Update of 5.6.4 OSED - Step 1

Document information	
Project Title	QM-7 – Integrated Sequence Building/Optimisation of Queues
Project Number	05.06.07
Project Manager	DFS
Deliverable Name	Update of 5.6.4 OSED – Step 1
Deliverable ID	D15
Edition	00.01.01
Template Version	03.00.00
Task Contributors	
ENAIRE, DFS, DSNA, EUROCONTROL, INDRA, NORACON.	

Please complete the advanced properties of the document

Abstract

This document is the final OSED S1V3 for OI Step TS-0305-A proposed by 05.06.07 for Step 1 of the SESAR Program (Solution 5 – Extended AMAN). It builds on the foundations of the 05.06.04 D35 Consolidated OSED v03.00.00 that includes a mature vision of the Extended Arrival Management (E-AMAN) concept. The concept extends the Arrival Manager horizon out to 200nm. Optional long range arrival management will reach out up to 400-550nm.
The content of the document has been developed on the basis of the results of a series of validation exercises carried out by P05.06.04, P05.06.07 and P05.03. For Release 4 represented by Solution 5, validation exercise EXE-05.06.07-VP-695 has finalized the validation path within OFA04.01.02 with the goal to reach full E-OCVM V3 maturity.

Authoring & Approval

Prepared By - *Authors of the document.*		
Name & Company	**Position & Title**	**Date**
[redacted] ENAIRE	[redacted]	15/07/2015
[redacted] ENAIRE	[redacted]	15/07/2015
[redacted] DFS	[redacted]	30/09/2015
[redacted] DSNA	[redacted]	15/07/2015
[redacted] DSNA	[redacted]	15/07/2015
[redacted]/ENAV	[redacted]	04/07/2014
[redacted]/ENAV	[redacted]	04/07/2014
[redacted] EUROCONTROL	[redacted]	04/07/2014
[redacted]/EUROCONTROL	[redacted]	04/07/2014
[redacted]/NORACON	[redacted]	04/07/2014
[redacted]/NATS	[redacted]	04/07/2014
Reviewed By - *Reviewers internal to the project.*		
Name & Company	**Position & Title**	**Date**
[redacted] EUROCONTROL	[redacted]	08/05/2015
[redacted] DFS	[redacted]	30/09/2015
[redacted] INDRA	[redacted]	11/05/2015
[redacted] INDRA	[redacted]	11/05/2015

Reviewed By - *Other SESAR projects, Airspace Users, staff association, military, Industrial Support, other organisations.*		
Name & Company	**Position & Title**	**Date**
[redacted] INDRA	[redacted]	16/06/2015
[redacted] NATS	[redacted]	30/06/2015
[redacted] AIRBUS	[redacted]	29/06/2015
[redacted]ENAV	[redacted]	No comments received
[redacted]/ENAV	[redacted]	No comments received
[redacted] EUROCONTROL	[redacted]	No comments received
[redacted]/NORACON	[redacted]	No comments received
[redacted]/NATS	[redacted]	No comments received
[redacted]/DFS	[redacted]	No comments received
[redacted]ENAV	[redacted]	No comments received
[redacted]	[redacted]	No comments received
[redacted]	[redacted]	No comments received
[redacted]/Novair	[redacted]	No comments received
[redacted]/Dassault Aviation	[redacted]	No comments received
[redacted]	[redacted]	No comments

		received
[redacted] ENAIRE	[redacted]	No comments received
[redacted] DSNA	[redacted]	No comments received

Approved for submission to the SJU By - *Representatives of the companies involved in the project.*		
Name & Company	Position & Title	Date
[redacted] DFS	[redacted]	30/09/2015
[redacted] EUROCONTROL	[redacted]	31/07/2015
[redacted] INDRA	[redacted]	31/07/2015
[redacted] ENAIRE	[redacted]	31/07/2015
[redacted] DSNA	[redacted]	03/08/2015
[redacted] NORACON	[redacted]	Silent

Rejected By – *Representatives of the company involved in the project.*		
Name & Company	Position & Title	Date
NA		

Rational for rejection
NA

Document History

Edition	Date	Status	Author	Justification
00.00.01	30/04/2015	Draft	[redacted]	First Draft of the Document based on D35-05.06.04 as parent document.
00.00.02	13/05/2015	Draft	[redacted]	Second Draft of the Document with integration of Partners' comments/review
00.00.03	15/07/2015	Consolidated Draft	[redacted]	Consolidated draft of document with integration of comments from External Members and from 05.06.04 - D35 SJU Assessment report.
00.01.00	31/07/2015	Final	[redacted]	Submission
00.01.01	30/09/2015	Final - Update	[redacted]	Re-submission after SJU assessment

Intellectual Property Rights (foreground)

This deliverable consists of SJU foreground

Table of Contents

TABLE OF CONTENTS 4
LIST OF TABLES 6
LIST OF FIGURES 6
EXECUTIVE SUMMARY 8
1 INTRODUCTION 10
1.1 Purpose of the document 10
1.2 Intended readership 11
1.3 Structure of the document 11
1.4 Background 12
1.5 Glossary of terms 12
1.6 Acronyms and Terminology 14
2 SUMMARY OF OPERATIONAL CONCEPT FROM DOD 22
2.1 Mapping tables 22
2.2 Operational Concept Description 25
2.3 Processes and Services (P&S) 27
2.3.1 Pre-sequence and sequence arrival aircraft 27
2.3.2 Sequence and Meter Arrivals with CTA and TTL/TTG 29
3 DETAILED OPERATING METHOD 31
3.1 Previous Operating Method 31
3.2 New SESAR Operating Method 32
3.2.1 Key Aspects of Extended Arrival Queue Management in SESAR Step 1 32
3.3 Differences Between New and Previous Operating Methods 58
4 DETAILED OPERATIONAL ENVIRONMENT 59
4.1 Operational Characteristics 59
4.2 Roles and Responsibilities 59
4.2.1 New Roles 59
4.2.2 Modification to existing B4.2 Roles and Responsibilities: 60
4.3 Constraints 60
5 USE CASES 61
5.1 Operational Scenario 1 (Medium Complexity/MediumDensity - Rome) 61
5.1.1 Conventional Extended AMAN Operations 62
5.1.2 Initial 4D Operations 63
5.1.3 Use Cases 64
5.2 Operational Scenario 2 (Medium Complexity/Medium Density - Stockholm) 64
5.2.1 Use Case: Departures from Satellite airports 69
5.3 Operational Scenario 3 (High Complexity/High Density - Amsterdam) 72
5.3.1 Amsterdam Scenario (VP-187bis) 72
5.3.2 Amsterdam scenario (VP-183) 75
5.4 Operational Scenario 4 (High Complexity/High Density – London) 76
5.4.1 Concept Summary 76
5.4.2 Methods of Operation 78
5.4.3 Use Case: Extended Long-Range AMAN for High Complexity/High Density 80
5.5 Operational Scenario 5 –Release 1 VP-189 specific issues/details 82
5.5.1 Validation scenario 82
5.5.2 Airport information 83
5.5.3 Airspace information 83
5.6 Operational Scenario 6 – Release 1 VP-188 specific issues/details 86
5.6.1 Validation scenario 86
5.6.2 Airport information 86
5.6.3 Airspace information 86

5.7 Operational Scenario 7 - Release 2 VP-244 and VP-244 bis specific issues/details 87
5.7.1 Extended AMAN Horizon scenario VP-244 88
5.7.2 Long Range AMAN scenario VP-244 bis 91
5.8 Operational Scenario 8 - Release 2 VP-34 (P5.3 crossed validation) specific issues/details 94
5.8.1 Airport Information 94
5.8.2 Airspace Information 94
5.8.3 Roles 96
5.9 Operational Scenario 9 – Release 4 – EXE-05.06.07-VP-695 (High Complexity/High Density – Long Range – Cross-border Reims/London) 98
5.9.1 Concept Summary 98
5.9.2 Methods of Operation 101
5.9.3 Use Case: Long Rang Cross-Border AMAN in En-Route Sectors 103

6 REQUIREMENTS 107

6.1 Current AMAN requirements 108
6.2 Additional AMAN requirements 117
6.3 Extended AMAN Requirements 119
6.4 Extended AMAN I4D/CTA requirements 122
6.4.1 OFA Related Requirements 124
6.5 Extended AMAN Satellite Airports Requirements 128
6.6 Long Range AMAN Requirements 131
6.7 Stream E Requirements 134
6.8 Requirements for Process / Service 135
6.9 Information Exchange Requirements 136
6.9.1 Interaction Rules and Policies 139

7 REFERENCES 143

7.1 Applicable Documents 143
7.2 Reference Documents 143

APPENDIX A JUSTIFICATIONS 144

APPENDIX B NEW INFORMATION ELEMENTS 146

B.1 Current AMAN Information Elements 146
B.1.1 Target Times for Arrival Management 146
B.1.2 Controlled Time of Arrival 147
B.1.3 Point definitions 147
B.1.4 Horizon Definitions 147
B.1.5 Time definitions 148
B.1.6 Definitions related to Arrival Management Information 149
New Properties 151
B.1.7 New AMAN Information Elements 151

APPENDIX C SIGNIFICANT RESULTS LINKED TO THE OPERATIONAL CONCEPT 153

APPENDIX D EXTENDED AMAN SECURITY CASE 156

List of tables

Table 1: List of relevant OIs within the OFA 22
Table 2: List of relevant DOD Scenarios and Use Cases 23
Table 3: List of relevant DOD Environments 23
Table 4: List of the relevant DOD Processes and Services 25
Table 5: List of the relevant DOD Requirements 25
Table 6 – Description of activities for “Sequence and Meter Arrivals” [source: EATMA data version: 5.1 (LDB)] 30
Table 7: CDM Time Definitions 46
Table 8:Information exchanges and actors 56
Table 9: Identification of the Operational Scenario in the WP5.2 DOD Scenario Concept Elements 65
Table 10: En-Route and TMA Sectors Assessed by EXE-05.03-VP-034 96
Table 11: LATC/LATC/En Route Delay Sharing values 101
Table 12: Initial Operational Procedure 102
Table 13: Example of Procedure with Single Variable Mach No Reduction at 350NM 102
Table 14: Example of Single M0.04 Reduction at latest procedure 102
Table 15: Example of TTO at latest procedure 103
Table 16: IER overview Information Exchanges for baseline and extended horizon operations 137
Table 17 IER Overview Additional Information Exchanges required for satellite airport integration 137
Table 18: IER Overview Additional Information Exchanges required for i4D/CTA operations 138
Table 19: IER Overview Reference Information Exchanges required by the AMAN Tool 138
Table 20: IER Interaction Rules and Policies 139
Table 21: IER Interaction Rules and Policies 140
Table 22: IER Interaction Rules and Policies 140
Table 23: IER Interaction Rules and Policies 141
Table 24: IER Interaction Rules and Policies 142

List of figures

Figure 1: OSED document with regards to other SESAR deliverables 10
Figure 2 - OFA 04.01.02 Enhanced Arrival & Departure Management 27
Figure 3 - Pre-sequence long-range arrival 28
Figure 4 - Pre-sequence departures from satellite airports 28
Figure 5 - Sequence and Meter Arrivals with CTA and TTL/TTG (i4D context) process 29
Figure 6: Current AMAN Configuration 31
Figure 7: Plan View Showing Impact of Adjacent FIR on AMAN Horizons 34
Figure 8: Vertical View of the Framework – Simple Horizon Extension 34
Figure 9: Vertical View of Framework – Long Range Extended Horizon 35
Figure 10: Long Range Pre-sequencing 37
Figure 11: AMAN Eligibility Horizon Extended from ~100nm to ~180-200nm 38
Figure 12: Aircraft departing from Satellite airports inside the AMAN horizon 45
Figure 13: TTL and TTOT calculation 47
Figure 14: Typical Speed Envelope Airbus A321 50
Figure 15: Reference Points for TTL/G 54
Figure 16: Airspace with 250NM of Rome 61
Figure 17: Rome TMA CTA Gates and Relevant Flows 63
Figure 18: Scandinavian Airspace with 200NM and 250NM range rings centred on ESSA 66
Figure 19: Satellite Airports of ESSA 67
Figure 20: En-route and ACC airspace servicing Schiphol arrivals 74
Figure 21: London Scenario Concept Parameters 77
Figure 22: London Scenario Controller Responsibility Parameters 79
Figure 23: London Scenario Pilot Responsibility Parameters 79
Figure 24: Arlanda Airport Layout 83
Figure 25 Airspace Stockholm experimental TMNA/TMA environment RWY 19 L 84
Figure 26 Routes in Stockholm experimental ETMA/TMA environment, RWY 19 L 86
Figure 27 East/West Cross-Section of Brecon Sector Organisation 87

160 Figure 28 Extended AMAN Horizon Operational Scenario 89
161 Figure 29 UK validation scenario 92
162 Figure 30: UK validation scenario sectors 93
163 Figure 31 Trombone procedures for Madrid-Barajas. North configuration 95
164 Figure 32: XMAN EGLL Horizon 99
165 Figure 33: Flows and sectors concerned by the Dynamic Delay Sharing 99
166 Figure 34: Dynamic Delay Sharing with TTO and TTL 100

167

Executive Summary

This document is the P5.6.7 Final Operational Service and Environment Definition (OSED) describing AMAN, Extended AMAN Horizon aspects of Tactical Queue Management. It builds on the foundation created by the earlier work of P5.6.4 in particular the D28 Preliminary OSED [8], D32 Updated OSED [21] and D35 Consolidated OSED [22]. It is the Master OSED for the OFA 04.01.02 Enhanced Arrival & Departure Management in TMA and En Route addressing Operational Improvements TS-0305-A Arrival Management Extended to En Route Airspace - single TMA

This document reports the main outcomes resulting from the validation exercise EXE-05.06.07-VP-695 executed in the context of Release 4 Plan within the overall Step 1 V3 of SESAR Programme. The focus was to validate the ability to apply the Cross-border AMAN in En-Route sectors notably those located across borders (cross-ANSPs).

For Release 4 represented by Solution 5, validation exercises EXE-05.06.07-VP-695 and EXE-05.03-VP-708 have finalized the validation path within OFA04.01.02 with the goal to reach full E-OCVM V3 maturity. In the case of EXE-05.03-VP-708 for the evolution of E-AMAN (TS0305A), no further validation of the concept is deemed necessary. The solution can be deployed as is, however further integrated validations may be needed to integrate the solution with other concept elements, like I4D/CTA, ASAS that is foreseen in the VP805. Therefore, EXE-05.03-VP-708 has not been included in this document.

Validation results and expert group discussions have enabled the concept described in the D28 Preliminary OSED and D32 Updated OSED to be heavily revised and more detail have been added. In particular many validation exercises of P5.3, P5.6.4 and P5.6.7 have been taken into account in order to update the information present in this document The focus of this document is the extended AMAN horizon and therefore a baseline of “current AMAN” functionality representing a typical European AMAN implementation is briefly described as the “current operating method” and is complemented by a full set of “current” AMAN requirements.

The extension of the AMAN Horizon is extended up to 200NM[1]. This is expected to result in improved arrival flight trajectories for airspace users with efficiency and environmental benefits, the expectations have been demonstrated according to the results of Validation Exercises. The traffic presentation at terminal area entry is greatly improved with the bulk of traffic sequencing being conducted in the en-route and descent phases. This will result in more efficient terminal area operations with greatly reduced low altitude path stretching for sequence building purposes. Efficient overall management of the extended arrival operation is essential and this is address in sections on arrival management strategies and a description of the Sequence Manager role which takes on greater importance when AMAN operations are extended to 200nm. In addition Extended AMAN (200 NM and beyond) has the supreme benefit of providing a set trajectory before ToD, this increases significantly the possibility for the AU to perform the most optimum descend.

Techniques are described including simple advice to controllers such as Time to Lose or Gain and speed advice and also advanced techniques in which the flight crew are instructed to use on-board avionics to achieve a Controlled Time of Arrival (CTA) over a metering fix. The needs of the Initial 4D (i4D) concept employing CTA have a significant impact on AMAN functionality; this is the reason why many aspects of this concept are addressed in this OSED.

D35 Consolidated OSED have been taken into account also the output of the P5.6.7 that with VP 485 validated the concept and operational requirements for an arrival management system supporting CTA/RTA including the i4D functionality and working with an extended AMAN horizon

The impact of new arrival management tasks on en-route sectors is addressed along with the required co-ordination dialogues between all actors involved in extended arrival management operations.

The other complementary option is Long Range Arrival Management which may be appropriate at specific locations and at specific times of the day. In this option the AMAN horizon is extended to 400-500nm with the objective of pre-sequencing traffic prior to arrival at the 200nm extended AMAN horizon and allowing as much delay as practicable to be absorbed at higher altitudes.

---

[1] These 200 NM refer to the aerodrome reference point (and not from the TMA boundaries).

In extending the AMAN horizon many more airports fall within the area of influence of AMAN. Methods of managing departures from satellite airports are described so that if necessary delay can be absorbed on the ground and these short-haul flights can enjoy the most efficient flight trajectory possible.

According to the updating purposes of this document, the Integration of Arrival Manager (AMAN) and supporting functionalities with application of P-RNAV procedures in a complex TMA developed by P5.3 have been taken into account

The validation work of P5.6.4 is Europe-wide and addresses both types of TMA scenario advocated by P5.2; High Density/High Complexity and Medium Density/Medium Complexity. The validation sites of Amsterdam and London fall into the first category whilst the validation sites of Rome and Stockholm fall into the second. Sub-scenarios and some use-cases for these airports are described and reports the further validation exercises carried out according to the following description:

Exercises in 05.06.04 D28 Preliminary OSED:

- EXE-05.06.04-VP-183: QM Advanced Techniques
- EXE-05.06.04-VP-187 & 187bis: Arrival Management Extended Horizon-RTS

Exercises added in 05.06.04 D32 Updated OSED:

- EXE-05.06.04-VP-188: Arrival Management Extended Horizon-MBS
- EXE-05.06.04-VP-189: iQ META related - AMAN V2 Extended Horizon
- EXE-05.06.04-VP-244 & 244bis: Arrival Management Extended Horizon-RTS
- EXE-05.03-VP-034: Integration of Arrival Manager (AMAN) and supporting functionalities with point P-RNAV procedures in a complex TMA

Exercises added in 05.06.04 D35 Consolidated OSED:

- EXE-05.06.04-VP-191: V2 Model Based Study - Arrival Manager (AMAN) extended horizon scenario
- EXE-05.06.07-VP-485: Arrival Management Supporting CTA/RTA

Exercise added in 05.06.07 D15 OSED:

- EXE-05.06.07-VP-695: Basic XMAN V3 live Trials in Reims UAC.

1 Introduction

1.1 Purpose of the document

The Operational Service and Environment Definition (OSED) further defines operational services, their environment, scenarios, use cases and requirements of the operational concept defined in the Detailed Operational Descriptions (DOD) of P4.2 [14] and P5.2 [14] in the scope of the Operational Focus Area (OFA) Enhanced Arrival & Departure Management in TMA and En Route.

This OSED will be 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 details the Operational Improvement within the Operational Focus Area (OFA) 04.01.02 Enhanced Arrival & Departure Management in TMA and En Route and addresses relevant Step 1 OI.

Because P5.6.7 & P5.6.4 are projects that traverses both the En-route and TMA phases of flight this OSED is a top-down refinement of both the TMA and En-route DOD's produced by the federating OPS 5.2 and 4.2 projects. It also contains additional information which should be later consolidated back into the higher level SESAR concept documents 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.

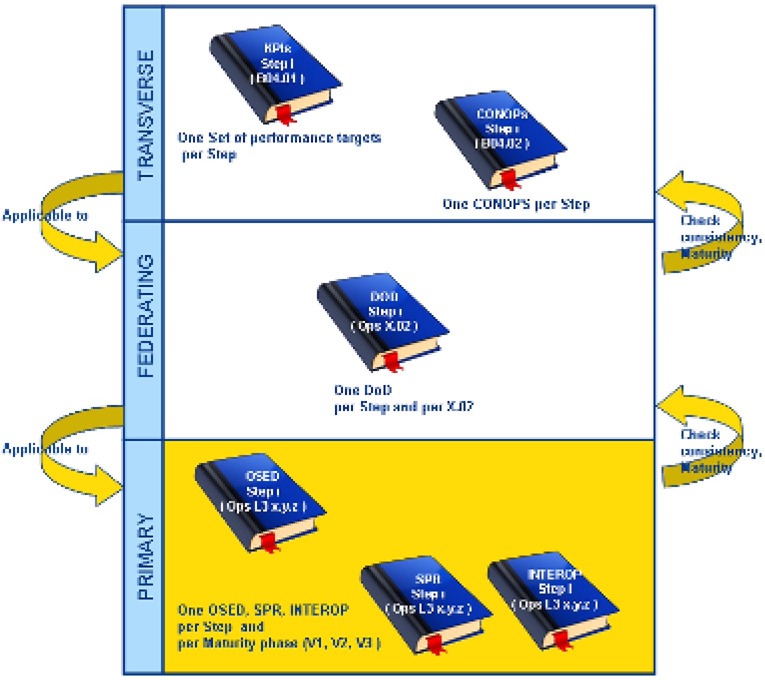


Figure 1: OSED document with regards to other SESAR deliverables

This OSED details the Operational Improvement within the Operational Focus Area (OFA) Enhanced Arrival & Departure Management in TMA and En Route for Step 1 of the SESAR Program.

This OSED addresses Operational Improvement TS-0305-A "Arrival Management Extended to En Route Airspace - single TMA".

This OSED therefore focuses on extending the horizon for arrival management, enabling more efficient trajectories and improved runway sequencing.

The scenarios for this OSED have been extracted from the P4.2 and P5.2 DOD [14] [14] and have been reconciled with the actual geographical scenarios studied by P5.6.4, P5.6.7 & P5.3. The traffic and airspace characteristics vary significantly in these locations and indeed, each may have quiet and busy periods in which a different mix of environmental, capacity and efficiency objectives are appropriate. Therefore this document focuses on a range of options, all aligned with the SESAR Target Concept, which may be appropriate to different locations or at different times.

This document takes account of expected SESAR Step 1 limitations in respect of ground-ground data exchange capabilities, aircraft equipage for trajectory negotiation, and network procedures for coordination of airborne times.

This OSED builds on the foundation of the P5.6.4 Preliminary OSED (D28) which was the basis for the validation activities conducted within Release 1 and Release 2, Updated OSED (D32) which added results of others (R2) activities and Consolidated OSED (D35) that it is focused on concept elements at V3 maturity (developed in the previous D32) Scope and gives an added values considering also the results of VP 485 of P5.6.7..

This document is the P5.6.7 OSED (D15) where includes the exercise EXE-05.06.07-VP-695: Basic XMAN V3 live Trials in Reims UAC improving Long Range AMAN performance and introduces the SWIM Environment in the New SESAR Operating Methods of TS-0305-A.

1.2Intended readership

Projects of the OFA 04.01.02 Enhanced Arrival & Departure Management in TMA and En Route in addition to P5.6.4 and P5.6.7:

05.03 Integrated and Pre-operational Validation & Cross Validation
05.06 Queue Management in TMA and En-Route
05.06.01 QM1 – Ground and Airborne Capabilities to Implement Sequence
10.09.01 Integration of Queue Management
10.09.02 Multiple airport arrival/departure management
12.04.04 Integration of Departure Management and Surface Management

Federating Projects:

P4.2 Consolidation of Operational Concept Definition and Validation
P5.2 Consolidation of Operational Concept Definition and Validation
WP 11.02
P10.1.7 ATC System Specification

Other Primary Projects whose work is relevant to OFA 04.01.02:

- WP4: P4.7.1 (Complexity Management)
- P4.3 Integrated and pre-operational validation & cross validation
- WP5: P5.4.2, P5.5.1, P5.7.4; P5.9

WP6: P6.8.4 (Coupled AMAN-DMAN)

WP9: P9.1

WP8:

- P08.01.03: AIRM Deliverable
- P08.03.10: Information Service Modelling deliverables

1.3 Structure of the document

The document follows the following structure:

- **Section 1 Introduction:** is the introduction and presents the purpose and scope of the document, the intended audience, the structure of the document and the main acronyms and terminology used through the document.
- **Section 2 Summary of Operational Concept**: are reported the Relevant OI of the project, the reference with P5.2 DOD in terms of scenario identification, operational environment, DOD requirements and Process and Services
- **Section 3 Detailed Operating Method**: contains the previous operating method, the new operating method and the difference between them.
- **Section 4 Detailed Operational Environment**: reports the operational characteristics, the roles and responsibilities of the actors and constraints
- **Section 5 Use Cases**: is a detailed description of use cases and Scenarios of the various validation exercises that validate the concept developed in the OSED
- **Section 6 Requirements**: are reported all the Requirements for Arrival Management Extended to En Route Airspace - single TMA (TS-0305-A).
- **Section 7 References**: List of applicable documents and reference documents.
- **Appendix A Justifications**: The material that justifies the requirements allocation. This appendix is not applicable for this OSED.
- **Appendix B New Information Elements:** This section contains a detailed description of the Information Elements that are exchanged by actors within ATM according to Information Exchange Requirements.
- **Appendix C Significant results linked to the Operational Concept**: P05.06.04 and P05.06.07 have provided the following outputs for the main KPAs.
- **Appendix D Extended AMAN Security Case:** This appendix reports the security case for the simple extension of the AMAN horizon from the current 100-120nm to 180-200nm. Developed by P16.06.02.

1.4 Background

The State of the Art in Tactical Arrival Management was described by P5.6.4 in V1 V2 and V3 Reports which addressed Advanced Techniques for sequence-building [5], Extending the AMAN Horizon [6], and Using Air Derived Data [7]. A Step 1 Preliminary OSED D28 [8], an Updated OSED D32 and Consolidated OSED D35 have also been produced on which this document is based.

1.5 Glossary of terms

Term	Definition
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]
AMAN	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]
CTA	Controlled Time of Arrival – An ATM imposed time constraint on a defined merging point associated to an arrival runway [SESAR lexicon].
CTO	Controlled Time Over – An ATM imposed time constraint over a point [SESAR Lexicon]

Term	Definition
DMAN	A planning system to improve departure flows at one or more airports by calculating the Target Take Off Time (TTOT) and Target Start Up Approval Time (TSAT) for each flight, taking multiple constraints and preferences into account. [SESAR Lexicon]
ETA min/max	ETA min/max is a reliable earliest/latest ETA at a waypoint; wind/temp error is also taken into account in order to guarantee that any CTA defined within associated ETA min/max interval will be satisfied with high probability (95%). [source P5.6.4]
E-TMA	Extended TMA – a terminal manoeuvring area extending to the aircraft top of descent. The E-TMA usually includes the TMA and nearby feeder sectors. [source P5.6.4]
Open Loop Clearance	An ATC clearance that does not include a specified or implied point where the restriction on the trajectory ends.
Operating Environment	An environment with a consistent type of flight operations.
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.
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.
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.
Operational Improvement	The result of any operational measure or action taken through time in order to improve the performance of the ATM system.
Primary Project	Projects that develop and perform validation on aspects of the operational concept and the system
Queue Management	The tactical establishment and maintenance of a safe, orderly and efficient flow of traffic.
RTA	Required Time of Arrival - A function of the airborne FMS that allows the flight to comply with a CTA/CTO. [SESAR Lexicon]
SESAR Programme	The programme which defines the Research and Development activities and Projects for the SJU.
SJU Work Programme	The programme which addresses all activities of the SESAR Joint Undertaking Agency.
Traffic Sequencing	Traffic sequencing is the process of organising aircraft into a specific order.
XMAN	The XMAN or cross border arrival management aims to implement the E-AMAN solution within a specific cross-border context in the core area and is an initiative of members of FABEC and the UK/Ireland FAB.

354

355

NOTE FOR THE AUDIENCE:

The names used for the various AMAN horizons in the document may sometimes have different meanings in one AMAN implementation or the other. The only reference for understanding and analysing the requirements of this document should be the definition of these horizons as provided in this document and the requirements of section 6.

In addition, Deliverable D06-05.06.07 (Technical Note to 05.06.04 OSED SPR INTEROP) was used as an input for production of information elements in this OSED.

1.6 Acronyms and Terminology

Term	Definition
AAH	Active Advisory Horizon
ABI	Advance Boundary Information
ACARS	Aircraft Communications Addressing and Reporting System
ACC	Area Control Centre
ACT	Activation message
ADD	Aircraft Derived Data
ADEP	Aerodrome of Departure
ADES	Aerodrome of Destination
A-DPI	Departure Progress Message with Actual Off-Block time
ADS-B	Automatic Dependent Surveillance - Broadcast
ADS-C	Automatic Dependent Surveillance - Contract
AIP	Aeronautical Information Publication
AIRM	ATM Information Reference Model
AMA	Arrival Management Message
AMAN	Arrival management software package
ANSP	Air Navigation Service Provider
AOC	Airline Operations Centre
AOR	Area of Responsibility
APLN	APP Planner
APP	Approach
APTO	AMAN Planned Time Over (new information element)

Term	Definition
APTT	AMAN Planned Threshold Time (new information element)
ARCID	Aircraft Identification
ASAS	Airborne Separation Assistance Systems
ASL	Arrival Sequencing List
ATCC	Air Traffic Control Centre
ATM	Air Traffic Management
ATMS	Air Traffic Management System
ATN	Aeronautical Telecommunications Network
ATC	Air Traffic Control
ATCO	Air Traffic Control Officer
ATO	Actual Time Over
ATS	Air Traffic Services
ATSU	Air Traffic Service Unit
AU	Airspace User
AVT	ADS-B/TIS-B Validation Testbed
BEBS	Best Equipped, Best-Served
CB	Cumulonimbus activity
CDA	Continuous Descent Approach
CDM	Collaborative Decision Making
CDO	Continuous Descent Operations
CFMU	Central Flow Management Unit
CHMI	CFMU Human Interface
CLP	Clearance Limit Points
COP	Co-ordination Point
CPDLC	Controller-Pilot Data Link Communications
CTA	Controlled Time of Arrival
CTO	Controlled Time Over

Term	Definition
CTOT	Calculated Take-Off Time
CTR	Control
CWP	Controller Working Position
DA	Downstream ATSU
DCB	Demand and Capacity Balancing
DMAN	Departure Manager
DOD	Detailed Operational Description
DPI	Departure Planning Information
EAT	Expected Approach Time
EATMA	European Air Traffic Management Architecture
EATMS	European Air Traffic Management System
E-DPI	Early DPI Message based on expected aircraft ready time
EEC	EUROCONTROL Experimental Centre
EET	Estimated Elapsed Time
EFS	Electronic Flight Strip
EH	Eligibility Horizon
ELDT	Estimated Landing Time
ENR	En Route
EOBD	Estimated Off-Block Date
EOBT	Estimated Off-Block Time
E-OCVM	European Operational Concept Validation Methodology
EPP	Extended Predicted Profile
E-TMA	Extended Terminal Manoeuvring Area
ETA	Estimated Time of Arrival
ETFMS	Enhanced Tactical Flow Management System
ETO	Estimated Time Over (a significant point)
ETOT	Estimated Take-Off Time

Term	Definition
EUROCAE	European Association for Civil Aviation Equipment
EXC	Executive Controller
FAB	Functional Airspace Block
FABEC	Functional Airspace Block Europe Central (Belgium, France, Germany, Luxembourg, Netherlands, Switzerland)
FAF	Final Approach Fix
FCFS	First-Come, First-Served
FDP	Flight Duty Period
FDPS	Flight Data Processing System
FEC	TMA Final Executive Controller
FIR	Flight Information Region
FL	Flight Level
FMS	Flight Management System
FPC	TMA Final Planner Controller
FTS	Fast-Time Simulation
FUM	Flight Update Message
GAT	General Air Traffic (civil)
GC	General Condition
GND	GrouND
GNSS	Global Navigation Satellite System
GS	Ground Speed
HMI	Human Machine Interface
IAF	Initial Approach Fix
IATA	International Air Transport Association
IAS	Indicated Air Speed
IE	Information Elements
IER	Information Exchange Requirements.
IMF	Initial Metering Fix

Term	Definition
IMH	Initial Metering Horizon
IMP	Initial Metering Point
ICAO	International Civil Aviation Organisation
ILS	Instrument Landing System
IOP	Interoperability Protocol
IP	Implementation Package
KPA	Key Performance Area
KPI	Key Performance Indicator
LAMP	London TMA Airspace Management Project
LDB	Limited Data Block
LoA	Letter of Agreement
LREH	Long Range Eligibility Horizon
LRP	Landing Rate Predictor
LTUP	Landing Time Update Point
LVP	Low Visibility Procedures
MF	Metering Fix
MH	Metering Horizon
MONA	Monitoring Aids
MOPS	Method of Operations
MP	Metering Point
MTCD	Medium Term Conflict Detection
MTOT	Managed Take-Off Time
NA	Not Applicable
NM	Nautical Mile
NOP	Network Operations Plan
OAT	Operational Air Traffic
OI	Operational Improvement (Step)

Term	Definition
OLDI	On-Line data Interchange
OPS	Operations Support
OSED	Operational Services and Environment Description
OTA	Optimal Time of Arrival
OTO	Optimal Time Over
PBN	Performance Based Navigation
PC	Planning Controller
PIR	Project Initiation Report
PMS	Point-Merge System
P-RNAV	Precision Area Navigation
QM	Queue Management
RBT	Reference Business Trajectory
REC	En-Route Executive Controller
RNAV	Area Navigation
RNP	Required Navigation Performance
RP	Reference Point
RPC	En-Route Planner Controller
RT	Radio Telephony
RTA	Required Time of Arrival
RTS	Real-Time Simulation
RUAC	Reims UAC
RWY	Runway
SARA	Speed And Route Advisor
SDA	Stack Departure Advisory
SEQ_MAN	SEQuence MANager
SES	Single European Sky
SESAR	Single European Sky ATM Research Programme

Term	Definition
SID	Standard Instrument Departure
SJU	SESAR Joint Undertaking (Agency of the European Commission)
SPO	ACC/Approach Supervisor
SPR	Safety and Performance Requirements
SSR	Secondary Surveillance Radar
STA	Scheduled Time of Arrival
STAR	Standard Arrival Route
STO	Scheduled Time Over
SWIM	System-Wide Information Management
TBO	Time Based Operations
TCP	Trajectory Change Point
TEC	TMA Executive Controller
TIS-B	Traffic Information Service - Broadcast
TLDT	Target Landing Time
TM	Trajectory Management
TMA	Terminal Manoeuvring Area
TMF	Trajectory Management Framework
TOBT	Target Off Block Time
ToD	Top of Descent
TP	Trajectory Predictor (or Prediction)
TPC	TMA Planner Controller
TS	Technical Specification
TSAT	Target Start Up Approval Time
TT	Target Time
TTG	Time to Gain
TTA	Target Time of Arrival
TTL	Time to Lose

Term	Definition
TTO	Target Time Over
TTOT	Target Take-Off Time
TWR	Tower
UA	Upstream ATSU
UAC	Upper Area Control
UC	Use Case
UG	Upstream Ground
UK	United Kingdom
UNL	Unlimited
UTA	Upper Traffic (Control) Area
VNAV	Vertical Navigation
WTC	Wake Turbulence Category
XEC	Extended TMA Executive Controller
XFL	Exit Flight Level (from a sector or volume of airspace)
XMAN	Cross-border AMAN[2]
XPC	Extended TMA Planner Controller

---

[2] Applied in En-Route sectors notably those located across borders (cross-ANSPs).

2 Summary of Operational Concept from DOD

This section has been completed using the available material from B4.2 and the P4.2 and P5.2 DODs.[14] [15]

2.1 Mapping tables

Each table has been filled with the available material from B4.2 and the P4.2 and P5.2 DODs.

Relevant OI Steps ref. (coming from the Integrated Roadmap)	Operational Focus Area name / identifier	Story Board Step	Master or Contributing (M or C)	Contribution to the OIs short description
TS-0305-A	OFA 04.01.02: Enhanced Arrival & Departure Management in TMA and En Route	Step 1	M	Arrival Management Extended to En Route Airspace - single TMA The system integrates information from arrival management systems operating out to an extended distance (beyond the typical Step 0 E-TMA horizon into En Route) to provide an enhanced and more consistent arrival sequence. The system helps to reduce holding by absorbing some of the queuing time further upstream well into En Route. Includes integration of traffic departing from within the AMAN horizon of the destination airport. In Step 1, the "newly" impacted En Route sectors are expected to contribute to the sequencing towards a single TMA.

Table 1: List of relevant OIs within the OFA

Table 2 below shows the relevant DOD scenarios and use cases. The P5.2 Sub-scenarios have been used by P5.6.4 in the development of the Use Cases described in section 5. The P4.2 scenario and use cases relate to trajectory management issues associated with the i4D concept which should be elaborated by P5.6.1. Nevertheless, the P4.2 scenario is fully compatible with the AMAN operational concept described in this OSED.

Scenario identification	Use Case Identification	Reference to DOD section where it is described
P5.2 Sub-scenario 1a: Plan/optimise with AMAN in M/M environment	Use cases not defined	P5.2 M315Ch.4.3
P5.2 Sub-scenario 2a:Plan/optimise with AMAN in H/H environment	Use cases not defined	P5.2 M315 Ch.4.3

Scenario identification	Use Case Identification	Reference to DOD section where it is described
P4.2 Trajectory Management Scenario 6: Negotiation & Application of an AMAN time constraint[3]	TM-UC-06-01 TM-UC-06-02 TM-UC-06-03 TM-UC-06-04 TM-UC-06-05 TM-UC-06-06 TM-UC-06-07 TM-UC-06-08 TM-UC-06-09 TM-UC-06-10 TM-UC-06-11 TM-UC-06-12 TM-UC-06-13 TM-UC-06-14 TM-UC-06-15	P4.2 D07 Ch.4.2.1.10

377 Table 2: List of relevant DOD Scenarios and Use Cases

Operational Environment	Class of environment	Reference to DOD section where it is described
En-route Environment for Step 1		P4.2 D07 Ch3
Environmentally Constrained TMA		P5.2 M315 Ch3.2.1
Airspace Constrained TMA		P5.2 M315 Ch3.2.2
ATC Staff or Equipment Constrained TMA		P5.2 M315 Ch3.2.3
Traffic Volume and Variations Constrained TMA		P5.2 M315 Ch3.2.4
Airfield Constrained TMA		P5.2 M315 Ch3.2.5

378 Table 3: List of relevant DOD Environments

379 Table 4 below lists relevant B4.2 processes which have yet to be elaborated in the TMA and En-route
380 DODs. This OSED describes concepts (in particular Long Range Arrival Management) that will
381 require new processes and services to be developed.

DOD / B4.2 Process & Service Title	Process/ Service identification	Process/ Service short description[4]	Reference to DOD section where it is described
5.2 DOD Synchronize		Traffic	5.2.1

---

[3] In the P4.2 D07 DOD STEP1 v.06.00 the updated scenario identification is the following: *"Trajectory Management Support for Application of Arrival Management time constraints"*. The related Use case Identification are: TM-UC-03-01, TM-UC-03-02, and TM-UC-03-03. The DOD section where are described in:4.2.1.6

[4] The P&S descriptions make reference to the information of the WPB4.2 - Processes and Services V01.00 and SESAR WPB4.2 High Level Process Models V01.00

DOD / B4.2 Process & Service Title	Process/ Service identification	Process/ Service short description[4]	Reference to DOD section where it is described
Traffic		synchronization deals with arrival and departure sequences planning. The synchronisation activities start during the En-Route phase and are also strongly linked to airport operations,	
4.2 DOD Provide CTA to en-route flight		This process represents the reception by an en-route ATSU of a CTA proposal issued by AMAN. The STAR clearance is a pre-requisite for setting a CTA on the IAF using an ETA min/max request	5.1.5
B4.2 Insert Flight into Arrival sequence		insert flight into arrival sequence via system, e.g place flight in the AMAN sequence	NA
B4.2 Establish trajectory data contract			NA
B4.2 Update the arrival sequence		When the flight is in the AMAN horizon, update the arrival sequence and adjust in the system as necessary (e.g. AMAN)	NA
B4.2 Assess the need for CTA		evaluate the need for CTA by referring to inbound holding delay and demand profile	NA
B4.2 Request ETA min/max		Request ETA min/max from the flight	NA
B4.2 Assign CTA		Assign the CTA to the flight	NA

DOD / B4.2 Process & Service Title	Process/ Service identification	Process/ Service short description[4]	Reference to DOD section where it is described
B4.2 Provide Descent Clearance		Through this process the controller issues the authorization to proceed to descent following given points, STAR to stated RWY	NA
B4.2 Monitor Traffic Situation		Through this process the Executive Controller monitors the situation to ensure safe separation from other traffic.	NA

Table 4: List of the relevant DOD Processes and Services

The DOD performance requirements are listed in Table 5 below. The KPA and KPI proposed by P5.2 do not seem to fully cover the expected performance improvements from extending the AMAN horizon. In 5.2 DOD are reported only 3 performance requirements for the following KPA: Environmental Sustainability, Capacity, and Cost Effectiveness. Further updates of performance requirements are needed in the next Versions of 5.2 DOD also taking into account the results from validation exercises carried out within OFA 4.1.2 E.

DOD Requirement Identification	DOD requirement title	Reference to DOD section where it is described
REQ-05.02-DOD-ENV1.0006	Enhanced Arrival & Departure Management in TMA and En Route Arrival Phase Environment Sustainability	P5.2 D84 Ch.6.2.2
REQ-05.02-DOD-CAP1.0026	Enhanced Arrival & Departure Management in TMA and En Route - Improved Complexity Management TMA Airspace Capacity	P5.2 D84 Ch.6.2.3
REQ-05.02-DOD-CEF1.0015	Enhanced Arrival & Departure Management in TMA and En Route - APP Controller Productivity	P5.2 D84 Ch.6.2.2.1
REQ-05.02-DOD-OPR1-0011	Arrival Management Extended to En Route Airspace - single TMA	P5.2 D84 Ch.6.2

Table 5: List of the relevant DOD Requirements

2.2 Operational Concept Description

This section of the OSED gives a high–level description of the concept which is elaborated in later sections.

Queue Management consists of sequencing, spacing, delay attribution and delay implementation. As stated in the SESAR Concept of Operations: *"Queue Management is about fine-tuning the position of an individual aircraft into a stream that optimises the utilisation of a constrained resource. Queue Management is not about just managing delay; the accent is on optimising position in the queue and hence improving the overall outcome of the process".*

The Queue Management process is presented with traffic that is the result of Network Management processes and as such is dependent on the quality of that traffic. If the traffic delivery is significantly higher that the capacity of the resource (normally a runway) there is limit to what queue management can achieve. However, if presented with traffic that is reasonably balanced with capacity tactical queue management can:

- assist in providing more efficient trajectories for Airspace Users by absorbing delay at more efficient altitudes thereby reducing fuel burn and co2 emissions
- improve the predictability of traffic delivery to the TMA;
- provide a traffic delivery that is optimised for wake vortex sequencing, thereby increasing runway throughput
- improve the organisation of the traffic delivery to the TMA, thereby decreasing TMA controller workload whilst minimising any increased task load on upstream sectors

The main method of achieving these aims is by earlier planning of arrival and related departure operations. This implies an extension of the AMAN Horizon. However this is constrained by trajectory prediction limitations, the need to integrate departures from airports within the horizon and the need to adapt to changing meteorological and runway conditions[5]

If there was no uncertainty, the ideal would be zero holding near the destination and all delay absorbed on the ground at origin. In practice, it is impossible to eliminate all uncertainty and under certain conditions it is desirable to plan trajectories so that there is a small reservoir of aircraft which is readily available to maintain good runway throughput in all conditions.

Another major challenge in extending the range of arrival management is the wide range of stakeholders involved: flight crew, TMA controllers, En Route controllers, and airports within the Arrival Management Horizon are all affected. Protocols to exchange the necessary information have been devised, but there are complex organisational issues; benefits may accrue to one actor while cost and workload is increased for another. Bi-lateral or multi-lateral agreements will be necessary to ensure that all stakeholders work collaboratively for the benefit of the whole system.

It is difficult but necessary to improve queue management by incremental steps; flights approaching from all directions should be managed in a consistent way within a symmetrical AMAN Horizon to achieve the goal of predictability and to ensure an equitable distribution of delay. Similarly, if there are agreements with only some airports inside the AMAN horizon to coordinate take-off times, then either flights from these airports may be disadvantaged, or complex procedures will be needed in the destination TMA to balance delay. The Europe-wide nature of the SESAR Target Concept should provide a good basis for moving forwards, but in SESAR Step 1 the boundaries between ANSPs will still have an effect.

Section 3.2 includes the latest version of New Operating Method which is based on the initial OSED text [8] but which has been heavily revised on the basis of the latest validation results and expert group discussion.

---

[5] According to the operational concept described in this section, a set of results per KPA, output from main validation campaigns, has been reported in the Appendix C of this document.

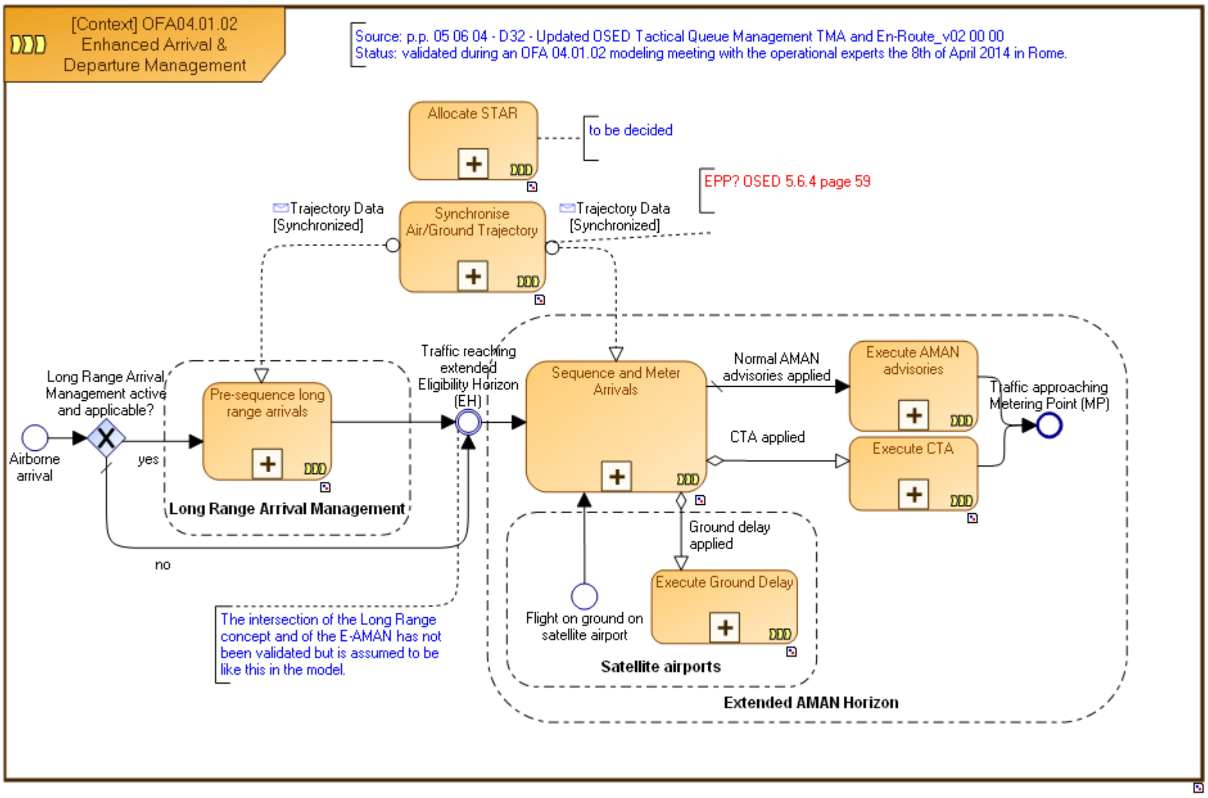
2.3 Processes and Services (P&S)

According to the Processes and Services[6] reported in the last update of P05.02 DOD, following details are reported for "Traffic Synchronisation" with main attention to "Pre-sequence and sequence arrival aircraft" and "Sequence and Meter Arrivals with CTA and TTL/TTG"

Note: It was decided to refer to EATMA models up to 4.0 only to establish consistency with SPR/INTEROP D34-05.06.04 (latest eATM Portal reference: EATMA data version: 5.1 (LDB)).

2.3.1 Pre-sequence and sequence arrival aircraft

The following figure shows the OFA 04.01.02 context in which the "Sequence and Meter Arrivals with CTA and TTL process" is executed. The "Synchronize Air/Ground Trajectory" process of the DOD 4.2 step 1 initiates i4D activities related to CTA.



Source: p.p. 05 06 04 - D32 - Updated OSED Tactical Queue Management TMA and En-Route_v02 00 00
Status: validated during an OFA 04.01.02 modeling meeting with the operational experts the 8th of April 2014 in Rome.

Figure 2 - OFA 04.01.02 Enhanced Arrival & Departure Management

The "Synchronize air/ground trajectory" process, which is done prior to any CTA allocation, is developed in DOD 4.2 based on the latest TMF Technical Note. Figure 3 and 4 detail the Extended AMAN concept. They will be further developed

---

[6] For the Services make reference to table 4 of this document. For a full report of these services descriptions, make reference to the information of the WPB4.2 - Processes and Services V01.00 and SESAR WPB4.2 High Level Process Models V01.00

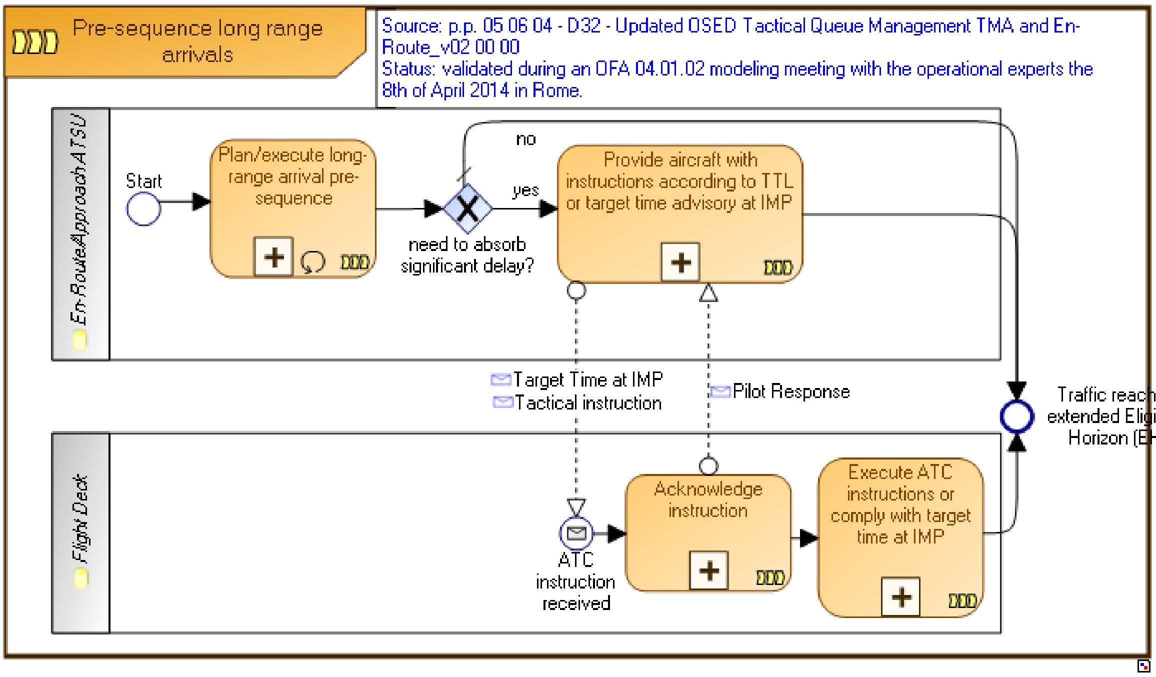


Figure 3 - Pre-sequence long-range arrival

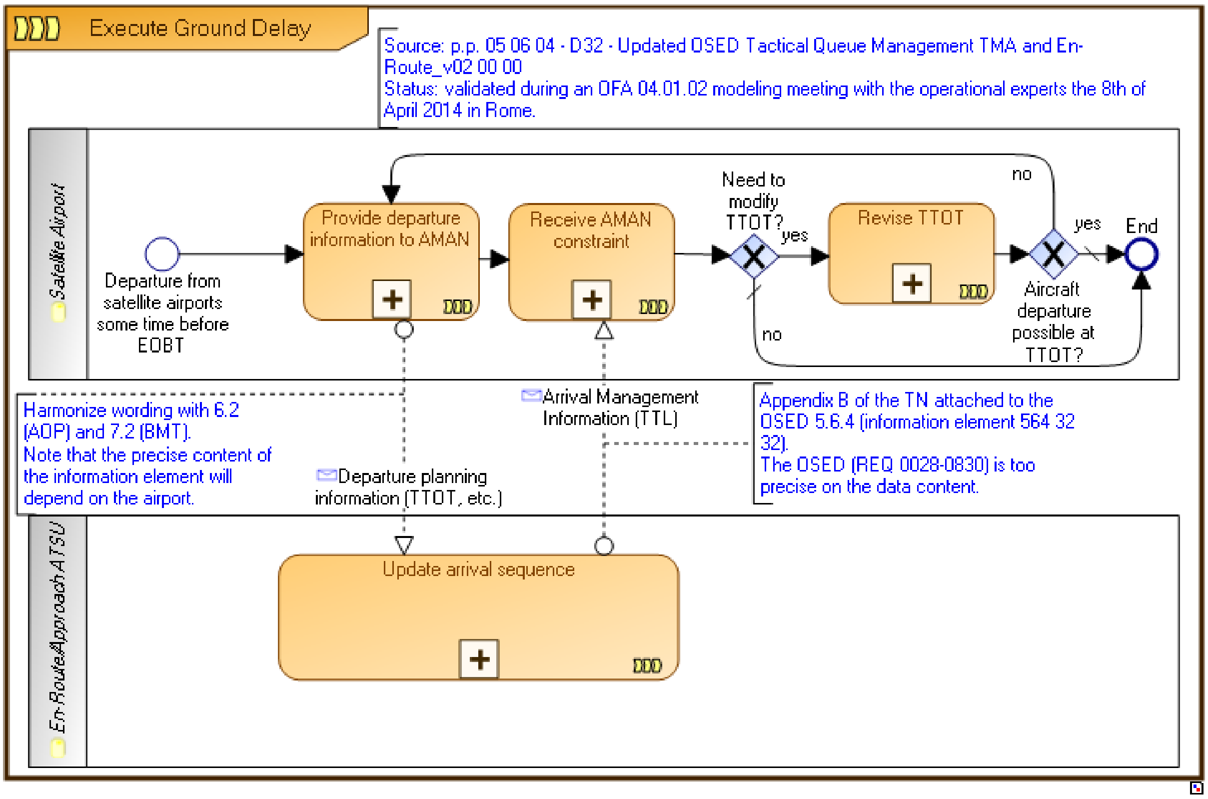


Figure 4 - Pre-sequence departures from satellite airports

2.3.2 Sequence and Meter Arrivals with CTA and TTL/TTG

The use of time constraints, associated to an arrival runway, serves as a means to meter and sequence traffic in the Terminal Manoeuvring Area (TMA). It is expected that Controlled Time of Arrival (CTA) constraints will be issued to aircraft operating within congested nodes of the air traffic network as a means of transferring arrival delay from low level (stack) holding to the en-route phase of flight by means of linear holding. The CTA constraint is based on the requirements of the Arrival Manager (AMAN), which is working to construct an optimised arrival sequence[7]. When the CTA is agreed within the context of i4D, it represents a contract between ground and air based on a time window provided by the aircraft - the Reliable RTA Interval. Aircraft that are subject to a CTA will 'self-manage' their speed profile in order to meet their assigned constraint. This will be achieved by utilising existing and enhanced on board navigation capabilities such as Required Time of Arrival (RTA).

The "Sequence and Meter Arrivals with CTA and TTL/TTG" process concentrates on the use of time constraints (CTA or TTL/TTG) to sequence and meter aircraft within the scope of i4D. i4D activities relate to the trajectory exchange between air and ground. After air/ground trajectory synchronisation and upon ATC request, the aircraft sends a Reliable RTA Interval at a waypoint on the aircraft's current flight route. The AMAN can then propose a Controlled Time of Arrival (CTA), ideally within the given Reliable RTA window. If accepted by the active controller of the flight, the aircraft will update its trajectory with the CTA constraint.

The model is produced in a bottom-up approach, based on the information found in the OSED 05.06.01 iteration 3 (20/09/2013). It has been linked to B4.2 models to ensure the top-down consistency. It is linked to the OFA 04.01.02 "Enhanced Arrival & Departure Management" and to the OIs TS-0103 "Controlled Time of Arrival (CTA)".

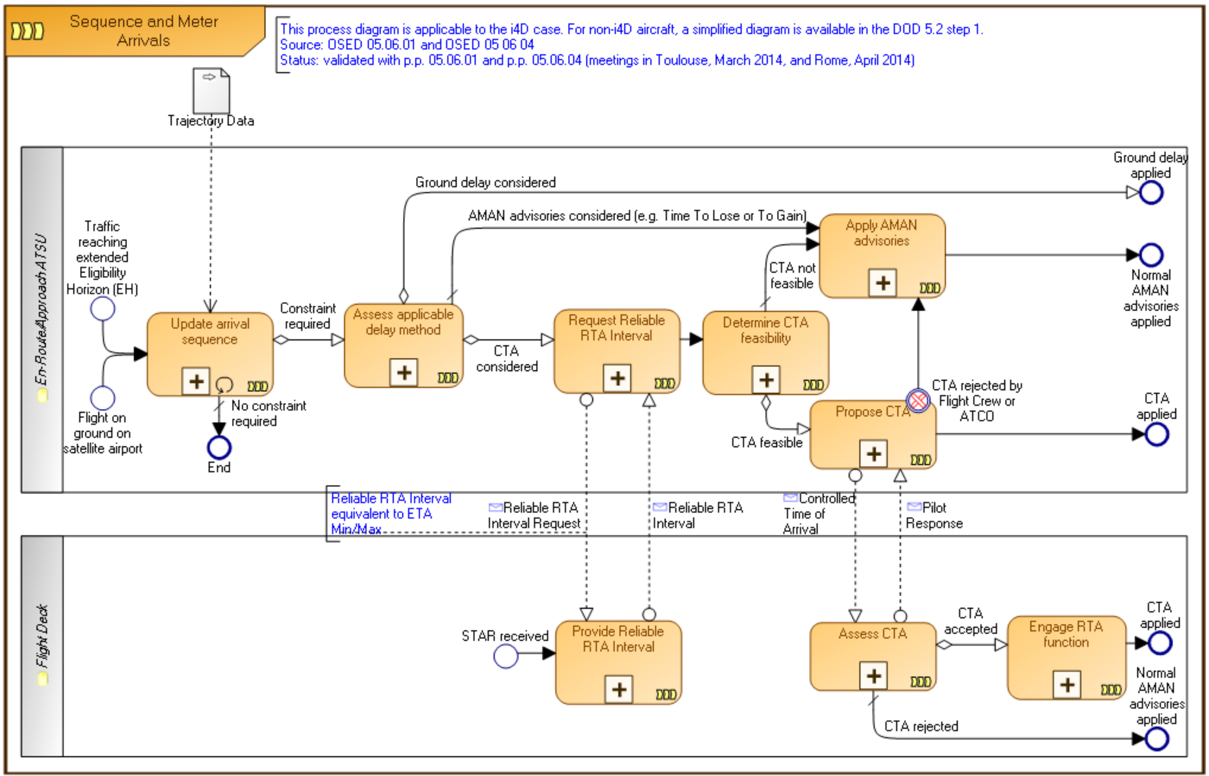

This process diagram is applicable to the i4D case. For non-i4D aircraft, a simplified diagram is available in the DOD 5.2 step 1.
Source: OSED 05.06.01 and OSED 05 06 04
Status: validated with p.p. 05.06.01 and p.p. 05.06.04 (meetings in Toulouse, March 2014, and Rome, April 2014)

Figure 5 - Sequence and Meter Arrivals with CTA and TTL/TTG (i4D context) process

---

[7] As indicated in the 05.06.01 OSED, it should be recognised that a CTA is a constraint and the intention for ATM (in using CTA) is to apply constraints only when necessary". (C.F 5.6.1 OSED section 2.2.1 seg. 4)

Node	Activity	Description
En Route/Approach ATSU	Update arrival sequence	The Arrival Manager (AMAN) of the destination ATSU builds and maintains its arrival sequence. It updates it with aircraft in its horizon, but also every time a CTA is rejected or cancelled.
	Assess applicable delay method	If the aircraft is on ground on a satellite airport, it might be possible to apply a ground delay if needed for the preliminary arrival sequence establishment. If the aircraft is airborne, the destination Arrival Management position (AMAN itself and/or associated CTA software) assesses whether CTAs should/could be applied, and on which aircraft. If it is not possible, standard AMAN advisories (e.g. TTL/TTG) can be applied.
	Request Reliable RTA Interval	For i4D flights, the ground system of the destination ATSU sends a request for the flight's ETA Min/Max time window over a known metering point on the arrival section of its trajectory. Note that for all flights, ground trajectory prediction is used by the AMAN to determine the ETA, unless/until supplemented by airborne information (EPP).
	Determine CTA feasibility	The Arrival Management position determines the location of the CTA point and time to be applied, and if it is able to place the aircraft within the RTA window. For i4D flights the CTA is calculated by the Arrival Manager of the destination unit based on the aircrafts calculated ETA Min/Max (for non-i4D flights, based on ground-calculated ETA). A request for CTA to be put in place is then transmitted to the en route unit controlling the flight, and the en route ATCO assesses the expected impact of the execution of the CTA on the traffic situation
	Apply AMAN advisories	If, in the course of planning the sequence, the AMAN is unable to place the required time for the i4D aircraft within the RTA window, or if the CTA proposed by the AMAN is rejected (by ATCO or aircrew) or is at any stage cancelled by the controlling ATSU, then standard AMAN advisories (TTL/TTG) are provided for the controller to execute..
	Propose CTA	If the request of the AMAN to implement a CTA is accepted, the controller proposes a CTA to the aircraft by sending a message containing the position and the time required for the aircraft at that position. In case the assigned CTA is not accepted either by the Executive Controller or by the Flight Crew (see OSED 05.06.01 UC_05 Segment 6 use case flow for further detail), the En-Route ATSU will inform the destination ATSU of the failure to implement the CTA, and the aircraft will be handled by other arrival management methods..
Airspace User Operations	Provide Reliable RTA Interval	Based on FMS calculation, the aircraft sends a Reliable RTA Interval.
	Assess CTA	The Flight Crew determines if the proposed CTA is acceptable/achievable.
	Engage RTA function	The Flight Crew enters the proposed CTA into the FMS as a RTA, adjusting the flight's speed accordingly.

491 **Table 6 – Description of activities for "Sequence and Meter Arrivals" [source: EATMA data**
492 **version: 5.1 (LDB)]**

493

3 Detailed Operating Method

3.1 Previous Operating Method

Today’s arrival management techniques and their supporting AMAN systems vary considerably and generally operate to a relatively short range. They have limited and sometimes inconsistent interaction with nearby airports and neighbouring ANSPs. The State of the Art with regard Arrival Management and existing AMAN tools is described in the P5.6.4 Stream C V1 Report [6].

Improvements should be achieved through the work in IP1 but much work remains to increase the effectiveness of arrival management processes that will better optimise the position of aircraft in the queue, minimise low-level path stretching and result in more efficient and predictable arrival trajectories.

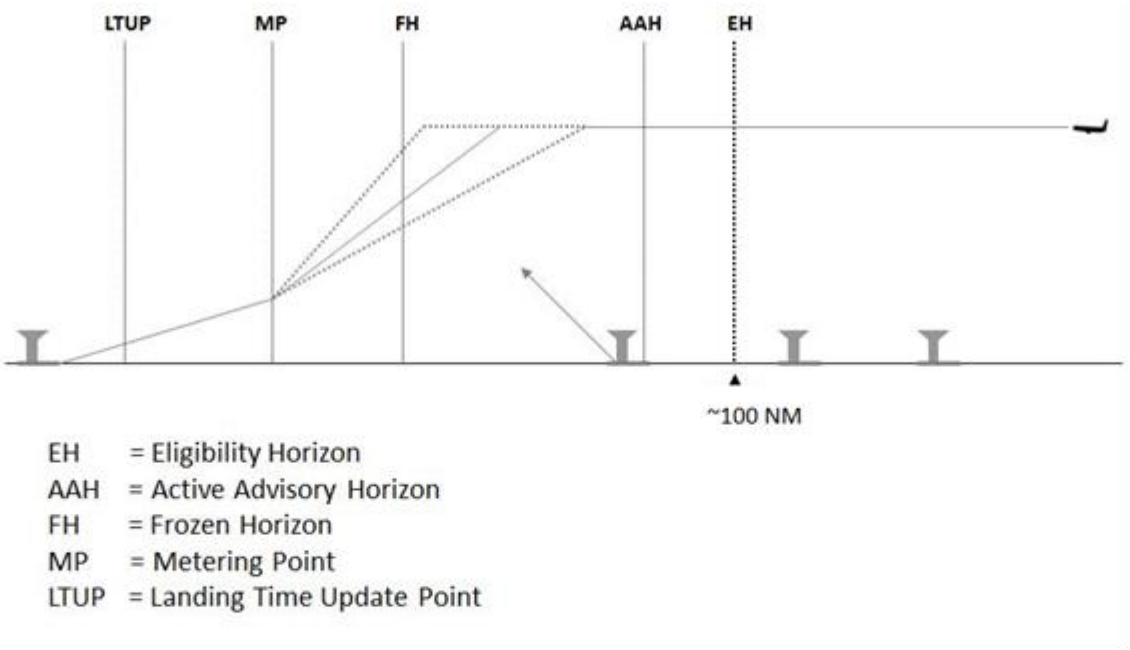


Figure 6: Current AMAN Configuration

Figure 6 above shows the configuration of current AMAN systems which generally consider aircraft within 100 NM of the runway. Some departures may occur within this horizon.

Traffic begins to be processed by the AMAN at the Eligibility Horizon (EH) and controllers are provided with AMAN advisories from the Active Advisory Horizon (AAH) onwards. Several controllers and/or ANSP may be involved in the arrival management process therefore delay sharing strategies may be implemented to allocate particular controllers or ANSP with absorbing a specific share of delay. The AMAN continues to re-calculate advisories and the sequence itself unless limited by parameters which stabilise the situation at a particular horizon for the benefit of control strategies. The sequence order may be stabilised at a specific horizon whilst advisories are still re-calculated in line with flight evolution. The degree of user control varies over the management of sequence stability. The AMAN is designed to deliver a sequence with the required spacing to the runway but this is often translated into a time to be achieved at one or more Metering Points (MP) with the aim of providing Approach Controllers with pre-sequenced flows of traffic which are then manually integrated. The Landing Time Update Point (LTUP) between 10NM and 3NM[8] from touchdown has a dual purpose; it may provide airport systems with an accurate predicted landing time and may also allow the automatic or manual adjustment of system planned sequence with respect to the actual landing sequence.

---

[8] 10NM and 3NM is the basis of current (Barco) implementations.

Existing AMAN systems include a range of well proven functionality and are considered as the baseline for the extension of the AMAN horizon. Existing AMAN systems have a degree of human supervision and allow a range of manual inputs and configurable parameters.

P5.6.4 considers that the human role is expanded in line with the extension of the AMAN horizon and therefore is proposing a specific ”significance change” in geographical range of Sequence Manager (SEQ_MAN) which is described in section 4.2.1.1 along with the current and future requirements associated with this role.

Existing AMAN implementations vary considerably but it was necessary for P5.6.4 to set a baseline which describes the functionality expected to be available in “today’s AMAN”. This baseline functionality is represented by a series of requirements listed in section 6.1. In addition to these basic AMAN requirements, P5.6.4 proposes a series of additional requirements in section 6.2 which are designed to improve AMAN performance but are not specifically related to Extended AMAN Horizon operations.

It is on top of this baseline that P5.6.4 proposes a new SESAR Operating Method described below extending the AMAN horizon to 200nm[9]. Proposals are also made for Long Range AMAN operations out to 400/500nm which may be appropriate at specific locations and during particular times of the day.

3.2 New SESAR Operating Method

The SESAR Operating Method advocates that the arrival management horizon will be extended with the objective of further improving the queue management process and assuring more efficient and predictable arrival trajectories, subject to retaining the capability to maintain pressure on the arrival runway if required, so that throughput is not lost. An extended horizon is expected to enable delay to be managed more efficiently with less lateral flight path interventions,

P05.06.04 is tasked with addressing Tactical TMA and En-route Queue Management, The extension of arrival management into en-route airspace is therefore a key aspect of the scope of P05.06.04 and the effectiveness with which arrival management can be performed at long range has a significant impact on TMA operations.

This OSED focuses on the extension of the arrival management horizon building on existing experience of the deployment of AMAN tools. Existing terminology is used wherever possible to facilitate the integration of the new techniques and the development of the necessary enhanced AMAN tools. Many aspects of arrival management and AMAN tools are already at a high level of maturity therefore the aim of this OSED is to describe what is new and is the subject of validation.

Relevant new requirements are listed briefly in this chapter. The full detail of the new requirements can be found in sections 6.3 to 6.7.

3.2.1 Key Aspects of Extended Arrival Queue Management in SESAR Step 1

Arrival management was originally designed to protect the TMA and runway from overload, optimise traffic for various runway configurations and wake vortex and to benefit capacity by maintaining pressure on the runway. The need now is to maintain these original goals whilst improving the predictability and efficiency of the trajectories of arriving aircraft.

This presents a significant new challenge which will be addressed by extending the scope of arrival management into the en-route phase and significantly enlarging the AMAN Horizon. Extending the horizon provides more time for queue management to act on the traffic and will potentially yield greater benefits particularly in terms of flight efficiency. However the need to maintain runway throughput remains paramount at many airports and in the case of London Heathrow the initial efficiency goal is to reduce typical holding times from 9mins to 3mins.

The terms “sequencing” and “pre-sequencing” are redefined in this OSED. The improved traffic delivery at the Metering Point thanks to the extension of the arrival management horizon should result

---

[99] These 200 NM refer to the aerodrome reference point (and not from the TMA boundaries).

in almost fully “sequenced” traffic and the long range arrival management described in 3.2.1.5.2 will result in “pre-sequenced” traffic. These terms are fully described in 3.2.1.3.

The content of this chapter is the outcome of a detailed expert group review of the P05.06.04 T06 Initial OSED and the results of recently conducted validation exercises both within and outside the SESAR program.

3.2.1.1 The Framework Supporting Arrival Queue Management

This section briefly describes the framework within which the concept is situated mainly from an airspace point of view.

The configuration of existing AMAN systems provides the basis for the framework which will support the extension of the AMAN horizon into en-route airspace. As explained above, existing AMAN are configured to provide advice from the Active Advisory Horizon (AAH) at 120 NM prior to the runway

It is proposed to extend the Eligibility Horizon (EH) by around 50% to around 180-200NM and to extend the AAH by a corresponding amount. However these distances may be limited by the nature and the number of adjacent airports. It is considered difficult to fully integrate major airports generating a significant amount of inbound traffic to the subject airport within the EH. This is due to the complexity of departure operations at major airports which would potentially require AMAN to be integrated with CDM operations and where the accuracy of delivery required by the AMAN at destination may not easily be achieved. Major airports lying within the horizon of an AMAN at another airport are therefore considered outside the scope of SESAR Step 1.

In the case when some smaller airports are included within the extended EH the procedures by which departures from these airports can be handled and smoothly integrated in the main arrival flows are described in section 3.2.1.6. . It should be noted however that similar difficulties with time adherence for multiple aircraft could be encountered in the case of integration of a large number of such “smaller” airports.

As a general rule, AMAN implementers in a dense part of Europe need to be cognizant of the potential increase of interfering traffic when considering even a small extension of the horizon.

REQ-5.6.4-OSED-0028-0500 *- The Eligibility Horizon (EH) and the Active Advisory Horizon (AAH) should be extended to support the controller in applying more efficient arrival management techniques at an earlier stage of flight.*

Two critical aspects of extending the AMAN Horizon are data availability and trajectory prediction. It is also important to address the need to communicate advisories to controllers. If the EH is geographically situated within the airspace of another ANSP then the AMAN may not be fed with accurate data on all flights. Radar flight tracking may not be possible from certain directions (lack of correlation) meaning that less accurate data such as Advanced Boundary Information (ABI) or ETFMS data may need to be relied upon resulting in accurate advisories being calculated for only a portion of the total number of aircraft with the EH. Even if data is available, the transmission of advisories will be more problematic where the flight is not within the same ACC as the AMAN. ATC strategies within the airspace of an adjacent ATSU may impact the trajectory in ways unknown to the AMAN and therefore co-operative working methods may need to be devised along with bi-lateral or multi-lateral agreements covering both conventional and i4D flights.

SWIM activities and solutions help to improve the information exchange between ground stakeholders by providing timely and more accurate reliable arrival management information. The Arrival Management Information Service establishes reliable information upstream suiting the information needs of the upstream station.

The impact of an asymmetric horizon affecting data availability is shown in Figure 7.

REQ-5.6.4-OSED-0028-0520 *- The required data to feed the TP shall be available at a time appropriate to the new horizon, to feed the Trajectory Predictor at an earlier phase of flight (or at a greater distance from the runway).*

REQ-5.6.4-OSED-0028-0530 *- The data referred to in requirement 0520 shall be of sufficient quality to enable reliable Trajectory Prediction calculation for extended horizon.*

Figure 7 below shows a EH defined in miles (circular) and an AAH defined in time (an ellipse due to wind effect). This represents a typical scenario with just a simple extension of the AMAN horizon; in the event that a Long Range Eligibility Horizon is implemented the airspace, data and communications issues become more complex. This is dealt with in greater detail in Chapter 4.

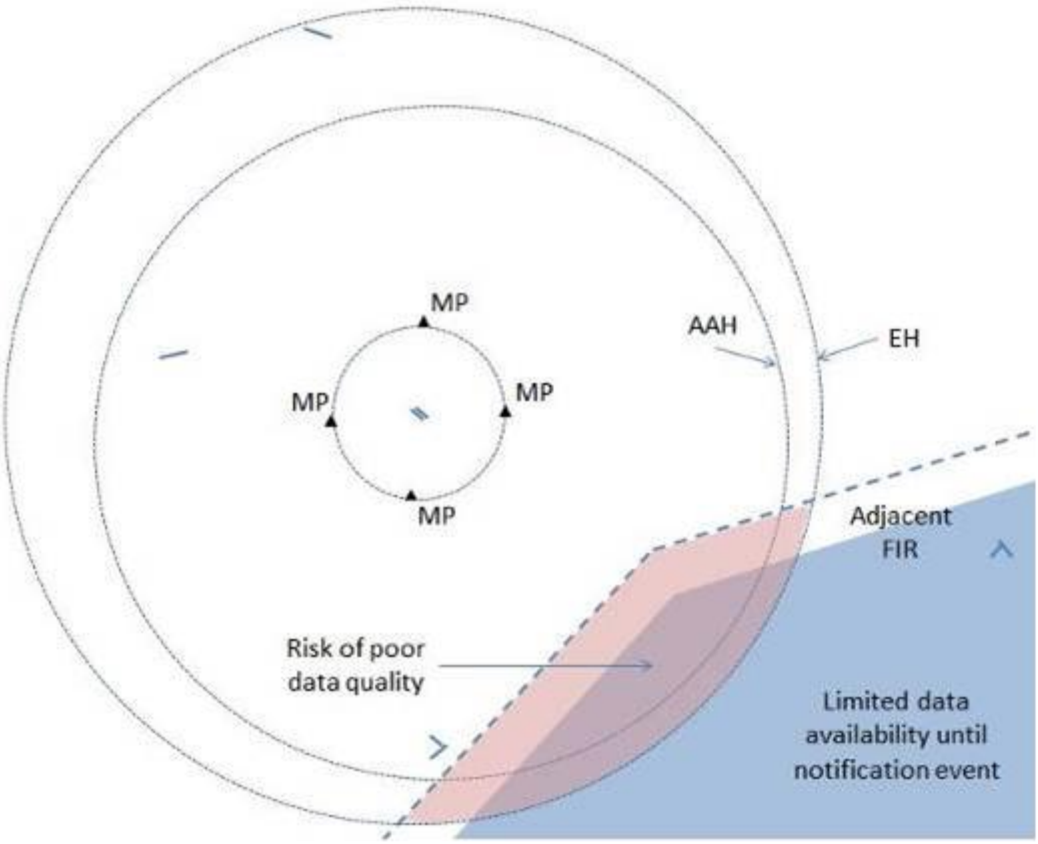


Figure 7: Plan View Showing Impact of Adjacent FIR on AMAN Horizons

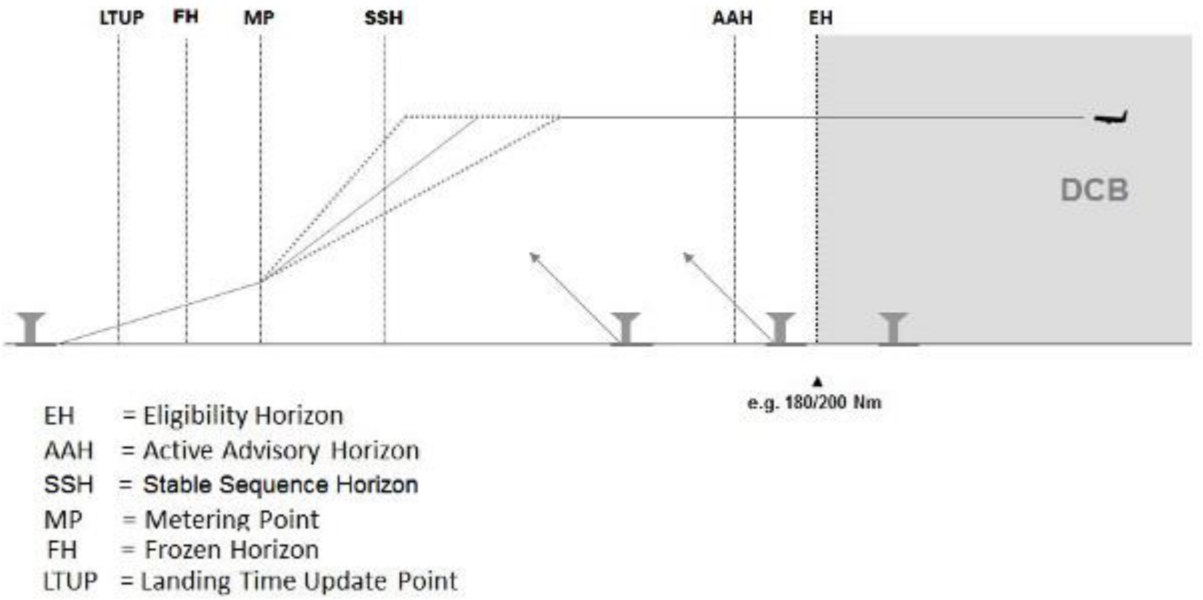


Figure 8: Vertical View of the Framework – Simple Horizon Extension

Figure 8 above shows a simple extended horizon and the approximate positioning of the various points and horizons. In Step 1 Demand and Capacity Balancing measures will be active outside the Eligibility Horizon (EH) ensuring that the subject airport is provided with an inbound flow that does not exceed declared capacity. It is recommended that the horizon extension should be homogeneous in every direction avoiding disparity of treatment in so far as possible on different flows depending on the data availability, especially in the case of fixed times being employed at distance and consider the flying time element rather than distance element

Long Range Arrival Management proposes to further extend the EH to the much greater distance of 400-500NM to include mainly high altitude traffic which will be subjected to early pre-sequencing to allow delay to be absorbed over a much greater distance. This proposal is linked with two new horizons: the Long Range Eligibility Horizon (LREH) and the Initial Metering Horizon (IMH), plus a new point: the Initial Metering Point (IMP) as shown in Figure 9 below. The locations will depend on stability of data, but appropriate values might be 80 minutes for the Initial Metering Horizon and 45 minutes for the Initial Metering Point. The operating method between the IMH and IMP is described in section 3.2.1.5.2.

REQ-5.6.4-OSED-0028-1000 *- Particular AMAN configurations may require a long range extension of the Eligibility Horizon (e.g. 400/500 NM).*

REQ-5.6.4-OSED-0028-1020 *- An Initial Metering Horizon (IMH) shall be defined, representing the point where aircraft are given a target time for the Initial Metering Point.*

REQ-5.6.4-OSED-0028-1030 *- An Initial Metering Point shall be defined on each route, at which flights can be pre-sequenced.*

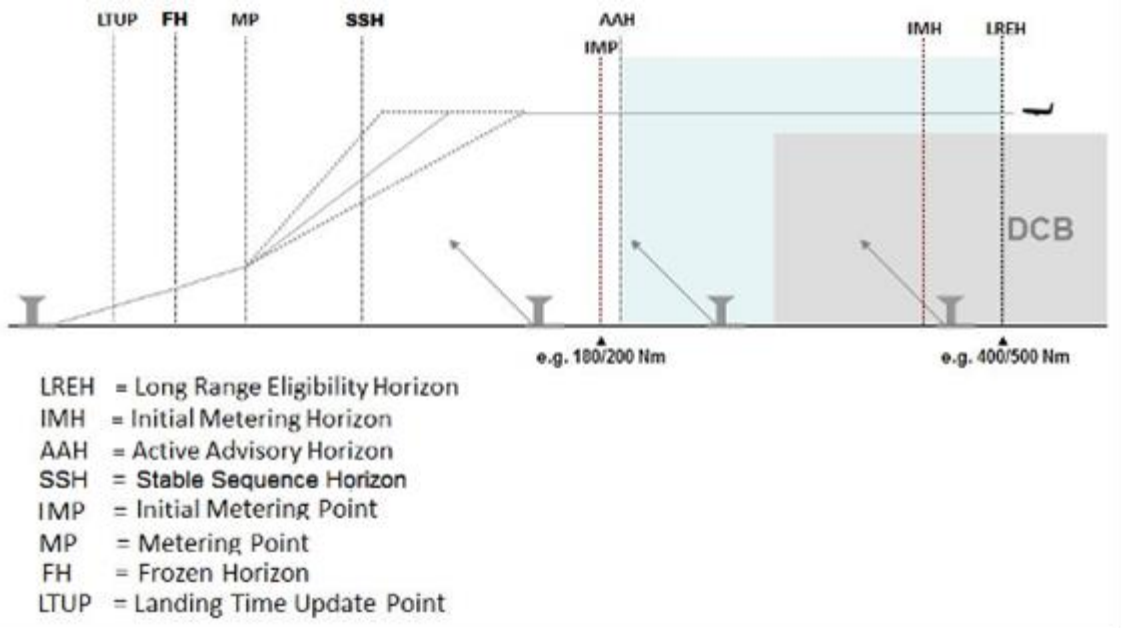


Figure 9: Vertical View of Framework – Long Range Extended Horizon

Figure 9 indicates that Demand and Capacity Balancing (DCB) which will also be active at this distance from the runway. It is envisaged that pre-sequencing at long range is co-ordinated with all relevant partners such as Network Management responsible for DCB and ANSP responsible for Complexity Management deployed by the en-route ACC. See also 0.

Note that the distances/times associated with the various horizons and points are not intended to be prescriptive. They may be changed by individual organisations to suit their airspace, traffic and other circumstances. For example, this would allow individual airports to set a horizon that reflects their proximity to other major airports that supply a significant proportion of their traffic. In the case of Long Range Arrival Management is also conceivable that these horizons could be changed by the user depending on the time of day and therefore off-line user configuration of time values for the Long Range Eligibility Horizon, the Initial Metering Horizon, and the Initial Metering Point.

REQ-5.6.4-OSED-0028-1035 *- The system shall permit the user to perform off-line configuration of time values for the Long Range Eligibility Horizon, the Initial Metering Horizon, and the Initial Metering Point.*

3.2.1.2 Relationship with Demand, Capacity and Complexity Management

Demand and capacity are balanced in processes managed by Network Management. In particular runways and complex TMAs are supplied with no more traffic than they can safely and efficiently handle. Where capacity cannot be provided to satisfy the pending demand, SESAR requires that CDM processes involving all stakeholders are used to determine the trade-offs necessary to reach a balanced situation. However in Step 1 techniques will still be deployed to regulate traffic so that the demand rarely exceeds capacity. Network Management should ensure that traffic flows received as input by Tactical Queue Management are sufficiently regulated so that the arrival management techniques deployed can successfully sequence the traffic in an efficient way. Inefficient trajectories will result from excessive demand - this cannot be fully mitigated by queue management which can only sequence and optimise the traffic it is presented with.

Different arrival management strategies may be implemented at different times of the day. During peak times the emphasis may be placed on capacity whilst outside of peak times the emphasis may be placed on efficiency. These two modes of operation may require different Arrival Management strategies to be in place (see also section 3.2.1.4).

WP7 of SESAR is developing advanced techniques such as Dynamic DCB to extend the DCB process into the en-route phase and act on aircraft in flight. It is envisaged that DCB and any Dynamic DCB (D-DCB) actions terminate when arrival management using a simple extended horizon starts, however it is accepted that close co-ordination will be required in the case of Long Range Arrival Management to ensure that all ATM services, potentially including a Complexity Management Service, operate in co-operative way. In fact, the extension of the AMAN horizon and the deployment of advanced arrival management techniques will add to the complexity of operations in en-route sectors. It is therefore important that Tactical Queue Management works closely with other projects to ensure that an optimum solution is developed satisfying the need to manage arrivals in en-route airspace whilst not overloading en-route sectors. The requirements for co-ordination between D-DCB and Long-Range AMAN will need to be defined as part of the work of WP7. A suitable option may be to apply the most penalising constraint in the case where both Network Management and Long-Range Extended AMAN perform actions. It is important to underline that the “connection” of long range AMAN with DCB is not part of Extended Arrival Management (AMAN) horizon.

REQ-5.6.4-OSED-0028-0560 *- In case of interaction with DCB, clear application rules shall be defined.*

3.2.1.3 Pre-Sequencing, Sequencing and Optimisation

The terms “sequencing” and “pre-sequencing” are redefined in this OSED – they are in line with the operational goals of tactical queue management. The improved traffic delivery at the Metering Point thanks to the extension of the arrival management horizon should be almost fully “sequenced”. Long range arrival management (3.2.1.5.2) and actions taken to manage traffic departing from satellite airports (3.2.1.6) will result in “pre-sequenced” traffic.

3.2.1.3.1 Pre-Sequencing

If the data available on the concerned aircraft to be included in sequencing calculations is imprecise then any actions taken on the evolving sequence are described as pre-sequencing. Imprecise data may be associated with aircraft still on the ground, at long range or in the airspace of an adjacent ANSP. The goal of pre-sequencing is to improve traffic presentation at the Active Advisory Horizon. It is considered that pre-sequencing is justified if it significantly improves the overall arrival queue management process.

Short-haul flights that depart within the normal Eligibility Horizon (EH) may be pre-sequenced through an agreed (Target Time of Arrival) TTA which effectively reserves a space in the sequence. The TTA will be used to calculate a corresponding Target Take-Off Time (TTOT) which should ensure that the task of subsequently inserting the aircraft in at the appropriate time/place in the sequence is eased. In the case of departures within the Eligibility Horizon any delay that can be absorbed on the ground instead of in the air is of course extremely beneficial (see also 3.2.1.6).

In the case of tactical queue management within a Long Range Eligibility Horizon (LREH), pre-sequencing will take place between the Initial Metering Horizon (IMH) and the Initial Metering Point (IMP) as shown in Figure 10 below. The implementation of pre-sequencing may be a task that can be effectively delegated to flight crew. Flight crew can gain or lose time over a large distance to arrive well positioned to be subsequently sequenced with all other arriving traffic within the AAH. They may be assisted in this by use of the FMS RTA function although this is not considered essential as the intention is for aircraft to arrive within a given tolerance. It is not critical how this is achieved - the RTA function is just one method. The target time at the IMP should not be considered as a clearance. It will be provided to the flight crew as information or as a planned time that they are requested to make their best endeavours to respect. Efficiency gains for AU will be commensurate with compliance.

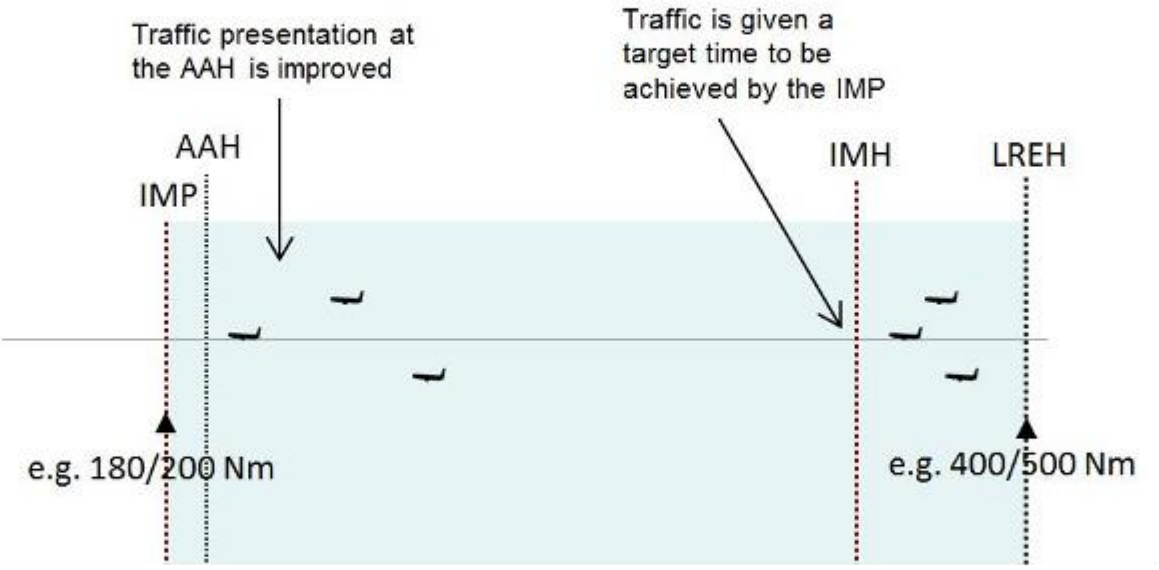


Figure 10: Long Range Pre-sequencing

Long range arrival management and the pre-sequencing of departures on the ground may involve many uncertainties in SESAR Step 1 including inaccurate trajectory prediction due to the lack of precise wind data. However, if data of sufficient accuracy is available (perhaps through the downlinking of trajectory data by suitably equipped aircraft) there is value in early traffic pre-sequencing in the air if the result is a more predictable and efficient flight profile.

3.2.1.3.2 Sequencing

The main aim of extending the AMAN horizon is to enable an improved sequencing process resulting in greatly improved traffic presentation at the Metering Point (MP). Unlike today where traffic is only “pre-sequenced” before the MP and most sequencing takes place within the TMA, this OSED explains how sequencing will be largely achieved before the MP.

As explained in 3.2.1.1 the Eligibility Horizon will be extended to around 180-200nm from the subject airport. Sequencing will therefore commence within an extended Active Advisory Horizon (AAH).

It is essential that high quality data is available on all arriving flights from all directions therefore it is important that the AAH is a symmetrical to ensure an adequate quality of data is available on all flights. Other important inputs to extended arrival management may be runway configuration options and DMAN departure planning (see section 3.2.1.4 concerning strategy).

When AMAN has data on the expected trajectories, the ways they can be changed, and the expected landing rate, it can compute an arrival sequence which optimises the efficiency of trajectories and runway throughput.

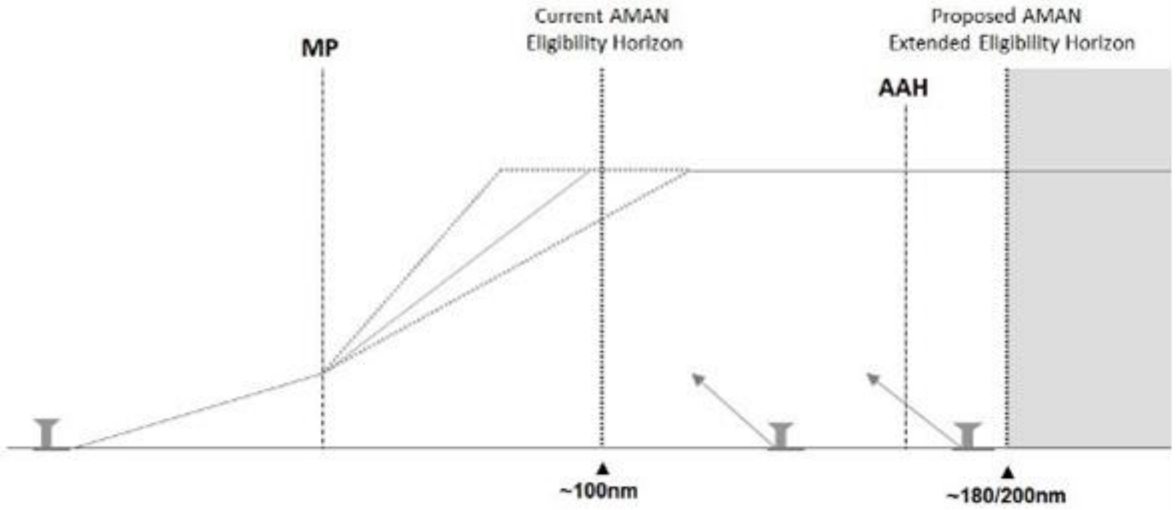


Figure 11: AMAN Eligibility Horizon Extended from ~100nm to ~180-200nm

Arrival Management currently establishes the sequence on the basis of first-come, first-served (FCFS) with adjustments for efficient wake vortex spacing and local special situations. In this context “first-come” is defined by the sequence of expected arrival times if no sequencing actions were taken. Extending the AMAN Horizon allows more space for aircraft to lose or gain time to achieve an improved sequence at the MP. An open issue is whether some priority should be attributed to aircraft with advance navigation capabilities such as Initial 4D (i4D). A high level policy decision on the issue of priority is awaited from the SJU. However an AMAN must of course recognise medical or emergency flights as well as potentially giving priority to VIP flights.

When a flight crosses the AAH it triggers the automatic AMAN sequencing process which attributes delay if needed and then constantly recalculates the sequence based on input parameters, events and flights progress. If left unchecked these processes can result in sequence instability in which a changing sequence order or advice poses difficulties for controllers. Therefore most AMAN tools include features that can stabilise the sequence such as a horizon after which the AMAN will not automatically re-order the sequence whilst advisories are still re-calculated in line with flight evolution. Extending the AAH to a greater range than normal significantly increases the problem of sequence instability.

Therefore an AMAN with an extended horizon must include features that assure adequate sequence stability out to the extended AAH. This may take the form of automated features that interpret controller inputs aimed at respecting AMAN advice or providing the controller with controls to override automatic re-sequencing. The key aspect is that sequence stabilisation as traffic approaches the MP should be progressive and be in line with ATC strategies.

When a CTA is issued to enable the flight crew to achieve the required time at Metering Point, the planned time of the aircraft at the MP is effectively locked. CTA-capable aircraft may move backwards or forwards in the sequence as time passes and the AMAN continues to update planned times for other aircraft. CTA capable aircraft therefore benefit in predictability and efficiency but may result in a potential loss of flexibility for controllers to manage an evolving situation which may result in CTA having to be cancelled. In addition, the stability benefits observed for those flights flying on a CTA may be accompanied by a detrimental effect on other flights (see §3.2.1.8.2).

Some difficulties may also be experienced when inserting a significant number of departures from satellite airports in a sequence that includes many aircraft flying to CTA[10]. It is clear that a balance must be found between automation support for sequence building and manual intervention. Validation of an extended AMAN horizon is now providing valuable guidance as to the type of features and functionality that need to be developed.

3.2.1.3.3 Optimisation

Sequence optimisation is the process of organising aircraft into a specific order and is a significant factor in maintaining high runway throughput. AMAN normally works on the first-come-first-served principle, but other factors may also apply, such as:

- Wake vortex separation; For example, the sequence “Medium-Medium-Heavy-Heavy” gives higher throughput than the sequence “Heavy-Medium-Heavy-Medium” because smaller total separation is needed for the same number of aircraft to land.
- Runway occupancy times;
- Multiple/parallel runway considerations (runway separations/dependencies);
- Flight profile characteristics;
- Equity including trade-offs made to minimize global delay at the cost of an individual delay;
- Selectable goals (such as minimum average delay or minimum deviation from preferred profiles);
- Applied limits on sequence swapping (AMAN may be instructed to limit sequence swap for an aircraft to x positions forward, xx backwards) may be taken into account.

Sequence optimisation is particularly valuable for segregated runways, because wake vortex constraints often determine the required spacing. When arrivals and departures are interleaved on a mixed-mode runway wake vortex separation does not normally constrain runway throughput because it does not apply between successive movements. However, many mixed-mode runways have arrival and departure waves, and even where flows of arrivals and departures are balanced there is never an exact interleaving, so sequence optimisation can be seen to also contribute to increased throughput on any runway.

Extending the AMAN horizon should increase the opportunities for optimisation for the overall benefit of the arrival management process.

3.2.1.4 Arrival Management Strategy

An important factor that must be established for any airport is the Arrival Management Strategy addressing such issues as runway allocation and acceptance rates, delay sharing, focus on efficiency or capacity, deployment of long-range arrival management operations etc. The strategy should be established in collaboration with all concerned actors, not only TMA and en-route ATM but also the concerned airport and Airspace Users.

The airport will be the client for the traffic delivery and therefore should be involved in determining the strategy. However commercial pressures on airport operators must not result in overoptimistic landing and departure rates being applied. The final arbiter and owner of the strategy must be ATC working closely with the Airspace Users who should be consulted on whether the focus should be on maximising runway throughput or efficiency of flight.

Airport operations should be harmonised with arrival management. For example, if the AMAN horizon is to be extended to 60mins before touchdown then airport planning needs to have a stable runway utilisation plan at this time horizon. If departing traffic has an impact on landing rate and runway utilisation, then departure management needs to work to the same time horizon. Minimizing airport surface taxiing for both outbound and inbound aircraft may be a significant factor in the strategy.

---

[10] Some validations within 05.06.04 (ref. to SESAR P05.06.04 D76 VP 191 VALR) have shown this to be the case, but local assessment would also be required to confirm the impact in any individual area/implementation.

Strategies may also take into account environmental factors such as noise and pollution as well as determining where priorities should be set when trade-offs are needed between capacity, predictability and efficiency.

The scenarios proposed by P5.2 and the options described in this OSED provide a basis for the Arrival Management Strategy:

Medium Density/Medium Complexity

This scenario foresees either the use of CTA/i4D techniques or conventional TTL/TTG techniques in a medium density/medium complexity environment. P5.6.4 proposes that these techniques are not mutually exclusive and depend on the numbers of equipped aircraft and the traffic volume that is anticipated. A strategy could be developed in this type of situation where emphasis is placed on efficiency for certain parts of the day when the traffic volume is lower and the corresponding landing interval can be greater. An increased landing interval would ease the use of efficient i4D techniques and reduce the likelihood that controllers would need to intervene tactically. During peak periods the emphasis could be placed on capacity with the focus on maximised runway throughput with a minimum landing interval that would perhaps preclude i4D operations.

High Density/High Complexity

This scenario includes also the possibility of CTA/i4D techniques (TS-109). It is the opinion of P05.06.04 that in this scenario long range arrival management involving flight crew implemented advisories could be beneficial for certain airports perhaps at certain times of the day. The aim of long range arrival management is to achieve improved flight efficiency by extending the range over which delay is absorbed (see 3.2.1.5.2).

The choice of strategy applied will have an impact on the many actors involved in an extended arrival management scenario and it is therefore essential that a clear strategy is agreed and regularly reviewed. There is a trade-off between the goals of equity, high throughput, and trajectory efficiency; an AMAN should allow this balance to be determined locally and variably throughout the day.

3.2.1.5 Operations between the AMAN Eligibility Horizon and the Runway

3.2.1.5.1 Extended AMAN Horizon

This section deals with the issues associated with simply extending the range of arrival management and placing the Active Advisory Horizon (AAH) (see
) at around 200nm from the runway. Extending the AMAN horizon introduces new complexities and amplifies existing arrival management problems.

The typical optimum top of descent is approximately 100-120NM from touchdown meaning that up to 100NM of flight within the extended AAH will be in en-route airspace. One factor that needs to be considered is speed inflexibility at high altitude and potential level changes to lower altitudes to either speed up or slow down. Many other factors also come into play. AMAN advisories will have to be applied across several sectors whose configuration and procedures have not previously had to accommodate arrival management tasks. Controllers in en-route sectors will need to be provided with suitable system support to ensure that their task load per flight remains reasonable.

***REQ-5.6.4-OSED-0028-0540** - The extension of the horizons will require the capability to transmit sequence advisories (as described in requirement 0240) to en-route sectors concerned with an earlier stage of flight (or at a greater distance from the runway).*

If the range of AMAN extends into airspace handled by other ANSPs then specific agreements will be needed particularly in the free exchange of surveillance data to reduce the asymmetry of the AMAN horizons. Procedures may also have to be established with neighbouring ANSPs so that co-operative delay sharing procedures can be implemented. Ideally this should result in complementary procedures where ANSP assist each other for equal benefits. Bi-lateral or multi-lateral agreements may be needed to cover situations where additional sector/longer opening hours/extra effort is required.

Particularly complex airspace may create additional difficulties. A symmetrical AAH is an important requirement to ensure that all relevant aircraft are taken into account in AMAN calculations therefore all issues that may prevent symmetry must be urgently addressed.

Extending the arrival management horizon implies early planning of the arrival flows. This planning will be based on runway configuration and capacity parameters which now need to be stabilised up to one hour before arrival. This requires a strategic approach to runway utilisation and careful planning of:

- Mixed mode operations, where arrivals and departures are competing for the same piece of concrete;
- Departure and arrival runways with dependencies such as crossing configurations or situations where taxiing departures have to cross a landing runway;
- Runway allocation and change scheduling;

- Periods of runway inspection, outage for maintenance, snow clearance, de-icing etc.

It is accepted that this needs to be done at a strategic level, as it’s impossible to predict the exact timing of events. However, AMAN should be able to account for “X” to occur within a certain timeframe.
Extending the AMAN horizon further strengthens the case for integrating arrival and departure management strategies where mixed mode operations or where procedures from different runways affect each other.

Without a well-defined and stable runway utilisation strategy, arrival management will be inefficient and actions taken at long range may later turn out to be futile.

Current ATC operations are quite flexible enabling controllers to often finalise sequences and spacing quite late on in the approach and therefore if sequencing processes are to start up to 1 hour prior to touchdown there is a risk that flexibility in the system to respond to events will be reduced. It is essential that the capability for flexibility is not lost or else invidious situations may occur in the event of snow in winter, CB[11] activity in summer or similar random events. It may be necessary to have dynamic plans readily available for a wide range of circumstances.

A particular problem may be the onset or termination of Low Visibility Procedures (LVP). Predicting how long fog stays or when it dissolves is known to be difficult. Lowered acceptance rates are currently either prolonged in intervals or cancelled at short notice. Operations with an extended AAH during transitions to and from LVPs will need to be carefully crafted.

The greater the range of the AMAN horizon, the greater the number of aircraft that will depart from airports inside it and in this case a horizon measured in time is considered appropriate. Such aircraft are likely to have a greater degree of uncertainty associated with them compared with aircraft already airborne when they reach the AMAN horizon. While the AMAN will be able to make sequencing and spacing calculations using predictions of aircraft departure time from airports within the AMAN horizon, the uncertainty associated with aircraft departures may lead to instability in the arrival sequence. Therefore the concept described in this OSED aims to ensure that AMAN is fed with the best possible data for departures within the AMAN horizon. This is detailed in section 3.2.1.6. In addition, other types of flights may affect the stability of the sequence such as joining flights, test flights and go-arounds. A large proportion of these types of flight will limit the effectiveness of extended arrival management operations.

Details of the specific techniques that may be applied with the extended AMAN horizon are detailed in section 3.2.1.8.

---

[11] Cumulonimbus activity: a heavy and dense cloud of considerable vertical extent in the form of a mountain or huge tower, often associated with heavy precipitation, lightning and thunder.

3.2.1.5.2 Long Range Arrival Management

At locations where it has been proved to be beneficial, Long Range Arrival Management may be implemented. It is expected that this technique will be applicable to specific situations where sufficient data is available at around 80mins from the runway for actions to be taken to pre-sequence flows. This technique provides benefit when a large proportion of the arriving aircraft are long-haul and the arrival sequence is not disturbed by major airports within the active horizon. This may only occur at certain times of the day.

REQ-5.6.4-OSED-0028-1010 *- The system shall receive flight progress information for every aircraft bound for the arrival-managed airport, when the flight crosses a defined Long Range Eligibility Horizon (LREH). Using this data, the system shall compute an optimised arrival sequence.*

The primary aim is to transfer any identified delay from the TMA to the en route phase of flight. Analysis suggests that 3-5 minutes of delay can be absorbed between an Initial Metering Horizon around 500nm and the Initial Metering Point around 180nm. Transferring this delay to en route saves fuel and emissions relative to spending the same amount of time holding at lower altitude in the TMA, and produces a safety benefit through reduced TMA congestion. It has a further benefit in reducing the volume of TMA airspace dedicated to holding, thereby improving the departure profiles. Another benefit is the reduction in bunching achieved through improved streaming. The amount of 'de-bunching' that is possible is dependent on the variation of speed that an aircraft can achieve in the cruise, and/or the distance over which this speed adjustment takes place.

Once the AMAN has data of sufficient quality on the arrival flow it will be possible to make pre-sequencing calculations and start to provide AMAN advice. This is the horizon shown in Figure 9 as the Long Range Eligibility Horizon (LREH). The range of the LREH from the runway may vary considerably depending on the specific scenario; NATS and LVNL consider that pre-sequencing from as far out as 550NM/80min may be beneficial under specific conditions. Depending on the techniques employed (see section 3.2.1.8) this may require a large degree of cross-border co-operation and either active or passive support from some "distant" ATM actors to resolve problems for an airport far outside their normal sphere of operations.

AMAN advice may be in the form of a Target Time at the Initial Metering Point (IMP) or time to lose/gain (TTL/G) advisories to controllers calculated by AMAN working back from the runway time. In SESAR Step 1 one possibility for additional AMAN advantages is to communicate AMAN advisories to flight crew via data link. The advantage of this is that it could be introduced without agreements on procedures and the use of ground-ground communications with neighbouring ATSUs. However, this option has issues which have not been addressed in validation: the sender of a data link message has no guarantee that it is received; such a message would be an advisory, not a clearance or an instruction, so this option could only be used where aircraft operators agreed in advance to comply. It would lead to flight crew, requesting speed changes. Such requests already occur due to instructions from Aircraft Operations Centres, but their number probably would increase. This could increase the workload of controllers and limit their ability to plan ahead. Further validation would be needed to develop this option. Alternatively, the AMAN advisories may be transmitted to controllers working at the Intermediate Horizon who then pass them to flight crews as a speed instruction or a target time. This option should only be used when it will be operated by all controllers handling arrivals at the IMH, which may necessitate several cross-border agreements.

REQ-5.6.4-OSED-0028-1060 *- A TTL/TTG speed instruction or a target time at the Initial Metering Point (IMP) shall be transmitted to the flight crew either by datalink or by the controller responsible for the flight.*

REQ-5.6.4-OSED-0028-1065 *– If an aircraft has received a Target Time at the initial metering point, either by datalink or from a controller, this shall be displayed to other En Route controllers handling the flight so they will endeavour not to impede it achieving this time.*

REQ-5.6.4-OSED-0028-1080 - *The IMP APTO shall be calculated by AMAN by working back from the runway time. It shall comply with all agreed policies for delay apportionment to different segments of* *the flight as well as to the agreed delay sharing strategy. IMP APTO shall be converted into TTL/TTG advisory for the controller (implemented via ATC instructions), speed proposal for the controller or a target time at IMP for the flight crew as appropriate.*

It is important that the Target Time message is not expressed as an ATC clearance. Education will be required to reinforce this, involving first flight operations departments and then line pilots. Compliance with target times received via datalink would be voluntary, with the incentive of major fuel savings if all operators agree. The intention is that flight crew would consult their FMS to determine whether any adjustment to their flight trajectory is required to comply with the target time. If altitude change or significant speed adjustment is required, the pilot must request this from the current controlling sector. This is similar to current airline practice where aircraft operators use ACARS to request aircraft to arrive at a given time for operational reasons, such as stand availability. Individual aircraft compliance with their target times would be recorded by AMAN for post-operational analysis and management action.

REQ-5.6.4-OSED-0028-1100 - The system shall record the IMP TTO[12] and the IMP ATO for each aircraft to permit post flight assessment of aircraft compliance

The Initial Metering Horizon (IMH) should be sufficiently far from the IMP for an efficient trajectory to be calculated which also meets arrival management constraints. To effectively manage the delay that can be absorbed, the maximum delay value shall be able to be dynamically modified. Intermediate points between the IMH and IMP may be established for planning and delay sharing purposes. The Long Range Arrival Management technique is not dis-similar to the miles-in-trail technique which also improves traffic presentation at a specified horizon, however by acting on specific aircraft taking account of anticipated landing delay it is considered to be a significantly more efficient technique.

REQ-5.6.4-OSED-0028-1037 - *The system shall allow the Sequence Manager to dynamically change the maximum delay value to be absorbed before the Initial Metering Horizon, after which the sequence shall be re-calculated.*

REQ-5.6.4-OSED-0028-1090 - *Intermediate points between IMH and IMP may be used for planning purposes and sharing delay between trajectory segments. For instance, the border between ATSUs may have an associated planning time.*

A target time at the IMP may not need to be achieved with high accuracy for the benefits to be achieved; therefore the use of the FMS RTA function is not considered essential. However the system will monitor aircraft progress and identify whether aircraft are likely to meet their planned times at IMP or alternatively the system can receive a message from the ATSU responsible for the aircraft advising on its expected ability to meet planned times.

REQ-5.6.4-OSED-0028-1040 - *The system will monitor aircraft progress, using radar data, or data/information available from other sources or ANSPs, to identify whether aircraft are likely to meet their planned times at IMP.*

REQ-5.6.4-OSED-0028-1050 - *From LREH to IMP, the controller will endeavour to implement the AMAN sequence. Local procedures will determine how accurate sequence compliance should be.*

REQ-5.6.4-OSED-0028-1070 - *There must be timely notification of the plan and any updates to pilots or controllers depending on who should achieve the AMAN targets.*

The Long Range Arrival Management technique may also be appropriate where the distance from the normal AAH to the terminal area Metering Point (MP) is insufficient for aircraft to gain or lose a significant amount of time efficiently. In this case a CTA for the MP could be allocated to suitably equipped aircraft at the Initial Metering Horizon (IMH). However, controllers would need to monitor and intervene to assure separation and good traffic presentation, as today, and the CTA would be cancelled by such intervention. The long-range assignment of a CTA has not been validated in P05.06.04 or investigated by P05.06.01 which is the lead project for the use of CTAs in arrival management. One aim of pre-sequencing from the IMH is to provide predictability to RTA capable aircraft which will be able to subsequently down-link an optimum arrival trajectory and ideal Top of Descent (TOD) both of which are useful for the predictability and efficiency of airline operations, but predictability would be limited because there could be no guarantee that controllers were able to facilitate the CTA. In addition, traffic prediction at long range is uncertain, and CTAs calculated using

---

[12] The TTO at IMP is different from TTO coming from Network Manager

inaccurate data might be infeasible or highly penalising in terms of fuel burn. These issues have not been addressed in validation.

See also: General Statement regarding system support in 3.2.1.9.2.

3.2.1.5.3 Impact of Terminal Area Operations on Extended Arrival Management

The Metering Point (MP) at which the sequence should be stabilised is expected to be geographically defined (there may be multiple MP points at a similar distance from the runway). Ideally, subject to density/complexity of the considered environment, the arrival sequence should be stabilised and correctly spaced by the time it passes the MP after which speed control alone should be sufficient to maintain spacing until final approach (either by ATC speed instructions or ASAS Spacing). However, at certain locations different techniques may be used after the Metering Point to optimise both sequence and spacing.

Where deployment or RNAV routes or airspace structures is envisioned to this end, their design/dimensioning and the positioning of the Metering Point may be strongly inter-related, and both may be influenced by local constraints (e.g. environmental impact, other traffic flows etc.). In many cases (very busy airports) radar vectoring may still be used at certain times of the day and therefore the position of the Metering Point will have to take into account conventional control techniques designed to maintain the correct pressure on the runway or to retain flexibility. The MP positions will also have to take into account outbound routings. The optimum position for metering points will be described in the scenarios of section 5 and subsequently validated. A suitable position for the MP is expected to be 30 to 40 track miles from the runway. There may be situations where Metering Points are “clustered” for Arrival Management purposes.

REQ-5.6.4-OSED-0028-0580 – *It may be necessary to cluster Metering Points* for presentation purposes.

For effective AMAN operations it is very important to apply corrections for wind between the MP and touchdown e.g. “factoring” of “standard” times depending on wind speed and direction. This is often not done today and sequence stability suffers greatly from that. Different metering points per runway concept or at least different standard times and potential wind adjustment factors (based on accurate information) per runway concept need to be a capability.

REQ-5.6.4-OSED-0028-0460 - *If AMAN uses standard times between the Metering Point and the runway it shall take into account the impact of wind variability.*

On final approach, the Landing Time Update Point provides airport systems with an accurate predicted landing time as well as being used by the AMAN itself to update its calculations for the subsequent sequence.

REQ-5.6.4-OSED-0028-0570 - *Optionally, a minimum inter-aircraft spacing parameter at the metering point could be defined. Such parameter could be either statically defined for different conditions, or it could be possible to input it manually.*

This would ensure that AMAN planning was consistent with provision of in-trail separation. However, it would remain the responsibility of the controller to monitor and assure separation.

3.2.1.6 Departures from Satellite Airports within the Queue Management Horizon

This section describes how departures from nearby Satellite airports will be handled and their interaction with the arrival sequence at the destination airport.

When there is an over-demand for the arrival airport runway, departures from nearby airports within the AMAN horizon need to be considered by arrival management prior to EOBT. The aim is to absorb delay on the ground and then fly an optimised trajectory which includes an optimum arrival time at the sequencing fix (MP) for the arrival runway. The efficiencies achieved by a “ground delay” must appear to Airspace Users to outweigh any negative reaction from passengers who often consider on-time departure to be a factor in their choice of carrier. For this reason, there is a good argument for airlines

to be measured on on-time arrivals rather than on-time departures, which would require a change in performance metrics and other actions to achieve the necessary culture change. IATA support reduced emission and fuel saving procedures by using delay code for "Departure Management" where "no delay" is logged when aircraft take delay on ground (before off block) for environmental reasons.
It is important to underline that is the Stable Sequence Horizon that is used to determine the flight status/category

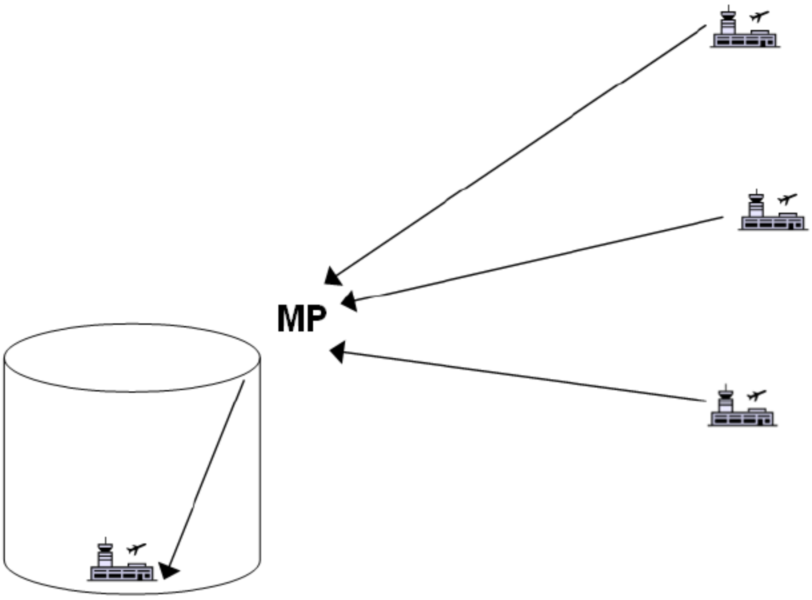


Figure 12: Aircraft departing from Satellite airports inside the AMAN horizon

To update the system with predicted times and target times, the processes defined in "Airport CDM" will be respected. Stated in Airport CDM are a number of time definitions to reflect readiness and preferences as follows;

CDM		
Acronyms	**Definition**	**Explanation**
EOBT	Estimated Off-Block Time	The estimated time at which the aircraft will start movement associated with departure (ICAO Flight Plan)
TOBT	Target Off Block Time	The time that an Aircraft Operator or Ground Handler estimates that an aircraft will be ready (all doors closed, boarding bridge removed, push back vehicle available and ready to start up/push back immediately upon reception of clearance from the TWR).
ETOT	Estimated Take Off Time	The estimated take off time taking into account EOBT (ICAO Flight Plan) plus the estimated taxi-out time
ELDT	Estimated Landing Time	The estimated time that an aircraft will touch down on the runway. (Equivalent to ATC ETA –Estimated Time of Arrival = landing)

TSAT	Target Start Up Approval Time	The time provided by ATC taking into account TOBT, CTOT and/or the traffic situation that an aircraft can expect start-up/push back approval to meet its TTOT
TTOT	Target Take Off Time	The Target Take Off Time taking into account the TOBT/TSAT plus the estimated taxi-out time
TLDT	Target Landing Time	Targeted Time from the Arrival management process at the threshold, taking runway sequence and constraints into account.

Table 7: CDM Time Definitions

3.2.1.6.1 Procedures at the Arrival Airport

The preliminary arrival sequence will be established by using trajectory prediction (Ground TP) to calculate an Estimated Landing Time (ELDT).

To establish an early arrival sequence data on all relevant flights needs to be available including information on departing traffic from satellite airports. When the AMAN horizon is extended, there will be an increase in the proportion of traffic originating from airports inside the horizon. Arrival Management (AMAN) at arrival airport will receive predicted Target Take-Off Times from the satellite airports. Departures from satellite airports will in this way be included in the planned arrival sequence before getting airborne. Arrival management at the arrival airport will then calculate a new preferred Target Landing Time that satisfies arrival management requirements, as close as possible to the original. Output from this AMAN calculation, is a Time to Lose figure (TTL). This time value will be sent to the satellite airport and, when there are constraints, used to set a revised Target Take-Off Time in order to absorb delay on the ground.

For arrivals to Satellite Airports it may not be possible to make coordination arrangements in SESAR Release 1 timescales. In this case AMAN receives information from these airports but does not influence it.

If the arrival airport is very busy with perhaps very heavily flows from long distance it is considered that a place-holder may be needed in the sequence before an accurate prediction of Take-Off from satellite airports is available. For example a significant amount of long-haul traffic may arrive an hour earlier than expected (strong jet streams over the Atlantic) and saturate the inbound sequence. This is a subject for validation and will require co-ordination with Network Management functions and therefore WP7.

REQ-5.6.4-OSED-0028-0800 *- The system shall integrate received flight progress information for departures from airports inside the extended Eligibility Horizon, from* <time tbd> *before EOBT. The system shall integrate the received data into the sequence calculation.*

REQ-5.6.4-OSED-0028-0810 *- AMAN shall receive the following data for subject flight from Satellite airport within Eligibility Horizon:*

- *Call sign*
- *Departure Aerodrome*
- *Destination Aerodrome*
- *TTOT*
- *Aircraft Type*
- *Runway*
- *SID or TMA Exit point*

REQ-5.6.4-OSED-0028-0820 *- AMAN shall receive the following data update for subject flight at regional airport:*

- *Call sign*
- *Revised TTOT*
- *Runway*
- *SID or TMA Exit point*

3.2.1.6.2 Procedures at the Satellite Airport

For departures from satellite airports with CDM, early prediction of Target Take-Off Time (TTOT) will be made in line with the CDM process. In smaller satellite airports where CDM is not in place there will be coordination between Airline/Handling and ATC before the first Target Take-Off Time can be set.

This Target Take-Off Time will be used for co-ordination with Arrival Management (AMAN) at arrival airport. Output after this coordination, when there are constraints, is a Time to Lose figure.

With the aim is to absorb delay on the ground the Time to Lose figure will be used for a revision of the Target Take-Off Time.

The figure below shows the information flows involved in AMAN calculating the Time to Lose (TTL) with effect and update of the Target Take off Time (TTOT² in figure):

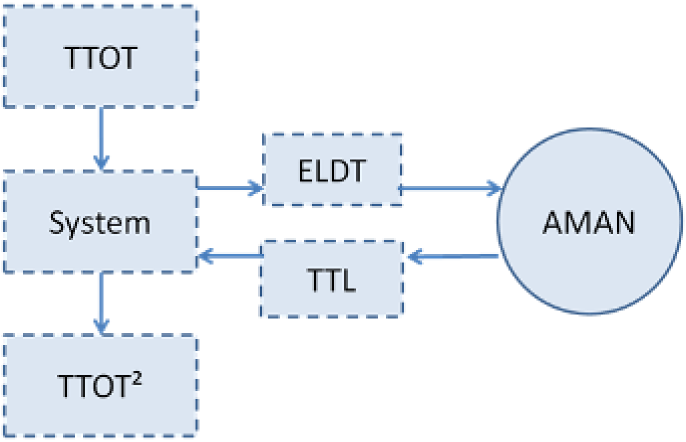


Figure 13: TTL and TTOT calculation

The Status of Satellite Airport should be determined in the course of local implementation activities, and that such airports need to be suitably equipped to support the procedure defined in the 0800 group of requirements. To be noted that there will also be cases where the estimated en-route time will be too short (flying time less than 20 minutes) to allow sequencing and special local procedures will be required to handle those flights.

Stringent TTOT adherence will be required from the airports within the Extended AMAN Horizon wishing to take advantage of the procedure. The Satellite Airport within the Extended AMAN Horizon should depart the respective flight no later than the determined TTOT. If the TTOT cannot be met, further coordination with AMAN shall take place.

The flying time from an airport can determine whether the flight will be inside the AMAN horizon or not. Only geographical defined position of a Satellite airport can have negative effect on the planning. There will normally be deviations between the predictions made by AMAN (based on the trajectory). At various times the deviations can result in the following cases:

a) A flight departing from a satellite airport is assessed as in need of on-the-ground sequencing and assigned a slot in the sequence. The corresponding TTOT is produced, resulting in delay taken on the ground. Subsequently the flight departs and due to a revision of its trajectory prediction and the following AMAN update, is reassessed as bound to miss its slot. Subsequently the flight is further delayed whilst the AMAN prepares a new slot. The revised prediction resulted in a missed landing slot and an aircraft being issued two instances of delay; one on the ground, one once airborne.

b) A flight departing from a satellite airport is assessed as not in need of on-the-ground sequencing and departs freely. Due to a revised trajectory once airborne, the flight is reassessed to be impacting into the stable sequence and receives a delay instruction while it is being sequenced in. The revised prediction resulted in an aircraft being issued an unexpected delay.

These two cases are currently seen as likely outcomes of the procedure as defined and it is proposed that this issue be investigated and validated at a future opportunity.

REQ-5.6.4-OSED-0028-0830 *- AMAN shall transmit the following data for subject flight at regional airport to the Tower EFS or the Tower Controller:*

Required

- *Identifier (e.g. ARCID, ADEP, ADES, EOBT, <EOBD>)*
  – ICAO defined
- *Call Sign*
- *TTL*

Optional

- *APTT*
- *Runway assigned to flight*
- *Sequence Number*
- *Arrival Delay (global)*
- *Delay Share assigned to recipient*
- *Time and delay at metering fix and other designated points on the trajectory*
- *Advisories (e.g. TTL/TTG, speed advisory, route advisory ...) proposed by AMAN*
- *Aircraft performance characteristics (e.g. type of aircraft, wake turbulence category, ...)*
  -- see ICAO definitions / AIRM
- *AMAN handling indicators*
- *Miles to fly to threshold*

3.2.1.7 Trajectory Prediction and Efficiency

As a basis for its sequence calculation, an AMAN calculates planned arrival times for flights (without constraints). Both the current positions of aircraft and predictions of their future trajectories are needed. Current ATSU surveillance data may be enhanced by surveillance data from a neighbouring ATSU and the ground trajectory prediction enhanced by basic Aircraft Derived Data (ADD). Outside of areas of direct surveillance the Enhanced Tactical Flow Management System (ETFMS) data from CFMU may be used. When ADS-C is available an Extended Predicted Profile (EPP) can provide an accurate trajectory calculated by the aircraft avionics. Data from airport systems, for airports within the AMAN horizon may be used for departure information on flights at airports within the AMAN horizon.

The operational needs are expressed via performance requirements on TP only (See SPR/INTEROP for TS-0305-A). Information exchanges as such are regarded as out of scope in this operational context.

Current AMAN have horizons set at around 100-120NM from the runway on the basis that this is the range at which flight data is available at the required level of integrity and where trajectory prediction of sufficient quality can be made for reliable advice to be generated. Extending the AMAN horizon puts increasing demands on trajectory prediction. Any prediction is only as good as the input data and a critical factor in trajectory prediction is accurate meteorological data. Accurate wind and temperature data is particularly important for the calculation of the descent profile. Wind information may be available directly from many aircraft[13]. This data could very well be supplied to an AMAN. If indicated airspeed (IAS) and heading information are available via Mode-S this could be compared to track and Ground Speed (GS) to accurately calculate winds.

---

[13] KLM and Boeing have initiated a project to downlink winds at various levels on the descent for the benefit of subsequent arrivals.

At the Eligibility Horizon the data should be of sufficient quality for a reasonable prediction to be made of the aircraft's unconstrained arrival time at the Metering Point. However at this stage the calculated sequence may still be relatively inaccurate and advisories issued at this stage will probably be more indicative of potential delay or trends, rather than being highly accurate advisories to be followed. The AMAN predictions and advisories at or after the Active Advisory Horizon should be more usable for stable sequence determination and/or action. Prediction may be ground based, calculated either by the trajectory predictor in the host system FDPS or by a specific TP serving the AMAN. When available an airborne prediction provided by the aircraft avionics will provide the most accurate estimates. Ideally a single prediction based on the best available data, be it airborne or ground based should be used by arrival management tools.

Solid and high quality of trajectory performance, particularly for flights from the Satellite airports, is the cornerstone of the procedure.

Therefore many initiatives using various technologies (Mode-S, ADS-C etc.) may enhance predictions. It is most important that all the available meteorological data is consolidated for the benefit of everyone – this is a SESAR wide issue beyond the remit of P5.6.4. If the goal of Step 1 is accurate Time Based Operations (TBO) then accurate estimates are essential. Without accurate wind information estimates will not be accurate.

Accurate forecasting of wind is also critical for predicting the runway direction. This is again especially important when the AMAN horizon is extended as the sequence for a particular runway will start to be established much earlier than today. Until time-based separation on final approach is introduced the wind may also change the runway landing rate.

Current AMAN tools monitor the evolution of the traffic situation and make adjustments in the event that aircraft do not proceed as predicted. This capability can be further developed but with an extended AMAN horizon it is likely that it will be more difficult to recover from the result of poor predictions than it is today.

3.2.1.7.1 Feasible Alternative Trajectories

In addition to knowing the natural arrival order and accurate expected undisturbed trajectories, AMAN should have information on what variation of trajectories is feasible.

When the AMAN landing sequence differs from the natural order, for example for reasons of optimising the wake vortex spacing, overtaking may be required. This may be 'virtual' – for example an aircraft from the East slows down while an aircraft from the West speeds up – or it may be 'real' – an aircraft from the East overtakes one which was ahead of it. Overtakes may be performed at a late stage of approach – for example, the first aircraft stays on a Point Merge Sequencing Leg, while one behind it is turned first towards Final Approach - or at an early stage, by assigning small differences in speeds which is clearly the most efficient option.

Ideally the AMAN will take account of "what is possible" in deriving its sequence. The main options, which may be combined, are:

- The AMAN has simple rules that can be applied in various circumstances (i.e. Max TTG +120secs over 200NM)
- If ADS-C is used it will be possible to obtain ETA Min/Max by downlink
- The AMAN has rules about the amount of delay absorption which is possible in different regions of airspace – particularly where the airspace is managed by an adjacent ATSU

The AMAN tool should also have an efficient "what-if" functionality for controllers to use (in particular the SEQ_MAN). It will be necessary to "trial" options before implementing them. These may be complex such as evaluating alternative runway strategies (such as "what impact will opening up a closed runway have on the sequence?") or more simple possibilities such as moving an individual aircraft backwards or forwards in the sequence.

***REQ-5.6.4-OSED-0028-0450** - The Sequence Manager should be able to propose and to assess the effects of proposed sequence changes using AMAN, without disrupting the sequences in effect.*

***REQ-5.6.4-OSED-0028-0590 -** The Arrival Management system shall be capable of reflecting ATC strategies in the sequence build i.e. when planning times (at RWY and metering points).*

Actual strategies will be subject to local implementation choices and constraints.

Possible strategies could include for instance:

(a) Overtake Principle - avoiding aircraft overtakes on the same inbound route (En-route and TMA airspace)

(b) Turboprop aircraft speed principles – jets normally overtake turboprops in En Route Airspace but they have similar speeds in the TMA

3.2.1.7.2 Trajectory Efficiency

An important objective of arrival management within SESAR is to improve the efficiency of trajectories. The ideal methods of achieving this is by absorbing delay on the ground or in the en-route phase rather than in the destination TMA.

An important aspect of extended arrival management is the degree of emphasis that should be placed on efficiency. This will be determined by the Arrival Management Strategy discussed in section 3.2.1.4.

In extended arrival management operations speed change will be the most likely method to absorb delay. An early descent from a very high cruising altitude where speed flexibility is limited may facilitate greater speed reduction whilst still at relatively efficient altitude. Path stretching at high altitude may also be feasible dependent on the airspace configuration. Figure 14 below shows the typical speed envelope for an A321.

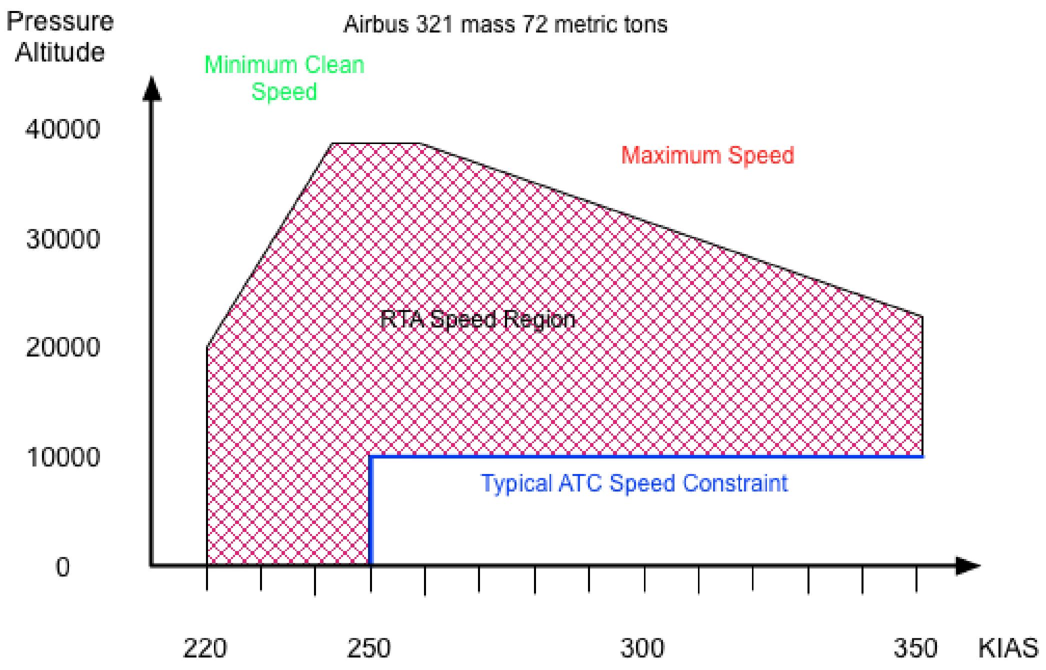


Figure 14: Typical Speed Envelope Airbus A321

Another important aspect is providing flight crew of early information when a constraint such as a CTA is to be applied. When calculating the subsequent trajectory the positioning of Top of Descent (TOD) is important and the optimum TOD will be different for every flight. The position of the TOD can be included in subsequent EPP messages and the controller made aware. It is important for efficiency that the flight crew have predictability of the trajectory to be flown; ATC should do everything possible to respect the calculated TOD and leave the subsequent descent profile undisturbed as any change in the trajectory during descent will be sub-optimal for the Airspace User.

Validation results indicate that several standard routes, with different lengths, may prove useful for the controller to allocate to flights in accordance with the adjustment in time needed between the AAH and the MP. This option may be suitable if there is sufficient airspace to accommodate a range of routes. In the event of a CTA being applied it is important that any necessary routing decisions are taken before the flight crew is requested to respect a CTA so that the lateral flight path remains predictable.

3.2.1.8 Calculation and Implementation of AMAN Advice

The AMAN sequence is converted into AMAN advice when required. The sequence is implemented by controllers who have the option to adhere to the AMAN sequence time by personally acting on AMAN advisories such as TTL/TTG, by approving and executing advisories for speed coming from tools like SARA (see section 3.2.1.9.2), or to delegate responsibility for adherence to a CTA to flight crew. Validation results achieved[14] indicate that when the AMAN horizon is extended and controllers are unaware of the full arrival management “picture”, they are recommended to accept AMAN advice and not make their own judgements. En-route sectors should endeavour to manage traffic destined for an adjacent ATSU in line with bi-lateral agreements that will cover arrival management issues.

3.2.1.8.1 Translating the AMAN Sequence into Advisories

The runway sequence is calculated as a planned time at the runway threshold for each aircraft. The AMAN may also convert this planned time into advice to the actor who will achieve the sequence. The AMAN planned times may be calculated to assure a slight over-demand, in order to “maintain pressure on the runway” and avoid the risk of losing runway throughput.

The AMAN planned time can be converted into:

- A target time at a specified fix
- Speed advisories
- Time to Lose (TTL) or a Time to Gain (TTG)

In addition, sequence information may be very useful to upstream sectors to enable controllers to be clearly aware of the required sequence. Route advisories where path stretching/shortening is feasible may also be theoretically provided however this option is not expected to be a feature of SESAR Step 1.

3.2.1.8.2 Delegation of Responsibility to Respect a CTA to Flight Crew

Extending the AMAN horizon may also increase opportunities for flight crew to more actively participate in queue management through the CTA technique in which AMAN generates a time constraint on the appropriate Metering Point (MP) or (IMP) and responsibility for achieving this time is delegated to the flight crew by the issuing of a Controlled Time of Arrival (CTA) instruction.

REQ-5.6.4-OSED-0028-0600 *- Where the I4D/CTA is expected to be used, the horizons extension shall provide sufficient look-ahead time to encompass the I4D/CTA concept*

AMAN will allocate a target time designed to achieve the required sequence at the Metering Point. AMAN performance in this respect will be enhanced if it is aware of the earliest and latest ETA (ETA Min/Max) at the Metering Point that the aircraft is capable of achieving by speed management alone – this information is considered desirable but not essential and will assist in assuring air-ground trajectory synchronisation at the MP.

The target time is provided to the flight crew as a Controlled Time of Arrival (CTA) at the MP. It is ground/ground transmitted to the controller currently responsible for the flight (for this OLDI is an option, although more advanced techniques and technology, such as Flight Object data shared via GND/GND IOP are envisaged) who then communicates it to the flight crew by R/T or CPDLC. It is then the flight crew’s responsibility to respect the CTA. When available, the FMS RTA function will normally be used depending on the precision with which the CTA needs to be achieved. The Airbus developed “Enhanced RTA” functionality 'guarantees' that if the CTA is located within the reliable ETA Min/Max window when it is set, the aircraft will arrive at the position, with a time accuracy of +/- 10 seconds, 95% of the time. It will remain a controller decision whether to issue a CTA to capable aircraft or not.

---

[14] P05.06.04 D23 Release 1 Validation Report Stream C (internal 6) – RTS conducted by NORACON

It should be noted that while improved quality of the time keeping accuracy enabled by an increasing rate of airborne time adherence (CTA/RTA) can have an overall positive effect, the increased stability introduced by, and experienced by, locked flights could also have a detrimental effect on those flights not locked in the sequence.

In the event that the AMAN target time is outside of the current ETA Min/Max window, additional measures may be used to enable the required delay to be efficiently absorbed or the controller can opt to implement normal delay management measures such TTL/TTG. At high altitude aircraft have a limited flight envelope, and in order to increase their ability to absorb delay via RTA functionality, aircraft will sometimes need to descend. Even when the aircraft leaves its most efficient altitude, this will generally still produce a more efficient trajectory overall than continuing at its planned level and then orbiting in the TMA.

Providing the flight crew with a CTA aligns with the overall SESAR philosophy that maintains that the airspace user should be allowed to calculate the way in which an aircraft can best respect an ATC constraint (in this case a time constraint over a metering point) and controllers then authorise the flight crew to execute the resulting trajectory and intervene only in the event of a predicted loss of separation. Controllers need to retain full situational awareness and should therefore be made aware of the CTA status (in progress, implemented, rejected, cancelled, etc.)

REQ-5.6.4-OSED-0028-0710 *- The system shall be updated with the CTA status (in progress, implemented, rejected, cancelled, etc.)*

The use of a CTA is an option available to controllers. They may wish to override it at any time for any number of reasons likeways for operational reasons (e.g. severe weather) a flight crew may ask ATC to cancel their CTA. Therefore, in the event of CTA-cancel, a corresponding TTL/TTG should always be available for this eventuality. This, itself, will have implications for the AMAN and dynamic sequence management.

REQ-5.6.4-OSED-0028-0730 *- The arrival management system should enable switching to/from TTL to CTA and back again.*

As explained in section 0, CTA have the effect of effectively freezing that individual aircraft's time over the MP (although CTA may always be updated). This may have the effect that a CTA-capable aircraft moves backwards or forwards in the sequence as time passes and the AMAN continues to update planned times for other aircraft. CTA-capable aircraft therefore benefit from potential predictability and efficiency gains but this may be accompanied with a potential loss in flexibility.

REQ-5.6.4-OSED-0028-0670 *- A CTA attributed to a flight shall be considered locked by the AMAN*

Future concepts are likely to require a relatively uniform speed management from before the MP until the runway. Therefore the downstream path and control logic needs to be taken into account rather than putting the highest priority on achieving a CTA at the MP. A transition needs to be included in the CTA calculation considering the delta in speed at the MP which, with the aid of a tailwind approaching the CTA point may be significant. The issue of speed management at or in the vicinity of the MP may be solved by including a required speed in the CTA instruction such as "Be at ABC at ww.xx.yy, with speed zzz" which is currently under discussion internationally.

Delegation of speed management to the flight crew should result in a reduction in controller task load; however this may be offset by a loss of control strategy flexibility and unknown behaviour along the trajectory. P5.6.4 is not expected to study every aspect of CTA/RTA operations which are the specific focus of P5.6.1.

3.2.1.8.3 Controllers Retain Full Responsibility

Internally, an AMAN generally develops a sequence in terms of time. It may convert this into speed advice or time-to-lose/time-to-gain advice which controllers are asked to implement. The advantage of this option is that controllers hold a more complete picture, and they can maintain separation and resolve potential conflicts while taking AMAN advisories into account. With an extended AMAN horizon complex communications may be required to provide advisories to the correct controllers with additional controller display features needed. Additional controllers will become involved in the process for whom arrival management may bring additional workload. This needs to be addressed in validation exercises and suitable mitigation put in place.

REQ-5.6.4-OSED-0028-0690 *- Relevant executive controllers need:*
a) the ability to see all AMAN target times and sequences including but not limited to:

1. *Sequence number*
2. *TTL/G in resolution down to minutes and seconds*
3. *Underlying TTL/G (only concerning i4D targets in this experiment):*
   - i) *Original value before it was set to zero as a result of the controller assigning a proposed CTA*
   - ii) *Residual actual value remaining at any given point in time.*

b) to know whether the targets have been accepted as feasible.
(General situation awareness – available if required.)

c) Distance to go for individual flights where available

A complicating factor with extending the range of AMAN is that some of the sectors within the new “AMAN horizon” may be within a different FIR and may be controlled by a different ANSP. At the working level, procedures and AMAN data displays will need to be agreed; at the organisational level new agreements on responsibilities will be needed. It may be that implementing AMAN advisories increases complexity to such an extent that a sector needs to be kept open for a longer period, thereby increasing costs for the neighbouring ANSP while delivering benefit to the ANSP operating the AMAN. All these aspects should be addressed in bi-lateral and multi-lateral agreements.

When controllers have responsibility, a delay apportionment for individual controllers may be employed to reflect the different delay absorption capabilities across sectors. In this case the AMAN could assign different targets to each controller. A Reference Point (RP) may be established to facilitate the calculation of the appropriate advice (see Figure 15 below). For example, a RP may be established at the TMA boundary with regard to which the TTL/TTG for en-route and E-TMA controllers may be calculated. An appropriate RP is likely to be particularly important when the trajectory passes through different FIRs, when an agreement about the proportion of delay to be absorbed in each location may be needed. AMAN will be able to take account of the sector configuration - whether they are split or band boxed - but it will not be able to apportion delay in a dynamic manner which would require sophisticated analysis of traffic complexity.

REQ-5.6.4-OSED-0028-0610 *- In the case when metering with CTA and metering with TTL/TTG are using different metering points, the AMAN shall extrapolate the required time over Metering Point (for CTA) and express it as a TTL/TTG relative to the appropriate Reference Point, in an appropriate form, taking into account specific spacing requirements and ATC strategies.*

REQ-5.6.4-OSED-0028-0700 - *If a Reference Point is implemented and an aircraft is flying towards a Metering Point on a trajectory bypassing the defined Reference Point (for instance as a result of a direct to instruction), the AMAN shall determine the "abeam" point to the flight planned RP on a curve equidistant to the Metering Point, and express all RP pertinent information to that equidistant point.*

AMAN provides system support to controllers but it is essential that the required degree of manual sequence adjustment is available to controllers to cope with changing scenarios and traffic fluctuations.

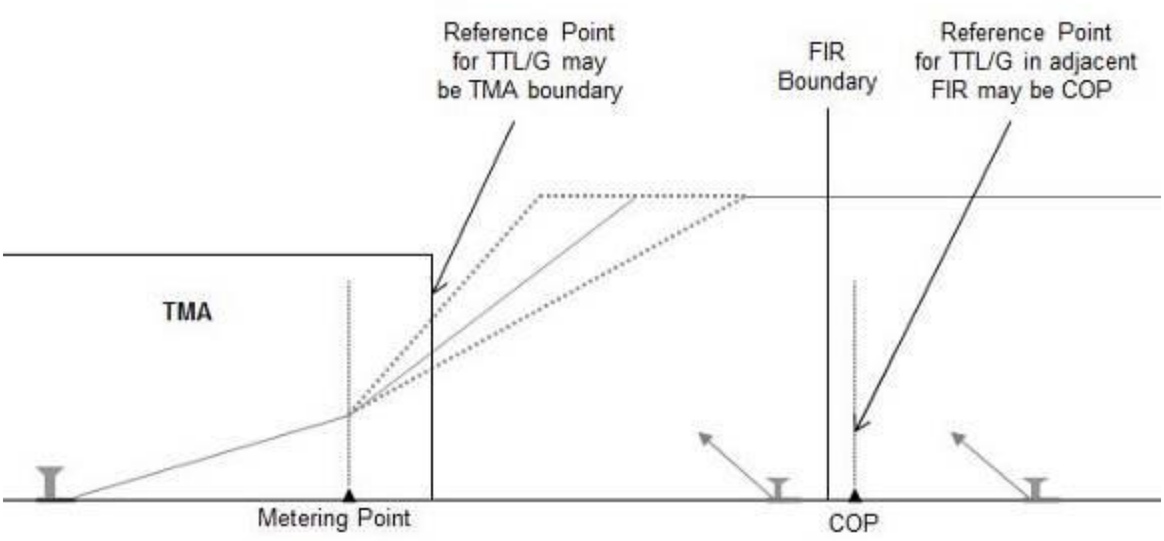


Figure 15: Reference Points for TTL/G

3.2.1.8.4 Non-compliance with Advisories

When an AMAN advisory cannot be respected, there is a risk that the overall sequence may be disrupted and it may mean there is little or no value for other aircraft to continue to follow their advisories. AMAN normally monitors surveillance data, and predicts whether its planned sequence will be delivered and therefore compensates when it detects non-compliance by revising advisories.

If a specific contract has been established for an agreed CTA at the MP the AMAN system needs to be informed. The AMAN will assume that the CTA will be respected unless informed otherwise. Therefore in the event that it is known that a CTA will not be respected the AMAN must be informed as well as the current sector controllers and the SEQ_MAN. The aircraft immediately reverts to being controlled conventionally and the controller should be provided with suitable advice (TTL/TTG etc.).

During long range operations described in 3.2.1.5.2 non-compliance with target times will not be monitored but will just result in a poorer traffic presentation at the AAH.

When the AMAN horizon is extended, the advisories will be implemented over a long distance and therefore the monitoring function becomes more challenging. Advisories may be passed to adjacent ANSP using OLDI which does not have a capability to send a message of non-compliance.

3.2.1.9 Co-ordination, System Support and HMI

Today there is a human AMAN controller (Sequence Manager) who is able to modify the sequence at any time. This role is expected to continue in SESAR but increase in scope and complexity (this role is fully described in 4.2.1.1). The Sequence Manager (SEQ_MAN) role in SESAR will be a controller who has received specific training and who is supported by an AMAN tool. The SEQ_MAN retains full control over the entire arrival management operation and is able to manually intervene as required to resolve any issues that may arise in the sequence building operation. The SEQ_MAN also requires access to co-ordination means as described below.

3.2.1.9.1 Co-ordination

The AMAN advisories which allow the landing sequence to be achieved must be conveyed to the actor who will implement them. AMAN advice may be in the form of target times (TTA, CTA), TTL/G, speed or sequence order information. Under certain circumstances a co-ordination dialogue may be required. Some of the concerned controllers may be in different FIRs and working for different ANSPs than the one in which the airport and its associated AMAN is located.

Currently some AMAN information can be passed to neighbouring ANSPs using the OLDI interface protocol; it defines messages which can be passed between Flight Data Processing systems and includes the AMA message for AMAN information.

In a SWIM environment communication is facilitated by advanced information exchanges as an option. In case of upstream ground communication the AMAN information service has been defined and would be available.

REQ-5.6.4-OSED-0028-0550 *- Appropriate two-way ground-ground coordination of information is needed over the extended Arrival Management area.*

In a non-SWIM environment the information and concerned actors affected by dialogues are as follows:

Co-ordination Dialogues					
Type	Arrival Management Specific Content	Sender	Receiver	Means	Response
Ground-ground coordination of AMAN advisory with adjacent ATSU	May contain: - Metering Fix and Time over Metering Fix; - Total TTL or TTG - Time at COP; - Assigned speed; - Route	System[15]	Adjacent ATSU	OLDI AMA	None
Ground-ground coordination of AMAN advisory with adjacent ATSU+1	May contain: - Metering Fix and Time over Metering Fix; - Total TTL or TTG - Time at COP; - Assigned speed; - Route	System[16]	Adjacent ATSU+1	OLDI AMA	None
Ground-ground co-ordination of CTA with the current controller	CTA Associated Metering Point	System[17]	Current Controller	OLDI AMA	Accept/Reject
Ground-air coordination of CTA	CTA Associated metering Point	Current controller	Aircraft	CPDLC (or R/T)	Wilco/Unable/Stand by
Ground-air co-ordination of advisory target time in long range operations	Target Time Associated Metering Point	System[18] (via AOC systems)	Aircraft	Voice	None
Ground-ground co-ordination of all	May contain: - TTL/TTG	System	All concerned	OLDI AMA	None

---

[15] May require operator validation prior to transmission
[16] May require operator validation prior to transmission
[17] May require operator validation prior to transmission
[18] May require operator validation prior to transmission

AMAN advisories with the all concerned controllers in current ATSU	- Assigned Speed - Sequence numbers - ??		controllers in current ATSU		
Non-compliance with CTA[19]	RTA Missed	Aircraft	System	ADS_C	None
EPP		Aircraft	System	ADS_C	None
ELDT	ELDT	Satellite Airport	System	EFS	None
AMAN Advisory (TTL)	TTL	System	Satellite Airport	EFS	None

Table 8: Information exchanges and actors

On-line Data Interchange (OLDI) has several limitations, one of which is that time is currently expressed in whole minute instead of seconds[20]. A workaround could be that any CTA transferred by OLDI in whole minutes is then updated to a more precise time on first contact with destination ATSU. The “COP” that may be defined in the OLDI AMA message could be the IMP in long range AMAN operations and would be the Reference Point for delay sharing strategies.

CTA instructions may be communicated to aircraft by voice or CPDLC. The AMAN needs to know precisely where the aircraft is located, and then to communicate in ground-ground dialogue with the sector which is currently responsible for the aircraft. There are specific message formats to convey CTA information defined by EUROCAE Working Group 78 and they will be supported in the prototypes for SJU Step 1 validations (project 9.1 for airborne and most likely also 10.7.1 for ground based equipment). However, they are not covered by the existing mandate and the number of equipped aircraft is not clear.

In a SWIM environment Information Elements and Information Exchange Requirements have been defined technology independent (See 6.9 and B.1.6).

Aircraft Communications Addressing and Reporting System (ACARS) is a datalink system which is principally used for communication between flight crew and their company operations departments. It is also used in Oceanic Air Traffic Control. This has advantages over CPDLC in that more aircraft will be ACARS-capable than CPDLC-capable in the immediate future, and this means of communication need not involve the responsible controller, or indeed the responsible ANSP. It also has disadvantages in that each aircraft must subscribe to a specific server to receive messages from any source, although the vast majority of ACARS-equipped aircraft log on to their company service. The sender of a message has no knowledge of whether it was received. Whether ACARS (as a temporary solution) is an acceptable communication means for arrival management data is an open validation issue.

3.2.1.9.2 System Support

Speed and Route Advisories (SARA):

As the goal of the AMAN with extended planning horizon is to deliver aircraft with greater accuracy to the TMA in accordance with the planning, the controller, involved in the arrival management process should be provided with information that the aircraft are arriving in accordance with their planning. This information can be provided simply by means of a delta-time between expected time over the fix

---

[19] A CPDLC message will be sent to the ground system with this information when detected by the aircraft system. This should be followed by a pilot judgment and an R/T message from the pilot to current ATCO.

[20] A significant SESAR-wide limitation for Step 1 unless addressed.

versus planned time over the fix. The SARA (Speed And Route Advisor) tool under development for Schiphol airport provides additional information to the controller. A speed advice (in combination with a proposed alternative route when necessary) which will bring the aircraft within a certain window (e.g. 30 seconds) of the planned time over the fix.

SARA will assist the controller in delivering flights at the IAF more accurately. In the current ATM system and with the current working methods a margin of ± 2 minutes is tolerated in delivering inbound Schiphol traffic at the IAF. The future ATM system requires a delivery accuracy of less than 30 seconds from the EAT at the IAF for 99% of inbound traffic.

The output of SARA, a speed and/or a route for a particular flight, must be conveyed to the controller responsible for the flight (and whose duty it is to issue instructions and clearances to flight crews).

Controller Support: Controllers, and in particular en-route controllers, will require controller support tools to enable the controller to assign appropriate speeds if required to do so. Such tools would have to be provided for all European sectors within the horizon of the concerned AMAN. Such tools should produce harmonious calculations to ensure that aircraft are not given conflicting speed changes as they transit from airspace supported by one set of tools to another. This option should aim to mitigate any increased controller task load per flight.

Sequence Manager Support: Important tool for the Sequence Manager is a “Probe Tool” so that the SEQ_MAN can “try something without changing data on sectors”.

General Statement: (considered applicable to Long Range Arrival Management) The AMAN shall be capable of generating and outputting information based on a view of forthcoming demand. This demand view is based on the most accurate information available about the specific flights that comprise this demand. This information may include some of the following: CTA, predicted delay, delay to be absorbed etc. This area will need to be developed. It should not constrain the solution to only being messages to pass to adjacent sectors or, ANSPs requiring controllers to take action to implement a delay absorption/sequencing plan. It should explicitly include the option of sending such information to aircraft via an appropriate mechanism such as datalink. Further discussions will be required to determine the trigger and frequency with which this information is generated and updated. – NATS propose to use a time horizon, but other organisations might want a different trigger.

3.2.1.9.3 Human Machine Interface (HMI)

The options available for the display of AMAN Advice to controllers are:

- Using a dedicated AMAN display
- Via the radar display,
- Via an electronic strip interface.

3.2.1.9.3.1 HMI Required for En-route/Approach Controller Situational Awareness

P5.6.4 “Stream E” addressed the use of Aircraft Derived Data (ADD) in extended arrival management and concluded that following operational requirements should be established:

REQ-5.6.4-OSED-0028-1200 - *To enhance his or her situational awareness, the controller should have instantaneous access to the following information:*

- Vertical rate in better quality than radar readout
- Magnetic Heading
- Indicated airspeed or Mach number as applicable.

REQ-5.6.4-OSED-0028-1210 *- To enhance his or her situational awareness, the controller should have instantaneous access to accurate and reliable information about current wind conditions at the location of an aircraft.*

REQ-5.6.4-OSED-0028-1220 *- To enhance his or her situational awareness, the controller should have instantaneous access to accurate and reliable information about the future intent of aircraft within his or her area of interest.*

REQ-5.6.4-OSED-0028-1230 *- If the EPP updated F-leg is used to convey long term intent information, the controller should have the possibility to simultaneously display F-legs to at least two targets. In such a case, the F-legs shall be distinct and differentiable, e.g. by colour.*

REQ-5.6.4-OSED-0028-1240 *- In situations when the AMAN proposed sequence involves an overtake of aircraft ahead it may be highlighted to the controller when locally specified conditions are satisfied*

3.2.1.9.3.2 HMI Required in the Tower of Satellite Airports

The followed requirements for the Electronic Flight-strip System (EFS) of satellite airports have been defined to enable the required dialogues described in 3.2.1.6.

REQ-5.6.4-OSED-0028-0720 - *The system shall reflect the CTA status in the HMI through clear and consistent information and symbols in different systems/places.*

REQ-5.6.4-OSED-0028-0840 *- The TWR System shall take into account the following static data for each flight:*

- *Call sign*
- *Departure Aerodrome*
- *Destination Aerodrome*
- *EOBT*
- *CFMU Regulations*
- *Aircraft Type*
- *Flight plan*
- *Runway*
- *SID and/or TMA Exit point*

REQ-5.6.4-OSED-0028-0850 *- The TWR System shall be able to insert, display and update the TOBT*

REQ-5.6.4-OSED-0028-0860 *- The TWR System shall be able to insert, display and update the TTOT*

REQ-5.6.4-OSED-0028-0870 *- The TWR System shall be able to send message to AMAN system including;*

- *Call sign*
- *Departure Aerodrome*
- *Destination Aerodrome*
- *TTOT*
- *Aircraft Type*
- *Runway*
- *SID or TMA Exit point*

REQ-5.6.4-OSED-0028-0880 *- The TWR System shall be able to receive TTL advisory from AMAN system*

REQ-5.6.4-OSED-0028-0890 *- The TWR System shall be able to propose a revised TTOT taking into account the received TTL advisory from AMAN system*

REQ-5.6.4-OSED-0028-0900 *- The TWR System shall be able to send update of TTOT to Arrival Management system.*

3.3 Differences Between New and Previous Operating Methods

This OSED has set out several options for the extension of the AMAN horizon, in view of the different requirements and characteristics of airports and TMAs throughout Europe. One key aspect is the new option available to controllers who may instruct aircraft to self-manage their longitudinal trajectory to achieve a known ground constraint (CTA).

4 Detailed Operational Environment

4.1 Operational Characteristics

The foreseen operational environment is as described in Chapter 3 of both the P4.2 and P5.2 Step 1 DODs.[14][14]

The “framework” for Extended AMAN Horizon operations described in chapter 3.2.1.1 is compatible with the Step 1 airspace and route structure environment.

The new point described in the Long Range AMAN Operations section 3.2.1.5.2 known as the Initial Metering Point may be in Free Route airspace and therefore may also be defined as a horizon measured in distance.

4.2 Roles and Responsibilities

This section is built on the basis of the B4.2 Roles and Responsibilities document [11].

Note: In the meantime Conops for Step 1 [24] is the latest reference.

4.2.1 New Roles

4.2.1.1 The Sequence Manager (SEQ_MAN) [21]

The Sequence Manager (SEQ_MAN) is part of the sector team responsible for providing approach control at a designated airport or for a cluster of designated airports within a specific TMA. S/he will participate in the setting of the Arrival Management Strategy and will be responsible for its execution and adaptation to evolving events. The role of the Sequence Manager is to increase the arrival flow stability by managing (planning) the arrival sequence. The Sequence Manager has the responsibility to put in place the coordination required to implement the sequence with the relevant En-Route and TMA planning controllers. The goal should be to provide the highest quality of service and most efficient flight profile to inbound traffic.

The SEQ_MAN shall be provided with an AMAN tool which will provide sequences for the runways of the designated airports and generate advisories for controllers.

The SEQ_MAN shall be provided with automated system support with which to conduct electronic co-ordination. Manual co-ordination is not considered an option with an enlarged AMAN horizon.

Sequence Manager Responsibilities:

1.	Responsible for the overall arrival sequence and for planning the sequences of traffic approaching the designated airports
2.	Participation in the setting of the Arrival Management Strategy for the runways of the designated airports
3.	Responsible for the execution the arrival management strategy and its adaptation to evolving events
4.	Responsible for the executive control of the AMAN tool as described in the relevant detail operating procedures and may override the AMAN sequence as s/he thinks fit
5.	May be responsible for requesting EPP and ETA min/max from i4D capable aircraft
6.	Shall be responsible for electronically co-ordinating AMAN Advisories with en-route sectors

---

[21] Note that Sequence Manager is not a new role, what is new is his "significant change" in geographical range.

7.	May be responsible for electronically co-ordinating CTA with en-route sectors
8.	May be responsible for electronically co-ordinating AMAN Advisories with adjacent ANSP
9.	May be responsible for electronically co-ordinating CTA with adjacent ANSP
10.	May be expected to adjust sequence rearrangements as required due to departing traffic

The following requirements are related to the Sequence Manager role:

REQ-5.6.4-OSED-0028-0090 *- The system shall have a designated 'role' for human Sequence Management.*

REQ-5.6.4-OSED-0028-0100 *- The Sequence Management 'role' shall be configurable. In locations it may be applied to a stand-alone Sequence Manager position or it may be applied to a designated combined* Sequence Manager */ATCO working position.*

REQ-5.6.4-OSED-0028-0110 *– The system shall accept manual configuration in the Sequence Management role to set constraints/conditions (exact scope to be defined locally).*

REQ-5.6.4-OSED-0028-0120 *- The system shall provide appropriate support to the Sequence Management role to enable a coherent view of the planned sequence, and to enable changes to be made manually to it.*

REQ-5.6.4-OSED-0028-0180 *- The Sequence manager may be able to manually adjust the Stable Sequence Horizon.*

REQ-5.6.4-OSED-0028-0190 *- The Sequence Manager may be able to freeze the order of a group of aircraft in the sequence (before the Stable Sequence Horizon).*

4.2.2 Modification to existing B4.2 Roles and Responsibilities:

In modelling the SEQ_MAN role it has been identified that changes to existing roles (EXC, PLN, TWR roles etc.) will need to be agreed with B4.2 in relation to:

- Arrival management responsibilities of APP and TWR supervisors;
- New tasks in relation to setting and managing the Arrival Management Strategy.

4.3 Constraints

This OSED describes a system for Step 1 within the constraints of the environment outlined by P4.2 and P5.2 in their Step 1 DODs.[14] [15]

5 Use Cases

This section provides a set of scenarios and use cases, based on the P05.02 DOD and the operational scenarios used for Validation Exercises by 05.06.04.

An operational scenario is considered to be described through a combination of solutions (techniques, tools) through flight/control phases (En Route, TMA), in a given environment (traffic presentation, route structure driving density/complexity). Such a combination may consist of successive use of solutions for all aircraft across flight phases, or parallel use of solutions for different aircraft (local traffic situation, equipage).

5.1 Operational Scenario 1 (Medium Complexity/Medium Density - Rome)

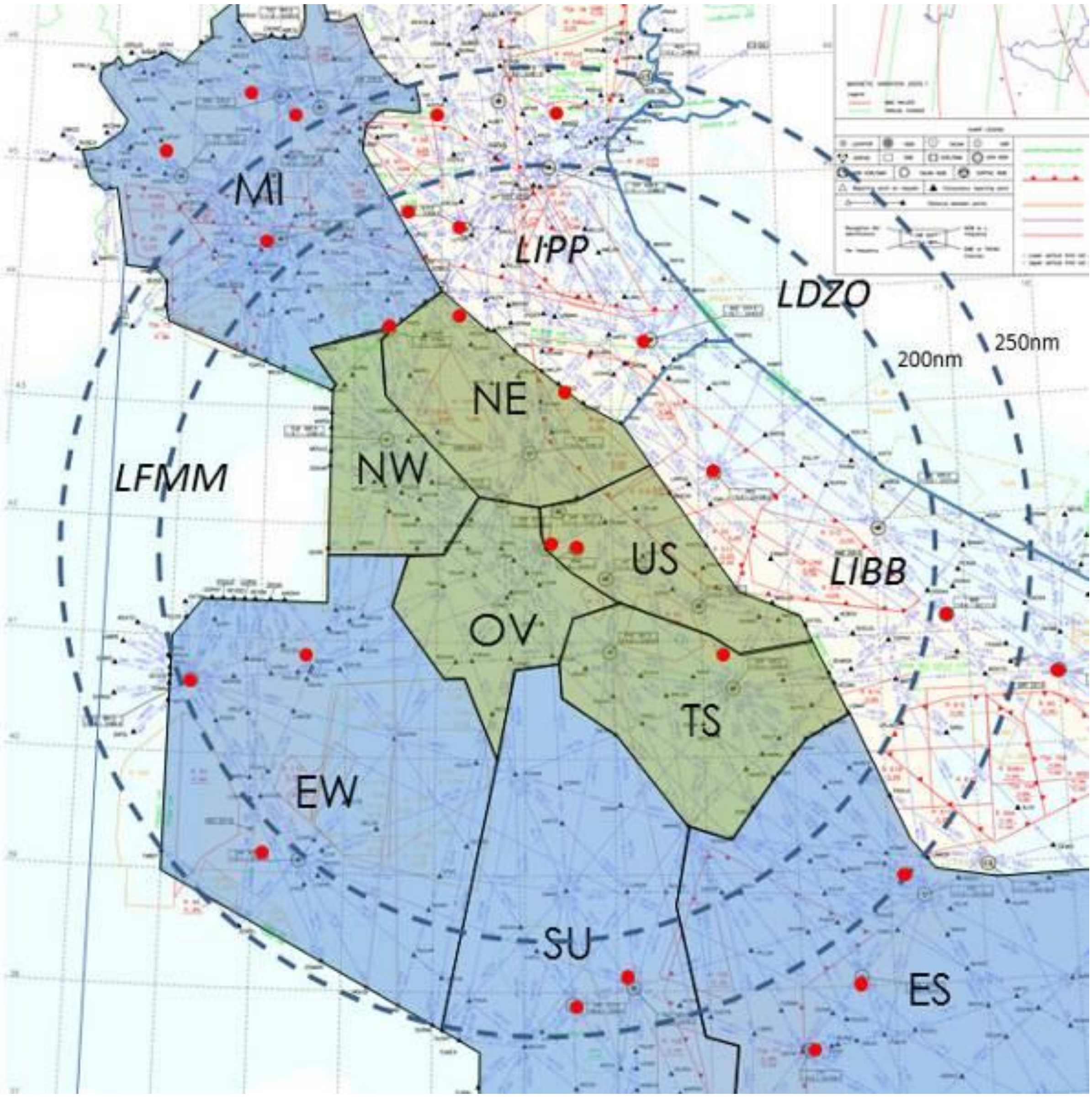


Figure 16: Airspace with 250NM of Rome

The airspace surrounding Rome is shown in Figure 16 above. Range rings are included at 250Nm and 200NM. These are candidate ranges for the Eligibility and Active Advisory Horizons which results in the airspace of adjacent ANSP being included. Within Italian airspace the Brindisi (LIBB) and Padua (LIPP) are included whilst outside Italian airspace the Marseilles (LFMM) and Zagreb (LDZO) are included. The general en-route sector clusters of the Rome ACC are shown in blue and the E-TMA sectors responsible for the descent portion of flight towards Rome are shown in green. Satellite airports are indicated by red dots.

Rome itself is served by two major airports:

- Fiumicino (LIRF) which has 3 runways – 16R/34L, 16L/34R and 25/07 which is normally used only for departures. Traffic is distributed between the landing runways (16R/34L, 16L/34R) depending on departures (25/07 conflicts with 16R/34L) and stand allocation (to minimise taxiing time).
- Ciampino (LIRA) has a single runway 33/15

Rome does not currently employ an AMAN tool and therefore the sequences for the Rome airports are largely created within the Rome TMA although some ad-hoc co-ordination is made with en-route sectors when it is considered that early speed reduction would reduce congestion in the TMA.

The intention is to deploy an AMAN tool and to further extend early intervention and new arrival management procedures in which the sequences for the Rome airports will be largely created prior to entry into the Rome TMA which occurs at around FL120-150.

It is anticipated that a Point Merge System (PMS) of RNAV arrival routes have been deployed at LIRF during 2012[22]. The result is expected to be improved efficiency and predictability of arrival trajectories resulting in reduced track mileage within the TMA and the potential for a Continuous Descent Approach (CDA). Therefore the expectation is that there will be an overall decrease in fuel consumption and gaseous emissions with the implementation of the AMAN Extended Horizon in Italian airspace. There is also expected to be a reduction in TMA controller workload.

So far two distinct modes of operation have been foreseen:

- “Conventional” extended AMAN operations with an AAH of 200NM
- “Initial 4D” operations with a CTA being calculated at a range of 250NM and issued to inbound aircraft no later than 200NM.

The conventional mode of operation (including Padua but not Brindisi) was evaluated in VP-187 and the Initial 4D mode of operation was evaluated in the VP-212 exercise conducted by P5.5.1.

5.1.1 Conventional Extended AMAN Operations

This type of operation was the basis for the VP-198 validation exercise[23].

The AMAN is configured to build sequences for the LIRF and LIRA runways based on throughput and runway availability parameters. The AMAN calculates the sequence for the runway threshold based on standard arrival routes via the TMA entry points. De-confliction at the TMA entry point is not considered. Sequence building takes place in at least two sequential sectors including one E-TMA sector. Sectors are provided with AMAN advice in the form of Time to Lose/Time to Gain (TTL/TTG) information. This can therefore be achieved within Italian sectors but with an “asymmetric” extended AMAN horizon of 150NM to the east and 130NM to the west. The optimum situation is to have a symmetrical AMAN horizon so that all aircraft from all directions are included in the AMAN calculations.

The closest sector is responsible for finalising the sequence and is therefore provided with the full AMAN List as well as Time to Lose/Time to Gain. The more distant sectors are located within the Rome FIR or within an adjacent FIR (Padua or Brindisi) depending on the scenario under evaluation. The AMAN information provided to the controllers in the Padua or Brindisi sectors is limited to that which can be transferred using the OLDI protocols; specifically, the AMA message. This means that the Padua or Brindisi sector have no overall visibility of the sequence being built by AMAN but are

---

[22] In 2015, there is no implementation or synthesis concerning PMS RNAV in LIRF at the moment.

[23] In this exercise the AMAN was used for the building of the sequence.

simply asked to implement Time-To-Lose/Time-To-Gain advice made available in the radar track label.

To achieve a symmetrical AMAN horizon, AMAN advice will need to be transmitted to the adjacent ATSU of Marseilles and Zagreb. This could be achieved by OLDI protocol. Draft procedures have not yet been developed.

Departures from within the 200NM range ring are treated as pop-up traffic and managed accordingly by the AMAN tool.

5.1.2 Initial 4D Operations

Sequence building is achieved by the allocation of a Controlled Time of Arrival (CTA) to suitably equipped Rome traffic. The CTA is calculated on the basis of the optimum sequence on the runway threshold and translated into a CTA on the appropriate “gate”. Non-equipped traffic and departures from airports within 250NM are managed as described in 5.1.1 above.

The figure below depicts the three gates considered for CTA calculation:

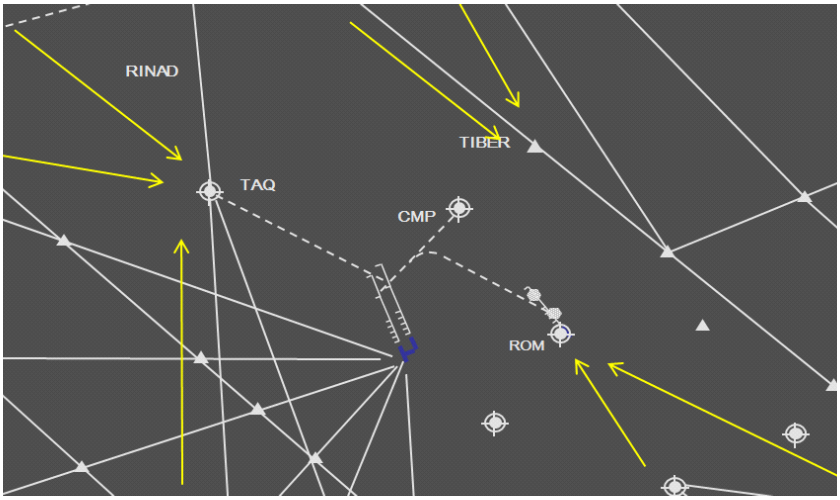


Figure 17: Rome TMA CTA Gates and Relevant Flows

The gates are positioned at around 35nm from touchdown which has been found to be optimal through validation. For LIRF this means TAQ (for traffic from the west), TIBER (for traffic from the north) and ROM (for traffic from the south).

An initial sequence is built using flight plan information and available surveillance data (full surveillance coverage of 250NM to be confirmed). It is assumed that an ADS Contract exists with all landing aircraft independent of the direction they are coming from and of the ATSU which is currently responsible.

As aircraft cross the 250NM range ring an aircraft trajectory prediction is requested by the system using ADS-C and is received from the aircraft in the form of an Extended Predicted Profile (EPP). This includes in particular an accurate ETA for the sequencing fix. The sequence is then revised on the basis of the precise estimate included in the aircraft trajectory prediction.

A CTA may be issued in line with the received ETA or an “ETA min/max” window is requested by ADS-C to the aircraft by the Sequence Manager (SEQ_MAN) and a reply is received from the aircraft. The SEQ_MAN then selects the optimum CTA for arrival sequence building at the appropriate gate from within the ETA min/max window.

Each CTA has then to be co-ordinated and finally delivered upstream, to the sector which is currently responsible for the relevant aircraft. The co-ordination path might differ depending on the aircraft location and cross-FIR boundary coordination could be required. The communication mechanisms and its constraints may differ depending on where the recipient ENR_EXE is physically located.

5.1.3 Use Cases

Two cases are considered:

Case A. The ENR_EXE is within the ACC where the APP_SEQ is located. In this case the co-ordination can rely upon the communication capabilities of one single FDP instance;

Case B. The ENR_EXE is in another ACC. In this case the communication will rely (for Step 1) on OLDI capabilities. The exchange has to be dealt at ACC level, i.e. using 'Metering Fix and Time over Metering Fix' and 'Total Time to Lose or Gain' from downstream ACC to the upstream ACC. The way the coordination is conducted might then change on the basis of the existing LoAs between the two ACCs. Clearly, response time might change on the basis of the interoperability level between ACCs and LoA in place between ROME FIR (TMA sector) and the foreign UIRs.

A problem is that OLDI AMA message cannot be rejected. Therefore in the event that the controller cannot accept the proposed “time over metering fix” does it mean a telephone call and a manual cancellation of the CTA in the Rome ACC system?

The aim is to upload the CTA to the aircraft before it crosses the 200NM range ring. From Figure 16 it can be seen that the Rome SEQ_MAN will have to coordinate/dispatch the CTAs with several other ACCs.

The system shall be capable of managing the following non-nominal events:

- The case when an ENR_EXE rejects the task to upload the CTA (i.e. because of workload or tactical traffic management constraints);
- The case when the CTA ground-ground coordination process is broken by the receiving of a new EPP or any relevant trajectory update, i.e. because the aircraft received an open loop constraint since the first download of EPP or estimate calculation at AMAN freeze horizon and ETA min/max;
- The case when the ground-ground coordination takes longer than the window of applicability of the ETAmin/max:
    - Because the ETAmin/max has an expiring time beyond which a new one has to be requested;
    - Because the aircraft crossed the 200NM range ring before the CTA was received onboard;
    - The case when ground-ground coordination cannot take place;
    - Because OLDI is not available;

Details of the applicable procedures and validation results can be found in P5.5.1 D06 [8]

5.2 Operational Scenario 2 (Medium Complexity/Medium Density - Stockholm)

The ENR and TMA environment is characterised as a Medium complexity and Medium density environment. The most dominant constraints are:

- Environment
- Airspace
- Traffic variation

Environmental constraints restrict the use of runways and are a limiting factor to efficiency. Traffic volumes and time direct the management of available resources. The airspace is constrained by a neighbouring city airport, making SIDs and STARs conflict at several crossings. Although traffic volume is medium, the peaks are close to high, which is requiring ATC to adapt and respond to the variations in demand.

In Table 9 below the relationship of the Operational Scenario described herein to the WP5.2 DOD scenarios is explained. The Operational Scenario builds upon DOD Scenario 1a applied for planning and optimization of AMAN, sub-scenario 1b in the ENR region and sub-scenario 1c in the TMA/APP region.

Scenario	Environment characteristics (Complexity/Density)		Arrivals processes		
	ENR/E-TMA	TMA/APP	Plan/optimise AMAN	Implement ENR/E-TMA	Implement TMA/APP
1	Med/Med	Med/Med	**Sub scenario 1a** Horizon: Extended Advisories: CTA (TMA entry point) Departure sequencing (***OFA4.1.2***)	**Sub scenario 1b** 2D: route allocation 3D: CDO and CCO with vertical restrictions (***OFA2.1.1***) 4D: i4D/CTA (***OFA4.1.2***) Transversal: Separation Management (***OFA3.3.2***)	**Sub scenario 1c** 2D: route allocation 3D: CDO and CCO with vertical restrictions (***OFA2.1.1***) 4D: speed control (ATC or ASAS) (***OFA3.2.1***) Transversal: Separation Management (***OFA3.3.2***)

Table 9: Identification of the Operational Scenario in the WP5.2 DOD Scenario Concept Elements

Description of Scenario

This scenario is applicable in medium complexity/density ENR and TMA airspace. Traffic volumes are characterised by levels that allow for an organisation of sequences where metering is possible to achieve and aircraft remain on planned 2D route.

Figure 18 below show the airspace within 200-250NM of Stockholm Arlanda which includes parts of Norwegian and Finnish airspace as well as parts of the Tallinn, Riga and Vilnius FIRs.

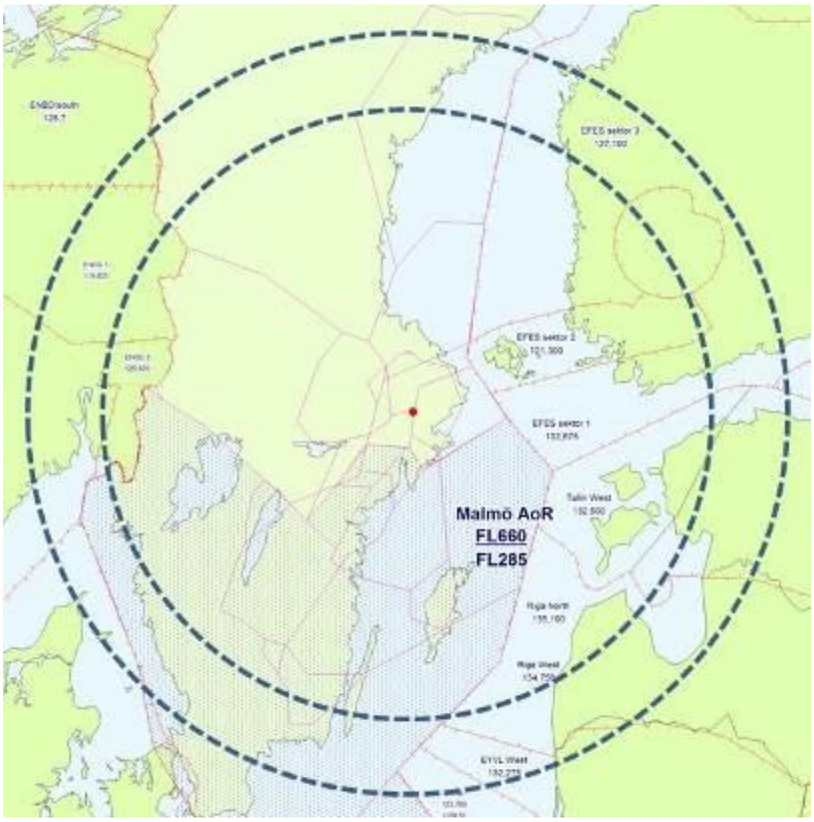


Figure 18: Scandinavian Airspace with 200NM and 250NM range rings centred on ESSA

The AMAN active advisory horizon is around 35-40 minutes (approximately 180NM) and is including TOD with margin. For validity of sequence the satellite aerodromes situated within the active advisory horizon are linked to the arrival management process through a TTOT dialogue. The early sequence built up by the AMAN tool and the sequence manager is normally maintained all the way to the runway. If situations require the sequence is updated, by this approach the aircraft sequence number is always valid.

Figure 19 below shows the satellite airports in the vicinity of Arlanda.

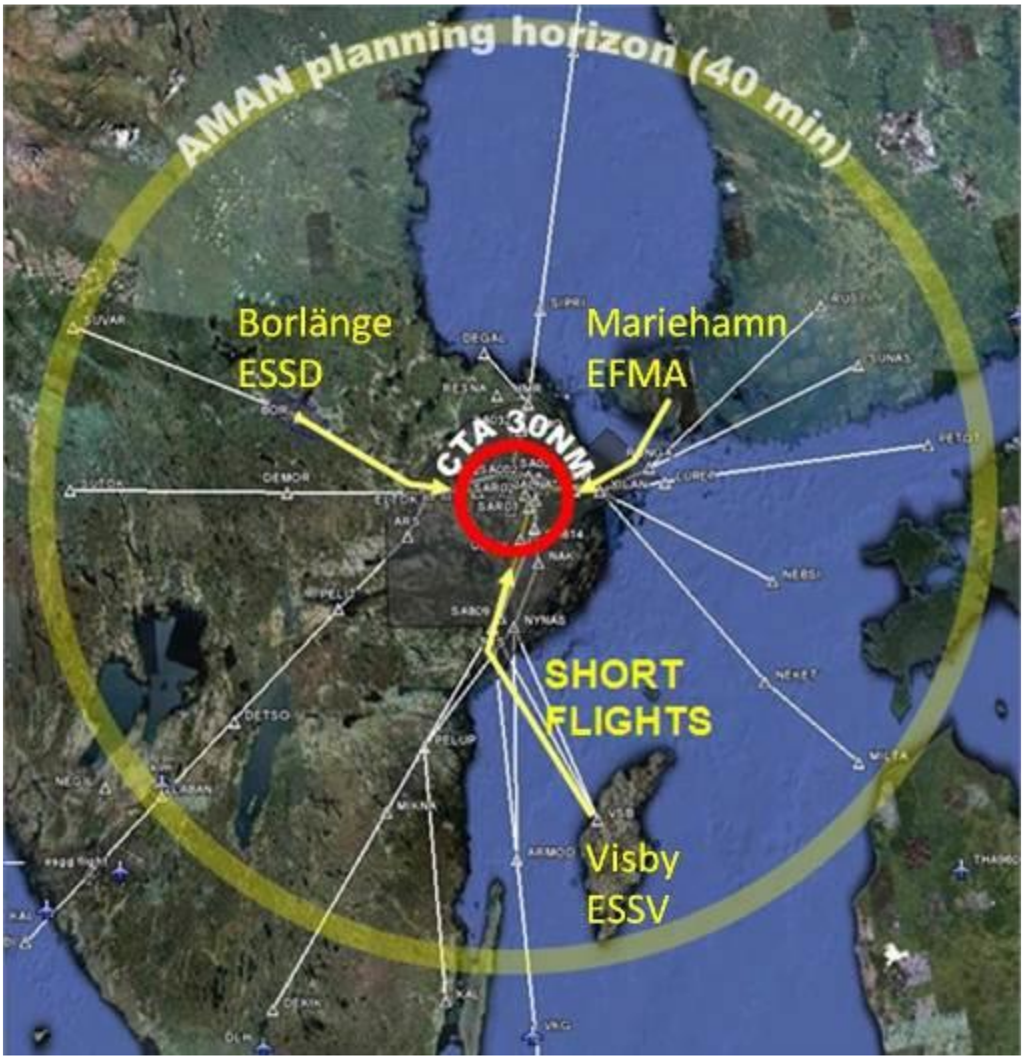


Figure 19: Satellite Airports of ESSA

The scenario is relying on a PBN route structure, including RWY and STAR being communicated well before TOD. If ATC requires metering for the sequencing and separation tasks the AMAN is producing CTA for equipped aircraft and also TTL/TTG for controller reference and fall-back purpose. The CTA point is situated 30 NM from touch-down, to allow for some flexibility in the final sequencing task. The AMAN planning of the sequence will contain some margin above the separation minima in order to create a more stable sequence allowing for differences in aircraft trajectory to achieve the CTA window. This margin is reasonable in traffic volumes around 30 acft/h, and will allow aircraft to optimise the descend phase.

The CTA and TTL/TTG needs to be communicated to the eventual upstream ATSU. CTA point and reference for TTL/TTG may not be the same. It is a preferred solution to have the TTL/TTG reference to be easy to identify and not varying with runway in use. TTL/TTG could be the TMA entry point. All controllers will have feedback on the effects of implementing the metering. If aircraft are given speed restrictions, the TTL figure will decrease.

After the CTA point ATC are likely to use speed control for the final merging of traffic and for maintaining safe distances between arriving traffic. If situations require, ATC will use vectoring for the tactical queue management task.

The task of monitoring is more dominant for controllers both in ENR and TMA airspace. Controlling shifts from active tactical actions to monitoring trajectory development after CTA allocation. To support ATC in this demanding task Aircraft Derived Data is used in several ways. The controller HMI will contain items like IAS and magnetic heading, to improve situation awareness and reduce the threshold to tactical intervention.

As a further means to improve situation awareness and support in sequencing and conflict management a down-linked 4D trajectory will improve the accuracy of ground system flight leg presentations.

Summary

Plan/optimise and Implement in ENR/TMA in M/M environment, ground	
Features	**Summary**
Expected benefits	• ENR Controller • (-) New task of implementing metering • (-) Monitoring of CTA trajectory development • TMA controller • (+) Better sequenced traffic, less instructions. Standardisation of operations (including use of constraints such as speed or vertical restrictions) • (-) Monitoring of trajectory development • (+) Predictability • Flight crew • (+) Predictability/Situation Awareness • (+) Use of vertical guidance information (potential for VNAV) • Airspace/route structure: Depends on type of PBN solution • Operating method: Depends on type of PBN solution • Ground system • (+) Predictability, TP accuracy • Air system • (+) Predictability, if closed loop: maintaining FMS calculations (laterally and possibly vertically) • ATM /KPA • (+) Predictability (closed loop, standardisation) • (+) Cost effectiveness (standardisation, training) • (+) Flight efficiency, environmental impact
Constraints	• Controller • (–) Less flexibility in working method/practices • (–)More and demanding monitoring • (–) Increased risks of loss of vigilance, vectoring deskilling, less job satisfaction • Flight crew • (–) Published routes = potential for long routes (subjective impact) • Airspace/route structure: Depends on type of PBN solution • Operating method: Depends on type of PBN solution • ATM • (–) Flexibility / published routes = long routes

5.2.1 Use Case: Departures from Satellite airports

This section describes the case where a nearby regional airport contributes traffic to the AMAN with estimated en-route times too short to allow for arrival coordination as described in the concept. In such a case the AMAN has no prior knowledge of the departing flight beyond the filed-EOBT based, CFMU governed CTOT time. The CTOT time in turn carries a -5/+10 min margin which is seen as impractical from the standpoint of a concept that requires ETA accuracy in the order of tens of seconds. In the absence of a reliable yet sufficiently narrow arrival time window, the AMAN would integrate the departing flight by appending it to the end of the sequence, which in turn would require the departing flight to spend additional time airborne, the longer the nearer[24] the departure airport lies to the arrival airport.

The use case described herein removes this excessive segment of flight by allowing the departure aircraft to absorb the required time delay on the ground. This yields benefits in the efficiency/environment KPA with further possible benefit in predictability.

Airport CDM may or may not be present in the information flow management; whichever the case, CDM acronyms are used liberally in this section. The definitions were included earlier in section 3.2.1.6.

General conditions:

- GC1 – One major airport with an integrated AMAN operating on an extended horizon as per concept description (‘Arrival airport’).
- GC2 – One or more lesser[25] airports nearby to the Arrival airport, within its AMAN’s horizon26 (‘Satellite airport’).’
- GC3 – A Letter of agreement is in place between Satellite airport and Arrival airport governing the operational and technical details of flight delivery and responsibilities for exact steps.
- GC4 – Departure procedures at the Satellite airport are published detailing any specific requirements imposed on flights departing to the Arrival airport.

Pre-conditions:

- PreC1 – An arrival flow to Arrival airport managed by the airport’s AMAN.
- PreC2 – The AMAN establishes and maintains a preliminary landing sequence by means of Estimated Landing Times (ELDT).
- PreC3 – A flight ready for departure at the Satellite airport, inbound to Arrival airport. A flight plan has been filed containing EOBT and EET and the crew/ground handling are in position to give an early estimate of when the aircraft will be able to leave the parking/docking area (TOBT).

Post-conditions:

- PostC1 - Upon its timely departure, the flight is seamlessly integrated into the existing arrival sequence at a reserved slot instead of at the end of the sequence, thus taking minimum to none delay while en-route.

Operating method:

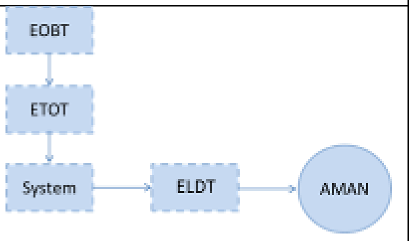
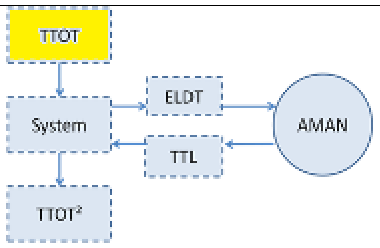
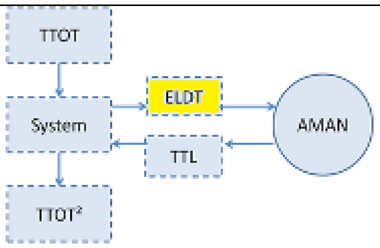
---

[24] Nearer in terms of network distances expressed in time units rather than geographically.

[25] Lesser airport in this context denotes an airport with traffic departing to the Arrival airport. A typical candidate would be a regional or small international airport with sufficiently streamlined operation so that the variation in time from AOBT to ATOT does not normally exceed 2 to 3 minutes.

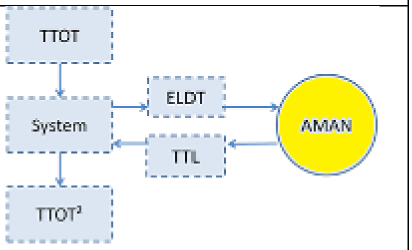
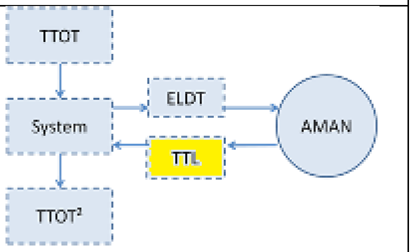
[26] Within the AMAN horizon denotes a situation where the planned Estimated En-route Time is less or equal to the span of the Eligibility horizon of the Arrival airport’s AMAN. Coordination with airports outside the AMAN’s Eligibility Horizon (as per this definition) is achieved through demand-capacity balancing.

The operating method is described in the workflow schedule below:

	Activity at Satellite airport	**Activity at flight data processing**	**Activity at Arrival airport**	**Process stage**
1	PreC3	The flight data processing system using the EOBT/Flight Plan time to extract ETOT (EOBT + taxi-out time) converts the ETOT into an ELDT, which is supplied to AMAN.	AMAN receives the ELDT from FDP and display the flight in HMI to be used by Sequence Manager for enhanced situational awareness. Sequence is not affected.	
2	The tower controller acting through CDM or in coordination with flight crew/handling/other elements produces a TTOT taking into account an updated TOBT as reported by flight crew in due time beforehand[27], customized start-up, pushback, taxi, deice and other constants dependent on the actual set of variable elements. The TTOT is communicated to the flight data processing system.		AMAN continuously builds and maintains sequence based on estimated landing times (ELDT).	
3		The flight data processing system receives the TTOT and using up to date information on routing, current airspace constraints,		

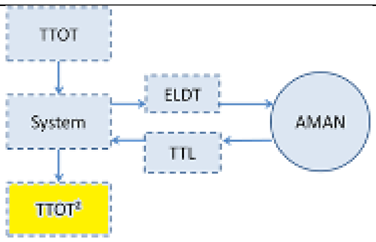
---

[27] The required look-ahead time as well as accuracy and reliability of the reported updated EOBT are the responsibility of the crew in accordance with published airport procedures, unless the local implementation requires otherwise.

		weather and other operational elements, converts the TTOT into an ELDT, which is supplied to AMAN.		
4			AMAN receives the ELDT from FDP and integrates the flight in the sequence, taking into account ATC strategies specific for this particular scenario. Namely, the flight must be integrated in such a manner that the resulting AMAN advisory is not a negative value (i.e. conductive to a TTG).	
5		The flight data processing system receives the AMAN TTL advisory and carries out a reverse calculation to obtain a revised TTOT[28] figure, which is then communicated to the Satellite airport tower. Alternatively, TTL may be forwarded to the tower with no intermediate steps.		

---

[28] A new acronym may be required to denote this item of information and distinguish it from the original TTOT. In the rightmost column, the revised TTOT is styled at TTOT^{2}.

6	The Satellite airport tower receives from FDP either the revised TTOT or TTL (in which case the controller converts the TTL to revised TTOT, with or without the participation of the crew as per local procedures). Crew, controller and other actors coordinate to achieve the revised TTOT within the required tolerance, as prescribed by the LoA and local procedures. Revised TTOT may be again forwarded back to AMAN for confirmation.			

Issues identified to be considered prior to implemenation:

- Operators may be reluctant to buy in owing to the negative perception of delay and its origin arising in the eyes of the passengers.
- Exact terms and definitions of the Letter of agreement/Service level agreement between the Satellite airport and Arrival airport, clearly detailing limits of responsibility on each party.
- Similarly, the extent and form of associated procedures at the Satellite airport, detailing various responsibilities as well as mitigation means for all failure modes, demonstrating themselves as unexpected delays whether in the planning or execution phase of the proposed use case.
- Precision, accuracy, reliability and integrity of all input information needs to be studied and determined. This in particular applies to the quality of trajectory prediction and the resulting time estimates.
- The impact of segregated trajectory predictions across the element chain should be studied (i.e. a situation where AMAN and FDP use each a dedicated TP function; the different performance requirements and working methods acting as input into one another.
- Effect of exceptional weather phenomena (strong winds aloft or weather severely limiting the capacity at the arrival airport and saturating the inbound flow to a point where no useful TTL advisory can be given) may present a limit on operational usefulness of the use case.
- Clarification of the BEBS principle in the use case.

5.3 Operational Scenario 3 (High Complexity/High Density - Amsterdam)

5.3.1 Amsterdam Scenario (VP-187bis)

The scenario consists of nominal traffic, regulated with sufficient control on the flow of arrival traffic to perform arrival sequencing and metering without being forced to perform holdings. Holding manoeuvring is performed only, if in spite of an acceptable regulated inbound flow, it turns out to be not possible to perform the planned flight-efficient operations.

A nominal scenario is simulated, feeding Amsterdam Schiphol with regulated and balanced traffic. Pre-departure and in-flight DCB will ensure sufficient regulations to cope with inbound traffic flows by an extended process of arrival management, operating within existing airspace constraints.

The future requirement to improve operations in TMA lower airspace is to accomplish accurate sequencing with ±30 s. maximum uncertainty at the TMA entry-point, transferring control to TMA. This is expected to be sufficient to reduce sequencing and merging problems. This requirement on the operation puts requirements on AMAN tools for the ATM system. These AMAN tools will be stepwise introduced.

The early AMAN tooling per July 2012 was consisted of

- The existing inbound planning system, enabling ATCOs to achieve an EAT adherence with a margin of 2 minutes
- TP feedback loop, feeding the TP with groundspeed for updates,
- Delta T being the difference of ETO-stack-EAT,
- AMA message to coordinate speeds to the adjacent En-route sector

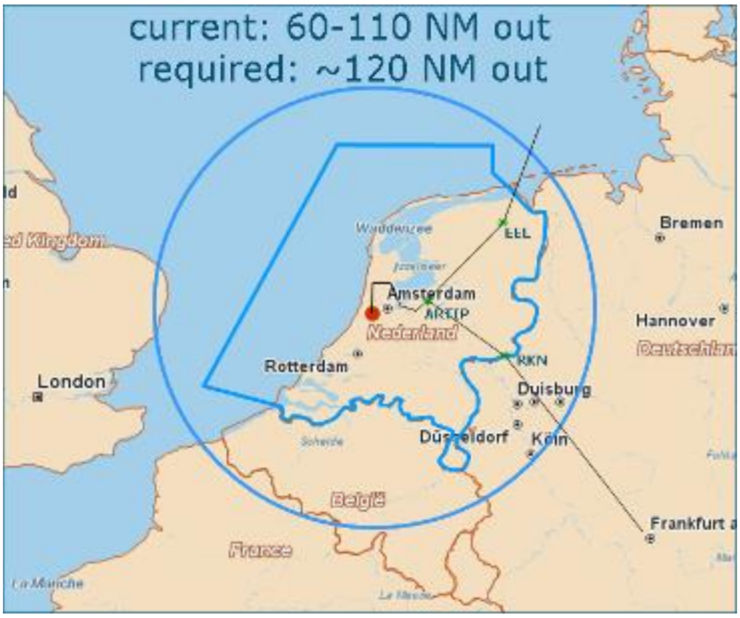


Figure 20: En-route and ACC airspace servicing Schiphol arrivals

Arrival management with extended horizon operates in an airspace extending into UK's, Belgian and German airspace, and in this exercise, EXE-VP-187Bis, coordination with MUAC controlled airspace is assumed to be sufficient to sequence East-bound arrival flows, planned to land at Rwy 18C (See Figure 20).

Arrival traffic will use existing routing for inbound traffic entering the Dutch FIR over Norku (from the East) and over Eelde (from the North), to merge over ARTIP.

The APP Planner (APLN) organises the sequence for landing by planning the Expected Approach time (EAT). In the current operation, the inbound planning plans the EAT of flights 14 minutes before ETOstack. To increase the planning horizon the APLN could manually plan flights as early as 22 minutes before ETOstack. Once the EAT has been determined, delta T will be calculated. Based on delta T the ACC planner could estimate speeds and coordinate these with MUAC through an AMA message.

Flight operations in En-route and ACC airspace are simulated to accomplish sequencing at TMA entry-point, and flights are planned for merging at IAF. Early and accurate sequencing in ACC airspace will allow flight-efficient procedures in lower airspace to validate beneficial use of accurate sequencing results on dense arrival flows in upper airspace. The RTS exercise simulates arrival traffic from the East, assuming arrival traffic from the West to land independently on the parallel Rwy 18R. Departures are assumed to depart efficiently and in compliance with standard departure procedures from a third runway that respects noise environmental constraints.

A traffic sample was used which is based on a training sample. The traffic sample started with an outbound peak from 13.30 to 14.15. In this window of 45 minutes 9 arrivals to NORKU and 5 to EELDE were scheduled. The following 35 minutes an inbound peak was simulated with 15 NORKU and 14 EELDE inbounds. Traffic to and from other sectors was scripted. The ACC controllers also dealt with outbound traffic.

	Outbounds EHAM	Inbounds EHAM	Inbounds sector 1 (EELDE)	Inbounds sector 2 (NORKU)
Outbound peak 13.30-14.15	72flights	38 flights	5 flights	9 flights

Inbound peak 14.15-14.50	19 flights	57 flights	14 flights	15 flights

Participants

The following participants took part in the simulation:

- Four ACC controllers were invited for each day
- On each day two approach controllers participated to fulfil the role of approach planner.
- Three pseudo-pilots
- One subject matter expert from MUAC supported a pseudo-pilot position, to respond to coordination calls and AMA messages and to evaluate these instructions.
- Scientific team representing procedures, systems, operations, performance, and human factors
- Project leader and experiment leader

Experimental design

Three different scenarios were run in the following sequence.

RUN 1: Current day operations delivering flights at IAF with an accuracy of 2 minutes, Delta T is presented in the stacklist. Different from current day operations is that delta T is calculated and updated on the basis of speed inputs. This run is sometimes referred to as the baseline.

RUN 2: Delta T is presented in the label at the position where normally EAT is shown. Delta T is also presented in the stack list. Delta T is calculated and updated on the basis of speed inputs. The operational goal is to adhere to the EAT plus or minus 120 seconds.

RUN 3: Delta T is presented in label (instead of EAT) and stacklist and calculated and updated on the basis of speed inputs. The operational goal is to adhere to the EAT as good as practically possible, using an early freeze of the planning and consequent speed requests to MUAC for early flow optimisation.

AMA was available in all three runs.

5.3.2 Amsterdam scenario (VP-183)

The EXE-183 scenario is to a large extent similar to that used for EXE-187bis. For EXE-183 however, all scenarios are based on actual recorded scenarios for Amsterdam FIR sectors 1 and 2. The upstream sectors are all handled by MUAC who will actively participate in the exercise. As Schiphol radar range is not enough to cover the extended planning horizon, traffic was “pushed back” such that traffic pops up early enough for extended horizon planning. This had to be done manually to ensure that a realistic traffic scenario was created in which aircraft can be treated and transferred by MUAC as usual.

Two main types of scenario can be distinguished: high density and inbound peak traffic. The high density traffic represents an average daily operation for Schiphol. The inbound peak scenarios represent an inbound peak that occurs every day at specific times. This inbound peak has been selected from recorded traffic

The baseline scenarios will be handled using current-day-practise. These include techniques such as vectoring (for path stretching or shortening), speed control and level-offs. If necessary aircraft can be requested to hold

The advanced scenarios will be handled using the same techniques but the controller is assisted by the Speed and Route advisory tool. Usual tactical techniques may still be applied if the controller decides this is necessary.

The above scenario categories result in the following matrix that describes the main features of each of the scenarios:

	Baseline	**Advanced Techniques**
High density	Controller - feels in control - is able to use some of its time for time based delivery to the next sector Flight crew - fair amount of clearances Ground system - plans traffic as usual	Controller - is requested to use time based operations - is assisted by speed advisory tool Flight crew - is expected to get less clearances Ground system - has larger planning horizon - exchanges data with upstream ATSU - generates speed advices
Inbound peak	Controller - has high workload - uses all available techniques to safely control traffic - has little/no time to use for time based operations Flight crew - high amount of clearances (e.g. level-offs) Ground system - plans traffic as usual	Controller - has high workload - is requested to use time based operations - is assisted by speed advisory tool Flight crew - is expected to get less clearances Ground system - has larger planning horizon - exchanges data with upstream ATSU - generates speed advices - will be challenged because of capacity

Time-based operations are in a basic form already part of the day-to-day work of the Amsterdam controllers. This is expressed by the agreement that aircraft must be delivered into the TMA with a margin not larger than 2 minutes. No tools are available for the controllers to support them in this task.

Introducing tools that support the controller in applying the time-based operations gives the opportunity to increase the requirements. The expected benefits of the shift towards time-based operation are better delivery into the TMA. TMA controllers will therefore be part of the simulation.

5.4 Operational Scenario 4 (High Complexity/High Density – London)

5.4.1 Concept Summary

Aircraft flying into Heathrow is likely to experience delay which is currently taken in the holding stack. These aircraft may save fuel and reduce their environmental impact by absorbing some of this delay in the en route and descent phase of flight. This will also reduce the amount of stack holding at Heathrow, producing a safety and workload benefit for the TMA. The greater the distance that aircraft can begin slowing down to absorb delay, the smaller the disturbance to their en route trajectory. Similarly, if a flight crew knows what delay an aircraft is required to absorb in the descent phase before descent has begun, the flight crew is better able to manage the aircraft and optimize its descent.

These factors have driven the concept in the direction outlined below. The following description is depicted in Figure 21 below. In broad terms, the concept envisages a planned level of delay in the hold to act as a ‘buffer’ and ensure that the runway is not starved of aircraft. Aircraft would partially absorb an element of any extra delay in the en route phase, and then a further portion of delay in the descent phase once a more stable sequence has been generated. Any remaining delay is taken in the hold.

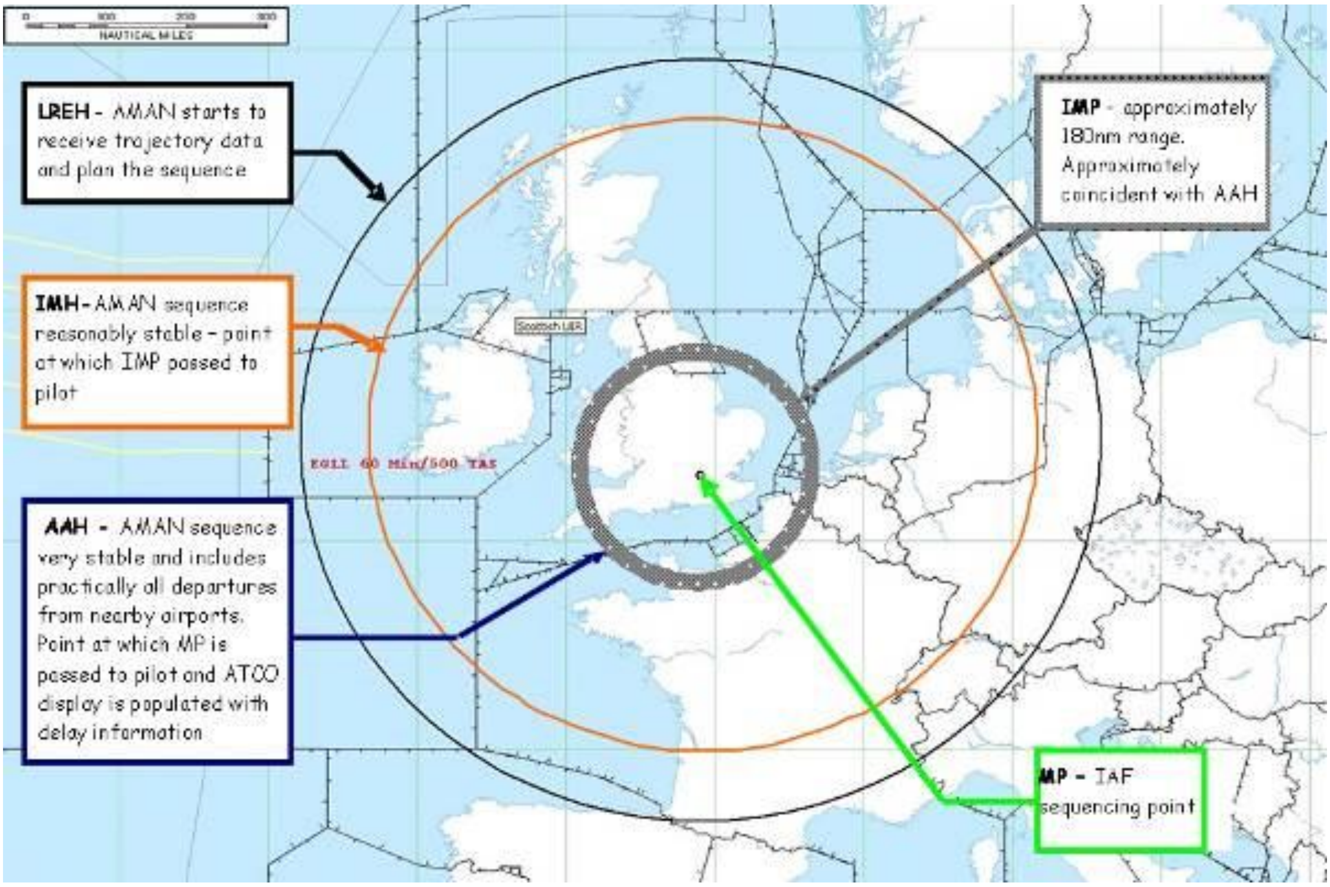


Figure 21: London Scenario Concept Parameters

As the current NATS AMAN horizon is limited by NATS radar coverage and by NATS’ capacity to correlate SSR returns with aircraft at the edge of radar coverage, an additional source of data must be found to extend the AMAN horizon to a range where aircraft can adjust their trajectory to achieve a meaningful amount of delay absorption. European Flight Data from the Central Flow Management Unit (CFMU) will be used to extend the AMAN horizon to 75 minutes, which equates to approximately 550NM, and is referred to as the Long Range Eligibility Horizon. This value has been selected to ensure that aircraft are outside oceanic airspace and therefore have an opportunity to adjust their speed.

The Barco AMAN is fed by aircraft ETAs from CFMU and derive an initial sequence between the LREH and the Initial Metering Horizon These values are currently envisaged as 75 minutes and 70 minutes respectively before the aircraft is expected to arrive at Heathrow. At the IMH (70 minutes before predicted arrival, which equates to approximately 500NM), AMAN will generate a Target Time Over (TTO) constraint at the Initial Metering Point A TTO is advisory information passed to the flight crew of aircraft. The TTO is not a clearance; pilots are expected to determine whether their aircraft trajectory is likely to change in order to comply with their TTO; where altitude adjustment or significant speed change is required, flight crew are expected to request this from the controlling authority handling their flight. This is equivalent to current procedures where an aircraft operator may request by datalink that an aircraft delay its arrival at an airport for stand availability reasons, for example.

The IMP is currently envisaged as the nearest waypoint on an aircraft's route to 180NM from touchdown. A message will be passed by via datalink to the aircraft and will request the aircraft to absorb a feasible amount of en route delay by slowing down. It is currently anticipated that aircraft will not be asked to absorb more than 3-5 minutes delay between the IMH and the IMP (approximately 500NM to 180NM). Studies have shown that most aircraft types can absorb 3-5 minutes over this duration by speed change alone, although some aircraft may have to descend one or two flight levels.

The IMP is 30 minutes from the stack, which equates to approximately 180NM, and is also approximately 10 minutes before top of descent. Thirty minutes is also significant in that this is the approximate flying time from Paris, Brussels and Amsterdam, and is therefore the point at which the AMAN-generated landing sequence, fed by CFMU data including Airport CDM and departure messages from nearby airports, would be expected to be stable. AMAN would therefore be expected to be able to generate accurate delay predictions. The SESAR 5.6.4 validation looked at two Methods of Operations, which are detailed in the next section. These MOps envisage in the nearer term controllers acting upon AMAN information once aircraft reach the IMP by instructing aircraft to absorb further delay in the descent prior to the Initial Approach Fix Metering Point*.* In the longer term, pilots may be passed a MP constraint, potentially by datalink, as the aircraft reach the IMP*.* Pilots would then be expected to manage their descent to meet the *MP* time. Again, it is recognized that an aircraft is limited in how much it can slow down so only a feasible amount of delay, currently envisaged to be 3 minutes, would be allocated in descent. Any excess delay would be taken in the hold.

Potentially, the more stable landing sequence established by the IMP could also enable the delivery of a smoother arrival flow into TMA airspace.

5.4.2 Methods of Operation

In the simulation, traffic samples from busy real days in 2010 were used. The AMAN traffic samples were modified by using the Barco fast time simulator to identify delay per aircraft. The appropriate amount of delay to be absorbed in the en route phase between the IMH and the IMP was identified and from this, a revised speed, and altitude where required, was calculated. This enabled aircraft to start in the UK measured sectors at the appropriate amount of time later than the baseline runs, and flying at the modified speeds.

The measured sectors included the final portion of en route flight and the descent phase. During this portion, two different Methods of Operation (MOps) were used during the real time simulations.

Method of Operations A, in which ATCOs are responsible for aircraft achieving the Metering Point. The 'controller responsibility' MOps is the more likely method in the nearer term. In this MOps, controllers would be expected to manage their aircraft taking into account the individual aircraft delay values displayed on the current Barco AMAN display. The target would be to hand aircraft to the TMA with 5 minutes delay remaining, which provides a 'buffer' to ensure the runway is not starved of aircraft. Clearly there will be many occasions when delay is too large to absorb everything above 5 minutes in the descent so controllers should operate on a 'best endeavours' basis. Rules of thumb may be developed, such that certain delay values trigger a minimum clean descent speed, while an intermediate amount of delay triggers an intermediate descent speed. Obviously, separation tasks will take priority over queue management tasks and the controller is under no obligation to carry out any delay absorption tasks if the traffic situation does not permit it. This is depicted in Figure 22 below.

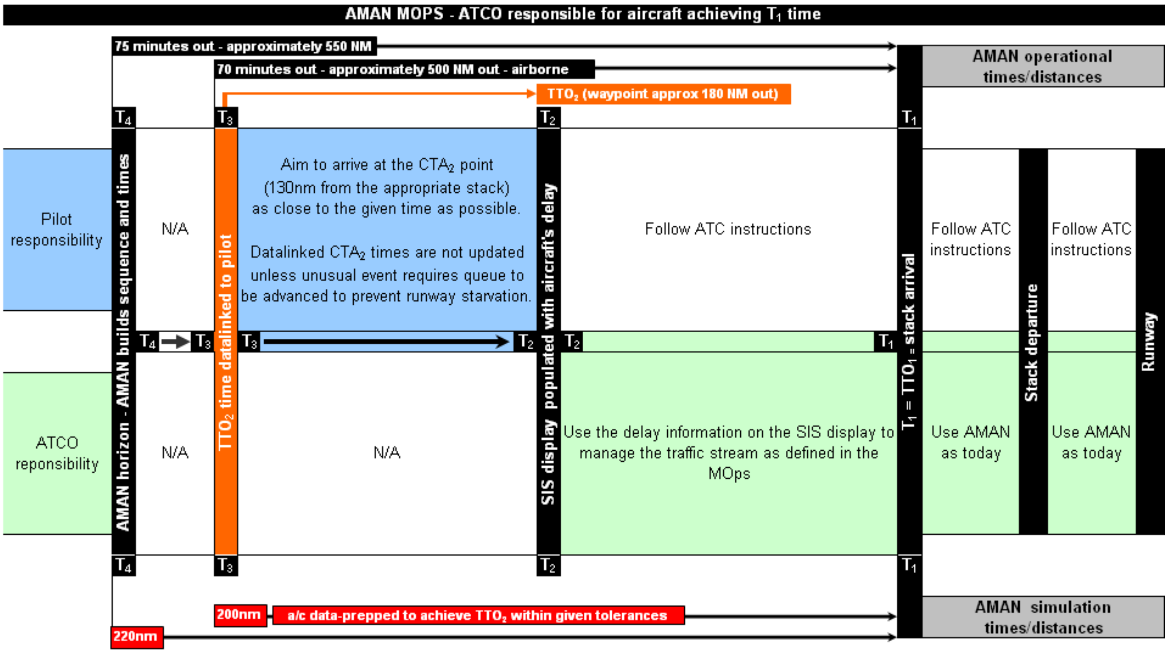


Figure 22: London Scenario Controller Responsibility Parameters

Method of Operations B, in which pilots are responsible for achieving the Metering Point. Pilots would be told at the Active Advisory Horizon, possibly by datalink, their MP time which would allow them to plan and execute an optimised descent. The controller responsibility would be to monitor aircraft descents and only intervene if separation was threatened. If a controller has intervened, neither the pilot nor the controller is under an obligation to meet the Metering Point time, although 'best endeavours' would still apply. This is depicted in Figure 23 below.

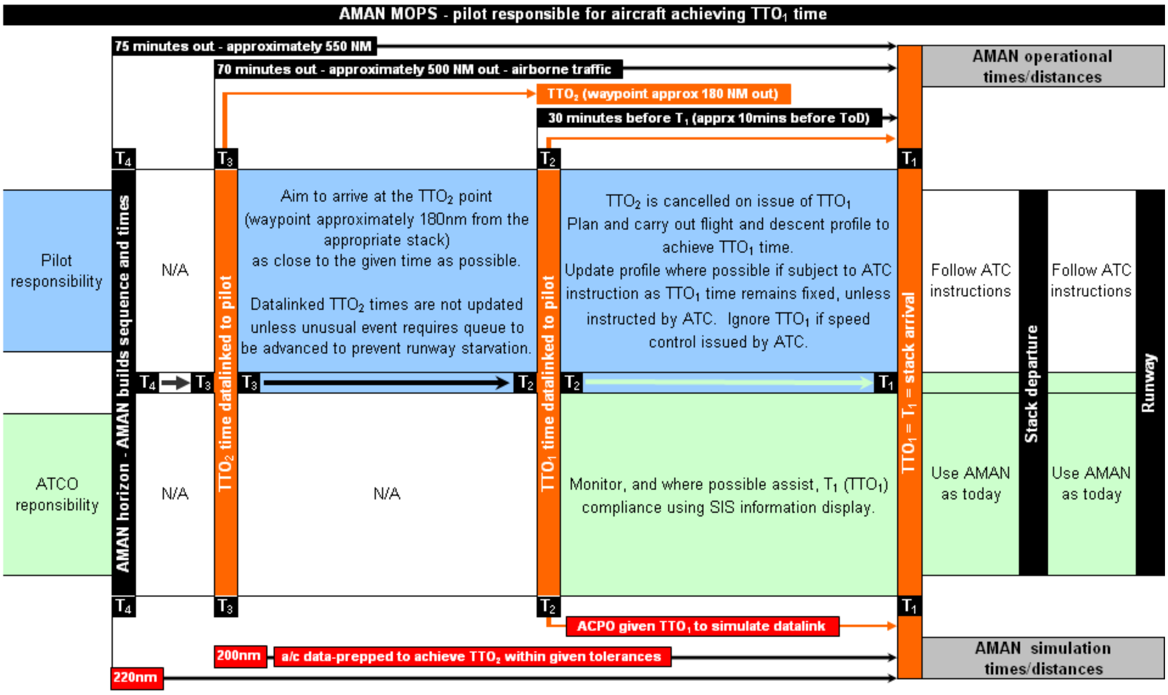


Figure 23: London Scenario Pilot Responsibility Parameters

5.4.3 Use Case: Extended Long-Range AMAN for High Complexity/High Density

Actors

En Route controllers, TMA Controllers, Pilots, Sequence Manager.

Scope

Managing the arrival sequence for a runway at a busy airport, from a range of 500NM.

Summary

Some arrival delay is absorbed between the Initial Metering Point, at about 500NM from the destination airport, and the Active Advisory Horizon, at about 180NM. Because the arrival sequence is still unstable at this point a portion of delay is left to be absorbed in the TMA. Within 180NM the sequence is reasonably stable, and further delay is absorbed in descent. Any additional delay is absorbed by TMA holding, path-stretching or speed control as today.

There are two options for both the En Route and Descent stages of Delay Absorption: Pilot Responsibility, where a target time which is passed to pilots, and Controller Responsibility, where controllers issue speed instructions.

This is a SESAR Step 1 solution, intended for use before i4D equipage is widespread.

Stakeholders

Aircraft operators, airport operator, pilots, en-route controllers, TMA controllers, sequence manager.

Goal

To reduce the fuel burn of delayed aircraft by commencing delay absorption early, while ensuring that instability in the arrival sequence does not lead to inefficient use of the runway.

Pre-Condition

AMAN is operating for a busy airport, and arrival delay exists for one or more aircraft even after the arrival sequence has been optimised.

Post-Conditions

Delayed aircraft have slowed down at long range, and thereby burn less fuel than if they had maintained their En Route and Descent Speeds and absorbed all delay in the TMA.

An element of delay remains to be absorbed in the TMA, which means that arriving aircraft are always available to ensure efficient use of the runway.

Steps

Step 1: Aircraft pass the Long Range Eligibility Horizon (550NM from destination). AMAN creates an optimised runway sequence, although this is not yet stable.

Step 2: Aircraft pass the Initial Metering Horizon (500NM from destination). Although the arrival sequence is not stable, an estimate of delay is available. Delay to be absorbed En Route is calculated, according to aircraft capability, and leaving a buffer to be absorbed later to ensure the runway will not be starved.

Sub-case alternatives (a) or (b)

Sub-case (a) – Pilot responsibility for En Route

Step 3a AMAN computes a Target Time at the Intermediate Metering Point (180NM from destination) from the delay to be absorbed.

Step 4a The AMAN system generates a datalink message giving the Target Time to the Pilot. This is not a clearance, but a request to absorb delay efficiently.

Step 5a The pilot determines how to modify the trajectory to achieve the requested Target Time efficiently.

Step 6a The pilot requests a modified trajectory – probably a change of speed - from the current executive controller.

Step 7a The executive controller grants the request if it is consistent with safety, traffic presentation, and workload.

Step 8a The pilot changes the trajectory.

Sub-case (b) – Controller responsibility for En Route

Step 3b AMAN computes a Speed to be adopted until reaching the Active Advisory Horizon, on the basis of the delay to be absorbed En Route.

Step 4b AMAN generates a ground/ground message, providing the speed to the controller currently handling the aircraft.

Step 5b The current controller instructs the aircraft to adopt the revised speed, provided this is consistent with safety, traffic presentation, and workload.

Step 6b The pilot complies with the instruction

End of alternatives (a) and (b)

Step 9 Controllers endeavour to allow the aircraft to proceed at its current speed, provided this is consistent with safety, traffic presentation, and workload.

Step 10 The aircraft reaches the Intermediate Metering Point. It is now within the Active Advisory Horizon, where the AMAN Sequence has a good level of stability.

Step 11 The AMAN generates a revised sequence to optimise runway use on the basis of improved information, and updates the delay for the aircraft.

Sub-case alternatives (c) or (d)

Step 12 For aircraft with expected delay, AMAN determines the portion of delay which should be absorbed in the Descent Phase.

Step 13a AMAN computes a Target Time for the Initial Approach Fix, on the basis of the delay to be absorbed in descent

Sub-case (c) – Pilot responsibility for Descent

Step 14a The AMAN system generates a datalink message giving the Target Time to the Pilot. This is not a clearance, but a request to absorb delay efficiently.

Step 15a The pilot determines how to modify the trajectory to achieve the requested Target Time efficiently.

Step 16a The pilot requests a modified trajectory from the current executive controller.

Step 17a The executive controller grants the request if it is consistent with safety, traffic presentation, and workload.

Step 18a The pilot changes the trajectory.

Sub-case (d) – Controller responsibility for Descent

Step 14b AMAN computes a Speed to be adopted until reaching the Initial Approach Fix, on the basis of the delay to be absorbed in descent.

Step 15b AMAN generates a ground/ground message, providing the speed to the controller currently handling the aircraft.

Step 16b The current controller instructs the aircraft to adopt the revised speed, provided this is consistent with safety, traffic presentation, and workload.

Step 17b The pilot complies with the instruction

End of alternatives (c) and (d)

Step 19 The flight reaches the Initial Approach Fix

Step 20 The TMA Controller manages the absorption of any remaining delay, as today, and endeavours to follow the AMAN sequence.

Step 21 Approach Controllers manage the approach phase as today.

5.5 Operational Scenario 5 –Release 1 Vp-189 specific issues/details

In this section is reported the detailed operational scenario used for the VP-189 **Real-Time Simulation on Stockholm airspace including En-route, Approach and Regional TWRs Release 1 step 1 V3**

5.5.1 Validation scenario

For this NORACON validation the Swedish FIR as published in the AIP will be used as a basis, in particular including:

- Arlanda Control Zone
- Stockholm Terminal Area
- Upper airspace Sweden, around Arlanda (SUECIA CTA/UTA)
- Cross Border Cooperation
- Regional Airports (Borlänge, Visby and Mariehamn)

5.5.2 Airport information

Stockholm Arlanda Airport layout Is showed in the following figure:

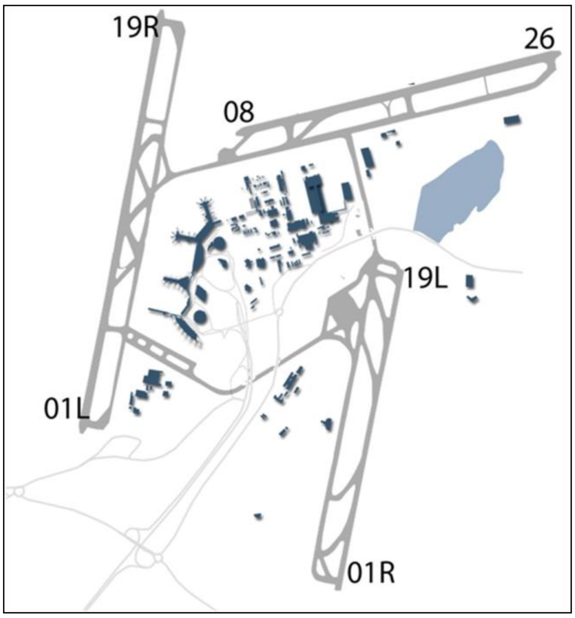


Figure 24: Arlanda Airport Layout

5.5.3 Airspace information

Airspace Organisation

The Operational Concept is applied in an airspace environment with a TMA, servicing both Stockholm Arlanda Airport and Bromma Airport. Stockholm Arlanda is a large airport, organised by four traffic flows delivering traffic over four TMA entry-points. Two main flows enter from the south and the west and two smaller flows from the north and the east. The arrival flows for Arlanda may reach today a maximum of 35 planned arrivals per hour. Today's traffic is handled by a main configuration of two separately operated runways, one for arrivals, and one for departures. There is growth capacity to deal with increased traffic flows, operated in the future from two parallel runways in mixed mode. Maximum future capacity is expected to be around 45 arrivals and 45 departures per hour.

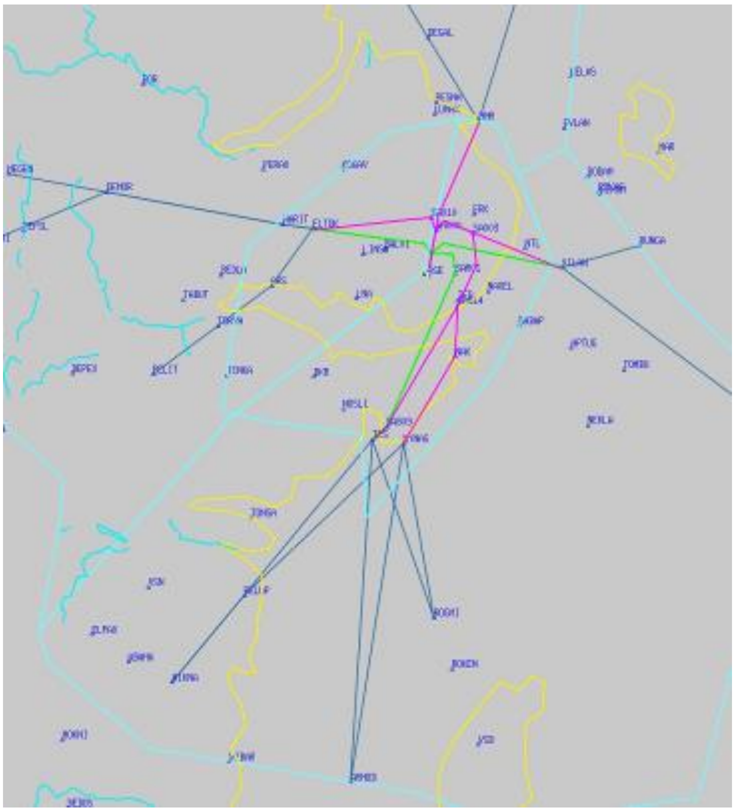


Figure 25 Airspace Stockholm experimental TMNA/TMA environment RWY 19 L

Bromma is a small city airport, although the second/third Airport of Sweden. Accommodated air traffic stays below traffic levels that justify dedicated arrival sequencing activities.

Airspace is deployed by mainly accommodating structured flows of departure and arrival traffic using de-confliction and appropriate planning of controlled traffic flows. The scenario specifics are discussed along the following subjects:

- Airspace specifics and Airspace usage
- Airspace routings

Airspace specifics and Airspace Usage

The airspace in Sweden is large and traffic density is low in general. That allows a more flexible response to Airlines requirements and optimisation of flight performance objectives than in more central parts of Europe.
The differences and specifics will be briefly summarised:

- Stockholm Arlanda is the only hub airport in a wide area. The Departure/Arrival routings are expected to be close to optimal routings, regarding flight-efficiency and environment. The most likely direct constraints are possible interaction of arriving and departing flights to/from Bromma, the city airport of Stockholm.
- The FIR controlled by LFV[29], covers the national territory of Sweden. Relatively short arrival tracks are flown by West-bound and East-bound flights. Given the aimed planning horizon of 45 minutes, short-haul flights offer inherent

---

[29] Air navigation service of Sweden

uncertainty due to their late departures. West-bound flights from Finland also tend to pop-up late in today's operations, due to close FIR border and late ground-ground co-ordination. This will cause instability in sequence planning.

- In ETMA airspace within the Sweden FIR, flights are planned and assigned to PRNAV tracks in order to meet planned CTAs on-time. These tracks are 2-D defined with level constraints to manage departing traffic from Arlanda and Bromma airports. Flights are planned to descend on the STAR according to their individual preferred flight profile from Top of Descent.
- Different routes may be available and used for aircraft with different performance. In ETMA, turboprops and jets may be separated by different lateral tracks to allow less constrained trajectories.
- In TMA airspace, approach paths with PRNAV STARs.

Airspace routings

The traditional airspace routings are adapted in two ways:

- The tracks from the south are doubled with a parallel track east of the nominal track. This is done in order to allow the AMAN to plan flights and to allocate tracks in a way that ensures minimum dependency and maximum fuel efficiency to flights. In other flight directions, this was avoided due to more departure conflicts.
- The CTA merge points are situated 30 Miles out. They will be used for metering purpose.
- In case of heavy traffic density, the Controller can intervene with speed constraints or vectoring. He will return to normal CDA operations by recovering from delayed stretching by gaps in the sequence.

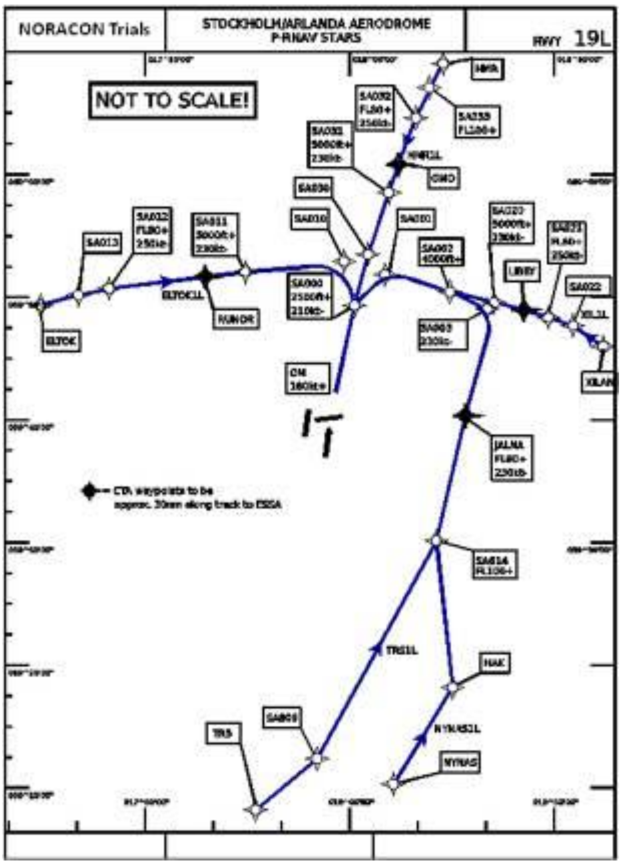


Figure 26 Routes in Stockholm experimental ETMA/TMA environment, RWY 19 L

5.6 Operational Scenario 6 – Release 1 Vp-188 specific issues/details

In this section is reported the detailed operational scenario used for the VP-188 **Real-time Simulation of London Arrival Management Release 1 step 1 V3.**

5.6.1 Validation scenario

The validation scenario will cover three sectors in En Route and one in Terminal Control which handle three inbound routes to the London TMA.

5.6.2 Airport information

An AMAN will be represented for London Heathrow, Gatwick, Stansted, Luton, and London City. All airports relevant to this simulation will operate in a westerly direction. It will be assumed that Approach Operations will be those developed in SESAR P5.7.4.

5.6.3 Airspace information

Four sectors in Area Control and one sector in Terminal Control will be handled with full accuracy and measured during the simulation. They handle three inbound routes to the London TMA. There is a substantial amount of traffic crossing these streams, so that the effect of AMAN on workload and complexity can be fully investigated.

The measured sectors will be:

- Bandboxed Sectors 5 and 23 (Brecon Group)
- Bandboxed Sectors 8 and 35 (Brecon Group)
- Bandboxed Sectors 6, 9 and 36 (Brecon Group)
- Bandboxed Sectors 21 and 22 (Worthing Group)
- Terminal Control Southwest

The next Figure 27 shows an East/West cross-section of Brecon Group sector organisation. Arrivals to London airports progress from left to right before reaching the London TMA.

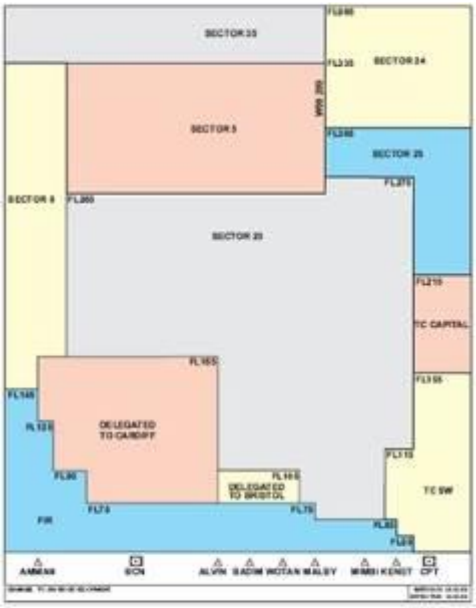


Figure 27 East/West Cross-Section of Brecon Sector Organisation

A current airspace development project within NATS – the London TMA Airspace Management Project (LAMP) - is expected to propose a new interface between Area Control and Terminal Control sectors. If a stable version of this design is available by July 2011[30] then this will be used for simulation; otherwise, the current airspace design will be used. The airspace used in this exercise will be consistent with the airspace used in exercise EXE-229.

5.7 Operational Scenario 7 - Release 2 VP-244 and VP-244 bis specific issues/details

In this section are reported the scenarios used for the validation in *VP-244/244bis* ***"Arrival Management Extended Horizon" Release 2 step 1 V3.***

These exercises aimed to validate the impact (on TMA / en route operations and on the traffic itself) of different AMAN Horizon ranges

- around 200 NM in case of Italian operational environment

---

[30] In 2015, there is not a new LAMP design in 2011. EXE-188 was run using existing London TMA airspace.

- 550 NM in case of UK/EI FAB operational environment

According to these concepts the specifics for the validations scenarios are the following:

Scenario 1	Extended AMAN Horizon scenario is composed of Rome Arrival Scenario including seven measured sectors (both for en-route and terminal sectors) plus four feeder positions.

Scenario 2	Long Range AMAN Horizon scenario is composed of high level sectors in Shannon FIR (Ireland) and London and Scottish FIRs (U.K.), above FL335.

The detailed scenarios are reported in the following paragraph

5.7.1 Extended AMAN Horizon scenario VP-244

5.7.1.1 Validation scenarios

Because the primary objective was to assess the delivered “pre-sequenced” traffic to TMA and the impact in terms of tasks performed by the en-route ATCOs, special attention of this validation was devoted to en-route sectors. These sectors play an important role due to the pre-sequencing traffic delivered to the TMA with the focus of the *delay sharing*[31] technique associated to AMAN tool. It is considered that a distance up to 250NM is needed to create the required sequence by the TMA entry point and therefore the study involved a very large airspace up to 250 NM from the airport.

The environment to be simulated is the Italy airspace, focussed on Rome E-TMA

The Validation Scenario was based on E-TMA Rome Airspace sectors namely MI1, NE, NW, TS and the approach sectors composed of: TNE,TNW and ARR. In addition, feeder sectors were taken into account for the simulation purposes. The task associated to the feeder sector was to guarantee the neighbourhood conditions in the measured sectors, which were:

- Feeder North (which managed traffic coming from North direction)
- Feeder South (which managed traffic coming from South direction). In addition this feeder sector assumed the role to manage the Traffic in the CTR area, according the advisory given by AMAN tool for all traffic inbound to LIRA and LIRF.

5.7.1.2 Airport Information

Rome airports are considered for simulation.

Rome Fiumicino (LIRF)	Landing: RWYs 16L/16R	Take-off: RWY 25
Rome Ciampino (LIRA)	Landing: RWY 15	Take-off: RWY 15

---

[31] For more information related to the delay sharing see D31 (Validation report for VP244 and VP244bis)

5.7.1.3 Airspace information

The scenario includes seven measured sectors (both for en-route and terminal sectors) which mainly manage Rome inbound traffic coming from the North and South direction of the area.

The measured sectors clusters of Rome ACC are shown in green and the feeder sectors which are responsible for pre-sequencing traffic in the measured one are shown in grey in the following figure 28.

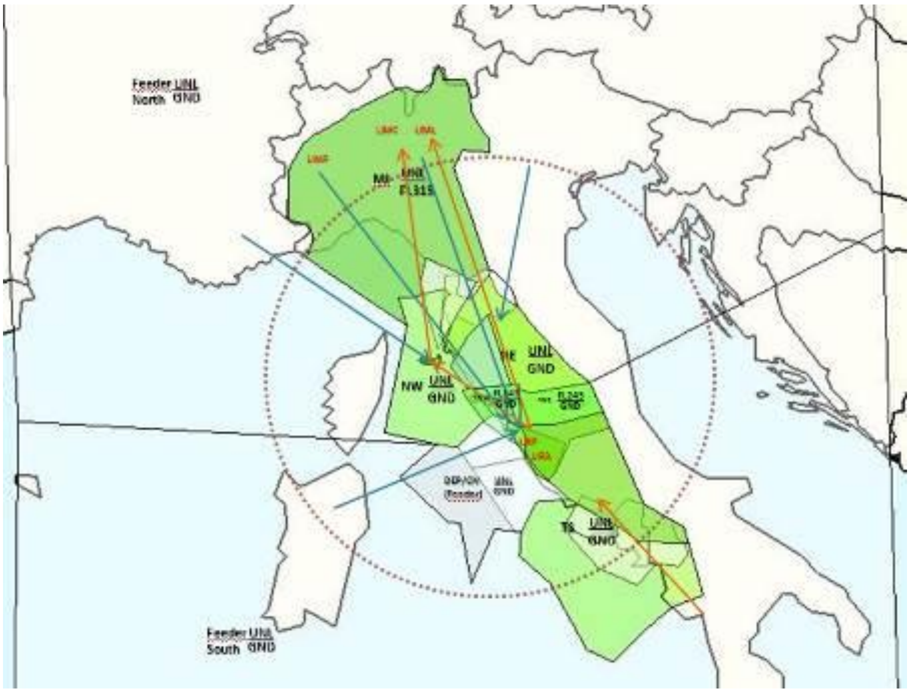


Figure 28 Extended AMAN Horizon Operational Scenario

Vertical limits of simulated sectors are reported in the table hereafter.

Sector	Vertical limits
MI1	FL 315-UNL
NW	GND-UNL
NE	GND-UNL
TS	GND-UNL
DEP-OV (FEEDER)	GND-UNL
FEED North	GND-UNL
FEED South	GND-UNL
TNE	GND-FL245
TNW	GND-FL195
ARR1	GND-FL115
Feed Satellite Airports	GND-6000ft

The E-AMAN tool in Rome will be served in two airports:

- LIRF (Rome Fiumicino). The AMAN tool will calculate the sequence for Dependent Parallel Approach Operation and Landing for RWY (16L/16R). The RWY 25 is normally used for the departure.
- LIRA (Rome Ciampino). It has the single RWY 15/33. The AMAN tool will be also investigated for this airport.

The task of these sectors is as follows:

"Distant" En-Route sector (MI1): this upper sector manages the traffic between 180-250 NM from Rome airports. The Top of Descent occurs in the vicinity of pre-sequencing sectors, i.e. NE and NW. These sectors will be provided with AMAN two types of advisory:

- The global Time to lose and Time to gain (TTL and TTG);
- The delay sharing advisory. It will show how AMAN is shared out across the sector.

Pre-sequencing En-Route Sectors (NE, NW, TS): The task of these sectors is to merge traffic coming from MI1 sector plus the traffic coming from Feeder sectors located in the North and South Area of Interest. These sectors are quite important because they will represent the final sequence towards the sequencing points of TIBER, TAQ and ROM which represents the IAFs point of the sequence to LIRF and LIRA airports. The AMAN delay sharing advisory lists will be also provided in these sectors.

TNE/TNW (Terminal East/West Sector): TN E/W clear all a/c to comply with a pre-sequencing phase as established by the Approach Sequence Manager and complies with AMAN advisories associated with the inbound traffic in his sector.

APP Sequence Manager position: s/he will be able to manually intervene to optimise the AMAN sequence as required. The AMAN shall consider inbounds to Rome LIRF and subject to performance may also consider inbounds to Rome LIRA. Traffic from NE will be optimised towards TAQ and TIBER and towards LAT for traffic from South, after which APP controllers will finalise the sequence tactically on the basis of the pre-sequencing established by the En-route sectors.

In the section related to the discussion of RTS results, this working position will be reported as "TMA sector" due to analysis reasons.

An ARR1 Executive Controller position will receive the pre-sequenced flows from NE, NW and South Feeder Sector and establish the final sequence towards the runways in use at LIRF and LIRA.

Departure/OV sectors: this sector is collapsed in a hybrid Feeder sector. It will provide an appropriate separation between departure from LIRF/LIRA airports and eventual traffic coming from west area. It will also coordinate a suitable flight level with the adjacent NW sector in case of traffic shuttle route for LIML airport.

Feeder Sectors (Feed South/North): ATCOs of these sectors will guarantee - according the GAT/OAT rules - the neighbourhood conditions in the measured sectors. The Feeder north will manage the traffic coming from the following airspace:

- LIPP (Padua Area)
- LFMM (Marseilles Area)
- LDZO (Zagreb Area)
- LSAZ (Zurich)
- LIMM (Milan Area)
- LMML (Malta Area)
- DTTT (Tunis Area)

Departure from satellite airports: satellite/regional aerodromes are situated within the active advisory horizon of AMAN and are linked to the arrival management process through an EOBT. The ATCOs in this position will apply the delay or early time of EOBT according to the Sequence Manager's order. There are several airports taken into account in the Italian airspace:

- LIRN (Naples);
- LIPE (Bologna)
- LIRQ (Firenze)
- LIRP (PISA)
- LIML (Milan Linate)

5.7.2 Long Range AMAN scenario VP-244 bis

The Long Range AMAN Horizon concept validated in VP188 (Release 1) demonstrated the concept of an extended AMAN horizon out to 550nm and obtained performance benefit metrics. However the concept requires cross-border cooperation with neighbouring ANSPs participating. In the Release 1 exercise, it was assumed that neighbouring ANSPs would cooperate fully and that aircraft would adjust their profile in accordance with AMAN constraints. This effect was scripted so that aircraft entered the simulation measured sectors already flying at their adjusted speeds.

In this limited-scale Release 2 exercise comprising only 9 runs, a simulation was held with two neighbouring sets of controllers. There were two scenarios; Shannon controllers from the Irish Aviation authority and NATS London FIR en route controllers cooperated together to help aircraft meet AMAN constraints; and secondly, NATS Scottish FIR controllers cooperated with London en route controllers.

The AMAN constraints were passed to Shannon or Prestwick controllers, who assessed the likely impact on aircraft behaviour (e.g. the aircraft reduces speed), assessed whether this had any separation implication (e.g. is there a following aircraft close behind the subject aircraft), and passed the constraint to the aircraft.

The simulation focused on which method of delay absorption was most appropriate in a variety of operational circumstances: giving responsibility to flight crews to meet a metering point time, or by controllers applying appropriate speed reduction measures.

Hence, this simulation provided an opportunity to validate the cross-border cooperation aspects of the Long Range AMAN Horizon. Some performance measurements were taken but the focus was on the cross-border[32] inter-operability aspects, as well as the implications of passing constraints to aircraft.

5.7.2.1 Validation scenarios

The important difference between UK scenario of VP-244 and VP-188 is that in the Release 2 exercise, Shannon controllers from the Irish Aviation Authority and NATS Scottish controllers cooperated in a real time simulation alongside NATS London controllers. This provided an opportunity to fully assess the workload and international cooperation implications of cross-border operations. In VP-188, the trajectories of traffic handled by adjacent ANSPs were modified in accordance with fast time results.

---

[32] Irish controllers used an emulation of their current CWP, but the AMAN information was provided separately and was not integrated with the Irish CWP. EXE-244bis considered interactions between controllers, but not interactions between the systems

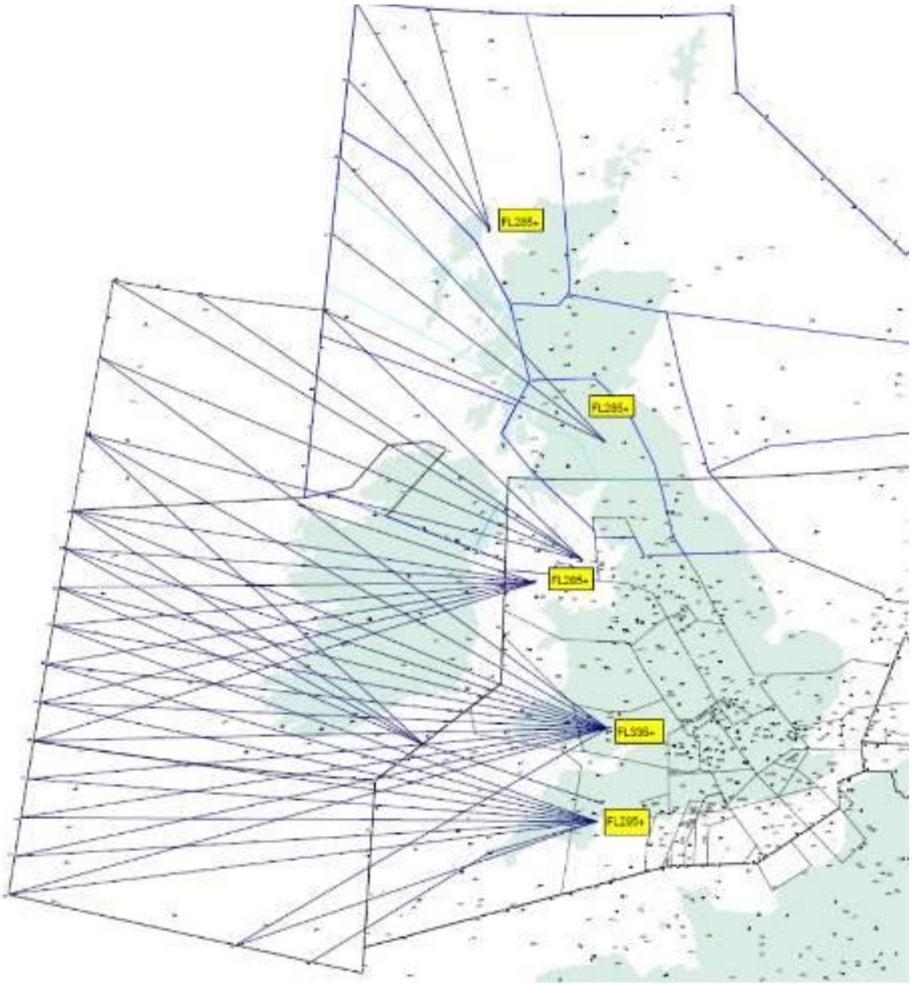


Figure 29 UK validation scenario

Figure 30: UK validation scenario sectors

5.7.2.2 Reference and solution scenarios

The Reference Scenario used current Irish free route airspace. UK airspace was modified such that aircraft inbound to the London TMA were given direct routes to a pre-descent waypoint (the Initial Metering Point in the figure above). Overflying west-east aircraft were given direct routes across UK airspace. All other background tracks followed current routes; this included the main north-south traffic flow up the spine of the UK. In the Reference scenario, London inbounds were not given any delay information from AMAN.

In the Solution Scenario, AMAN information was passed to Shannon, Scottish and London controllers, who then carried out the appropriate actions. The airspace remained the same.

5.7.2.3 Airport information

No airports were directly represented in the simulation. The Heathrow AMAN used a typical landing rate for Heathrow’s normal operating mode in which one segregated-mode runway is dedicated to arrivals.

5.7.2.4 Airspace information

High level sectors in Shannon FIR (Ireland) and London and Scottish FIRs (U.K.), above FL335, were simulated.

5.8 Operational Scenario 8 - Release 2 VP-34 (P5.3 crossed validation) specific issues/details

In this section are reported the scenarios used for the validation of VP-34 “Integration of Arrival Manager (AMAN) and supporting functionalities with P-RNAV procedures in a complex TMA” Release 2 step 1 V3.

This exercise provides an early opportunity to assess P-RNAV applications, such as trombone procedures, with arrival management in order to improve trajectory and queue management in complex TMAs. In addition, this activity will go a step further from current deployment in low and medium complex TMAs, by analysing the benefits of this integration in a high complex TMA with more than one airport. The mode of operation used to manage the integration of AMAN with Trombone procedures has showed a potential benefit by doing the final merging after the Metering Points (40NM from the runway) tactically. Tactical merging was achieved by using the trombone procedures that started at the MPs that were used by the AMAN as calculation points, at which TTL/TTG indications were provided.

Such MPs were equidistant from the runway what simplified the execution of the sequence proposed by the AMAN, given that all TTL/TTG indications were comparable as they were referred to the same reference distance.

The combination of AMAN and trombone procedures is a facilitator for airport configuration changes thanks to the symmetric approach procedures for both runway configurations what simplifies recalculation of AMAN sequence under these situations.

According to these concepts the specifics of the validations scenarios are the following:

Name	Description
One runway north	All flights will take-off and land on one runway. The runway simulated is Madrid-Barajas 33L North configuration. However, runway configuration may change during the execution of the runs.
Two runways dependent approach	Aircraft will land on two parallel runways with dependent approaches. Take-offs will be performed from different runways, in North and South configurations.
Two runways independent approach	Aircraft will land on two parallel runways with independent approaches. Take-offs will be performed from different runways, in North and South configurations.

5.8.1 Airport Information

The airport environment was based in Madrid-Barajas airport, LEMD, as main airport with Torrejón airport, LETO, as secondary airport in the vicinity.

All scenarios were initiated in North Configuration for LEMD with LETO using RWY05. Only approaches to LETO were simulated as departures don’t affect arrivals neither departures to/from LEMD.

5.8.2 Airspace Information

The airspace in the validation exercise was represented by En-Route, Extended TMA and Core TMA sectors:

- **En-route sectors** managed different flows of aircraft including arrivals to LEMD international airport and LETO military airbase open for civilian use. This included part of the cruise phase and initial descent into TMA. The rules to manage these flights were standard radar control with separation provided by tactical sector controllers with radio communication with aircrews.

- **Extended TMA** airspace (Feeder sectors) acted as interface airspace between en-route and core TMA airspace. Extended TMA sectors were responsible for transferring flights inbound core TMA through gates (called Clearance Limit Points, CLP). The flow through a gate had been longitudinally spaced by using speed control and holding stacks if needed.
- **Core TMA** airspace (Director and Final Approach sectors) was represented by sectors that managed the sequences of flights after the gates proceeding along the trombones structure. The P-RNAV structure was designed to merge two inbound flows (north and south) per runway to produce a unique flow. Spacing was adjusted by both path stretching and speed control. The trombones procedures were used to stretch or shorten the path of each aircraft to achieve a correct interval with the preceding one in the sequence. The trombones were followed by a ‘grid’ of P-RNAV paths connected to the runway localiser to facilitate the interval adjustment into final approach. The figure below shows the trombone procedures for Madrid-Barajas airport operating in North Configuration.

The AMAN Active Horizon and Eligibility Horizon, which was the same, was set to 200NM from LEMD. This was also the same horizon as the SSH. The sequence was frozen 20 minutes before ETA, near to the TMA entry points.

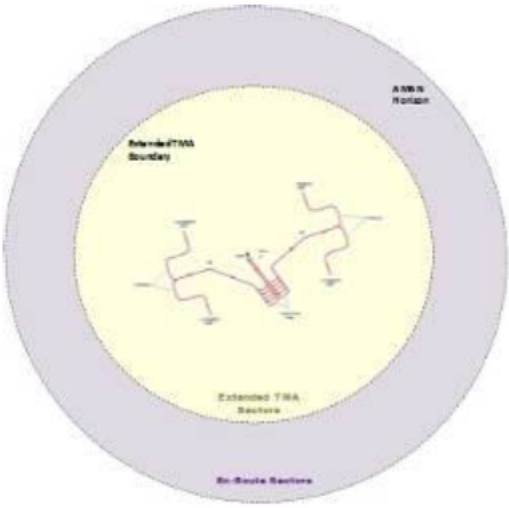


Figure 31 Trombone procedures for Madrid-Barajas. North configuration

The table below summarises the En-Route and TMA sectors that were assessed during the execution of each simulation scenario.

Validation scenario	En-Route Sectors	‘Extended TMA’ Sectors	‘Core TMA’ Sectors
Madrid Barajas - Single Runway	CJN (Castejón - Upper & Lower)	ENN/ESN/REN (East Feeder & Director)	
	PPN/TER (Pamplona + Teruel)	WNN/WNN/RWN (West Feeder & Director)	
	BL/SOM/DOM (Bilbao – Upper & Lower, Somosierra & Domingo)	AFEN/AFWN (Final Approach)	
Madrid Barajas - Two runways dependent approaches	CJN (Castejón - Upper & Lower)	ENN/ESN (East Feeder)	REN (East Director)
	PPN/TER (Pamplona & Teruel)	WNN/WSN (West Feeder)	RWN (West Director)
	BL/SOM/DOM (Bilbao – Upper & Lower,		AFEN/AFWN

Validation scenario	En-Route Sectors	'Extended TMA' Sectors	'Core TMA' Sectors
	Somosierra & Domingo)		(Final Approach)
Madrid Barajas - Two runways independent approaches	CJN (Castejón - Upper & Lower)	ENN (East-North Feeder)	REN (East Director)
	ZGZ + TER (Zaragoza + Teruel)	ESN (East-South Feeder)	AFEN/AFWN (Final Approach)
	PPN (Pamplona)		

Table 10: En-Route and TMA Sectors Assessed by EXE-05.03-VP-034

It should be pointed out that only East side (approaches to RWY33R) was simulated for the scenarios with independent approaches due to this independency between approaches and the symmetry of the trombones procedures. The criterion to select the East side was based on the influence that the approaches to LETO has on it.

5.8.3 Roles

This section describes the roles and responsibilities of the different actors involved in the EXE-05.03-VP-034.

- **ACC/Approach Supervisor (SPO)** is responsible for:
    - Managing RWY configuration, RWY arrival rate and RWY availability (e.g. RWY closed for revisions) in co-ordination with Tower (TWR);
    - Leading the process of RWY change, determining last flights in the old configuration sequences in co-ordination with TWR;
    - Managing E-AMAN configuration parameters such as arrival rate (interval separation) to adapt it to actual RWY throughput;
    - Managing sectorisation in the Operations Room;
- **Sequence Manager (SEQ_MAN)**:
    - Validates the order of the flights in the sequence according to the radar picture, airspace and weather situation;
    - Would manually change the order of flights where SEQ_MAN estimates were not accurate enough to adapt the sequence to the relative position of flights inbound a reference fix (e.g. CLPs);
    - Would manually change the order of flights to facilitate the task of smoothing traffic peaks and reducing the complexity of sequence managing in the initial phase of descent;
    - Would manually manage priority flights insertion in the sequence;
    - Would manually manage 'Close RWY' time blocks;
    - Would manually manage insertion of 'missed approach' flights into the arrival sequence;
    - Would manually input the new arrival (STAR or Direct to point) procedure to flights affected by a RWY change and not eligible by the system for STAR revision (too close to RWY threshold);

  Initially it was considered that the SEQ_MAN role could be compatible with the tasks performed by planning controllers, and so during the exercise execution, the SEQ_MAN role was performed by the TMA Planner Controller of the Director sectors, except in the Single Runway scenario (in this case, the role was performed by the TMA Final Planner Controller).

  The role of SEQ_MAN is independent of the runway mode of operations.
- **ATC Sector Executive Controller:**

For the specific scenario of Madrid TMA and to provide a better description of roles responsibilities, there have been defined the following executive controller roles:

  - **En-Route Executive Controller (REC)**:
    - Executes the sector plan determined by his/her RPC to smooth the flow of flights inbound LEMD/LETO;
    - Would issue speed control clearances to gain longitudinal separation between cruising flights according to the RPC sector plan;
    - Would initiate early descent of flights to reduce complexity during the descent phase of flights and allow the building of longitudinal separation between the maximum number of flights during the descent phase;
  - **Extended TMA Executive Controller (XEC)** is in charge of:
    - Executing the sector plan determined by their XPC to obtain longitudinal separation in the flow of flights inbound a CLP;
    - Clearing the planned flights into the holding stack, managing the flights in the holding stack and clearing the flights to resume flight when longitudinal separation with the preceding flight is obtained;
  - **TMA Executive Controller (TEC)** of the Director sectors:
    - Manages the intervals of the sequenced flights in the trombone RNAV structure to merge the two flows (north and south) into the approach sequence;
    - Would clear the flights ‘direct to point’ to shorten the path in the trombone structure;
    - Would revise speed clearances to guarantee longitudinal separation is not lost;
    - Would handle ‘missed approach’ flights into the position in the sequence determined by the SEQ_MAN;
  - **TMA Final Executive Controller (FEC)**:
    - Revises speed clearances to guarantee longitudinal separation is not lost in the final phase of approach;
    - Would clear flights through the sequencing legs or by vectoring into the localiser;
    - Would transfer flights to TWR.

- **ATC Sector Planning Controllers:**

  For the specific scenario of Madrid TMA and to provide a better description of roles responsibilities, there have been defined the following planning controller roles:

  - **En-Route Planner Controller (RPC)**:
    - Determines the sector plan for LEMD/LETO flights (setting XFL and route across sector) taking into account validated E-AMAN information;
    - Would propose speed adjustments to the executive sector controller according to E-AMAN information;
    - Would manually swap the order of contiguous flights in the sequence according to the sector mid-term (5-10 min.) traffic situation coordinating it with the SEQ_MAN. The RPC would be entitled to do so if both flights affected by the swapping were co-ordinated into or controlled by the sector;
  - **Extended TMA Planner Controller (XPC)**:
    - Determines the sector plan for LEMD/LETO flights (setting route across sector) taking into account validated AMAN information;
    - Would plan entry into holding stacks of flights with not enough predicted longitudinal separation with their preceding flights in the sequence after CLP;
  - **TMA Planner Controller (TPC)** of the Director sectors:
    - Determines the sector plan for LEMD/LETO flights (setting route across sector) taking into account validated E-AMAN information;

- **TMA Final Planner Controller (FPC)**:
    - Determines the sector plan for LEMD/LETO flights (setting route across sector) taking into account validated E-AMAN information;

5.9 Operational Scenario 9 – Release 4 – EXE-05.06.07-VP-695 (High Complexity/High Density – Long Range – Cross-border Reims/London)

5.9.1 Concept Summary

Operational Concept being addressed

In order to optimize traffic flows inbound major hub while improving descent profile, Arrival flights will be managed well before the top of descent. The consequence is that metering and sequencing activities need to be shared between several ATS units and will start in the en-route phase when flights are cruising.

This will allow absorbing tactical delay in line at a much higher altitude than the current holding or radar vectoring within the TMAs, and thus saving fuel and reducing CO2 emissions for our customers.

When an Arrival Manager (AMAN) is available at an airport, its horizon is at present usually limited to the geographical scope of the terminal control center. It is implicating that the view is not always time symmetrical from the runway and somehow blind at what's happening further out.

These shortfalls will be overcome by:

- Expanding the planning horizon of AMAN systems up to 200NM[33] in order to include the economical Top of Descent (ToD).
- Providing upstream ATS units with Arrival Management Information and so allowing cross border (be it system border, ATS unit border, ANSP border, State or Regional organization border) activities.

The exercise VP-695 focused on the key SESAR objective of extending arrival management into the En-Route phase of flight and investigated the long range AMAN horizon.

The exercise VP-695 assessed the impact of cross-border arrival management between two ANSPs (DSNA and NATS) on En-Route part through live trials (exercise VP-695 focuses on Reims UAC airspace). The validation scenario considered the extension of the planning horizon of AMAN systems into the airspace of upstream ACC/UAC to 350 NM.

The XMAN horizon for EGLL is defined as 350 NM from EGLL, however for this exercise, which focuses on RUAC only the relevant reference point is the COP at ABNUR. The XMAN horizon is at 210 NM from the COP.

This live trial took place in autumn 2014 in Reims UAC for London Heathrow arrivals, NATS providing Reims with information communicated via SWIM for the pre-sequencing of the arrival stream.

The en-route capability to deal with this Arrival Management information in that context characterizes an XMAN.

Contextual Elements

---

[33] These 200 NM refer to the aerodrome reference point (and not from the TMA boundaries).

Traffic inbound EGLL handled by Reims UAC is delivered to LACC LYDD sector (S17) at cruising FL via exit point ABNUR towards the IAF BIG. Top of Descent is just after ABNUR, LACC controls the initial descent phase in order to achieve FL150 by BIG.

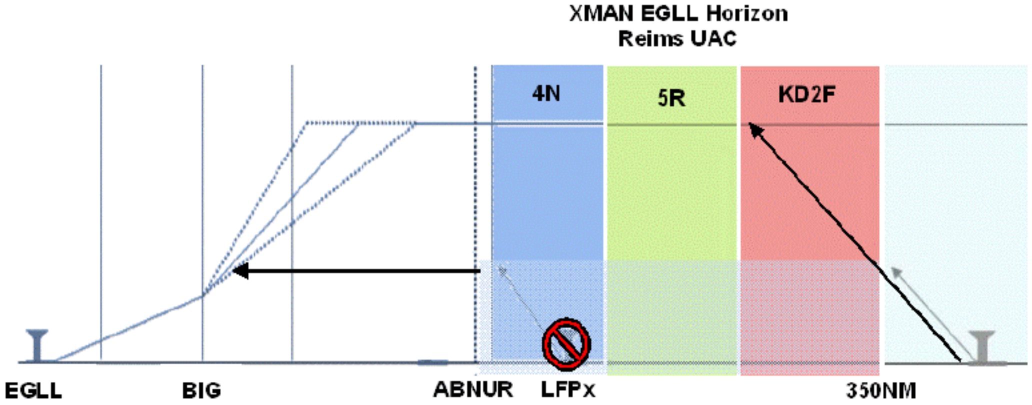


Figure 32: XMAN EGLL Horizon

The live trials of EXE-05.06.07-VP-695 experiments an operational scenario of Dynamic Delay Sharing between cross-border ANSPs (DSNA and NATS) with TTO and TTL via initial SWIM.

The flows and sectors concerned by the Dynamic Delay Sharing are as follows:

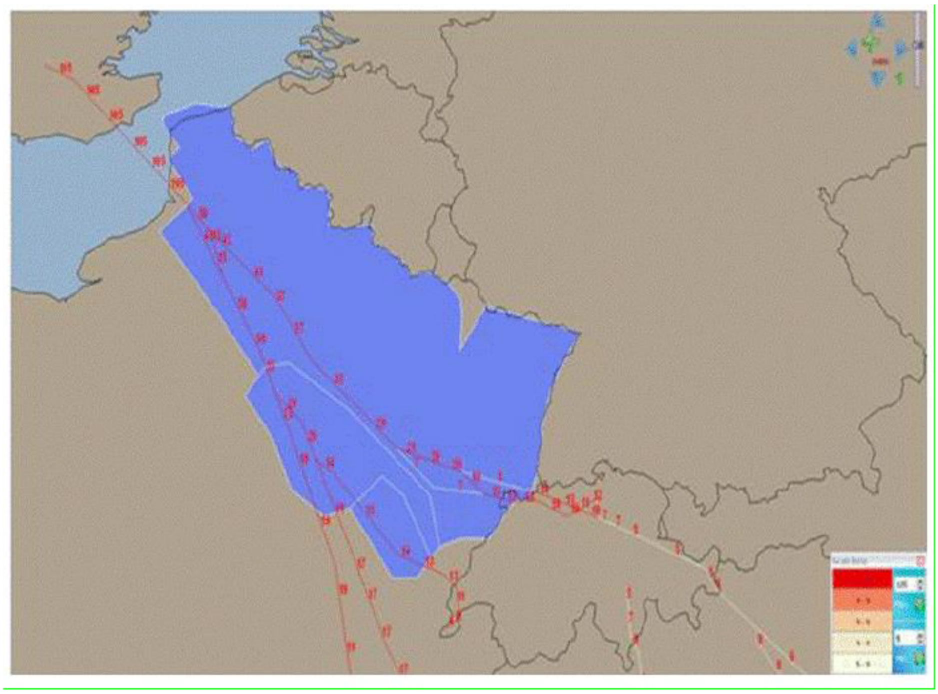


Figure 33: Flows and sectors concerned by the Dynamic Delay Sharing

The concerned flows of traffic are those entering Reims ACC by:

- EAST: overflights and departures from LSZH, LFSB
- SOUTH: overflights and departures from LSGG, LFLL

Geographical sectors concerned in Reims ACC:

- KD/2F, 4R, 4N (from South/East to North/West)

Dynamic Delay Sharing Strategy

Here are some acronyms useful to understand the figure below:

- LREH: Long Range Eligibility Horizon
- IMH: Initial Metering Horizon
- AAH: Active Advisory Horizon
- IMP: Initial Metering Point
- MP: Metering Point
- FH: Frozen Horizon
- LTUP: Landing Time Update Point

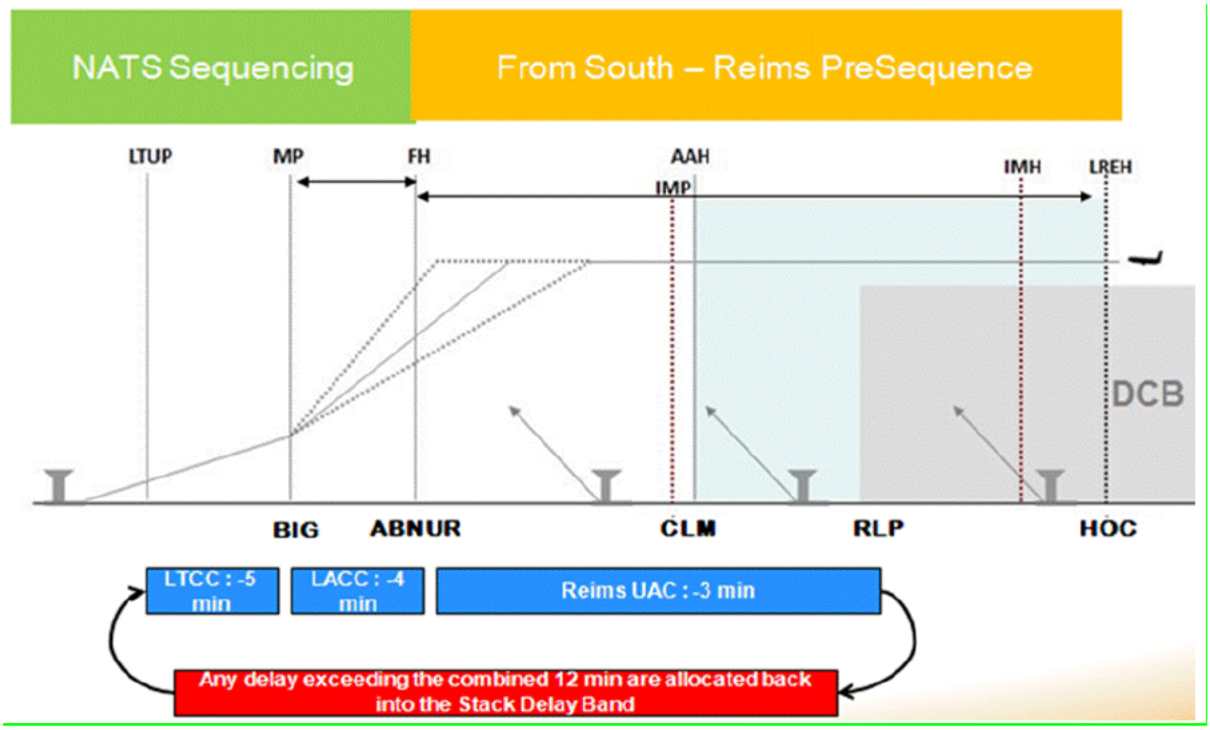


Figure 34: Dynamic Delay Sharing with TTO and TTL

For each flight, a total delay at the IAF (BIG) calculated and transmitted by the AMAN is divided into different bands allowing the sharing of the delay between the different actors.

LATC Delay: Delay in the stack and between the IAF and the runway. In order to keep some pressure on the runway, this is the first allocated delay.

LACC Delay (LYDD Sector S17): Delay from to COP to the IAF. That's the delay band where AC controllers apply the "speed in descent procedure"

En-route Delay (KD2F, 4R, 4N sectors for inbounds via Reims): Delay from a maximum range of 350NM out of EGLL to the relevant COP (ABNUR)

The delay sharing strategy is defined as the order in which the delay is successively attributed and the maximum value that can be absorbed for each band. This strategy is dynamic in the sense that the order of delay attribution and the delay values may be adapted to specific conditions.

It is understood that any delay which exceed the combined band delay is reallocated into the stacks.

Standard Delay Sharing Strategy Values

Maximum delay that can be attributed to each band in the following order:

1. LATC Delay: 5 min
2. LACC Delay: 2 min
3. En-route Delay: 3 min

Any delay which exceeds the combined 10 minutes is allocated back into the stacks.

The following table will then be updated accordingly.

Total Delay	LATC Delay	LACC Delay	En-Route Delay
1	1	0	0
2	2	0	0
3	3	0	0
4	4	0	0
5	5	0	0
6	5	1	0
7	5	2	0
8	5	2	1
9	5	2	2
10	5	2	3
11	6	2	3
12	7	2	3
13	8	2	3
14	9	2	3
15	10	2	3
16	11	2	3
17	12	2	3
Etc.	Etc.	Etc.	Etc.

Table 11: LATC/LATC/En Route Delay Sharing values

5.9.2 Methods of Operation

5.9.2.1 Planned En-route XMAN Operational Procedures

Operational Procedure 0: Initiation

A single speed reduction of M0.03 at 350NM should be applied for all aircraft if the en-route delay reaches 1 minute.

Total Delay	En-route Delay	Mach No. Reduction Guide

0-9 min	0 min	User Preferred Mach No
10+ min	1+ min	M0.03

Table 12: Initial Operational Procedure

In this initial scenario, the uniform application of a common Mach No. reduction of M0.03 disregarding the actual delay may result in creating potential bunching of aircrafts at the COP. To mitigate that effect, it is left at controllers' discretion to apply smaller Mach No. reduction so that aircraft could anyway be presented at the COP with an element of streaming.

Operational Procedure 1: Single Variable Mach No Reduction at 350NM

A single Mach No reduction of .M at 350NM should be applied for all aircraft as soon as the en-route delay is reaching 1 minute. The principle is to have a Mach No. reduction advisory presented to the en-route controller on its XMAN HMI. Mathematically, we have M=f(En-route Delay).

Example:

Total Delay	En-route Delay	Mach No. Reduction Guide
0-7 min	0 min	User Preferred Mach No
8 min	1 min	M0.02
9 min	2 min	M0.03
10 min	3 min	M0.04

Table 13: Example of Procedure with Single Variable Mach No Reduction at 350NM

Operational Procedure 2: Single M0.04 Reduction at the Latest

As soon as the en-route delay reaches 1 min, a speed reduction of M0.04 should be applied at a distance D from COP depending on this en-route delay. The principle is to have a uniform speed reduction applied at the latest but acceptable distance from the COP. By doing so, the expectation is to avoid losing the aircraft place in the sequence due to pop-up flights. The distance should be presented on the controller XMAN HMI. Mathematically, we have D=f(En-route Delay).

Example:

Total Delay	En-route Delay	Mach No. Reduction Guide	Distance to COP (ABNUR Case)
0-7 min	0 min	User Preferred Mach No	NA
8 min	1 min	M0.04	150NM
9 min	2 min	M0.04	200NM
10 min	3 min	M0.04	250NM

Table 14: Example of Single M0.04 Reduction at latest procedure

Operational Procedure 3: TTO at 350Nm

As soon as the en-route delay reaches 1 min, en-route controllers instruct aircrew to "arrange the flight so as to cross COP at TTO". This instruction is constantly given at 350NM.

Operational Procedure 4: TTO at the Latest

As soon as the en-route delay reaches 1 min, en-route controllers instruct aircrew to "arrange the flight so as to cross COP at TTO". This instruction is given at a distance D from COP depending on the en-route delay. By doing so, the expectation is to avoid losing the aircraft place in the sequence due to pop-up flights. The distance should be presented on the controller XMAN HMI. Mathematically, we have D=f(En-route Delay).

Example:

Total Delay	En-route Delay	TTO instruction given at Distance to COP (ABNUR Case)
0-7 min	0	NA
8 min	1 min	150NM
9 min	2 min	200NM
10 min	3 min	250NM

Table 15: Example of TTO at latest procedure

5.9.2.2 Retained En-route XMAN Operational Procedures

As result of EXE-05.06.07-VP-695, among the five procedures that were planned (i.e. single speed M0.03 reduction at 350 NM, single variable Mach No reduction at 350 NM, single M0.04 reduction at latest, TTO at 350NM, TTO at latest), only Operational Procedure 0 (Single speed reduction of M0.03 at 350NM) and Operational Procedure 1 (Single Variable Mach No Reduction at 350NM) were tested and validated live. The others were fully evaluated during the preparation phase of the exercise and deemed less likely to deliver significant results, and consequently unnecessary to test during the live trial.

5.9.3 Use Case: Long Rang Cross-Border AMAN in En-Route Sectors

Actors

En-Route controllers, TMA Controllers, Pilots, Sequence Manager.

Note: Although EXE VP 695 is concentrating on analysing En-route part of XMAN, EXE695 has been supported externally by the partners involved in the FABEC and FAB UKIRL XMAN EGLL Trial (MUAC, Shannon, Prestwick, Brest, LACC) that applied the concept in the same time for the EGLL arrivals under their responsibility even if no measures will be done at their sites.

Scope

The exercise VP-695 assesses the impact of cross-border arrival management between two ANSPs (DSNA and NATS) on En-Route part through live trials with a Long Range Cross-Border AMAN Horizon at 350 NM from the destination airport (London).

EXE VP 695 is concentrating on analysing En-route part of XMAN. The use case is then presented from the En-Route perspective.

Summary

The aim is to assess the impact on Reims UAC operational environment of a Long Range AMAN Horizon on operations, with focus on cross-border arrival management with the U.K to further validate the concept in real operational conditions with high traffic density between two ANSPs.

The assessment mainly focuses on:

- The feasibility for En-Route controllers to slow down aircraft to a certain extent following XMAN advisories received from a single AMAN (London).

- The acceptability in terms of workload of the implications of cross-border use of the Long Range AMAN Horizon, i.e. the workload of controllers in one ANSP (Reims UAC) for aircraft managed by AMAN implemented in the other ANSP (London LACC, London LATC).

DSNA XMAN @UAC REIMS (PCU / AMAN2 P10.09.02-D08 prototype integrated with P14.02.09-D70-003 prototype) has been used, interconnected with London LATC and Reims UAC.

The focus was to validate the ability to apply the Cross-border AMAN in En-Route sectors notably those located across borders (cross-ANSPs)).

Stakeholders

Neighboured ANSPs, Airspace Users, Ground Industry.

Goal

The current goal of XMAN implementation is to slow down flights in En-Route sectors in order to lose time in anticipation of TMA saturation.

General Conditions

Whatever the delays are, ensuring separation and reaching Letters of Agreement exit conditions must always be prioritized over the metering or sequencing task. Moreover, the followings should apply only when workload allows; at this stage XMAN procedures are understood as “best effort” measures.

In order to enable pilots to plan their descent in advance, every effort will be made to give aircraft appropriate warning of current or further expected delay. That means en-route controller should endeavour to inform aircrew to expect a maximum conversion descent speed of 250Kts as soon as the total delay reaches 7 minutes.

It is likely that AMAN sequence calculation results in proposing overtake situations at the COP which are not suitable for traffic presentation. To mitigate that potential bunching effect, it is left at en-route controllers’ discretion to adapt Mach No. reduction, to adjust TTO or to move from TTO instructions to speed control instructions so that aircraft could be presented at the COP with an element of streaming.

In the event of unusual situations, such as runway loss, bad weather conditions or technical problems, it is the responsibility of LACC supervisor to agree a plan of action regarding the delivering of traffic with en-route supervisors and whether the en-route XMAN procedures should still be applied.

Pre-Conditions

At TMA level, AMAN is operating for a busy airport, and arrival delay exists for one or more aircraft even after the arrival sequence has been optimised.

The AMAN establishes and maintained a pre-sequencing of the arrival stream.

The TMA ANSP provides the En-Route Centre with information communicated via SWIM for this pre-sequencing of the arrival stream.

Post-Conditions

In En-Route sectors, delayed aircraft have slowed down at long range, and thereby have lost time in anticipation of TMA saturation.

An element of delay remains to be absorbed in the TMA, which means that arriving aircraft are always available to ensure efficient use of the runway.

At the TMA level, a part of flights recorded as holding are effectively instructed a speed reduction and absorbed a part of their delay in En-Route sectors. More generally, most of candidate flights are issued XMAN speed control instructions (among which a certain percentage of flights recorded as holding are candidate to XMAN speed reduction). Thereby, these flight burn less fuel than if they had maintained their En Route and Descent Speeds and absorbed all delay in the TMA.

Steps

The following steps focus on En-route part of XMAN, and are then mainly presented from the En-Route perspective.

Step 1: Aircraft pass the Long Range Eligibility Horizon (500NM from destination). AMAN creates an optimised runway sequence, although this is not yet stable. Although the arrival sequence is not stable, an estimate of a Total AMAN delay is available.

Step 2: Aircraft pass the Long Range XMAN Activity Horizon (at 350 NM from destination (EGLL) or 210 NM from COP (ABNUR)). London AMAN starts transmitting to the XMAN in Reims UAC the delay information (XML message), approximately every 20 seconds. The delay sharing strategy starts to be applied entering in this Long Range XMAN Activity Horizon and the Total Delay information is divided in two different bands:

- The London TMA delay which is defined as the delay from the COP to the metering fix for EGLL. This has been defined at a minimum of 7 minutes in EXE VP-695.

- The en-route delay. This is defined as the delay that can be absorbed from a maximum range of 350 NM from EGLL (210 NM from the relevant COP (ABNUR)). The maximum en-route delay has been defined at 3 minutes in EXE VP-695.

In the meantime:

- London AMAN starts sending TTOs (Target Time Over) to the XMAN in Reims UAC for flights belonging to the EGLL arrival flow. These TTOs and the TTL (Time To Lose) as Total Delay are computed from ETFMS data and rely on ETOs.
- RUAC XMAN also starts computing its own ETO@COP and its own_the TTL (Time To Lose) as en-route delay value (computed from Radar Data and XMAN Trajectory Prediction). En-route delay computed by XMAN in Reims is updated at each receipt of XML message sent by London AMAN (approximately each 20 sec.)

Step 3: For aircraft from 210 NM from COP, if 0<En-Route Delay (TTL) < 3 minutes, XMAN in Reims displays related Speed Advisories to En-Route Controllers.

Sub-Case alternatives (a), (b) and (c)

(a) 0<En-Route Delay <=3 minutes

Step 3a: The installed XMAN provides ATCOs with the needed information to implement the speed reduction: the TTL (i.e. En-Route delay value), the speed reduction value (i.e. 0.01, 0.02, 0.03, or 0.04 Mach) and the distance from the COP where the flight is to reduce its speed.

Step 4a: The current en-route controller endeavours instructing the aircraft to adopt the revised speed provided this is consistent with safety, traffic presentation, and workload.

Step 5a: The pilot endeavours complying with the instruction provided this is consistent with its safety.

Step 6a: Whenever it has been effective, the current en-route controller inputs in XMAN HMI the speed reduction action.

(b) En-Route Delay > 3 minutes

Step 3b: The installed XMAN provides ATCOs with information adapted to Reims maximum absorption capability, i.e. TTL of 3 minutes (i.e. maximum En-Route delay value), speed reduction value of 0.04 Mach and the distance from the COP where the flight is to reduce its speed.

Step 4b: The current en-route controller endeavours instructing the aircraft to adopt the revised speed provided this is consistent with safety, traffic presentation, and workload.

Step 5b: The pilot endeavours complying with the instruction provided this is consistent with its safety.

Step 6b: Whenever it has been effective, the current en-route controller inputs in XMAN HMI the speed reduction action.

(c) En-Route Delay < 0 (due to AMAN/XMAN delay computation inconsistencies)

Step 3c: The installed XMAN provides ATCOs with information adapted to Reims maximum absorption capability, i.e. TTL of 0 minutes (i.e. En-Route delay value). No speed advisory is provided.

End of sub-case alternatives (a), (b) and (c)

Alternative (d)

(d) Total Delay >= 5 minutes

Step 7d: The installed XMAN provides ATCOs with information of expected Speed in Descent of 250 kts

Step 8d: The current en-route controller informs the aircraft of the expected Speed in Descent of 250 kts

Step 9d: The pilot prepare its aircraft in order to endeavours complying with the information

End of alternatives (d)

Step 10 The current En-Route Controllers endeavour to allow the aircraft to proceed at its current speed, provided this is consistent with safety, traffic presentation, and workload.

Step 11 The current En-Route Controllers transfers the aircraft to the next sector.

6 Requirements

The following section describes a set of requirements of AMAN system. At first a set of Current AMAN requirements is provided then the structure is the following:

- Additional AMAN requirements
- Extended AMAN requirements
- Extended AMAN I4d/CTA Requirements
- Extended AMAN Satellite Airports Requirements
- Long Range AMAN Requirements

In addition a set of HMI Requirements have been analysed by project 5.9. The results of this work are reported in the document P05.09 2013 Technical note iteration 1 edition 01.00. The scope of the technical note is to analyse and consolidate the WP4/5 Operational Requirements dealing with Human Machine Interface (HMI) for both the En-Route and TMA environments.

The purpose of this first iteration of 2013 Technical Note is to provide as main outcome the consolidation of HMI Requirements produced by different WP 4/5 Projects through identification of gaps or inconsistencies among OSEDs and between OSEDs and DODs.

According to this work new HMI requirements have been added in the D35 Consolidated OSED. Following is reported a summary of new HMI Requirements added in section 6.1:

REQ-05.06.04-OSED-0028.**0351**
REQ-05.06.04-OSED-0028.**0352**
REQ-05.06.04-OSED-0028.**0353**

At the moment only the following requirements (operational & performance) are available for OFA 04.01.02 and for OI TS-0305-A in 05.02 DOD for the traceability of this OSED’s Requirements:

REQ-05.02-DOD-OPR1-0011
REQ-05.02-DOD-CAP1.0026
REQ-05.02-DOD-CEF1.0015
REQ-05.02-DOD-ENV1.0006

The update of requirements done in the version of the 05.06.04 OSED (D35) takes also into account the output coming out from VP485 of P5.6.7. After the exercise 485, P5.6.7 produced an “ad hoc” technical note (D05 Technical Note to 5.6.4 OSED Step 1) with recommendations/integrations for requirements (of 5.6.4 OSED) used and analysed during the simulation activities. According to this view, the following requirements have been updated:

REQ-05.06.04-OSED-0028.0230
REQ-05.06.04-OSED-0028.0260
REQ-05.06.04-OSED-0028.0280
REQ-05.06.04-OSED-0028.0340
REQ-05.06.04-OSED-0028.0350
REQ-05.06.04-OSED-0028.0420
REQ-05.06.04-OSED-0028.0450
REQ-05.06.04-OSED-0028.0460
REQ-05.06.04-OSED-0028.0500
REQ-05.06.04-OSED-0028.0530
REQ-05.06.04-OSED-0028.0540
REQ-05.06.04-OSED-0028.0660
REQ-05.06.04-OSED-0028.0690
REQ-05.06.04-OSED-0028.0720
REQ-05.06.04-OSED-0028.0730
REQ-05.06.04-OSED-0028.0810
REQ-05.06.04-OSED-0028.0830

REQ-05.06.04-OSED-0028.1200

In addition with reference to CTA requirements:

Dedicated OFA 04.01.02 working sessions have taken place to align the requirements from projects 5.6.1 and 5.6.4. The output of these sessions was an agreement by the projects:

- to change, where necessary, the text of some identified requirements within each individual OSED and
- to reference relevant requirements from the other projects

Where needed, identified changes to requirement text have been incorporated, and any 'referenced requirements' are now contained in Subsection 6.4.1 – 'OFA Related Requirements'. “”

The update of requirements done in this version of the OSED (D15) takes also into account the output coming out from VP695 of P5.6.7. According to this view, the following requirements have been updated:

REQ-05.06.04-OSED-0028-1010

REQ-05.06.04-OSED-0028-1060

REQ-05.06.04-OSED-0028-1080

6.1 Current AMAN requirements

The following paragraph describes a set of the requirements of AMAN system currently in use. This list is not intended to be exhaustive, but is reported here in order to illustrate the baseline set of functionalities on which the extension of the AMAN will be based.

[REQ]

Identifier	REQ-05.06.04-OSED-0028.**0010**
Requirement	ATCOs is supported in the performance of Arrival Queue Management tasks. This includes Planning and Implementing an efficient Landing Sequence to the concerned airport.
Title	System Support for Arrival Queue Management/Traffic Synchronisation
Status	<Validated>
Rationale	An efficient landing sequence will allow optimal runway usage while catering for capacity constraints.
Category	<Operational>
Validation Method	
Verification Method	

[REQ Trace]

Relationship	Linked Element Type	Identifier	Compliance
<SATISFIES>	<ATMS Requirement>	REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0020**
Requirement	The system shall support the technique(s) employed to absorb arrival management delays towards the destination airport. This includes the following elements: a) appropriate horizons and metering points in relation with the Arrival Management phases b) appropriate advisories c) display to all concerned actors
Title	Adequacy of System Support
Status	<Validated>
Rationale	Current situation: standard horizon, TTL/TTG and possibly speed

	advisories. 05.06.04 concept: extended horizon, CTA (link with 05.06.01).
Category	<Operational>
Validation Method	<Real Time Simulation>
Verification Method	

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0030**
Requirement	Notwithstanding the employed technique to absorb the arrival management delays the planned Landing sequence shall progressively become more stable when getting closer to the runway.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0040**
Requirement	Flight progress information for every aircraft bound for the arrival-managed airport are received, when the flight crosses a defined Eligibility Horizon (EH). The system shall initiate sequence computation on the received data, and maintain a planned landing sequence which includes every aircraft which has reached the Eligibility Horizon.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0050**
Requirement	
	Departure within Eligibility Horizon
	AMAN shall be able to integrate aircraft taking off from airports situated within the EH in the sequence. In order to do so, the data shall be transmitted in due time, even before the aircraft is airborne.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0060**
Requirement	Arrival sequence information may be presented on aircraft which have reached the Eligibility Horizon (local implementation choice).
	Display Advisories at EH
	As traffic builds, ATCOs may want advance information on expected flows to assist planning, and/or may want to apply rough, global delay measures at distance.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0070**
Requirement	The system may allow a downstream ATSU to provide the neighbouring upstream ATSUs with the level of arrival delay (Local implementation choice).
	Information to contributing ATSUs
	This may allow the upstream ATSU to handle the flights appropriately - so they are not kept fast when there is delay ahead, and not slowed when

	there is none.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0080**
Requirement	An Active Advisory Horizon shall be defined, representing the Arrival Management range at which advisories for AMAN sequence implementation presented to the ATCO are reliable and useful (i.e. stable)

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0090**
Requirement	The system shall have a designated 'role' for human Sequence Management.
	Sequence Management Role
	The system shall present to the Sequence Manager all necessary information and advisories, allowing him/her to decide on the landing sequence, in coordination with the involved ATCOs. The system shall also enable manual inputs for the modification of the system sequence accordingly. This High level requirement is developed also in OSED 0100 and 0110.

		REQ-05.02-DOD-OPR1-0011	<Full>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0100**
Requirement	The Sequence Management 'role' shall be configurable. In locations it may be applied to a stand-alone Sequence Manager position, or it may be applied to a designated combined Sequence Manager /ATCO working position.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0110**
Requirement	The system shall accept manual configuration in the Sequence Management role to set constraints/conditions (exact scope to be defined locally).

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0120**
Requirement	The system shall provide appropriate support to the Sequence Management role to enable a coherent view of the planned sequence, and to enable changes to be made manually to it.
	System Support to Sequence Manager
	<Validated>
	Current system, as will still be the case in Step 1, includes the sequence manager role.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0130**
Requirement	For all aircraft having reached the defined AAH, the ATCOs concerned with the implementation of the arrival sequence shall have access to landing sequence information (including sequence order and time/other advisories) planned by the system. In the case when the AAH encompasses multiple ATSUs, the system shall allow a downstream ATSU that operates an AMAN tool to provide the neighbouring upstream ATSUs with the applicable arrival management information/requests for every flight.
	System Support for Sequence Implementation.
	<Validated>
	The system shall present to all concerned executive and planning controllers (as determined locally and even in different ATSUs) advisories supporting them in the implementation of the sequence. These advisories are expected to result from automatic system sequence computations and where applicable of manual input from a Sequence Manager.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0150**
Requirement	The system shall provide appropriate information in an appropriate form, manner and time for each position using it, as determined locally.
	Display of appropriate information for sector type
	AMAN may need to display information in a different way for different sector types. For instance, for a high-level route sector then target times may be needed; for a TMA sector only sequence numbers may be needed; and for a feeder sector for the TMA then both may be needed.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0160**
Requirement	For every aircraft within the EH, the system shall calculate an AMAN Planned Threshold Time (APTT) for the runway threshold and a total delay at the runway (calculated as the difference between the STA and the ground system estimated time at runway), based on: a) the ground system estimated time at the runway b) the runway constraints (e.g. defined runway rate, WTC separation, etc..) including runway planned over-delivery c) the optimisation of the planned sequence order according to locally defined parameters such as: - reduction of average delays - reduction of individual delays - ordering according to Wake Turbulence Categories - runway throughput - etc.
	Time/Delay at the runway
	In capacity constrained environments, in order to maintain the desired runway throughput, a slight runway over-delivery must be accounted for in the system (notion of "runway pressure"). The sequence is first of all calculated based on FCFS (First Come First

	served) basis, then the order maybe optimised according to relevant optimisation criteria.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0170**
Requirement	A horizon may be defined through a parameter in the system indicating the limit after which no automatic sequence swapping will occur. Time estimates and/or advisories could still be updated automatically by the system, but without changing the sequence order. New flights may still appear automatically in the sequence. It shall be possible for the sequence manager to update the sequence order manually.
	Stable Sequence Horizon
	The closer to the runway, the more stable the planned sequence shall be.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0180**
Requirement	The Sequence manager may be able to manually adjust the Stable Sequence Horizon.
	Adjustment of Stable Sequence Horizon
	Optional. Stable Sequence Horizon adjustment with reference to a flight in the sequence or per flight basis.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0190**
Requirement	The Sequence Manager may be able to manually freeze the order of a group of aircraft in the sequence (before the Stable Sequence Horizon).
	Partial "semi-freeze" of sequence
	Optional. Capability of freezing manually the group of arrival a/c

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0200**
Requirement	A Frozen Horizon may be defined through a parameter in the system, indicating the limit after which both no automatic sequence swapping will occur, and no automatic change of landing time will occur. It shall remain possible for the sequence manager to update the sequence manually within the frozen horizon.
	Frozen Horizon
	FH "artificially" further stabilises the sequence, by preventing automatic sequence swapping by the system and re-computation of estimated landing times is terminated.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0210**
Requirement	The Sequence manager may be able to manually adjust the Frozen

	Horizon.
	Optional. Frozen Horizon adjustment with reference to a flight in the sequence or per flight basis.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0220**
Requirement	The Sequence Manager may be able to manually freeze the order of a group of aircraft in the sequence (before the Frozen Horizon), or to lock the planned over flight time of the metering point for a single aircraft or a group of aircraft in the sequence.
	Partial sequence freeze
	Optional.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0230**
Requirement	One metering point shall be defined for each traffic flow feeding the TMA.
	Metering Point
	This point (e.g. IAF or TMA entry point) shall serve as reference fix for the pre-sequencing on each flow according to the downstream constraints. Pre-sequencing used to de-bunch arrival traffic to an acceptable level prior to entering the TMA, i.e. "protect" the TMA according to its capacity.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0240**
Requirement	The system shall support a delay sharing according to the local working methods and agreements.
	Delay Sharing
	The delay sharing may consist in an apportionment of Arrival Management delay before/after metering point and or across individual sectors or units prior to the metering point. Link with "functional view" of Current arrival management: a) Pre-sequencing before metering point. b) Sequencing (i.e. Integration towards the runway after metering point), typically in TMA

		REQ-05.02-DOD-OPR1-0011	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0250**
Requirement	For every aircraft within the EH, the system shall calculate: a) APTO for the relevant metering point based on back calculation from the APTT, delay sharing strategy (before/after the metering point) including runway planned over delivery (if employed). b) A delay at the metering point (calculated as the difference between the APTO and the ground system estimated time over the metering point).
	Time/Delay at Metering Point

	Time/Delay advisories at metering point shall be derived from Time/Delay at runway including the optimised sequence order and delay sharing parameters.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0260**
Requirement	Based on the arrival management system computation, the concerned ATCOs shall be provided, as a minimum, with the following AMAN advisories: -TTL/TTG at RWY and/or at MP Optionally, where relevant, additional advisories and/or information may be considered, such as: - Sequence Order - Planned APTO/APTT - Speed - Route - TOD
	Arrival Management Advisories
	ATCOs shall receive the relevant advisories and/or information in order to implement the landing sequence.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0270**
Requirement	The system shall update the Planned Sequence and the related advisories at an adequate rate, taking into account the evolution of flights as available in the ground system. The update may be triggered by the availability of updated flight data and any manual update performed by the Sequence Manager or at a rate locally prescribed.
	Planned Sequence Update
	The updates include sequence order, STA, STO, delays and other advisories if applicable, according to the different horizons. After reaching the Frozen Horizon, while the times and delays will continue to be automatically updated, the sequence optimisation will only be possible with a manual intervention of the ATCO.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0280**
Requirement	System will monitor progress using radar or data/information available from other sources or ANSP's, to provide accurate and up to date advisory information to the ATCO to identify whether aircraft are likely to meet their planned times at the MP.
	Monitor Progress against AMAN Planned Times towards the MP
	To maintain the sequence.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0290**
Requirement	A Landing time update point (LTUP) may be defined, allowing the automatic or manual adjustment of system sequence times with respect to the actual landing sequence. At this point, data may be distributed to A-CDM or as required or locally determined.
	Landing time update point (LTUP)
	Actual sequence time may drift with respect to planned sequence time. In the part of the sequence close to the runway the sequence may not be continuously/automatically updated by the system, hence a final updated may be necessary.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0295**
Requirement	The system shall permit the user to perform off-line configuration of: 1) Time values for the Eligibility Horizon, the Active Advisory Horizon, the Frozen Horizon, 2) Metering Point and the Landing Time Update Point 3) ATC strategies for arrival management (e.g. delay sharing, runway allocation criteria etc.).
	Configurable system parameters
	Needed to support implementation at different airports

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0340**
Requirement	The arrival management system shall develop a runway sequence which is consistent with ATC strategies, addressing such issues as runway allocation and acceptance rates, delay sharing, focus on efficiency or capacity. Such ATC strategies may be reflected both by parameters in the system and by sequence manager interventions.
	AMAN consistent with ATC strategies
	Simple strategies under nominal conditions can be input through parameters, while for more complex strategies and/or under non-nominal conditions, manual intervention of the Sequence Manger may be required.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0350**
Requirement	The system shall take into account the impact of wind variability in its calculations, all the way to RWY.
	Inclusion of wind data
	To ensure that sequence predictions reflect the real sequence order, even in case of strong wind.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

The following new HMI requirements have been added by P5.9:

Identifier	REQ-05.06.04-OSED-0028.**0351**
Requirement	The CWP shall display the information regarding TTL,TTG and the sequencing number
	Display AMAN Information
	The ATCO need to know all relevant information to handle the arriving traffic.

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0014	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.05	N/A

Identifier	REQ-05.06.04-OSED-0028.**0352**
Requirement	The information provided by AMAN tool shall be properly displayed on the CWP in terms of priority and relevant actors
	Prioritization of AMAN Information
	The information provided by AMAN toll shall be properly displayed to bring benefits to the Controllers

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0014	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.05	N/A

Identifier	REQ-05.06.04-OSED-0028.**0353**
Requirement	The system shall properly integrate the information coming from the AMAN tool and the information regarding the CTA
	Integration of AMAN and CTA Information
	The information coming from AMAN and shall be properly integrated with the CTA information to bring benefits to the Controllers

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0014	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.05	N/A

6.2 Additional AMAN requirements

The following paragraph describes a set of additional AMAN requirements not implemented in the systems currently in use. These requirements, even if not being in direct relation with the extension of the AMAN horizon, are considered to be useful for behaviour of the future systems.

Identifier	REQ-05.06.04-OSED-0028.**0410**
Requirement	The system may take into account flow rates constraints defined at metering points. The constraints may be modified dynamically in order to adapt to different flows conditions (i.e. during the day).
	Flow Rate Constraints

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0420**
Requirement	For the cases where it is agreed to use time and/or speed constraints, the En-route ATS system shall be able to monitor the flights' compliance with the constraints and warn the controller when a deviation that exceeds a predefined value is detected
	Aircraft compliance monitoring

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0430**
Requirement	The ATS System of the Approach Control unit may be able to compare the operational data contained in coordination and revision messages it receives to the arrival management constraints notified for the corresponding flight (e.g. COP discrepancy with ACT message).
	Coordination messages and AMAN plans consistency monitoring.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0440**
Requirement	In the case that the previous requirement (REQ 0430) is implemented, the ATS System of the Approach Control unit detects a discrepancy that exceeds a predefined value between the co-ordination data and the arrival management constraints for the corresponding flight, an indication will be presented at the appropriate working position.
	Non-compliancy display

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0450**
Requirement	The Sequence Manager should be able to propose and to assess the effects of proposed sequence changes using AMAN, without disrupting the sequences in effect.
	What-if capability
	This capability is needed to avoid having to perform a sequence re-computation in order to check the effect of a modification. The Sequence Manager needs a what-if functionality to evaluate the impact of events such as: 1) Temporary closure of runways 2) Runway strategies Traffic distribution

	4) Change of runway configuration/direction 5) All manual interaction with AMAN having an impact on the sequence should be testable beforehand.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

3130

Identifier	REQ-05.06.04-OSED-0028.**0460**
Requirement	If AMAN uses standard times between the Metering Point and the runway it shall take into account the impact of wind variability
	Wind Variability between Metering Point and Runway

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

3133

3134

6.3 Extended AMAN Requirements

The following paragraph describes a set of additional AMAN requirements derived by the extension of the AMAN horizon.

Identifier	REQ-05.06.04-OSED-0028.**0500**
Requirement	The Eligibility Horizon (EH) and the Active Advisory Horizon (AAH) should be extended to support the controller in applying more efficient arrival management techniques at an earlier stage of flight.
	Extension of horizons
	Extended Horizon OI STEP main focus of 05.06.04 The extension of the arrival management horizons will provide more time to implement the arrival sequence, also allowing the ATCO to use more efficiently the various arrival management techniques. Thanks to an early implementation, the impact of the arrival management constraints on the optimal flight profile will be reduced. On the other end, the extension of the eligibility horizon will cause a larger number of flights to be included in the arrival management calculations. Additionally, a larger number of regional airports could be included into the Eligibility Horizon. A typical extension of the EH would be around 180/200 Nm Depending on the precise needs of the implementation to consider the flying time element rather than distance element

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0520**
Requirement	The required data to feed the TP shall be available at a time appropriate to the new horizon, to feed the Trajectory Predictor at an earlier phase of flight (or at a greater distance from the runway).
	Availability of data for extended horizon
	The need for data for a flight may require additional data and/or transmission mechanism. In particular, data at cross-border between ACCs should be adequately available. In the context of an extended AMAN instantiation of "System Support to Sequence Planning" requirement.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0530**
Requirement	The data referred to in requirement 0520 shall be of sufficient quality to enable reliable Trajectory Prediction calculation for extended horizon.
	Quality of data for extended horizon
	The need for data for a flight on an extended horizon will require improvements in the system in order to produce data of sufficient quality in a timely manner. It is a matter of TP quality and having reliable and good quality information to feed accurate TP at long range. The data quality will be expressed in terms of integrity, reliability and accuracy.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0540**
Requirement	The extension of the horizons beyond *ATS AOR* borders will require the capability to transmit sequence advisories (as described in requirements 0240) to en-route sectors concerned with an earlier stage of flight (or at a greater distance from the runway).
	Distribution of Sequence Advisories
	In the context of an extended AMAN instantiation of "System Support to Sequence Implementation" requirement. In particular, data should be transmitted at cross-border between ACCs when adequate. The quality of AMAN calculated sequence should support en-route sectors to follow the proposed sequence or otherwise coordination will be needed with the Sequence Manager to update the sequence in AMAN.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0550**
Requirement	Appropriate two-way ground-ground coordination of information is needed over the extended Arrival Management area.
	Ground-ground coordination of information
	Need for downstream unit coordinating with the upstream units, sending elements such as TTL/TTG/Sequence Number.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0560**
Requirement	In case of interaction with DCB, clear application rules shall be defined.
	Interaction with DCB
	The horizon extension may cause the extension of AMAN advisory to that portion of en-route airspace that could be subject to DCB restrictions. This is a low level maturity requirement. Needs clarification possibly with WP7.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0570**
Requirement	Optionally, a minimum inter-aircraft spacing parameter at the metering point could be defined. Such parameter could be either statically defined for different conditions, or it could be possible to input it manually.
	Spacing at Metering Point
	Ensure sufficient buffer to enable traffic to continue on closed routes to runway.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0580**
Requirement	It may be necessary to cluster metering points for presentation purposes.
	When Metering Points are close to each other they may have to be

	considered as one point for presentation purposes.

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

3154

Identifier	REQ-05.06.04-OSED-0028.**0590**
Requirement	The Arrival Management system shall be capable of reflecting ATC strategies in the sequence build i.e. when planning times (at RWY and metering points). Actual strategies will be subject to local implementation choices and constraints. Possible strategies could include for instance: (a) Overtake Principle - avoiding aircraft overtakes on the same inbound route (En-route and TMA airspace) (b) Turboprop aircraft speed principles – jets normally overtake turboprops in En Route Airspace but they have similar speeds in the TMA
	Support for ATC Strategies
	The extension of the horizon will make the work of the Sequence Manager more complex. Avoid unnecessary increases of workload for controllers The procedure for en-route controllers is to follow the arrival sequence proposed by the Extended Horizon AMAN. If the sequence cannot be implemented the en-route controller have to co-ordinate with the Sequence Manager, resulting in a possible update (change) of sequence

		REQ-05.02-DOD-OPR1-0011	<Partial>
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

3157

3158

6.4 Extended AMAN I4D/CTA requirements

The following paragraph describes a set of additional AMAN requirements derived by the extension of the AMAN horizon, with particular reference to the introduction of I4D/CTA concepts.

Identifier	REQ-05.06.04-OSED-0028.**0600**
Requirement	Where the I4D/CTA is expected to be used, the horizons extension shall provide sufficient look ahead time to encompass the I4D/CTA concept
	Extension of horizons (I4D)
	The AMAN horizon should extend far enough to allow the various elements of the i4D/CTA concept to be achieved. This means being extended sufficiently to: - Complete the CTA/RTA coordination process (AUs estimate this needs to be completed 5 - 10 minutes prior to ToD)- - Maximise the extent/usability of the ETA Min/Max window for ground sequencing purposes.

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0014	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.05	N/A

Identifier	REQ-05.06.04-OSED-0028.**0610**
Requirement	In the case when metering with CTA and metering with TTL/TTG are using different metering points, the AMAN shall extrapolate the required time over Metering Point (for CTA) and express it as a TTL/TTG relative to the appropriate Reference Point, in an appropriate form, taking into account specific spacing requirements and ATC strategies.
	Reference Point
	This point (e.g. IAF or TMA entry point) shall serve as reference point for the pre-sequencing on each flow according to the downstream constraints. Sequence computation may be required on both the Reference and Metering Points for all aircraft of a sequence (e.g. decision for CTA implementation and/or possible reversion to TTL/TTG). A consistent delay sharing strategy including the Metering Point and the Reference Point used for TTL/TTG may be required (per flow).

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0014	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.05	N/A

Identifier	REQ-05.06.04-OSED-0028.**0660**
Requirement	The criteria and method for assessing the need to apply a CTA to any particular flight(s) in an arrival flow shall be determined on a local basis. It may be an automated process, a human process, or a combined human/automated process, using appropriate system support.
	REQ-05.06.01-OSED-SG04.0100

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0014	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.05	N/A

Identifier	REQ-05.06.04-OSED-0028.**0670**
Requirement	A CTA attributed to a flight shall be considered locked by the AMAN
	Impact of CTA on Stability
	Use of CTA may de facto result in locking aircraft to an absolute time on the Metering Fix in the sequence. This may result in the flight moving forwards or backwards in the sequence but the CTA will remain unchanged, May need to be clarified with 05.06.01

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0014	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.05	N/A

Identifier	REQ-05.06.04-OSED-0028.**0680**
Requirement	Additional ground-ground coordination capabilities associated with arrival management may be required to support I4D but are not fully defined yet
	CTA/I4D system support for ground-ground negotiation.
	Low maturity requirement, to be clarified later; to be maintained as a placeholder for further development.

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0014	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.05	N/A

Identifier	REQ-05.06.04-OSED-0028.**0690**
Requirement	Relevant executive controllers need: a) the ability to see all AMAN target times and sequences including but not limited to:. *4. Sequence number* *5. TTL/G in resolution down to minutes and seconds* *6. Underlying TTL/G (only concerning i4D targets in this experiment):* *i) Original value before it was set to zero as a result of the controller assigning a proposed CTA* *ii) Residual actual value remaining at any given point in time.* b) to know whether the targets have been accepted as feasible. (General situation awareness – available if required.) c)Distance to go for individual flights where available
	View overall AMAN plan
	Ground need to know if the CTA has been sent and accepted. Note: Which data are displayed and on which CWP should be a local choice. The situational awareness should be fully configurable

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0014	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.05	N/A

Identifier	REQ-05.06.04-OSED-0028.**0700**
Requirement	If a Reference Point is implemented and an aircraft is flying towards a Metering Point on a trajectory bypassing the defined Reference Point (for

	instance as a result of a direct to instruction), the AMAN shall determine the "abeam" point to the flight planned RP on a curve equidistant to the Metering Point, and express all RP pertinent information to that equidistant point.
	Reference Equidistant
	Unlike at the MP, aircraft should not be forced to pass overhead the Reference Point. An equidistant curve to the MP point should be considered in lieu of RP when a/c not passing directly over.

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0014	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.05	N/A

Identifier	REQ-05.06.04-OSED-0028.**0710**
Requirement	The system shall be updated with the CTA status (in progress, implemented, rejected, cancelled, etc.)
	System reception of CTA status
	The system needs to be updated with the CTA process status (the AMAN including the Seq Manager needs to be informed by the 'updated CTA' process)

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0014	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.05	N/A

Identifier	REQ-05.06.04-OSED-0028.**0720**
Requirement	The system shall reflect the CTA status in the HMI through clear and consistent information and symbols in different systems/places.
	Display of CTA Status
	The ATCO need to know when the CTA is implemented to handle the flight in accordance.

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0014	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.05	N/A

Identifier	REQ-05.06.04-OSED-0028.**0730**
Requirement	The arrival management system should enable switching to/from TTL/TTG to CTA and back again.
	Switch between delay absorption techniques
	Switch between TTL/TTG and CTA will be needed (e.g. in case of cancellation of CTA).

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0014	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.05	N/A

6.4.1 OFA Related Requirements

This section contains a reference to P05.06.01 Requirements that are strictly linked and valid for P05.06.04. The contents of this work, agreed by the two projects, are output of a Dedicated OFA04.01.02 working sessions taken place on 27/07/2013 at EEC in Bruxelles.

During the working sessions the requirements were aligned by projects 5.6.1 and 5.6.4. The output of these sessions was an agreement by the projects:

- to change, where necessary, the text of some identified requirements within each individual OSED and
- to reference relevant requirements from the other projects

Where needed, identified changes to requirement text have been incorporated, and any 'referenced requirements' are now contained in this subsection, in particular the output of the working sessions and information about requirements are reported in the following files:

OFA Enhanced
Arrival and Departure

Minute OSED 5.6.4
OFA Reqs consolidatio

The list of the 5.6.1 Requirements (from D74 5.6.1 OSED [20]) is reported as following

Locally Determined CTA Metering Fix

Identifier	REQ-05.06.01-OSED-SG05.0100
Requirement	*The precise location of the CTA Metering Fix (distance from touchdown) shall be determined locally, based on Arrival Management requirements.*

CTA Metering Fix on Standard Instrument Arrival Route (STAR)

Identifier	REQ-05.06.01-OSED-SG05.0200
Requirement	*Notwithstanding local arrival management considerations (Ref: REQ-05.06.01-OSED-SG05), the CTA Metering Fix shall be associated with a published instrument arrival route.*

CTA within Aircraft Performance Capability

Identifier	REQ-05.06.01-OSED-SG05.0300
Requirement	*Ground computed constraints shall only be proposed as a CTA when the CTA is known (i4D flights) or estimated by the ground system (non i4D flights) to be within the aircraft's performance and navigation capability.*

Ground Trajectory Prediction Accuracy

Identifier	REQ-05.06.01-OSED-SG05.0400
Requirement	*Ground computed predictions of aircraft performance and navigation capability used for CTA shall be of sufficient accuracy and quality to enable their use to be 'operationally acceptable'.*

Ground System Messaging 1

Identifier	REQ-05.06.01-OSED-SG05.0500
Requirement	*The ground system shall support the necessary messaging associated with*

	extending arrival management and CTA proposals to en route units.

Ground System Messaging 2

Identifier	REQ-05.06.01-OSED-SG05.0600
Requirement	*The ground system shall enable the required ground-ground exchanges to be completed in a timely manner.*

CPDLC Log-on Capability (Airborne)

Identifier	REQ-05.06.01-OSED-SG01.0100
Requirement	*Aircraft shall be capable of logging-on with ground systems via CPDLC*

ADS-C Log-on Capability (Airborne)

Identifier	REQ-05.06.01-OSED-SG01.0200
Requirement	*Aircraft intending to use i4D ‘services’ shall be capable of logging on with ground systems via ADS-C.*

CPDLC Capability (Ground)

Identifier	REQ-05.06.01-OSED-SG01.0300
Requirement	*Ground systems shall be capable of connecting/communicating with aircraft via CPDLC*

ADS-C Capability (Ground)

Identifier	REQ-05.06.01-OSED-SG01.0400
Requirement	*Ground systems providing/utilising i4D ‘services’ shall be capable of connecting/exchanging trajectory-related information via ADS-C.*

4D Trajectory Processing (Ground)

Identifier	REQ-05.06.01-OSED-SG02.0200
Requirement	*Where ground systems are providing/utilising ‘i4D services’ the ground system shall be capable of receiving and processing the downlinked aircraft 4D trajectories.*

3D Route Uplink Capability (Ground)

Identifier	REQ-05.06.01-OSED-SG03.0100
Requirement	*The ground system shall be capable of up-linking 3D route clearance CPDLC messages to the aircraft.*

Ground System Messaging 1

Identifier	REQ-05.06.01-OSED-SG05.0500
Requirement	*The ground system shall support the necessary messaging associated with extending arrival management and CTA proposals to en route units.*

Ground System Messaging 2

Identifier	REQ-05.06.01-OSED-SG05.0600
Requirement	*The ground system shall enable the required ground-ground exchanges to be completed in a timely manner.*

6.5 Extended AMAN Satellite Airports Requirements

The following paragraph describes a set of additional AMAN requirements derived by the extension of the AMAN horizon, with particular reference to the inclusion of traffic departing from satellite airports within the extended horizon.

Identifier	REQ-05.06.04-OSED-0028.**0800**
Requirement	The system shall integrate received flight progress information for departures from airports inside the extended Eligibility Horizon, from <time tbd> before EOBT. The system shall integrate the received data into the sequence calculation.
	Departure within an extended Eligibility Horizon
	AMAN shall be able to integrate aircraft taking off from local (regional?) airports situated within the EH in the sequence. In order to do so, the data shall be transmitted in due time, even before the aircraft is airborne. The extension of the Eligibility Horizon will mean that more regional airport will fall into the eligibility area, and therefore a greater number of departing aircraft will need to be integrated into the arrival management sequence calculation. It should be noticed that uncoordinated departures could be a major source of sequence instability. It could be locally defined if an airport should be defined as a Satellite airport or not. Both the flying time and the geographical location should be considered.

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0010	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0810**
Requirement	AMAN shall receive the following data for subject flight from Satellite airport within Eligibility Horizon: • Call sign • Departure Aerodrome • Destination Aerodrome • TTOT • New TTOT in case of update • Aircraft Type • Runway • SID or TMA Exit point
	AMAN Reception of TTOT
	Data shall be transmitted when TTOT is available, to be used by AMAN to update arrival sequence. This data shall be received when a new subject flight becomes available and/or a new TTOT (a revised TTOT outside a defined window) becomes available.

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0010	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0820**

Requirement	AMAN shall receive the following data update for subject flight at regional airport: • Call sign • Revised TTOT • Runway • SID or TMA Exit point
	AMAN Reception of TTOT /revised TTOT
	AMAN receive information on flight progress at regional airport - TTOT or revised TTOT

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0010	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0830**
Requirement	AMAN shall transmit the following data for subject flight at regional airport to the Tower EFS or the Tower Controller: *Required* • *Identifier (e.g. ARCID, ADEP, ADES, EOBT, <EOBD>) – ICAO defined* • *Call Sign* • *TTL* *Optional* • *APTT* • *Runway assigned to flight* • *Sequence Number* • *Arrival Delay (global)* • *Delay Share assigned to recipient* • *Time and delay at metering fix and other designated points on the trajectory* • *Advisories (e.g. TTL/TTG, speed advisory, route advisory ...) proposed by AMAN* • *Aircraft performance characteristics (e.g. type of aircraft, wake turbulence category, ...) -- see ICAO definitions / AIRM* • *AMAN handling indicators* • *Miles to fly to threshold*
	AMAN transmit TTL to Satellite Airport
	AMAN transmit TTL direct to Satellite Airport

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0010	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0840**
Requirement	The TWR System shall take into account the following static data for each flight: • Call sign • Departure Aerodrome • Destination Aerodrome • EOBT • CFMU Regulations • Aircraft Type • Flight plan • Runway • SID and/or TMA Exit point

	TWR System Flight Display Requirement - Static
	The TWR Controller needs basic flight information for flights.

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0010	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0850**
Requirement	The TWR System shall be able to insert, display and update the TOBT
	Flight Display Requirement – TOBT
	The TWR Controller can set TOBT in TWR System and also update TOBT.

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0010	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0860**
Requirement	The TWR System shall be able to insert, display and update the TTOT
	TWR EFS Flight Display Requirement – TTOT
	Display TTOT for the TWR Controller

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0010	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0870**
Requirement	The TWR System shall be able to send message to AMAN system including: • Call sign • Departure Aerodrome • Destination Aerodrome • TTOT • Aircraft Type • Runway • SID or TMA Exit point
	TWR EFS Flight Time Data Transfer Requirement – TTOT
	Send Flight data with TTOT to the AMAN system

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0010	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0880**
Requirement	The TWR System shall be able to receive TTL advisory from AMAN system
	TWR EFS receives TTL from the AMAN system
	Receive TTL from the AMAN system

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0010	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0890**
Requirement	The TWR System shall be able to propose a revised TTOT taking into account the received TTL advisory from AMAN system
	TWR EFS proposed revised TTOT computation
	Proposed revised TTOT could be based on delay absorption on ground.

		REQ-05.02-DOD-OPR1-0011	

		REQ-05.02-DOD-OPR1-0010	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0900**
Requirement	The TWR System shall be able to send update of TTOT to Arrival Management system
	TWR EFS Flight Time Data Transfer Update Requirement – TTOT Update
	Possibility for tower ATCO to send update of TTOT to the AMAN system may be necessary

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0010	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**0910**
Requirement	The Satellite Airport within the Extended AMAN Horizon shall depart the respective flight no later than the determined TTOT. If the TTOT cannot be met, further coordination with AMAN shall take place with the objective to secure a new suitable sequence position.
	Required stringent TTOT adherence at the satellite airport

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-OPR1-0010	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

6.6 Long Range AMAN Requirements

The following paragraph describes a set of additional AMAN requirements derived by the Long Range extension of the AMAN horizon.

Identifier	REQ-05.06.04-OSED-0028.**1000**
Requirement	Particular AMAN configurations may require a long range extension of the Eligibility Horizon (e.g. 400/500 NM).
	Long Range Eligibility Horizon
	Small speed adjustments performed early are more fuel efficient than large speed adjustments or path stretching later. Particular AMAN configurations may require a long range extension for pre-sequencing based on a Long Range Eligibility Horizon (from where the pre-sequence is built), an Initial Metering Horizon (from where aircraft are actively pre-sequenced), and an Initial Metering Point (where the pre-sequence will be delivered). The locations will depend on stability of data, but appropriate values might be 80 minutes for the Initial Metering Horizon and 45 minutes for the Initial Metering Point.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1010**
Requirement	The system shall receive flight progress information for every aircraft bound for the arrival-managed airport, when the flight crosses a defined Long Range Eligibility Horizon (LREH). Using this data, the system shall compute an optimised arrival sequence.
	Long Range Flight Eligibility

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1020**
Requirement	An Initial Metering Horizon (IMH) shall be defined, representing the point where aircraft are given a target time for the Initial Metering Point.

	Initial Metering Horizon
	The IMH is where the speed of an aircraft can be changed in accordance with expected delay, because the sequence is semi-stable. Particular AMAN configurations may require a long range extension for pre-sequencing based on a Long Range Eligibility Horizon (from where the pre-sequence is built), an Initial Metering Horizon (from where aircraft are actively pre-sequenced), and an Initial Metering Point (where the pre-sequence will be delivered). The locations will depend on stability of data, but appropriate values might be 80 minutes for the Initial Metering Horizon and 45 minutes for the Initial Metering Point.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1030**
Requirement	An Initial Metering Point shall be defined on each route, at which flights can be pre-sequenced.
	Initial Metering Point
	Pre-sequencing can be used to absorb some delay before the sequence is fully stable. Particular AMAN configurations may require a long range extension for pre-sequencing based on a Long Range Eligibility Horizon (from where the pre-sequence is built), an Initial Metering Horizon (from where aircraft are actively pre-sequenced), and an Initial Metering Point (where the pre-sequence will be delivered). The locations will depend on stability of data, but appropriate values might be 80 minutes for the Initial Metering Horizon and 45 minutes for the Initial Metering Point.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1035**
Requirement	The system shall permit the user to perform off-line configuration of time values for the Long Range Eligibility Horizon, the Initial Metering Horizon, and the Initial Metering Point.
	Configurable system parameters (Long Range)
	Needed to support implementation at different airports

		REQ-05.02-DOD-OPR1-0011	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1037**
Requirement	The system shall allow the Sequence Manager to dynamically change the maximum delay value to be absorbed before the Initial Metering Horizon, after which the sequence shall be re-calculated.
	Dynamic change of delay parameters
	This allows the Sequence Manager to reduce the amount of extended-range delay absorption if he judges that the landing rate is more uncertain than normal.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1040**
Requirement	The system will monitor aircraft progress, using radar data, or data/information available from other sources or ANSPs, to identify whether aircraft are likely to meet their planned times at IMP.
	Monitor Progress against AMAN Planned Times towards IMP
	To maintain the sequence.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1050**
Requirement	From LREH to IMP, the controller will endeavour to implement the AMAN sequence. Local procedures will determine how accurate sequence compliance should be.
	Long range sequence management.
	To define expectations for conformance with the AMAN sequence and

	achieve consistent delivery on all arrival routes.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1060**
Requirement	A TTL/TTG speed instruction or a target time at the Initial Metering Point (IMP) shall be transmitted to the flight crew either by datalink or by the controller responsible for the flight.
	Transmit Times

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1065**
Requirement	If an aircraft has received a Speed Instruction or Target Time at the initial metering point, either by datalink or from a controller, this shall be displayed to other En Route controllers handling the flight so they will endeavour not to impede it achieving this time
	Display of aircraft with Target Time at the IMP
	This will allow controllers to facilitate aircraft meeting their target times, whenever possible.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1070**
Requirement	There must be timely notification of the plan and any updates to pilots or controllers depending on who should achieve the AMAN targets.
	Timely notification of plan
	To allow the responsible person (pilot or controller) to achieve the AMAN target.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1080**
Requirement	The IMP APTO shall be calculated by AMAN by working back from the runway time. It shall comply with all agreed policies for delay apportionment to different segments of the flight as well as to the agreed delay sharing strategy. IMP APTO shall be converted into TTL/TTG advisory for the controller (implemented via ATC instructions), speed proposal for the controller or a target time at IMP for the flight crew as appropriate.
	Derive APTO at IMP from MP Time

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1090**
Requirement	Intermediate points between IMH and IMP may be used for planning purposes and sharing delay between trajectory segments. For instance, the border between ATSUs may have an associated planning time.
	Long Range plan at intermediate points
	To define clear responsibilities for all actors involved with establishing the AMAN sequence.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1100**
Requirement	The system shall record the IMP TTO and the IMP ATO for each aircraft to permit post flight assessment of aircraft compliance.
	Long Range AMAN Compliance Monitoring
	Recording of the IMP TTO and ATO enables the ANSP to assess the level of compliance achieved.

		REQ-05.02-DOD-OPR1-0011	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Stream E Requirements

The following paragraph describes a set of additional requirements derived by the Stream E of the project which addresses the potential use of Airborne Derived Data. These requirements, not directly correlated with the extension of the AMAN horizon, are expected to provide benefit to the overall behaviour of the system.

Identifier	REQ-05.06.04-OSED-0028.**1200**
Requirement	To enhance his or her situational awareness, the controller should have instantaneous access to the following information: - Vertical rate in better quality than radar readout - Magnetic Heading - Indicated airspeed or Mach number as applicable.
	Aircraft state
	Increases the ATCO situational awareness by knowledge of the aircraft planned behaviour. This supports the ATCO monitoring task when using the concept.

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-SAF1.0009	
		REQ-05.02-DOD-SAF1.0010	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1210**
Requirement	To enhance his or her situational awareness, the controller should have instantaneous access to accurate and reliable information about current wind conditions at the location of an aircraft.
	Current Wind at aircraft position
	Increases the ATCO situational awareness by knowledge of the wind. Wind may be down linked directly or obtained as a vector sum of down linked Air vector and down linked or calculated Ground vector.

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-SAF1.0010	
		REQ-05.02-DOD-SAF1.0009	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1220**
Requirement	To enhance his or her situational awareness, the controller should have instantaneous access to accurate and reliable information about the future intent of aircraft within his or her area of interest.
	Aircraft Intent
	Increases the ATCO situational awareness. Intent may be either long term i.e. past the next trajectory change point (TCP) or short term (up to the next TCP) or both, as available. If long term intent is displayed, all TCPs should be shown including ETO

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-SAF1.0010	
		REQ-05.02-DOD-SAF1.0009	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1230**
Requirement	If the EPP updated F-leg is used to convey long term intent information, the controller should have the possibility to simultaneously display F-legs to at least two targets. In such a case, the F-legs shall be distinct and differentiable, e.g. by colour.
	F-leg EPP
	Increases the ATCO situational awareness.

3320

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-SAF1.0010	
		REQ-05.02-DOD-SAF1.0009	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

Identifier	REQ-05.06.04-OSED-0028.**1240**
Requirement	In situations when the AMAN proposed sequence involves an overtake of aircraft ahead it should be highlighted to the controller when locally specified conditions are satisfied
	Highlighting of Overtakes

3323

		REQ-05.02-DOD-OPR1-0011	
		REQ-05.02-DOD-SAF1.0010	
		REQ-05.02-DOD-SAF1.0009	
<APPLIES_TO>	<Operational Focus Area>	OFA04.01.02	N/A

3325 6.8 Requirements for Process / Service

3326

6.9 Information Exchange Requirements

The following table lists the Information Exchange Requirements.

[IER]

Identifier	Name	Issuer	Intended Addressees	Information Element	Involved Operational Activities	Interaction Rules and Policy	Status	Rationale	Satisfied DOD Requirement Identifier	Service Identifier
IER-5.6.4-IERS-0032-0010	Arrival Management Information_US	Arrival Management	Stakeholder ATSU	Arrival Management Information Items of Interest may depend on airspace structure (FIR, sector, route, fix, …) receiving role, … (see New Information Elements)	Monitor Traffic Situation Separate Traffic	See below	<Validated>	REQ-5.6.4-OSED-0028 -0020, item c) -0070 -0130 -0240 -0260 -0540 -0690 -1070	REQ-05.02-DOD-OPR1-0004<Partial>; REQ-05.02-DOD-OPR1-0011<Partial>; REQ-05.02-DOD-OPR1-0014<Partial>	
IER-5.6.4-IERS-0032-0020	AMAN Plan Implementation	Stakeholder ATSU	Flight Crew	Information Elements[34] in use may be • ATC Instruction (to comply with TTL or TTG) • Speed advisory • Target Time Over	Provide Arrival Information	See below	<Validated>	REQ-5.6.4-OSED-0028 -1060 -1070	REQ-05.02-DOD-OPR1-0011<Partial>	
IER-5.6.4-IERS-0032-0030	Arrival Management Information_DS	*Arrival Management*	*Destination Airport*	Arrival Management Information *Items of Interest may be* • *Landing Time* • *Runway (when AMAN manages multiple runway)* *TWR should be treated as an ATC stakeholder, i.e. with all options.*[35]	*Implement Updated Arrival Sequence*	*See below*	<Validated>	*Not in scope of current OSED, but part of baseline AMAN. See, e.g.* - *A-CDM manual* - *6.8.4 OSED*	REQ-06.02-DOD-6200.0060*<Partial>*	

---

[34] It is assumed that the EATMA contains the ICAO baseline terminology or it is imported from the AIRM foundation.

[35] Means that TWR, depending on local procedures, may require any of the properties of the "Arrival Management Information" IE.

Identifier	Name	Issuer	Intended Addressees	Information Element	Involved Operational Activities	Interaction Rules and Policy	Status	Rationale	Satisfied DOD Requirement Identifier	Service Identifier
IER-5.6.4-IERS-0032-0040	Runway Usage Constraints	Destination Airport	Arrival Management	Runway Usages Constraints (see New Information Elements)	Implement Updated Arrival Sequence	See below	<Validated>	REQ-5.6.4-OSED-0028, REQ-5.6.4-OSED -0160	REQ-06.02-DOD-6200.0062<Partial>	

Table 16: IER overview Information Exchanges for baseline and extended horizon operations

[IER]

Identifier	Name	Issuer	Intended Addressees	Information Element	Involved Operational Activities	Interaction Rules and Policy	Status	Rationale	Satisfied DOD Requirement Identifier	Service Identifier
IER-5.6.4-IERS-0032-0050	Arrival Management Information_UG	Arrival Management	Satellite Airport	Arrival Sequence Information. Depending on implementation, items of interest may be • Time To Lose on the ground / Delay Share assigned • APTT at destination • Time over Metering Fix (see New Information Elements)	Provide Takeoff Clearance	See below	<Validated>	REQ-5.6.4-OSED-0028, REQ-5.6.4-OSED -0830	REQ-05.02-DOD-OPR1-0004<Partial>; REQ-05.02-DOD-OPR1-0011<Partial>	
IER-5.6.4-IERS-0032-0060	Departure Planning Information	Satellite Airport	Arrival Management	Flight – Departure Data	Implement Updated Arrival Sequence	See below	<Validated>	REQ-5.6.4-OSED-0028, REQ-5.6.4-OSED -0810, REQ-5.6.4-OSED -0820	REQ-05.02-DOD-OPR1-0004<Partial>	

Table 17 IER Overview Additional Information Exchanges required for satellite airport integration

[IER]

Identifier	Name	Issuer	Intended Addressees	Information Element	Involved Operational Activities	Interaction Rules and Policy	Status	Rationale	Satisfied DOD Requirement Identifier	Service Identifier
IER-5.6.4-IERS-0032-110	CTA Status	Aircraft	Stakeholder ATSU	AMAN Handling Indicators (See New Information Elements)	Assign CTA Implement Updated Arrival Sequence	See below	<Validated>	REQ-5.6.4-OSED-0028 -0710	REQ-05.02-DOD-OPR1-0004<Partial>; REQ-05.02-DOD-OPR1-0011<Partial>	
IER-5.6.4-IERS-0032-120	CTA status	Stakeholder ATSU	Arrival Management	AMAN Handling Indicators (See New Information Elements)	Assign CTA Implement Updated Arrival Sequence	See below	<Validated>	REQ-5.6.4-OSED-0028 -0710	REQ-05.02-DOD-OPR1-0004<Partial>; REQ-05.02-DOD-OPR1-0011<Partial>	
IER-5.6.4-IERS-0032-121	Airborne Trajectory	Aircraft	Arrival Management	FMS Trajectory (e.g. as ADS-C EPP report)	Implement Updated Arrival Sequence	See below	<Validated>	REQ-5.6.4-OSED-0028 -0640	REQ-05.02-DOD-OPR1-0004<Partial>; REQ-05.02-DOD-OPR1-0011<Partial>; REQ-05.02-DOD-OPR1-0014<Partial>	

Table 18: IER Overview Additional Information Exchanges required for i4D/CTA operations

Identifier	Name	Issuer	Intended Addressees	Information Element	Involved Operational Activities	Interaction Rules and Policy	Status	Rationale	Satisfied DOD Requirement Identifier	Service Identifier
For info only	Ground Trajectory Information	(automated)	Arrival Management	Shared and Reference Business Trajectory	Implement Updated Arrival Sequence	See below	<Validated>	REQ-5.6.4-OSED-0028 -0640	REQ-05.02-DOD-OPR1-0004<Partial>; REQ-05.02-DOD-OPR1-0011<Partial>	
For info only	Flight Plan and Coordination Information	(automated)	Arrival Management	Flight Plan Messages	Implement Updated Arrival Sequence	See below	<Validated>	REQ-5.6.4-OSED-0028 -0070 -0520	REQ-05.02-DOD-OPR1-0004<Partial>; REQ-05.02-DOD-OPR1-0011<Partial>	

Table 19: IER Overview Reference Information Exchanges required by the AMAN Tool

6.9.1 Interaction Rules and Policies

Note: The following table is only indicative and not fit for use in Service Activities. The normative information will be contained in the SPR/INTEROP.

Information Exchanges for baseline and extended horizon operations

Identifier	Name	Issuer	Intended Addressees	Interaction Rules and Policy					
				Interaction Type	Frequency	Maximum Time of Delivery	Confiden-tiality	Safety Criticality	Comments
IER-5.6.4-IERS-0032-0010	Arrival Management Information_UA	Arrival Management	Stakeholder ATSU	<One-way>	Ad hoc (at each recalculation with significant impact of STA/STO)	< 1 s (approach center, airport) < 10 s(enroute center)	<restricted>	<minor>	Misunderstanding of the sequence in approach center could lead to erroneous tactical instructions.
IER-5.6.4-IERS-0032-0020	AMAN Plan Implementation	Stakeholder ATSU	Flight Crew	<One-way>	<ad hoc>	< 10s	<restricted>	<minor>	Efficiency loss but should not endanger separation
IER-5.6.4-IERS-0032-0030	Arrival Management Information_DA	*Arrival Management*	*Destination Airport*	<One-way>	*TBC*	*TBC*	*TBC*	*TBC*	*Consumer requirements not available*
IER-5.6.4-IERS-0032-0040	Runway Usage Constraints	Destination Airport	Arrival Management	<One-way>	<ad hoc>	< 10s	<restricted>	<minor>	Computation of the sequence for an incorrect set of constraints could lead to erroneous tactical instructions

Table 20: IER Interaction Rules and Policies

Additional Information Exchanges required for satellite airport integration

Identifier	Name	Issuer	Intended Addressees	Interaction Rules and Policy					
				Interaction Type	Frequency	Maximum Time of Delivery	Confiden-tiality	Safety Criticality	Comments
IER-5.6.4-IERS-0032-0050	Arrival Management Information_UG	Arrival Management	Satellite Airport	<One-way>	<ad hoc> (at each recalculation with significant impact of TTL for flights at airport in question)	<10 s	<restricted >	<minor>	Efficiency loss but should not endanger separation
IER-5.6.4-IERS-0032-0060	Departure Planning Information	Satellite Airport	Arrival Management	<One-way>	<ad hoc>	< 10 s	<restricted >	<minor>	Efficiency loss but should not endanger separation

Table 21: IER Interaction Rules and Policies

Additional Information Exchanges required for satellite airport integration

Identifier	Name	Issuer	Intended Addressees	Interaction Rules and Policy					
				Interaction Type	Frequency	Maximum Time of Delivery	Confiden-tiality	Safety Criticality	Comments
IER-5.6.4-IERS-0032-0050	Arrival Management Information_UG	Arrival Management	Satellite Airport	<One-way>	<ad hoc> (at each recalculation with significant impact of TTL for flights at airport in question)	<10 s	<restricted >	<minor>	Efficiency loss but should not endanger separation
IER-5.6.4-IERS-0032-0060	Departure Planning Information	Satellite Airport	Arrival Management	<One-way>	<ad hoc>	< 10 s	<restricted >	<minor>	Efficiency loss but should not endanger separation

Table 22: IER Interaction Rules and Policies

Additional Information Exchanges required for i4D/CTA operations

Identifier	Name	Issuer	Intended Addressees	Interaction Rules and Policy					
				Interaction Type	Frequency	Maximum Time of Delivery	Confidentiality	Safety Criticality	Comments
IER-5.6.4-IERS-0032-110	CTA Status	Aircraft	Stakeholder ATSU	<One-way>	<ad hoc>	< 10 s	<restricted>	<minor>	Efficiency loss but should not endanger separation
IER-5.6.4-IERS-0032-120	CTA status	Stakeholder ATSU	Arrival Management	<One-way>	<ad hoc>	< 10 s	<restricted>	<minor>	Efficiency loss but should not endanger separation
ER-5.6.4-IERS-0032-120	Airborne Trajectory	Aircraft	Arrival Management	<Collaboration>	<ad hoc>	< 20 s	<restricted>	<minor>	Loss of airborne trajectory compromises CTA/i4D operation.

Table 23: IER Interaction Rules and Policies

Reference Information Exchanges required by the AMAN Tool

Identifier	Name	Issuer	Intended Addressees	Interaction Rules and Policy					
				Interaction Type	Frequency	Maximum Time of Delivery	Confidentiality	Safety Criticality	Comments
For info only!	Ground Trajectory Information	(automated)	Arrival Management	<Collaboration>	<ad hoc> (as dictated by trajectory updates)	< 1s	<restricted>	<minor>	Loss of trajectory renders the sequence useless.

Identifier	Name	Issuer	Intended Addressees	Interaction Rules and Policy					
				Interaction Type	Frequency	Maximum Time of Delivery	Confiden-tiality	Safety Criticality	Comments
For info only!	Flight Plan and Coordination Information	(automated)	Arrival Management	<One-way>	<ad hoc>	< 10s	<restricted>	<minor>	Loss of flight plan information impedes the sequence prediction, leading to loss of efficiency
For info only!	Surveillance Information	(automated)	Arrival Management	<One-way>	<periodical>l	~ 5s (radar update)	<restricted>	See note	Loss of surveillance input compromises the AMAN trajectory.

Table 24: IER Interaction Rules and Policies

7 References

7.1 Applicable Documents

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

[1] Template Toolbox 03.00.00
https://extranet.sesarju.eu/Programme%20Library/SESAR%20Template%20Toolbox.dot

[2] Requirements and V&V Guidelines 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Requirements%20and%20VV%20Guidelines.doc

[3] Templates and Toolbox User Manual 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Templates%20and%20Toolbox%20User%20Manual.doc

[4] EUROCONTROL ATM Lexicon
https://extranet.eurocontrol.int/http://atmlexicon.eurocontrol.int/en/index.php/SESAR

7.2 Reference Documents

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

[5] SESAR P5.6.4 V1 Stream B Report: Advanced Techniques for Arrival Sequencing; 21/10/2010

[6] SESAR P5.6.4 V1 Stream C Report: Extending the Arrival Management Horizon; 29/10/2010

[7] SESAR P5.6.4 V1 Stream E Report: The Use of Air Derived Data in Arrival Management; 27/10/2010

[8] SESAR P5.6.4 D28 Preliminary OSED 00.01.00 14/07/2012

[9] SESAR P5.6.4 D29 Initial Operational Requirements 00.02.02 11/07/2011

[10] SESAR DLT-0612-222-02-00_D3_Concept of Operations_V2.0 09/01/2008

[11] SESAR WPB4.2 Actors Roles and Responsibilities v00 01 05 May 2011

[12] SESAR P5.5.1 D06 Phase 1 Validation Report 00.01.04 02/05/2012

[13] SJU - Operational Focus Area – Programme Guidance 03.00.00 04/05/2012

[14] SESAR D98 WP 4 Detailed Operational Description Step 1 V7.0 Final Submission to SJU

[15]SESAR DEL05.02-D84 - Step 1 DOD Report - 2014 Update

[16]SESAR P5.6.4 - D76 - V2 validation report Stream C - internal 8 v 1.0 - 31/03/2014

[17] SESAR P5.6.4 D31 VP 244 Validation Report 13/05/2013

[18] EXE-05.06.04-VP-184 Validation Report (VALR) 12/12/2013

[19]SESAR P05.06.07 D06 Technical Note to 5.6.4 OSED SPR INTEROP - Step 1

[20]SESAR P5.6.1 Step 1 OSED - Iteration 3_M194_v1.0_20130920.doc

[21]SESAR P5.6.4 D32 Updated OSED 02.00.00 21/02/2014

[22]SESAR P5.6.4 D35 Consolidated OSED 03.00.00 14/01/2015

[23]SESAR P5.6.7.D49 VALR EXE-5.6.7-VP-695 00.01.00 17/04/2015

[24]SESAR B04.02 CONOPS Step 1

Appendix A Justifications

NA

Appendix B New Information Elements

The following New information elements are an extract from DEL 05.06.07 D06-Technical note to P5.6.4 OSED SPR INTEROP

B.1 Current AMAN Information Elements

This section captures the Information Elements defined in 5.6.4 D32 that are used in the description of the 'Baseline Arrival Manager functionality'. In absence of any previous standardization of arrival management functionality (beyond implicit definitions in the OLDI 4.2 AMA message), these Information Elements are here reported as 'new' to ensure that they are entered into the repository.

B.1.1 Target Times for Arrival Management

The SESAR Lexicon currently does not include a definition of 'Target Time Over' (TTO) and a definition of 'Target Time of Arrival' (TTA) that is sufficiently precise for the purposes of this OSED. Therefore, the present OSED uses the TTO and TTA definitions given below. They are generalizations from the SESAR Lexicon definition of 'Target Landing Time' (TLDT) which reads

"*Targeted Time from the Arrival management process at the threshold, taking runway sequence and constraints into account. It is not a constraint but a progressively refined planning time used to coordinate between arrival and departure management processes.*"

It should be noted that the precise relations between the TTA definition used in this OSED and in other SESAR projects will be revisited as part of Step 2 work within OFA04.01.02.

Identifier	IE-5.6.4-0032-0001
Name	Target Time Over (TTO)
Description	A progressively refined ATM planning Time Over a Significant Point which is not a constraint.
Properties	"Significant Point" as defined by ICAO and contained in AIRM.
Rules applied	
Comments	Synonym: Target Time of Arrival (when used in AMAN context). Sometimes TTA and TTO are not discriminated. TTO is primarily relevant to the En-route point environment. See below.

Identifier	IE-5.6.4-0032-0002
Name	Target Time of Arrival (TTA)
Description	A Target Time Over referring to a Significant Point associated to an Airport.
Properties	"Significant Point" as defined by ICAO and contained in AIRM.
Rules applied	
Comments	The current definition of TTA in the SESAR lexicon is "*An ATM computed arrival time. It is not a constraint but a progressively refined planning time that is used to coordinate between arrival and departure management applications*". The issue with this definition is that concept of "time of arrival" is not well defined (there are conflicting definitions in ICAO and SESAR terminology). Therefore the above definition, which explicitly includes a point of reference, is proposed as a revision of the Lexicon.

B.1.2 Controlled Time of Arrival

The notion of a "Controlled Time of Arrival" is not particular to this OFA. The definition given below is based on 05.06.01 D67 (i4D & CTA OSED Step 1, 2nd iteration). It is included for reference because it constitutes a slight refinement of the current definition in the SESAR lexicon (*"An ATM imposed time constraint on a defined merging point associated to an arrival runway"*)

The change from 'arrival runway' to 'arrival airport' needs to be discussed with P5.6.1.

Identifier	IE-5.6.4-0032-0003
Name	Controlled Time of Arrival
Description	An ATM imposed time constraint on a defined point associated with an arrival airport using airborne capabilities to improve arrival management.
Properties	"Significant Point" as defined by ICAO and contained in AIRM.
Rules applied	
Comments	Abbreviation: CTA See REQ.5.6.4-OSED-0028-0710

B.1.3 Point definitions

Identifier	IE-5.6.4-0032-0004
Name	Metering Fix
Description	A reference point over which traffic is metered, i.e. measured and/or spaced in time.
Properties	See "Significant Point" as defined by ICAO and contained in AIRM.
Rules applied	
Comments	Abbreviation: MF Synonyms: Metering Point, CTA Point (in the context of CTA operations) See REQ.5.6.4-OSED-0028-0230

B.1.4 Horizon Definitions

The following definitions are not required to cover the Information Exchange Requirements listed in Section 6.2 of the OSED. They are integrated into this document because these terms are not yet defined anywhere in the literature but should be integrated into the ATM dictionary.

Identifier	IE-5.6.4-0032-0011
Name	Eligibility Horizon
Description	The boundary of the airspace within which Arrival Management receives flight progress information for every aircraft bound for the arrival managed airport.
Properties	Aerodrome for which the horizon is used. Defined by ICAO (see AIRM).
Rules applied	
Comments	Abbreviation: EH See REQ.5.6.4-OSED-0028-0030 The Eligibility Horizon may be defined either as a time horizon or a geographical area.

Identifier	IE-5.6.4-0032-0012
Name	Active Advisory Horizon
Description	The Arrival Management horizon at which advisories for AMAN sequence implementation presented to the ATCO are reliable and useful (i.e. stable)
Properties	Aerodrome for which the horizon is used. Defined by ICAO (see AIRM)..
Rules applied	

Comments	Abbreviation: AAH See REQ.5.6.4-OSED-0028-0080

Identifier	IE-5.6.4-0032-0013
Name	Metering Horizon
Description	The horizon where aircraft are given a target time for the Metering Point
Properties	Aerodrome for which the horizon is used. Defined by ICAO (see AIRM)..
Rules applied	
Comments	Abbreviation: MH

Identifier	IE-5.6.4-0032-0014
Name	Stable Sequence Horizon
Description	The arrival management horizon within which no automatic swapping of flights in the sequence will occur, but landing time will still be updated by the AMAN algorithm.
Properties	Aerodrome for which the horizon is used. Defined by ICAO (see AIRM)..
Rules applied	
Comments	Abbreviation: SSH See REQ-5.6.4-0028-0170

Identifier	IE-5.6.4-0032-0015
Name	Frozen Horizon
Description	The arrival management horizon within which no automatic swapping of flights in the sequence, and no update of landing time will occur.
Properties	Aerodrome for which the horizon is used. Defined by ICAO (see AIRM)..
Rules applied	
Comments	Abbreviation: FH See REQ-5.6.4-OSED-0200

B.1.5 Time definitions

Identifier	IE-5.6.4-0032-0021
Name	AMAN Planned Threshold Time
Description	The time, calculated by the Arrival Manager tool, at which the aircraft is planned to cross the runway threshold This is also the landing time shown to the Controller on the AMAN timeline.
Properties	Runway / runway direction the time refers to. Defined by ICAO (see AIRM).
Rules applied	
Comments	Abbreviation: APTT Synonyms in use: Optimal Time of Arrival (OTA) See REQ.5.6.4-OSED-0028-1030 Note: could in the future be extended to landing, runway exit … see OFA 04.01.01 and 04.02.01. • In previous work, this time has also been referred to as “Scheduled Time of Arrival” (STA). However, in the wider ATM community, “STA” is predominantly used with a different meaning, namely as the planned arrival time used in Airport Slot Allocation during the strategic planning phase.

	• There is a functional difference between the APTT (which is the automated proposal of the AMAN optimization algorithm) and the TLDT (which is the shared planning objective based on the APTT but subject to stakeholder discretion). • For the definition of TLDT see the SESAR Lexicon (also quoted above). Notice that other than stated in Chap 3.6.2.1, TLDT is not part of Airport CDM.

Identifier	IE-5.6.4-0032-0022
Name	AMAN Planned Time Over
Description	The time, computed by the Arrival Manager tool, at which the aircraft is predicted to be over a significant point (in particular, the metering point).
Properties	Significant point the time refers to. Defined by ICAO (see AIRM).
Rules applied	
Comments	Abbreviation: APTO Synonyms in use: Optimal Time Over (OTO) See REQ-5-6-4-OSED-0028-0260 Notes: see IE-5.6.4-0032-0021

Identifier	IE-5.6.4-0032-0024
Name	Time To Gain / Time to Lose
Description	An arrival management advisories in form of the amount of time that a flight is supposed to lose or gain to arrive at the Metering Fix to land at the AMAN planned threshold time.-
Properties	Metering Point the advisory refers to. See “Metering Point” Information Element
Rules applied	
Comments	Abbreviation: TTL/TTG See REQ.5.6.4-OSED-0028-0260 Notice that this definition is aligned with ADEXP.

B.1.6 Definitions related to Arrival Management Information

Identifier	IE-5.6.4-0032-0031
Name	Landing Sequence
Description	The order in which two or more aircraft are planned to land taking into account ATM constraints, i.e. the order by APTT.
Properties	Runway / Runway direction referenced Set of flights, ordered by time. For each flight, (selected) Arrival Management Information -- see below. Optional: AMAN strategy in effect – see below
Rules applied	
Comments	Synonyms in use: Arrival Sequence, Runway Sequence, Planned Sequence See REQ.5.6.4-OSED-0028-0160 Notice • The ‘Landing Sequence’ Information Element is generally considered the ‘container’ for communicating any operationally relevant data item

	output by the AMAN tool. • The properties listed above are either defined as Information Elements elsewhere in this section, or already available in the AIRM

Identifier	IE-5.6.4-0032-0032
Name	Arrival Management Information
Description	Information Record for a given flight subject to Arrival Management, as issued by the AMAN support tool
Properties	Contents of the record depend on the Information Exchange in question. I.e. 'required' items must always be present, whereas "optional" items can be omitted if not mandated for the operational purpose of a given Information Exchange Required • Identifier (e.g. ARCID, ADEP, ADES, EOBT, <EOBD>) – ICAO defined Optional[36] • APTT – see IE defined above • Runway assigned to flight • Sequence Number – see below • Arrival Delay (global)[37] – see below • Delay Share assigned to recipient • Time and delay at metering fix and other designated points on the trajectory -- see other IEs in this section • Advisories (e.g. TTL/TTG, speed advisory, route advisory ...) proposed by AMAN -- see IE above for TTL; AIRM definition for speed advisory • Aircraft performance characteristics (e.g. type of aircraft, wake turbulence category, ...) -- see ICAO definitions / AIRM • AMAN handling indicators – see new Information Element • *Miles to fly to threshold* Notes: • Logically, "CTA" could be grouped here. However, whether or not this information is to be considered part of the present Information Element needs to be discussed with 5.6.1. As mentioned above, this is out of scope of the OSED. • *The "miles to fly to threshold" property has been identified in a post-OSED discussion and is listed here as a suggestion for inclusion in the consolidated OSED*.

Identifier	IE-5.6.4-0032-0033
Name	Runway Usage Constraints
Description	The set of parameters describing the available capacity of runway(s) available to Arrival Management in operational terms.

---

[36] Depends on local implementation

[37] There was no operational consensus on this point. So the definition given is only tentative, as required for the upcoming exercise EXE-5.6.7-VP-695.

Properties	Depending on local procedures and implementation decisions, this may comprise, for instance • Runway in use / closure / change / change of mode • ILS category • Landing Rate / Flow Rate / Runway Pressure • Arrival Free Interval (request) • AMAN strategy (request)
Note	As this Information Element is so strongly implementation dependent, a detailed description of the property of general applicability cannot be provided.

New Properties

Note: This paragraph contains preliminary information only!

The following properties of 'Arrival Management Information' are not IEs and not defined elsewhere, therefore they should be taken into account when updating the OSED, i.e. D35 [22]:

Identifier	IE-5.6.4-0032-0032-PR001
Name	Sequence Number
Description	The ordinal number describing the position of a flight in the temporal sequence of threshold crossings. This is fixed for a given flight when the sequence is frozen, it does NOT change when the first plane lands. This is required to improve situational awareness by directly showing the ordering of flights, see REQ-5.6.4-OSED-0028-0690
Value Range	Integer > 0

Identifier	IE-5.6.4-0032-0032-PR002
Name	Arrival Delay[38]
Description	For the purposes of the EXE-695, defined as the difference between time APTT and ETA as per the flight plan instance maintained by the flight data processing system used by the Sequence Manager.
Value Range	Numeric

Identifier	IE-5.6.4-0032-0032-PR003
Name	AMAN Strategy
Description	The name of the set of operational rules and procedures underlying the AMAN tool optimisation algorithm. The strategy implements the trade-off between the goals of equity, high throughput, and trajectory efficiency which has agreed between the stakeholders
Value Range	Implementation dependent character string

B.1.7 New AMAN Information Elements

This section captures the Information Elements defined in 5.6.4 D32 [21] onwards that are used in the new operational concepts introduced. Note that not all of these terms are actually used in the Information Exchange Requirements.

---

[38] There was no operational consensus on this point. So the definition given is only tentative, as required for the upcoming exercise EXE-5.6.7-VP-695.

Identifier	IE-5.6.4-0032-0101
Name	Long Range Eligibility Horizon
Description	The extended boundary of the airspace within which Arrival Management receives early flight progress information for every aircraft bound for the arrival managed airport.
Properties	Aerodrome(s) for which the horizon is used. Defined by ICAO (see AIRM).
Rules applied	
Comments	Abbreviation: LREH

Identifier	IE-5.6.4-0032-0102
Name	Initial Metering Horizon
Description	Aerodrome(s) for which the horizon is used. Defined by ICAO (see AIRM).
Properties	The horizon where aircraft are given a target time for the Initial Metering Fix.
Rules applied	
Comments	Abbreviation: IMH See REQ-5.6.4-OSED-0028-1020

Identifier	IE-5.6.4-0032-0103
Name	Initial Metering Fix
Description	In the context of long-range arrival management, a point on a route towards which flights can be pre-sequenced for an arrival-managed airport.
Properties	See "Significant Point" as defined by ICAO and contained in AIRM.
Rules applied	
Comments	Abbreviation: IMF Synonyms: Initial Metering Point See REQ.5.6.4-OSED-0028-1030

Identifier	IE-5.6.4-0032-0104
Name	AMAN Handling Indicator
Description	Descriptors of the status of a flight in the sequencing process, as required to give the executive controller appropriate situational awareness, e.g. 'Pre-sequenced', 'CTA accepted', See REQ-5.6.4-OSED-0028-0690, -0710
Value Range	Enumeration of predefined codes. Implementation dependent -- depends on procedures implemented in the ATCC in question.

Appendix C Significant results linked to the Operational Concept

According to the concept expressed in section 2.2 of this Consolidated OSED the validation campaigns carried out till nowadays by P05.06.04 and P05.06.07 have provided the following outputs for the main KPAs

KPA	P05.06.04 validation Outputs	P05.06.07 Validation outputs
Flight Efficiency, Environmental Sustainability and Fuel Efficiency	Rome 250 NM extension: Track miles are decreased considering the overall results analysed. Path stretching reduction in TMA sectors has also been observed. Due to the application of extended horizon arrival management concept lower fuel consumption and distance flown have been assessed for the most of analysed configurations. Such reduction is especially well marked in the three sectors closest to the airports of Rome, while a small increase in overall fuel consumption was recorded for just one complete traffic pattern. The results highlight that an accurate arrival management over traditional routing, enabled by E-AMAN concept, is potentially beneficial for the environment. A reduction of holdings has also been assessed comparing the solution scenarios (E-AMAN) with reference. London 550 NM extension: Aircraft saved between 68 and 98kgs of fuel per flight during the en route portion assessed.	The trajectory element of the i4D concept was seen as showing significant promise for future operations
Predictability	Analysis run in agreement with the WPB4.1guidelines (delay time <10 min) suggests that the trajectories predictability takes advantage of the use of E-AMAN mainly in high traffic load condition. Particularly, E-AMAN tool maximizes its benefit on traffic predictability reducing (even if not statistically significantly) the average delay time of traffic in high density	The predictability and precision of traffic delivery from En-Route to TMA was improved, resulting in the controller needing to interfere less.

	scenario. Predictability was also addressed by EXE-05.06.04-VP-184 FTS: Considering the reduction of total delayed flights for LIRA and LIRF airports the predictability is increased	
Capacity	This aspect was not assessed directly. An increase of estimated sector capacity was assessed by EXE-05.06.04-VP-184	The AMAN and the arrival procedures needs to further developed by including ATC strategies (e.g. overtaking principles in TMA) to improve optimisation and ability to increase runway throughput.
Human Performance	The E-AMAN concept and the delay sharing technique (DS) were considered acceptable by ATCOs as potential improvement for the traffic synchronization in TMA. MI and TS sectors report the main advantage in terms of perceived MWL, showing a lower rate compared to the baseline. The extended TMA sectors (especially NE and NW) on the contrary, reported that the need to monitor and implement the time advisories issued by delay sharing, represent for them an additional task that may increase their taskload, although still maintaining it at acceptable levels. The taskload of TMA controller slightly increase in E-AMAN condition. This effect is likely due to the technical issues encountered during the evaluation. The analyses conducted in terms of tactical intervention issued by ATCOs working with and without E-AMAN, provide further support to these results. Supplementary EXE-05.06.04-VP-184 FTS showed a reduction of a total daily ATCO's workload.	Both the Extended AMAN Horizon and the i4D/CTA concepts worked sufficiently well in the implemented environment (medium complexity)

The Security KPA was not object of the P05.06.04, for this reason was not addressed during the validation campaigns. P16.06.02 produced an E-AMAN security case that is reported in the Appendix D.

Appendix D Extended AMAN Security Case

Note: Old information has been deleted! Please refer to SPR/INTEROP D16-05.06.07 for updated Security Assessment including resulting security requirements.

-END OF DOCUMENT-