S01V3 Final SPR

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Abstract

This document collects P06.08.04 final Step1V3 Safety and Performance Requirements. It addresses requirements that apply to Operational concept elements that are described in S1V3 Final OSED [9] according to the results obtained in S1V3 validation exercise EXE-06.08.04-VP-453 [12], which further refined previous S1V2 validations addressing Coupled AMAN/DMAN [12]. Such operational concept has adopted a pattern based solution in Step 1, where AMAN acts as master to DMAN in optimising the traffic flows. The process executed to define the requirements is illustrated in detail in Appendix A.

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Rational for rejection
None.

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00.00.03	16/04/2015	Draft		Updated Draft integrating further ENAV and NATS inputs and ready for internal and external review
00.01.00	04/05/2015	Final		Updated Draft integrating internal and external review comments and ready for approval
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00.01.10	15/08/2015	Final		Integration of 16.6.1 comments
00.01.11	28/09/2015	Final		Status of Requirements updated

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Executive summary

This document contains final S1V3 list of Safety and Performance requirements (SPR) of SESAR P06.08.04 “Coupled AMAN/DMAN”, within the scope of OFA04.01.01 Integrated AMAN and DMAN. It addresses SPR requirements that apply to the operational concept elements of P06.08.04.D17 S1V3 Final OSED, edition 00.01.00 [9].

The following operational improvement steps (as described in DS13) are addressed in this SPR:

- **Solution #53 ‘Pre-Departure Sequencing supported by Route Planning’**

  TS-0202 - Pre-Departure Sequencing supported by Route Planning
  Pre-Departure management has the objective of delivering an optimal traffic flow to the runway. Accurate taxi time forecasts provided by route planning are taken into account for TSAT-Calculation before off-block. Pre-Departure sequence (TSAT sequence) is set up by Tower Clearance Delivery Controllers who will follow TSAT-window when issuing startup approval.

- **Solution #54 ‘Flow based Integration of Arrival and Departure Management’**

  TS-0308 - Flow based Integration of Arrival and Departure Management
  Integrated Arrival and Departure management aims at increasing throughput and predictability at an airport by improved co-ordination between En-Route/Approach and Tower controllers. Arrival and Departure flows to the same runway (or for dependent runways) are integrated by setting up fixed arrival-departure pattern for defined periods. The successive pattern might be chosen by the operators or provided by an optimization algorithm considering arrival and departure demand. Departure flow to the runway is managed by pre-departure sequencing (integrating route planning) while arrival flow to the runway is managed by arrival metering.

From the safety perspective, the safety assessment intends to analyse two scenarios:

- Success: Referred to the pre-existing hazards which by definition exist in the operational environment before any form of de-confliction has taken place.
- Failure: Referred to failure of the change introduced and not with what the change is required to do in the first place. Therefore this phase includes the conditions under which the system has to operate in degraded mode

The main results derived from that assessment are:

- Safety objectives to maximise the safety benefit from the introduction of the concept and to mitigate the operational effects of system-generated hazards.
- Safety requirements to meet the above defined safety objectives. They could be seen as risk mitigation means required to reduce the risk (s) to a tolerable level.

From a performance perspective, the OPA aims at defining the performance requirements associated to the Coupled AMAN/DMAN. To achieve these objectives, Key Performance Areas (KPAs) and related Key Performance Indicators (KPIs) expected to be impacted by the Coupled AMAN/DMAN have been considered as a starting point. At this stage, the main KPAs identified are capacity, efficiency, predictability, environmental sustainability and cost effectiveness. The concept is not expected to deliver safety benefits however, no safety detriment is anticipated ((expert judgement).

The Performance Indicators evaluated in this SPR S01V3 according to the Validation reports available:

P06.08.04.D09 Validation Basic DMAN/A-SMGCS Report v00.01.00 [10],

P06.08.04.D11 S01V2 Validation Report Basic AMAN/DMAN v00.01.00 [11],

P06.08.04.D12 S1V3 AMAN/DMAN/A-SMGCS Validation Report V2 00.01.01 [12], P06.08.04-D16 EXE-06.08.04-VP-453 [13].

1 Introduction

1.1 Purpose of the document

This Safety and Performance Requirements (SPR) document provides P06.08.04 Step 1 Final Safety and Performance requirements for Services related to the operational processes detailed in the P06.08.04.D17 S1V3 Final OSED, edition 00.01.00 [9].

1.2 Scope

This SPR document contributes to the Operational Focus Area OFA04.01.01 "Integrated AMAN/DMAN" as part of the Operational Sub Package "SPC04.01 Traffic Synchronisation" of the Operational Package "PAC04 End to End Traffic Synchronisation", and to SESAR solution #15: "Integrated and throughput-optimised sequence of arrivals and departures".

This document supports the operational services and concept elements identified in the P06.08.04.D17 S1V3 Final OSED, edition 00.01.00 [9], being its objective to ensure and demonstrate that the implemented systems can meet the relevant safety and performance requirements for the services described in the OSED.

To this aim the document updates the initial analysis of the KPAs impacted by the Coupled AMAN/DMAN and the specific KPIs involved for each KPA made in SPR S01V2 according to the results obtained in EXE-06.08.04-VP-453 [13].

This document covers a Success Case Analysis and a Failure Case Analysis for Coupled AMAN and DMAN.

- Success Approach: Referred to the pre-existing hazards which by definition exist in the operational environment before any form of de-confliction has taken place and which the concept is expected to mitigate
- Failure Case: Referred to risks introduced by the change. Therefore this phase includes the abnormal operating conditions under which the system has to operate in degraded mode

The main results derived from that assessment are:

- Safety objectives to maximise the safety benefit from the introduction of the concept and to mitigate the operational effects of system-generated hazards.
- Safety requirements to meet the above defined safety objectives. They could be seen as risk mitigation means required to reduce the risk (s) to a tolerable level.

With the distance based coupled AMAN/DMAN the operational procedures for controllers do not change compared to current operations with un-coupled AMAN & DMAN systems (as described in the OSED). What changes is just the underlying planning algorithm of AMAN and DMAN. Therefore only the same hazards as in current operations can occur. These hazards are already safety assessed for the existing systems.

The following assumption has to be considered for the SPR:

HMI Design is covered at very high level in the OSED as various specific local implementations already exist for an AMAN and a DMAN that are uncoupled. The HMI for a coupled AMAN/DMAN therefore will most probably also be locally different. Therefore the safety objectives and requirements are at very high level in this document.

This document does not cover:

- Time-Based Spacing
  TBS is covered by Project P06.08.01 (Flexible and Dynamic Use of Wake Vortex Separations) and is not addressed in this SPR.
- An analysis of the baseline scenario (Uncoupled AMAN and DMAN)
  The safety objectives and safety requirements that apply for a basic AMAN that is not coupled to DMAN still apply for the coupled AMAN/DMAN. This is addressed in the assumption made in chapter 2.6. The baseline systems of AMAN and DMAN (not coupled with each other) are in operations today and have undergone safety assessments.
  This explains why there are not so many safety objectives and requirements for the coupled AMAN/DMAN.
- A-CDM
  A-CDM is also a baseline for the coupled AMAN/DMAN and is not addressed in the SPR (except for referencing to TOBT as input to DMAN)

It also needs to be highlighted that the Safety Target for coupled AMAN/DMAN is zero, i.e. the coupled AMAN/DMAN is not expected to increase safety (compare 6.2 VALS [14]). The concept is not expected to deliver safety benefits however, no safety detriment is anticipated (expert judgement).

The comments provided from EASA on a previous version (D14) were considered.

The hierarchy of the main operational deliverables within SESAR and their relation with the SPR is presented in Figure 1 below.

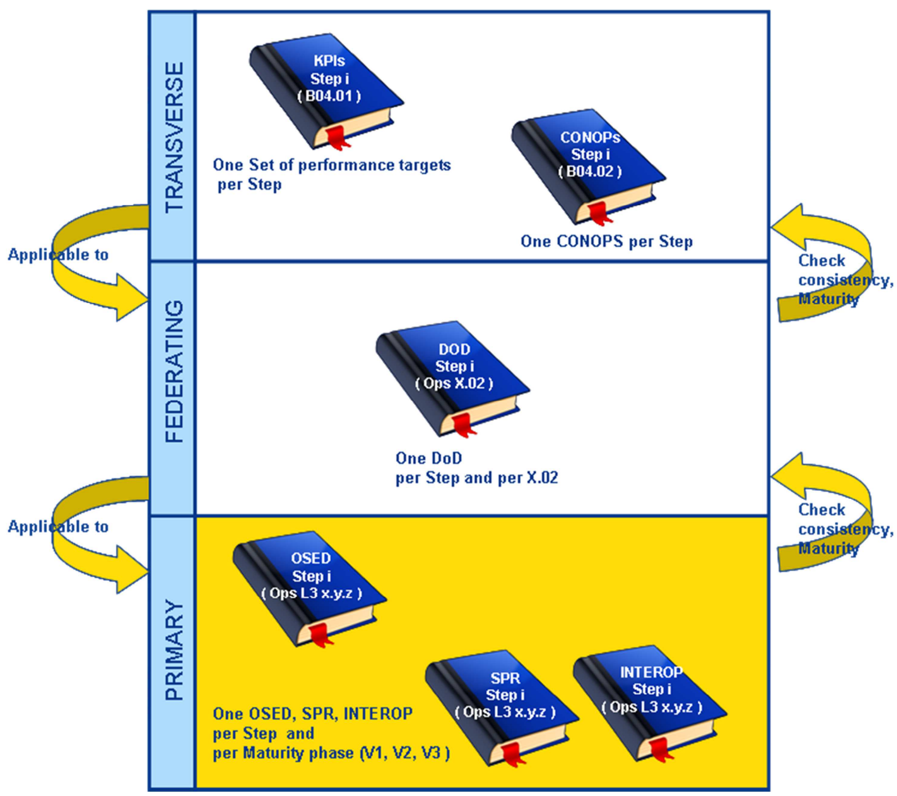

Figure 1: SPR document with regards to other SESAR deliverables

In the Figure 1, the Steps are driven by the OI Steps addressed by the project in the B.01 Integrated Roadmap [19].

1.3 Intended readership

Following projects could be interested in this Final SPR document:

- Primary projects P06.07.02 (A-SMGCS Routing and planning) and P06.07.03 (A-SMGCS Guidance) as a full integration between departure management and Routing and Planning service is expected to optimize the departing traffic flow;
- P12.04.04 (Integration of Departure Management and Surface Management), as the safety and performance requirements related to the integration between departure and surface management have to be considered for future prototypes development;
- P10.9.1 (Integration of Queue Management) and P10.09.02 Multiple airport arrival/departure management to provide the reference set of Coupled AMAN/DMAN safety and performance requirements describing a basis for further operational improvements;
- P16.06.01 Safety support and coordination function in order to ensure that the safety aspects and analysis within this SPR are coherent across SESAR programme.
- P06.09.02 Advanced integrated CWP (A-CWP) to ensure HMI requirements coherence
- P06.02 for consolidation,
- WPB, transverse and federating projects for architecture and performance modelling;
- And, more generally, the SESAR JU community.

1.4 Structure of the document

The structure of this SPR is as follows:

- **Chapter 1** (the present section) provides general information about the document.
- **Chapter 2** provides a summary of the operational concept and services described within the P06.08.04.D17 S1V3 Final OSED, edition 00.01.00 [9].
- **Chapter 3** is dedicated to the collection of the safety and performance requirements coming from both safety and performance assessment
- **Chapter 4** lists the applicable and reference documents
- **Appendix A** describes the whole safety and performance assessment performed to derive the related requirements.

1.5 Background

This SPR is the Final SPR developed for the P06.08.04 Step 1. It uses as the main input the P06.08.04 D17 Final OSED [9], refined with the results obtained in EXE-06.08.04-VP-453 [13].

1.6 Glossary of terms

A list of the important terminology and acronyms used in this document is presented below; they are taken, when available, from the SESAR ATM Lexicon https://extranet.eurocontrol.int/http://atmlexicon.eurocontrol.int/en/index.php/SESAR.

Term	Definition	Source
AFI – Arrival Free Interval	*An AFI describes the standard amount of nautical miles (NM) to be maintained between two consecutive arrivals in order to process one or more departures in between. Internal to the system, those Nautical Miles shall have to be converted into times to be used by DMAN.*	*Internal 6.8.4*
Arrival Management Service	*Arrival Management Service describes the procedures used to establish sequences and target times planned by the arrival manager.*	*To be added to ATM-Lexicon*
Arrival Manager (AMAN)	*AMAN is 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*
AOBT	*The Actual Off-Block Time (AOBT) is the time the aircraft pushes back / vacates the parking position. (Equivalent to Airline / Handlers ATD – Actual Time of Departure & ACARS=OUT)*	*ATM-Lexicon*
ASAT	*Actual Start Up Approval Time is the time that an aircraft receives its start-up approval.*	*ATM-Lexicon*
A-SMGCS (Advanced – Surface Movement Guidance and Control System)	*A system providing routing, guidance and surveillance for the control of aircraft and vehicles in order to maintain the declared surface movement rate under all weather conditions within the aerodrome visibility operational level (AVOL) while maintaining the required level of safety.*	*ATM-Lexicon*
ATOT	*The Actual Take Off Time (ATOT) is the time that an aircraft takes off from the runway. (Equivalent to ATC ATD–Actual Time of Departure, ACARS = OFF).*	*ATM-Lexicon*
CTOT	*The Calculated Take Off Time (CTOT) is a time calculated and issued by the Central Flow Management unit, as a result of tactical slot allocation, at which a flight is expected to become airborne. (ICAO Doc 7030/4 – EUR, Table 7)*	*ATM-Lexicon*
Departure Management Service	*Departure Management Service describes the procedures used to establish sequences and target times planned by the departure manager.*	*To be added to ATM-Lexicon*

Term	Definition	Source
Departure Manager (DMAN)	*DMAN is 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.*	*ATM-Lexicon*
EOBT	*The estimated time at which the aircraft will commence movement associated with departure.*	*ATM-Lexicon*
EXOP	*The estimated Outbound Taxi (EXOP) is the Expected Taxi Period from Off-Block to Runway Holding Point (with no buffer or delay) i*	*To be added to ATM-Lexicon*
EXOT	*The estimated time between off-block and take off. This estimate includes any delay buffer time at the holding point or remote de-icing prior to take off.*	*ATM-Lexicon*
Late tweaks	*Short term changes of the planned sequence when the aircraft have already entered the TMA and are on the final or approaching the final*	*Internal 6.8.4*
Push-Back	*Movement of an aircraft on the ground consisting of leaving the parking area in reverse motion as far as alignment on the taxiway.*	*To be added to ATM-Lexicon*
Sequence Pattern	*The order in which aircraft are planned to use the RWY (either take-off or landing) describes the RWY sequence.* *Only looking at the departing aircraft describes the DEP sequence and only looking at the arriving aircraft describes the ARR sequence.*	*Internal 6.8.4*
TOBT	*The Target Off-Block Time (TOBT) is 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 Tower Controller.*	*ATM-Lexicon*
TSAT	*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* *Note: The actual start up approval (ASAT) can be given in advance of TSAT*	*ATM-Lexicon*
TSAT Window	*A time-frame of +/- 5 minutes around the TSAT, in which a Start-Up and Push-Back approval may be issued.*	*To be added to ATM-Lexicon*
TTOT	*The Target Take Off Time taking into account the TOBT/TSAT plus the EXOT.* *Each TTOT on one runway is separated from other TTOT or TLDT to represent vortex and / or SID*	*ATM-Lexicon*

Term	Definition	Source
	separation between aircraft.	
Tower Controller	*Position(s) or person(s) in a control tower responsible for take-off and landing of aircraft on airports.*	*To be added to ATM-Lexicon*
Variable Taxi Time	*The estimated time that an aircraft spends taxiing between its parking stand and the runway or vice versa.* *Variable Taxi Time is the common name for inbound (EXIT) and outbound (EXOT) taxi times, used for calculation of TTOT or TSAT.*	*ATM-Lexicon*

1.7 Acronyms and Terminology

Term	Definition
AFI	**RVT.ATC-01** Arrival Free Interval
ALDT	Actual LanDing Time
ANS	Air Navigation Service
ANSP	Air Navigation Service Provider
AOBT	Actual Off-Block Time
AODB	Airport Operational Data Base
ASOR	Allocation of Safety Objectives and Requirements
ATC	Air Traffic Control
ATCO	Air Traffic COntroller
ATM	Air Traffic Management
ATOT	Actual Take-Off Time
APP	Approach
ADD	Architecture Definition Document
AFI	Arrival Free Interval
AMAN	Arrival Manager
A-SMGCS	Advanced – Surface Movement Guidance and Control System
BC	Basic Causes

Term	Definition
CFMU	Central Flow Management Unit
DCB	Demand Capacity Balancing
DMAN	Departure Manager
DOD	Detailed Operational Description
EOBT	Estimated Off-Block Time
ELDT	Estimated LanDing Time
FCFS	First Come First Served
FDPS	Flight Data Processing System
FHA	Functional Hazards Assessment
HMI	Human Machine Interface
IER	Information Exchange Requirements
KPA	Key Performance Area
KPI	Key Performance Indicator
OFA	Operational Focus Area
OH	Operational Hazard
OHA	Operational Hazard Assessment
OI	Operational Improvement
OPA	Operational Performance Assessment
OSED	Operational Service and Environment Definition
PSSA	Preliminary System Safety Analysis
RCS	Risk Classification Scheme
SAC	Safety Criteria
SAM	Safety Assessment Methodology
SCS	Severity Classification Scheme
SESAR	Single European Sky ATM Research Programme
SJU	SESAR Joint Undertaking (Agency of the European Commission)

Term	Definition
SO	Safety Objectives
SOCS	Safety Objective Classification Scheme (SOCS)
SPR	Safety and Performance Requirements
SR	Safety Requirements
SRM	Safety Reference Material
SWIM	System Wide Information Management
TBD	To be Defined
TBS	Time-based Separation
TLDT	Target LanDing time
TOBT	Target Off-Block Time
TSAT	Target StArt-up Time
TTOT	Target Take-Off Time
TWR	Tower
VTT	Variable Taxi Time
WCC	Worst Credible Case

2 Summary of Operational Concept (from OSED)

2.1 Description of the Concept Element

The operational concept developed in the P06.08.04.D17 S1V3 Final OSED, edition 00.01.00 [9] describes the coupling between AMAN and DMAN envisaged for Step 1, which is based in a **master/slave configuration** where AMAN acts as master and DMAN as slave.

In this configuration, the AMAN calculates an arrival sequence (understood as a list of TLDTs) coordinated with the DMAN, that calculates a departure and a pre-departure sequence (understood as a list of TTOTs and TSATs, respectively). This coordination between them is based on an integrated arrival/departure sequence which is based on a fixed pattern and on Arrival Free Intervals (AFIs) which are input by Airport Tower Supervisor or by ACC/Approach Supervisor depending on local procedures.

Additionally, Step1 concept also sets the baseline for an additional optional support tool, in which the AMAN, taking into account the departure and the arrival demand, proposes to the Air Traffic Controllers an **arrival and departure pattern sequence** that optimize certain selected KPIs (such as minimum delay or maximal schedule adherence) using **Arrival Free Intervals** (AFIs) as input by the Airport Tower Supervisor or by ACC/Approach Supervisor depending on local procedures.

These AFIs would afterwards be filled by the DMAN to set the KPI-optimized Departure Sequence. This system would assist the operational controllers towards a more objective assessment of the situation in advance and would improve its management. This additional support tool, however, has not been validated so far and therefore its associated requirements are set as <In Progress>.

The establishment of an integrated arrival/departure sequence is directly linked to the optimization of the departure sequence and hence in turn to the optimization of the pre-departure (i.e. from the stand) sequence. For that reason, this SPR addresses also the integration between departure and surface management. However, for Step 1 that integration is limited just to a more accurate taxi-out time provided by Routing and Planning service. This is an improvement respect to the current situation where DMAN, operating in a standalone solution, takes as input static taxi-out time.

More into detail, this project address two Step 1 Operational Improvements:

- TS-0202: Pre-Departure Sequencing supported by Route Planning
- TS-0308: Flow based Integration of Arrival and Departure Management

2.2 Description of Operational Services

The operational processes addressed by P06.08.04 are the Turn-Round and the Surface-Out processes.

The operational services linked to the Turn-Round and Surface-Out processes in the scope of the project are triggered after the TOBT has been issued as input by the A-CDM. The services as described in the OSED and defined in the Airport DOD for Step 1 [15] are:

- RunwayMixSequence service
- CalculatedPreDepartureSequenceDelivery service

For more details, refer to the P06.08.04.D17 S1V3 Final OSED, edition 00.01.00 [9]. Although these operational services are not immediately related to AIM Model functions, the latter are presented in-depth with regards to Coupled AMAN/DMAN in section A.1.1.4 Affected AIM functions.

However as there are no services currently listed in the 06.02 DOD [15], these services are not aligned with a service hierarchy at a higher level and therefore have not been used to structuring the current version of the document.

2.3 Description of Operational Environment

The detailed operational environment, as defined in the P06.08.04.D17 S1V3 Final OSED, edition 00.01.00 [9], section 4, is given below:

2.3.1 Operational characteristics

This section provides an overlook of the operational characteristics of Step 1 Coupled AMAN/DMAN concept. More information on this topic can be found in section 4.1 "Operational Characteristics" of the S1V3 OSED [9].

- Airport Layout:
  applicable for all layouts, from single to multiple runways.
- Runway Operating Mode:
  though all mode operations (mixed, segregated) can be handled, the focus will be on single runway with mixed mode operations.
- Route Structure:
  The departure routes and missed approach routes do not diverge directly at the end of the runway.
- Separations:
  vortex separations have to be respected, although in general the same separations will be chosen for a certain pattern for a longer time interval (most conservative ones).
- Traffic:
  provides highest benefits in high traffic density situations.
- Weather:
  all weather conditions

2.3.2 Roles and Responsibilities

This section provides an overlook of the roles and responsibilities of Step 1 Coupled AMAN/DMAN concept. More information on this topic can be found in section 4.2 "Operational Characteristics" of the S1V3 OSED [9].

- Approach and Tower Supervisor
  will agree on sequence pattern and AFI-Size. It is decided at local level if it is the Approach Supervisor or Tower Supervisor who will input the respective values for pattern and AFI-Size into AMAN.
- Approach controllers
  will as in previous operating method establish the landing sequence considering the agreed sequence pattern and AFI-Sizes.
- The Clearance Delivery Controller
  will provide start-up approval based on TSAT (considering that TSAT is a window of -/+ 5 minutes) provided by DMAN as in the previous operating method. The only change to previous operations is that TSAT calculation will be based on more accurate estimated taxi times provided by routing and planning (OFA 4.1.2).
- Tower Runway Controller
  as in previous operations verifies that the runway is clear and that the aircraft will meet arrival/departure separation requirements. It has to be highlighted that it remains the controller's task to further optimise the departure sequence whenever possible, i.e. controllers do not have to adhere to TTOT.
- Flight Crew
  requests a departure clearance by voice (R/T) or by datalink communications as in previous operations.
- Airspace Users
  are required by the A-CDM process to update their TOBT (as in current operations).

3 Requirements

This section collects all the safety and performance requirements derived from the assessment illustrated in the Appendix A. The requirements identifiers are set accordingly to the rules defined in the Requirements and V&V Guidelines 03.00.00
https://extranet.sesarju.eu/Programme%20Library/Requirements%20and%20VV%20Guidelines.doc

The generic pattern applied is as follows:

<Object type>-<Project code>-<Document code>-<Reference number 1>.<Reference number 2>

Where:

- <Object type> is **REQ**
- <Project code> is **06.08.04**
- <Document code> is **SPR**
- <Reference number 1> reflects the following organization:
  - 0131 – Safety Requirements Solution 01 V3
  - 0132 – Performance Requirements Solution 01 V3
- <Reference number 2> is a sequence number (incremental by 10) for each series of requirements.

3.1 Safety Requirements

Identifier	REQ-06.08.04-SPR-0131.0010
Requirement	ATCO has to compare the planned sequence with the actual aircraft position in order to detect any inconsistencies.

Identifier	REQ-06.08.04-SPR-0131.0020
Requirement	A failure (partial or total loss) of the Coupled AMAN/DMAN function shall be properly notified on approach and Tower Controller and Supervisor HMI.

Identifier	REQ-06.08.04-SPR-0131.0070
Requirement	Controllers shall be properly trained in the back up procedures for loss of AMAN/DMAN functionality

Identifier	REQ-06.08.04-SPR-0131.0210
Requirement	The coupled AMAN/DMAN shall display any runway closure on the HMI

Identifier	REQ-06.08.04-SPR-0131.0220
Requirement	The coupled AMAN/DMAN shall re-plan traffic if a runway closure is entered

Identifier	REQ-06.08.04-SPR-0131.0230
Requirement	The coupled AMAN/DMAN shall display any change of runway operating direction on the HMI

Identifier	REQ-06.08.04-SPR-0131.0240

Requirement	The coupled AMAN/DMAN shall re-plan traffic if a change of runway operating direction is entered

Identifier	REQ-06.08.04-SPR-0131.0250
Requirement	The coupled AMAN/DMAN shall re-plan traffic if parameters on AFI-size and pattern are adjusted due to Abnormal Weather Conditions

Identifier	REQ-06.08.04-SPR-0131.0260
Requirement	The coupled AMAN/DMAN shall re-plan a missed approach (either automatically or manually by the controller)

Identifier	REQ-06.08.04-SPR-0131.1010
Requirement	Coupled AMAN/DMAN shall support coordination between TWR and Approach by showing the planned integrated sequence and the selected sequence pattern.

Identifier	REQ-06.08.04-SPR-0131.1020
Requirement	Approach or Tower Supervisor, depending on local procedures, shall be able to adjust sequence pattern and AFI-Size in AMAN to provide sufficient spacing for departures in a mixed mode environment.

Identifier	REQ-06.08.04-SPR-0131.1030
Requirement	AMAN needs to be provided with all relevant information for sequencing traffic (Flightplan / ELDT / CTOT / TTOT / Sequence Pattern / AFI-Size)

Identifier	REQ-06.08.04-SPR-0131.1040
Requirement	The information provided to the AMAN needs to be correct.

Identifier	REQ-06.08.04-SPR-0131.1050
Requirement	The planned number of arrivals shall not exceed the available arrival capacity.

Identifier	REQ-06.08.04-SPR-0131.1070
Requirement	The AMAN shall display the arrival sequence to the Approach/En-route Controller.

Identifier	REQ-06.08.04-SPR-0131.1080
Requirement	DMAN needs to be provided with all relevant information for sequencing traffic (TOBT/ Flightplan / CTOT / TLDT / Pattern / EXOP)

Identifier	REQ-06.08.04-SPR-0131.1100
Requirement	The planned number of departures shall not exceed the available departure capacity.

Identifier	REQ-06.08.04-SPR-0131.1120
Requirement	The DMAN shall display the departure sequence to the Clearance Delivery

	Controller

Identifier	REQ-06.08.04-SPR-0131.1130
Requirement	The planned separation between successive arrivals with the coupled AMAN/DMAN shall not be lower than the applicable minimum separations between arrivals as used today with AMAN. Considering the departures shall only result in an increase in arrival separations.

Identifier	REQ-06.08.04-SPR-0131.1140
Requirement	The planned separation between departures with the coupled AMAN/DMAN shall not be lower than the applicable minimum separations between departures as used today with DMAN, if baseline DMAN already includes this function. Considering the arrivals shall only result in an increase in departure separations

Identifier	REQ-06.08.04-SPR-0131.1150
Requirement	Parameters for adjusting EXOP to specific situations (e.g. slower taxi speeds due to low visibility conditions) shall be established.

Identifier	REQ-06.08.04-SPR-0131.1160
Requirement	Supervisors shall be able to revert to static taxi time tables (VTT) that were used before introduction of routing functionality within A-CDM as fall-back.

Identifier	REQ-06.08.04-SPR-0131.1170
Requirement	The integrated sequence shall be compliant with CTOT.

Identifier	REQ-06.08.04-SPR-0131.1180
Requirement	Controllers shall be trained for the case that the sequence does not consider all minimum separations.

3.2 Performance Requirements

Identifier	REQ-06.08.04-SPR-0132.0010
Requirement	The TOBT information shall be maintained updated by the Airspace User, based on all the available information about the status of the turn-around process.

Identifier	REQ-06.08.04-SPR-0132.0015
Requirement	TTOT information shall be maintained updated using all information available from A-CDM (e.g. latest TOBT, CTOT, ASAT) as well as the EXOP, until the start-up approval has been issued. From this moment the TTOT shall be kept stable in order to stick to the original departure sequence.

Identifier	REQ-06.08.04-SPR-0132.0020
Requirement	The ELDT information shall be maintained updated as in current operations.

Identifier	REQ-06.08.04-SPR-0132.0030
Requirement	The most appropriate pattern may be automatically calculated by AMAN

	based on the traffic demand and the impact on performances (e.g. the forecast delay, the forecasted schedule deviation…).

Identifier	REQ-06.08.04-SPR-0132.0040
Requirement	In those cases where automatic implementation of pattern is supported, the AMAN shall calculate the most appropriate pattern under the following conditions: The modified pattern, given the latest available information, has a better performance impact than the active one, provided that the deviations of the forecasted KPIs are greater than a specified ∆KPI. The minimum duration of the pattern is guaranteed (XX minutes). The earliest flight in the modified pattern has a TLDT at least XX minutes after the time of modification takes place. A reasonable value for XX is 20 minutes, although this can be modified (as preset parameter) depending on the operating environment.

Identifier	REQ-06.08.04-SPR-0132.0050
Requirement	Airport Tower Supervisor or ACC/Approach Supervisor must be able to modify the pattern. Any change of pattern shall be performed after an agreement between Airport Tower Supervisor and ACC/Approach Supervisor, but only one of them shall be allowed to input the pattern into the AMAN.

Identifier	REQ-06.08.04-SPR-0132.0060
Requirement	In case the system is unable to calculate the optimal pattern, the system shall activate a default pattern based on a pre-determined list of feasible ones (e.g. based on a first-come-first-served order).

Identifier	REQ-06.08.04-SPR-0132.0070
Requirement	During phases where traffic demand is well below the available capacity values, the first-come-first-served (FCFS) principle shall be applied instead of a pattern, in order to provide a traffic picture to the ATCO which represents his actual way of working.

Identifier	REQ-06.08.04-SPR-0132.0090
Requirement	To maintain TOBT information updated specific mechanisms may be adopted as incentive (waiting list for the a/c not requesting start-up approval at TSAT + x minutes).

3.3 Information Exchange Requirements (IER)

In this subsection the safety and performance requirements on the information exchange are listed. They are the same IER as identified in the corresponding P06.08.04.D17 S1V3 Final OSED, edition 00.01.00 [9], but completed with the required safety and performance requirements. Therefore the same Name and Identifier values have been used to ensure traceability.

The IER are derived in the annex chapter 1.2 based on the functional model.

[IER]

Identifier	Name	Content Type	Frequency	Safety Criticality	Confidentiality	Maximum Time of Delivery	Interaction Type	Free
IER-06.08.04-OSED-0103.0010	Flight identifiers from Flight Plans filled by the Airspace Users – Flight identifier / Call sign	<Data>	Ad hoc Upon Flight Plan update	<Major>	<Public>	60s	<One-way>	as in current operations with uncoupled AMAN/DMAN; i.e. not subject of this SPR
IER-06.08.04-OSED-0103.0020	Arrival Information to Arrival Management Function from Flight Plans filled by the Airspace Users - Estimated Landing Time (ELDT)	<Data>	Ad hoc Upon Flight Plan update	<Major>	<Public>	60s	<One-way>	as in current operations with uncoupled AMAN/DMAN; i.e. not subject of this SPR
IER-06.08.04-OSED-0103.0030	ATCO Input on required size of Arrival Free Intervals (AFIs)	<Data>	Ad Hoc At the discretion of Airport Tower or ACC/approach Supervisor	<Major>	<Restricted>	60s	<One-way>	An incorrect AFI size could induce breach of separation minima, however, this situation can be recovered during the tactical phase by the runway controller.
IER-06.08.04-OSED-0103.0040	ATCO Input on required pattern to Arrival Management Function	<Data>	Ad Hoc At the discretion of Airport Tower or ACC/approach Supervisor	<No Effect>	<Restricted>	60s	<One way>	Incorrect pattern would lead to poor optimisation, but would have no effect on safety
IER-06.08.04-OSED-0103.0050	Departure demand information to Arrival Management Function (Optional) – Target Off-Block Time (TOBT)	<Data>	Ad Hoc Upon TOBT update by the ground handling agent	<Minor>	<Restricted>	60s	<One way>	Optional Functionality: The data exchange is between the A-CDM and the AMAN of the same airport

Identifier	Name	Content Type	Frequency	Safety Criticality	Confidentiality	Maximum Time of Delivery	Interaction Type	Free
IER-06.08.04-OSED-0103.0060	Departure demand information to Arrival Management Function (Optional) – Calculated Take-off Time (CTOT)	<Data>	Ad Hoc Upon CTOT Update by the NM	<Minor>	<Restricted>	60s	<One way>	Optional Functionality: The data exchange is between the Network manager and the AMAN
IER-06.08.04-OSED-0103.0070	Departure demand information to Arrival Management Function (Optional) – Expected Taxi-out Period (EXOP)	<Data>	Ad Hoc Upon EXOP update by the RPF	<Minor>	<Restricted>	60s	<One way>	Optional Functionality: The data exchange is between the Routing and Planning Function and the AMAN of the same airport
IER-06.08.04-OSED-0103.0080	Departure demand information to Departure Management Function – Target Off-Block Time (TOBT)	<Data>	Ad Hoc Upon TOBT update by the ground handling agent	<Minor>	<Restricted>	60s	<One way>	as in current operations with uncoupled AMAN/DMAN; i.e. not subject of this SPR
IER-06.08.04-OSED-0103.0090	Departure demand information to Departure Management Function – Calculated Take-off Time (CTOT)	<Data>	Ad Hoc Upon CTOT Update by the NM	<Minor>	<Restricted>	60s	<One way>	as in current operations with uncoupled AMAN/DMAN; i.e. not subject of this SPR
IER-06.08.04-OSED-0103.0100	Departure demand information to Departure Management Function – Expected Taxi-out Period (EXOP)	<Data>	Ad Hoc Upon EXOP update by the RPF	<Minor>	<Restricted>	60s	<One way>	The data exchange is between the Routing and Planning Function and the DMAN of the same airport.
IER-06.08.04-OSED-0103.0170	Optional AMAN-calculated pattern proposal to Airport Tower Supervisor and ACC/Approach Supervisor to optimise a set of KPIs	<Data>	Ad Hoc Upon Pattern calculation by the Arrival Management Function	<Minor>	<Restricted>	60s	<One way>	This is an HMI requirement
IER-06.08.04-OSED-0103.0110	Pattern information to Departure Management Function	<Data>	Ad Hoc Upon pattern update at the discretion of ATCO in charge of pattern input (Airport Tower or ACC/Approach Supervisor depending on local procedures)	<No Effect>	<Restricted>	60s	<One way>	Incorrect pattern would lead to poor optimisation, but would have no effect on safety.

Identifier	Name	Content Type	Frequency	Safety Criticality	Confidentiality	Maximum Time of Delivery	Interaction Type	Free
IER-06.08.04-OSED-0103.0120	Arrival sequence information to Departure Management Function – Target Landing Time (TLDT)	<Data>	Ad Hoc Upon TLDT update by the Arrival Management Function	<Minor>	<Restricted>	60s	<One way>	The data exchange is between the DMAN and the AMAN of the same airport.
IER-06.08.04-OSED-0103.0130	Arrival sequence information to ATCO – Target Landing Time (TLDT)	<Data>	Ad Hoc Upon TLDT update by the Arrival Management Function	<Minor>	<Restricted>	60s	<One way>	as in current operations with uncoupled AMAN/DMAN
IER-06.08.04-OSED-0103.0140	Pre-departure sequence information to ATCO issuing Start-Up approval - Target Start-Up Time (TSAT)	<Data>	Ad Hoc Upon TSAT update by the Departure Management Function	<Minor>	<Restricted>	60s	<One way>	as in current operations with uncoupled AMAN/DMAN
IER-06.08.04-OSED-0103.0150	Pre-departure sequence information to ATCO issuing push-back approval - Target Start-Up Time (TSAT)	<Data>	Ad Hoc Upon TSAT update by the Departure Management Function	<Minor>	<Restricted>	60s	<One way>	as in current operations with uncoupled AMAN/DMAN
IER-06.08.04-OSED-0103.0160	Departure sequence information to Tower Runway Controllers and approach controllers - TTOT (Target Take-Off Time)	<Data>	Ad Hoc Upon TTOT update by the Departure Management Function	<Minor>	<Restricted>	60s	<One way>	Optional Functionality: This is an HMI requirement
IER-06.08.04-OSED-0103.0180	Pre-departure sequence (TSAT) information to routing and planning function	<Data>	Ad Hoc Upon TSAT update by the Departure Management Function	<Minor>	<Restricted>	60s	<One-way>	The data exchange is between the DMAN and the Routing and Planning function of the same airport.

Table 1: Information Exchange Requirements

It is worth noting that the confidentiality level for each IER is derived according to expert judgement.

4 References and Applicable Documents

4.1 Applicable Documents

This SPR 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] SESAR ATM Lexicon
https://extranet.eurocontrol.int/http://atmlexicon.eurocontrol.int/en/index.php/SESAR

4.2 Reference Documents

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

[5] SESAR Security Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[6] SESAR Environment Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[7] SESAR Human Performance Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[8] SESAR Business Case Reference Material
https://extranet.sesarju.eu/Programme%20Library/Forms/Procedures%20and%20Guidelines.aspx

[9] P06.08.04.D17 S1V3 Final OSED, edition 00.01.00, dated 08/05/2015

[10] P06.08.04.D09 Validation Basic DMAN/A-SMGCS Report v00.01.00 dated 10/01/2013

[11] P06.08.04.D11 S01V2 Validation Report Basic AMAN/DMAN v00.01.00 dated 21/09/2012

[12] P06.08.04.D12 S1V3 AMAN/DMAN/A-SMGCS Validation Report V2 00.01.01

[13] P06.08.04 D16 Validation Report P06.08.04-VP453 Coupled AMAN/DMAN/A-SMGCS v00.01.01 dated 02/03/2015

[14] P06.02 D105 Airport Validation Strategy Step1 2014 update 00.01.00

[15] P06.02 Step 1 Airport DOD 2014 Update 00.01.01 30th December 2014

[16] P16.06.01 D26 SESAR Safety Reference Material, Edition 00.03.01, dated 7th February 2012

[17] 16.06.01 D26 Guidance to Apply the SESAR Safety Reference Material, Edition 00.02.01, dated 30th January 2012

[18] EATMP Air Navigation System Safety Assessment Methodology, Ed. 2.0, ref. SAF.ET1.ST03.1000-MAN-01, 30 April 2004

[19] B.01 Integrated Roadmap (DS14)

[20] Ball, Michael, Cynthia Barnhart, George Nemhauser, Amedeo Odoni, C. Barnhart, and G. Laporte. "Air transportation: Irregular operations and control." Handbooks in Operations Research and Management Science 14, no. 1 (2007): 1-67.

[21] Dear, Roger G., and Yosef S. Sherif. "An algorithm for computer assisted sequencing and scheduling of terminal area operations." Transportation Research Part A: General 25, no. 2 (1991): 129-139.

[22]B.04.01. Updated Step 1 Validation Targets; Edition V00.01.00; dated December 2014

[23]P06.05.05-D16; OFA 05.01.01 Operational Service and Environment Definition Part 2; v00,03.00; April 2015.

Appendix A Assessment / Justifications

A.1 Safety and Performance Assessments

A.1.1 Safety Specifications at OSED Level

A.1.1.1 OFA Operational Environment and Key Properties

See chapter 2.

A.1.1.2 Airspace Users Requirements

There are no new AU Requirements as the Flight Crew requests a departure clearance by voice (R/T) or by datalink communications as in previous operations.
The Airspace users are required by the A-CDM process to update their TOBT (as in current operations).

A.1.1.3 SAfety Criteria

The following Safety Criteria were identified from AIM for the coupled AMAN/DMAN (solution #53 and solution 54):

SAC 1: With the use of AMAN/DMAN integrated sequence, the number of planned tactical conflict remains constant.

This SAC is related to the barrier B10 of the Mid Air Collision (TMA) Risk model.

Rationale:

Controllers might face high traffic density due to a corrupt sequence in terms of too much traffic that is planned. This can lead to an increased workload.

Controllers might expect a different situation due a corrupt sequence in terms of the order of flights is different to what the controller expects based on the current aircraft position

SAC 2: With the use of AMAN/DMAN integrated sequence, the number of imminent runway incursion remains constant.

This SAC is related to the barrier B4 of the Runway Incursion Risk model.

Rationale:

The Tower Runway Controller might be provided with a sequence, which does not correctly consider the separation constraints.

SAC3: With the use of AMAN/DMAN integrated sequence, the number of planned pre-tactical taxiway conflict remains constant.

This SAC is related to the barrier B5 Taxiway Collision Risk model.

Rationale:

Wrong taxitimes provided by the Routing functionality might have an impact on the number of taxiing aircraft (too many aircraft taxiing at the same time) which could increase workload of Ground Controller.

SAC4: With the use of AMAN/DMAN integrated sequence, the number of separation minima infringements remains constant

This SAC is related to the barrier B8 of the Wake-Induced Risk model.

Rationale:

If wrong wake vortex separations are considered in the planning this might lead to additional workload for the controller as he has to adjust his expectation when separating traffic.

A.1.1.4 Affected AIM functions

The introduction of coupled AMAN/DMAN improves upon the uncoupled AMAN & DMAN functionalities present in current operations. The introduction of Couple AMAN/DMAN affects functions in a number of the AIM models. The goal for the concept is for there to be no safety detriment resulting from its introduction. Therefore, where an impact on AIM has been identified in the AIM models, the corresponding accident pre-cursor has been listed. A SAC has then been derived for this accident pre-cursor of the form 'no worse than today'. These affected functions are listed in the table here-after, along with the related type of accident, the AIM Model used and the corresponding Safety Criteria (as explained in previous section):

SAC	AIM Model Used	Barrier	Pre-cursor	AIM Functions affected by the introduction of Coupled AMAN/DMAN service
SAC#1 With the use of AMAN/DMAN integrated sequence, the number of planned tactical conflict remains constant	MAC-TMA	B10 Traffic Planning and Synchronisation	Planned Conflict (MF5.1)	Inadequate AMAN information (MB10.2.1a)
				Inadequate synchronisation regarding arrivals (MB10.2.1b)
				Inadequate DMAN information (MB10.2.2.a)
				Inadequate synchronisation regarding departures (MB10.2.2b)
SAC#2 With the use of AMAN/DMAN integrated sequence, the number of imminent runway incursion remains constant	RWC	B4 ATC Runway Entry Management	Imminent Runway Incursion (RP4)	Inadequate coordination between Tower and Approach (RB4.1.3.2)
		B9 Runway DCB	Potential Runway Use (RP9)	Mixed mode failure in managing sequence causes insufficient spacing (MB9.3.4)
SAC#3 With the use of AMAN/DMAN integrated sequence, the number of separation minima infringements remains constant	TWC	B5 Pre-Tactical Ops Planning	Planned Pre-tactical Taxiway Conflict (TP4B)	Ineffective Demand Prediction (TB5.1.5)
SAC#4 With the use of AMAN/DMAN integrated sequence, the number of planned pre-tactical taxiway conflict remains constant.	WAKE	B7 Separation Management of ATC-induced Conflict	Separation Minima Infringement (WE5F)	Wake Vortex – no Planning Data (Bx.1.1.2.2)
			Separation Minima Infringement (WE5F)	Wake Vortex – Incorrect planning Information (Bx.1.1.2.1)

Table 2: List of affected functions in AIM

A.1.1.5 Achievement of SACs – Normal Operations

A.1.1.5.1 Operational Services to Address the impacted functions in AIM

This section describes the ATC services that are provided by the Coupled AMAN/DMAN in the relevant operational environment to address (all/some of) the SAC identified above. They have been defined using the following sources:

- AIM from 16.1.1 [16]
- Expert judgement

Note that these services are the same as the ATC services provided in current operations.

ID	Service Objective	Related AIM Functions
CAD.ATC-01	▸ Traffic planning ▸ Traffic synchronisation	Inadequate coordination between Tower and Approach (RB4.1.3.2) Mixed mode failure in managing sequence causes insufficient spacing (MB9.3.4)
CAD.ATC-02	▸ Traffic monitoring ▸ Conflict resolution	Wake Vortex – no Planning Data (Bx.1.1.2.2) Wake Vortex – Incorrect planning Information (Bx.1.1.2.1)
CAD.ATC-03	▸ Potential collision detection ▸ Collision avoidance	Wake Vortex – no Planning Data (Bx.1.1.2.2) Wake Vortex – Incorrect planning Information (Bx.1.1.2.1)
CAD.ATC-04	▸ TWY Collision avoidance	Ineffective Demand Prediction (TB5.1.5)
CAD.ATC-05	▸ Runway Entry/exit management ▸ Take-off Management ▸ Landing Management	Inadequate AMAN information (MB10.2.1a) Inadequate synchronisation regarding arrivals (MB10.2.1b) Inadequate DMAN information (MB10.2.2.a) Inadequate synchronisation regarding departures (MB10.2.2b)

Table 3: ATC services and related AIM Functions

A.1.1.5.2 Derivation of Safety Objectives for Normal Operations

This section provides the functionality Safety Objectives (concerning the success part of the assessment) for Coupled AMAN/DMAN providing the ATC services listed in A.1.1.5.1. They have been defined based on the services presented in previous section, using the same sources mentioned in that section.

These safety objectives describe WHAT the Coupled AMAN/DMAN (CAD) system has to perform in order to provide the ATC services. The complete set of safety objectives achieves the safety criteria defined in section A.1.1.3.

The HOW this is to be done will be described by the safety requirements, derived from those safety objectives, in terms of requirements on technical equipment (information to be provided and associated performance characteristics), controller competence/training, and procedures.

Ref	Services provided	Phase of Fight / Operational Service	Related AIM Barrier	Safety Objective
CAD.ATC-01	Traffic planning Traffic synchronisation	Takeoff Land	ATC Runway Entry Management Barrier (B4 RWC Model) Runway DCB Barrier (B9 RWC Model)	SO-0001 SO-0002 SO-0003
CAD.ATC-02	Traffic monitoring Conflict resolution	Takeoff Land	Separation Management of close-following traffic Barrier (B9 WAKE Model)	SO-004
CAD.ATC-03	Traffic monitoring Conflict resolution	Takeoff Land	Separation Management of close-following traffic Barrier (B9 WAKE Model)	SO-0005 SO-0006
CAD.ATC-04	TWY Collision avoidance	Surface-in Surface-out (Apron/Taxi-in/Taxi-out)	Pre-Tactical Airport OPS Planning Barrier (B5 TWC Model)	SO-0007
CAD.ATC-05	Runway Entry/exit management Take-off Management Landing Management	Takeoff Land	Traffic Planning and Synchronisation Barrier (B10 MAC-TMA Model)	SO-0008 SO-0009 SO-0010 SO-0011

Table 4: Coupled AMAN/DMAN Services & Safety Objectives (success approach)

The following table describe the Safety Objectives referred above:

AIM Function Addressed	Safety Objective
Inadequate coordination between Tower and Approach (RB4.1.3.2)	SO-0001 Coupled AMAN/DMAN shall support coordination between TWR and Approach
Ineffective ATC runway entry/exit management (RB4)	SO-0002 Coupled AMAN/DMAN shall support effective ATC runway management
Mixed mode failure in managing sequence causes	SO-0003 Coupled AMAN/DMAN shall support managing the sequence in mixed mode environment.

insufficient spacing (MB9.3.4)	
Inaccurate information for separation management (BX.1.1)	SO-0004 Coupled AMAN/DMAN shall be provided with accurate wake vortex information
Wake Vortex – no Planning Data (Bx.1.1.2.2)	SO-0005 Coupled AMAN/DMAN shall be provided with wake vortex information
Wake Vortex – Incorrect planning Information (Bx.1.1.2.1)	SO-0006 Coupled AMAN/DMAN shall be provided with correct wake vortex information
Ineffective Demand Prediction (TB5.1.5)	SO-0007 DMAN shall be provided with reliable demand prediction
Inadequate AMAN information (MB10.2.1a)	SO-0008 AMAN needs to be provided with all relevant information for sequencing traffic
Inadequate synchronisation regarding arrivals (MB10.2.1b)	SO-0009 Synchronisation of arrivals should not be worse than in current operations with standalone AMAN
Inadequate DMAN information (MB10.2.2.a)	SO-0010 DMAN needs to be provided with all relevant information for sequencing traffic
Inadequate synchronisation regarding departures (MB10.2.2b)	SO-0011 Synchronisation of departures should not be worse than in current operations with standalone DMAN

Table 5: List of Safety Objectives (success approach) for ATC services in Normal Operations

A apart from the safety objectives listed above, the following assumptions are also to be considered in order to ensure the appropriate provision of the services described.

Description
AO-01. The safety objectives that apply for a basic AMAN that is not coupled to DMAN still apply
AO-02. The safety objectives that apply for a basic DMAN that is not coupled to AMAN still apply

Table 6: List of operational assumptions concerning the provision of ATC services in normal conditions

A.1.1.6 Coupled AMAN/DMAN Operations under Abnormal Conditions

The purpose of this section is to assess the coupled AMAN/DMAN functionality under abnormal conditions.

A.1.1.6.1 Identification of Abnormal Conditions

The following abnormal conditions scenarios have been identified.

- Runway Closure
- Change of runway operating direction (due to weather)
- Abnormal weather (strong headwind/crosswind conditions)
- Missed Approach

A.1.1.6.2 Potential Mitigations of Abnormal Conditions

The abnormal conditions listed above are assessed in this section. The following assumption is made:

Description
AO-03. All abnormal conditions and mitigations are already covered by basic AMAN/DMAN and need to remain in the coupled solution

The potential operational effects of the abnormal conditions and the potential mitigation of these effects are presented in the following table:

Ref	Abnormal Conditions	Operational Effect	Mitigation of Effects
1	Runway Closure	Supervisor needs to re-plan traffic to remaining runway using parameters provided by coupled AMAN/DMAN In one runway environment traffic needs to be put on hold or to be diverted.	Closure of runway needs to be displayed in coupled AMAN/DMAN Coupled AMAN/DMAN shall support re-planning of traffic to remaining runway(s). Coupled AMAN/DMAN shall automatically reschedule traffic after expected runway opening
2	Change of runway operating direction	Supervisor needs to re-plan traffic to new operating direction using the given standard parameters provided by coupled AMAN/DMAN	Change of runway operating direction needs to be displayed in coupled AMAN/DMAN Coupled AMAN/DMAN shall support re-planning of traffic to new runway direction.
3	Abnormal Weather conditions	Supervisor needs to re-plan traffic to meet new capacity constrains given by weather conditions using the given	Coupled AMAN/DMAN shall automatically reschedule traffic after receiving new parameter sets.

		standard parameters provided by coupled AMAN/DMAN	
4	Missed Approach	Missed Approach needs to be re-sequenced into arrival sequence	Missed approach needs to be re-entered into the arrival sequence either manually or automatically by the AMAN

Description
SO-020. For abnormal conditions the same safety objectives remain as for uncoupled AMAN/DMAN

Table 7: List of Safety Objectives for Abnormal Operations

Safety Requirement ID	Requirement - Description	Derived from SO
REQ-06.08.04-SPR-0131.0210	The coupled AMAN/DMAN will display any runway closure on the HMI (analogous to current AMAN/DMAN)	SO-020
REQ-06.08.04-SPR-0131.0220	The coupled AMAN/DMAN shall re-plan traffic if a runway closure is entered (analogous to current AMAN/DMAN)	SO-020
REQ-06.08.04-SPR-0131.0230	The coupled AMAN/DMAN shall display any change of runway operating direction on the HMI. (analogous to current AMAN/DMAN)	SO-020
REQ-06.08.04-SPR-0131.0240	The coupled AMAN/DMAN shall re-plan traffic if a change of runway operating direction is entered (analogous to current AMAN/DMAN)	SO-020
REQ-06.08.04-SPR-0131.0250	The coupled AMAN/DMAN shall re-plan traffic if parameters on AFI-size and pattern are adjusted due to Abnormal Weather Conditions	SO-020
REQ-06.08.04-SPR-0131.0260	The coupled AMAN/DMAN shall re-plan a missed approach (either automatically or manually by the controller)	SO-020

Table 8: List of Requirements concerning abnormal operations

A.1.1.7 Mitigation of System-generated Risks (failure approach)

A.1.1.7.1 Identification and Analysis of System-generated Hazards

This section identifies and analyses Coupled AMAN/DMAN operations under internal failure conditions.

The following table shows for each hazard:

- the corresponding hazard described at operational level
- the related safety objective from which the hazard is derived
- the assessed operational effects of the hazard accounting for the mitigation means identified
- the possible mitigations of the hazard consequences with a reference to existing functional and performance safety objectives (or assumptions) or to new ones.
- the assessed severity of the mitigated consequence determined used the risk classification schemes provided Accident Incident Model (AIM).

It must be noted that for those operational hazards related to the wake vortex AIM model, no severity classification is included in the current SESAR Safety Reference Material (SRM) [16].

ID	Description	Related SO *(success approach)*	Operational Effects	Mitigations of Effects	Severity *(most probable effect)*
OH-01	Inadequate coordination between Tower and Approach	SO-0001	An imminent runway Incursion (RP4) could occur.	SO-0002 SO-0003	RWY-SC5 (1e-4)
OH-02	Ineffective ATC Runway Management	SO-0002	An imminent runway Incursion (RP4) could occur.	SO-0003	RWY-SC5 (1e-4)
OH-03	Mixed mode failure in managing sequence causes insufficient spacing	SO-0003	Potential Runway Use (RP9)	n/a	RWY-SC5
OH-04	Inaccurate information for separation management	SO-0004	A separation Minima Infringement could occur (WE5F).	SO-0005 SO-0006	No severity allocated
OH-05	No Wake Vortex information is provided	SO-0005	A separation Minima Infringement could occur (WE5F).	n/a	No severity allocated
OH-06	Incorrect Wake Vortex information is provided	SO-0006	A separation Minima Infringement could occur (WE5F).	n/a	No severity allocated
OH-07	Ineffective demand prediction fails to reduce taxiing conflicts	SO-0007	A pre-Tactical Taxiway Conflict could occur (TP4B).	n/a	TInc-SC5 (1)

OH-08	Inadequate synchronisation of arrivals	SO-0008	A planned tactical conflict could occur (MF5.1).	SO-0009	MAC-SC4.b (1e-2)
OH-09	AMAN is provided with inadequate information	SO-0009	A planned tactical conflict could occur (MF5.1).	n/a	MAC-SC4.b (1e-2)
OH-10	Inadequate synchronisation of departures	SO-0010	A planned tactical conflict could occur (MF5.1).	SO-0011	MAC-SC4.b (1e-2)
OH-11	DMAN is provided with inadequate information	S0-0011	A planned tactical conflict could occur (MF5.1).	n/a	MAC-SC4.b (1e-2)

Table 9: System-Generated Hazards and Analysis

A.1.1.7.2 Derivation of Safety Objectives (integrity/reliability)

The following integrity objectives were derived from the figures given in the AIM Risk Model. The table below also provides the reference to the Operational hazard.

Hazard-ID	Safety Objectives
OH-01	**SO-201** The likelihood that coupled AMAN/DMAN causes inadequate coordination between Tower and Approach (RB4.1.3.2) should be 0,003482 per flight hour
OH-02	**SO-202** The likelihood that coupled AMAN/DMAN causes mixed mode failure in managing sequence causes insufficient spacing (MB9.3.4) should be 0,01875 per flight hour
OH-09	**SO-203** The likelihood that coupled AMAN/DMAN causes inadequate AMAN information (MB10.2.1a) should be 1,27E-03 per flight hour
OH-08	**SO-204** The likelihood that coupled AMAN/DMAN causes inadequate synchronisation regarding arrivals (MB10.2.1b) should be 1,27E-03 per flight hour
OH-11	**SO-205** The likelihood that coupled AMAN/DMAN causes inadequate DMAN information (MB10.2.2.a) should be 1,27E-03 per flight hour
OH-10	**SO-206** The likelihood that coupled AMAN/DMAN causes inadequate synchronisation regarding departures (MB10.2.2b) should be 1,27E-03 per flight hour
OH-05	**SO-207** The likelihood that coupled AMAN/DMAN causes separation infringements due to no planning data on Wake Vortex (Bx.1.1.2.2) should be 3,60E-03 per flight hour
OH-06	**SO-208** The likelihood that coupled AMAN/DMAN causes separation infringements due to incorrect planning information on Wake Vortex (Bx.1.1.2.1) should be 3,60E-03 per flight hour
OH-07	**SO-209** The likelihood that coupled AMAN/DMAN causes ineffective Demand Prediction (TB5.1.5) should be 0,050 per flight hour

Table 10: Safety Objectives (integrity/reliability)

Likelihoods for each Operational Hazard, as quoted in the table above, are computed based on AIM Models and on the methodology proposed by the SESAR Safety Reference Material (SRM) [16], taking as inputs the data shown in the table below.

AIM Model	Base Event	Barrier	Barrier Failure Contribution	Barrier Failure Rate	Accident and Precursor	Accident and Precursor Budget
Wake	BX1.1.2.1	B9	1,5%	0,05%	WE5F	1,20E-04
	BX1.1.2.2		1,5%	0,05%		

MAC - TMA	MB10.2.1a	B10	30% · 60% · 75% = 13,5%	10%	MF5.1	1,50E-02
	MB10.2.2b		8% · 15% · 75% = 0,8438%	10%		
Taxiway Collision	TB5.1.5	B5	5% · 50% = 2,5%	80%	TPB4	1,6
Runway Incursion	MB9.3.4	B9	5% · 75% = 37,5%	80%	RP9	0,4
	MRB4.1.3.1	B4	8% · 11% = 0,88%	0,0023%	RP4A	9,10E-06

Table 11: Input data for the calculation of the likelihoods of each of the identified Operational Hazards

A.1.1.8 Impacts of 04.01.01 OFA operations on adjacent airspace or on neighbouring ATM Systems

As neither the operating method nor the information provided to neighbouring ATM-System changes with coupling AMAN/DMAN, this chapter is not applicable.

A.1.1.9 Achievability of the SAfety Criteria

The achievability of the safety criteria was mainly based on subjective controller assessment. No issues regarding safety were mentioned by the controllers for the distance based coupled AMAN/DMAN except for the following two points:

- CTOT was missing (that was due to the design of the simulation – in real life the same information for CTOT as for uncoupled DMAN is available.)
- The pattern change needs to be allocated to an aircraft rather than to a point in time. (this is now reflected in a new requirement in the OSED)

A quantitative evidence of the achievability of the safety criteria through the specification of the safety objectives was given indirectly by the measures of stability of the sequence (compare D16 VALR). Stability is the pre-requisite for the following safety objectives: SO-0001 / SO-0002 / SO-0003 / SO-0007 – SO-0011

A.1.1.10 Validation & Verification of the Safety Specification

The Requirements for solution #53 were validated in the following exercises:

- o EXE-06.08.04-VP231 V2 DMAN/A-SMGCS – Paris Charles de Gaulle (RTS)
- o EXE-06.08.04-VP298 V2 DMAN/A-SMGCS – Malpensa Milano (RTS)
- o EXE-06.08.04-VP339 V2 AMAN/DMAN/A-SMGCS – Gatwick (FTS)
- o EXE-06.08.04-VP453 V3 AMAN/DMAN/TBS – Gatwick (RTS)

The Requirements for solution #54 were validated in the following exercises:

- o EXE-06.08.04-VP338 V2 AMAN/DMAN – Munich (Shadow Mode)

- EXE-06.08.04-VP339 V2 AMAN/DMAN/A-SMGCS – Gatwick (FTS)
- EXE-06.08.04-VP663 V2 AMAN/DMAN/TBS – Gatwick (RTS)
- EXE-06.08.04-VP453 V3 AMAN/DMAN/TBS – Gatwick (RTS)

The results from these exercises have allowed the project to obtain evidence on the validity of the specification for normal operating conditions, but limited evidence concerning abnormal conditions operations and degraded modes (related to internal system failure) has been obtained.

A.1.2 Safe Design at SPR Level

A.1.2.1 Scope

The functional model of the coupled AMAN/DMAN is provided in the next subchapters.

A.1.2.2 The OFA 04.01.01 Functional Model

This section contains a global functional model updated according to the basis of the information found in the P06.08.04.D17 S1V3 Final OSED, edition 00.01.00 [9]. While the functional model in 10.9.1-D02 Technical Specification describes the AMAN functions, the one in the 6.8.4 OSED covers the coupling of AMAN/DMAN.

A functional model is a structured flow-representation of the main functions of a system (application) with the aim to define the relationships between the related inputs and outputs. The functions broadly translate into processes that transform input to output. Therefore, the functional model is sometimes referred to as a process model.

It provides an efficient baseline for functional assessment (safety and performance assessment) because it decomposes the system (application) into structured subsystems and processes and hereby visualises the critical transactions. Therefore, the functional model will be used as a baseline for a systematic assessment of a system (application).

As regards the Operational Performance Assessment, the functional model of figure 2 will be used as a support to develop the OPA. The different interactions between R&P functionalities and input/output information will be analysed, thus leading to the identification of causes underpinning potential performance issues. The approach assumes that the Coupled AMAN/DMAN functionalities operate as expected under **nominal conditions** and assesses potential drops on performance levels caused by incorrect or non-existent input/output parameters. The new AMAN/DMAN operating method expected for Step 1 aims at optimizing traffic flow rather than providing a proper integrated arrival/departure sequence. It means that a flow-based integration will not be achieved until Step 2. Therefore, one of the expected benefits will be related to the number of movements on the runway (take-off and landing) realized in a given period. The solution reflects the scenario based on a Master/Slave configuration. Master/Slave is a model of communication where one device (the master) has unidirectional control over one or more other devices (slaves). In our case AMAN will act as master in the coupling and DMAN will act as slave. It means that no further coupling functionality will be introduced. Moreover, AMAN and DMAN planning horizons might be different. Synchronisation of the planning horizons is not expected since TOBT will always be provided as input to AMAN coupling before AMAN starts planning activities.

A.1.2.2.1 Description of Functional Model

In order to identify the concept of the Coupled AMAN/DMAN function, as well as its inputs, outputs, internal processes and interaction with external agents (Routing and Planning Function, ATC) in a visual way, a block diagram was defined based on the functional description provided in the final OSED [9]. Afterwards, the different performance issues identified will be referred to the different unique functions of this diagram.

Generally speaking, the AMAN, as master, will be in charge of calculating the arrival sequence according to the pattern and the AFI sizes that are input by Airport Tower Supervisor or by ACC/Approach Supervisor depending on local procedures.

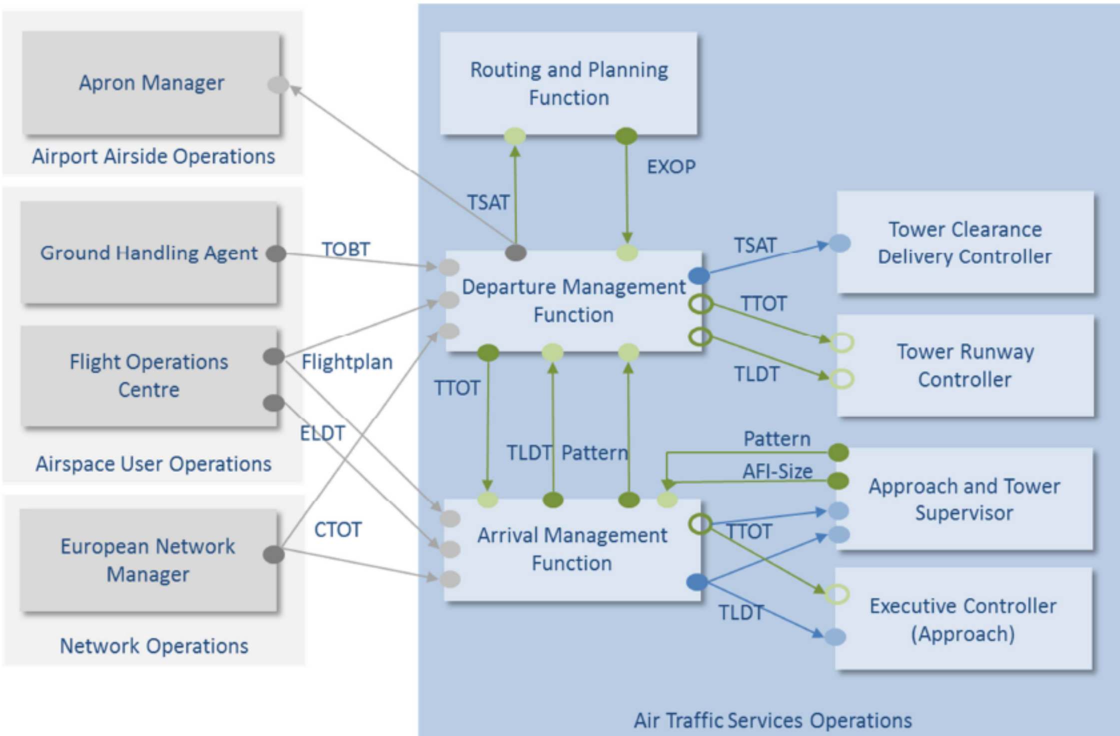

Figure 2: OFA 04.01.01 Functional Model

The interfaces to the external entities are shown in grey on figure 2. As they do not change compared to the current operations, they are not subject of this SPR. The following IERs were derived:

Airspace User Operations

Identifier	Name
IER-06.08.04-OSED-0103.0010	Flight identifiers from Flight Plans filled by the Airspace Users – Flight identifier / Call sign
IER-06.08.04-OSED-0103.0020	Arrival Information to Arrival Management Function from Flight Plans filled by the Airspace Users - Estimated Landing Time (ELDT)
IER-06.08.04-OSED-0103.0080	Departure demand information to Departure Management Function – Target Off-Block Time (TOBT)
IER-06.08.04-OSED-0103.0090	Departure demand information to Departure Management Function – Calculated Take-off Time (CTOT)

The interfaces that are shown in green are new compared to uncoupled AMAN/DMAN and will be considered in detail in this SPR. The interfaces that are shown in blue are already existing in current operations with uncoupled AMAN/DMAN and are shown for completeness only.

ATCO / Supervisor

Identifier	Name
IER-06.08.04-OSED-0103.0030	ATCO Input on required size of Arrival Free Intervals (AFIs)
IER-06.08.04-OSED-0103.0040	ATCO Input on required pattern to Arrival Management Function

Arrival Management Function

Identifier	Name
IER-06.08.04-OSED-0103.0110	Pattern information to Departure Management Function
IER-06.08.04-OSED-0103.0120	Arrival sequence information to Departure Management Function – Target Landing Time (TLDT)
IER-06.08.04-OSED-0103.0130	Arrival sequence information to ATCO – Target Landing Time (TLDT)

Departure Management Function

Identifier	Name
IER-06.08.04-OSED-0103.0180	Pre-departure sequence (TSAT) information to routing and planning function
IER-06.08.04-OSED-0103.0140	Pre-departure sequence information to ATCO issuing Start-Up approval - Target Start-Up Time (TSAT)
IER-06.08.04-OSED-0103.0150	Pre-departure sequence information to ATCO issuing push-back approval - Target Start-Up Time (TSAT)
Missing	TTOT to Arrival Management Function

Routing and Planning Function

IER-06.08.04-OSED-0103.0100	Departure demand information to Departure Management Function – Expected Taxi-out Period (EXOP)

The interface that are just outlined are optional for step 1 (but compulsory for step2).

ATCO / Supervisor

Identifier	Name
IER-06.08.04-OSED-0103.0160	Departure sequence information to Tower Runway Controllers and approach controllers - TTOT (Target Take-Off Time)

Departure Management Function

Identifier	Name
IER-06.08.04-OSED-0103.0050	Departure demand information to Arrival Management Function (Optional) – Target Off-Block Time (TOBT)
IER-06.08.04-OSED-0103.0060	Departure demand information to Arrival Management Function (Optional) – Calculated Take-off Time (CTOT)
IER-06.08.04-OSED-0103.0070	Departure demand information to Arrival Management Function (Optional) – Expected Taxi-out Period (EXOP)

Alternatively, the AMAN could also propose to the ATCO a pattern and Arrival Free Intervals (AFIs), which the ATCO would take into account for setting the optimal pattern. In it, the DMAN will allocate the departure sequence and derive the pre-departure sequence taking into account the estimated taxi-time. This mode of the AMAN was not subject of the validations and is not covered in the functional model (In this case the TOBT and CTOT needs to be provided from DMAN to AMAN and EXOP needs to be provided from Routing to AMAN – which is considered in the IERs).

The following analysis focuses on the essential information needed for the coupled AMAN/DMAN and does not include the not-validated information elements (IER-06.08.04-OSED-0103.0050, IER-06.08.04-OSED-0103.0060 and IER-06.08.04-OSED-0103.0070) needed for the optional AMAN calculated pattern proposal to Airport Tower Supervisor and ACC/Approach Supervisor to optimise a set of KPIs (for more information, see OSED [9] section 3.5.1.3).

Departure Management Function

Identifier	Name
IER-06.08.04-OSED-0103.0170	Optional AMAN-calculated pattern proposal to Airport Tower Supervisor and ACC/Approach Supervisor to optimise a set of KPIs

A.1.2.2.1.1 External Entities

The external entities (Network Operations and Airspace User Operations) will provide the same information and with the same quality as with the uncoupled AMAN/DMAN and are therefore not within the scope of this SPR.

A.1.2.2.1.2 Data Sources

A.1.2.2.1.2.1 Arrival Management Function performance issues

Considering the AMAN function as a black box, we can identify its inputs and outputs as:

Figure 3: Arrival Management Function - input/output model

Nº	Cause		Operational Performance Issue	
	Functional Model Element Impact	Description	Functional Model Element Impact	Description
AFI size	Unstable AFI sizes	AFI sizes experience frequent changes as input by ATCO to adapt to late peaks, or to unstable arrival or departure demand	Unstable TLDTs	Due to the low reliability of the arrival and departure input data, the TLDT calculation by AMAN based on ATCO-

N°	Cause		Operational Performance Issue	
	Functional Model Element Impact	Description	Functional Model Element Impact	Description
Pattern	Unstable Pattern	ATCO chosen pattern experience frequent changes to adapt to late peaks, or to unstable arrival or departure demand		input AFI sizes and pattern is poor. This condition jeopardizes the usefulness of the TLDT values.
CTOT	Unstable CTOT	as in current operations		
ELDT	Inaccurate ELDT	as in current operations		
Call sign	None	as in current operations	None	N/A
TTOT	None	Just to be displayed	None	N/A

Table 12: AMAN function – operational performance

The following operational effects will occur if the operational performance is low:

1. The pattern used will rarely fit the demand. As a result, the runway throughput will decrease while the departure delay is prone to increase.

3. The ATCO supervisor analysis on the necessity of varying the TLDTs and TTOTs is mostly based on the arrival and departure demand data accuracy, which may lead into wrong conclusions if it's based in unstable input data.

A.1.2.2.1.2.2 Departure Management Function performance issues

Figure 4: Departure Management Function input/output model

o	Cause		Operational Performance Issue	
	Functional Model Element Impact	**Description**	**Functional Model Element Impact**	**Description**
TOBT	Unstable TOBT	as in current operations	Unstable TTOT Unstable TSAT	Due to the low reliability of the input data, the TTOT and TSAT calculations performed by the DMAN are poor. This condition jeopardizes the usefulness of the departure sequence
TLDT	Unstable TLDT	TLDTs experience frequent changes during the execution phase, possibly with very short notice.		
EXOP	Inaccurate EXOP	EXOP values don't match closely the actual taxi-out times. This issue should be limited to the maximum thanks to the Variable Taxi Time (VTT) calculation performed by Routing and Planning Function		
Pattern	Unstable input pattern	ATCO chosen pattern experience frequent changes to adapt to late peaks, or to unstable arrival or departure demand		
CTOT	Unstable CTOT	as in current operations		
Flight-plan	None	as in current operations		

Table 13: DMAN function – operational performance

The following operational effects will occur if the operational performance is low:

1. The estimated TTOT will rarely fit the departure demand. As a result the departure delay is likely to increase, the runway throughput will consequently decrease and the overall predictability will decrease.

A.1.2.2.1.3 Safety functions

In this chapter the System mitigations are presented that are already covered by operational requirements. These will be referenced to the different functions of the block diagram shown in Figure 2: OFA 04.01.01 Functional Model

The main causes for the operational performance can be generally categorized into the following categories:

- Update of input parameters:
  the arrival and departure sequences are calculated based on a number of estimations available from different sources. It is of the utmost importance to guarantee that these inputs are constantly maintained updated to ensure that the pattern and therefore the arrival and departure sequences are efficient with respect to the actual situation.
- Unexpected traffic behaviours:
  apart from the update of input parameters covered by the previous category, an unexpected situation can always verify in real operations requiring the application of specific procedures by ATC and pilots. It is of the utmost importance to guarantee that the Coupled AMAN/DMAN is robust enough to such situations, by giving the flexibility to adapt to them on a non-recurring basis, without dramatically deteriorating performances.
- System failure:
  whenever the system is not able to suggest an appropriate arrival and departure sequence supporting the calculation of arrival and departure sequences for whatever reason, a standard procedure shall be applied to ensure the continuity of operations. This could possibly be represented by a FCFS criterion of ordering departures and arrivals, which is a natural way of working for ATCOs and has proven to be efficient in cases where demand is well below the capacity.

The causes and mitigations below are structured along this classification.

The update of input parameters can lead to inefficient pattern:

Cause	Specific mitigation	Traceability to OSED 06.08.04 Requirements
EXOP – values don't fit real taxi-out times	Parameters for adjusting EXOP to specific situations (e.g. slower taxi speeds due to low visibility conditions) need to be established. Supervisors should be able to revert to static taxitime tables (VTT) that were used before introduction of routing functionality within A-CDM as fallback.	REQ-06.08.04-OSED-1300.0040 IER-06.08.04-OSED-0103.0070

Unexpected traffic behaviour can result in the need for adjusted sequence pattern:

Cause	Specific mitigation	Traceability remarks to OSED 06.08.04 Requirements

Pattern - Traffic demand is well below the available capacity.	In those cases it is instead essential to implement the first come first served principle (FCFS) in order to provide a traffic picture to the ATCO which represents his actual way of working. Thus no specific pattern is implemented, but instead the order of traffic based on FCFS is displayed.	REQ-06.08.04-OSED-1200.0050

System errors can lead to unavailability of sequence pattern:

Cause	Specific mitigation	Traceability remarks to OSED 06.08.04 Requirements
Pattern - Too short value for the pattern's "no change time" (defined as XX minutes)	Provide possibility of manually overruling "no change time" by supervisor to react to unforeseen situations	REQ-06.08.04-OSED-1200.0055
Pattern - Too long value for the pattern's "no change time" (defined as XX minutes)	Provide possibility of manually overruling "no change time" by supervisor to react to unforeseen situations	

Table 14: Identified system mitigations

From the discussions in the chapters before the following performance requirements are derived:

ID	Performance Requirement
REQ-06.08.04-SPR-0132.0010	The TOBT information shall be maintained updated by the Airspace User, based on all the available information about the status of the turn-around process.
REQ-06.08.04-SPR-0132.0015	TTOT information shall be maintained updated using all information available from A-CDM (e.g. latest TOBT, CTOT, ASAT) as well as the EXOP, until the start-up approval has been issued. From this moment the TTOT shall be kept stable in order to stick to the original departure sequence.
REQ-06.08.04-SPR-0132.0020	The ELDT information shall be maintained updated as in current operations.
REQ-06.08.04-SPR-0132.0030	"The most appropriate pattern may be automatically calculated by AMAN based on the traffic demand and the impact on performances (e.g. the forecast delay, the forecasted schedule deviation…)".
REQ-06.08.04-SPR-0132.0040	In those cases where automatic implementation of pattern is supported, the AMAN shall calculate the most appropriate pattern under the following conditions: The modified pattern, given the latest available information, has a better performance impact than the active one, provided that the deviations of the forecasted KPIs are greater than a specified ΔKPI. The minimum duration of the pattern is guaranteed (XX minutes). The earliest flight in the modified pattern has a TLDT at least XX minutes after the time of modification takes place. A reasonable value for XX is 20 minutes, although this can be modified (as preset parameter) depending on the operating environment.
REQ-06.08.04-SPR-0132.0050	Airport Tower Supervisor or ACC/Approach Supervisor must be able to modify the pattern. Any change of pattern shall be performed after an agreement between Airport Tower Supervisor and ACC/Approach Supervisor, but only one of them shall be allowed to input the pattern into the AMAN.
REQ-06.08.04-SPR-0132.0060	In case the system is unable to calculate the optimal pattern, a default pattern should be activated based on a pre-determined list of feasible ones (e.g. based on a first-come-first-served order).
REQ-06.08.04-SPR-0132.0070	During phases where traffic demand is well below the available capacity values, the first-come-first-served (FCFS) principle shall be applied instead of a pattern, in order to provide a traffic picture to the ATCO which represents his actual way of working.
REQ-06.08.04-SPR-0132.0080	The ATCO shall follow as much as possible the system-calculated pattern, in order to ensure predictability
REQ-06.08.04-SPR-0132.0090	To maintain TOBT information updated specific mechanisms can be adopted as incentive to maintain the TOBT updated (waiting list for the a/c not requesting start-up approval at TSAT + x minutes).

Table 15: Final identified performance requirements

A.1.2.3 The OFA 4.01.01 SPR-level Model

A.1.2.3.1 Description of SPR-level Model

The SPR-level Model for the coupled AMAN/DMAN is described in the figure below.

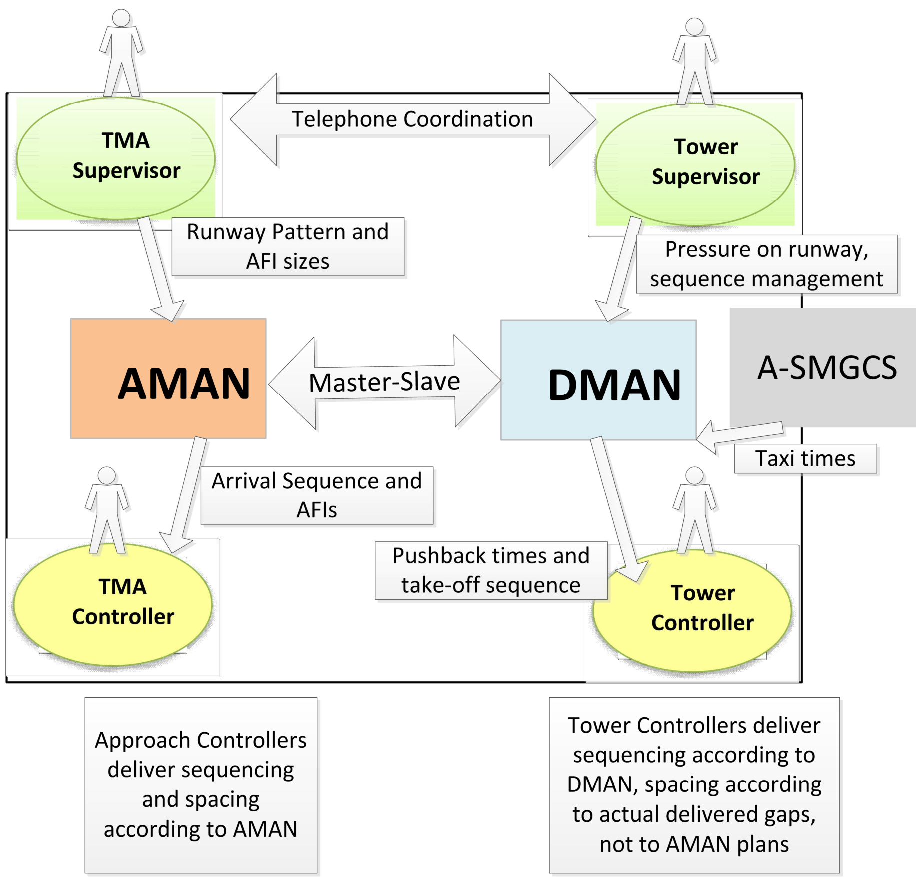

Figure 5: OFA 04.01.01 SPR-level Model

A.1.2.3.1.1 Aircraft Elements

There are no new Aircraft Elements in the coupled AMAN/DMAN

A.1.2.3.1.2 Ground Elements

The Ground Element Introduced with coupled AMAN/DMAN is the coupling function based on the master-slave configuration between AMAN and DMAN.

A.1.2.3.1.3 External Entities

The External Entities do not change compared to uncoupled AMAN/DMAN

A.1.2.3.2 Task Analysis

The task analysis shows that the tasks for all controllers remain as they are with the uncoupled AMAN/DMAN. Only the Approach and Tower Supervisors will input the parameters into the system.

- Approach and Tower Supervisor
  will agree on sequence pattern and AFI-Size. It is decided at local level if it is the Approach Supervisor or Tower Supervisor who will input the respective values for pattern and AFI-Size into AMAN.
- Approach controllers
  will as in previous operating method establish the landing sequence considering the agreed sequence and AFI-Sizes.
- Clearance Delivery Controller
  will provide start-up approval based on TSAT (considering that TSAT is a window of -/+ 5 minutes) provided by DMAN as in the previous operating method. The only change to previous operations is that TSAT calculation will be based on more accurate estimated taxi times provided by routing and planning service.
- Tower Runway Controller
  as in previous operations verifies that the runway is clear and that the aircraft will meet arrival/departure separation requirements. It has to be highlighted that it remains the controller's task to further optimise the departure sequence whenever possible, i.e. controllers do not have to adhere to TTOT.
- Flight Crew
  requests a departure clearance by voice (R/T) or by datalink communications as in previous operations.

A.1.2.3.3 Derivation of Safety Requirements (Functionality and Performance – success approach)

The following results were provided in the VALR for VP-453 and need to be considered in the Safety Requirements:

- Runway Policy (Pattern) needs to be displayed based on aircraft (SR-001)
- Integrated sequence needs to be compliant with CTOT (SR-17)
- Controller needs to be trained that sequence does not consider all minimum separation (SR-18)

Safety Objectives ***(Functionality and Performance from success approach)***	Safety Requirement	Reference
SO-0001 Coupled AMAN/DMAN shall support coordination between TWR and Approach	SR-001 Coupled AMAN/DMAN shall support coordination between TWR and Approach by showing the planned integrated sequence and the selected sequence pattern (with a pattern change to be	FM - HMI

	allocated to a flight rather than point in time)	
SO-0002 Coupled AMAN/DMAN shall support effective ATC runway management	SR-002 AMAN shall display the arrival sequence to the Approach/En-route Controller	FM- HMI
	SR-003 DMAN shall display the departure sequence to the Clearance Delivery Controller	FM- HMI
	SR-100 ATCO has to compare the planned sequence with the actual aircraft position in order to detect any inconsistencies.	Causal Analysis
	SR-103 Controllers shall be properly trained in the back up procedures for loss of AMAN/DMAN functionality	Causal Analysis
	SR-18 Controllers shall be trained for the case that the sequence does not consider all minimum separations.	Causal Analysis
SO-0003 Coupled AMAN/DMAN shall support managing the sequence in mixed mode environment.	SR-004 Approach or Tower Supervisor, depending on local procedures, shall be able to adjust sequence pattern and AFI-Size in AMAN to provide sufficient spacing for departures in a mixed mode environment.	FM HMI-Supervisor
	SR-102 The Coupled AMAN/DMAN function must allow reverting to uncoupled AMAN/DMAN	Causal Analysis
SO-0004 Coupled AMAN/DMAN shall be provided with accurate wake vortex information	SR-006 Coupled AMAN/DMAN shall consider wake vortex separation between successive arrivals	FM – AMAN /DMAN
	SR-007 Coupled AMAN/DMAN shall consider wake vortex separation between successive departures (if basic DMAN also considers them)	FM – AMAN /DMAN
SO-0005 Coupled AMAN/DMAN shall be provided with wake vortex information	SR-008 Coupled AMAN/DMAN shall be provided with flightplan information; including wake vortex information	FM - AMAN

SO-0006 Coupled AMAN/DMAN shall be provided with correct wake vortex information	SR-008 Coupled AMAN/DMAN shall be provided with flightplan information; including wake vortex information	FM - AMAN
SO-0007 DMAN shall be provided with reliable demand prediction	SR-009 Parameters for adjusting EXOP to specific situations (e.g. slower taxi speeds due to low visibility conditions) need to be established.	FM - Routing
	SR-010 Supervisors should be able to revert to static taxitime tables (VTT) that were used before introduction of routing functionality within A-CDM as fallback.	FM - Routing
SO-0008 AMAN needs to be provided with all relevant information for sequencing traffic	SR-011 AMAN needs to be provided with all relevant information for sequencing traffic (Flightplan / ELDT / CTOT / TTOT / Sequence Pattern / AFI-Size))	FM - AMAN IERs
SO-0009 Synchronisation of arrivals should not be worse than in current operations with standalone AMAN	SR-012 The planned number of arrivals shall not exceed the available arrival capacity.	FM - AMAN
	SR-013 The planned separation between successive arrivals with the coupled AMAN/DMAN shall not be lower than the applicable minimum separations between arrivals as used today with AMAN. Considering the departures shall only result in an increase in arrival separations.	FM -AMAN
	SR-101 A failure of the Coupled AMAN/DMAN function shall be properly notified on approach and Tower Controller and Supervisor HMI.	Causal Analysis
SO-0010 DMAN needs to be provided with all relevant information for sequencing traffic	SR-014 DMAN needs to be provided with all relevant information for sequencing traffic (TOBT/ Flightplan / CTOT / TLDT / Pattern / EXOP)	FM – DMAN IERs

SO-0011 Synchronisation of departures should not be worse than in current operations with standalone DMAN	SR-15 The planned number of departures shall not exceed the available departure capacity.	FM - DMAN
	SR-16 The planned separation between departures with the coupled AMAN/DMAN shall not be lower than the applicable minimum separations between departures as used today with DMAN. Considering the arrivals shall only result in an increase in departure separations.	FM - DMAN
	SR-101 A failure of the Coupled AMAN/DMAN function shall be properly notified on approach and Tower Controller and Supervisor HMI.	Causal Analysis
	SR-17 The integrated sequence shall be compliant with CTOT.	Causal Analysis

Table 16: Mapping of Safety Objectives to Safety Requirements

Safety Requirement ID	Requirement
REQ-06.08.04-SPR-0131.1100	SR-001 Coupled AMAN/DMAN shall support coordination between TWR and Approach by showing the planned integrated sequence and the selected sequence pattern (with a pattern change to be allocated to a flight rather than point in time)
REQ-06.08.04-SPR-0131.1070	SR-002 AMAN shall display the arrival sequence to the Approach/En-route Controller
REQ-06.08.04-SPR-0131.1120	SR-003 DMAN shall display the departure sequence to the Clearance Delivery Controller
REQ-06.08.04-SPR-0131.1020	SR-004 Approach or Tower Supervisor, depending on local procedures, shall be able to adjust sequence pattern and AFI-Size in AMAN to provide sufficient spacing for departures in a mixed mode environment.
REQ-06.08.04-SPR-0131.1130	SR-006 Coupled AMAN/DMAN shall consider wake vortex separation between successive arrivals
REQ-06.08.04-SPR-0131.1140	SR-007 Coupled AMAN/DMAN shall consider wake vortex separation between successive departures (if basic DMAN

	also considers them)
REQ-06.08.04-SPR-0131.1030	SR-008 Coupled AMAN/DMAN shall be provided with flightplan information; including wake vortex information
REQ-06.08.04-SPR-0131.1150	SR-009 Parameters for adjusting EXOP to specific situations (e.g. slower taxi speeds due to low visibility conditions) need to be established.
REQ-06.08.04-SPR-0131.1160	SR-010 Supervisors should be able to revert to static taxitime tables (VTT) that were used before introduction of routing functionality within A-CDM as fallback.
REQ-06.08.04-SPR-0131.1030	SR-011 AMAN needs to be provided with all relevant information for sequencing traffic (Flightplan / ELDT / CTOT / TTOT / Sequence Pattern / AFI-Size)
REQ-06.08.04-SPR-0131.1050	SR-012 The planned number of arrivals shall not exceed the available arrival capacity.
REQ-06.08.04-SPR-0131.1130	SR-013 The planned separation between successive arrivals with the coupled AMAN/DMAN shall not be lower than the applicable minimum separations between arrivals as used today with AMAN. Considering the departures shall only result in an increase in arrival separations.
REQ-06.08.04-SPR-0131.1080	SR-014 DMAN needs to be provided with all relevant information for sequencing traffic (TOBT/ Flightplan / CTOT / TLDT / Pattern / EXOP)
REQ-06.08.04-SPR-0131.1100	SR-15 The planned number of departures shall not exceed the available departure capacity.
REQ-06.08.04-SPR-0131.1140	SR-16 The planned separation between departures with the coupled AMAN/DMAN shall not be lower than the applicable minimum separations between departures as used today with DMAN. Considering the arrivals shall only result in an increase in departure separations.
REQ-06.08.04-SPR-0131.0020	SR-101 A failure of the Coupled AMAN/DMAN function shall be properly notified on approach and Tower Controller and Supervisor HMI.
REQ-06.08.04-SPR-0131.0030	SR-102 The Coupled AMAN/DMAN function must allow reverting to uncoupled AMAN/DMAN
REQ-06.08.04-SPR-0131.0070	SR-103 Controllers shall be properly trained in the back up procedures for loss of AMAN/DMAN functionality
REQ-06.08.04-SPR-0131.0010	SR-100 ATCO has to compare the planned sequence with the actual aircraft position in order to detect any inconsistencies.
REQ-06.08.04-SPR-0131.1170	SR-17 The integrated sequence shall be compliant with CTOT.
REQ-06.08.04-SPR-0131.1180	SR-18 Controllers shall be trained for the case that the

	sequence does not consider all minimum separations.

Table 17: Derivation of Safety Requirements (functionality and performance) from Safety Objectives

A.1.2.4 Analysis of the SPR-level Model – Normal Operational Conditions

A.1.2.4.1 Scenarios for Normal Operations

ID	Scenario	Rationale for the Choice
UC1	Arrival overload: ARR peak will build up	Protection from Traffic overload is safety relevant
UC2	Departure overload: DEP peak will build up	Protection from Traffic overload is safety relevant
UC3	Simultaneous overload of arrivals and departures: Concurrent ARR and DEP peak	Protection from Traffic overload is safety relevant
UC4	Change of traffic mix on ARR side: Action required due to changing WTC mix (only relevant if the trend goes towards a general increase in complexity)	Protection from Traffic overload is safety relevant
UC5	Change of traffic mix on DEP side / SID separation: Action required due to changing WTC mix (only relevant if the trend goes towards a general increase in complexity) or due to provision for SID separation	Protection from Traffic overload is safety relevant

Table 18: Operational Scenarios – Normal Conditions

In all the use cases listed in table 19 the coupled AMAN/DMAN will support managing the traffic in order to avoid traffic overloads. If a traffic overload occurs none the less, controllers will stack the traffic in order to avoid an overload in workload.

A.1.2.4.2 Thread Analysis of the SPR-level Model – Normal Operations

For all Scenarios described for normal operations, the coupled AMAN/DMAN is designed to optimise for predictability and runway throughput and to avoid traffic overload and thus prevent an overload in workload. No new safety objectives are derived from the normal operations scenarios as the following SR covers all use cases

SR-XXX Approach or Tower Supervisor, depending on local procedures, shall be able to adjust sequence pattern and AFI-Size to react to different traffic demand scenarios.

The process is the same for all Use cases (compare SPR-level Model):

- Approach and/or Tower Supervisor
  will detect need for adjustment of parameters (AFI-size and pattern) based on arrival and departure demand. Supervisor will enter the parameters that best fits to the demand into AMAN.
- Tower Clearance Delivery
  will follow TSAT as in current operations

- Tower Runway Controller
  will provide take-off according to actual delivered arrival gaps (not according to AMAN or DMAN plan!) as in current operations
- Approach Controllers
  will deliver sequencing and spacing according to AMAN as in current operations

A.1.2.4.3 Effects on Safety Nets – Normal Operational Conditions

As coupled AMAN/DMAN does not introduce any new procedures, the current safety nets will also work as in current operations – that applies for ground as for airborne safety nets (e.g. TCAS and STCA). No new safety requirement can be derived.

A.1.2.5 Analysis of the SPR-level Model – Abnormal Operational Conditions

A.1.2.5.1 Scenarios for Abnormal Conditions

ID	Scenario	Rationale for the Choice
UC6	Runway capacity will reduce due to: Contamination on RWY, weather influences etc. Generally this will affect both ARR and DEP	Additional workload induced
UC7	Go-Around: An aircraft needs to conduct a Go-Around because of some reason (e.g. traffic on RWY, technical problems etc.)	Additional workload induced
UC8	Take-Off abortion: An aircraft has to abort Take-Off because of some reason (e.g. engine failure)	Additional workload induced
UC9	Departure abortion: An aircraft has to abort departure while taxing because of some reason and return to its stand position	Additional workload induced
UC10	RWY inspections: Traffic cannot be planned onto the RWY because of required runway inspections	Additional workload induced

Table 19: Operational Scenarios – Abnormal Conditions

The use cases all might result in additional workload – but this can always be compensated by the controller by reducing the traffic volume and stacking aircraft until they can be processed further. The required steps are explained in the next chapter.

A.1.2.5.2 Derivation of Safety Requirements (Functionality and Performance) for Abnormal Conditions

Ref	Abnormal Conditions / SO (*Functionality and Performance)*	Mitigations (SR 0xx and/or A 0xx)
1	The coupled AMAN/DMAN shall provide parameters (AFI-Sizes) to consider reduced runway capacity	A03 Requirement already covered by uncoupled AMAN and DMAN
2	The coupled AMAN/DMAN shall integrate a Go-Around into the sequence again (automatically or manually by the controller).	A03 Requirement already covered by uncoupled AMAN
3	The coupled AMAN/DMAN shall be able to enter a temporary runway closure and re-plan traffic accordingly (e.g. after Take-Off Abortion.)	A03 Requirement already covered by uncoupled AMAN and DMAN
4	The Routing Functionality needs to consider a new stand for calculating the taxi-time if an aircraft had to return to stand	A03 Requirement already covered by uncoupled DMAN
5	The coupled AMAN/DMAN shall be able to provide gaps on the runway for a runway inspection and re-plan traffic accordingly.	A03 Requirement already covered by uncoupled AMAN

Table 20: Safety Requirements or Assumptions to mitigate abnormal conditions

A.1.2.5.3 Thread Analysis of the SPR-level Model - Abnormal Conditions

For all Scenarios described for abnormal operations, the coupled AMAN/DMAN has to provide the same requirements that are already available for uncoupled AMAN/DMAN.

A.1.2.5.4 Effects on Safety Nets – Abnormal Operational Conditions

In the abnormal Scenarios safety will even be improved as the parameters for any constraints like runway inspection may be entered only once into the system and the same information will be available for Tower as for Approach controllers.

A.1.2.6 Design Analysis – Case of Internal System Failures

A.1.2.6.1 Causal Analysis

A top-down identification of internal system failures leading to hazards has been conducted, identifying each of these causes and linking them to the possible hazards they could lead to, which are identified and listed in section A.1.1.7.1 Identification and Analysis of System-generated Hazards. Table 21 lists the causes identified and relates them to these hazards.

Cause	Cause Description	Related OH

1	Total Loss of Coupled AMAN/DMAN function	OH-01, OH-02
2	Corruption of Coupled AMAN/DMAN function	OH-01, OH-02

Table 21: List of causes leading to operational hazards

As part of the top-down identification of internal system failures that could lead to a hazard, the causal analysis includes a description of these system failures supported by fault trees including the basic causes of such failures. Additionally, Safety Objectives have been included associated to the hazard causes where applicable.

A.1.2.6.1.1 Total Loss of Coupled AMAN/DMAN function

Total Loss of Coupled AMAN/DMAN function describes a situation where a total unavailability of AMAN/DMAN function occurs.

Two barriers have been considered to mitigate the effects of the hazard:

1. An alert is sent to the ATCO HMIs in order to allow the detection of the failure.

   SR-101 A failure (partial or total loss) of the Coupled AMAN/DMAN function shall be properly notified on approach and Tower Controller and Supervisor HMI.

2. In case the alert has not been sent, the ATCO can always detect on the HMI that the aircraft sequence has not been calculated.

   SR-100 The ATCO has to compare the planned arrival sequence with the actual aircraft position in order to detect any inconsistencies.

In both cases, ATCO can contact the technical personnel to communicate the failure and can revert to the today procedures used in case of failure of AMAN or DMAN. Both cases should envisage just a slight impairment of working conditions due to an increase of ATCOs workload as in current operations. The increase in ATCO workload in turn will be compensated by reduced traffic throughput.

Regarding the identification of the basic causes, fault tree analysis has led to the following outcomes:

BC1. – No aircraft sequence is calculated due to failure of Coupled AMAN-DMAN Server.

SR-102 The Coupled AMAN/DMAN function must allow reverting to uncoupled AMAN/DMAN

BC2. – Aircraft sequence is calculated but ATCO cannot be able to see it due to failure of controller HMI.

SR-106 Controllers shall be properly trained in the back up procedures for Loss of AMAN/DMAN functionality

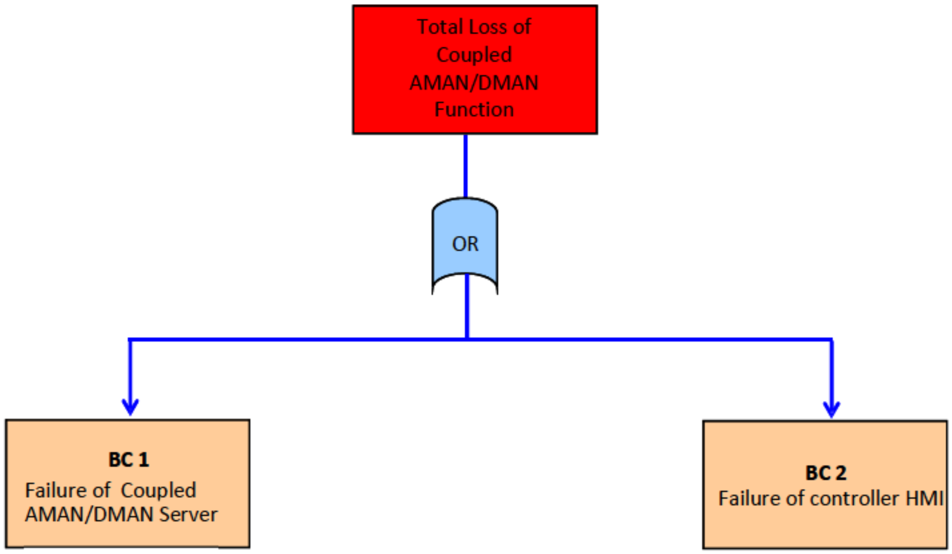

Figure 6: OH 01. Fault Tree

A.1.2.6.1.2 Corruption of coupled AMAN/DMAN function

The same external mitigation as for Total Loss of Coupled AMAN/DMAN function is considered.

For Corruption of Coupled AMAN/DMAN function, all basic causes have been identified by means of Fault Tree Analysis.

Regarding the identification of the basic causes, fault tree analysis has led to the following outcomes:

BC1. – Corrupted aircraft sequence is generated due to a wrong or missing data provided from DMAN as input to AMAN

SR-100 The ATCO has to compare the planned sequence with the actual aircraft position in order to detect any inconsistencies.

SR-103 The Coupled AMAN/DMAN function must allow reverting uncoupled AMAN/DMAN

.

BC2. – Corrupted aircraft sequence is generated due to a wrong or missing data provided from AMAN as input to DMAN.

SR-100 The ATCO has to compare the planned sequence with the actual aircraft position in order to detect any inconsistencies.

SR-103 The Coupled AMAN/DMAN function must allow reverting to uncoupled AMAN/DMAN

BC3. – Corrupted aircraft sequence is generated due to algorithm malfunction. It means that the inputs are correct but the system doesn't produce the right output.

SR-101 A failure (partial or total loss) of the Coupled AMAN/DMAN function shall be properly notified on approach and Tower Controller and Supervisor HMI.

SR-100 The ATCO has to compare the planned sequence with the actual aircraft position in order to detect any inconsistencies.

SR-103 The Coupled AMAN/DMAN function must allow reverting to uncoupled AMAN/DMAN

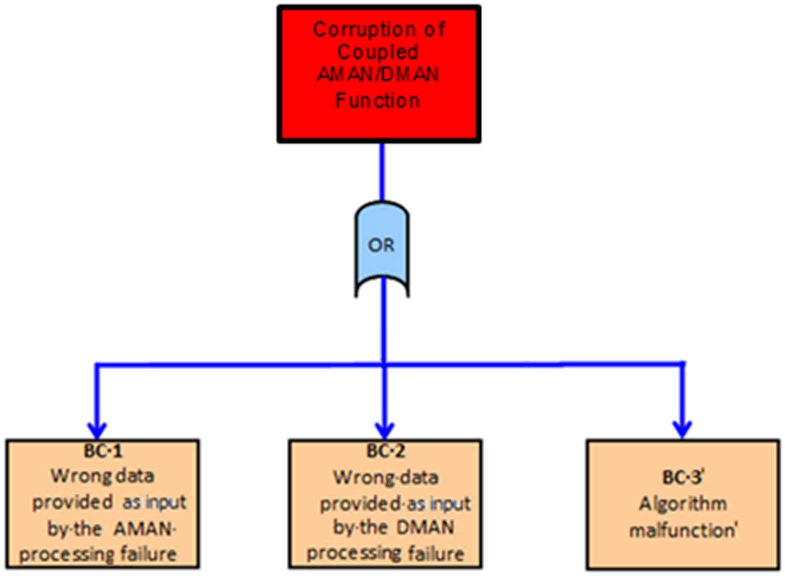

Figure 7: OH 02. Fault tree

A.1.2.6.2 Safety Requirements concerning system failure conditions

From the causes identified and listed in previous section, the following safety requirements have been derived.

SR#	Safety Requirement	Related to SO
SR-100	ATCO has to compare the planned sequence with the actual aircraft position in order to detect any inconsistencies.	SO-0002
SR-101	An alert must warn the Controller and Supervisor HMI in case of a failure (partial or total loss) of the Coupled AMAN/DMAN function.	SO-0009
SR-102	The Coupled AMAN/DMAN function must allow reverting to uncoupled AMAN/DMAN	SO-0003
SR-103	Controllers shall be properly trained in the back up procedures for loss of AMAN/DMAN functionality	SO-0002

Table 22: List of Safety Objectives mitigating the system generated hazards and their causes.

A.2 Security risk assessment

N/A

A.3 Environment impact assessment

The environment impact assessment can be retrieved from *Table 26: Environmental Sustainability KPIs indicators*.

A.4 Operational Performance Assessment

A.4.1 Introduction

The purpose of the Operational Performance Assessment (OPA) is to make an evaluation of working effectiveness and suitability of a system through test methods. This evaluation will be done developing potential issues that would appear in the Key Performance Areas (KPAs)/Key Performance Indicators (KPIs) defined in the Strategic Guidance of SESAR Programme.

This OPA is aimed at:

- Identification of defects
- Measurement of the adequacy of the outputs
- Assessment of the reliability of the operations

In order to achieve these objectives the OPA is organized around two different methodologies which will produce independent and complementary requirements and recommendations as an outcome.

- On the one side, a list of Performance Indicators is defined in relation to the Coupled AMAN/DMAN
- On the other hand, a set of performance issues is derived by analysing the functional model described in XXX. Issues will lead to performance mitigations, which will be eventually formally expressed as requirements.

The formal outcome of the OPA will be taken into account in the definition of the operational concept in future V-phases (i.e., Final OSED).

Finally, in the last section of this chapter, the most relevant conclusions extracted from this Operational Performance Assessment & Requirements are illustrated.

A.4.2 Performance aspects implied by the concept

In a single runway with mixed mode operations environment a trade-off exist between the arrival and departure capacities depending on the applicable separation requirements (IMC, VMC, wake vortexes categories, mix of movements, etc.). The capacity envelop is typically approximated by a piecewise linear boundary as depicted in Fig. 2 (source [20]). Points 1 and 4 indicate the capacity of the runway, when it is used only for arrivals and only for departures, respectively. Point 2 is known as the “free departures” point because it has the same capacity for arrivals as Point 1 and a departures capacity equal to the number of departures that can be inserted into the arrivals stream without increasing the separations between successive arrivals – and, thus, without reducing the number of arrivals from what can be achieved in the all-arrivals case. These “free” departures are obtained by exploiting large inter-arrival gaps between two consecutive arrivals.

Point 3 represented in Fig. 2 can be attained, in principle, by alternating arrivals and departures, i.e., by performing an equal number of departures and arrivals through an A-D-A-D sequence. This sequencing strategy can be implemented by “stretching,” when necessary, inter-arrival (inter-departure) gaps by an amount of time just sufficient to insert a departure (arrival) between two successive arrivals (departures). Because it is difficult for air traffic controllers to sustain this type of operation for extended periods of time, Point 3 can be viewed as somewhat theoretical. However, it provides a useful upper limit on the total achievable capacity (landings plus takeoffs) when arrivals and departures share a runway in roughly equal numbers.

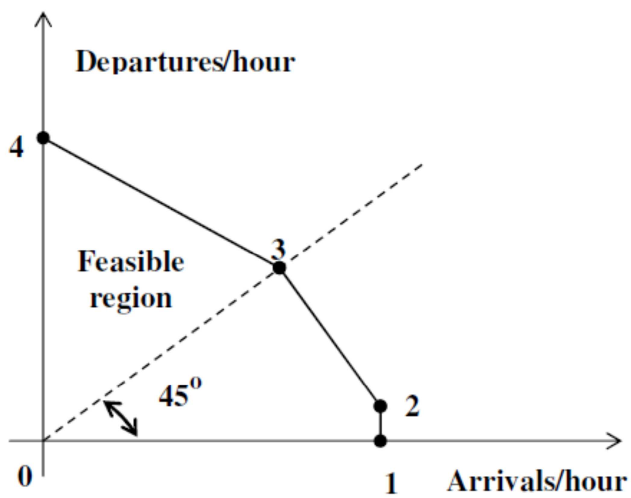

Figure 8: Capacity envelop for a single runway (source [20])

Once the most suitable pattern has been selected and activated to best meet the expected demand profile, this constitute a framework for Coupled AMAN/DMAN to schedule specific aircraft target times in accordance, thus permitting enhanced coordination between the involved controllers (e.g. APP and TWR ATCOs).

Whilst separation requirements constitute hard constraints which are inviolable, the scheduled and target times represent an example of weak constraints, since they allow some flexibility in their management. The degree of violation of these constraints determine how far from the optimality the system will be driven, depending on the KPIs optimized. Therefore during actual operations some degree of flexibility is always guaranteed for the ATCO to deal with deviations from the plans, by modifying the order of aircraft in the sequence or as a last recourse to apply late tweaks in the management of arrivals. In these cases the Coupled AMAN/DMAN itself could forecast that an extension or reduction of the pattern duration would be recommended due to a positive effect on the KPI figures.

It is important to highlight that the application of a pattern is no longer providing benefits in the case that the demand is well below the capacity. In this case in fact the pattern just constitutes a not necessary (soft) constraint for the controller to be applied, being the capacity constraint relaxed. The application of the first come first served (FCFS) principle in these cases generally guarantees scheduling efficiency, scheduling fairness and controller preference since it represents his actual way of working.

A slight variation of FCFS principle is the concept of *constrained positioning shifting* (CPS) [21], which consist in a limit over the number of positions that an aircraft can deviate from its First-come-first-served position in the arrival queue. For instance, an aircraft in the 16th position in an FCFS queue, would have to land in one of the positions 14 through 18, if the specified maximum position shift is 2. Through many numerical examples and for several reasonable objective functions, it has been showed in [21] that by setting MPS to a small number, such as 2 or 3, one can obtain most (e.g., 60-80%) of the potential benefits offered by unconstrained optimal sequences and, at the same time, ensure reasonable fairness in accessing runways.

A.4.3 Performance Indicators definition

SESAR Programme Strategic Guidance establishes the existence of 11 KPAs classified into 3 blocks according to their scope, as illustrated in Figure 8.

Figure 9: SESAR Performance Areas (KPA)

The P06.02 Airport Validation Strategy for Step 1 P06.02 D105 Airport Validation Strategy Step1 2014 update [14] stated that for OI Step TS-0203 the relevant KPAs are Capacity, Efficiency, Predictability and Safety for the Coupled AMAN/DMAN function. However, safety is considered out of scope of the OPA as it has already been analysed in detail in the Safety Assessment.

These KPAs have been compared with those set out in the OFA 05.01.01 P06.05.01 OSED [23] which tried to identify the generic Key Performance Indicators as a part of the Airport Operations Plan (AOP).

Additionally, Cost Effectiveness and environmental sustainability have been included as the fourth and fifth KPA for the coupled AMAN/DMAN function, as this project is clearly focused on increasing predictability values, thus decreasing associated delays and thereby increasing capacity and reducing fuel consumption. Furthermore, tower controller's workload would be reduced, increasing their productivity resulting in a decrease of the ANSP costs. Therefore, a positive impact on the Predictability KPA implies a reduction on costs and a positive impact on the Cost Effectiveness and Environmental Sustainability KPAs.

Therefore, the Key Performance Indicators have been classified into these five different KPAs:

- Capacity
- Efficiency
- Predictability
- Environmental Sustainability
- Cost Effectiveness

It is also important to remark that different KPIs will often be a trade-off between effects for different KPAs.

The current KPI identification is not binding for the OPA, meaning that not all identified KPIs will be addressed either quantitatively or qualitatively, but only those mentioned in the Validation Reports[10][11][12], and [13].

Capacity

The contribution of the coupled AMAN/DMAN function to Capacity KPA can be defined as the runway number of operations per hour, measured as Landing, Take Off and Total operations. These KPIs are consistent with P06.05.01 identification and analysis of airport KPIs [23]

KPI Assessed	Indicator	Definition	Results
Absolute Total Capacity shortage	Number of movements which cannot be handled	Number of aircraft in time period minus capacity in time period	Not directly addressed in the Validation Reports
Absolute Arrival Capacity shortage	As above, for arrivals	As above, for arrivals	Not directly addressed in the Validation Reports
Absolute Departure Capacity shortage	As above, for departures	As above, for departures	Not directly addressed in the Validation Reports
Relative Total Capacity shortage	Percentage of demand which cannot be handled	(1 – (Number of arrivals and departures) / (Capacity)) x 100%	Not directly addressed in the Validation Reports
Relative Arrival Capacity shortage	As above, for arrivals	As above, for arrivals	Not directly addressed in the Validation Reports
Relative Departure Capacity shortage	As above, for departures	As above, for departures	Not directly addressed in the Validation Reports

Table 23: Capacity KPA – parameters under assessment

The SESAR project B4.1 [22] defined the validation targets envisaged for certain airport KPIs at Step1, defining an intended increase in Runway Throughput per Hour of 14% for step1 out of the total 20% increment envisaged for step3. Out of this 14% increase in the runway throughput, a 1.62% is expected to come directly from the Integrated AMAN/DMAN OFA04.01.01.

The results of the V2 Exercise VP-339 [12] showed in an increase of the best hour throughput of 5.7%, exceeding considerably the 1.62% objective. The results of the V3 Exercise VP-453 [13] showed an increase in throughput from 44.9 to 47.9 movements per hour, which is a 6.7% increase.

Although no direct relation exists between the measures used by OFA04.01.01 and project 06.08.04, these can be used as indicative values.

Efficiency

This KPA addresses the actually flown 4D trajectories of aircrafts in relationship to their initial Shared Business Trajectory. In order to assess the Operational Performance of Coupled AMAN/DMAN functionalities in relation to the Efficiency KPA, the following measurable parameter were analysed:

KPI Assessed	Indicator	Definition	Results
Average Landing Delay	Average Delay for landing operations	Average of (Forecast Landing Time) minus (Intended Landing Time)	[12] VP-339 simulation resulted in an increase of the average arrival delay of 6.3%. Delay was not measured in VP-453.
Average Take-Off Delay	Average Delay for take-off operations	Average of (Forecast Take-off Time) minus (Intended Take-off Time)	[12] VP-339 simulation resulted in a reduction of the average departure delay of 21.3%.
Average Delay AD	Overall Average Delay including both take-off and landing operations	Average of (Forecast Runway Time) minus (Intended Runway Time)	[12] VP-339 simulation resulted in a reduction of the average delay of 9.5%. Thus, we can conclude that the decrease in the departure delays compensates the arrival ones achieving lower overall delays.

Table 24: Efficiency KPA – parameters under assessment

Except for the Runway availability Delay, which could be included in the taxi-out movement Delay, all the analysed KPIs are consistent with P06.05.01 identification of airport efficiency KPIs analysis.

The global efficiency improvements were defined in project B4.1 through the KPI fuel burned by flight, which is considered in this document as an environmental sustainability KPI.

Predictability

Predictability indicators aim to assess the contribution of the Coupled AMAN/DMAN function to the enhancement of average adherence to the expected target times for arrival (landing) and departures (take-off) operations. High adherence levels to target times will allow increased predictability on runway demand and capacity estimations. The contribution of Coupled AMAN/DMAN functions to Predictability KPA has been divided into arrival, departure and overall predictability values.

KPI Assessed	Indicator	Definition	Results
Arrival Predictability	Adherence to pre-calculated planned times for in-block	Percentage of arrivals with in-block time no later than X minutes after scheduled block time (early counts as on-schedule).	[12] VP-339 simulation resulted in a decrease of the arrival predictability of 10%, for runway times. [13] VP-453 found significant improvements in ELDT accuracy.
Departure Predictability	Adherence to pre-calculated planned times for off-block	Percentage of departures with off-block time no later than X minutes after scheduled block time (early counts as on-schedule).	[12] VP-339 simulation resulted in an increase of the departure predictability of 18.9%. [10] D9 simulation resulted in an increase of the on-time take-off capacity of 25% and 15% for the cases of medium and high traffic density respectively. This is due to the more accurate taxi time caused by the integration of DMAN and the Routing and Planning function [13] VP-453 found significant improvements in TTOT accuracy.
Overall Predictability	Adherence to pre-calculated target times, all operations	Percentage of aircraft with in-block/off-block time no later than X minutes after scheduled block time (early counts as on-schedule).	[12] VP-339 simulation resulted in an increase of the overall predictability of 4.7%. Thus, we can conclude that an increase of the departure predictability compensates the decrease in the arrival one achieving better overall values. [13] VP-453 found significant improvements in the accuracy of planned runway times.

Table 25: Predictability KPA – parameters under assessment

The arrival and departure analysed KPIs are consistent with P06.05.01 identification of airport predictability KPIs analysis Appendix A.

Environmental Sustainability

The contribution of the coupled AMAN/DMAN function to Environmental Sustainability KPA has been defined as the emissions during taxi-out (expected to decrease because of the more accurate taxi-out time estimation provided by Routing and Planning service), during landing and during take-off.

KPI Assessed	Indicator	Definition	Solution
Emissions during taxi-	Average Fuel burned by	∑fuel burned by aircrafts (Tn.) for a given time (e.g. 1 day) / # pax.	VP-453 [13] found a 6.5% reduction in taxi-out fuel.

out operations	aircrafts, taxi-out	for the given time (e.g. 1 day), for taxi-out ops	However, only very high levels of traffic were covered.
Emissions during landing operations	Average Fuel burned by aircrafts, landing per pax	∑fuel burned by aircrafts (Tn.) for a given time (e.g. 1 day) / # pax. for the given time (e.g. 1 day), for taxi-out ops	VP-453 [13] found a 3.5% reduction in fuel burned before landing. However, only very high levels of traffic were covered.
Emissions during take-off operation	Average Fuel burned by aircrafts, take-off per pax	∑fuel burned by aircrafts (Tn.) for a given time (e.g. 1 day) / # pax. for the given time (e.g. 1 day), for taxi-out ops	VP-453 [13] found fuel reductions for both arrivals and departures, and therefore for overall departures also.

Table 26: Environmental Sustainability KPIs indicators

VP-453 found a 6.5% fuel reduction for taxi-out and a 3.5% fuel reduction before landing with Coupled AMAN-DMAN. This exercise featured very high levels of traffic, so these figures should not be counted as typical, but they suggest that the B04.01 targets can be met.

Although no improvements were defined in project B04.01 for this KPA in a direct way, it can be analysed indirectly through the efficiency KPA, defined through fuel burned by flight, which is expected to be reduced a 2.8% in Step1 as defined in project B04.1. Out of this 2.8%, a 0.19% is expected to come directly from the Integrated AMAN/DMAN OFA04.01.01.

Cost Effectiveness

The contribution of Coupled AMAN/DMAN functions to Cost Effectiveness KPA has been divided into ANS Costs through Airport Operator and Airspace Users Costs.

In order to assess the impact of this contribution of the Coupled AMAN/DMAN functions to Cost Effectiveness KPA, the following parameters are proposed:

KPI Assessed	Indicator	Definition	Solution
ANS Costs	Cost per operation of ANS derived from runway operations	∑ costs of ANS services derived from runway ops for a given time(e.g. 1 year) (€) / # of operations in the given time (e.g. 1 year)	Not addressed in the Validation Reports
Airspace Users Direct Costs	Cost per operation for Airspace Users derived from runway operations	∑ costs for Airspace users derived from runway ops for a given time(e.g. 1 year) (€) / # of operations in the given time (e.g. 1 year)	Not addressed in the Validation Reports
Airport Operator Direct Costs	Cost per operation for Airport Operator derived from runway operations	∑ costs for Airport Operator derived from runway ops for a given time(e.g. 1 year) (€) / # of operations in the given time (e.g. 1 year)	Not addressed in the Validation Reports

Table 27: Cost Effectiveness KPA – parameters under assessment

The identification of airport KPIs analysis for different KPAs in project P06.05.01 was not performed for the cost effectiveness KPA. However, the improvements in this area were defined in project B04.01 through the direct ANS costs KPI, which is expected to reduce a 6.3% in Step1.
Out of this 6.3%, only a 0.02% is expected to come directly from the Integrated AMAN/DMAN OFA04.01.01.

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