definition
PBN	Performance Based Navigation
PMS	Point Merge System

Term	Definition
P-RNAV	Precision Area Navigation
RF	Radius-to-Fix (turns)
RMA	Radar Manoeuvring Area
SAR	Safety Assessment Report
SESAR	Single European Sky ATM Research Programme
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SID	Standard Instrument Departure
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
SPR	Safety and Performance Requirements
STAR	Standard Instrument Arrival Route
TS	Technical Specification
TAD	Technical Architecture Description
TMA	Terminal Manoeuvring Area
VFR	Visual Flight Rules
VHC	Very High Capacity
VMC	Visual Meteorological Conditions

2 Summary of Operational Concept from DOD

This section addresses WHAT is to be developed and provides the traceability to the relevant DODs. It details in simple terms and plain language the operational concept in the scope of the addressed Operational Focus Area Point Merge in Complex TMA.

2.1 Mapping tables

This section contains the link with the relevant DOD, scenarios and use cases, environment, processes and services relevant for this particular OSED.

The following tables shall be coherent with the related DOD Ops SWP5.2: iterations with OPS SWP5.2 may be necessary in relation with the consolidation activities.

Table 1 lists the Operational Improvement steps (OIs from the definition phase or new OIs), within the associated Operational Focus Area addressed by the OSED.

Each OI Step should in general be allocated to a single OSED, but the possibility of having multiple OSEDs for the same OIs may occur. In this case, the OSED is either the 'Master' (M) or 'Contributing' (C) for the OI Step.

Relevant OI Steps ref. (coming from the definition phase)	Any new / changed OI step (textual form)	Operational Focus Area name	Story Board Step	Master or Contributing (M or C)	Contribution to the OIs short description
AO-0703 - Aircraft Noise Management and Mitigation at and around Airports	No	Point Merge in Complex TMA	IP1	M	All Arrivals and Departures designed to minimise aircraft noise emissions as far as possible given the other influencing factors (e.g. capacity).
AOM-0404 - Optimized Route Network using advanced RNP1	No	Point Merge in Complex TMA	Step 1	C	All procedures designed using one P-RNAV/RNP1 route structure, with such routes extending from final approach, or start of departure SID, into TMA feed sectors.
AOM-0601 - Terminal Airspace Organization Adapted through Use of Best practice, PRNAV and FUA (where suitable)	No	Point Merge in Complex TMA	IP1	C	Terminal Airspace capacity was enhanced by exploiting RNAV capabilities to optimise: placement of SIDs/ STARs, design of terminal airspace structures to evenly distribute ATC workload and minimise adverse ATM-related environmental impact. FUA is not covered.
AOM-0602 - Enhanced Terminal Airspace	No	Point Merge in Complex TMA	IP1	C	All Arrivals use RNP-based segmented approaches, with

with Curved/Segmented Approaches and PRNAV Approaches (where suitable)					vertical constraints, to respond to local operating requirements such as conflict with departures and environmental impact.
AOM-0603 - Enhanced Terminal Airspace for RNP-based Operations	No	Point Merge in Complex TMA	Step 1	C	Terminal Airspace enhanced with the use of RNP terminal routes (incl. A-RNP1 SIDs and STARs).

Table 1: List of relevant OIs within the OFA

Table 2: List of relevant DOD Scenarios and Use Cases identifies the link with the applicable scenarios and use cases of the DOD. At the time of writing this OSED, the DOD Use Cases are not available, so this table refers to expected/applicable Use Cases (plus references to their respective sections in the OSED). The OSED Use Cases are derived from the EUROCONTROL OSED on Point Merge [14] and controller workshops.

Scenario identification	Use Case Identification	*Reference to DOD section where it is described*
Implement TMA/APP in H/H environment, ground solution	High Traffic Demand (multiple: sections 5.1 & 5.3)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in **M/M** environment, ground solution	Low Traffic Demand (multiple: section 5.2)	SWP5.2 DOD, Section 4.1, Sub scenario 1 - variant
Implement TMA/APP in H/H environment, ground solution	P-RNAV equipped aircraft (sections 5.1.1, 5.2.1 & 5.3.1)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	Non-equipped aircraft (section 5.1.2 & 5.3.2)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	Adverse Meteorological Conditions (section 5.1.3 & 5.3.3)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	Emergencies (section 5.1.4 & 5.3.4)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	Sequencing Leg Run-off (section 5.1.5)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	Runway Closure (section 5.1.6)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	Missed Approach (section 5.1.7)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	Runway Change (section 0)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	Wind Direction Change (section 0)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in	Single Aircraft Radio	SWP5.2 DOD, Section

Scenario identification	Use Case Identification	*Reference to DOD section where it is described*
H/H environment, ground solution	Telephony Failure (section 5.4)	4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	P-RNAV Equipage Failure (section 5.4)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	Loss of dedicated airborne hold (section 5.4)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	Level Bust on Sequencing Leg (section 5.4)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	Category B flights operating in the region of the Merge Point (section 5.4)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	Total loss of Radio Telephony (section 5.4)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	Total loss of Surveillance (section 5.4)	SWP5.2 DOD, Section 4.1, Sub scenario 1
Implement TMA/APP in H/H environment, ground solution	Total loss of Navigation (satellite / ground system) (section 5.4)	SWP5.2 DOD, Section 4.1, Sub scenario 1

Table 2: List of relevant DOD Scenarios and Use Cases

Table 3: List of relevant DOD Environments identifies the link with the applicable environments of the DOD.

Operational Environment	Class of environment	*Reference to DOD section where it is described*
London TMA & Milan TMA	Airspace Constrained TMA	Section 3.1
London TMA & Milan TMA	Traffic Volume and Variation Constrained TMA	Section 3.1
London TMA & Milan TMA	Environmentally Constrained TMA	Section 3.1
London TMA & Milan TMA	Airfield interaction Constrained TMA	Section 3.1

Table 3: List of relevant DOD Environments

Table 4: List of the relevant DOD Processes and Services identifies the link with the applicable Operational Processes and Services defined in the Ops WPB4.2 Process Models [7]. This does not list all processes that pertain to the period of flight in question (climb & descent) but to those that are potentially impacted by the 'Point Merge in Complex TMA' concept.

DOD Process / Service Title	Process/ Service identification	Process/ Service short description	*Reference to DOD section where it is described*
Long Term Planning	Plan and Implement ATC Sectors	ATS Operations This corresponds to the airspace design taking into account international procedures and specifications as well as Airspace User requirements and afterwards implementation of new airspaces, e.g. new sectorisations.	WPB4.2
Descent	Execute Descent	AU Operations At TOD, fly and monitor the conformance to the RBT and clearances, e.g. a Continuous Descent Approach integrating route/altitude constraints and the CTA when required, i.e. a near idle descent profile based on optimum engine and airframe settings.	WPB4.2
Descent	Monitor Traffic	ATS Operations Monitor traffic situation and detect potential hazards.	WPB4.2
Descent	Separate Traffic	ATS Operations Keep aircraft in the air or on the manoeuvring area away from hazards.	WPB4.2
Descent	Synchronise Traffic	ATS Operations Traffic synchronization principles include the ability to tactically and collaboratively modify sequences to optimize aerodrome operations, including gate management and/or airspace user operations, evolution into 4-D control where a flight is given a time profile to follow to optimize throughput, delegation of maintenance of spacing to the flight deck to increase traffic throughput while reducing ground system workload, and wake vortex, which will continue to be a determinant of minimum spacing.	WPB4.2
Climb	Execute Climb	AU Operations Fly and monitor the conformance to the RBT between take-off and TOC.	WPB4.2
Climb	Monitor Traffic	ATS Operations Monitor traffic situation and	WPB4.2

DOD Process / Service Title	Process/ Service identification	Process/ Service short description	*Reference to DOD section where it is described*
		detect potential hazards.	
Climb	Control Traffic	ATS Operations Prevent collisions between aircraft, and on the manoeuvring area between aircraft and obstructions. Expedite and maintain an orderly flow of traffic.	WPB4.2

Table 4: List of the relevant DOD Processes and Services

From this table, if can be seen that there are 4 key ATC processes:

1. Plan and Implement ATC Sectors – creating the P-RNAV/PMS airspace design
2. Monitor Traffic – on P-RNAV routes during climb and descent/approach phases
3. Separate Traffic - on P-RNAV routes during climb and descent/approach phases (‘Control Traffic’ can be equated with ‘Separate Traffic’)
4. Synchronise Traffic – via the PMS during descent/approach phase.

Table 5: List of the relevant DOD Requirements summarizes the Requirements including Performance (KPA related) requirements relevant of the OSED. This table supports defining the performance objectives in the scope of the addressed OFA. The DOD performance requirements are structured to respond to Key Performance Indicators (PI) targets / decomposed PIs, so this table will support traceability to the performance framework.

DOD Requirement Identification	DOD requirement title	*Reference to DOD section where it is described*
REQ-05.02-DOD-OPER-0001	Advanced RNP-1 shall be implemented and shall support enhancements of route structure. Spacing between routes shall be reduced where required, with commensurate requirements on airborne navigation and ground systems capabilities.	Section 6
REQ-05.02-DOD-OPER-0002	RNP-1 based instrument procedures with vertical guidance shall be used to increase safety (reduce the risk of CFIT).	Section 6
REQ-05.02-DOD-SAF0.0001	OFA “Point Merge in Complex TMA” shall deliver a 5% safety benefit to the barrier “MAC-TMA - Tactical Conflict Management Induced”.	Section 6
REQ-05.02-DOD-SAF0.0002	OFA “Point Merge in Complex TMA” shall deliver a 5% safety benefit to the barrier “MAC-TMA - Tactical Conflict Management Planned”.	Section 6
REQ-05.02-DOD-	OFA “Point Merge in Complex TMA”	Section 6

DOD Requirement Identification	DOD requirement title	*Reference to DOD section where it is described*
CAP0.0005	shall deliver a 5.0% increase in capacity in respect to Improved Separation Management TMA.	
REQ-05.02-DOD-CAP0.0006	OFA "Point Merge in Complex TMA" shall deliver a 5.0% increase in capacity in respect to Improved Complexity Management TMA.	Section 6
REQ-05.02-DOD-ENV0.0004	OFA "Point Merge in Complex TMA" shall deliver a 10% reduction in fuel burn per flight in the TMA arrival phase of flight	Section 6
REQ-05.02-DOD-CEF0.0007	OFA "Point Merge in Complex TMA" shall deliver a 2.5% improvement in predictability in respect to TWR APP Controller Productivity.	Section 6
REQ-05.02-DOD-PRED.0006	OFA "Point Merge in Complex TMA" shall deliver a 5.0% improvement in predictability in the TMA Arrival phase.	Section 6

Table 5: List of the relevant DOD Requirements

2.2 Operational Concept Description

This section of the OSED describes in simple terms and plain language the addressed Operational Concept elements (in coherence with the DOD description), that are further developed in the document.

The Operational Concept of Point Merge has already been defined by EUROCONTROL. Details can be found in their Operational Services and Environment Definition document [14], of which, the following is an extract:

"The route structure supporting Point Merge is denoted "Point Merge System" (PMS). A PMS may be defined as an RNAV STAR, transition or initial approach procedure, or a portion thereof, and is characterised by the following features:

- A single point – denoted 'merge point', is used for traffic integration;
- Pre-defined legs – denoted 'sequencing legs', isodistant and equidistant from the merge point, are dedicated to path stretching/shortening18 for each inbound flow. These legs shall be separated by design vertically, laterally or both.

The resulting envelope of possible paths towards the merge point is contained in a "triangle-shaped" area.

The Point Merge operating method aims at integrating inbound flows, using a PMS route structure, and comprises two main phases:

- Create the spacing through:
  - path stretching without ATC intervention – by leaving aircraft fly along the sequencing leg, followed by
  - a "direct-to" instruction to the merge point, issued when the appropriate spacing is reached with the preceding aircraft in the sequence;
- Maintain the spacing through speed control after leaving the legs.

The normal procedure only involves one ATC lateral intervention i.e. the direct-to instruction. As this is a closed loop intervention, aircraft remain under lateral guidance by the FMS all along the procedure. This "direct-to" instruction is key to the operation of Point Merge as it creates both the sequence order and the initial longitudinal inter-aircraft spacing in the sequence. Alternate procedures in the frame of Point Merge may involve the use of open-loop vectors e.g. for non-equipped aircraft or to deal with unexpected events."

Figure 2 is an extract of the EUROCONTROL OSED that illustrates the Point Merge concept.

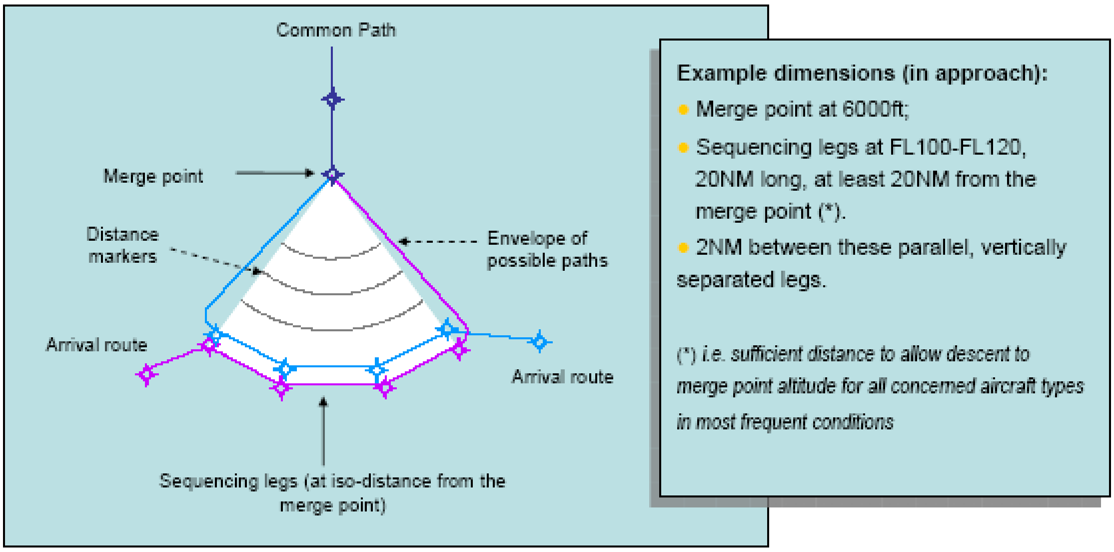

Figure 2: Example Point Merge Route Structure

The Operational Concept of P-RNAV has already been defined by a myriad of documentation, including ICAO [18][19] and EUROCONTROL [20][21].

This OSED builds upon these concepts with the following objectives:

- Develop the Point Merge concept, with P-RNAV procedures, to solve safety, capacity, complexity, environment or efficiency limitations in complex TMAs, based upon current deployment in medium complexity TMAs.
- Develop TMA design to address complex traffic management in multi-airport and mixed mode environments.

Environmental Sustainability

Benefits of the concept are expected in Fuel Efficiency and Environment KPAs, through the increased provision of Continuous Descent Approaches and Continuous Climb Departures. CDAs can be directly designed into the P-RNAV approach routes, as described in EUROCONTROL's Operational Services and Environment Definition [14]:

"The normal procedure…only involves one ATC vertical intervention i.e. a **descent** clearance that may be given after direct-to, when clear of traffic on the other [sequencing] leg(s)… The descent profile can be optimised accordingly, at least from the sequencing legs altitude/level, in the form of a **Continuous Descent Approach** (CDA) – as the distance to go is known by the FMS."

The P-RNAV approach routes should also be designed so as to enable design of efficient CCDs. Use P-RNAV routes with CDAs can enable vertical stack holds to be moved higher and further away from the runway, which frees up altitudes/levels for CCDs to be designed.

CDAs will improve the fuel efficiency for TMA arrivals and CCDs will improve the fuel efficiency for TMA departures; Figure 3 illustrates how this affects the WPB4.1 Influence Models [25].

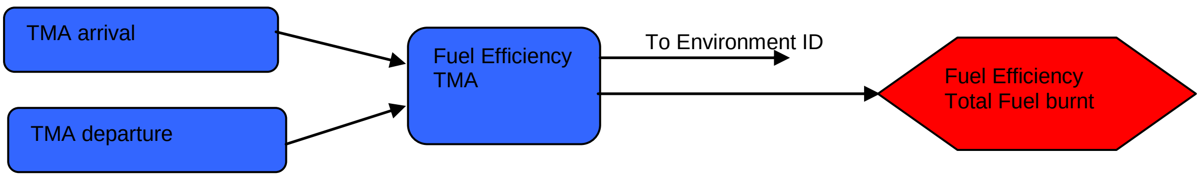

Figure 3: The elements of the Fuel Efficiency KPA that relate to Point Merge in Complex TMA

Benefits of the concept are also expected in reduction of noise pollution for the environments local to the impacted airfields. The use of P-RNAV routes enables greater use of CDAs and CCDs, which lessen the net noise impact generated by arriving and departing aircraft respectively. Point Merge procedures provide a limited amount of lateral holding, which enables reduction in Stack (vertical) holding; depending upon how the Point Merge procedures are designed, there is a potential to lessen the net noise impact generated by arriving aircraft. The current Environmental Sustainability KPIs do not encompass noise.

Predictability, Flexibility & Capacity

The design of TMA airspace using a P-RNAV route structure increases the predictability of air traffic position and heading, but it also has a negative impact on flexibility in terms of options that the Approach controller has to space and sequence the traffic. This is described in EUROCONTROL's Operational Services and Environment Definition [14]:

"There is obviously a trade-off between flexibility and predictability regarding procedures for arrival flows integration. Current vectoring procedures offer high flexibility, but on the other hand, predictability is low and the corresponding tasks are quite demanding for air traffic controllers and for the aircrew."

In a P-RNAV route structure, the Controllers have reduced options on how to manage the traffic, which may result in the runway throughput being decreased where runway throughput is very high under current day operations. Correspondingly, it is also expected that the increased systemisation may make the P-RNAV implementation marginally less resilient to abnormal events, such as runway closure. Flexibility of options for the Approach controller is necessary to allow them to maintain throughput and to have contingency to deal with abnormal events. To counteract this negative trade-off, the introduction of Point Merge procedures into a P-RNAV route structure re-instates some of this necessary flexibility, whilst retaining much of the predictability benefit of P-RNAV. Point Merge is a closed-loop procedure; for example, Arrival Management systems are able to operate using Point Merge constructs.

Note: Benefits of the concept are also expected in 'geographical' Predictability but the current Predictability KPIs are only identified in the form of 'time' predictability. The use of P-RNAV routes with Point Merge procedures will increase the predictability of aircraft performance and, as a result, situational awareness for both Controller and Flight Crew.

There is an increase in the potential airspace capacity - movements through the TMA - which is enabled by:

- Reduced route separation across the TMA due to P-RNAV route design.
- The aforementioned improvements in predictability due to P-RNAV.
- Reduced Controller and Flight Crew workload due to Pre-defined P-RNAV routes and he relative simplicity of ATC instruction for Point Merge procedures: "Turn [left/right] direct to Merge Point"/"Descend to be below [altitude] by Merge Point". This in contrast with the conventional heading/level instructions, where R/T workload for the Controller and the Flight Crew is high

The last two bullets in the list above also enable the delivery of traffic closer to airport capacity requirements, i.e. making best use of available airport capacity, because the Approach controller can manage greater numbers of flights, at any one time, due to their workload reduction per flight.

It is expected that the increased systemisation may make the P-RNAV implementation marginally less resilient to some abnormal events, but more resilient to other abnormal events. The validations did not prove conclusive on this point, for example the London TMA Test Case found that the P-RNAV implementation was less resilient to a Runway Closure event whereas the Milan TMA test case found that it was more resilient [26].

However, it all cases P-RNAV provided a better situational awareness when compared with baseline situation, due to the possibility to provide for holding patterns inside the Point Merge structure.

Safety

As with airspace capacity, there is a potential increase in Safety, which is enabled by:

- The aforementioned improvements in predictability due to P-RNAV.

- Reduced Controller and Flight Crew workload due to Pre-defined P-RNAV routes and he relative simplicity of ATC instruction for Point Merge procedures: "Turn [left/right] direct to Merge Point"/" Descend to be below [altitude] by Merge Point". This in contrast with the conventional heading/level instructions, where R/T workload for the Controller and the Flight Crew is high
- Reduction in situational display clutter caused by multiple aircraft at different levels in a holding stack.

A safety risk may be introduced through the increased number of aircraft flying at the same one or two levels in close proximity, i.e. on the Point Merge sequencing legs. Robust procedures need to be generated to deal with non-nominal situations when recovery of high numbers of aircraft from the same level is necessary; these are covered in Section 5, Detailed Operational Scenarios / Use Cases.

Cost Effectiveness

The simplicity of the Point Merge procedures, and potential to use them to homogenise Approach procedures for each airfield within a given TMA, enables ANSP cost reduction due to:

- The reduced training/re-training needs of the Approach Controllers
- Improved flexibility of resourcing Approach operations

Security

ATM Security needs to be considered for the following:

Asset	Vulnerability	Threats	Evaluation	Treatment
Technical System	<no Technical system change>	n/a	n/a	n/a
System Adaptation	Resilience: P-RNAV Indicator	Data Integrity compromised	L kelihood: low Impact: low	Control: Technical - Access control Control: Organisational – staff security check
	Resilience: Radar maps	Data Integrity compromised	L kelihood: low Impact: low	Control: Technical - Access control Control: Organisational – staff security check
Procedures	<no change to Roles & Responsibilities>	n/a	n/a	n/a
	Resilience: Ops Procedures	Runway Closure due to security breach	L kelihood: low Impact: low	/Safety Assessment of Ops procedures under this event
		Degraded Modes of Operation	L kelihood: medium Impact: medium	As per Safety Assessment of Ops procedures under such events

KPIs

Benefit Mechanisms apply as illustrated:

Benefit Mechanisms

Table 6 lists the Key Performance Indicators (KPIs), as defined for the SESAR Programme, that the concept OFA is expected to contribute to. Results of the P5.7.4 validation exercises per KPA [26], for the TMA overall (Approach and TMA sectors), are displayed in the final two columns to provide an indication of potential benefits.

FOCUS AREAS	Lower level Focus Areas		KPIs	London TMA	Milan 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	**Refer to SAR** [28]	TMA safety levels not impaired Strong reduction in workload Descent management included inside PMS
ENV1 Environmental Sustainability Outcome	**ENV11** Atmospheric Effects	**ENV1111** Gaseous Emissions	**ENV1111 O1 I1:** Average fuel consumption per flight as a result of ATM improvements	2%	Improved vertical profile allowing for continuous descent Benefits observed also for Milan Linate and Milan Malpensa departures due to the availability of higher level for initial climb
			ENV1111 O1 I2: Average CO2 emission per flight as a result of ATM improvements	2%	Improved vertical profile allowing for continuous descent Benefits observed also for Milan Linate and Milan Malpensa departures due to the availability of higher level for initial climb
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 the number of handled traffic per hour as inbound arrival capacity for Malpensa airport; Surrounding aerodromes not impaired;
CAP3 Airport capacity	**CAP31** BIC capacity in VMC[2]	**CAP 311** Single RWY Airport capacity in VMC	**CAP311 O1 I1**: Best In Class (BIC) declared airport capacity in VMC (1 RWY), mov/hr	4%	Increase in runway throughput potentially achievable depending on aerodrome layout
		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 depending on aerodrome layout
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 6: 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).

2.3 Processes and Services (P&S)

The OSED refines the following processes and services (DOD elements) identified by Ops WPB4.2 Process Models and Operational Services definition [7]

[2] Visual Meteorological Conditions

Diagram	Node	Process	Operational Service Name	Refinement through this OSED
Long Term Planning	ATS Operations	Plan and Implement ATC Sectors	<None Identified>	Changes to TMA Airspace Design to incorporate P-RNAV routes or other Performance Based Navigation (PBN), using Point Merge Procedures.
Medium/Short Term Planning	ATS Operations	Plan and Implement ATC Sectors	<None Identified>	Changes to TMA Airspace Design to incorporate P-RNAV routes or other PBN, using Point Merge Procedures.
Descent	ATS Operations	Separate Traffic Traffic	Traffic Separation Provision Service	Traffic separation maintained by speed control on P-RNAV routes and timing of instructions on Point Merge procedures. Reliance on open loop vectoring greatly reduced under nominal operating conditions.
	ATS Operations	Synchronise Traffic	Arrival Traffic Sequencing Service	It is assumed that Arrival Management will sequence traffic accordingly prior to entry to the TMA. However, as per the SESAR CONOPS [17], flexibility is key to maximum use of capacity. PBN-based route structures lack flexibility so Point Merge provides the ability to achieve optimum spacing and a limited ability to resequence.

Table 7: Processes & Services refined by the ‘Point Merge in Complex TMA’ OFA

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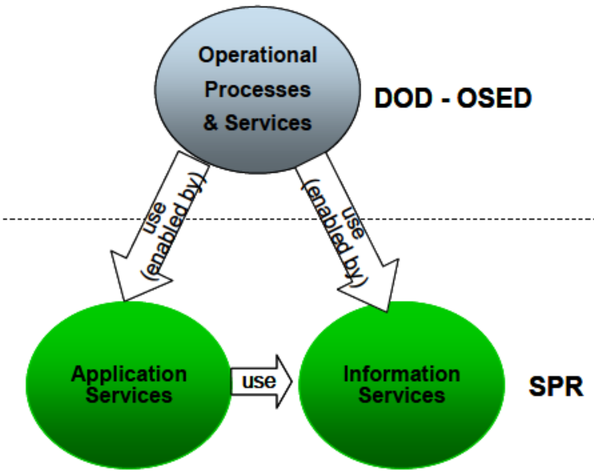


Figure 4: Application services and Information Services dependency to Operational Processes and Services

3 Detailed Operating Method

3.1 Previous Operating Method

OVERVIEW

Flight-planned routes end at the holding stacks. To get flights from the holding stacks to the runway, a combination of procedural approach and radar vectoring is used.

Approach controllers employ "Open-loop" operations, using tactical vectors: heading, speed and vertical altitude intervention, to sequence and space the arrival traffic.

Aircraft navigate using direct signals from ground-based navigation aids (DME, VOR & NDB), so route design is constrained by the location of the navigation beacons. Optimal arrival and departure routes are impracticable due to siting and cost constraints on installing ground-based radio navigation aids [19].

Tactically Enhanced Arrival Mode (TEAM) operations employed at London Heathrow airport, which allows for up to six aircraft per hour to be landed on the departures runway during peak periods of high arrival delay

3.2 New SESAR Operating Method

This section details the new operating method for each of the 4 phases of flight identified in Section 4. Within each phase, the operating method is considered for 'Normal Mode – Main Flow' and 'Normal Mode – Alternative Flows'; Abnormal Modes are detailed in Section 5.

These 'modes' and 'flows' are described in EUROCONTROL's Operational Services and Environment Definition [14]:

"The normal mode (i.e. in the absence of failures) comprises:

- A "main flow" for the nominal case, describing the core operating method and its main options for equipped aircraft;
- And "alternative flows" for specific variants, covering special/non-nominal cases (still normal i.e. not involving any particular failure) such as non-equipped aircraft, sequencing leg run-off or missed approach, and inducing alternative sequences of actions.

The abnormal mode corresponds to exception handling or service failure cases, such as loss of RNAV capability."

OVERVIEW

The new operating method should comply with the Guiding Rules, Constituents, Route Structure and Operating Method provided in Section 5.1 of the EUROCONTROL OSED [14] and the EUROCONTROL TMA Design Guidelines [20].
The new operating method detailed below includes implicit selections of the options provided by the EUROCONTROL guidelines. These selections have been made through a combination of the following inputs:

- Concept and safety workshops with participation of Approach and TC controllers from London & Milan TMA.
- Concept Airspace Design work, undertaken by Airspace Design specialists and Controllers, to determine feasible Arrival and Departure routes for a sub-set of the airfields within the London & Milan TMA.
- Fast-Time and Real-Time Simulations of Point Merge Procedures for a selection of airfields in the London TMAs.
- Airspace User feedback on the concept through design reviews and limited Cockpit Sessions for Descent and Approach phases at London Stansted and London Heathrow.

Two Real Time simulations of Point Merge procedures for Milan TMA area; the selection of design options was focussed on gaining the most efficient route structure and operating method possible whilst staying within the constraints imposed by the Airspace Configuration Characteristics [Section, 4.1].

Point Merge procedures are implemented as part of a Performance-Based Navigation (PBN) concept of operations, using P-RNAV routes.

3.2.1Arrivals: Extended TMA boundary to TMA Boundary

3.2.1.1 Normal Mode – Main Flow

High traffic density & complexity

To fully support the new operating method, traffic is expected to arrive at the Extended TMA (ETMA) boundary on P-RNAV routes, under the responsibility of Area Control. Within the ETMA boundary, the flights will reach Top of Descent (ToD). Wherever possible, the P-RNAV routes should provide a continuous descent to a holding stack within the TMA boundary. Before the flight reaches the TMA boundary, the Area Controller should handover to Terminal Control.

P-RNAV routes will likely need to be merged at, and/or before, the TMA boundary. This could be achieved by various means:

- via holding stacks,
- via Point Merge Systems or
- via the simple joining of routes.

Within SESAR Step 1, traffic arriving at the ETMA boundary is not expected to be fully sequenced and spaced[3]. Therefore, it is expected that some changes to sequencing and spacing will be required within the ETMA boundary to improve delivery to the TMA. The use of holding stacks or Point Merge Systems at the merging of routes could be effective at absorbing delay and sequencing the traffic for delivery into the TMA. However, in this OSED, we will only consider the use of speed controls and holding stacks to manage traffic flows on merging routes outside of the TMA; Point Merge is only considered within the TMA boundary.

To enable further traffic sequencing, alternative STARS, waypoints or vectors may be used by the ACC controller.

Medium traffic density & complexity

No change in operating method from the High traffic density and complexity scenario.

3.2.1.2 Normal Mode – Alternative Flows

Non-equipped aircraft

If airspace availability permits, conventional routes may also be applied in parallel to the P-RNAV routes. However, it is assumed that all aircraft are B-RNAV capable and therefore capable of following the P-RNAV routes but with a greater degree of tolerance required, due to:

> Fewer number of waypoints programmable in the FMS and

> Uncertified to meet the accuracy requirements of P-RNAV.

Using the same routes/SIDs/STARs/IAF/FAF for equipped and non-equipped aircraft reduces the complexity of the route network in the ETMA, which may be necessary to do in a high-density traffic environment. However, the controller clearly cannot rely on route separation alone, which makes it essential for the controller to be fully aware of any non-equipped aircraft entering his/her airspace so that they can react accordingly, where necessary, due to the reduced navigational accuracy of such aircraft. For example, where parallel P-RNAV routes are 5nm apart.

Controller awareness can be achieved by:

[3] The Arrival Management concept will provide Calculated Times of Arrival (CTA) ± a tolerance at the ETMA boundary.

> P-RNAV equipage indicator on the flight strip and

> Flight crew reporting by exception (i.e. if not P-RNAV equipped).

Where necessary, the controller can use speed controls, transitions or vectors to maintain separation.

Adverse Meteorological conditions

In the event of strong wind conditions: controllers will apply greater longitudinal separation on the P-RNAV routes and/or speed controls.

In the event of Thunderstorms directly affecting P-RNAV routes, controllers will seek to use alternative STARs or Direct-To waypoint clearances. Where this is not possible, they will revert to radar headings to avoid the affected area.

Emergency

Where alternative STARs or Direct-To waypoint clearances are possible from each ETMA Entry Point to the TMA Boundary, these could be used to prioritise aircraft with an emergency squawk by placing them on the shorter route, whilst placing other aircraft on longer routes; speed controls may also be employed. If such options are not available, or the use of them in not feasible, then the controller will revert to radar headings.

3.2.2 Arrivals: TMA Boundary to IAF

3.2.2.1 Normal Mode – Main Flow

High traffic density & complexity

Traffic is expected to arrive at the TMA boundary on P-RNAV routes, under the responsibility of Terminal Control. Within the TMA boundary, the P-RNAV route will take the flight to a holding stack and the controller will determine whether the flight needs to hold in the stack or can continue directly to the Initial Approach Fix (IAF).

Where aircraft are following an RNP route, and are not diverted from their STAR, "Silent Releases" could be used for handover between controllers. In this case, the downstream controller knows what to expect (where and when) from the upstream controller so no verbal release is necessary. This reduces controller workload.

P-RNAV routes will likely need to be merged at the holding stacks, Stacks close to the PMS should be controlled by the Approach controller so that they can effectively manage loading on the sequencing leg(s). Therefore, before the flight reaches the holding stack, the Terminal Controller should handover to Approach Control.

The holding stack should be used to deliver the traffic sequence and loading levels as required by the Approach controller managing the Point Merge sequencing leg(s).
For 'Traffic Volume and Variation Constrained' TMAs, where pressure on the runways needs to be maintained at a high level, the controller will always have aircraft available in the holds (the Point Merge sequencing legs and/or holding stacks) to ensure that a consistent flow of traffic through Approach can be maintained. During peak traffic periods, this necessitates an average holding per aircraft equal to the time it takes to perform one circuit of the stack.

In a 'Traffic Volume and Variation Constrained' TMA, it is recommended that each sequencing leg is fed by a dedicated holding stack because this enables optimum flexibility & control over the traffic flows into the Point Merge System.

It is recommended that the IAF be defined prior to entry to the Point Merge System. The reason for this is that Airlines are regulated to fuel for the full STAR. If the airline has to fuel for the full PMS then add additional fuel to account for holding time, they are carrying more fuel than required; time on sequencing leg must be considered as holding time. The PMS should be defined as a Transition.

Level restrictions must be in place to ensure aircraft are in level flight 5nm before entry into the sequencing legs; this is to ensure that minimum vertical separation is achieved before minimum lateral separation is breached. One option is that Procedures are designed so that the level restrictions are tactically managed, as opposed to planned, e.g. "Expect level <x>" instead of "At level <x>". This would allow the controller to use the level restrictions to maintain separation when the sequencing legs have traffic on them but also allow the controller to give a continuous descent through the PMS when there are no potential conflicts. In this case, the controller must notify the pilot as early as possible of any constraints to be applied, so that the pilot can plan accordingly a fly the most efficient descent possible given the constraints.

Medium traffic density & complexity

Waypoints may be defined at the entry points of the sequencing to provide the controllers with the opportunity to direct traffic straight to the Point Merge arcs. This would provide path shortening where an aircraft could descend rapidly enough and mitigate some non-nominal scenarios, such as P-RNAV equipage failure.

3.2.2.2 Normal Mode – Alternative Flows

Non-equipped aircraft

As per section 3.2.1.2

Adverse Meteorological conditions

In the event of strong wind conditions: controllers will apply greater longitudinal separation on the P-RNAV routes and/or speed controls, as dictated by PMS loading necessary to meet the runway spacing requirements.

In the event of Thunderstorms directly affecting P-RNAV routes, controllers will revert to radar headings to avoid the affected area, with the stacks used to control the traffic flow as necessary.

Emergency

The following assumes that an Emergency diversion to an alternative airfield is not an option or is not necessary:

As per 'Medium traffic density & complexity'

3.2.3 Arrivals: IAF to FAF

3.2.3.1 Normal Mode – Main Flow

High traffic density & complexity

Point Merge Systems

Each landing runway is fed by one or more Point Merge Systems with multiple sequencing legs, dependent upon the volumes of airspace available within which to site the Point Merge Systems and the quantity of delay absorption required.

The Point Merge System should be used for final adjustment to traffic sequencing, sequencing multiple traffic flows together (as arriving on the sequencing legs), optimising spacing of traffic delivery to either the base leg or final approach and prioritising emergencies where necessary.

There are several ways for the pilot to perform descent/approach (full managed, V/S, DES, OP DES, NAV, HDG...), which may lead to different behaviours in handling constraints and clearances. This should be further considered when developing operational procedures.

Following controller workshops and Real-Time Simulations, the nominal mode of operation recommended is Point Merge with level-off and single level on the sequencing legs. General conditions, Pre-conditions, Post-conditions & Operating Method as per section 7.1.1 of the EUROCONTROL OSED [14]. Accordingly, there would need to be an “At level [FL/altitude] by” restriction prior to entering the sequencing legs, at a distance equal to or greater than the separation minima.

Point Merge Systems with multiple levels, or without level-off, on the sequencing legs are likely to provide improved descent efficiency and may be possible, but implementation within the limited airspace of a complex TMA is expected to be difficult:

- Greater complexity for the controller to manage the sequencing legs.
- Takes up more levels in the airspace, which will impact on potential for CCDs.

The London TMA test case used level-offs on the sequencing legs but the Milan TMA test case did not. Both test cases demonstrated environmental benefits; refer to the Validation Report [26].

If facilitated by the P-RNAV route structure, continuous descent could be provided from the Top of Descent (ToD) to the "At level [FL/altitude] by" restriction then from the sequencing leg to runway. Therefore, the shorter the hold on the sequencing leg, the better the vertical profile.

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).

Guidance from EUROCONTROL is that the most efficient size of Point Merge System is 20nm from Merge Point to closest sequencing leg. However, in an 'Airspace Constrained' and/or 'Airfield Interaction Constrained' TMA, this size of Point Merge System may not be practical. Point Merge Systems of less than 15nm from Merge Point to closest sequencing leg provide severely limited lateral holding, making it difficult for Approach Controllers to manage high volumes of traffic. Therefore, a Point Merge System size of 15nm or more is recommended for 'Airspace Constrained' and/or 'Airfield Interaction Constrained' TMAs which are also 'Traffic Volume and Variation Constrained'.

Consideration should be given to how the Point Merge Sequencing Legs are comprised:

(a) Multiple waypoints to create a pseudo arc

(b) Radius-to-Fix (RF) Turn around the Merge Point, where the sequencing leg maintains a constant radius turn around the fix.

Option (a) is better suited to cope with a mixed-equipage environment (see Assumptions in Section 4.1), which is highly likely – especially during a period of transition.

Option (b) may be implemented where aircraft equipage allows. The primary benefit of using RF Turns is the reduction in the number of waypoints that need to be defined for the approach route. This option may also help solve the problem of lack of homogeneity in autopilot engagement, where automated trajectory execution still represents a problem in airports where early turn departures are needed to avoid surrounding noise sensitive areas.

Whether Options (a) and (b) could be defined in parallel (i.e. use RF Turns if equipped, follow multiple waypoints if not) is not concluded here but is deemed to be a potential option. The Sequencing Legs do not rely on lateral separation, so there is no risk of conflict between them. The risk of catch-up: one aircraft on an RF Turn, the following aircraft flying via multiple waypoints, is similar to that of a B-RNAV equipped aircraft following a P-RNAV equipped aircraft; this has been analysed as part of the Safety Assessment Report [28].

Invariant Design

For an 'Airspace Constrained' TMAs with 'Airfield Interaction' constraints, it is recommended that an invariant Point Merge design is used, i.e. the PMS and STARs do not change whether Easterly or Westerly runways are in use (this applies equally to both the lateral and vertical dimensions), only the Transitions to runway (Approach Via) change.

The Point Merge system constitutes a set of Transition options after the end of the STAR (at the IAF), where the options pertain the landing runway. The flight crew should be notified of the expected Transition and distance to fly on sequencing legs, as soon as possible in advance - ideally at, or before, clearance for the STAR - so as to allow suitable time to update the FMS for fuel planning /management considerations.

The sequencing legs are to be considered as lateral holds, so that any time spent on a sequencing leg is time spent in a hold and not, therefore, considered as part of the route for fuel planning purposes.

Figure 5 provides an example of an invariant Point Merge design. Such a design minimises the complexity of the route structure for arrivals and departures because they do not need to change dependent on the wind direction or runway in use. The STARs do not change and the change in SIDs due to runway in use is minimal. When each airfield is considered as just one overlapping puzzle piece of the TMA, it is clear to see how this invariant design significantly reduces the complexity of the overall TMA design, which frees up space for more efficient routes and use of airspace.

The drawback of an invariant design is that the transitions for arrivals cannot be optimised for both runway directions. In the example given by Figure 5, assuming that the altitudes/flight-levels on the sequencing legs are invariant, it can be seen that the descent for the westerly runway may be quite tight whilst the descent for the easterly runway must be shallow and inefficient in comparison.

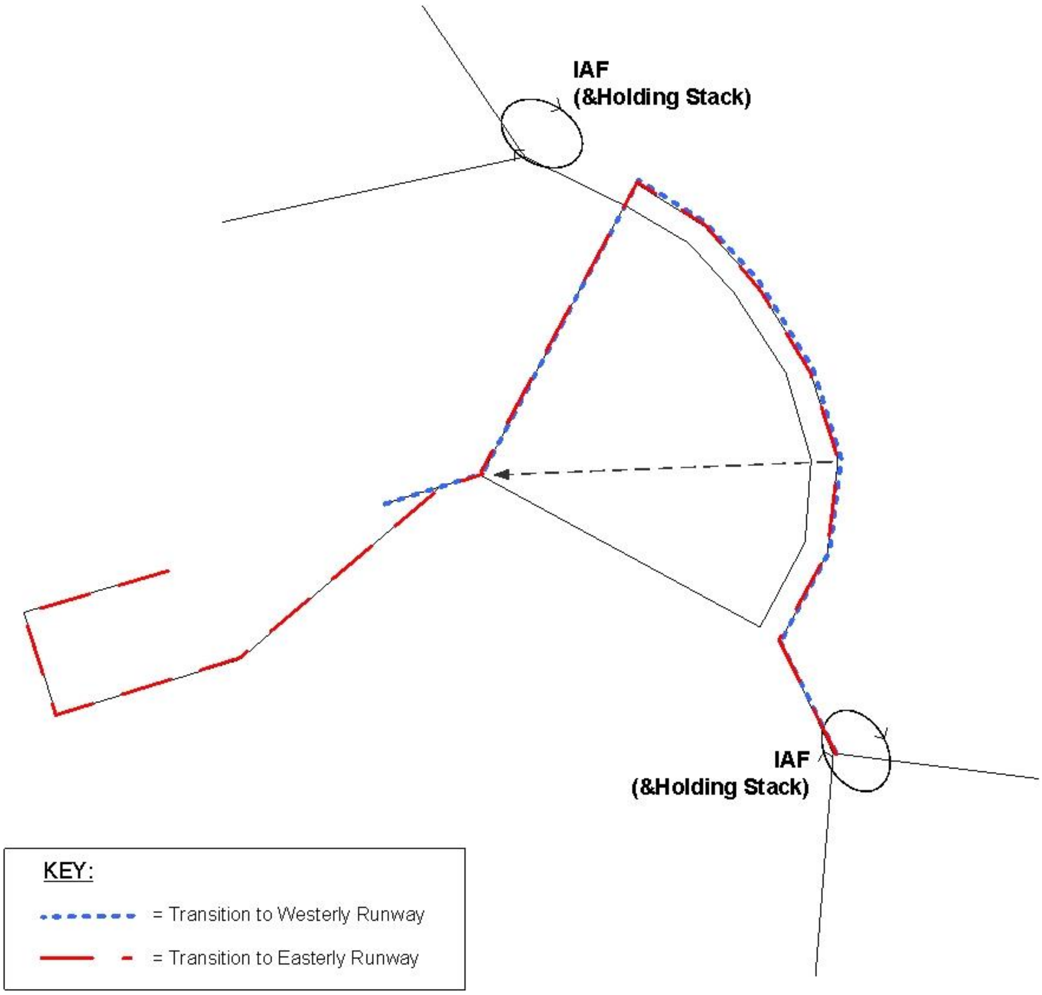


Figure 5: Example of an Invariant Point Merge Design

One way to offset the potential inefficiencies of the invariant design is to offer short-cuts outside of the Point Merge System. The Point Merge System is designed to deal with periods of high density traffic but, during periods of low density traffic (e.g. night time) shorter, more efficient routes should be made available.

Under low traffic density, short routes can work well either as tactical controller intervention (Direct-To or Expect Route x-y-z) or as predefined short transitions (outside of the PMS). The use of predefined short transitions is expected to be limited to very specific quiet times of the day; at other times, Approach controllers should attempt to provide tactical short routes when possible – liaising with TMA controllers as necessary.

It is recommend that all short routes (even night-time) be provided on a tactical basis but ATC will notify pilot “Expect Direct-To” as early as possible; this means that Short Routes do not need to be raised as additional published procedure. Instead, the published procedure should have a Short Route(s) added as an alternative. For example: a dotted line annotated with “Expect this route after 2330hrs”. Outside of this time the controller can still provide the Short Route when possible. One of the primary benefits of adding this ‘alternative’ route to the published procedure is that the pilot will know the exact distance to touchdown.

The evolution of the concept (for Dynamic TMA management in SESAR Step 2), should see the direct route - the "Short Route" – as the standard planned route and the PMS as an alternative/contingency transition. This will only become possible with effective time and trajectory management.

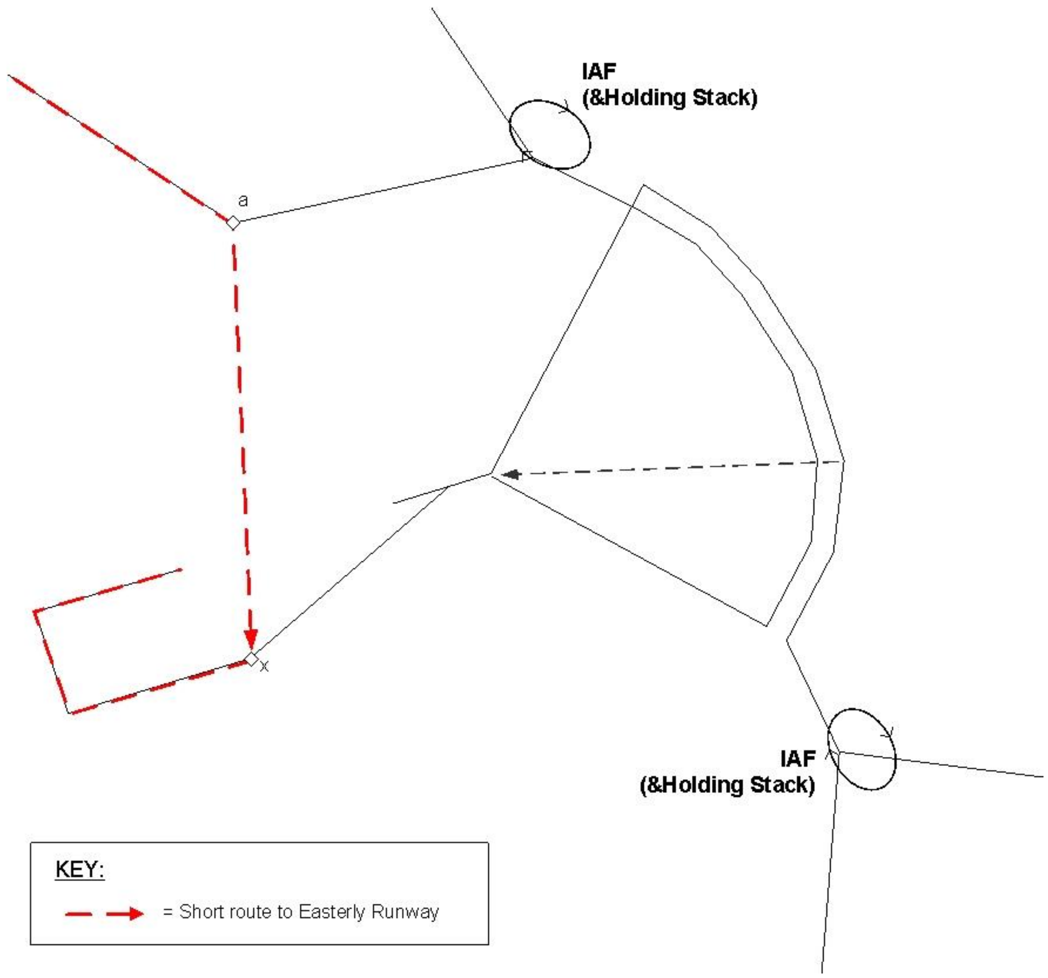


Figure 6: Example of a short route for an Invariant Point Merge Design

Operation of the Point Merge System

There are two distinct sets of responsibilities in the Point Merge System:

1. Manage traffic on the sequencing legs to create spacing: issuing the “Turn [left/right] direct to Merge Point”
2. Manage traffic after leaving the legs to maintain/optimise spacing.

These two sets of responsibilities could be managed by two separate roles or one combined role. Note: the Roles & Responsibilities of the Approach Controllers should comply with the definitions given in Section 4.2.

The controller needs to account for the potential decrease in separation following issuance of the “Turn [left/right] direct to Merge Point”. The turning aircraft may be caught up by the following aircraft on the sequencing leg, i.e. in-trail separation on the sequencing legs is recommended to be greater than the minima.

The Approach controller responsible for managing traffic on the sequencing legs must coordinate the traffic flows with the controller responsible for managing the holding stack(s) that are feeding the sequencing leg(s) to ensure the appropriate level of loading on the Point Merge system. The point at which aircraft need to hold may be earlier than it intuitively feels to the controller given the reduced R/T usage and number and vectoring instructions. For Point Merge Sequencing Legs with maximum of c.8mins holding, controllers should consider using the holding stacks once aircraft begin to use approximately half of the sequencing leg. There is a temptation to keep accepting aircraft onto the sequencing legs until it is too late (PMS overloaded).

The sequencing legs must be vertically separated so that they can be close together laterally, which enables Direct-To Merge Point clearances to be provided irrespective of traffic on the other sequencing leg(s). The controller must ensure longitudinal separation is maintained for traffic on the same leg. To aid simplicity and reduce controller workload, it is recommended that speed restrictions are applied from the IAF. If possible, the speed restrictions should allow all, or the vast majority, of aircraft to fly clean, e.g. set at 230kts.

Speed constraints or speed assignment by ATC, e.g. 230kts by IAF, should be notified to the pilot prior to ToD to allow the FMS to calculate optimum descent profile and hence deliver fuel/environmentally efficient approaches.

The Approach controller responsible for managing traffic after leaving the legs will issue the "Descend to be below [altitude] by Merge Point" clearance once they are satisfied that there is sufficient longitudinal separation between the aircraft and other traffic on the Point Merge System.

Speed controls should be applied to maintain spacing and, when required, optimise spacing.

Path Stretching/Shortening

In a complex TMA, there may be constraints (refer to section 4.1) that do not allow a Point Merge System to deliver traffic directly onto final approach, making it difficult to maintain optimal spacing for landing at the runways. In these cases, Path Stretching/Shortening areas, downstream of the PMS, will provide the means for fine adjustment of the longitudinal spacing. These should be located as close to the runways as possible to enable optimum delivery rates; the size should be limited in accordance with the environmental constraints of the local area (e.g. noise pollution). The path stretching or shortening may be achieved through sets of P-RNAV waypoints or radar vectoring.

Use of radar vectoring provides the greatest flexibility for the Approach Controller to optimise landing rates but it removes some of the predictability benefits of P-RNAV.

Medium traffic density & complexity

If demand is less than capacity such that there is zero holding on the Point Merge System, then flights may be cleared for a Short Route, which may be a Direct-To <waypoint> or radar heading. The Direct-To may be to a waypoint in the PMS (e.g. the Merge Point) or a waypoint outside of the PMS, depending on the route design and potential conflicts. Such short routes should provide the opportunity for the flight to descend continuously without the need to level-off.

Under these circumstances there should be a CDA extending all the way from the holding stack to the landing runway.

3.2.3.2 Normal Mode – Alternative Flows

Non-equipped aircraft

For each Approach function, a Radar Manoeuvring Area (RMA) may be defined to allow radar vectoring for path-shortening, where rapid changes in spacing are needed to maintain Approach throughput, or to deal with equipage failure, system failure or significant adverse impact from weather

This RMA should be defined with the same lateral dimensions as the PMS. In this way, non-equipped aircraft can be vectored to the Merge Point and merged with the equipped traffic for delivery to the FAF.

In the event of equipage failure, controllers will revert to radar headings to create and maintain spacing on the Point Merge System. The controller may choose to vector an unequipped aircraft to follow the Sequencing Legs and then towards the Merge Point, to maintain consistent delivery.

Missed Approach

Aircraft on missed approaches should be re-inserted onto Final Approach (i.e. after the merge point) via vectors. A waypoint should be defined close to the landing runway where an aircraft can be held for a limited time after a missed approach if it is not an emergency and time is needed to create a gap in the landing sequence. Where necessary, the Approach controller responsible for managing traffic on the sequencing legs may request the controller responsible for loading the sequencing leg to make a gap to allow re-insertion of the flight into the traffic flow.

Moreover another way of managing missed approaches could be the design of a holding procedure inside PMS (for instance at the Merge Point vertically separated by PMS leg structure) from where re-direct again the traffic in sequence.

Sequencing Leg run-off

When reaching the end of a sequencing leg without receiving a turn-to-merge instruction from the controller, the pilot shall turn to the Merge Point via a fly-by waypoint and request clearance to descend to the Merge Point. If the controller can appropriately sequence the aircraft, whilst maintaining separation, then they can clear the aircraft for descent. If not, then the controller can either:

1. Vector the aircraft within the RMA to gain the appropriate sequence spacing, or
2. Instruct the aircraft to hold at a pre-defined waypoint alongside the PMS.

If the aircraft is not given clearance to descend to the Merge Point, then they should hold at a defined waypoint alongside the PMS.

When necessary, the Approach controller responsible for managing traffic on the sequencing legs may request the controller responsible for loading the sequencing leg to make a gap to allow re-insertion of the flight into the traffic flow.

Note that a fly-by waypoint which results in a >60 degree turn, will result in the flight guidance to fly a ‘turn anticipation’, thus shortening the track and causing maybe unwanted flight paths. This may be solved by the use of RF turns (see Section 3.2.3.1).

Runway Closure

The following assumes that the runway closure is of a short duration and re-routing to other airfields is not necessary:

In the event of temporary runway closure, the holding stack(s) that are feeding the sequencing leg(s) will be used to delay aircraft entering the PMS.

For aircraft on the Sequencing Legs, the controller will direct them to contingency holding stacks, which may be defined at the Merge Point and/or at waypoints alongside the PMS. There should be sufficient capacity to hold aircraft up to the maximum number that may be in the Point Merge System at any one time. When directing aircraft to the contingency holds, the controller will provide climb or descent instructions per aircraft as necessary to provide vertical separation between all aircraft in the stacks.

Aircraft that are already on the PMS and have been given clearance to Descend to Merge should be held in a stack at the Merge Point. The Approach controller will need to assign aircraft to different FL/altitudes in the stack by instructing level-offs to curtail the descent. When the runway reopens, this stack should be cleared first to free up the Merge Point for resumption of normal operations.

Runway Change

The PMS does not change whether Easterly or Westerly runways are in use, only the downstream routes, i.e. after the Merge Point, change. Therefore, the procedure for notification of runway change:

(a) When on, or prior to, the sequencing leg, ATC to instruct a change of Transition from runway x to runway y, i.e. remain on RNAV.

(b) If the flight has already been cleared to descend to the Merge Point, the use of vectoring may be necessary; arrival traffic will be rerouted to an alternative Final Approach leg, with or without an additional Base leg.

Change in Wind Direction

Change in Wind Direction should be managed through speed controls in the first instance; stack holding can be used where necessary to alleviate pressure on the PMS. Impact to Final Approach should be managed through Runway change, as per previous sub-header.

Meteorological conditions

In the event of strong wind conditions, follow guidance as per section 7.2 of the EUROCONTROL OSED [14]:

Controllers may have to adapt to the situation specifically – as is already the case with current operations, in particular to:

- take account of wind effect when assessing the sequence order, and later instructing the “direct-to” in case the wind has a different effect on the preceding aircraft (e.g. if it is in a different […] sequencing leg);
- compensate, through adapted speed instructions, for the differences in wind effect for aircraft flying along different sequencing legs or while ”direct-to” the merge point;

In the event of Thunderstorms directly over the PMS, controllers will revert to radar headings to avoid the affected area, with the stacks used to control the traffic flow as necessary.

Emergency

An aircraft with an emergency squawk can be prioritised through the Point Merge System: to the merge point or directly onto final approach, as most appropriate. If necessary, controllers may use radar headings on the Point Merge System to deconflict other aircraft from the emergency. The Approach controller responsible for managing traffic on the sequencing legs may request a gap in traffic from the controller responsible for managing the holding stack(s) to resolve any disruption caused.

3.2.4 Departures: Take-off to TMA Boundary

3.2.4.1 Normal Mode – Main Flow

High traffic density & complexity

A P-RNAV route structure using Point Merge (or alternative Sequencing & Merging procedures that utilise rigidly defined blocks of airspace) simplifies the deconfliction of arrival and departure routes, thereby enabling improved flight profiles for the departures. Conversely, departure routes can also be designed so as to minimise the potential impact (in terms of safety & efficiency) to arriving traffic.

Traffic is expected to follow a P-RNAV route from take-off to exit of the TMA boundary, under the responsibility of Terminal Control.

Wherever possible, the P-RNAV Departure routes should be designed with Continuous Climb (CCD) because this is where the most significant environmental benefits can be realised. To facilitate this, some or all of the following may be considered:

- All departures able to out-climb arrivals.
- Minimise the placing of Stacks near to an airfield: move the Stacks further out and place at higher Flight Levels.
- Minimise the number of levels in the Stacks
- Minimise the placing of Approach routes near to other airfields within the TMA.
- Use P-RNAV routes as much as possible across the TMA to enhance predictability.
- Minimise the need for level flight at low altitudes: use CDAs from a high Flight Level to runway.

Before the flight reaches the TMA boundary, the Terminal Controller should handover to Area Control.

Medium traffic density & complexity

No change in operating method from the High traffic density and complexity scenario.

3.2.4.2 Normal Mode – Alternative Flows

Non-equipped aircraft

Unequipped aircraft are expected to be delivered onto onward conventional routes at the TMA Boundary. To accommodate these unequipped aircraft, conventional routes from runway to TMA boundary need to be provided as alternatives to the P-RNAV routes.

Adverse Meteorological conditions

In the event of strong wind conditions: controllers will apply greater longitudinal separation on the P-RNAV routes and/or speed controls.

In the event of Thunderstorms directly affecting P-RNAV routes, controllers will seek to use alternative P-RNAV routes. Where this is not possible, they will revert to radar headings to avoid the affected area.

Emergency

No change in operating method from the Main Flow [Section 3.2.4.1] is considered in this OSED.

3.2.5 Supporting Infrastructure

Point Merge is implemented as part of a P-RNAV route structure, so navigation is provided by satellite and/or a DME/DME ground-based network. VORs and NDBs ground-based navigation aids have been withdrawn from service.

3.3 Differences between new and previous Operating Methods

The key differences between new and previous Operating Methods are as follows:

- Approach & TMA operations have changed from “Open-loop” operations, to “Closed-loop” operations. Point Merge Systems provide closed-loop operations for the sequencing and merging part of the Approach operation.
- There is reduced reliance on holding stacks as a means to synchronise traffic and a reduced need for holding overall; traffic synchronisation and holding capability has been transferred to the Point Merge Systems.
- The disparate operating methods and controller validations required for each individual airport approach have been made common and consistent through homogenous design using Point Merge Systems.
- There is reduced reliance on tactical deconfliction of Arrival and Departure routes because they are strategically deconflicted with improved vertical profiles.
- There is reduced reliance on ground-based navigational aids resulting in more efficient SIDs and STARs.
- PMS could also allow for a better management of contingencies situation

4 Detailed Operational Environment

This section describes the expected operational environment of a complex TMA in which Point Merge procedures will be implemented.

The SESAR ATM Master Plan [27] equates complexity with capacity needs. By this scale, the Operational Environment of “Complex TMA” applicable to this concept equates to TMAs with **Very High Capacity (VHC)** needs. This categorisation is for Airports or TMAs with >100 movements per hour (e.g. London or Milano).

4.1 Operational Characteristics

Point Merge operations are defined within the context of wider operational assumptions and a set of airspace characteristics. This section describes those assumptions and the generic characteristics of complex TMA airspace in which Point Merge procedures are expected to be used.

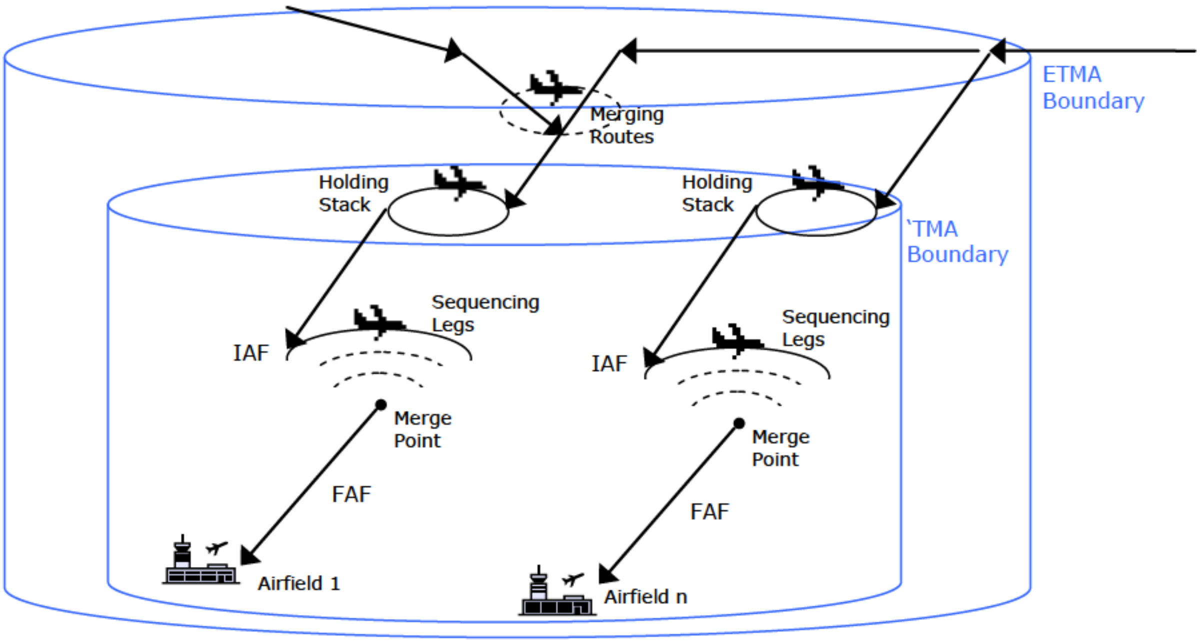


Figure 7: The Phases of Arrival through a Complex TMA

The airspace up to the Extended TMA (ETMA) boundary is controlled by En-route.

The 4 phases to be considered in detail, as part of this OSED [Section 3], are:

1. The airspace between the ETMA and TMA boundaries is controlled by ACC.[4]
2. The airspace between the TMA boundary and the Holding stack is controlled by Terminal Control; the Holding Stack and routes to Initial Approach Fix (IAF) are typically controlled by Approach Controllers.
3. The Point Merge system between IAF to Final Approach Fix (FAF) - Approach Control. Control will be handed over to the Tower Controller when the aircraft is established on final approach;
4. Departing traffic from Tower handover to the TMA boundary are controlled by Terminal Control.

[4] This phase is not a key part of the concept but is considered here for completeness.

Under current day operations, vertical holding stacks are commonly employed within the TMA boundary to control traffic flow rates into Approach. Holding stacks are still expected to be used as part of a Point Merge centric P-RNAV route structure but there is potential to move them to higher altitudes and further from the airfield. Figure 7 shows where Point Merge procedures may be employed for Approach control, with the IAF marking the entry point to the Point Merge Sequencing Legs and the traffic being delivered onto the ILS via the Merge Point then the FAF (at intercept of glideslope). Point Merge procedures provide limited lateral holding; they are not expected to replace holding stacks but will reduce the levels required in the stacks.

ASSUMPTIONS

The focus of Point Merge operations for this OFA is primarily on the approach routes for busy commercial airports. Therefore, the concept encompasses commercial & business aircraft only; helicopters, VFR General Aviation (GA) and military flights are not considered.

A significant proportion of TMA traffic is suitably P-RNAV equipped so as to enable it to follow the defined P-RNAV route structure to the specified level of accuracy.

The operating environment considered for this OSED is within the TMA boundary only, though it may be necessary to consider airspace designs up to the Extended TMA boundary if physical constraints determine so.

All TMA Controllers are able to revert to conventional operations (vectored transitions) when necessary to cater for non-nominal situations, whether this be for a single aircraft or for all TMA traffic.

All Approach Controllers are able to revert to conventional operations (vectored transitions) when necessary to cater for non-nominal situations, whether this be for a single aircraft or for all Approach traffic.

There will be no change to the separation minima from current day operations.

All aircraft are B-RNAV capable.

Aircraft with B-RNAV capability are not able to fully follow the P-RNAV route structure but they are able to use it, albeit to a lesser degree of accuracy than P-RNAV capable aircraft. If airspace availability permits, conventional routes may also be applied.

Aircraft Vertical Navigation (VNAV) capabilities are not mandatory in a TMA based on a P-RNAV route structure.

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

The aircraft FMS is able to store sufficient RNAV waypoints to enable compliance with the P-RNAV routes, using Point Merge Systems.

AIRSPACE CONFIGURATION CHARACTERISTICS

Point Merge procedures shall be incorporated into the Approach routes of more than one airfield within a complex TMA (as defined in **Table 8**).

The airspace configurations described here apply to all the concept elements considered in this OSED for Step 1.

Within the SESAR context the TMA phase is defined as that portion of flight from take-off to top of climb and from top of descent to runway threshold.

The following table summarises the airspace configuration characteristics for a complex TMA:

Class of Environment	Complexity
Airspace Constrained TMA	Highly sectorised as a result of previous TMA development to handle capacity. The sectors are small and typically have standing agreements to coordinate the presentation of traffic into and out of the sector. Merge points exist for inbound arrival flows from different directions. The merge points are defined as waypoints in published procedures (typically the IAF). Multiple route geometries may converge upon a single merge point. Presence of acute angle crossing point(s) – that is, where multiple flows of traffic cross at acute angles Close proximity of crossing/conflict/merge point(s) to the TMA boundary Close proximity of the TMA to an FIR boundary (so traffic handed to/from neighbouring FIR) High Number of holding areas in use (e.g. stacks, path-stretch) Lack of space for vectoring, path stretching or holds The size and number of Point Merge arcs are limited by the space constraints.
Traffic Volume and Variation Constrained TMA	Mainly capacity constrained for large periods throughout the day with a strong business driver to ensure that runway utilisation is maintained at near capacity. Several airports are characterised by a seasonal demand (summer and holidays peaks), with an extremely wide range of aircraft with different navigation capabilities including a significant percentage that are not P-RNAV compliant. Route complexity is high to the degree that arrivals and departures can interact, as can the arrival streams inbound to different airports. Holding may still be used at peak times (albeit at reduced levels) to maintain runway pressure and avoid losing slots. Amount of flights not meeting standing agreements/Flight Level allocations so requiring co-ordination. R/T frequency congestion. TMA/Approach controllers require the flexibility to manage the traffic flows to maintain high throughput levels. P-RNAV routes need to accommodate mixed performance capabilities, so impose path shortening/stretching for sequencing, as well as level changes for deconfliction among flows (arrival and departures).
Environmentally Constrained TMA	Environmental constraints, especially those related to departure noise nuisance, are still an issue in most European airports. The opportunity to automatically fly departure profiles and tailored trajectories as early as possible can help tackle this issue. The lack of homogeneity in autopilot engagement and consequent automated trajectory execution still represent a problem in airports where early turn departures are needed to avoid surrounding noise sensitive areas, preventing the aircraft from an efficient trajectory management. The lateral and vertical profile of the P-RNAV routes is limited by environmental impact on the communities within the TMA: both in terms of gaseous emissions and noise pollution.
Airfield interaction Constrained TMA	Multiple major commercial airports within the TMA. Airports serve a mixture of traffic types: scheduled, chartered, business, military, general aviation (powered/unpowered). Amount of non-standard traffic (e.g. police, survey, hospital, state flights, and flights requiring special co-ordination). Route confliction between arrival and departures flows of neighbouring airports resulting in potential for departures or arrivals being held at long periods of low-level flight.

Table 8: Airspace Configuration Characteristics

TRAFFIC CHARACTERISTICS

The generic traffic characteristics considered for this OSED can be categorised as follows:

- A short term traffic increase as compared to today's (2010) levels
- There are no significant changes to the traffic mix (in terms of ICAO types)
- Although a significant proportion of TMA traffic is suitably P-RNAV equipped, there will be mixed aircraft equipage levels and mixed performance capabilities that will need to be accounted for in the TMA design.

The complexity traffic characteristics considered for this OSED can be categorised as follows:

- High traffic volumes
- Mix of traffic types (e.g. wake vortex category/speed/manoeuvrability), leading to sequencing or metering problems.
- Lack of predictability of traffic (e.g. when avoiding weather, wind shear)

CERTIFICATES / REGULATION

Point Merge is merely a procedural airspace construct, so the implementation of Point Merge would be as part of an airspace design change, which means it would only need follow the standard process for implementation of airspace design (dependent on the regulatory terms covering the specific FIR).

There would need to be standards on P-RNAV (/B-RNAV) and RNP but these are already defined, so this concept need not define anything new. There is no industrialisation of new system components necessary

4.2 Roles and Responsibilities

As a legal foundation, the controller is responsible for maintaining the minimum prescribed separation between aircraft. With the introduction of the P.57.4 Point Merge in complex TMA, fundamental responsibilities will not change. However, due to the introduction of new procedures, tasks and operating methods will change. A detailed description of the roles and tasks undertaken by controllers is provided in Appendix D of this document. (This is an extract from SESAR WPB4.2 Roles and Responsibilities appendix in the B4.2 Concept of Operations [16]). This section provides an overview the changes that will affect the Planning and Executive (tactical Controller).

Note: In the London Terminal Control operation the role of the 'Multi-Sector Planning' controller equates to the role performed by the "Co-ordinator" and the 'Executive' controller equates to the "Approach/TMA" controller. In relation to P5.7.4 the introduction of Point Merge procedures have an impact upon the Approach and TMA controller tasks and responsibilities; hence these have been selected as the key human actor for discussion. The Approach Controller role is further distinguished into two: 'Intermediate' & 'Final'.

Human Actors	Change of tasks and responsibilities
Intermediate Controller	The design of TMA airspace using a P-RNAV route structure increases the predictability of air traffic position and PRNAV transitions. The introduction of Point Merge will provide flexibility in a P-RNAV route structure and, during standard operating conditions will result in the simplification of procedures. It is anticipated that there will be some changes in terms of allocation of tasks and responsibilities (e.g. responsible for releases and stack management will be shared between the Approach and TMA controller with either party being able to suspend the silent release procedure as necessary). The changes in responsibility and tasks are mainly likely to result in potential benefits (e.g. reduced communication and workload and more predictability). The changes may also present a risk of some negative impact in terms of vigilance issues, deskilling and job satisfaction.) (Further details contained in Section 5.3 and 6 in ref [14].
Final Controller	There will no change in responsibilities to FIN. The design of TMA airspace using a P-RNAV route structure increases the predictability of air traffic position and .PRNAV transitions. The introduction of Point Merge will provide flexibility in a P-RNAV route structure and, during standard operating conditions will result in the simplification of procedures. The FIN controller will need to provide accurate spacing on final approach by minor speed adjustments and/ or vectoring as necessary.
TMA Controller	The introduction of Point Merge will "sterilise" more airspace, but the positioning of the arcs allows aircraft to climb to higher SID levels. It is anticipated that there will be some changes in terms of allocation of tasks and responsibilities (e.g. responsible for releases and stack management will be shared between the Approach and TMA controller with either party being able to suspend the silent release procedure as necessary). These changes are mainly likely to result in potential benefits (e.g. reduced communication and workload and more predictability). The changes may also present a risk of some negative impact in terms of vigilance issues, deskilling and job satisfaction.) (Further details contained in Section 5.3 and 6 in ref [14].

Aircrew (Pilot Flying, Pilot Non Flying)	No change of responsibilities. The introduction of Point Merge will simplify procedures and increase in predictability of aircraft routing.

For the air traffic controllers the changes associated with the Point Merge Procedures are mainly related to the tasks of monitoring, solution planning and implementation and conflict search, but also the other tasks are affected to some extent. For example the different operational scenarios generally the same tasks apply although the characteristics, the priority and the associated task load may differ significantly.

4.2.1 Intermediate Controller (Approach)

General: The Intermediate Controller is part of the sector team responsible for a designated area (e.g. London TMA). S/He is responsible for the safe and expeditious flow of all flights operating within his area of responsibility. The principal tasks are to separate and sequence known flights operating within his area of responsibility and to issue instructions to pilots for conflict resolution and segregated airspace circumnavigation.

The responsibilities of the Intermediate (Tactical) Controller are focused on the traffic situation, as displayed at the Controller Working Position (CWP), and are very much related to task sharing arrangements with the FINAL DIRECTOR. The introduction of Point Merge as described in this document will allow merging arrival flows with existing technology including precision area navigation (P-RNAV).

INT Controller Tasks:

1. Monitoring

   The introduction of Point merge will standardise the routes flown by aircraft so monitoring by the INT controller will focus on identification of deviations from the planned routes, vertical level allocation and responding to appropriate speed instructions to ensure separation on the legs and/or to the merge point. This more passive monitoring role may have impact when controllers are required to undertake more active vectoring techniques.

2. Conflict detection:

   The Tactical (INT) Controller is primary responsible for assuring and maintaining separation between flights under his control (and against flights which are known to him, but may be under the control of another sector) whilst ensuring that sequencing for maximising runway utilisation is achieved. The introduction of point merge will standardise the routings, however controllers will be required to actively detect and resolve situations when exceptions occur due to weather, satellite problems, blocked RWY etc.

3. Planning of solutions:

Point merge introduction will limit the options that are available to the INT controller to sequence aircraft, with speed control being relied on more. Controllers allow aircraft to follow sequence legs until being given an instruction to route to the merge point. In some configurations of the concept there are opportunities to further improve the efficiency of traffic by routing aircraft along the way points within the system. In addition to the implementation of Point Merge there may be an Arrival Management Tool which should assist the INT controller to optimise arrival sequence from the hold. All Approach Controllers will still be able to revert to conventional operations (vectored transitions) when necessary to cater for non-nominal situations, whether this be for a single aircraft or for all Approach traffic.

4. Communication and implementation of solutions:

   The INT Controller will maintain communications with the aircraft under his jurisdiction, and ensure communications are successfully transferred to the receiving unit at the appropriate time.

5. Update of data

   The INT Controller is responsible for maintaining and updating the appropriate flight data display (be it paper or electronic strips, or other advanced HMI) with the clearance instructions and constraints (and other pertinent data) that have been issued to the flights under his jurisdiction.

6. Handover instructions:

   INT controller will continue to use similar standard handover procedures and checklists

7. Emergency:

   The Tactical (INT) Controller will take action to provide the necessary help to an aircraft in difficulty or suffering an emergency whilst ensuring that other traffic is neither unnecessarily involved in the emergency nor overlooked so that they are, themselves, put into an unsafe situation. The INT should ensure that the nature of the emergency is made known to the co-ordinator and other controllers as appropriate as soon as possible so that supportive action can be put in place.

4.2.2 FIN Controller (Approach)

General: The FINAL DIRECTOR (FIN) Controller is part of the sector team responsible for a designated area (e.g. London TMA). S/He is responsible for the safe and expeditious sequencing of all traffic operating within his area of responsibility. The principal tasks are to provide separation in the latter stages of approach and to sequence arriving traffic.

The responsibilities of the FIN Controller are focused on the traffic situation, as displayed at the Controller Working Position (CWP), and are very much related to task sharing arrangements within the INT Controller. The introduction of Point Merge as described in this document will allow merging arrival flows with existing technology including precision area navigation (P-RNAV).

<u>FIN Controller Tasks:</u>

1. Monitoring

   The introduction of Point merge will standardise the routes flown by aircraft so monitoring by the FIN controller will focus on identification of deviations from the planned routes, vertical level allocation and adherence to speed to ensure separation on the legs and to merge point. This more passive monitoring role may have impact when controllers are required to undertake more active vectoring techniques.

2. Conflict detection:

   The FIN Controller is primary responsible for assuring and maintaining separation between flights under his control (and against flights which are known to him, but may be under the control of another sector) whilst ensuring that optimum spacing for maximising runway utilisation is achieved. The introduction of point merge will standardise the routings, however controllers will be required to actively detect and resolve situations when exceptions occur due to weather, satellite problems, blocked RWY etc.

3. Planning of solutions:

Point merge introduction will limit the options that are available to the FIN controller to sequence aircraft, with speed control being relied on more. In addition to the implementation of Point Merge there will be an Arrival Management Tool which should assist the FIN controller to optimise arrival sequence from the hold All Approach Controllers will still be able to revert to conventional operations (vectored transitions) when necessary to cater for non-nominal situations, whether this be for a single aircraft or for all Approach traffic

4. Communication and implementation of solutions:

   The FIN Controller will maintain communications with the aircraft under his jurisdiction, and ensure communications are successfully transferred to the receiving unit at the appropriate time.

5. Update of data

   The FIN Controller is responsible for maintaining and updating the appropriate flight data display (be it paper or electronic strips, or other advanced HMI) with the clearance instructions and constraints (and other pertinent data) that have been issued to the flights under his jurisdiction.

6. Handover instructions:

   FIN controller will continue to use standard handover procedures and checklists

7. Emergency:

   The FIN Controller will take action to provide the necessary help to an aircraft in difficulty or suffering an emergency whilst ensuring that other traffic is neither unnecessarily involved in the emergency nor overlooked so that they are, themselves, put into an unsafe situation. The TC should ensure that the nature of the emergency is made known to the PC and other controllers as appropriate as soon as possible so that supportive action can be put in place.

4.2.3 TMA Controller

TMA Controller Tasks:

1. Monitoring

   The introduction of PRNAV SIDs and STARs will standardise the routes flown by aircraft so monitoring by the TMA controller will focus on ensuring compliance with route and on adherence of aircraft to published procedures.

2. Conflict detection:

   The TMA Controller is primary responsible for assuring and maintaining separation between flights under his control and against flights which are known to him, but may be under the control of another sector. The introduction of Point Merge will not change this task; Controllers will be required to actively detect and resolve situations when exceptions occur due to weather, radar problems etc.

3. Planning of solutions:

   Point merge introduction will increase the reliance of planning ahead on the departure TV due to the introduction of free flow.

4. Communication and implementation of solutions:

The TMA Controller will maintain communications with the aircraft under his jurisdiction, and ensure communications are successfully transferred to the receiving unit at the appropriate time.

5. Update of data

   The TMA Controller is responsible for maintaining and updating the appropriate flight data display (be it paper or electronic strips, or other advanced HMI) with the clearance instructions and constraints (and other pertinent data) that have been issued to the flights under his jurisdiction.

6. Handover instructions:

   TMA controller will continue to use standard handover procedures and checklists.

7. Emergency:

   The TMA Controller will take action to provide the necessary help to an aircraft in difficulty or suffering an emergency whilst ensuring that other traffic is neither unnecessarily involved in the emergency nor overlooked so that they are, themselves, put into an unsafe situation.

4.3 Constraints

This section identifies the technical constraints that might impact the concept or the solution. **Table 9** Lists the Technical, Procedural, Human and Institutional Enablers that need to be in place for the concept to be effective (these are derived from the applicable OI Steps given in Table 1).

Enabler	Contribution of the Enabler
A/C-04 - Flight management and guidance to improve lateral navigation (2D RNP)	*Applies to: Point Merge & associated P-RNAV route structure* Flight management and guidance to improve lateral navigation e.g. 2D RNP value down to 0.3NM, and ensure adherence to RNP routes. An increase in the number of waypoints an FMS can process would enhance the potential scope of any change using the proposed concept.
BTNAV-0206 - Community Specifications for RNP - Development of a means of compliance to PBN manual RNP: European initiative towards worldwide recognition.	*Applies to: Point Merge & associated P-RNAV route structure* The Airspace and route re-design must comply with regulations and standards.
HUM-AOM-0404 - Initial training, competence and/or adaptation of new/active operational staff for the application and use of the enhancements and improvements included in the OI Step Optimised Route Network using Advanced RNP1	*Applies to: Point Merge & associated P-RNAV route structure* Existing and new Controllers will need to be trained to use the Point Merge procedures with P-RNAV route structures.
HUM-AOM-0603 - Initial training, competence and/or adaptation of new/active operational staff for the application and use of the enhancements and improvements included in the OI Step Enhanced Terminal Airspace for RNP-based Operations	*Applies to: Point Merge & associated P-RNAV route structure* Existing and new Controllers will need to be trained to use the Point Merge procedures with P-RNAV route structures.
HUM172-04 – Training	*Applies to: Point Merge* Existing and new Controllers will need to be trained to

	use the Point Merge procedures. Training in the Approach role should be simpler for new Controllers. Training could be aided by standardising and simplifying approach procedures. Training would alter to emphasise non-nominal scenarios as opposed to nominal: regular refresher training on vectoring needed to maintain this skill. Training for pilots would help familiarisation with the new concept and mean that they will be able to react as swiftly to instructions such as ‘Direct-To <waypoint>’ as they do to heading instructions under current operations.
HUM172-02 - Regulations and standards	*Applies to: Point Merge & associated P-RNAV route structure* The Airspace and route re-design must comply with regulations and standards.
HUM172-07 - System design encompassing training feasibility	*Applies to: Point Merge* Training and simulation systems need to be capable of supporting the new procedures.
HUM173-04 - Social & People Management Factors	*Applies to: Point Merge* Existing Controllers may perceive the use of Point Merge procedures as “dull” and will de-skill them.
HUM173-05 - Change and Transition Management Factors	*Applies to: Point Merge* Transition to Point Merge procedures in a Complex TMA should be introduced as part of a package of airspace change.
CTE-N3a – ABAS	*Applies to: Point Merge & associated P-RNAV route structure* Aircraft-Based Augmentation Systems (ABAS) i.e. needs to be supported by suitably equipped aircraft to ensure adherence to RNP routes.
CTE-N5a - DME / DME	*Applies to: Point Merge & associated P-RNAV route structure* Ground system infrastructure required to provide alternate navigation to GNSS.
PRO-AC-04a - A-RNP Cockpit Procedures - A-RNP Cockpit Procedures	*Applies to: Point Merge & associated P-RNAV route structure* All aircraft to fly RNP routes in the TMA.
PRO-ENV-15 - ASM Procedure to ensure that airspace is designed to avoid unnecessary noise and emissions from non-optimal departure profiles (noise and atmospheric emissions)	*Applies to: Point Merge & associated P-RNAV route structure* Greater use of Continuous Climb Departures and Continuous Descent Approaches is expected to reduce noise pollution and emissions.
PRO-019 - ATC Procedures to integrate arrival and departure streams in such a manner as to permit more continuous climb and descent profiles	*Applies to: Point Merge & associated P-RNAV route structure* PBN-based route structures lack flexibility so the use of queue management techniques is needed to stream the aircraft.

PRO-021 - ATC Procedures to facilitate the design and utilization of more noise sensitive and efficient SID/STAR routings including CDA and to integrate PRNAV capabilities into the TMA route structure	*Applies to: Point Merge & associated P-RNAV route structure* The Point Merge concept is expected to enable increased provision of Continuous Descent Approaches and Continuous Climb Departures. Greater use of CCDs and CDAs is expected to reduce noise pollution and emissions,
PRO-207a - A-RNP Procedures - ARNP Procedures covering ground operational tasks in Approach ATC	*Applies to: Point Merge & associated P-RNAV route structure* TMA route designs using one P-RNAV/RNP1 route structure, with such routes extending from final approach, or start of departure SID, into En-Route.

Table 9 - Enablers

5 Detailed Operational Scenarios / Use Cases

This section provides Use Cases for Main Flow, Alternative Flows and Abnormal Mode. These are as follows:

- Operational Scenario 1: High Density / High Complexity Arrivals
  - *Use case 1.1: Normal Mode - Main Flow*
  - *Use case 1.2: Normal Mode – Alternative Flow – Non-equipped aircraft*
  - *Use case 1.3: Normal Mode – Alternative Flow – Meteorological Conditions*
  - *Use case 1.4: Normal Mode – Alternative Flow – Emergency Mode*
  - *Use case 1.5: Normal Mode – Alternative Flow – Sequencing Leg Run-Off*
  - *Use case 1.6: Normal Mode – Alternative Flow – Runway Closure*
  - *Use case 1.7: Normal Mode – Alternative Flow – Missed Approach Procedure*
- Operational Scenario 2: Medium Density / Medium Complexity Arrivals
  - *Use case 2.1: Normal Mode - Main Flow*
  - *Use case 2.2: Normal Mode – Alternative Flow*
- Operational Scenario 3: High Density / High Complexity Departure
  - *Use case 3.1: Normal Mode – Main Flow*
  - *Use case 3.2: Normal Mode – Alternative Flow – Non-equipped aircraft*
  - *Use case 3.3: Normal Mode – Alternative Flow – Emergency Returns on Departure*
- Additional Abnormal Modes & Internal Failure

Note that Use Cases are not provided for all Alternative Flows as identified in section 3.2, these are as follows:

> ‘Low Traffic Demand’ – This represents the ‘Implement TMA/APP in M/M environment, ground solution’ scenario [Section 5.2].

> ‘High Traffic Demand’ – This represents the ‘Implement TMA/APP in H/H environment, ground solution’ scenario [Section 5.1 and Section 5.3].

5.1 Operational Scenario 1: High Density / High Complexity Arrivals

Processes:

- Implement ENR/ETMA
- Implement TMA/APP

5.1.1 Use case 1.1: Normal Mode - Main Flow

The General Conditions, Pre-conditions and Post-Conditions for this Use Case are as per section 7.1.1 of the EUROCONTROL OSED [14]:

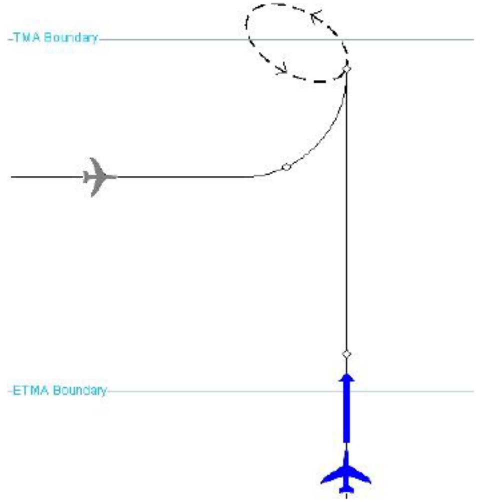
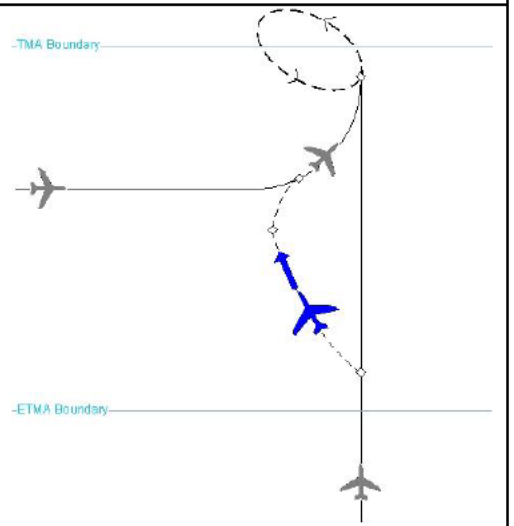
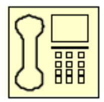
Pre-conditions:

- PreC1 - Aircraft equipped with procedure loaded into FMS and flown by flight crew, with lateral navigation engaged, in accordance with ATC route clearance;
- PreC2 - Appropriate acceptance rate(s) set for Point Merge system's entry – taking into consideration such issues as longitudinal separation, wake turbulence constraints, meteorological conditions, capacity constraints of the Point Merge system itself and at its exit, etc...
- PreC3 - Delivery of metered traffic flow(s) in accordance with this(ese) rate(s) e.g. through an AMAN
- PreC4 - Traffic delivery with longitudinal separation within each inbound flow.
- PreC5 - Aircraft stable at the defined level/altitude for each sequencing leg prior to leg's entry;
- PreC6 - Traffic level such that path stretching is needed for some, if not all flights in the sequence, in order to integrate inbound flows;

Plus the following addition:

- PreC7 – The arrival and departure routes are deconflicted from each other and from those of neighbouring airfields, so as to allow a flyable and effective P-RNAV route structure.

Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)

1	The ACC controller detects a new flight entering their area of responsibility. The ACC controller detects potential conflicts between merging routes at, or before, the TMA boundary, and detects a conflict with a flight on an adjoining route.	Follow the P-RNAV route programmed into the FMS.	Incoming traffic flow metered by Arrival Manager, but is not expected to be fully sequenced and spaced by the Extended TMA boundary, so the TMA controller will need to manage the arrival flows.	
2	To deconflict and sequence the arriving aircraft with other traffic from another arrival route, the ACC controller instructs flight to follow an alternative waypoint. The controller enters the new route into the ground system; this update is then visible to affected controllers downstream.	Additional waypoint inserted into the route, programmed into FMS.	Where necessary the controller may revert to vectors. A Point Merge System at the merging of routes could be an effective way of absorbing delay and sequencing traffic. However, this is not further explored in this OSED because it is being investigated as part of SESAR project 5.6.7	
3	The ACC controller hands over to the TMA controller prior to the TMA boundary. The ACC controller notifies the TMA controller that the flight is off it standard RNAV route to re-join at	Contact TMA controller on given frequency.	-	

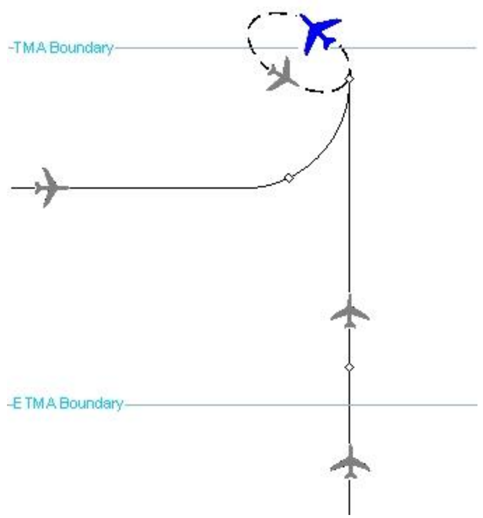
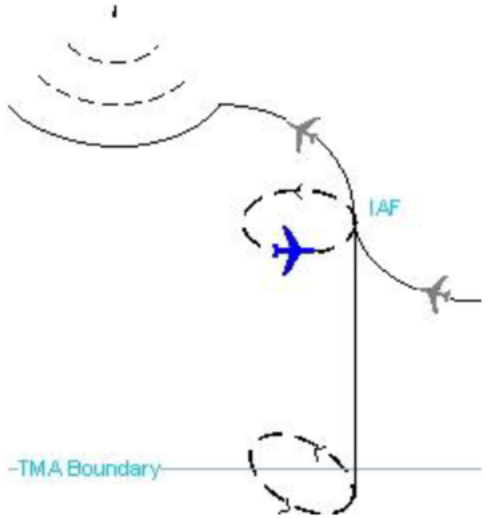
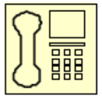
	waypoint <x>.			
4	The TMA controller assesses the traffic situation in their sector for loading and potential conflicts. The Approach controller requests a reduced rate of delivery so the TMA controller uses the holding stack at the TMA boundary. Determine when to feed the aircraft off the stack to maintain the appropriate delivery rate for Approach.	Stay on route but fly RNAV holding pattern.	Aim to minimise stack holding but stacks are retained as a key control to allow the TMA controller to maintain sequencing and spacing.	

Table 10 - Use Case 1.1 Main Flow: ETMA boundary to TMA boundary

Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)

1	The TMA controller releases the flight from the hold at the TMA boundary. The TMA controller determines expected time on sequencing leg by either AMAN system information or from the Approach controller. The TMA controller advises the flight crew that the PMS is in operation and gives expected time on sequencing leg. The TMA controller provides clearance for flight to follow the STAR to IAF; deconflicted from other traffic merging at the stack. Notify flight crew of expected stack holding time, the PMS transition (including level restrictions) and any expected shortcuts on the transition (i.e. a direct-to from the Point Merge sequencing legs to Merge Point).	Follow the STAR to IAF. Update FMS with waypoint s for the instructed transition plus estimated holding time in stack and on the sequencing leg.	Distance flown on Point Merge Sequencing Legs should be treated as holding.	
2	Prior to the flight reaching the holding stack, the TMA controller hands over to the Approach controller. The flight is following the standard STAR, according to flight plan, and is part of a traffic delivery rate agreed between the TMA controller and the Approach controller. Therefore, the flight can be co-ordinated via a Silent Release, where the handover is the same as usual but with no verbal communication between controllers required.	Contact Approach controller on given frequency.		

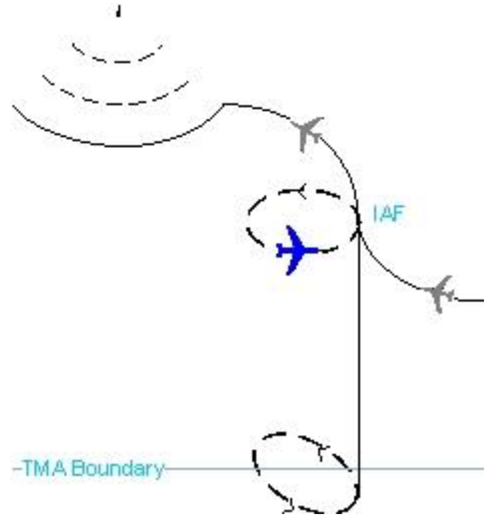
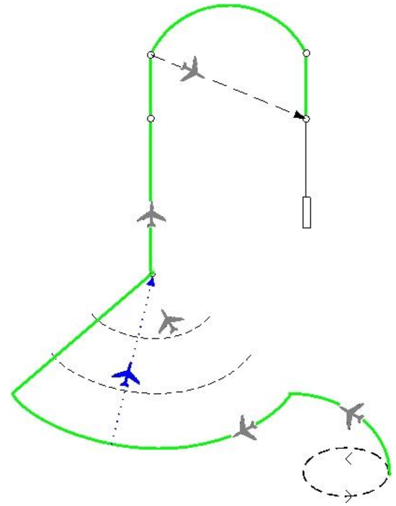
3	The Approach controller uses the holding stacks to deliver the traffic sequence and loading levels as required on the Point Merge sequencing leg(s). Transition provided for flight crew to follow after the end of the STAR (at IAF): this is the PMS.	Fly holding pattern if/as instructed, and then proceed on the PMS transition following any speed controls and level restrictions given, such as level flight by 5nm before entry to sequencing leg.	The controller should always have aircraft available in the stacks to ensure that a consistent flow of traffic through Approach can be maintained. During peak traffic periods, this necessitates an average holding per aircraft equal to the time it takes to perform one circuit of the stack.	

Table 11 - Use Case 1.1 Main Flow: TMA boundary to IAF

Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)
1	The Approach Controller manages the PMS as a transition. . The Approach controller determines the appropriate time to release the aircraft from the hold either by using AMAN system information or by working to a throughput rate. Clear the flight to follow the PMS route to the FAF. Apply speed control of 230kts. Consider the sequence and the necessary spacing behind the previous aircraft, check time to lose/gain indication from the ground system. It states time to lose 1 minute, decide to turn the flight 4 miles into the sequencing leg to lose the time. Once the aircraft has turned off the sequencing leg and lateral separation is established, give clearance to descend to merge point.	Fly the PMS transition. When given the instruction to turn to merge, set a direct-to in the FMS (deleting intermediate waypoints), and manoeuvre accordingly. Request clearance to descend to Merge Point. When given the instruction to descend to merge, set the appropriate level in the FMS and manoeuvre accordingly.	The green line in the illustration depicts the transition. The blue aircraft has been given a Direct-To (Merge Point). From the end of the STAR there is a transition to each runway direction. All transitions are defined using the full sequencing leg but the controller will give Direct-To (Merge Point) instructions off the sequencing legs as appropriate to maintain the sequence and separation. For a full description of the phase of flight from IAF to FAF, through the Point Merge System under Normal Mode (Main Flow) operations, refer to the Use Case in section 7.1.1 of the EUROCONTROL OSED [14]	

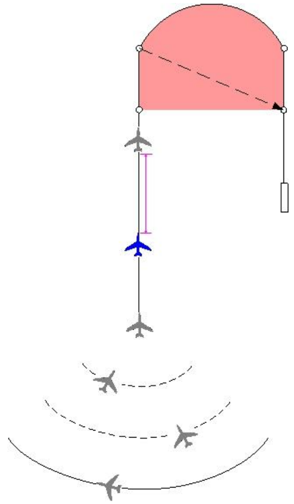
2	On a long P-RNAV leg, the longitudinal spacing delivered at the Merge Point of the PMS has been eroded. The Approach Controller uses speed controls and the vectoring area (the shaded area on the illustration), where aircraft can be given shortcuts using radar vectors or Direct-To clearances, to manage the spacing.	Follow the P-RNAV route programmed into the FMS along with any speed instructions or transitions within the Path Stretching/Shortening area.	1. With only one traffic flow feeding the Path Stretching/Shortening area, there is only finite capacity to continually stretch or shorten flight paths, so the feed from the PMS will need to be carefully controlled, i.e. the feed from the Holding Stacks will need to be carefully controlled. 2. The PMS may deliver directly onto final approach, where this additional path stretching or shortening is not required. Final approach should be as short as possible to enable maximum landing rates. 3. The vectoring area could be replaced with a trombone with waypoint-to-waypoint shortcuts but the use of a vectoring area reduces the number of waypoints that need to be input into the FMS.	

Table 12 - Use Case 1.1 Main Flow: IAF to FAF

5.1.2 Use case 1.2: Normal Mode – Alternative Flow – Non-equipped aircraft

The General Conditions for this Use Case are as per section 7.1.1 of the EUROCONTROL OSED [14].

Pre-Conditions

- PreC1 – Appropriate acceptance rate(s) set for Point Merge system's entry – interlacing conventional traffic with P-RNAV capable inbound traffic.
- PreC2 – Both equipped and unequipped traffic metered in via an Arrival Management system,
- PreC3 – Unequipped traffic delivered with longitudinal separation within each flow and sequenced together with P-RNAV capable inbound traffic.
- PreC4 – Traffic level such that path stretching is needed for some, if not all, flights in the sequence, in order to integrate inbound traffic flows.

The Post-Conditions for this Use Case are as per section 7.1.1 of the EUROCONTROL OSED [14].

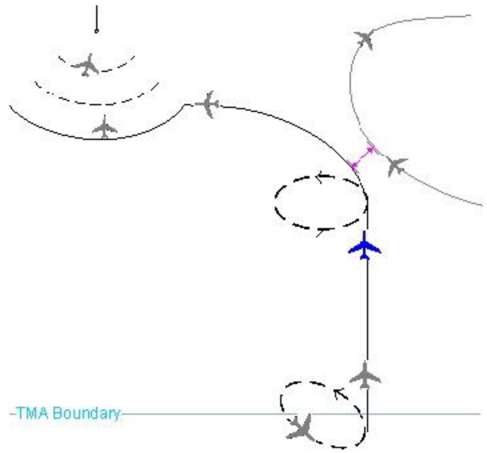
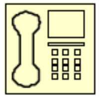
Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)
1	As per Table 11 - Use Case 1.1 Main Flow: TMA boundary to IAF, plus: From the flight strip, the TMA controller notes that the blue aircraft is unequipped; this is confirmed by the flight crew. The controller marks or cocks the strip to identify the lack of P-RNAV capability. The controller uses speed controls to maintain separation between the unequipped aircraft and P-RNAV equipped aircraft on an adjacent P-RNAV route that it closely spaced with the route in question.	As per Table 11 - Use Case 1.1 Main Flow: TMA boundary to IAF, plus: The flight crew of the unequipped blue aircraft notifies the TMA controller that they are unequipped.	Control of unequipped aircraft is expected to be by exception only.	
2	Prior to the flight reaching the holding stack, the TMA controller hands over to the Approach controller using a verbal Release, including notification of non-equipage. The controller marks or cocks the strip to identify the lack of P-RNAV capability.	Contact Approach controller on given frequency.	-	

Table 13 - Use Case 1.2 Alternative Flow - Unequipped Aircraft: ETMA boundary to IAF

Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)

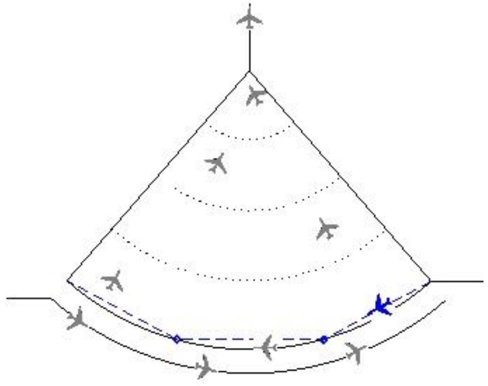
1	As per Table 12 - Use Case 1.1 Main Flow: IAF to FAF, plus: The blue aircraft is not P-RNAV equipped but is B-RNAV capable. It follows fewer waypoints on the sequencing leg than used by P-RNAV capable aircraft. The Approach controller controls this aircraft in the same way as the P-RNAV equipped aircraft.	As per Table 12 - Use Case 1.1 Main Flow: IAF to FAF, plus: Fly sequencing leg holding, following the speed controls where applied.	It is assumed that the majority of, if not all, aircraft using the PMS will be B-RNAV capable. An RMA should be defined with the same lateral dimensions as the PMS. In this way, non RNAV-equipped aircraft (e.g. under equipage failure) can be vectored to the Merge Point and merged with the equipped traffic for delivery to the FAF.	

Table 14 - Use Case 1.2 Alternative Flow - Unequipped Aircraft: IAF to FAF

5.1.3 Use case 1.3: Normal Mode – Alternative Flow – Meteorological Conditions

The General Conditions, Pre-conditions and Post-Conditions for this Use Case are as per the Main Flow [Section 5.1.1], with the following addition:

Pre-Conditions

- PreC8 – Strong wind conditions in effect: these may be head wind, tail wind or cross-wind.
- PreC9 – Thunderstorms directly affect the defined routes.

Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)

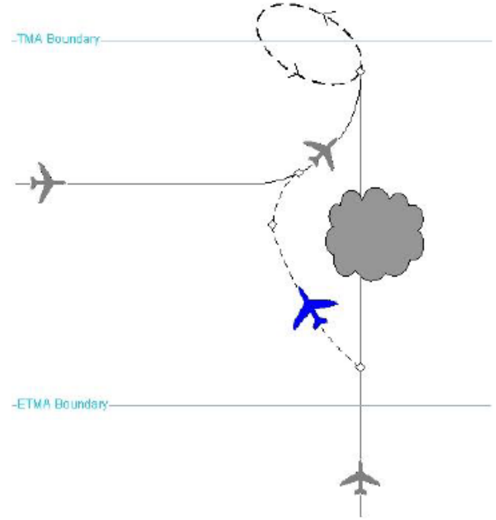
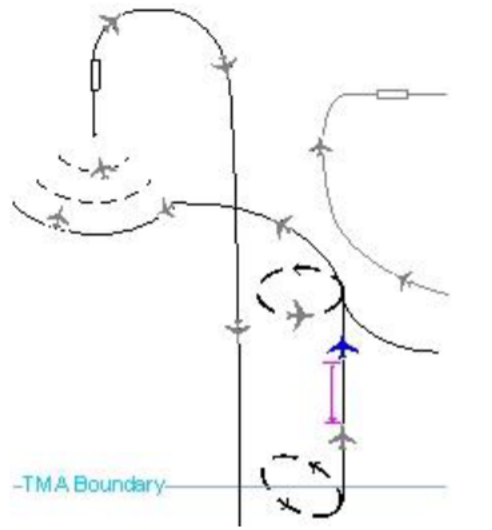
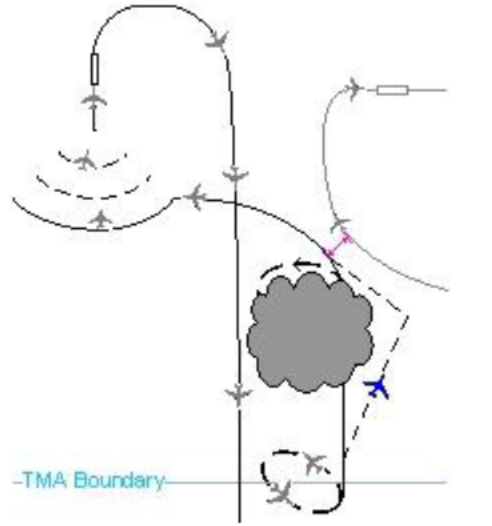
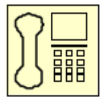
1	The ACC controller receives notification from the flight crew that a thunderstorm is affecting the STAR. To avoid the thunderstorm, the ACC controller instructs flight to follow an alternative waypoint. The controller enters the new route into the ground system; this update is then visible to affected controllers downstream. .	The flight crew informs the ACC controller of a thunderstorm affecting the STAR and they would like to avoid it. Additional waypoint inserted into the route, programmed into FMS. Contact TMA controller on given frequency.	Where the use of alternative RNAV waypoints is not possible, the controller will revert to radar headings to avoid the affected area. To compensate for the strong wind conditions, controllers will apply greater longitudinal separation on the P-RNAV routes and/or speed controls.	
2	The ACC controller hands over to the TMA controller prior to the TMA boundary. The ACC controller notifies the TMA controller that the flight is off it standard RNAV route to re-join at waypoint <x>.	Contact TMA controller on given frequency.	-	

Table 15 - Use Case 1.3 Alternative Flow - Meteo: TMA boundary to IAF

Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)

1	After handover from the ACC controller, the TMA controller provides clearance for flight to follow the STAR to IAF. The TMA controller determines expected time in holding stack and on sequencing leg by either AMAN system information or from the Approach controller. Notify flight crew of expected time on sequencing leg, To compensate for the strong wind conditions, the TMA controller exercises speed controls to increase longitudinal separation between other traffic on the STAR.	Follow the STAR to IAF. Update FMS based on updates from ATC regarding holding time and distance to fly. Contact Approach controller on given frequency.	May also need to apply greater longitudinal separation and/or speed controls on the P-RNAV routes to manage the PMS loading required by the Approach controller. Holding, whether in stack or on sequencing legs, is likely to increase under adverse meteorological conditions.	
2	In the event of Thunderstorms directly affecting P-RNAV routes, controllers will revert to radar headings to avoid the affected area, with the stacks used to control the traffic flow as necessary. Prior to the flight reaching the holding stack, the TMA controller hands over to the Approach controller using a verbal Release.	Follow vectors as instructed by ATC. Contact Approach controller on given frequency.	In a multi-airport TMA with more closely spaced parallel routes, there is an added risk in vectoring off the defined route structure.	
3	Prior to the flight reaching the holding stack, the TMA controller hands over to the Approach controller using a verbal Release. The TMA controller notifies the	Contact Approach controller on given frequency.	-	

	Approach controller that the flight is off it standard RNAV route to re-join at waypoint <y>.			

Table 16 - Use Case 1.3 Alternative Flow - Meteo: TMA boundary to IAF

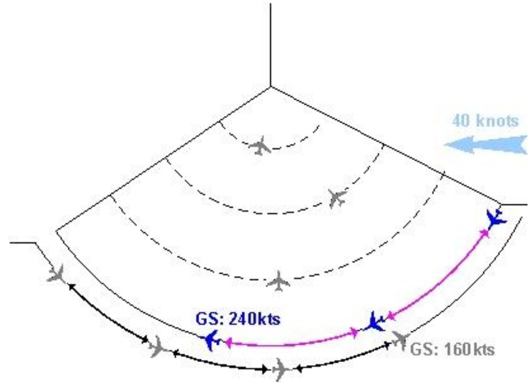
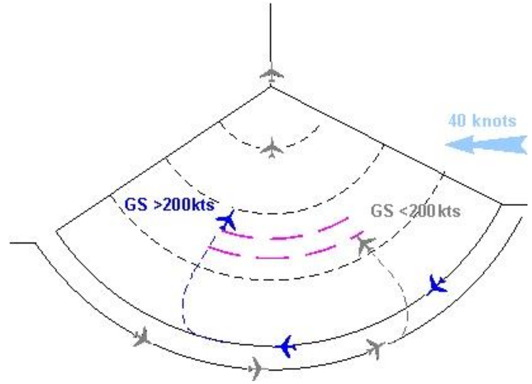
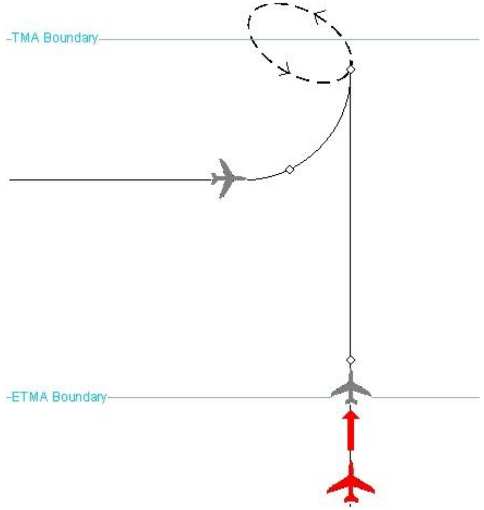
Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)
1	From the ground system, the controller can see a strong cross wind on PMS, causing a tail wind on one of the sequencing leg. The Approach controller compensates for the differences in wind effect on aircraft flying along different sequencing legs through adapted speed instructions and/or increasing longitudinal separation. Approach controller takes account of wind effect when assessing the sequence order.	Fly sequencing leg holding, following the speed controls where applied.	The illustration shows the Ground Speeds (GS) of two aircraft: one flying with a tailwind of 40 knots and one into a headwind of 40 knots; both aircraft in this case have an Indicated Air Speed of 200 knots. Controllers may have to adapt to the situation specifically – as is already the case with current operations.	
2	Approach controller takes account of wind effect when instructing the “direct-to” due to the differing wind effects / speed controls on the two sequencing leg. Adjust speed controls following “direct-to” to maintain sequence spacing to merge point.	Follow transition (“Turn [left/right] direct to Merge Point”) and request clearance to descend to Merge Point. Follow speed controls where applied.	The illustration shows degraded sequence spacing through lack of tactical intervention after the aircraft have left the sequencing legs. In the event of Thunderstorms directly over the PMS, controllers will revert to radar headings to avoid the affected area, with the stacks used to control the traffic flow as necessary. Method similar to that in “Use Case 1.3: TMA boundary to IAF”.	

Table 17 - Use Case 1.3 Alternative Flow - Meteo: IAF to FAF

5.1.4 Use case 1.4: Normal Mode – Alternative Flow – Emergency Mode

The General Conditions, Pre-conditions and Post-Conditions for this Use Case are as per the Main Flow [Section 5.1.1].

Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)
1	The ACC controller detects a new flight entering their area of responsibility. The ACC controller looks at options to expedite the emergency flight, analysing potential conflicts between merging routes at, or before, the TMA boundary. They determine alternative waypoints to use to manage the conflict.	Emergency squawk. Follow the P-RNAV route programmed into the FMS.	This Use Case assumes that an Emergency diversion to an alternative airfield is not an option or is not necessary.	

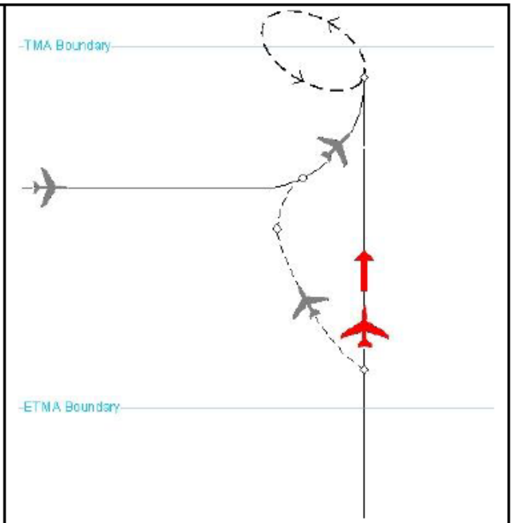
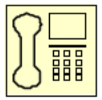
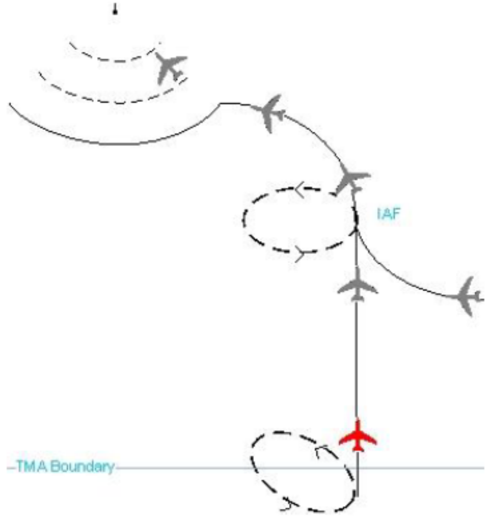
2	To deconflict other inbound traffic from the aircraft in emergency, the ACC controller instructs a potential conflicting flight to follow an alternative waypoint and allow the Emergency flight priority. The ACC controller hands over to the TMA controller prior to the TMA boundary, notifying of emergency condition.	For other flights, additional waypoint inserted into the route, programmed into FMS. Contact TMA controller on given frequency	-	
3	The ACC controller hands over to the TMA controller prior to the TMA boundary. The ACC controller notifies the TMA controller that the flight is following the standard route.	Contact TMA controller on given frequency.	-	

Table 18 - Use Case 1.4 Alternative Flow - Emergency: ETMA boundary to TMA boundary

Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)

1	Once handed over by the ACC controller, the TMA controller looks at options to expedite the emergency flight, and where to integrate this flight into the merging traffic sequence. The TMA controller contacts the Approach controller to determine whether they could accept the emergency flight on a Direct-To the Merge Point. The Approach controller agrees to manage the other traffic to facilitate this Direct-To. The TMA controller clears the flight direct to the Merge Point.	Set a direct-to in the FMS (deleting intermediate waypoints), and manoeuvre accordingly.	-	
2	The TMA controller hands over to the Approach controller early using verbal release. The TMA controller notifies the Approach controller that the flight is off it standard RNAV route – as agreed - to re-join at the Merge Point.	Contact Approach controller on given frequency.	-	

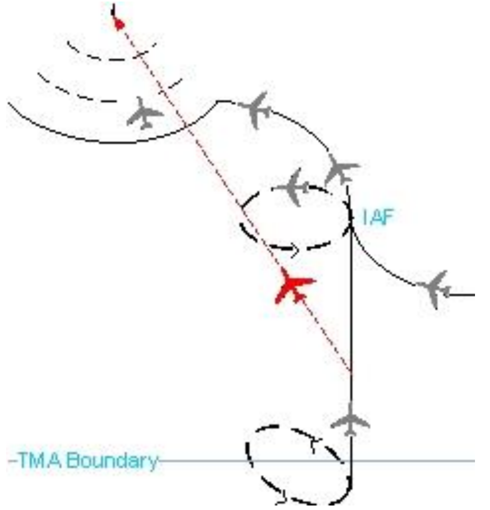
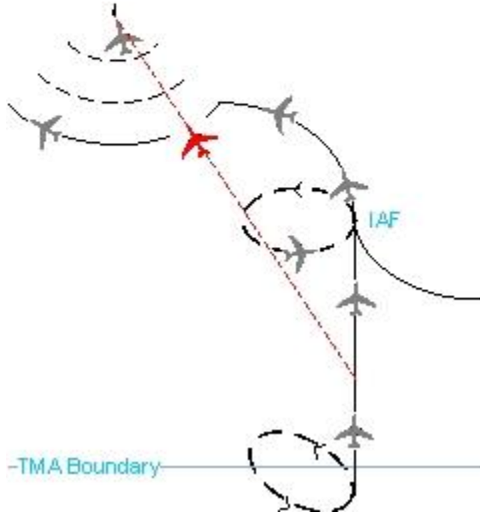
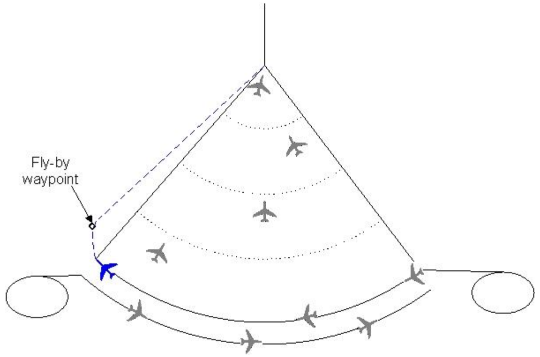
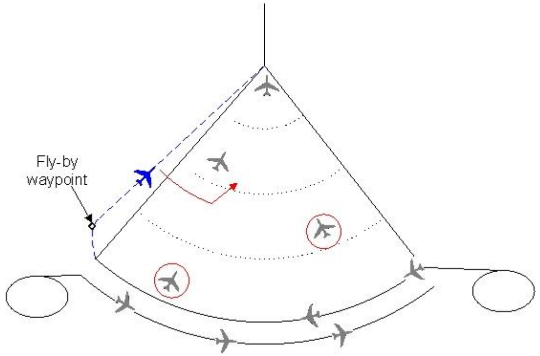
3	The Approach controller alleviates the traffic pressure on the Point Merge system by moving flights into the holding stack. Co-ordinating with Approach, the TMA controller applies speed controls to inbound aircraft.	Continue to follow Direct-To clearance to Merge Point.	Instead of a Direct-To clearance to Merge Point, the controller may issue a Direct-To Final Approach. Alternatively, a Direct-To clearance to the IAF may make sequencing easier (in this illustration, it would provide no shortcut), if time permits.	
4	The Approach controller uses speed controls and the lateral holding capacity of the sequencing leg(s) to create a gap in the sequence for the aircraft in emergency.	Continue to follow Direct-To clearance to Merge Point.	-	

Table 19 - Use Case 1.4 Alternative Flow - Emergency: TMA boundary to IAF and IAF to FAF

5.1.5 Use case 1.5: Normal Mode – Alternative Flow – Sequencing Leg Run-Off

The General Conditions, Pre-conditions and Post-Conditions for this Use Case are as per the Main Flow [Section 5.1.1].

Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)
1	-	When reaching the end of a sequencing leg without receiving a turn-to-merge instruction from the controller, the pilot shall turn to the Merge Point via a fly-by waypoint and request clearance to descend to the Merge Point.	-	
2	The controller cannot give clearance to descend without breaching separation, so they look at the option of vectoring the aircraft within the PMS, e.g. as per the red line on the illustration. In this case the PMS is fully loaded and vectoring the aircraft would create conflicts with following aircraft (circled in red on the illustration). The controller instructs the aircraft to hold at the Merge Point.	Continue to Merge Point but without descending.	If the controller was able to appropriately sequence the aircraft, whilst maintaining separation, then they could have cleared the aircraft for descent to the Merge Point and the aircraft could merge into the sequence as per the Main Flow.	

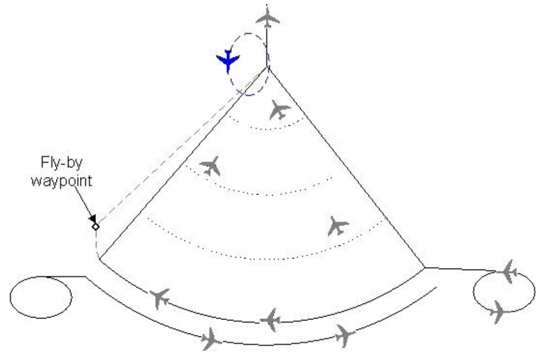
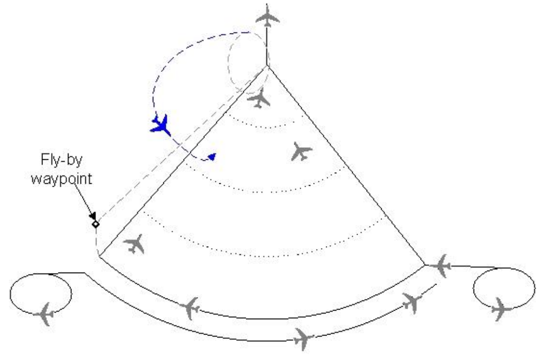
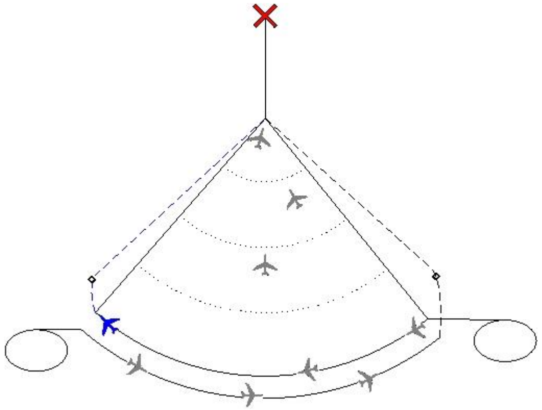
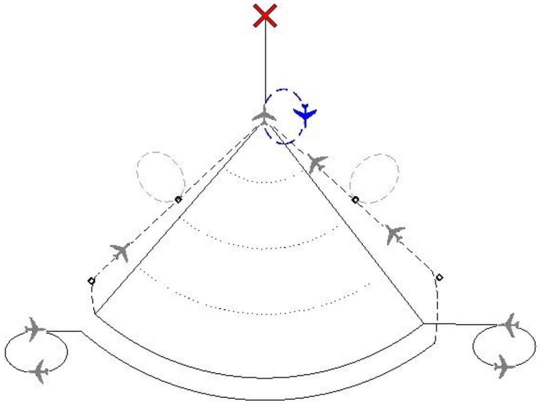
3	The feeder holding stacks are used to make a gap to allow re-insertion of the flight into the traffic flow.	Hold at the contingency stack and program FMS based on updates from ATC regarding any further holding time.	-	
4	The controller vectors the aircraft off the stack, descending the aircraft so that it is inserted into a gap created in the sequence. The flight is cleared for remainder of appropriate Transition.	Follow vectors from controller, until the FMS can pick up the RNAV route again. A "Direct-To" the merge point has to be inserted in the FMS. Most likely a "flight plan discontinuity" will be displayed in the FMS. If so, this is deleted in order to sequence the FMS flight plan.	Instead of vectoring the aircraft, the controller can descend it through the stack before clearing to descend to FAF. However, if the PMS is busy, then this may create potential conflicts with other aircraft descending from the sequencing legs to the Merge Point.	

Table 20 - Use Case 1.5 Alternative Flow – Sequencing Leg Run-off: IAF to FAF

5.1.6 Use case 1.6: Normal Mode – Alternative Flow – Runway Closure

The General Conditions, Pre-conditions and Post-Conditions for this Use Case are as per the Main Flow [Section 5.1.1].

Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)

1	(i) In the event of temporary runway closure, the controller managing the holding stacks uses them to delay aircraft entering the PMS. (iii) For aircraft that are already on the PMS and have been given clearance to descend to merge, the controller managing the PMS will instruct each aircraft to level-off at a unique FL/altitude then to hold in a contingency stack at the Merge Point (ii) The controller managing the PMS instructs aircraft on the Sequencing Legs to follow the flyby waypoint and to also hold at the Merge Point, providing climb or descent instructions per aircraft as necessary to fill the stack levels.	(i)+(ii)+(iii) Update FMS based on updates from ATC regarding any further holding time.	Runway closure may be due to a security and/or safety incident. This Use Case assumes that the runway closure is of a short duration and re-routing to other airfields is not necessary.	
2	-	All aircraft to fly their respective stack holding pattern.	Space-permitting, holds may be defined at waypoints alongside the PMS. These additional holds may be necessary for implementations where the PMS is large (i.e. can be loaded with high numbers of aircraft) and there are limited vertical levels available for stacking at the Merge Point. In this case, the controller managing the PMS instructs each aircraft on the Sequencing Legs to follow the flyby waypoint and to hold at a defined waypoint alongside the PMS	

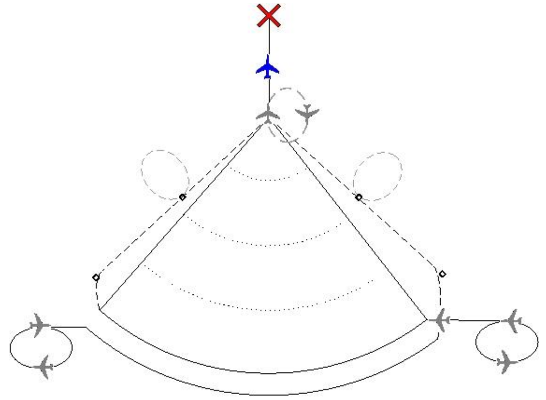
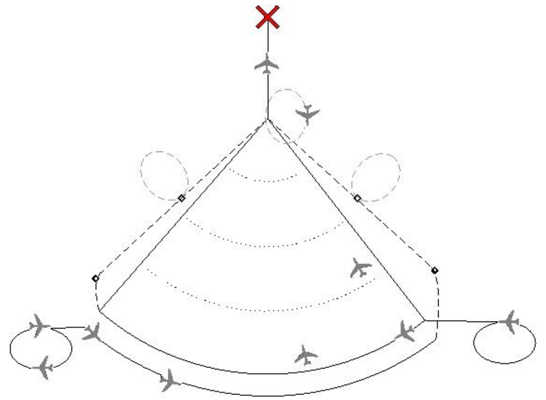
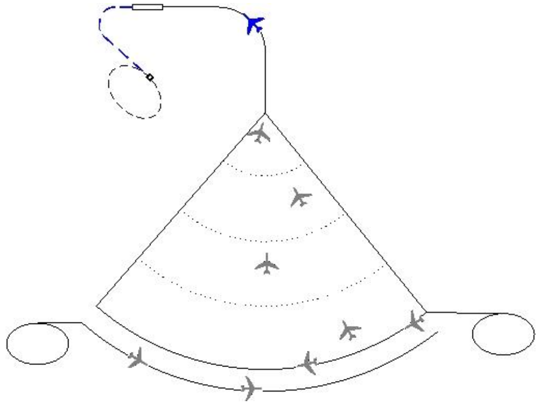
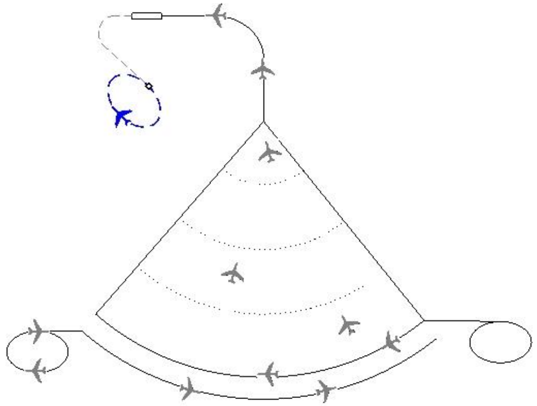
3	In this case, the runway is re-opened and the controller begins taking aircraft off the stacks, starting with the hold at the Merge Point (descending aircraft through the levels in the stack).	The blue aircraft is descended through the stack the then, when cleared, descends to the FAF and makes ready for final approach.	-	
4	As the contingency stack at the Merge Point is cleared (and, if applicable, the stacks alongside the PMS are cleared), other traffic is released from the feeder stacks to load the sequencing legs in readiness for recommencement of normal traffic flow.	-	-	

Table 21 - Use Case 1.6 Alternative Flow – Sequencing Leg Run-off: IAF to FAF

5.1.7 Use case 1.7: Normal Mode – Alternative Flow – Missed Approach Procedure

The General Conditions, Pre-conditions and Post-Conditions for this Use Case are as per the Main Flow [Section 5.1.1].

Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)

1	Following the pilot's request, the Approach controller clears the blue aircraft to follow the Missed Approach Procedure (MAP), vectoring the aircraft if/as necessary. The PMS is fully loaded so the Approach requests the controller responsible for loading the sequencing leg to make a gap to allow re-insertion of the flight into the traffic flow	The blue aircraft advises ATC of a Missed Approach and follows the Missed Approach procedure by flying to a defined holding waypoint (this may be pre-programmed in the FMS).	The defined holding waypoint(s) could be located within the PMS. For example, if vertical separation can be provided, the Merge Point could be used as the waypoint for the Missed Approach Procedure, with aircraft on the MAP holding at a level below that of aircraft on the PMS.	
2	Using the sequencing legs and feeder stacks, a gap is created in the traffic flow. The blue aircraft is not in an emergency state so no other action is taken with the traffic flow (such as vectoring) to create an earlier gap and the blue aircraft is instructed to hold at a pre-defined waypoint.	Fly holding pattern as instructed.	The hold is used at the controller's discretion. It may not be necessary to hold in low traffic periods. If necessary (e.g. the aircraft on the MAP advises of an on-board emergency), the controller may use open-loop vectoring of aircraft already on the PMS to create a suitable gap in the traffic sequence to allow the emergency aircraft to land.	

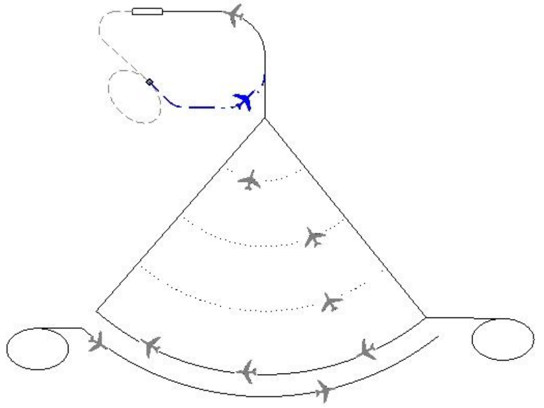
3	The controller vectors the aircraft off the stack so that it is inserted into a gap created in the sequence. Clear for remainder of appropriate Transition.	Follow vectors from controller, until the FMS can pick up the RNAV route again or intercept the ILS.	Merging Missed Approaches after the Merge Point minimises the additional track miles needed to follow the MAP, but give the controller only a short time to manage the traffic flow for re-insertion. Therefore, some optional holding capacity on the MAP is necessary to deal with busy periods.	

Table 22 - Use Case 1.7 Alternative Flow – Missed Approach Procedure: IAF to FAF

5.2 Operational Scenario 2: Medium Density / Medium Complexity Arrivals

Processes:

- Implement ENR/ETMA
- Implement TMA/APP

5.2.1 Use case 2.1: Normal Mode - Main Flow

The General Conditions, Pre-conditions and Post-Conditions for this Use Case are as per section 7.1.1 of the EUROCONTROL OSED [14]:

Pre-Conditions

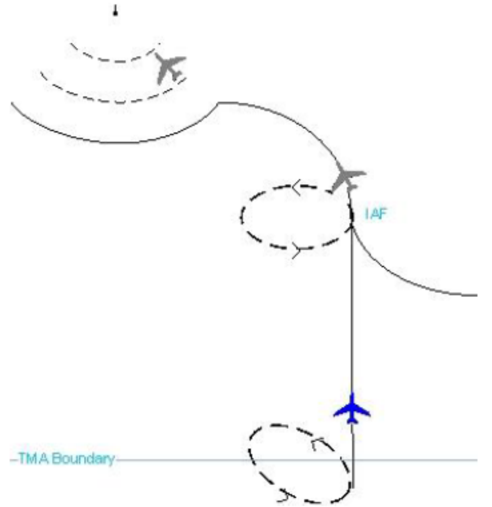
- PreC1 - Aircraft equipped with procedure loaded into FMS and flown by flight crew, with lateral navigation engaged, in accordance with ATC route clearance;
- PreC2 - Appropriate acceptance rate(s) set for Point Merge system's entry – taking into consideration such issues as longitudinal separation, wake turbulence constraints, meteorological conditions, capacity constraints of the Point Merge system itself and at its exit, etc...
- PreC3 - Delivery of metered traffic flow(s) in accordance with this(ese) rate(s) e.g. through an AMAN
- PreC4 - Traffic delivery with longitudinal separation within each inbound flow.
- PreC5 - Aircraft stable at the defined level/altitude for each sequencing leg prior to leg's entry;
- PreC6 - Traffic level such that path stretching is needed for some, if not all flights in the sequence, in order to integrate inbound flows;

Plus the following addition:

- PreC7 – The arrival and departure routes are deconflicted from each other and from those of neighbouring airfields, so as to allow a flyable and effective P-RNAV route structure.

For the phase of flight from **ETMA boundary** to **TMA boundary**, there is no change from Operational Scenario 1 [Section 5.1.1].

Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)

1	Once handed over by the ACC controller, the TMA controller looks at options to expedite all flights, while detecting potential conflicts. The TMA controller contacts the Approach controller to determine whether they could accept the flight on a Direct-To the Merge Point. The Approach controller agrees to facilitate this Direct-To. The TMA controller clears the flight direct to the Merge Point.	Set a direct-to in the FMS (deleting intermediate waypoints), and manoeuvre accordingly	The controller should always consider the trade-off between a Direct-To clearance and the potential for an inefficient descent profile, e.g. with additional level-offs required to deconflict traffic.	
2	The TMA controller hands over to the Approach controller early using verbal release. The TMA controller notifies the Approach controller that the flight is off it standard RNAV route – as agreed - to re-join at the Merge Point.	Contact Approach controller on given frequency	-	

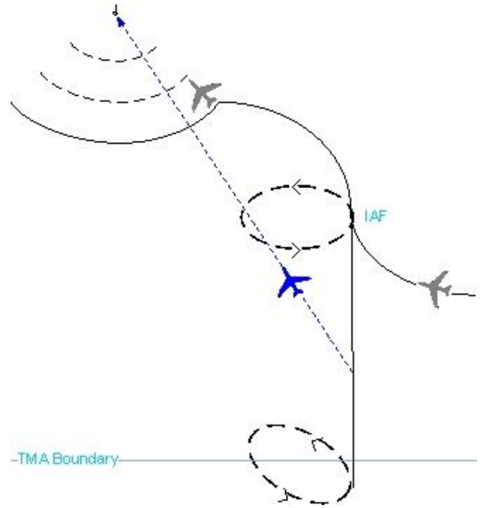
3	The Approach controller gives instruction to descend to provide vertical separation with stack.	Continue to follow Direct-To clearance and update FMS. .	Where practical, a Direct-To clearance to the Merge Point or ILS may provide an even better profile.	

Table 23 - Use Case 1.4 Alternative Flow – Low Traffic Demand: TMA boundary to IAF and IAF to FAF

5.2.2 Use case 2.2: Normal Mode – Alternative Flow

The Use Cases for the Alternative Flows under the 'Medium Density / Medium Complexity Arrivals' Operational Scenario are essentially the same as under the 'High Density / High Complexity Arrivals' Operational Scenario [Section 5.1].

5.3 Operational Scenario 3: High Density / High Complexity Departures

Processes:

- Implement TMA

5.3.1 Use case 3.1: Normal Mode – Main Flow

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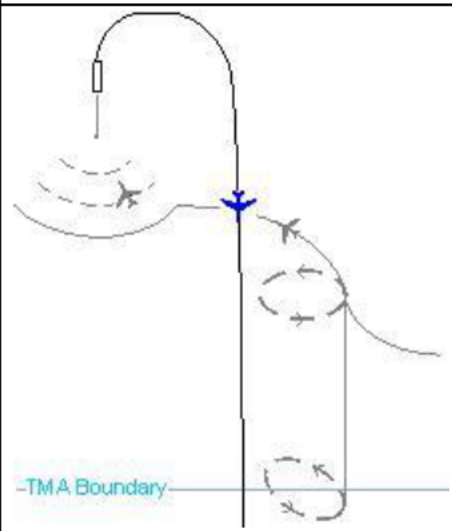
Step	ATC	Flight Crew	Notes	Phase (high level ATCO tasks)
1	The TMA controller monitors longitudinal separation and compliance with the SID. No deviations are detected so no tactical intervention necessary. Before reaching the TMA boundary, the TMA controller hands over to the ACC controller.	Follow the SID, which out-climbs the arrival routes, to provide a continuous climb to cruise level out of the TMA.	This illustration does not depict the interaction of arrivals and departures with neighbouring airfields, which will also need to be considered.	
2	Before reaching the TMA boundary, the TMA controller hands over to the ACC controller via verbal release. The TMA controller notifies the ACC controller that the flight is following the standard RNAV route.	Contact ACC controller on given frequency	-	

Table 24 - Use Case 3.1 Main Flow - Departures: Take-off to TMA boundary

5.3.2 Use case 3.2: Normal Mode – Alternative Flow – Non-equipped aircraft

The Use Cases for the Alternative Flows are essentially the same as under Main Flow [Section 5.3.1], with the following exceptions:

> For Non-equipped Aircraft, the TMA controller may need to apply greater longitudinal separation on the P-RNAV routes and/or speed controls.

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5.3.3 Use case 3.2: Normal Mode – Alternative Flow – Meteorological Conditions

The Use Cases for the Alternative Flows are essentially the same as under Main Flow [Section 5.3.1], with the following exceptions:

> Under adverse meteorological conditions, the TMA controller may need to apply greater longitudinal separation on the P-RNAV routes and/or speed controls.

5.3.4 Use case 3.3: Normal Mode – Alternative Flow – Emergency Returns on Departure

As per Current Day operations, vectors are used to control the Emergency Returning aircraft.

The holding capacity at the stacks and sequencing legs is used to generate a suitable gap in the arrival traffic flow to enable the Emergency Return to be inserted into the landing sequence. Where a suitable gap in the arrival traffic cannot be generated in a quick enough time, the Approach controller will also revert to vectors to manage traffic that is already past the Merge Point (all other traffic should be able to use holding capacity as necessary

5.4 Additional Abnormal Modes & Internal Failures

In addition to abnormal modes (alternative flows) described in sections 5.1 to 5.3, and those given in the operating methods as per section 7.3 of the EUROCONTROL OSED [14], the following abnormal modes and internal failures are considered:

Abnormal Modes:

- Single Aircraft Radio Telephony Failure
  - If available, use alternative means of air-ground communication, such as Datalink or ACARS. Where impossible or impractical, use the following steps.
  - Flight crew to squawk '7600' and Follow the STAR to IAF then hold in the stack for a pre-defined period of time, e.g. 1 circuit, to give the controller sufficient time to clear the transition/PMS of potential conflicts. After the pre-defined holding period, the aircraft follows the maximum transition along the Point Merge sequencing leg via the flyby waypoint, descend to the Merge Point then to FAF and intercept ILS glideslope to runway.
  - If, at any stage, the aircraft has an emergency, e.g. low fuel, then the squawk is changed from '7600' to '7700', it undertakes no further stack holding and follows the PMS transition but with zero holding on the sequencing legs through to landing. In this scenario, the controller may revert to open-loop vectors to other aircraft that may come into potential conflict with the emergency aircraft.
- Category B flights[5] operating in the region of the Merge Point.
  - Treat the same as if a Thunderstorm were similarly affecting the PMS [refer to Section 5.1.3].
  - The PMS is expected to allow the controller more time to deal with a CAT B flight because, except for the affected area, no vectoring is required (as with current day operations); aircraft are passively proceeding along the route or within the PMS.
- Loss of dedicated airborne hold
- Level Bust on Sequencing Leg

Internal Failures:

- P-RNAV Equipage Failure
  - Flight crew to notify ATC. ATC mark or cock the strip to identify the lack of P-RNAV capability. Follow the P-RNAV routes as per unequipped (B-RNAV capable) aircraft if able. If not, then controlled by vectors and put into stack holds when/where necessary.
- Total loss of Radio Telephony
- Total loss of Surveillance
- Total loss of Navigation (satellite / ground system)

The internal Failures are captured in the Hazard Log [Refer to Appendix C].

[5] Flights operating for search and rescue or other humanitarian reasons. Post accident flight checks. Other flights, including Open Skies Flights, authorised by the CAA. Police flights under normal operational priority [23].

6 Requirements

This section describes the functional or qualitative requirements applicable to every operational service.

This section develops the DOD requirements which are applicable to the Operational Focus Area addressed by this OSED. The OSED defines the requirements, which will be refined lower-level requirements in the Safety and Performance document (SPR).

The requirements shall be traced with respect to the high level operational requirements identified in the DOD, when available:

- For Step 1, if the DOD is not available, a provisional description of Operational Requirements shall be provided, based on the Operational knowledge of the project team,
- For step 2 & 3 where a top down approach is applied, the requirements shall be derived from the DOD.

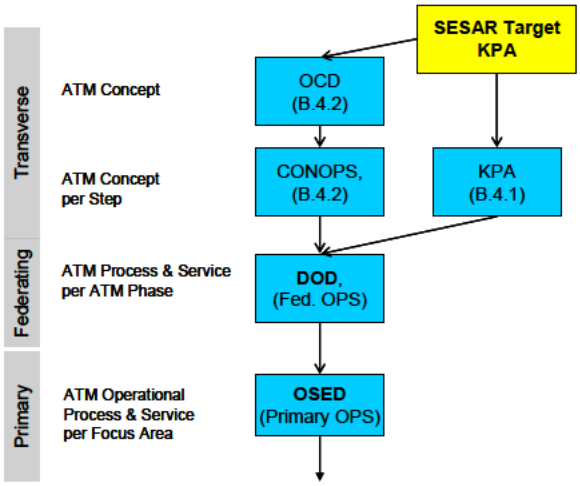


Figure 8: Requirements traceability

The Operational Requirements for the ‘Point Merge in Complex TMA’ OFA were developed from controller and safety workshops and are as follows:

6.1 High-Level Operational Requirements

Identifier	REQ-05.07.04-OSED-KPA0.0001
Requirement	Runway Throughput shall be maintained at Current Day levels or increased.
	5.7.4- HLReq -001
	Airfield throughput must be maintained.
Validation Method	<Real Time Simulation>

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>		
<APPLIES_TO>	<Operational Process> or <Operational Service>	N/A	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA 02.01.02	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	VHC TMA	N/A

Identifier	REQ-05.07.04-OSED-KPA0.0002
Requirement	Controller and Flight Crew Workload shall be reduced.
	5.7.4- HLReq -002
	Contribution to the Local Airspace Capacity KPA
Validation Method	<Real Time Simulation>

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<APPLIES_TO>	<Operational Process> or <Operational Service>	N/A	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA 02.01.02	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	VHC TMA	N/A

Identifier	REQ-05.07.04-OSED-KPA0.0003
Requirement	Approach Controllers' Human Performance levels shall be maintained at Current Day levels or enhanced.
	5.7.4- HLReq -003
	Contribution to the Local Airspace Capacity KPA
Validation Method	<Real Time Simulation>

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<APPLIES_TO>	<Operational Process> or <Operational Service>	N/A	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA 02.01.02	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	VHC TMA	N/A

Identifier	REQ-05.07.04-OSED-KPA0.0004
Requirement	Safety levels for the TMA shall be maintained at Current Day levels or improved.
	5.7.4- HLReq -004
	Safety levels must not be impaired.
Validation Method	<Real Time Simulation>

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<APPLIES_TO>	<Operational Process> or <Operational Service>	N/A	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA 02.01.02	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	VHC TMA	N/A

Identifier	REQ-05.07.04-OSED-KPA0.0005
Requirement	Efficiency of Arrival & Departure Management shall be improved,
	5.7.4- HLReq -005
	Quality of Service must be maintained so as not to compound TMA congestion
Validation Method	<Real Time Simulation>

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>		
<APPLIES_TO>	<Operational Process> or <Operational Service>	N/A	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA 02.01.02	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	VHC TMA	N/A

Identifier	REQ-05.07.04-OSED-KPA0.0006
Requirement	Hold Occupancy & Levels shall be maintained at Current Day Levels or reduced.
	5.7.4- HLReq -006
	Quality of Service must be maintained so as not to compound TMA congestion
Validation Method	<Real Time Simulation>

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>		
<APPLIES_TO>	<Operational Process> or <Operational Service>	N/A	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA 02.01.02	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	VHC TMA	N/A

Identifier	REQ-05.07.04-OSED-KPA0.0007
Requirement	Fuel Burn and CO_2 Emissions shall be reduced.
	5.7.4- HLReq -007
	Contribution to the Environmental Sustainability KPA

Validation Method	<Real Time Simulation>

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>		
<APPLIES_TO>	<Operational Process> or <Operational Service>	N/A	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA 02.01.02	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	VHC TMA	N/A

Identifier	REQ-05.07.04-OSED-KPA0.0008
Requirement	The impact of Noise pollution shall be reduced.
	5.7.4- HLReq -008
	Airfield throughput must be maintained.
Validation Method	<Real Time Simulation>

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>		
<APPLIES_TO>	<Operational Process> or <Operational Service>	N/A	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA 02.01.02	N/A
<APPLIED_IN_ENVIRONMENT>	<Environment Class>	VHC TMA	N/A

6.2 Operational Requirements: Plan and Implement ATC Sectors

Identifier	REQ-05.07.04-OSED-OPS0.0001
Requirement	All SIDs, STARs and extended routes shall be comprised of P-RNAV routes.
	Advanced RNP is proposed as an ECAC-wide navigation specification to be used in En-route as well as Terminal airspace and to cover all phases of flight.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0002
Requirement	Level constraints shall be applied (mandatory or 'expected') on SIDs or STARs where necessary to deconflict arrivals and departures.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0003
Requirement	CCDs shall be incorporated into the Departure routes.
	CCDs are considered a key method for improving the environmental efficiency of the vertical profile for outbound aircraft. CCDs are considered a key benefit of P-RNAV route structures and should be considered part of efficient TMA design.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0004
Requirement	CDAs shall be incorporated into the Approach routes.
	CDAs are considered a key method for improving the environmental efficiency of the vertical profile for inbound aircraft. CDAs are considered a key benefit of P-RNAV route structures and should be considered part of efficient TMA design.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0005
Requirement	A path stretching/shortening capability shall be available to deliver onto Final Approach
Validation Method	<Real Time Simulation>

Identifier	REQ-05.07.04-OSED-OPS0.0006
Requirement	The Point Merge System shall be implemented as an invariant design
	For an 'Airspace Constrained' TMAs with 'Airfield Interaction' constraints, it is recommended that an invariant Point Merge design is used, i.e. the PMS and STARs do not change whether Easterly or Westerly runways are in use.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0007
Requirement	Each Point Merge procedure shall be part of P-RNAV routes only.
	Point Merge procedures are considered part of a P-RNAV route structured TMA.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0008
Requirement	The airspace design shall be able to deliver Point Merge operations for any runway direction, without degradation of service level.
	Runway change is part of standard operations dependent on predominant wind

	direction (easterly or westerly).
Validation Method	<Real Time Simulation>

Identifier	REQ-05.07.04-OSED-OPS0.0009
Requirement	Waypoints should be defined at the entry points of the sequencing to provide the controllers with the opportunity to direct traffic straight to the Point Merge arcs
	This could be used as part of standard operation to provide path shortening under low traffic density conditions or to mitigate some non-nominal scenarios, such as Emergencies.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0010
Requirement	The Point Merge Sequencing Legs should be defined as Radius Fix (RF) turns around the Merge Point.
	This reduces the number of waypoints needed in the FMS to be coded for the STAR/Transition, which reduces pilot workload. Dependent of Aircraft equipage.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0011
Requirement	For each Approach function, a Radar Manoeuvring Area (RMA) should be defined to allow radar vectoring.
	where rapid changes in spacing are needed to maintain Approach throughput, or to deal with equipage failure, system failure or significant adverse impact from weather. This could cover the area of the PMS.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0012
Requirement	Pre-defined Short Routes shall bypass the Point Merge System(s) when capacity constraints allow.
	Point Merge Systems with level-off and speed constraints on sequencing legs

	manage high traffic density situations well but do not provide the most fuel-efficient approaches. Pre-defining the short routes enables pilots to plan the most efficient descent and approach under low traffic density periods.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0013
Requirement	Holding capacity shall be available to the TMA controllers, prior to the Approach phase
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0014
Requirement	Holding capacity shall be available to the controllers responsible for managing the loading of the Point Merge System
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0015
Requirement	There shall be contingency holding capacity available downstream of the Point Merge System.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

6.3 Operational Requirements: Monitor Traffic

Identifier	REQ-05.07.04-OSED-OPS0.0016
Requirement	Silent Release should be used for handover between controllers.
	For aircraft that are following an RNP route, and are not diverted from their STAR. In this case, the downstream controller knows what to expect (where and when) from the upstream controller so no verbal release is necessary. This reduces controller workload
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0017
Requirement	Pilots should be allowed to fly (FMS) managed descent or climb wherever possible.
	There are several ways for the pilot to perform descent/approach (full managed, V/S, DES, OP DES, NAV, HDG...), which may lead to different behaviours in handling constraints and clearances. This should be further considered when developing operational procedures.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		

6.4 Operational Requirements: Separate Traffic

Identifier	REQ-05.07.04-OSED-OPS0.0018
Requirement	Level-offs shall be used for the Point Merge sequencing legs.
	Point Merge without level-off on the sequencing legs is not recommended for implementation within the limited airspace of a complex TMA; this is a trade-off with flight efficiency.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0019
Requirement	Constant speeds should be used on the Point Merge System
	The controller must ensure longitudinal separation is maintained for traffic on the same leg. To aid simplicity and reduce controller workload, it is recommended that speed restrictions are applied from the IAF. If possible, the speed restrictions should allow all, or the vast majority, of aircraft to fly clean, e.g. set at 230kts
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0020
Requirement	Controllers should consider using stack holding once aircraft begin to use approximately half of the sequencing leg.
	The point at which aircraft need to hold may be earlier than it intuitively feels to the controller given the reduced R/T usage and number and vectoring instructions.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0021
Requirement	The controller shall be aware of the P-RNAV capability of every aircraft under their control.
	It is essential for the controller to be fully aware of any non-equipped aircraft entering his/her airspace so that they can react accordingly, where necessary, due to the reduced navigational accuracy of such aircraft.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

6.5 Operational Requirements: Synchronise Traffic

Identifier	REQ-05.07.04-OSED-OPS0.0022
Requirement	The Point Merge System shall be used for final adjustment of traffic sequencing, sequencing multiple traffic flows together (as arriving on the sequencing legs), optimising spacing of traffic delivery to either the base leg or final approach and prioritising emergencies where necessary.
	The Point Merge System provides the Sequencing and Merging capability in the fixed P-RNAV route structure.
Validation Method	<Real Time Simulation>

Identifier	REQ-05.07.04-OSED-OPS0.0023
Requirement	The Point Merge sequencing legs shall be considered as lateral holds.
	Any time spent on a sequencing leg is time spent in a hold and not, therefore, considered as part of the route for fuel planning purposes.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0024
Requirement	The controller shall notify the pilot of all constraints, direct-routings or delay as early as possible.
	The controller should endeavour to notify the flight crew of intentions as soon as possible so that the FMS can be updated in a timely manner and calculate an efficient arrival profile. If not, then predictability and environmental efficiency is poor.
Validation Method	<Real Time Simulation>

<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-OPS0.0025
Requirement	Under high density traffic conditions, the controller shall always have aircraft available in the holds (the Point Merge sequencing legs and/or holding stacks).
	To ensure that a consistent flow of traffic through Approach can be maintained
Validation Method	<Real Time Simulation>

6.6 Safety Objectives: Plan and Implement ATC Sectors

The following table lists the complete set of Functional and Performance Safety Objectives (and sub-Objectives) taken from the 5.7.4 Safety Assessment Report [28].

Identifier	REQ-05.07.04-OSED-SAF0.0001
Requirement	Point Merge arrivals traffic shall be metered according to RWY throughput and holding capacity (ECTL-SO#16.)
Title	SO#1
Status	<In Progress>
Rationale	To avoid overloading the runway and holds
Category	<Safety><Functional>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-SAF0.0002
Requirement	Point Merge arrivals traffic shall be metered in order to achieve max RWY capacity commensurate with the need to maintain separation/wake minima
Title	SO#1.1
Status	<In Progress>
Rationale	To avoid reducing aircraft separation below the appropriate minima
Category	<Safety><Functional>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-SAF0.0003
Requirement	Controllers shall be continuously knowledgeable of aircraft P-RNAV capability in complex TMA (ECTL- SO#4)
Title	SO#2.2
Status	<In Progress>
Rationale	The Controller must be aware of whether an aircraft is P-RNAV capable or not in order to understand and anticipate the performance characteristics of the aircraft (e.g. route following accuracy) and plan accordingly.
Category	<Safety><Functional>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

6.7 Safety Objectives: Monitor traffic

Identifier	REQ-05.07.04-OSED-SAF0.0004
Requirement	Each aircraft shall be monitored for conformance to its cleared route in complex TMA (or heading if vectored), assigned altitude, descent/departure profile and speed instructions.
Title	SO#2.3
Status	<In Progress>
Rationale	To prevent conflicts occurring
Category	<Safety><Functional>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

6.8 Safety Objectives: Separate Traffic

Identifier	REQ-05.07.04-OSED-SAF0.0005
Requirement	The required separation/spacing between aircraft shall be maintained through Point Merge arrivals to IAF and through departures
Title	SO#2
Status	<In Progress>
Rationale	To avoid reducing aircraft separation below the appropriate minima
Category	<Safety><Functional>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-SAF0.0006
Requirement	Point Merge arrivals traffic shall conform to entry criteria: entry point, route (or heading if vectored), altitude, speed constraint (ECTL-SO#18), separation constraints (including for adverse meteorological conditions)
Title	SO#2.1
Status	<In Progress>
Rationale	To ensure that separation is maintained on the sequencing leg
Category	<Safety><Functional>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-SAF0.0007
Requirement	Controller capability for reversion to vectors shall be maintained
Title	SO#2.4
Status	<In Progress>
Rationale	To ensure that Controllers have the capability to revert to vectors when required (e.g. during emergency situations)
Category	<Safety><Functional>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-SAF0.0008
Requirement	Emergency squawk aircraft shall be prioritised
Title	SO#3
Status	<In Progress>
Rationale	To ensure emergency aircraft are managed with highest priority
Category	<Safety><Functional>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-SAF0.0009
Requirement	The required separation/spacing between aircraft in the event of severe weather shall be maintained through Point Merge arrivals to IAF and through departures
Title	SO#4
Status	<In Progress>
Rationale	To ensure separation of aircraft is maintained during severe weather operations
Category	<Safety><Functional>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-SAF0.0010
Requirement	The required separation/spacing between aircraft shall be maintained on and between the Point Merge sequencing legs
Title	SO#5
Status	<In Progress>
Rationale	To ensure separation is maintained for aircraft on or between the sequencing legs
Category	<Safety><Functional>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

<SATISFIES>	<ATMS Requirement>		

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-SAF0.0011
Requirement	The required separation/spacing between aircraft shall be maintained in converging Point Merge arrival flows to final approach acquisition
Title	SO#6
Status	<In Progress>
Rationale	To ensure separation is maintained for aircraft on converging PMS flows
Category	<Safety><Functional>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-SAF0.0012
Requirement	Obstacle and terrain clearance for Point Merge arrivals shall be provided
Title	SO#7
Status	<In Progress>
Rationale	To prevent conflict with obstacles or terrain
Category	<Safety><Functional>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

Identifier	REQ-05.07.04-OSED-SAF0.0013
Requirement	The required separation/spacing between aircraft in the event of severe weather shall be maintained within Point Merge structure
Title	SO#8
Status	<In Progress>
Rationale	To ensure separation of aircraft is maintained during severe weather operations within the Point Merge System
Category	<Safety><Functional>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

<SATISFIES>	<ATMS Requirement>		

<SATISFIES>	<ATMS Requirement>		

6.9 Safety Objectives: Synchronise Traffic

Identifier	REQ-05.07.04-OSED-SAF0.0014
Requirement	Physical capacity for aircraft that have deviated, or been vectored, irretrievably from their cleared route / altitude to be re-inserted into the (Point Merge) landing sequence or direct-to clearance shall be provided in such a way as to avoid as far as possible propagating the need for the reversion to vectors for other aircraft in the landing sequence (ECTL-SO#27)
Title	SO#2.5
Status	<In Progress>
Rationale	To ensure that Controllers have the capability to revert to vectors when required (e.g. during emergency situations)
Category	<Safety><Functional>
Validation Method	<Real Time Simulation>
Verification Method	N/A

[REQ Trace]

<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		
<SATISFIES>	<ATMS Requirement>		

7 References

7.1 Applicable Documents

This OSED complies with the requirements set out in the following documents:

[1] SESAR SEMP v2.0

[2] B4.2 Initial Service Taxonomy document

[3] Template Toolbox 02.00.00

[4] Requirements and V&V Guidelines 02.00.00

[5] Toolbox User Manual 02.00.00

7.2 Reference Documents

The following documents were used to provide input/guidance/further information/other:

[6] B4.2 High Level Process Models

[7] B4.2 WPB4.2 – D08 processes and Services, dated 12/09/2010

[8] ED-78A Guidelines for Approval of the provision and use of Air Traffic Services supported by Data Communications

[9] B4.3 Architecture Description Document

[10] ICAO Document 9694

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

[12] EUROCONTROL "Point Merge Integration of Arrival Flows Enabling Extensive RNAV Application and Continuous Descent OSED" V2.0, 19/07/10, CND/COE/AT/AO

[13] OATA Operational Scenario and Use Case Guide V1.0

[14] Point Merge Integration of Arrival Flows Enabling Extensive RNAV Application and Continuous Descent - Operational Services and Environment Definition, EUROCONTROL CND/COE/AT/AO, Version 2.0, 19th July 2010

[15] Operational Focus Areas Programme Guidance, SJU, Edition 02.00.00, 15th April 2011

[16] SESAR B4.2 Concept of Operations Step 1, Edition 01.00.00, 9th May 2012.

[17] DLT-0612-222-02-00_D3_Concept of Operations, SESAR Consortium, 2007

[18] ICAO Doc 9573, Manual of Area Navigation (RNAV) Operations, First Edition.

[19] ICAO Doc 9613 –AN/937, 'Performance Based Navigation Manual (Final Draft)', 2007.

[20] EUROCONTROL Airspace Planning Manual Volume 2, Section 5 – Terminal Airspace Design Guidelines, Ed 2.0 -Amendment 1, 17.01.2005.

[21] EUROCONTROL Guidance Material for the Design of Terminal Procedures for Area Navigation (DME/DME, B-GNSS, Baro-VNAV & RNP-RNAV), Ed. 3.0, March 2003.

[22] B4.1 Methodology for Allocating Targets and Performance Requirements at the Appropriate Levels, Edition 00.01.00, 27th July 2010.

[23] Manual of Air Traffic Services Part 1, UK CAA CAP493, June 2011

[24] SESAR 05.06.04 Initial OSED, Edition 00.01.00

[25] SESAR B4.1 Validation Target Allocation for Step 1, Edition 00.02.00, November 2011

[26] SESAR P05.07.04 WS2 Validation Report (VALR) – London TMA & Milan TMA, Edition 00.02.00, June 2012.

[27] SESAR European ATM Master Plan, Draft Edition 2, March 2012

[28] SESAR P.05.07.04 Point Merge in Complex TMA – London & Milan (OFA) Safety Assessment Report (SAR), v00.01.00, March 2012

Appendix A Justifications

Refer to Safety Assessment Report [28] and additional Appendices below.

Appendix B Interface with Project 5.6.4

The airspace under consideration is that within the TMA boundary only. For this OSED, the TMA boundary is demarked by the 'Outer' holds', but this may be represented by other constructs, e.g. merging traffic flows. Streamed traffic will be delivered to the Outer Holds by Arrival Management functions, which are being developed by SESAR project 5.6.4 [24]. Figure 7 illustrates the interfaces between projects 5.7.4 and 5.6.4 using boundary definitions that form part of the Arrival Management concept. T_2 is represented by the Extended TMA boundary, which is approx 150NM from the centre of the TMA. T_1 is approx 30 track miles from touchdown and is represented by the Initial Approach Fix (IAF), which may be the entry point to holding stacks or to Point Merge sequencing legs.

Arrival Management is expected to deliver aircraft to the Extended TMA boundary within defined tolerances to specified time constraints - Controlled Times of Arrival (CTA). Depending upon the magnitude of the tolerances at the Extended TMA boundary, there may be a need for further sequencing and streaming of inbound traffic after this point. Given the airspace limitations within a Complex TMA (see **Table 8**) there is only a very limited amount of sequencing and streaming possible within the TMA boundary. Therefore, there may need to be such capability between T_2 and T_1, which has the potential to generate high workload for TMA controllers streaming aircraft for Approach; they need to provide optimum landing sequence and miles in trail delivery to reduce holding.

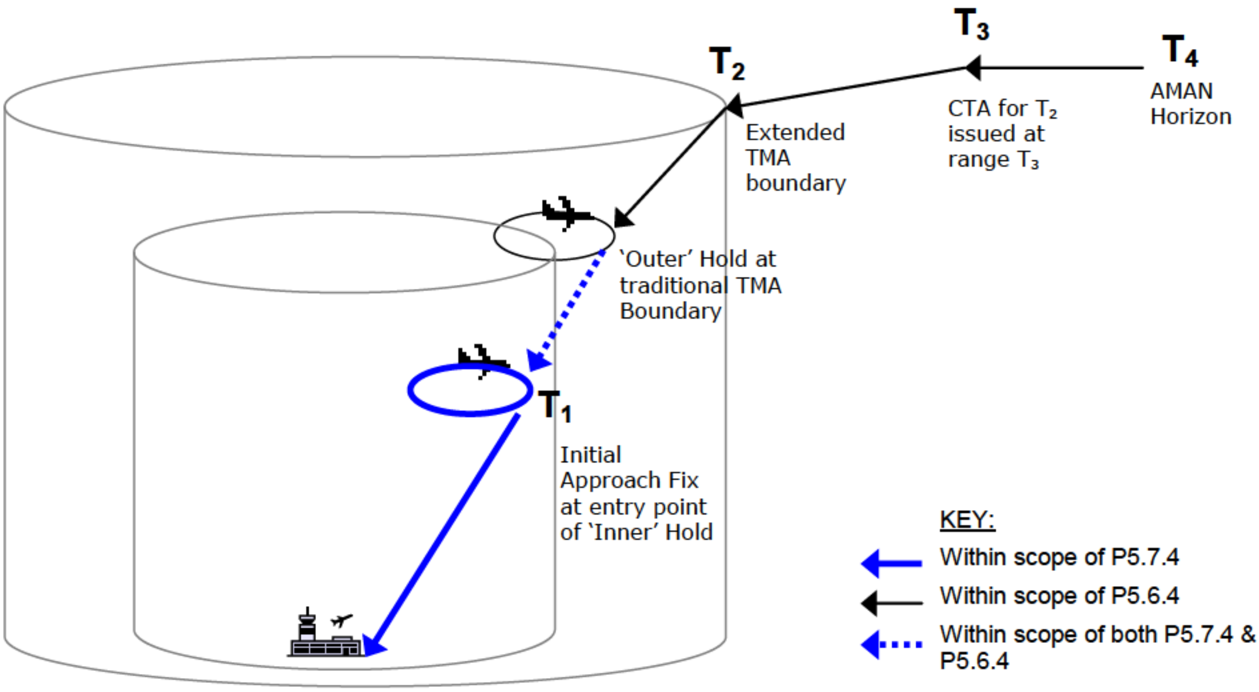


Figure 9: The interfaces between projects 5.7.4 and 5.6.4

Appendix C - Hazard Log

1 Introduction

This appendix describes the derivation of Safety Acceptance Criteria (SACs) for the 5.7.4 Project as per E-OCVM[6] Validation 1 (V1) level for the 'Definition' of the Point Merge in Complex TMA concept. The criteria were derived based on guidance from SESAR Project 16.6.1 (Safety Support and Coordination), and in accordance with the SESAR Safety Reference Material[7].

The SACs identified will also be included within the Validation Strategy/Plan(s). Further safety assurance activities will then be undertaken at E-OCVM[6] V2 'Design' level, which will address how safe the system needs to be in order to satisfy the SACs, in turn to fulfil the barriers of the relevant Accident Model to support the ATM service through introduction of the new concept.

A Safety Plan has been produced to cover the "Definition" and "Design and Validation" phases (i.e. V1 to mid-V3 phases) of the E-OCVM lifecycle, and will describe the activities to be carried out at each phase to satisfy the high-level SACs, including derivation of Safety Objectives and lower-level Safety Requirements.

1.1 Derivation of Safety Acceptance Criteria

There are considered to be five pre-existing reference hazards, which are not caused by the ATM system but are inherent in the operational environment and which the ATM system is designed to mitigate against, or at least to maintain the level of operational risk at an acceptable level, as defined by an ANSPs Safety Management System (SMS).

They are defined as follows:

Hp#1 – Conflicts between pairs of trajectories[8]
Hp#2 – Controlled flight towards terrain or obstacle
Hp#3 – Aircraft entry into unauthorised areas[9]
Hp#4 – Aircraft encounters with severe weather conditions
Hp#5 – Aircraft encounters with wake vortices

These pre-exiting hazards were considered in conjunction with the SESAR Accident Incident Model (AIM) during a series of meetings involving project operational and technical representation from NATS, EUROCONTROL in order to derive the SACs through understanding the concept's potential positive and negative impact on risk.

In order to order to achieve this goal it was necessary to:

- Understand the safety assurance process for V1 to V3;
- Consider the Operational Concept and Scenarios;
- Consider the ATM Operational Environment;
- Consider the pre-existing hazards;
- Consider the ATM services that mitigate the pre-existing hazards;

[6] European Operational Concept Validation Methodology (E-OCVM), Version 3, Volumes I and II, March 2010.
[7] SESAR P16.06.01, Task T16.06.01-006, SESAR Safety Reference Material, Edition 00.01.00, 15th December 2010.
[8] Include consideration of conflicts with airspace infringers
[9] Include aircraft leaving controlled airspace when they should not

- Derive potential risk effects;
- Analyse and confirm the Safety Acceptance Criteria.

The following sections depict the activities of the process followed to meet the overall objective of deriving the project's Safety Acceptance Criteria.

2. ATM Operational Environment

The ATM Operational Environment is described in Section 3 of the 5.7.4 OSED for Point Merge in Complex TMA, and was used as the basis upon which to conduct the safety assessments.

The OSED (Section 3.1.1) contains numerous assumptions which will require validation later in the project lifecycle. For convenience these have been listed below.

- The focus of Point Merge operations for this OFA is primarily on the approach routes for busy commercial airports. Therefore, the concept encompasses commercial & business aircraft only; helicopters, VFR General Aviation (GA) and military flights are not considered.
- P-RNAV routes available for all suitably equipped arrival traffic, with alternative dedicated procedures available for all non-equipped arrival traffic.
- P-RNAV routes available for all suitably equipped departure traffic, with alternative dedicated procedures available for all non-equipped departure traffic.
- A significant proportion of TMA traffic is suitably P-RNAV equipped so as to enable it to follow the defined P-RNAV route structure.
- The operating environment considered for the OSED is within the TMA boundary only, though it may be necessary to consider airspace designs up to the Extended TMA boundary if physical constraints determine so.
- All TMA Controllers are able to revert to conventional operations (vectored transitions) when necessary to cater for non-nominal situations, whether this be for a single aircraft or for all TMA traffic.
- All Approach Controllers are able to revert to conventional operations (vectored transitions) when necessary to cater for non-nominal situations, whether this be for a single aircraft or for all Approach traffic.
- There will be no change to the separation minima from current day operations.
- All aircraft are B-RNAV capable.
- Aircraft Vertical Navigation (VNAV) capabilities are not used in a TMA based on a P-RNAV route structure.
- P-RNAV and conventional route structures can be designed to accommodate low performance commercial & business aircraft.

3. Pre-existing Hazards

For an ATM system, the pre-existing hazards are those that are inherent in aviation and for which the main raison d'être of ATM is to provide as much mitigation as possible. The pre-existing hazards include both traffic-related hazards (for this project, hazards associated with aircraft) and environmental hazards (due for example to weather phenomena). These pre-existing hazards are associated with a pre-existing risk, which is the risk that would be associated with them in the absence of any ATM service. In accordance with Appendix D of the SESAR Safety Reference Material[10], the pre-existing hazards that the ATM/ATS has to continue to mitigate, through introduction of Point Merge in Complex TMA are:

- Conflicts between pairs of trajectories[11]
- Controlled flight towards terrain or obstacle
- Aircraft entry into unauthorised areas[12]
- Aircraft encounters with severe weather conditions
- Aircraft encounters with wake vortices

4. ATM Services

The primary purpose of ATM is to mitigate the pre-existing hazards such that the Safety Acceptance Criteria (section 0) are satisfied. The ATM services to mitigate these hazards, and which will still apply upon implementation of Point Merge in Complex TMA, are:

- Establish and maintain the arrival sequence (i.e. order the arrivals and space them so as to maximise RWY throughput)
- Maintain separation within the same arrival flow of the landing sequence
- Create and maintain separation between the arrival flows of the landing sequence
- Create and maintain spacing / separation between aircraft in converging arrival flows of the landing sequence
- Facilitate acquisition of the Final approach path
- Separate arrivals from terrain/obstacles
- Separate arrivals from departures, transit flights, overflights and other arrivals (i.e. to other airports)
- Prevent unauthorised entry of aircraft into restricted airspace
- Prevent adverse-weather encounters

5. Safety Acceptance Criteria

It is considered all pre-existing hazards named in Section 0 are applicable to Point Merge in Complex TMA, and the types of accident relevant for Project 5.7.4 are Mid-Air Collision, Controlled Flight Toward Terrain and Wake Vortex Encounter. These are depicted by SESAR Project 16.6.1 via Accident Barrier Models, which were analysed to identify the Safety Acceptance Criteria (SACs) for the change.

[10] SESAR P16.06.01, Task T16.06.01-006, SESAR Safety Reference Material, Edition 00.01.00, 15th December 2010.
[11] Include consideration of conflicts with airspace infringers
[12] Include aircraft leaving controlled airspace when they should not

The SACs below were derived by analysing, with respect to each type of relevant accident:

- The contribution to aviation safety of the ATM services;
- The potential impact of the change on that contribution (indicated as (+) for increased risk impact, (-) for reduced impact); a Safety Acceptance Criterion is defined only when potential for impact is identified.

Please note that the references provided within the SACs provide cross-reference to the potential conflicts and barriers identified in the Accident Barrier Models held within SESAR Project 16.6.1.

5.1 Mid-Air Collision (TMA Ops)

The breakdown towards Mid-Air Collision prevention is as follows:

- MF5.1 – Planned traffic conflict
- MF6.1 – Crew/Aircraft Induced conflict
- MF7.1 – ATC Induced Conflict

Therefore next barriers towards accident prevention as below

- B5 - Plan induced conflict management (i.e. ATC has to manage traffic-induced conflict)
- B6 – Crew/Aircraft induced conflict management (i.e. ATC has to manage a conflict that has been induced by crew/aircraft as above)
- B7 – ATCO induced conflict management (i.e. ATC has to manage a conflict that has been induced by ATC as above)

Failure of which leads to:

- MF5,6, 7 – Imminent Infringement

Therefore next barriers towards accident prevention as below

- B4 – ATCO Expedite

Failure of which leads to:

- MF4 – Imminent collision

5.2 Controlled flight toward Terrain

The breakdown towards Controlled Flight Toward Terrain prevention is as follows:

- CF5.1 – Flight toward terrain commanded by pilot
- CF5.2 – Flight toward terrain commanded by systems
- CF5.3 – Flight toward terrain commanded by ATC
- CF5.4 – Flight toward terrain from lateral/vertical design of routes

Therefore next barriers towards accident prevention as below

- B4 – Flight crew monitoring

Failure of which leads to:

- CF4 – Controlled flight toward terrain

Therefore next barriers towards accident prevention as below

- B3 – ATCO warning

Failure of which leads to:

- CF3 – imminent CFTT

5.3 Wake Induced Accident

The breakdown towards Wake Induced Accident prevention is as follows:

Barrier towards accident prevention as below

- W4 – Wake Spacing Management

Failure of which leads to:

- WP4b – Under spacing allows for Wake Vortex Encounter

5.3.1 The Accident Incident Model (AIM) – Mid-Air Collision

Planned conflicts (output of the tactical planning barrier)

SC #1 – There shall be no increase in number of plan induced conflicts (MF5.1 in output of B9) arising from inadequate upstream planning (MB9.2.2.B) or inadequate co-ordination (MB9.3) despite the short term traffic increase as compared to 2010.

Applies to WS 1 and 2

- Risk 1 (+): En-route Planner ATCO workload might increase due to conditions for traffic entry in TMA becoming more constraining in terms of traffic metering (assuming the metering of traffic is mandatory)

SC #2 – There shall be no increase in number of plan induced conflicts (MF5.1 in output of B9) arising from inadequate arrival sequence management (MB9.B) despite the short term traffic increase as compared to 2010.

Applies to WS 1 and 2

- Risk 2 (-): ATCO task for arrival sequence management is standardised (i.e. delivered via AMAN). Streamed traffic will be delivered to the Outer Holds by Arrival Management functions, which are being developed by SESAR project 5.6.4.

SC #3 – There shall be no increase in number of plan induced conflicts (MF5.1 in output of B9) arising from inadequate departures sequence management (MB9.B) despite the short term traffic increase as compared to 2010.

Applies to WS 1 only

- Risk 3 (-): ATCO tasks for departures sequence management is standardised
- Risk 4 (+/-): There is an impact on departure sequencing due to aircraft performance mix (climb rates, turn capability, etc), different departure routes are needed for different performance levels
- Risk 5 (+/-): The set of different routes for departure should be well separated from feeders.

Imminent Infringements with other aircraft (output of the tactical conflict resolution barrier)

SC #4a – There shall be no increase in number of imminent infringements with other aircraft (MF5 in output of B5) arising from TMA and Approach ATC ineffective management of Plan induced tactical conflicts (MB5) despite the short term traffic increase as compared to 2010.

Applies to WS 1 and 2

- Risk 6 (-): The routes design offers different and flexible ways to enter into the final approach.
- Risk 7 (-): Less Approach ATCO workload with tactical de-confliction (standardised method where de-confliction is facilitated by dedicated P-RNAV route structure and stream having been delivered by TMA ATCO). Improves management of separation from departures or other routes.
- Risk 8 (-): fewer instructions (no vectoring) for finalising the landing sequence, more monitoring. Reduced reliance on human intervention (ATCO instructing headings and Pilot

conforming to the instructions). Less opportunity for wrong separation instructions or inadequate pilot response to ATC (i.e. ATCO more likely to clarify an inadequate response).

- Risk 9 (+): The increase in TMA ATCO workload with the delivery of the traffic steam for the Approach ATCO at IAF (i.e. for traffic metering, for reaching prescribed level and speed) may affect the ability of the TMA ATCO to manage separation from departures or other routes.
- Risk 10 (-): PMS occupies more lateral airspace, however P-RNAV routes reduce the airspace required and complementary stacks require less vertical airspace, thereby allowing for de-confliction of routes and aircraft manoeuvring, in turn improving the management of separation from departures or other routes.

SC #4b – There shall be no increase in number of imminent infringements with other aircraft (MF6 in output of B6) arising from TMA and Approach ATC ineffective management of Crew/aircraft induced tactical conflicts (MB6) despite the short term traffic increase as compared to 2010.

Applies to WS 1 and 2

- Risks 7, 9 and 10 apply. Less Approach ATCO workload and airspace improvement allow increased opportunity for monitoring and managing crew/aircraft induced conflicts. Increase in TMA ATCO workload may affect the ability of the TMA ATCO to detect and manage crew/aircraft induced conflicts.
- Risk 11 (+): Better trajectory predictability may, in the medium to long term (i.e. when most flight-planned for P-RNAV), affect controller's situation awareness (e.g. boredom / routine standardised method) and tactical skills. Controller's ability to detect and manage a deviation may be affected without practice of vectoring in busy operations.
- Risk 12 (+): Mix of P-RNAV and vectored PMS operations may affect the controller's ability to detect and react to a deviation from instruction or route

SC #4c – There shall be no increase in number of imminent infringements with other aircraft (MF7 in output of B7) arising from TMA and Approach ATC ineffective management of ATC induced tactical conflicts (MB7) despite the short term traffic increase as compared to 2010.

Applies to WS 1 and 2

- Risks 7, 9 and 10 apply. Less Approach ATCO workload and airspace improvement allow increased opportunity for monitoring and managing ATC induced conflicts. Increase in TMA ATCO workload may affect the ability of the TMA ATCO to detect and manage ATC induced conflicts.

Induced conflicts

SC #5 – There shall be no increase in number of ATC induced conflicts (MF7.1) arising from TMA and Approach ATC inducing new conflicts (MF7.1.1 to MF7.1.7) when managing the arrivals despite the short term traffic increase as compared to 2010.

Applies to WS 1 and 2

- Risks 7 and 9 apply. Less Approach ATCO workload may improve arrival management; increased TMA ATCO workload may affect arrival management.
- Risk 13 (+): Risk for wrong or untimely instruction to finalise sequence (e.g. "Direct to"). Potential for PMS overload, depending on TMA delivery, noting that holding via the sequencing legs is finite (aircraft sequenced too early or too late for iso-spacing)

SC #6 – There shall be no increase in number of ATC induced conflicts (MF7.1) arising from Tower and TMA ATC inducing new conflicts (MF7.1.1 to MF7.1.5 and MF7.1.7) when managing the departures despite the short term traffic increase as compared to 2010.

Applies to WS 1 only

- Risk 3 applies.
- Risk 14 (+): ATC must take into account the different aircraft performances for continuous climb departures.

SC #7 – There shall be no increase in number of Crew/aircraft induced conflicts (MF6.1) arising from conflict due to crew/aircraft deviation from instruction (MF6.1.2.1 to MF6.1.2.4) despite the short term traffic increase as compared to 2010.

Applies to WS 1 and 2

- Risk 15 (+/-): Better trajectory predictability for pilot might incite him to take action in anticipation of ATCO instruction; this should be compared with today regarding leaving stacks without instruction (aircraft currently fly stacks via FMS)
- Risk 16 (+): (departures) increased aircraft autonomy with Continuous Climb Departures (CCDs); additionally, a higher probability for deviation from the cleared trajectory to induce conflict with other departing aircraft, due to aircraft performance mix (different climb rates, turn capability, etc) and higher complexity of SIDs (different departure routes for different performance levels).

SC #8 – There shall be no increase in number of Crew/aircraft induced conflicts (MF6.1) arising from conflicts due to airspace infringement by CAT, MIL or VFR flights (MF6.1.1.2.1 to MF61.1.2.3) despite the short term traffic increase as compared to 2010.

Applies to WS 1 and 2

- Risk 17 (-): The airspace design guides to a more static approach pattern, reducing the dynamic airspace to be used (radar vectoring is not so standardized).

5.3.2 The Accident Incident Model (AIM) – CFIT

Flights towards terrain (output of the strategic and tactical conflict resolution barrier)

SC #9 - There shall be no increase in number of Flights towards terrain commanded (CF5 in output of B5) arising from Pilot deviation from planned trajectory (CF5.1) during Arrivals despite the short term traffic increase as compared to 2010.

Applies to WS 1 and 2

- Risk 18 (+/-): With regards to PMS: For arrivals post IAF, separation from terrain is different, because achieved under pilot responsibility through altitude constraints on P-RNAV routes instead of ATCO responsibility in vectoring.

SC #10 – There shall be no increase in number of Flights towards terrain commanded (CF6 in output of B6) arising from deviation due to onboard systems despite the short term traffic increase as compared to 2010.

Applies to WS 1 and 2

- Risk 19 (+/-): Higher reliance on route conformance and hence reliance on systems to ensure aircraft conforms to route centre-line tolerances and meet altitude constraints

SC #11 – There shall be no increase in number of Flights towards terrain commanded (CF7 in output of B7) arising from ATC trajectory command despite the short term traffic increase as compared to 2010.

Applies to WS 1 and 2

- Risk 20 (+/-): The arrival vertical profile is changed with PMS; there will be one level instruction to Merge Point altitude when leaving the leg, with the pilot/aircraft managing the descent (safety issue of high terrain between sequencing leg and merge point)
- Risks 7 and 9 apply. Less Approach ATCO workload may improve management of separation from terrain; increased TMA ATCO workload may affect the ability to manage separation from terrain.

SC #12 – There shall be no increase in number of Flights towards terrain commanded (CF8 in output of B8) arising from lateral/vertical design of the routes and their publication, including MSA, despite the short term traffic increase as compared to 2010.

Applies to WS 1 and 2

- Risk 21 (+): “Direct To” instructions may contravene with minimum altitudes/ MSAs associated with terrain avoidance, especially when aircraft is in descent (e.g. Direct To Merge Point)
- Risk 22 (-): CDAs defined with minimum altitudes and strategically placed waypoints associated with minimum clearances
- Risk 19 applies.
- Risk 23 (+) : Vectoring along P-RNAV routes may contravene lateral limitations associated with terrain (only applies to ‘abnormal’ conditions).

Regarding Flight Crew Monitoring barrier B4: TO CHECK with pilot operational expert whether the onboard monitoring is improved when following P-RNAV routes instead of Vectoring – this depends on whether aircraft is conformant with RNP 1?

Imminent CFITs (output of the ATC collision prevention barrier)

SC #13 – There shall be no increase in number of imminent CFITs (CF3 in output of B3) arising from failure of ATCO to identify and/or resolve conflict in time (CB3.2.2.1.2 and CB3.2.2.1.3 respectively) despite the short term traffic increase as compared to 2010.

Applies to WS 1 and 2

- Risks 7 and 9 apply. Less Approach ATCO workload may allow increased opportunity for monitoring and managing conflicts; increased TMA ATCO workload may affect the ability of the TMA ATCO to detect and manage a conflict in time.

5.3.3 The Accident Incident Model (AIM) – Wake Induced Accident

Wake vortex encounters (output of the wake spacing management barrier)

SC #14 - There shall be no increase in number of Wake Vortex Encounters (WP4b in output of W4) arising from Approach ATC creating or maintaining insufficient separation (WF4.1.1.1 and WF4.1.1.2 respectively) despite the short term traffic increase as compared to 2010.

Applies to WS 1 and 2

- Risk 24 (+): With PMS: The method for creating and maintaining spacing/separation is changed; the sequence order cannot be changed after the Direct To MP instruction, unless reverting to Vectors; reduced flexibility due to sole reliance on speed for maintaining spacing (need to revert to Vectors when that becomes insufficient)

Appendix D: Roles and Responsibilities in London and Milan Terminal Control.

London Terminal Control

Section 3.2 of this report describes the Changes in Roles and Responsibilities that occur due to the Introduction of Point Merge System. The description of these roles is based on guidance outlined in WPB4.2 [16]. In the London Terminal Control operation the title of the Air traffic controller's roles and their responsibilities differs slightly. In general terms the 'Multi-Sector Planning' controller equates to the role performed by the "Co-ordinator" and the 'Executive' controller equates to the "Approach/TMA" controller. The differences between the responsibilities as described in SESAR WPB4.2 Roles and Responsibilities [16] are detailed below in this Appendix.

7.3 Multi-Sector Planner

General: The Multi-Sector Planner (MSP) is responsible for a multi-sector area (MSA) comprising of two or more of the present control sectors. The MSP may substitute for the Planning Controller (PC) in some ANSPs and performs planning tasks with an extended planning horizon of up to ~~20~~ 30 minutes ~~assisted by automated tools providing conflict resolution and advisories~~ (there are no automated tools within London TC environment). His principal task is to check the planned trajectory of aircraft within his area or intending to enter his area of responsibility for potential separation risk, and to co-ordinate entry/exit conditions with adjacent MSPs/PCs leading to conflict free trajectories.

Responsibilities

The MSP's main responsibilities are:

1.	Check flight plans/RBTs for possible conflicts and complexity issues within his area of responsibility.
2.	Plan conflict-free flight path through his area of responsibility.
3.	Co-ordinate re-routing options with adjacent control areas/sectors.
4.	In coordination with the Supervisor/LTM determine the need for additional Executive Controller(s) in case of forecast overload situations developing.
5.	~~Coordinate with the Planning/Executive Controllers about planned conflict solution strategies based on system derived solution proposals~~. (There are not system derived solutions within London TC)
6.	~~Implement solution strategies by communicating trajectory changes to the aircraft through the concerned Executive Controller via Data Link.~~ (There are not system derived solutions within London TC)
7.	~~Coordinate the implementation system derived conflict solutions with the Planning/Executive Controllers.~~ (There are not system derived solutions within London TC)
8.	Co-ordinate with adjacent control areas/sectors for the delegation of airspace or aircraft.
9.	Evaluate flight plan data according to the airspace status.
10.	Determine action needed to meet requirements in the flight plan and inform the responsible Planning/Executive Controller for implementation.
11.	Modify flight plan data according to airspace status and planned actions.
12.	Analyse expected traffic for potential overload risks.
13.	Inform the Planning/Executive Controller about necessary actions required.
14.	Co-ordinate entry and exit conditions.
15.	Monitor airspace status.
16.	Monitor weather situation.
17.	~~Input~~ tactical trajectory changes into the Flight Data Processing System when delegated by the Executive Controller. The co-ordinator would not input data. They may ask an Assistant to do this

Table 25 - MSP's responsibilities

5.5 Executive Controller

General: The Executive Controller is part of the sector team responsible for a designated area (e.g. control sector, multi sector area). He is responsible for the safe and expeditious flow of all flights operating within his area of responsibility. His principal tasks are to separate and sequence known flights operating within his area of responsibility and to issue instructions to pilots for conflict resolution and segregated airspace circumnavigation. Additionally, he monitors the trajectory (4D and 3D) of aircraft according to the clearance they have received. He is assisted in these tasks by automated tools for conflict detection and resolution, trajectory monitoring and area proximity warning (APW). The responsibilities of the Executive Controller are focused on the traffic situation, as displayed at the Controller Working Position (CWP), and are very much related to task sharing arrangements within the sector team.

The executive controller equates to the Approach controller (i.e. Intermediate controller / Final Director controller). Where differences do occur these have been highlighted within the table below.

Responsibilities

Executive Controller main responsibilities are:

1.	Identify conflict risks between aircraft.
2.	Provide separation between controlled flights.
3.	Provide sequencing between controlled flights.
4.	Provide flight information to all known flights.
5.	Provide information on observed but unknown flights that may constitute traffic for known aircraft.
6.	Monitor flights regarding adherence to flight plan/RBT.
7.	Monitor the air situation picture.
8.	Communicate with pilots by means of R/T or data link.
9.	Monitor information on airspace status, e.g. activation/ deactivation of segregated/reserved airspace.
10.	~~Input~~ data into the flight data processing system regarding tactical route modification, modification of flight level etc. (Controller would not input, but make a request to the Assistant who would modified data)
11.	Monitor the weather situation.
12.	Relay to pilots SIGMETS that may affect the route of a flight.
13.	Re-route flights to avoid bad weather areas if so requested.
14.	Monitor aircraft equipment status according to information provided by the system.
15.	Co-ordinate with Planning Controller or MSP (inter-sector co-ordination) and adjacent centre/sector Executive Controllers.
16.	~~Coordinate with the Planning Controller about planned conflict solution strategies based on system derived solution proposals.~~ (There are not system derived solutions within London TC)
17.	~~Coordinate the implementation of system derived conflict solutions with the Planning Controller.~~ (As above in item 16. There are not system derived solutions within London TC)
18.	Handle flight-information.
19.	Apply appropriate separation to all controlled flights departing his area of jurisdiction.
20.	Transfer control of aircraft to the appropriate ~~Executive~~ INT / FIN Controller when clear of traffic within his area of jurisdiction.
21.	Assign specified headings, speeds and levels suitable for the planned approach.
22.	Inform pilots about the intended approach procedures and determine (if not done by arrival management systems) the approach sequence.
23.	Issue approach and, if necessary, holding instructions.
24.	Issue approach clearance.
25.	He provides Alerting Service (ALRS) to all known flights according to the following three different phases (INCERFA,ALERFA,DETRESFA)

Table 26 - EC's responsibilities

Milan Terminal Control

The Sectors involved in RTS are:

- ✓ASW (Arrivals South West), Single Man Position.
- ✓ADE (Arrivals and Departures East), Single Man Position.
- ✓LAR (Linate Arrivals), Single Man Position.
- ✓ANE (Arrivals and Departures North East), Single Man Position.
- ✓ANW (Arrivals and Departures North West), Single Man Position.
- ✓MAR (Malpensa Arrivals), Single Man Position.

In this particular Simulation the Sectors ADE and LAR will be collapsed, as well as ANE and ANW.

ASW is responsible for sequencing all south arrivals mainly to LIMC and transfer it to MAR, with a spacing of 10NM constant or increasing

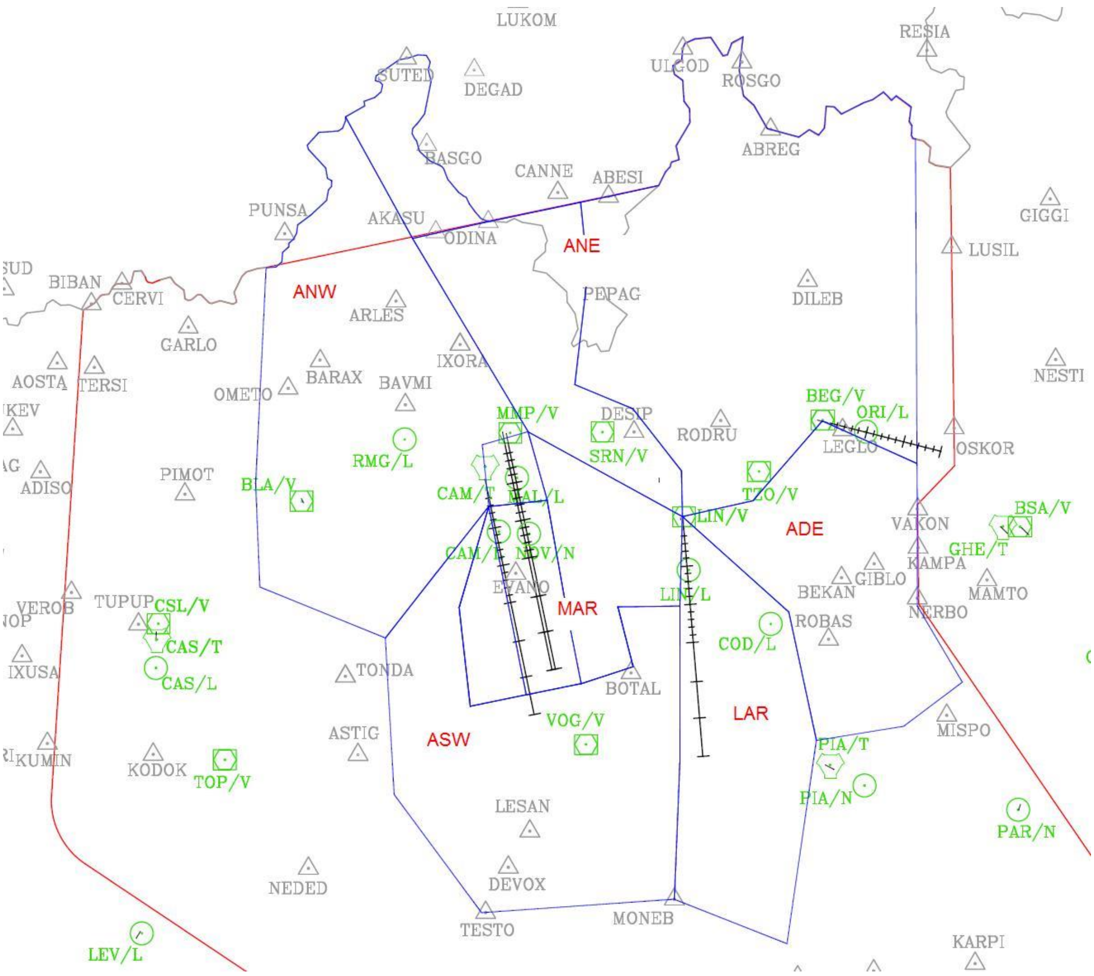
ADE is responsible for final approach sequence to LIME, and for LIML and LIME south departures.

LAR is responsible for final approach sequence to LIML and for sequencing arrivals to LIMC from **EAST** before transferring them to MAR with a spacing of 10NM constant or increasing

ANE is responsible for LIMC, LIML and LIME north departures, and for sequencing north arrivals to LIMC before transferring them to MAR with a spacing of 10NM constant or increasing. ANE is also responsible of pre-sequencing north arrivals to LIML and LIME before transferring them to LAR or ADE.

ANW is responsible for west and south LIMC departures and approach sequence to LSZA.

MAR is responsible for intermediate and final approach sequence to LIMC.



Appendix E: Safety Assessment Report (SAR)

The full details of the Safety Assessment activities conducted under OFA 02.01.02 are documented in the Safety Assessment Report [28].

E.1– Executive Summary (SAR).

The Safety Assessment Report (SAR) documents the Safety Assessment for the Operational Focus Area (OFA) of **Point Merge in Complex TMA** (OFA 02.01.02) in line with the proposed activities described in the Point Merge Safety Plan.

As a high level summary, Point Merge is an innovative concept developed by the EUROCONTROL Experimental Centre (EEC); it enables the merging of traffic flows, whilst incorporating the predictability of P-RNAV routes, but affording Controllers a degree of flexibility in the way they manage aircraft associated with traditional ATM.

The introduction of Point Merge procedures is 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, even when allowing for increased traffic levels, scaled up to the level anticipated for 2015.

The SAR aims to present the assurance that the Safety Requirements for the V1-V2 (SPR-Level) phases are complete, correct and realistic, thereby providing all material to adequately inform the OFA Safety and Performance Requirements (SPR) document.

The SAR draws upon the detailed descriptions of the Operating Environment and Use Cases documented in the OSED in order to define a list of achievable Safely Criteria (SC) that are required to be fulfilled to satisfy the those safety benefits and also to satisfy any appropriate regulatory requirements. In order to achieve these goals a series of Safety workshops were conducted to identify all potential hazards, associated causal factors (and mitigations), and internal system failures for both 'normal' and 'abnormal' conditions, using the pre-defined Use Cases and scenarios described in the OSED.

Functional & Performance Safety Objectives which were defined to support the Safety Criteria were, following the Safety workshops, supplemented by lower level Safety Requirements for both the success case and failure case. Integrity Safety Objectives were also defined to limit the occurrence of internal system failures. Setting Integrity Safety Requirements was considered to be too low-level at this stage in the project and with the knowledge base available.

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, and by two real Time Simulations for Milan TMA. During the Real Time Simulations a range of scenarios were tested (including normal and abnormal conditions) with Controller feedback 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, Safety Objectives, and Safety Requirements was also demonstrated.

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.

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