
	<p align="center">Episode 3</p> <p align="center">D5.3.4-01 - FTS Experimental Plan on Multi-Airport TMA operations in the core area of Europe</p>	<p align="right"><i>Version : 1.00</i></p>
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EPISODE 3


Single European Sky Implementation support through Validation



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DOCUMENT CONTROL

Approval

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0 EXECUTIVE SUMMARY

This document describes an Experimental Plan for the fast-time simulation experiment conducted in WP5.3.4 of the Episode 3 project. This Experimental Plan is based on the workplan described in Annex 1 of Episode 3, the DOW, version 3.0, as well as the WP5 Management plan and the Validation Strategy of WP5. In addition, discussion by the TMA Expert Group was feeding the plan.

This FTS exercise will address Arrival Management and Trajectory Management – enabling advanced CDAs in a multi airport TMA.

The exercise will cover:

- Increased demand in each of the airports,
- Handling/solving the potential imbalances in capacity in the hub airports,
- Accuracy in arrival management,
- Accuracy in flight trajectory planning,
- Accurately sequenced arrival flows at TMAs,
- Fuel efficiency and low noise CDAs.

The fast time simulation will be run at NLR in Amsterdam and simulate the Dutch/German airspace and the impact of SESAR on a multi airport TMA environment.

The Experimental Plan describes this experiment, based on elements of the Operational Concept of SESAR and the Detailed Operational Descriptions (DODs) aiming to refine this concept. The experiment aims to validate parts of the planning processes of departure and arrival management in the core area of Europe.

The Experimental Plan describes:

- The concept addressed,
- Objectives, metrics and indicators of the validation experiment,
- Scenarios, experimental set-up and organisation of the experiment,
- Planning, analysis and detailed experimental design.

The validation objective of the experiment is:

This fast-time experiment aims to validate that the ATM capability of ETMA/TMA airspace in a multi hub-airport environment, i.e. Schiphol and the Düsseldorf area, is sufficient to cope with increased demand in each airport, taking into account the forecast capacity of each of the airports.

Descent operations starting from Top-of-Descent, typically 200NM out, have to become highly efficient compared to today's operations, i.e. 2009. The Experimental Plan describes how to assess the potential to reduce the length of the flight path, to fly more efficient profiles (CDAs), and to enhance the efficiency of flight planning and control.



1 INTRODUCTION

1.1 PURPOSE OF THE DOCUMENT

This document provides the Validation Exercise Plan for the experiment on Multi-Airport TMA operations in the core area of Europe. This experiment is conducted by NLR in workpackage WP5.3.4 of the Episode 3 project.

The experiment addresses enhanced sequencing and traffic synchronisation of high density traffic flows in high complexity airspace in the core area of Europe. The aim is to assess the potential to improve arrival operations to hub airports in this area. The experiment is performed by fast-time simulation of air traffic in an area that covers the Benelux and part of the West side of Germany. The airports of interest are: Schiphol (EHAM), Düsseldorf (EDDL), Köln (EDDK) and Brussels Zaventem (EBBR).

The concept of interest is adopted from SESAR, SESAR D3, Ref. [7]) and its Concept of Operations, Ref. [8]. This concept has to be validated in order to bring it to operations and this experiment, being part of the early validation process of Episode 3, aims to contribute to the validation of part of this concept, i.e. the validation of high density arrival operations.

1.2 INTENDED AUDIENCE

This document is intended to be used by the participants of the fast-time experiment conducted in Workpackage WP5.3.4, Multi-Airport TMA operations in the core area of Europe. Other workpackages with an interest in the set-up and conduct of this experiment are:

- WP5.3.1: The WP5 TMA Expert Group, and
- WP2: managing system consistency.

1.3 DOCUMENT STRUCTURE

The document is structured as follows:

- Chapter 2 introduces the scope and justification of the validation exercise. The chapter provides an overview of the concept of interest, the KPAs and the exercise objectives. This is followed by an overview of experimental set-up, applicable validation scenarios and metrics.
- Chapter 3 describe planning and management of the experiment.
- Chapter 4 and 5 gives a brief overview of planned use of analysis tools and methodology, as well as the planned way to execute the experiment.
- Chapter 6 lists the applicable references.
- Section 2.8 and Annex 2 are providing an overview of assumptions and critical issues, which are scoping the relevance of the experiment to future operational implementation. This relates to discussion material provided by the EP3 WP5 TMA Expert Group (WP5.3.1).



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1.4 BACKGROUND

Episode 3 (EP3) is charged with beginning the validation of the operational concept expressed by SESAR Task 2.2 and consolidated in SESAR D3, Ref. [7]. The initial emphasis is on obtaining a system level assessment of the concept's ability to deliver the defined performance benefits in the 2020 time horizon corresponding to ATM Capability Level 2/3 and the Implementation Package 2 (IP2).

The validation process as applied in EP3 is based on the E-OCVM, Ref. [2], which describes an approach to ATM Concept validation. However, to date the E-OCVM has not been applied to validation of a concept on the scale and complexity of SESAR. Such a system level validation assessment must be constructed from data derived from a wide range of different validation activities, integrating many different levels of system description, different operational segments and contexts and different planning horizons. The data will be collected through a variety of methods and tools and will vary in its quality and reliability.

The process of performing systematic validation and the integration of results must be actively planned and managed from the beginning of the whole validation activity. This validation management is coordinated by EP3/WP2.3, which is responsible for ensuring the effective application of the E-OCVM, the consolidation of the Episode 3 Validation Strategy, and establishing a Validation Framework.

Validation exercises should produce evidence, and preferably measured, about the ability of some aspect of the concept to deliver on some aspect of the performance targets. In order to be able to do Validation Exercises, there is a need for concept clarification, requirements development or elaboration activities in preparation for down line validation activities.

This exercise plan is based on a general template that has been produced collaboratively between WP2.3, the Validation Strategy and Support Tasks within WP3, 4 & 5 (x.2), and complementary guidance material for E-OCVM Step 2, as provided by WP2.3, Guidance Report, Ref. [11].

In addition, the objectives, concepts and conduct of experiment have been discussed with the WP5 TMA Expert Group, Expert Group Plan, Ref. [18]. The results of these discussions are part of this experimental plan.

1.5 GLOSSARY OF TERMS

Term	Definition
A/C	Aircraft
ACC	Area Control Centre
ACDA	Advanced Continuous Descent Approach
A-G	Air-Ground
AMAN	Arrival Management (tool)
ANSP	Air Navigation Service Provider
AOM	Airspace Organisation and Management
ASAS	Airborne Separation Assistance System
ATC	Air Traffic Control
ATM	Air Traffic Management
BT	Business Trajectory
CDA	Continuous Descent Approach



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Term	Definition
CDM	Collaborative Decision Making
CONOPS	Concept of Operations
CDTI	Cockpit Display of Traffic Information
CTA	Controlled Time of Arrival
CTFM	Collaborative Traffic Flow Management
DCB	Demand & Capacity Balancing
DOD	Detailed Operational Description (of Episode 3)
DOW	Description Of Work
DTG	Distance To Go
ECAC	European Civil Aviation Conference
E-OCVM	European Operational Concept Validation Methodology
EP3	Episode 3
ETMA	Extended Terminal Manoeuvring Area
FAB	Functional Airspace Block
FAF	Final Approach Fix
FAP	Future ATM Profile (EEC)
FMS	Flight Management System
FOC	Flight Operations Centre
FTS	Fast-Time Simulation
HIL	Human In the Loop
HMI	Human Machine Interface
IAF	Initial Approach Fix
ICAO	International Civil Aviation Organisation
IP	Implementation Package (SESAR)
KPA	Key Performance Area
KPI	Key Performance Indicator
LAQ	Local Air Quality
Lden	Load, during Day, Evening, Night (Noise)
Lnight	Load, during Night (Noise)
LoC	Lines of Change (SESAR)
MTCD	Medium-Term Conflict Detection
NAM	Network Analysis Model (Modelling tool)
NLR	National Aerospace Laboratory of the Netherlands
NM	Nautical Mile
NOP	Network Operations Plan
OI	Operational Improvement (SESAR)
OPTIMAL	Optimised Procedures and Techniques for Improvement of Approach and Landing (EU, 6th Framework Programme)



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Term	Definition
P-RNAV	Precision Area Navigation
PRR	Performance Review Report (EUROCONTROL)
PTC	Precision Trajectory Clearance
RBT	Reference Business Trajectory
RFM	Refined Flow Management
RNAV	Area Navigation
RNP	Required Navigation Performance
RTA	Required Time of Arrival
RWY	Runway
SBT	System managed Business Trajectory
SESAR	Single European Sky ATM Research
SID	Standard Instrument Departure
STAR	Standard Arrival Route
STATFOR	EUROCONTROL's Statistics and Forecast Service
SWIM	System Wide Information Management
TAAM	Total Airport and Airspace Model® (Fast-time simulation tool)
TMA	Terminal Manoeuvring Area
TBS	Time Based Spacing
TOC	Top of Climb
TOD	Top of Descent
TTA	Target Time of Arrival
TTOT	Target Take-Off Time
WP	Work Package
WP5 TMA EG	Episode 3 WP5 TMA Expert Group
2D/3D/4D	In 2/3/4 Dimensions



2 EXERCISE SCOPE AND JUSTIFICATION

2.1 STAKEHOLDERS AND THEIR EXPECTATIONS

This section identifies for external and internal stakeholders the subject of interest of this exercise. It is explained which operational requirements are driving the need for ATM improvements, and why these improvements are expected to provide performance improvement.

Hub airports are characterised by delivering and receiving continuous flows of traffic. Runway capacity as well as TMA capacity limitations are constraining the throughput in busy hours or even continuously starting from 7:00 in the morning until late in the evening, 22:00 hours, i.e. the busy performance reference hours according to SESAR D2, Ref. [5]. The problem to accommodate the demand in an appropriate and cost-efficient way is highly complex because these airports are constrained usually by restricted use of runway configurations, by limited access to airspace and by operations of other nearby large and/or regional airports. These constraints are conditioned often by history and environment, i.e. by nearby urbanised areas, and have to be considered therefore as unavoidable and persistent in most cases.

The problems with hub operations are focussing on:

- Traffic congestion problems, causing inefficiency of operations and waste of airspace,
- Traffic sequencing problems, causing waste of runway capacity and inefficiency,
- Loss of capacity in airspace and at the runway, causing reduced throughput and delays,
- Limited predictability and unnecessary inefficiency in turn-around operations caused by delays and inaccurate planning,
- Overload of controllers, causing loss of capacity and loss of efficiency,
- And also, a non-optimal environmental load, caused by flying non-optimal landing profiles as a consequence of restrictions to perform arrival and departure operations in controlled airspace under high density traffic conditions.

Addressing Multi-Airport TMA operations in the core area of Europe (see Figure 1), stakeholders want to address those problems that are limiting their operations. Improved operations have to facilitate higher throughput, removing capacity constraining bottlenecks. This has to be accomplished in a most efficient way, saving flight duration and fuel, and it has to be accomplished in a most environmental friendly way, reducing emissions and noise. In some cases, noise is even the most constraining element to accommodate increased demand, and noise-friendly descent profiles are for that reason a highest priority mandatory improvement.



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- The scope of the simulation is the core area of Europe with a focus on the Dusseldorf area and Amsterdam, Schiphol
- The reference airspace organisation is adopted from traditional airspace due to constraining conditions
- Main flows of interest:
 - Dusseldorf area,
 - Schiphol
 - (and Brussels) (see figure)



Figure 1 - Main flows of air traffic from Amsterdam Schiphol, the Dusseldorf area and Brussels by the present-day reference scenario (2006)

The high level stakeholder requirements to perform commercial air transport operations and to operate a hub or large airport in the most optimal way are summarised below, focusing on their impact on ETMA/TMA operations, indicated as far as addressed in this experiment:

- To optimise traffic throughput and to make best use of available airspace and runway capacity, achievable in particular by:
 - Optimising the planning of departure and arrival sequences to reach achievable separation minima when needed (**addressed for arrivals**),
 - Optimising executive operations of departure and arrival sequences to realise the planned minimal separations (**addressed for arrivals**),
 - Optimising runway utilisation by allocating demand according to the best runway configuration and runway utilisation scheme available,
 - Minimising variability of demand during peak periods, avoiding waste of capacity and gaps in the sequences (**addressed by DCB emulation**),
 - Minimising the variability of planned sequences of departure and arrival flows to avoid gaps (**addressed by DCB emulation**),
 - Minimising the variability of the actual achievable sequencing by flight execution in order to avoid gaps by departure and arrival executive operations,
 - Minimising the workload in order to avoid loss of capacity due to controller load (**partly addressed by emulation via 4D guidance support**),
 - Minimising in-flight separations, e.g. by flying PRNAV routes and applying advanced concepts (**addressed by emulation**).
- To optimise efficiency of operations, achievable in particular by:
 - Flying as much as possible an optimal descent profile in the lateral as well as vertical plane (**addressed**),
 - Avoiding speed variations and to anticipate planned RTAs/CTAs as early as possible (**partly addressed by early sequencing and emulation**),
 - Optimising towards punctuality in order to realise minimal average delays and a minimal spread of delays (**addressed by DCB emulation**),
 - To identify those concepts that are best performing in final adjustments regarding achievable separations at runway threshold,



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- To achieve reduced uncertainties in departure and arrival planning, and in this way to support operations with minimal turn-around times.
- To preserve safety at an acceptable level, maintaining or improving previous levels of safety, achievable in particular by:
 - Proper adjustment of applicable separations according to the capabilities of concepts to provide guidance, monitoring and control to flight operations,
 - To identify and promulgate those solutions that are providing stability and robustness of flight operations in highly tactical manoeuvring areas like hub airport ETMA/TMAs (**addressed by emulation**),
 - To identify those concepts that are best performing with respect to (short-term) predictability of flight operations,
 - To ensure the effectiveness of monitoring, alerting and last resort services under operations of advanced concepts,
 - To ensure the effectiveness of exception handling under new procedures for departure and arrival operations (**impacting airspace usage**).
- To control the environmental load and to ensure an acceptable level of emissions and noise, achievable in particular by:
 - Flying as much as possible an optimal descent profile in the lateral as well as vertical plane, and specifically to fly CDAs to the Final Approach Fix (FAF) (**addressed**),
 - Avoiding speed variations as much as possible and to anticipate the planned RTAs/CTAs (**partly addressed by early sequencing**),
 - Flying an optimal initial climb profile with respect to environment and efficiency and ensure undisturbed departure operations as much as possible (**taken as a constraining condition**),
 - Designing arrival and departure procedures that respect noise abatement restrictions (**addressed**), and
 - Maximise capacity, so that delays are minimised, aiming to reduce airborne holding and ground queuing (**addressed by emulation**).

The table below contains a summary of reasons why the stakeholders expect improved operations from an enhanced concept of operations of ATM operating in ETMA/TMA airspace to improve hub and large airport operations.

Stakeholder	External / Internal	Involvement	Expectations	Concerns
Controllers	Not part of FTS exp.	Responsible for executive control and separation	Expecting sufficient anticipation for planning and execution and safety ensured.	Planning and control are impacted but not addressed by FTS. Given an extension of sequencing into en-route airspace more planning data exchange and more coordination is expected. Also En-route control is loaded by extra tasks in support of lower airspace control.
Pilots	Not part of FTS exp.	Pilots will get an extended involvement in flight planning	Better predictability may help to have better control on flight execution against some extra effort in planning.	Flight-efficient descent paths combined with sequencing effort requires a strategy to meet time constraints. It might be complex for the pilot to understand how to meet time constraints.



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Stakeholder	External / Internal	Involvement	Expectations	Concerns
Airline	Internal SESAR	Owner of flight, having an interest to perform their flights as planned	Accommodating more traffic and flying scheduled traffic as planned, is most economic and gives satisfaction to the passengers and meets their expectations.	There is a trade-off between optimised flight efficiency and optimised capacity. The Airline has an interest in non-delayed but flight efficient arrivals, and to find a "true" optimum. This is impacted by the definition of arrival procedures.
Airport	Internal SESAR	Service provider to facilitate flight operations	Flying as planned ensures maximum throughput and best deployment of scarce resources (runways, gates and stands). Flight connectivity is important for transfer passengers.	It is important also to achieve maximum throughput with minimal environmental load for reasons of community acceptance. The risk is to loose capacity due to noise restrictions, therefore the definition of CDA patterns in the TMA is critical.
ANSP	Internal SESAR / involved in experim.	Service provider to facilitate flight operations	Flying as planned allows to manage the controller workload and helps to manage the cost of service provision.	<p>Extended sequencing and CDAs have an impact on airspace organisation, coordination procedures and ATC planning and control task distributions. The results of the FTS are indicative but don't solve these issues.</p> <p>A DCB process that limits variability of demand reduces the controller load and allows to perform traffic synchronisation in a most effective way, but it is not clear how effective this process could be and how to anticipate its performance.</p> <p>A DCB process allows to ensure safety and to restrict airspace requirements but again this depends on reliability and effectiveness.</p> <p>The FTS improves operations by enabling CDAs. It is not sure if CDA approaches on parallel runways are feasible and safe. (This is a problem for Schiphol approach operations)</p>
Pas-sengers	External SESAR	Customers, receiving travelling services	Safe, low cost, on-time service provision is his natural interest.	<p>Their interest in ANSPs services is high for reasons of safety and predictability (to ensure an expeditious and orderly process of ATM).</p> <p>The FTS gives an indication of enhanced predictability, but the experiment ignores constraining interests of other airspace users.</p>



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Stakeholder	External / Internal	Involvement	Expectations	Concerns
The community	External SESAR	External interests, community shares and third parties interests	<p>The government shall ensure low cost and best use of resources by competition.</p> <p>The government shall ensure least hindrance and minimal hazards for all inhabitants affected by flight operations.</p>	<p>Minimal hazards, a high level of safety and minimal environmental load, in terms of emissions and noise (at low altitude e.g. below 3000 ft).</p> <p>The FTS does not address safety and environmental performance very limitedly, but the applicable profiles are assumed to be acceptable.</p>

Table 1 - Stakeholder expectations

2.2 DESCRIPTION OF ATM CONCEPT BEING ADDRESSED

This section explains how the subject of interest in this experiment is linked to SESAR and how this subject relates to the DoDs, which provide a more detailed description of the Operational Concept of SESAR. The following topics are addressed:

- The scope of the operational concept of interest, providing links to LoCs and OIs,
- The detailed outline of the operational concept, derived from the DODs,
- The level of maturity of the concept of interest, and
- The KPAs related to the concept of interest, giving indications of relevant areas of potential benefits and performance assessment.

2.2.1 Scope of the Operational Concept of Interest


According to the Episode 3 DOW, Ref. [1], the experiment shall validate how operations in part of the network can be served in an optimised way against minimal penalties and imposing minimal requirements on airspace usage. The increased demand has to be accommodated by high performance ATM, capable to serve dense departure and arrival flows in limitedly available airspace volumes.

SESAR operational concepts can help to optimise the service provision to these air traffic flows by:

- Ensuring low variability of departure and arrival flows in order to ensure maximum use of available capacity, a result of DCB and Departure Management at airport level.
- Ensuring highly accurate arrival management and flight trajectory planning, guidance and control through new ATM techniques and air-ground information exchange achieving accurately sequenced and separated arrival flows at multiple TMA entry-points.
- Allowing fuel-efficient, noise-friendly advanced CDAs supported by SESAR 4D planning and Performance Based Navigation achieving maximum runway utilisation.
- Ensuring accurately 3D planned departures to be operated in a noise-friendly, efficient and undisturbed way in order to achieve maximum runway utilisation and terminal airspace efficiency.
- To achieve this against minimal airspace required in terms of TMA and ACC/En-route airspace, and to allow structuring of departure and arrival flows over safe and efficient routings, taking into account requirements of other operations in the same airspace.

This scope of validation targets are addressing:

- F6.2 (3D routing and selection and allocation of routing), and
- F3.3 (3D Departure and arrival routes, including pre-defined and dynamic 3D routing).

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Referring to the DODs, mainly DOD E5, Ref. [12], the following Operational Improvements (OIs) are addressed:

- L02 Moving from Airspace to trajectory based operations:
 - AOM-0702: Advanced Continuous Descent Approach (ACDA):
 - ACDAs are subject of the simulations, i.e. the simulations have to demonstrate feasibility to perform ACDAs in lower airspace with sufficient capacity and efficiency by accurate delivery on TMA entry-point. However, no specific operational executive issues are investigated in detail.
- L03-01 Collaborative layered planning through NOP:
 - DCB-0103: SWIM enabled NOP:
 - Enhanced planning is expected to result in predictable, stable and balanced demand at the start of the arrival management process. The scenarios are required to deliver conditions that represent present-day operational conditions and accurately managed future conditions to allow assessment of differences in operational performance.
- L01-05 Airspace User data to improve Ground Tools Performance:
 - IS-0303: Use of predicted trajectory to enhance ATM Ground system performance through TMA:
 - Accurate 4D trajectory prediction and enhanced arrival management can be emulated, whereas the effect of enhanced arrival management on performance of sequencing and metering can be validated by simulation.
- L07-01 Arrival traffic synchronisation:
 - TS-0102: Arrival Management, supporting TMA improvements (including CDAs and P-RNAV):
 - Arrival Management in support of accurate sequencing at TMA entry-point is addressed and its performance shall be validated by fast-time simulation regarding achievable accuracy of operations.
 - TS-0103: Controlled Time of Arrival (CTA) through use of datalink:
 - An agreed CTA as part of the execution of a sequencing process is assumed. No datalink procedures are included in the simulation or the validation process. Validation by performance assessment will focus on planning and flight execution in compliance with planning.
 - TS-0303: Arrivals into multiple airports:
 - Delivery to multiple airports is simulated and is applicable in the TMA of the Düsseldorf area.
 - TS-0305: Arrival management extended to en-route airspace:
 - Arrival flows are assumed to be sequenced and metered from ~60 min. before landing (up to 150 to 200 NM out) through dedicated arrival flow corridors. Air traffic service provision is assumed, but appropriate sectorisation is not the focus of the current simulation experiment. Applicable workload in dedicated volumes of arrival corridor airspace will be evaluated.

A full description of OIs, adopted from DOD E5, is included in Annex 1.

2.2.2 Detailed outline of the Operational Concept of Interest

The outline of the Operational Concept below summarises the DODs, in particular DOD E5, Ref. [12], DOD M2, Ref. [13] and The Operational concept of the CASSIS project, Ref. [25]. The current conceptual overview is not deviating from SESAR, but presents an overview with the following purpose:



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- The experiment can not be understood without an understanding of the Concept of Operation, this overview provides the required comprehensibility of what is addressed.
- The DODs are not describing a systematic justification of conceptual improvements; the focus here is on explicit justification in order to support an understanding of validation.
- The present description is more explicit than the DODs, because the text is focused on direct applicability and performance assessment, however, there are no deviations from the SESAR Concept of Operations.

The way the concept is addressed by the experiment is described in section 2.3, Exercise Objectives.

Dealing with a convergent layered planning process from a top-down perspective, the following conceptual elements can be considered for arrival/departure operations in ETMA/TMA airspace around a hub airport, i.e. a large airport or group of large airports:

➤ **Demand and Capacity Balancing, DOD E5, Optimise Arrival Queue, Section 4.1.4.1, Ref. [12], DOD M2, Network Support to DCB, Section 4.4, Ref. [13]**

The concept of operations for hub/large airports and their environment is focussed on high density air traffic operations with a secondary interest in occasional periods of low density traffic, for example in the evening and during the night. This concept assumes that the operations are determined by a planning available in a Network Operations Plan (NOP) that is converging in level of confidence, in level of detail and in quality of planning towards the executive phase. On the one hand, departure operations are expected to follow the NOP and to behave in compliance with the planning, making the planning reliable, on the other hand arrival operations are expected to be executed in compliance with high predictability by up-to-date planning and a high quality to accomplish traffic synchronisation.

This implies for departing and arriving traffic, that:

- The pre-departure planning is accomplished with 4D precision.
- The traffic synchronisation process is successful to manage bottlenecks and hot spots, in particular at airport level and in TMA airspace, and will result in ground holdings that manage the throughput and the workload, and that ensure that 4D-planning is compliant with selected and accepted departure constraints.
- The traffic synchronisation process ensures also a minimal variation of traffic demand at the start of an arrival management process for a congested hub airport. The requirement is to start Arrival Management roughly 60 min. before landing (from around 150-200 NM from the airport), while the actual descent starts from Top of Descent (ToD) with active executive control on sequencing starting roughly from 120 NM out.
- There is no (significant) overload of declared capacity of departure and arrival sectors of each hub/large airport, ensured by the traffic synchronisation process.
- The maximum load of arrival and departure flows is not exceeding the permissible levels of traffic load, given the runway configuration in use.
- The departure flows of the airport of interest are following the accomplished planning and selected/accepted planning constraints and are departing in conformance with their planning.

➤ **Airspace Management and Design, DOD E5, Optimise Arrival Queue, Section 4.1.4.1, Ref. [12], Network Support to DCB, Section 4.4, Ref. [13]**

Airspace requirements are derived from an optimised routing network. This network is based on:

- City-pair connectivity and to a large extent unconstrained routing,



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- Ideal vertical and lateral profiles to reach the destination in the most fuel-efficient way,
- Constraints at departure and destination to follow flight profiles which ensure the required capacity around the airport of interest,
- Constraints that respect the environmental regulations and that are optimised towards fuel efficiency but constrained by minimal noise load,
- A routing structure required to build up manageable traffic flows to and from the airport of interest,
- All constraints imposed to meet the requirements of other traffic flows and other flight operations and to establish a best compromise for conflicts of interest.

The airspace required comprises the airspace needed to perform optimised advanced-concept operations for the airport of interest:

- To accommodate all departure and arrival flows to and from the airport in a most expeditious, efficient, safe and environmental friendly way,
- To maintain separations for all traffic that meets the declared runway capacity levels,
- To permit to apply speed and profile variations, sufficient to realise the planned landing sequence for the foreseen variability in departure and arrival demand,
- To perform stack manoeuvring in case of exception handling to cope with unforeseen arrival traffic overloads, and
- To perform exception handling in case of breaking-off an initiated CDA procedure and/or in case of performing a go-around.

It is required to define routings that allow to fly with minimum separation but that realise the maximum capacity in airspace as well on the runway. If necessary, double CDA arrival paths might be required in order to enlarge the capacity of TMA CDA arrival paths over a specific Initial Approach Fix (IAF) by approaching in a “staggered” way, to be defined by specific RNAV tracks. An alternative might be to follow tight-sequenced ASAS CDA approaches when these approaches are sufficiently stable in spite of tight sequencing, however ASAS will not be part of the area of research of this experiment.

In summary, it is envisaged that these requirements are sufficient to define and accomplish an airspace structure that is ideal for the airport or airport group of interest, but that these are to be balanced against requirements and constraints that are forthcoming from all other operations that are interfering in one way or another with other ATM operations.

Sectorisation¹ is derived from the amount of traffic, the complexity and manoeuvring intensity of traffic, and the scope of control of the executive controller to manage and control flows of air traffic in a volume of airspace operating under a given concept of operation. The routing, the manageable amount of air traffic and the expected variability of air traffic determine the acceptable declared capacity, but this declared capacity shall be compliant with the airport declared capacity, runway capacity and the expected demand through the sectors.

➤ **Flight management and planning, DOD E5, Implement Arrival Queue, Section 4.1.4.2, Ref. [12]**

Flight management and planning is considered separately for arrivals and departures.

For arriving flights three stages of flight management and planning can be discerned:

¹ It should be noted that sectorisation and assessment of declared capacity are essential elements of airspace management. However, sectorisation and redesign of airspace is not subject of this experiment. Rather airspace reservations are made, just sufficient to allocated dedicated arrival flows, and assessment of capacity will be applied on airspace volumes of interest.



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1. Before executing an arrival sequencing process roughly 60 min. before landing, between roughly 200 and 150 NM out, and still En-route, an early arrival sequence is established and coordinated.
2. At ETMA entrance and during the process to establish the sequence, sequence monitoring, re-sequencing and re-planning will be part of the ATM process.
3. Before and at the moment to issue the CDA clearance, the planned RTA/CTA at threshold has to be confirmed while ensured separation is accomplished.

Ad 1, before executing an arrival sequencing process:

Different contributions can be made allowing to determine the sequence and to support each flight in preparing implementation of the planned sequence:

- Accurate pre-departure planning and on-time departures are the primary means to support En-route sectors to deliver traffic on-time at those exit points where being on-time is critical regarding the arrival management process at the destination airport.
- Planning and surveillance information available are the starting point on the ground to perform an arrival management process that determine the RTA/CTA at threshold optimised towards, scheduled and eventually prioritised, punctuality against minimal deviation penalties from the optimised descent path.
- Down-linked 4D trajectory information can be made available to the Arrival Manager. This will improve the level of confidence of the arrival management process and is expected to reduce the need to deviate from an undisturbed arrival.
- The established and sequenced CTA for each flight can be up-linked to the aircraft as the outcome of sequencing by arrival management. The pilot can re-plan its descent profile to meet the up-linked CTA constraint.
- Other constraints, constraining the planned descent profile in ETMA/TMA airspace can be uplinked.
- The established CTA, and its related profile, can be coordinated also with the En-route ANSP. This can be used to modify the planned level and exit time of the En-route sector or area and the Executive Controller can use this calculated requested exit condition to deliver the flight as good as possible on-time and at the planned level at the exit point. The lateral part of the flight is assumed not to change in this part of its profile and in this stage of flight execution.

Ad 2, during building up the planned sequence:

The early phase of building-up the arrival sequences shall provide a planned conflict-free routing up to the threshold and shall provide Time-Based Separation (TBS) at the threshold, ensuring the required wake-vortex separation. Different kinds of planning information can be made available:

- An established ground-based 4D planning shall be the starting point to plan a conflict-free routing for each flight. The stability of planning may increase if planning of “staggered” approaches over specific RNAV tracks can be supported. A received down-linked RTA/CTA might have been applicable to confirm a consolidated planning between air and ground.
- Ground-based 4D planning is considered mandatory in order to preserve integrity and consistency of data. Down-linked trajectory information can be used by ATC to adopt or to find a best match with a 3D profile and up-linked trajectories can be used by the pilot to adopt a 3D constrained descending trajectory.
- A down-linked RTA by the aircraft and an up-linked CTA constraint by ATC can be used to update the planning on the ground and in the air by speed adjustments.

Ad 3, when ready to issue the CDA clearance:

The moment of issuing a CDA clearance is the last moment that ATC has to confirm the planning and may initiate a short-term planning change. The interest is to rely as much as possible on the aircraft's planning because the intention is to delegate the descent operation to the Pilot and to rely therefore on the aircraft's planned routing and on the



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aircraft's guidance process. The down-linked 4D trajectory is therefore applicable to guidance and control on the ground and can be used in addition to monitor flight progress on the ground.

If no down-linked trajectory is available, it will be possible for ETMA ATC to issue the requested 4D trajectory or to make a request to the pilot/aircraft to downlink its trajectory. Once available on the Ground this trajectory will be applicable. When this trajectory is not available, the Ground Support Tools will provide a calculated trajectory functioning as a planning back-up function with higher uncertainty.

For departing flights, flight management and planning takes place before pre-departure clearance and before going off-blocks. Afterwards, planning deviations will be monitored and anticipated, whilst a significant update of 4D planning can be expected after take-off.

Multiple inputs are possible at this stage of planning (CDM processes):

- 4D Reference Business Trajectories (RBTs), specified by Airline Operators Centres, are the main inputs to define the departure planning. Three hours before departure, the trajectory will include the preferred departure runway and the estimated taxiing routing and timing. The planning may include a prioritisation indication regarding the importance of adherence to punctuality.
- The traffic synchronisation process may lead to accept planning constraints due to sector loading problems and Airport capacity deficiencies, solved by selected and accepted departure slots. Also, arrival constraints at congested destinations may lead to imposed departure constraints by calculated mini-slots [+2,-3 min].
- The Airport may impose constraints on departure planning due to Gate planning, Airport service provision, and runway configuration changes.
- The ANSP determines an optimised departure planning, taking into account all external (other stakeholders' inputs) and internal constraints (restrictions in operating the Airport executive ATC process) as well as all late changes in planning.

The planning process by ATC is a process optimised towards punctuality of departures according to trajectory management and the planning of an RBT for each flight including a Target Take-Off Time (TTOT), derived from the Target Arrival time (TTA):

- Departure planning is iterative and convergent taking into account late planning changes and possibly prioritisation requests.
- The planning process includes to retain some buffer capacity and to improve the punctuality at a late stage in order to benefit expeditious departures of delayed flights.
- The departure planning process takes into account taxiing times and ground congestion problems.
- The process optimises also towards a balanced accommodation of departure and arrival traffic in agreement with the applicable runway configuration scheme.
- Efficient use of available runway capacity implies that optimisation towards punctuality includes also an optimisation towards wake vortex separation, if necessary.

➤ **Collaborative Decision Making (CDM) during planning, DOD E5, Optimise and Implement Arrival Queue, Section 4.1.4.1 and 4.1.4.2, Ref. [12]**

Different CDM options were envisaged during traffic management and planning:

- In principle, departure and arrival sequencing takes place in an equity respecting way aiming to reach overall optimised punctuality with minimal average delay and minimal spread in delay.
- Down-linked and up-linked 4D trajectories may play a role in increasing the level of confidence of the accomplished planning and in making this planning consistent on the Ground and in the Air. The interest is to establish a planning:
 - That provides planning consistency in the Air as well as on the Ground,
 - That defines a highly efficient approach path,
 - And that is safe to fly.



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- Airlines preferences and solutions are part of the departure planning process by being able to monitor the departure sequence planning as well as the applicable traffic synchronisation constraints. Optimisation can be achieved by selecting alternative routings and by adapting the prioritisation of specific flights.

➤ **Short-term planning and Executive control**

In ETMA Airspace, DOD E5, Implement Arrival Queue, Section 4.1.4.2, Ref. [12]

Short-term planning and executive control of arrival traffic in ETMA airspace aim to achieve:

- Increased capacity by reduction of controller workload,
- Increased capacity by reduced separations, building up sequences as tight as possible,
- Increased punctuality by realising the planning and building up the planned sequence.

Assuming that minimal airspace requirements were ensured by pre-departure control on the variability of demand, the capacity is further limited by the effort required by the controller to control a flight. Therefore, concepts are favoured in the executive control phases that aim to reduce the controller workload and allow to increase declared capacity and thus the amount of traffic present in the sector. The same holds for reduced separations during approach that will support a tighter sequencing and thus increased throughput.

Increased punctuality in reaching the planned TMA entry condition, supports execution of an optimal CDA operation in the TMA and thus to realise a timely and undisturbed arrival at the runway threshold in the best possible way.

The operational concepts supporting these ETMA objectives are concepts that support the executive process to reach a predetermined exit condition against minimised controller workload:

- **4D Guidance by the aircraft:** The aircraft supports accurate guidance along a trajectory segment to a planned 4D waypoint. The controller has to make sure that this trajectory segment is conflict-free.
- **ASAS² Sequencing:** The controller controls the safe execution of a sequencing manoeuvre of one aircraft behind its predecessor and delegates the execution to the pilot.
- **ASAS² Merging:** The controller controls the safe merging of a flight between two consecutive flights and delegates the execution to the pilot.

Departure traffic in ETMA airspace sectors have to merge in En-route traffic flows in the most efficient and expeditious way. No specific concepts are foreseen as long as the merging is not originating from several airports merging at one En-route merge point and as long as the flow is not so dense that specific regulation on merging is required. If this is the case, departure metering has to be applied, but this is not foreseen to be applicable to operations in the AMS-DUS TMA within the anticipated timeframe.

In TMA Airspace, DOD E5, Deconflict and Separate Traffic, Section 4.3, Ref. [12]

It is assumed that sequencing of arrivals is planned and accomplished in ETMA airspace. Time-based separation is ensured by planning and execution following a planned descent path for all flights to one TMA entry-point, dedicated to feed one airport with one sequence of arriving flights feeding one runway. It is more complicated if multiple

² ASAS is a concept of SESAR that can be applied under these conditions but ASAS will not be part of the current experiment.

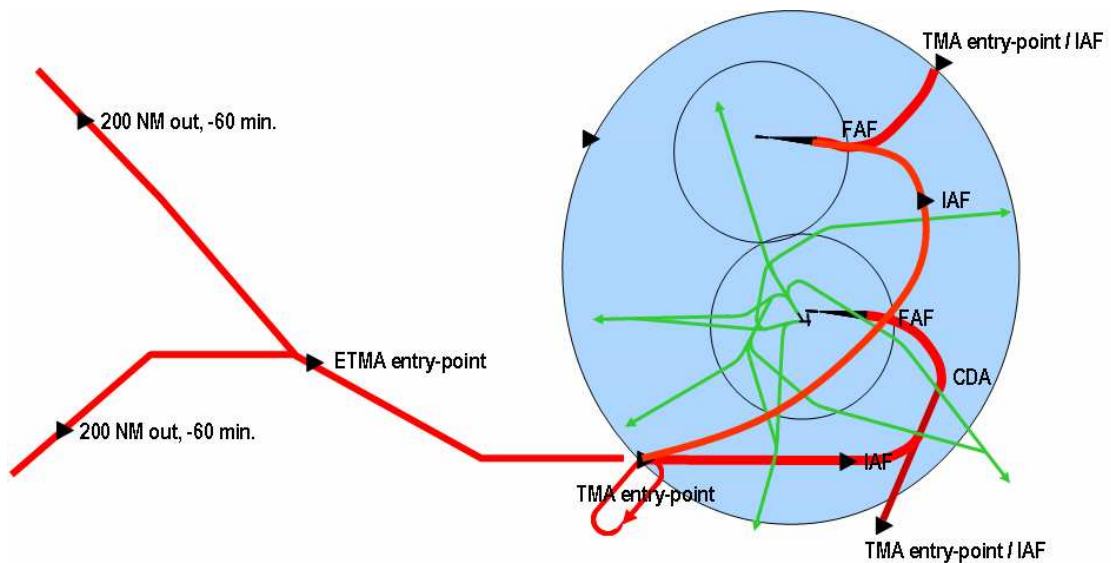


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(parallel) runways are addressed or even runways allocated at different airports. In this case, there is not one sequence of separated flights passing and flights are required to pass the TMA entry-point independent from other flows for other runways or airports. One option to deal with multiple arrival flows over one TMA entry-point is to ensure independency of entering traffic flows either by lateral or by vertical separation. In the case of the TMA of the Düsseldorf area, the most relevant airports, Köln and Düsseldorf are located at considerable distance from each other, allowing arriving flights for both airports to pass vertically separated over each TMA entry-fix. This procedure is illustrated by an example (see Figure 2).



Example of "CDAs over several TMA-entry-points to several runways/airports
(*diverging flows*, multiple TMA entry-points, multiple IAFs, multiple runways)"

Figure 2 – Example of a CDA approach over TMA entry-point via multiple IAFs to multiple runways

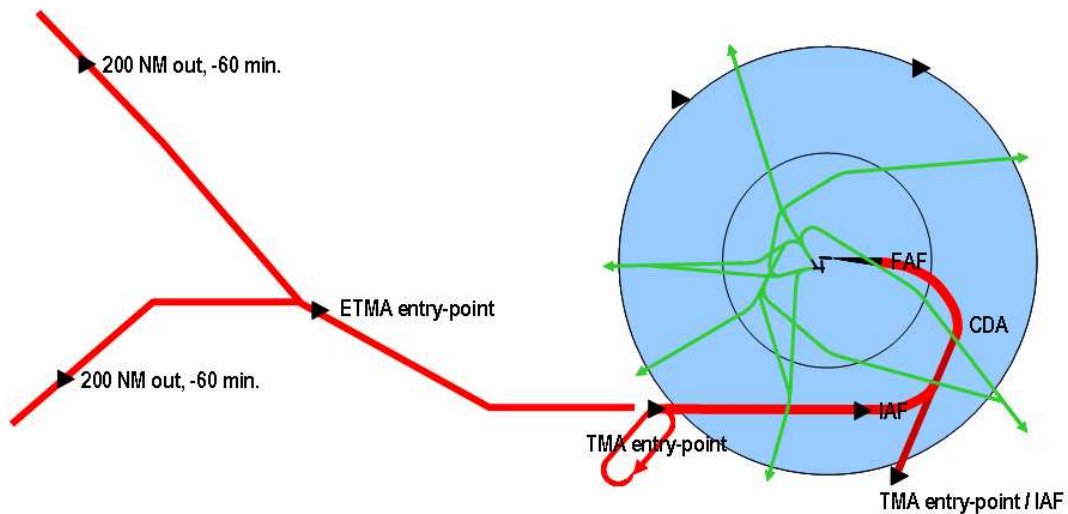
The flights, entering TMA airspace and belonging to one arrival flow for one specific runway, are required to be prepared now for a CDA clearance by final adjustment. The clearance will be issued after passing the IAF. The effectiveness of ATM in TMA airspace depends on planning accuracy and reliability. The better the capability to follow the CDA descent path and to correct for deviations, the more successful TMA controllers will be in meeting the objectives: the optimal capacity reached in the most efficient, environmental-friendly and safe way. This procedure is illustrated by an example (see Figure 3).



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Example of “CDAs over one TMA entry-point to one runway merging with a second flow over a second TMA entry-point (converging flows, multiple IAFs)”

Figure 3 - Example of a CDA approach over TMA entry-point via one IAF to one runway

Success in the planning phase is dependent on the quality of 4D planning capability to ensure the planning of an undisturbed conflict free landing at threshold. Success in the executive phase is dependent on 4D-guidance capability and a tight control loop of monitoring, guidance and control. There are five options to improve execution of CDAs:

- **4D Guidance by the aircraft:** The aircraft provides the 4D guidance to the FAF. The aircraft’s FMS has the superior control loop to realise the planned FAF interception time with highest precision, but there has to be freedom to perform speed adjustments and the descent path has to be conflict free.
- **ASAS Sequencing:** The aircraft has a superior control loop to maintain distance to its predecessor, and assuming that this aircraft arrives on-time on the FAF, and that the next one is capable to maintain time-based minimal spacing, maximum capacity can be realised.
- **ASAS Merging:** The aircraft has the capability to merge at a waypoint (the FAF) with high 4D precision, and assuming that the predecessor arrives at the FAF on-time with minimal separation, also the next one will arrive with minimal time-based separation.
- **“Staggered” approach paths:** Whenever the sequencing of aircraft is not stable enough to follow the CDA descent path through TMA to realise the tight sequencing at the FAF, required to realise maximum throughput, there is an option to create independent descent manoeuvring by following staggered approaches. Each aircraft has ensured freedom now to accelerate and decelerate along the prescribed CDA, correcting for 4D deviations and merging as late as possible, e.g. by respecting noise abatement policies at lower altitude, but at the cost of more airspace and more complexity in the structuring of air traffic in TMA airspace.
- **PRNAV:** High precision navigation is applicable, along precisely planned routings, using predefined 3D profiles, limited to speed corrections only. It reduces the need of airspace and will allow easier de-confliction of air traffic.

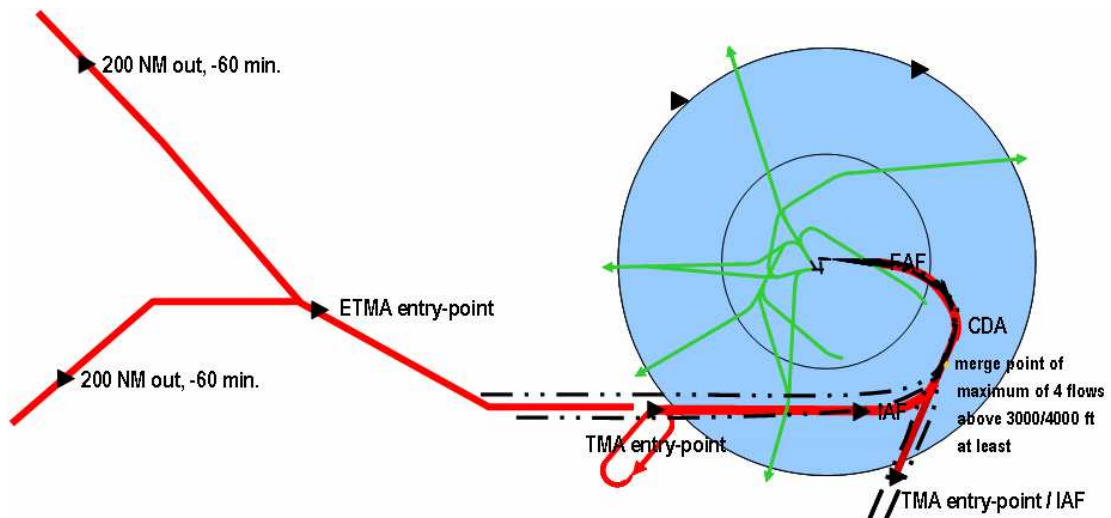
The experiment will apply staggered approaches on dense arrival flows over one TMA-entry-point, using PRNAV tracks (see dotted tracks in Figure 4). Also 4D-guidance capability will be assumed to be applicable on 100% of the traffic, and if technically feasible also partly equipped scenarios will be applied. No ASAS procedures will be applicable.



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Example of “CDAs over one TMA entry-point to one runway merging with a second flow over a second TMA entry-point (converging flows, multiple IAFs)” with *optimised spacing by staggered approach*

Figure 4 – Example of a staggered CDA approach over TMA entry-point via one IAF to one runway

Departures traffic in TMA airspace has to be able to perform the initial climb in optimal way regarding noise load and at least respect noise abatement regulations. In addition, a wide spread of climbing profiles have to be anticipated due to existing differences in climb performance behaviour of departing traffic. Departing traffic has to be kept separated in a structural way by definition of departure and arrival routing schemes in the TMA.

Based on these basic requirements, departure traffic has to be accommodated in a way that is optimised towards a most efficient way to merge into en-route traffic flows. Departure traffic will fly over arrival flows in the experiment, but in conflicting cases, it will be necessary to split traffic and to guide part of the traffic over and part of the traffic under the arrival flow.

➤ Interoperability between Air and Ground

In order to keep the 4D planning up-to-date, an update is expected directly after departure or at Top-of-Climb. This update makes the 4D planning more accurate and reliable than before take-off. The executive phase of departure operations is expected to be in-line with this updated 4D planning.

2.2.3 Level of Maturity of Concept of Interest

Concerning the level of maturity of the concept of interest, the following can be stated:

➤ Demand and Capacity Balancing:

DCB is a pre-departure process. The process doesn't make use of any advanced technology and therefore there are no transition issues. The process is in a V3 status, and validation can be consolidated quite easily. The most complicated issue may be agreement and operational implementation may be dependent therefore on acceptance mainly.

➤ Airspace Management and Design:

Airspace re-organisation will be initiated by the process of creating Functional Airspace Blocks (FABs). However, it is doubtful if, at a first stage, agreement on FABs will be so far reaching as required for arrival management in the core area according to the operational



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concept of SESAR. Given the interests of all airspace users a more refined step-by-step approach is more likely than a solution fulfilling all requirements at once. Therefore, further reaching assumptions are mandatory for concept validation in this experiment.

➤ **Flight management, planning and Automation support:**

Flight management, planning and automation support with its main focus on traffic synchronisation and sequencing, is not highly safety critical, whereas the benefits can be considerable. It is estimated therefore that this part of the concept is appropriate to be brought to maturity for implementation at an early stage. Part of the concept has passed the V3 stage.

➤ **Collaborative Decision Making (CDM) during planning:**

CDM during departure and arrival management is relatively mature. Parts of this concept are in operation and passed the V5 status.

➤ **Short-term Planning and Executive control:**

Planning and executive control have to be considered separately due to the technical complications and the safety issues related to operational implementation.

The 4D planning concept, including air-ground exchange can be considered as good candidates for short-term implementation if applied to arrival management, by time-based planning, and not for the planning of de-confliction and separation. Integration of down-linked information is relatively simple as long as applicable to arrival management and not to de-confliction. Therefore, the short-term focus shall be on demonstrating the benefits of using 4D planning information to enhance the accuracy of the arrival management process.

Enhancement of executive control is difficult to overview. The implications of 4D-guidance as well as ASAS for executive ATC are badly known. Also, the implications of applying ASAS on 4D precision approach processes are unknown as well as the best way to combine 4D-guidance with ASAS applications. For that reason, performance assessment by fast-time simulation has problems to assess the benefits. The concept must be considered as being still in a V1 or V2 stage.

➤ **Interoperability between Air and Ground:**

There are no technical problems to implement datalink. Bandwidth, reliability and communication protocols can be implemented easily. The problems are related to two aspects mainly:

- How to integrate datalinked information exchange within ATM ground systems and avionics systems, and
- How to come to standardisation and to address transition issues, and to achieve implementation with mixed equipage levels providing still the expected benefits.

The datalink applications are in a V3 stage due to integration aspects and performance benefits that are not yet fully solved.

2.2.4 KPAs related to the Concept of Interest

As demonstrated by the previous chapters, the departure and arrival procedures are strongly dependent on AOM in ETMA/TMA airspace and on DCB performed in a European context. The focus will be in this experiment on ETMA/TMA operations to multiple airports in the core area, whereas DCB effects determine the initiating conditions. DCB effects operating under an advanced concept of operation are unknown and not validated yet. Effects of DCB on Arrival Management have to be emulated therefore, and the contributing performance of DCB is "assumed".



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The following list formulates some high level benefits expectations for applicable KPAs:

- **Cost-Effectiveness:** This is a main issue, the overall costs of flight operations in the ETMA/TMA environment of the airport are expected to decrease in costs due to less human interventions, shorter flight duration and optimised profiles to be flown. Operational assessment experiments will typically evaluate critical inputs to cost-effectiveness, such as flight efficiency, throughput, delays and workload. These are dealt with under their associated KPAs.
- **Capacity:** The capacity of the airspace volumes and applicable runway configurations involved in the operation to serve a hub airport have to be evaluated, because throughput and delays are critical issues of appraisal of advanced concepts of operation. If the concept makes more efficient use of airspace, the capacity may increase and throughput may increase while delays decrease.

Secondly, the capacity of the network of airspace volumes and airports has to be in proper balance in order to avoid bottlenecks. In this respect, in particular TMA operations are most critical.

- **Efficiency:** Efficiency can be improved by reduced flight duration, by enhanced punctuality, reducing Airline's internal costs, and by reduction of workload. These cases are all critical for the success of the concepts of operation around a hub airport.
- **Flexibility:** The concepts investigated are designed to serve congested hub airport operations and to improve the use of scarce resources. This requires planning and strict adherence to planning. The benefits are expected to come from enhanced predictability by iterative and accurate planning and adherence to planning. Nevertheless, the iterative character is meant to support the flexibility needed to cope with incidental and badly predictable events during flight preparation and execution. The success of flexibility and its operations can not easily be incorporated in fast-time simulation experiments to evaluate capacity, efficiency and cost-effectiveness at the same time.
- **Predictability:** Because benefits of enhanced operations to and from the airport, as well as by enhanced turn-around are strongly dependent on enhanced predictability, the concept supports enhanced predictability and this has to be assessed.
- **Safety:** Safety is definitely critical for operations in ETMA/TMA airspace. There are many safety-related issues, however, these are not part of assessment for general traffic operations by fast-time simulation. The separation standards of part the operations, i.e. the CDAs, are critical and are evaluated separately, see OPTIMAL, Stroeve, Ref. [15]. The findings of this study are used in this validation experiment. Another critical issue is to perform CDA approaches simultaneously on parallel runways. This is addressed by applying lateral separated inbound turns and different glide slopes (see also section 2.5.3).
- **Environmental sustainability:** Some of the concepts to be validated are sensitive for environmental sustainability. Quantitative noise assessment for CDAs, however, requires to take into account the population density in the TMA³. This is not taken into account. Optimised routing is considered from the point of view of the shortest routes and the most fuel-efficient routing. This relates directly to emissions but not to noise.

Security, Access and Equity, Interoperability, and Participation by the ATM community are not addressed in this experiment.

³ Quantitative noise assessment can be performed by calculating the area of the noise contours for Lden and Lnight (this will be done in WP2.4.4). In addition, it should be noted that fuel optimised routes will have a large negative impact on the noise hindrance.



2.3 EXERCISE OBJECTIVES

This section identifies the subject of the fast-time simulation experiment. A distinction is made between validation objectives (“addressed” concepts) and concept clarification objectives (“emulated” concepts) and also the scope of validation is summarised briefly.

The present experiment shall address those areas of the SESAR concept that allow to improve departure and arrival operations to and from hub and large airports by enhanced flight management and planning, that are expected to be effective when traffic is operated within an enhanced airspace environment, and that are operating under enhanced executive procedures. The focus of the experiment is to measure the effect of enhanced planning on executive operations to and from hub airports within an airspace environment that is optimised towards the requirements of the airports of interest under partly idealised airspace conditions.

The hub airports selected are located in the core area and at such distances that their TMAs are small and constrained by other airspace user activities and that their extended arrival operations are heavily dependent on each other. In order to facilitate these extended arrival operations for all hub airports in the area in an undisturbed and equivalent way, there is a need to create fairly concise but dedicated arrival flow corridors for all dense arrival flows in the area of interest. One objective of the experiment is to demonstrate the benefits of the creation and use of these dedicated arrival flow corridors for all concerned arrival flows. The advanced design of ETMA airspace in the area of interest shall provide the aimed benefits for all airports involved together with extensions of these flow corridors in En-route airspace, under partly realistic constraining conditions, i.e. no guarantee of services to regional airports and the Military. The adapted planning, coordination and executive procedures, adopted from SESAR, shall provide the means to deploy the airspace in a meaningful way. The integrated use of airspace establishes a “super”-ETMA/TMA airspace area servicing a multi-hub airport environment in this way.

Considering the operational concept of SESAR, Ref. [8], and the DOD E5, Ref. [12], addressing the arrival and departure operations in high density airspace, the high level concept elements are:

- Queue management,
- Separation provision,
- Collision Avoidance.

The emphasis in this experiment is put on performance assessment of Queue Management, comprising traffic management, traffic synchronisation, sequencing and planning. The experiment aims to measure achievable performance improvement by advanced Queue Management under realistically simulated future operational conditions. It is assumed that conceptual ideas can be brought to operation, but it has to be validated yet, if success is achievable in dense traffic complex areas, operating under “real” constraining conditions. For applying CDAs, the experiment investigates achievable accurate sequencing at TMA entry-point, assuming that operating CDAs is feasible under the modes of operation, assessed by Expert Judgement, Expert Group Plan, Ref. [18] (see also assumptions, section 2.8). The experimental set-up is not appropriate to investigate and validate for example separation, stability of sequencing, and experienced Controllers workload (in absolute figures), however, the experiment is able to assess overall impact of separation problems, and impact on workload (indicative trend), flight efficiency and throughput under assumed and modelled conditions of operations over large time periods and large areas of ATM applicability.

The following main areas of operational improvement are described by DOD E5 and addressed partly by the experiment:

- Trajectory based operations by 4D trajectories (**emulated**),
- Extended temporal scope of arrival queue management (**addressed**),
- Introduction of new types of airspace structures (**re-organisation of airspace addressed**),



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- The introduction of new separation modes, including the introduction of initial ASAS based operations (**not addressed, for technical reasons**),
- Information managed on a system-wide basis and air-ground datalink (**emulated**),
- Automation support – contributing to capacity increase through workload reduction (**emulated**).

The experiment shall focus on measuring the improvement of operations of part of the operations in the core area of Europe. Specifically, the arrival operations have to suffer at present from restrictions imposed by traditional routing and national boundaries, and these limitations are prohibitive for implementation of advanced SESAR concepts of operation. For that reason two focal points have been selected at both sides of the Dutch-German frontier that are suffering both from these airspace restrictions.

At the German side, the Düsseldorf area is selected as a cluster of airports. The airports in this cluster are heavily dependent on each other and can be considered all as large airports that may profit from enhanced arrival/departure operations. The airports may profit from creation of one TMA around them and feeding them all. The operations inside this TMA can be improved by creating long stretched “dedicated arrival flow corridors”, feeding the TMA-entry points of this TMA. One of these ETMA arrival sectors is a cross-border sector stretching at least 150 NM out inside Dutch airspace. Inside the TMA, the departure flows are structurally separated from the arrival flows.

At the Dutch side, Schiphol Airport is selected, acting as the dominating airport in Dutch airspace. On the one hand the airports operate with an enlarged TMA compared to today, 2009, to allow deployment of a 2x2 runway configuration, operating with 4 TMA-entry points (and stacks) and staggered approaches by CDAs, structurally separated from departure flows. The TMA entry-points are fed by stretched “dedicated arrival flow corridors” of which two are allocated partly in Germany: one over the present-day, 2009, East-bound arrival routes and a new one feeding the newly created South-East TMA-Entry point.

En-route traffic and traffic to and from other large and small hub and regional airports in the area are simulated but not measured. The objective of the simulation is to measure the performance of the two areas of interest, i.e. around the Düsseldorf area and around the Schiphol airport by measuring the performance improvement of all arrival and departure flows to and from the airports of interest. Improvement is defined in this case by comparing the performance of present-day, 2009, operations operating in present-day airspace, with the performance of future operations, operating under the assumed implementation of part of the operational concept of SESAR and operating in an assumed re-organised airspace that fulfils the SESAR operational requirements.

In addition, departure/arrival traffic operations are simulated for the airport of Brussels, Zaventem, because the arrival flows for this airport can not be ignored when simulating advanced departure/arrival procedures for Amsterdam and the Düsseldorf area. The same is applicable for an extra arrival flow through the Netherlands to the London area.

This means that the experiment is focused on operations of the airports of Schiphol (EHAM), Düsseldorf (EDDL), Köln (EDDK and Brussels (EBBR). These airports are characterised by “multi-airport” interdependencies summarised in the following table (Table 2).

Airport of interest	Dependent relationship	Type of dependency	Role in FTS experiment
Amsterdam (EHAM operations)			
	Rotterdam and Eindhoven mainly	Regional airport dependencies	nearby, and simulated but not investigated
	Düsseldorf area (EDDL/EDDK) - East-bound traffic	Hub airport dependencies	ETMA dependent, and simulated



	Brussels (EBBR) - South-bound traffic		
Düsseldorf area (EDDL and EDDK operations)			
	Düsseldorf (EDDL) and Köln (EDDK)	Nearby hub airport dependencies	Simulated
	Nieder-Rhein, Dortmund, Hannover etc., but also Luik (Liege) and Maastricht-Aken	Regional airport dependencies	nearby, and simulated but not investigated
	Schiphol (EHAM) - West-bound traffic	Hub airport dependencies	ETMA dependent, and simulated
	Brussels (EBBR) - South-West-bound traffic		
	Frankfurt (EDDF)	Hub airport dependencies	ETMA dependent and simulated but not investigated
Brussels area (EBBR operations)			
	Charlerois, Luik (Liege) and Antwerpen mainly	Regional airport dependencies	nearby, and simulated but not investigated
	Schiphol (EHAM) - North-bound traffic	Hub airport dependencies	ETMA dependent, and simulated
	Düsseldorf area (EDDL and EDDK) - North-East-bound traffic		
	London area - West-bound traffic	Hub airport dependencies	ETMA dependent and partly simulated
	Paris area - South-bound traffic		

Table 2 - Multi-airports aspects of traffic flows simulated in the FTS experiment

2.4 CHOICE OF INDICATORS AND METRICS

This section describes applicability of the Key Performance Areas and the use of Performance Indicators.

The concepts to be studied have an impact on several KPAs. Some high level benefits expectations are formulated for KPAs in section 2.2.4, while fast-simulation is intended to be selected in order to address quantitative performance benefits assessment. The expected outcome by **quantitative fast-time validation assessment** of the most relevant KPAs is described below:

➤ **Capacity:**

Due to the **bottleneck behaviour of the ATM network**, the performance of the network is critical for the most constraining sectors and airports. For hub airport operations, the TMAs are the most critical sectors. The aim is to realise sufficient capacity through all departure and arrival sectors to realise the forecasted Airport capacity with sufficient robustness to cover variations in departure/arrival rates and to deal with typical flow bunching in different



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directions. E.g. large airports discern typical periods during the day of inbound and outbound peaks and some peak periods may have specific long-haul and others typical short-haul character. The SESAR forecasts are addressing 2012 and 2020 capacity figures and KPI measurements will be accomplished by measuring **throughput, delays and workload**. Present-day, 2006/2007, routing and sectorisation is compared with a more ideal airspace organisation, operated by application of advanced SESAR concept elements operated through “dedicated arrival flow corridors”.

- Throughput potential of the network is measured with the Network Analysis Model (NAM), counting number of flights through sectors, length of queues and accumulating waiting time (counting network queuing waiting times).
- Delays are measured with TAAM, simulating different scenarios and comparing measured results. Imposed ground delays, necessary to realise minimum in-flight delays are characterising capacity limitations. Also, departure delays may be a measure of capacity deficits, but might be caused by inefficient use of available runway capacity as well.
- Workload is measured as load on human actors, required to provide control services to a flight. The workload modelling is based on an acceptable 70% load in an average en-route sector controlled by one controller (2520 sec/hour). The measured workload is used for this reason in a relative and indicative way showing the impact of changes in scenarios.

KPAs	Local PIs ID	Local PI Name (unit)	Local PIs Definition
Capacity	CAP.LOCAL.TMA.PI 1	Sector capacity (Nb. aircraft/h)	Maximum number of aircraft that can exit the geographic area or the most penalising TMA sector in one hour. It must be measured when the system is in high traffic conditions (at the limit of what a controller can deal without reducing safety) for a whole hour. It can be based on the maximum task load the tactical controller can deal with in this period of time.
	CAP.LOCAL.TMA.PI 2	Maximum simultaneous number (Nb. aircraft)	Maximum simultaneous aircraft being controlled in the TMA.
	CAP.LOCAL.TMA.PI 3	Total delays (min)	Sum of delays, due to the TMA, for arrivals and for departures. The delay for arrivals is the difference between the planed arrival time and the actual arrival time. The delay for departures is given while it is on the ground.
	CAP.LOCAL.TMA.PI 4	Total period throughput (Nb. aircraft)	Total number of aircraft controlled in the TMA during the 6h00-22h00 period.
	CAP.LOCAL.TMA.PI 5	Maximum measured throughput (Nb. aircraft/h)	It is the maximum number of aircraft that actually exited the geographic area, or the most penalising TMA sector per hour with the considered traffic demand. It can be lower than the sector capacity, but can be equal to it when the system is fully loaded. This maximum measured throughput might be computed as the average of the maximum measured throughput for different controllers and traffic samples.

Table 3 - KPIs applicable to Capacity KPA



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➤ Efficiency:

The airspace users wish is to fly **undisturbed city-pair connections following an optimised vertical profile**, while present operations are inefficient due to all kinds of constraining conditions by other airspace users. The objective of this exercise is to find a rough high level design of airspace suitable to serve AMS-DUS TMA operations in an “idealised” way. This can become a starting point to iterate to new airspace design in the core area, structuring all traffic flows to be served in this area in a better and more harmonised way as well as the operations of the military. It is essential to address re-design of airspace and the improvements of concept of operations and procedures as an integrated set of changes because increased demands as well as advanced concepts are expected to change the requirements on airspace needs.

An increased level of efficiency is expected by early planning and anticipation through all phases of flight. Enhanced CTFM, departure operations and in-flight operations will result in **higher punctuality and less variability of demand at TOD**, and enhanced arrival management will increase the **punctuality at touch-down** against fewer deviations from the optimal Reference Business Trajectory (RBT). The efficiency is measured by **delays** related to the RBT and its related **flight duration** as a measure of fuel consumption and emissions.

- Punctuality improvement is assessed by comparing scenarios and measuring the difference between scheduled/planned arrival time by unconstrained RBT and actual arrival time, taking into account applicable threshold values (3 min.).
- Improvement of flight efficiency is measured by comparing actual flight time between ToD and Touch-down for different scenarios.
- The same aspect of flight performance is assessed by measuring fuel consumption as a rough indicator of flight benefits by optimised arrival procedures.

KPAs	Local PIs ID	Local PI Name (unit)	Local PIs Definition
Efficiency	EFF.ECAC.TMA.PI 1	Total flight duration (min)	Sum of the flight durations in the scenario. Times during which aircraft are not in the geographic area are not considered.
	EFF.ECAC.TMA.PI 2	Optimal total flight duration (min)	Sum of the “best controlled” flight durations. The “best controlled” flight duration is the one the aircraft would have if it were alone in the geographic area, following applicable procedures, from the first point of the geographic area to the last point of the geographic area. It can be computed by taking into account aircraft performances. See the beginning of the TMA section for precisions on the geographic area.
	EFF.ECAC.TMA.PI 3	Total Fuel consumption (kg)	Fuel consumption in the geographic area. If it is not computable, then fuel consumption can be replaced by the flown distance (Nm).
	EFF.ECAC.TMA.PI 4	Optimal total fuel consumption (kg)	Sum of the “best controlled” fuel consumptions. The “best controlled” fuel consumption of an aircraft is its fuel consumption that would be used to travel in the geographic area if it was alone, with no other traffic to disturb its trajectory. If not computable, it can be replaced by <i>total effective distance</i> in the “general performance indicators” section.



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KPAs	Local PIs ID	Local PI Name (unit)	Local PIs Definition
	EFF.ECAC.TMA.PI 5	Number of delays (Nb aircraft)	Number of aircraft delayed by more than 3 minutes (a delay is the difference between expected time and actual time). Delay information can be found using flight plan data.
	EFF.ECAC.TMA.PI 6	Total delays (min)	Sum of delays due to the TMA, for arrivals and for departures.

Table 4 - KPIs applicable to Efficiency KPA

➤ **Predictability:**

The concepts of flight management, regulating flows and sequencing, and planning, accomplishing conflict free planning, are improving the predictability as long as flight plans are updated and the executive process adheres to the planning. Validation has to ensure realism, feasibility and operability of the adherence.

- The quality of predictability increases by enhanced in-flight planning. The planned arrival time of the managed trajectory, the SBT, is compared with actual arrival time and is a measure of predictability of enhanced planning, assuming to allow referencing to accurate take-off planning.

KPAs	Local PIs ID	Local PI Name (unit)	Local PIs Definition
Predictability	PRE.ECAC.TMA.PI 2	Flight time deviation (no unit)	Flight time standard deviation divided by mean flight time. This PI does not capture the fact that sub-groups of trajectories can have regular flight times internally, while their average flight time is different (two different procedures in TMA for example). It also does not capture the fact that aircrafts of different category have different speeds. Those two points could make <i>flight time deviation</i> big, while flight times are actually very predictable.

Table 5 - KPI applicable to predictability KPA

➤ **Safety:**

At the level of anticipated validation experiments, safety assessment will be restricted to ensure that similar levels of safety as at present, 2009, can be expected, and that no new risks are introduced by the concepts to be validated. This is not measured but comprised in the imposed separations applicable to simulated air traffic.

- What is monitored and measured for reasons of consistency and integrity, are the differences in number of conflicts between scenarios. It is required to maintain the number of identified conflicts at a similar level for scenarios with equivalent density of traffic irrespective of airspace organisation. No experimental results are aimed to be obtained.

➤ **Environmental sustainability:**

Environmental sustainability is in the context of present validation experiments a secondary assessment KPA. Although admittedly an important reason to introduce CDAs is to improve noise load, the first objective of the experiment is to facilitate CDAs under high density conditions, and not to validate the optimal CDA profiles. However, CDA profiles will be applied



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(at low altitude) that are compliant with noise abatement regulations and that will provide benefits. Therefore, indicative figures related to noise abatement benefits will be measured. Further, reduction of flight duration provides a first order estimate of anticipated benefits⁴ regarding the environment. Effects on emission levels can be derived from the flight profiles during initial climb and during the arrival descent phase. Effects on noise can be derived from calculated footprints below 3000 ft.

- The flight profiles from different scenarios are measured and delivered for processing to WP2.4.4⁵.

KPAs	Local Pls ID	Local PI Name (unit)	Local Pls Definition
Environmental sustainability	ENV.ECAC.TMA.PI 8	TMA Noise areas	Sum of Surface areas with Noise Level: - Lden > 55dB day - Lnight > 50dB night

Table 6 - KPI applicable to Environmental sustainability KPA

2.5 VALIDATION SCENARIO

This section provides a detailed description of applicable validation scenarios referencing different time frames and advanced concept application levels.

A performance assessment validation experiment shall be executed to assess performance improvement by SESAR conceptual improvements in ETMA and TMA operations in the core area of Europe. The operational impact shall be measured for operations of airports in the Düsseldorf area and in Amsterdam Schiphol, WP5 validation Strategy, Ref. [14], see also Table 7. Because an extended time horizon for arrival management is addressed, a coherent airspace area is selected that covers part of the core area, but that excludes at least the London area, the Paris area and the Frankfurt area.

Validation Objective: The objective of this fast-time exercise is to validate that the ATM capability of ETMA/TMA airspace in a multi hub-airport environment (Schiphol and Düsseldorf.) is sufficient to cope with increased demand in each airport, taking into account the forecast capacity of each of the airports.

Descent operations starting from Top-of-Descent, typically 100NM out, have to become highly efficient compared to today's operations, i.e. 2009, by starting an arrival sequencing process ~150-200NM out.

Rationale: The ATM capability, including the SESAR 2020 conceptual improvements, will facilitate the required highly accurate operations with minimised airspace requirements. In 2020 the scope of hub airport operations are extended significantly due to implementation of the SESAR concept of 4D trajectory management, supporting at least 3D with predicted RTA and high-precision departure and approach operations. The ETMA/TMA operations of a hub airport are growing therefore so much in size and complexity that several hub airports in the core area are to be considered now to belong to one single ETMA/TMA environment. The operations in this environment have to be integrated and harmonised in order to achieve maximum efficiency under heavily constrained conditions.

⁴ This effect is limited since the flight time in the TMA is low compared to the total flight time. OIs in the TMA will mainly contribute to noise reduction (for example the increase in CDAs will reduce the noise impact) and also some OIs will have an effect on the local air quality. However, the effect on the LAQ will be indirect: increasing the capacity will reduce ground queuing and thereby be beneficial for the LAQ.

⁵ Quantitative noise assessment can be performed by calculating the area of the noise contours for Lden and Lnight (this will be done in WP2.4.4).



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The experiment shall validate how operations in part of the network can be served in an optimised way against minimal penalties and imposing minimal requirements on airspace usage. The increased demand has to be accommodated by high performance ATM, capable to serve dense departure and arrival flows in limitedly available airspace volumes.

Reference to SESAR Con. Ops.: F3.3 High Complexity Terminal Operations, F.6.2 Terminal Area Operations

Table 7 - Validation exercise description according to the WP5 Validation Strategy, Ref. [14]

The reference organisation shall be a present-day airspace organisation, 2006/2007, aligned along the national boundaries, following present-day procedures and letters-of-agreement. The advanced organisation shall be organised in such a way that at least all arriving and departing flows to the Düsseldorf area and Amsterdam Schiphol are following an optimised sectorisation scheme, offering TMAs and dedicated stretched arrival and departure sectors in ETMA airspace that allow to perform 4D trajectory management in compliance with SESAR. All air traffic to and from other airports is simulated as much as possible in a similar and equivalent way, except Brussels traffic which may receive an allocation of at least one dedicated arrival sector for Nord-bound traffic, stretching through the Dutch airspace (see Figure 5).

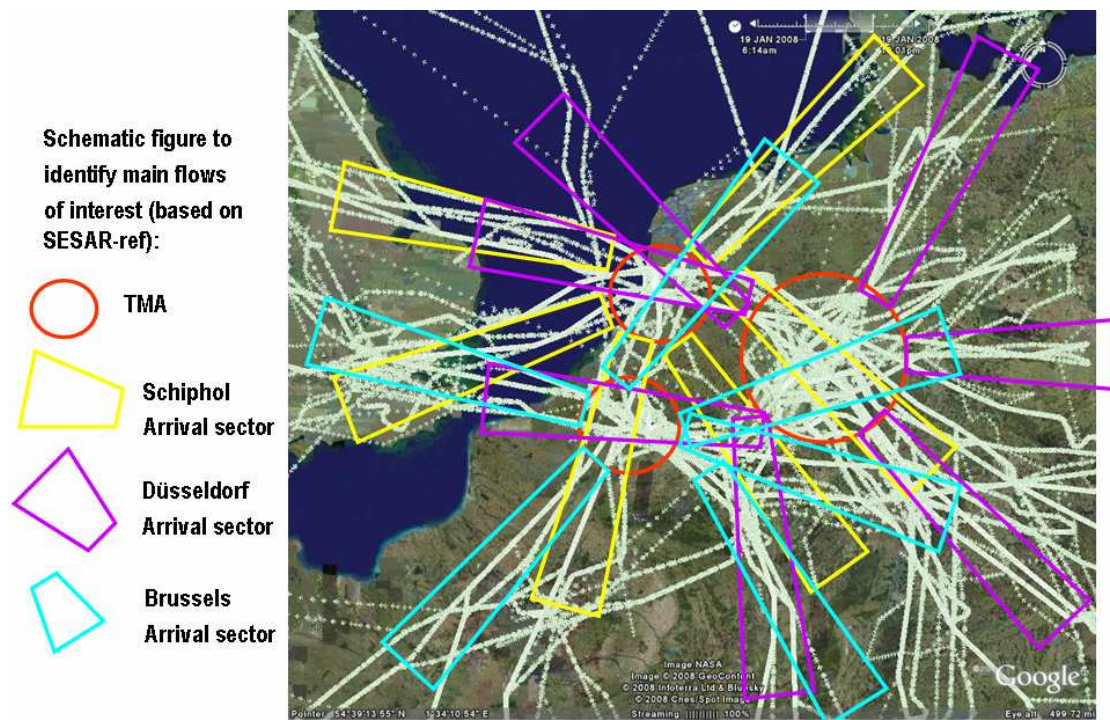


Figure 5 - Schematic figure of allocation of enhanced TMAs and stretched arrival sectors for the advanced organisation

Demand for different years will be assessed in order to be able:

- To assess the performance improvement of reorganised airspace and new operational conceptual elements under present-day conditions (year 2006/2007),
- To assess a strong increase of traffic demand (year 2015),
- And possibly, also to assess SESAR required levels of traffic demand (year 2020) (depending on the availability of appropriate scenarios, time and effort).

The following steps are executed to perform the fast-time performance assessment experiment (for each year):



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- 1.1 **Reference Scenario, Balanced:** Assess balance in throughput and capacity of the network, based on present-day airspace organisation, by applying network analysis on the reference scenario (Network Analysis Model, i.e. NAM).
- 1.2 **Reference, “Do nothing”:** Run this reference scenario and assess throughput and efficiency (TAAM).
- 1.3 **Reference, arrival synchronised:** Run this reference scenario under traffic synchronised conditions and assess penalising effects in order to avoid overload and delays (CTFM and TAAM).
- 2.1 **Advanced Scenario, Balanced:** Assess balance in throughput and capacity of the network by applying network analysis on the advanced scenario, based on stretched arrival sectors (Network Analysis Model).
- 2.2 **Advanced, “Do nothing”:** Run this advanced scenario and assess throughput and efficiency (TAAM).
- 2.3 **Advanced, arrival synchronised:** Run this advanced scenario under traffic synchronised conditions and assess penalising effects in order to avoid overload and delays (CTFM and TAAM), and application of advanced Arrival Management, based on 4D trajectory management and Air-Ground trajectory exchange.
- 2.4 **Advanced, arrival synchronised, including 4D-guidance:** The same scenario as for 2.3, but short-term planning and control are enriched with 4D guidance support. ***This last option is added, time and effort permitting.*** The question is also, whether it is feasible to model emulation of 4D-enhanced guidance in a realistic creditable way to measure the added value of the concept and not the benefits due to preference-benefitting models.

The final result in terms of benefits are assessed by comparing the **Reference, “Do nothing”** scenario with the **Advanced, arrival synchronised** scenario, and by assessment of extra benefits due to 4D-guidance during the executive phase.

2.5.1 Hypothesis

In this section the hypothesis for each metric is mentioned. The hypotheses are different by comparing each time two scenarios, assessing the expected outcome of the critical metrics.

The experiment executes a performance assessment experiment applying scenarios with several parameters being relevant to indicate possible changes in performance. The scenarios are ordered such that significance of changes can be judged one by one. The hypothesis of this experiment is formulated therefore as a set of step-wise incremental performance assessment criteria, providing the benefits expected.

1. **Network performance:** Network throughput analysis leads to adding required capacity at those nodes of the network that are critical bottlenecks of the network. It assumed that small changes at critical nodes, changing “declared capacity” of these selected nodes in “required capacity”, can have a more than proportional impact on reduction of delays and increase of throughput through the network. The added capacity is not “created” but “assumed”.
 - Validation scenarios 1.1 and 2.1 are simulated with NAM to assess optimal performance of the network by measuring effective throughput.
2. **Advanced airspace management:** Due to the enlarged scope of operations for each airport/airport-area of interest, it is assumed to be possible to define a network of operations with significant higher throughput potential than the network based on “traditional” airspace organisation. Assuming realistic “declared” capacities for the newly created “dedicated arrival flow corridors”, the throughput capacity shall be sufficient to cope with forecasted expected airport demand.



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- Validation scenarios 1.2 and 2.2 are executed and compared with respect to effective throughput. The better flight profiles allow more efficient flight performance, and measurements are possible of so-called “Optimal total flight duration” (see KPIs, section 2.4).
- 3. **ATM enhanced delivery:** SESAR processing by DCB and early arrival traffic synchronisation accomplished by 4D trajectory management and advanced planning shall have a positive effect on in-flight delays and workload at sector level. The trade-off is pre-departure delay and inefficiency by tactical manoeuvring against in-flight efficiency. The assumption is that even within a “traditionally” organised airspace structure benefits must be achievable, although against high penalties.
 - Validation scenario 1.3 is executed and results are compared with scenario 1.2 results; throughput, flight efficiency and predictability are measured.
- 4. **ATM enhanced delivery in enhanced airspace:** Operating within an advanced airspace organisation, the SESAR processing by DCB and early arrival traffic synchronisation accomplished by 4D trajectory management and advanced planning, shall have an even stronger positive effect on in-flight delays and workload at sector level. The trade-off is again pre-departure delay and inefficiency by tactical manoeuvring against in-flight efficiency, but the penalties will be significantly reduced compared to “traditional” airspace. The assumption is that the achievable benefits must be much higher within “advanced” organised airspace structures due to better tuning to required airspace, and at the same time the penalties are expected to be significantly lower than with a “traditional” organisation of airspace.
 - Validation scenario 2.3 is executed and results are compared with scenario 2.2 results; throughput, flight efficiency and predictability are measured.
 - Also, the achievable performance improvement is expected to be better than for hypotheses 3.
- 5. **Executive services (RNAV+4D):** The performance can still be improved by providing ATM services that will contribute to enforce the punctuality objectives of planning by changing the objective of flight executive services from “safe, orderly and expeditious” to “safe, orderly and on-time”. The priority is given to those flights that are approaching a congested area. Because Amsterdam airport and the airports in the Düsseldorf area are going through periods of congestion, benefits are expected to be measured in those time periods for flights arriving at these airports of interest.
 - Validation scenario 2.4 is executed and results are compared with scenario 2.3 results; throughput, flight efficiency and predictability are measured.
 - Comparing scenario 2.4 with 1.2 allows to assess the benefits of all improvements combined in an advanced scenario, compared to a scenario based on “traditional” operations.
 - The simulated end state allows also to assess achievable benefits related to noise abatement (low-altitude noise load).

The following table, Table 8, summarises the hypotheses and how to assess performance benefits. The table relates Validation scenarios to applicable Hypotheses, starting from applicable input scenarios and creating different reference and advanced scenarios.

Hypothesis Scenario	Network performance	Advanced Airspace design	ATM enhanced delivery	ATM enhanced delivery in enhanced airspace	Congestion priorities
1.1 Ref, Bal.	More throughput by NAM				



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1.2 Ref. DoN.		Traditional performance by constrained profiles			
1.3 Ref. arrival			Operated in traditional airspace		
2.1 Adv. Bal.	More throughput by NAM				
2.2 Adv. DoN.		Enhanced performance by more efficient profiles			
2.3 Adv. arrival				Operated in advanced airspace	
2.4 Adv. 4D					ATM applicable prioritisation under congested conditions

Table 8 - Relationship between hypothesis assessment and related validation scenarios/experimental steps

2.5.2 Airport Information

Airport Environment

This section deals with the relevant airports and their environment, e.g. urban areas, foreign frontiers, environmental areas, obstacles, etc.

The airports of Düsseldorf area, i.e. Düsseldorf, Köln, Dortmund and several others, and in the area of Amsterdam, i.e. Schiphol and Rotterdam mainly, are all characterised by a long history of airport development within a highly urbanised environment. The consequence is that operations in the direct environment of the airports are highly constrained by the compromise of optimal deployment of the airport and the third party's interests of the population. Departure and arrival operations are restricted by law and noise load is accurately monitored and controlled.

As a consequence, advanced operations shall maintain and/or improve the environmental load, whereas also increase of demand is strictly constrained.

Airport Layout

Airport lay-out characteristics are briefly summarised for the airports of interest. This relates to number of RWYs, RWY length and orientation, RWY usage (dep, arr, mix), RWY dependencies, etc.

The simulation experiment is an experiment to investigate enhanced operations under the most frequently applied runway configurations. The objective of the experiment is not to investigate all applicable configurations, although differences in operational procedures can be significant. In particular, Schiphol operates a very complicated set of runways with significant changes in operational characteristics and achievable throughput. However, in this experiment, only the most frequent used configuration (18R and 18C) are simulated with the maximum achievable throughput for this airport.



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Düsseldorf EDDL

Düsseldorf:

- RWY: 23L/23R
- Present-day applicable arrival procedure:
 - traditional approach procedure
 - vectors on down-wind
 - cross-wind at 3000 ft, turning to FAF
- Advanced procedure:
 - Flight-efficient CDA procedures
 - Turning straight from TMA-entry-point over IAF to FAF
- TMA:
 - 4 TMA entry-points/IAFs:

ARKON	FL 170
DOMUX	FL 140
KUBIM	FL 150
LIMA	-

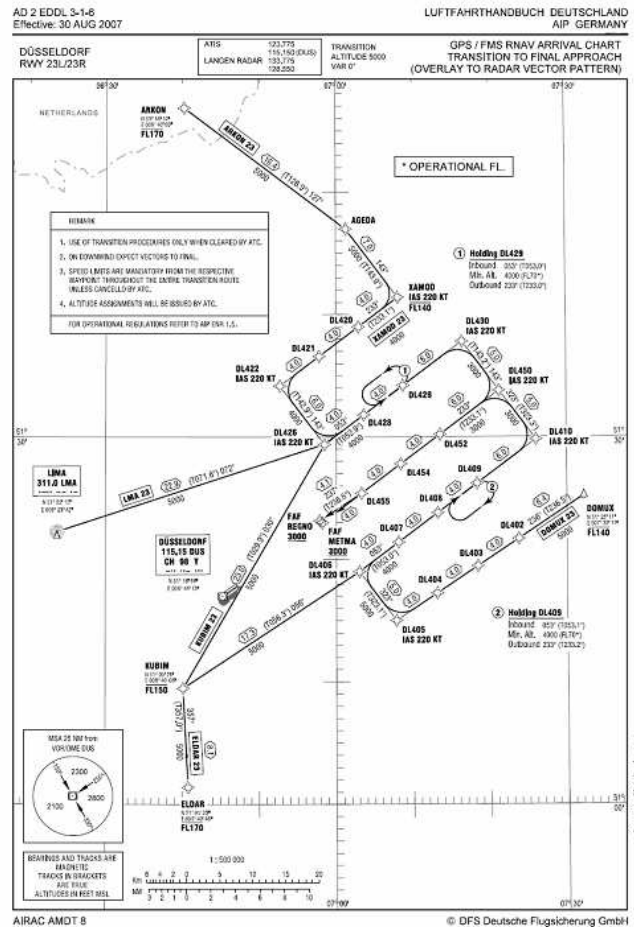


Figure 6 - Present-day approach procedures for Düsseldorf (EDDL) (Source: DFS)

- **Düsseldorf area (Düsseldorf - EDDL, Köln - EDDK and Dortmund - EDLW):**

EDDL (See Figure 6):

- The airport will operate in the simulations with the preferred runway configuration 23L/23R, departures RWY 23L, inbounds both from 23L and 23R⁶. Runway 23L is operated in mixed-mode, 23R in segregated mode.
- The operations are capacity restricted according to capacity agreements by law rather than physical runway capacity. Therefore, the runways are operating far below their physical maximum capacity.
- The climb and descend profiles are restricted due to noise abatement regulations. SIDs are applicable, and in the arrival phase, flights will follow CDAs that are in agreement with present-day, 2009, procedures for the last segments.

⁶ It should be noticed that preferred RWY operations maybe simplified in the simulations to evaluate easier the effects of CDA operations and enhanced guidance on arrival operations. This is accomplished by separating departures and arrivals as much as possible.



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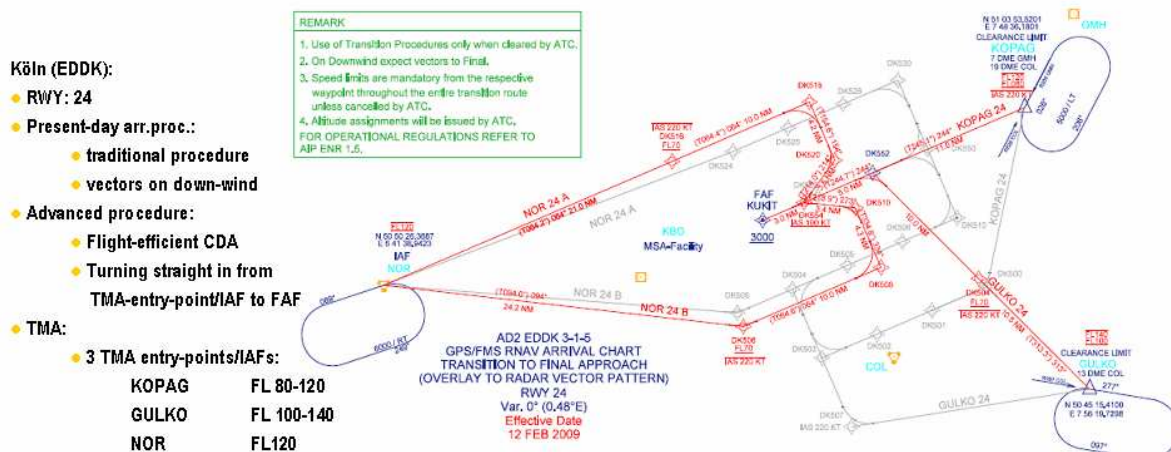


Figure 7 - Advanced approach procedures for Köln (EDDK) (Source: DFS)

EDDK (see runway 24, Figure 7):

- The airport will be operated in the simulations by flying departure/arrival procedures on runway 14 and 24, 60% of all air traffic is for RWY 14, 40% is RWY 24. The inbounds are mainly operated from 246.
- The runways are operated in mixed mode.
- Vectored arrival procedures are applicable in the reference scenarios, more direct CDAs in the advanced scenarios. The same TMA entry-points are applicable for both scenarios.

• Amsterdam, Schiphol - EHAM:

EHAM:

- Runways are operated in segregated mode. 18R and 18C are used for arrival traffic, 24 and 18L are used for departures.
- There are dependencies in case of overshoots between 18R, 18C and 24.
- Other runway configurations are ignored, and this relates to the associated capacity changes as well as the usual configuration changes over the day.
- There are strict noise regulations applicable for each runway for arriving as well as departing traffic. The applicable profiles (possibly in CDA-applicable versions) are simulated and all noise abatement agreements are respected as good as possible in both types of scenarios: traditional and advanced airspace organisation.

• Other Airports of interest:

Brussels, Zaventem, EBBR:

- The only airport fully simulated in addition to Schiphol and the Düsseldorf area is Brussels Zaventem because the arriving flows are showing critical interference with Schiphol and Düsseldorf area arrival operations through CDAs. The airport will operate on a default west-wind scenario.

Airport Technologies

Relevant means of applicable technologies are mentioned here. This relates to guidance means, surveillance means, etc.



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The runways on all airports of interests are equipped with ILSs and no advanced procedures on Final Approach are applicable. Advanced technology and CNS systems at airport level are irrelevant for that reason.

Airport characteristics

The experiment is a runway to runway experiment and/or en-route to runway experiment. The interest in airport characteristics is limited therefore to operational characteristics and runway configurations available. No attention is spent on local facilities and ground movement operations.

The airports of interest are:

- **Düsseldorf area** (Düsseldorf - **EDDL**, Köln - **EDDK** and Dortmund - **EDLW**):

EDDL:

- Total number of movements per year: 215.000 at present, 2006/2007, growing possibly to 270.000, provided 8 hours of limited operation at present will increase to an hourly capacity of 45-47 mov. as well.
- The applicable RWY configuration in the reference organisation is 23L/23R, (see inbounds, present-day operations, 2006/2007, Figure 6).
- The sustainable capacity of DUS International airport can go up to 60 mov/hour peak capacity.
- Düsseldorf airport operates within strict limitations regulated by court. The permissible operating characteristics seem to be stable for the next years. As the airport is a fully coordinated one, till the end of 2005 a total 40-42 aircraft were coordinated per hour with an increase to 45-47 aircraft per hour starting in 2006, thus leading nowadays to a traffic volume of up to 55-58 aircraft per hour depending on daily delay situation. These traffic figures are valid for 8 hours a day between 06:00 and 22:00 hours. In the remaining 8 hours at present, 2006/2007, 40 coordinated movements are allowed. (These 8 hours will have single runway operations only, the additional 8 hours with increased traffic will be allowed to operate on both runways. In addition there are reduced operations (33 mov/h) up to 23:00, single runway operation.)

EDDK:

- The total amount of mov/year is 153.000 at present, 2006/2007.
- The airport operates with two runways: 14 and 24. (see inbounds on 24, present-day and future operations, Figure 7).

EDLW:

- The total amount of mov/year is 35.000 at present, 2006/2007.
- The airport is of secondary interest in the present experiment and its performance will not be measured.

- **Amsterdam, Schiphol - EHAM:**

EHAM:

- Total number of movements per year: 450.000 at present, 2006/2007, growing to 480.000 mov/year in 2010, and with a growth capacity of roughly 600.000 mov/year for the long term.
- The maximum hourly capacity is at present 108 mov/hour sustainable capacity under nominal weather conditions. The maximum hourly capacity can increase to 120 mov/hour if operations with 2x2 runways will be applied for the major part of the operations. 2x2 runway configurations can be applicable for North-bound as well as South-bound operations.



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- The experiment will focus on the most frequently applicable configuration, operating inbound on 18C and 18R and outbound on 24 and 18L, all operated in segregated mode.
- **Other Airports of interest:**
 - Brussels, Zaventem,
 - Regional airports in the Netherlands,
 - Regional airports in Germany,
 - Regional airports in Belgian and Luxembourg, and
 - Airports and airport areas at the boundaries of part of the core area of interest: London Area, Paris area and Frankfurt area.

2.5.3 Airspace Information

This section provides information on vertical and lateral boundaries, prohibited/restricted/segregated areas, sectorisation as well as other possible airspace restrictions. Thereafter, airspace usage and procedures through TMA and ETMA airspace are discussed.

Airspace Characteristics

The airspace in the area of interest is characterised at present by large airports operating in the neighbourhood of national boundaries. Heavily constrained procedures are applied to operate the airports while respecting the National boundary conditions with negative effects on capacity and flight efficiency.

The advanced airspace organisation aims to provide an airspace environment in which advanced ATM as described by SESAR can be applied in a beneficial way. The assumption is that these benefits are not achievable when operating in the present-day constrained airspace environment. The most important change is that generic airspace volumes are defined for each major flow of arriving traffic in the area, and that other operations such as operations for regional airports and the Military are adapted in one way or another in order to respect undisturbed arrival procedures as much as possible.

The advanced airspace organisation expresses the requirements of hub airport operations in this area in the case that no further restrictions are applicable and that hub airports are allowed to specify their preferred departure/arrival procedures taking into account only each others interest.

All present-day applicable routings are adapted to follow flight efficient flight profiles towards the destination airport. Prohibited areas and restrictions are ignored, and the same for sector boundaries. No regulations are applicable to force flights to follow sub-optimal flight profiles.

Flights will enter TMAs by most efficient and/or shortest routings; prohibited areas are available for civil use and no area will be closed.

TMA Procedures

Now, routes / arrivals / approach procedures / departures / holdings information and conflicting points are described.

The experiment runs scenarios with two types of airspace organisation:

- ***Traditional airspace organisation***, applying present-day, 2006/2007, applicable procedures, using present-day route structures and using present-day sectorisation.
- ***Advanced airspace organisation***, applying advanced procedures, using an extension on and modifications of present-day route structures and using a sectorisation adapted to use of “***dedicated arrival flow corridors***”.



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The experiment has a focus on the Düsseldorf area (EDDL, EDDK and EDLW) and Amsterdam Schiphol (EHAM). There is an interest therefore in detailed airspace characteristics for applicable TMAs, servicing those airports, and ETMA characteristics (routings and procedures) for those traffic flows servicing these TMAs. In addition, there is a limited interest in how to accommodate traffic flows in ETMA airspace for all traffic to and from other airports in the area, such as in particular to and from Brussels airport, and its specific arrival procedures.

The TMAs of interest are:

- **The TMA of the Düsseldorf area (feeding EDDL, EDDK and EDLW):**
 - Two airports are simulated and measured: EDDL and EDDK.
 - The lay-out of those parts of this TMA, feeding the airports EDDL and EDDK, are given in Figure 6 and Figure 7.
 - EDDL will operate 2 runways (23R/23L), fed from 4 TMA entry-points/IAFs:
 - ARKON FL 170
 - DOMUX FL 140
 - KUBIM FL 150
 - LIMA -
 - EDDK will operate 1 runway (24), fed from 3 TMA entry-points/IAFs:
 - KOPAG FL 80-120
 - GULKO FL 100-140
 - NOR FL120
 - EDLW: unspecified, no advanced CDAs are applicable for this airport.
 - The traditional scenario simulates approach procedures by levelling off, giving vectors on downwind.
 - The advanced scenario simulates CDA procedures by curved approach procedures.
- **The TMA of Amsterdam (feeding Schiphol, EHAM):**
 - Schiphol plans to operate in the future 2x2 runway configurations. Two arrival, two departure runways with dedicated arrival and departure flows. The most frequently used configuration is applicable to the experiment (see Figure 8, left-side picture).
 - Schiphol will operate in the future with four TMA-entry points, the TMA entry-point at the TMA South-East side is new. This new TMA-entry-point requires also a new en-route flow to allow South-East inbound traffic to descend, to be sequenced and metered towards this TMA entry-point.
 - Each runway is fed by two TMA-entry-points. Traffic is sequenced accurately with ~30 s. precision when passing this entry-point.
 - CDAs are applicable for all descending traffic after passing the IAF by issuing a CDA clearance, applying 4D-guidance or otherwise manually controlled. The clearance is applicable when the merging conditions are fulfilled. If necessary, traffic can be guided by a two-step CDA descent clearance to FAF. The first CDA clearance is to reach the merging point of two flows, the second CDA clearance is given after successful merging on the cross-wind leg.
 - To ensure high flight efficiency and large stability, 4D-guided flights are made independent of each other by approaching each entry-point in a staggered way, separated sufficiently to be independent of its predecessor flight. After merging, at low altitude below 4000 ft and above populated areas there is one merged flow of traffic left over only.
 - Above populated areas and at low altitude, CDAs and optimal noise-friendly profiles will not be compromised, except to accommodate optimised noise-friendly departure operations. At higher altitude CDA profiles are the most optimal to realise, but compromises are acceptable to accommodate all traffic flows in the best structural way, achieving strategic de-confliction of traffic.



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- The CDA arrival flows in the advanced scenario are approaching the SPL parallel runway configuration simultaneously. Because CDAs are not allowing to apply vertical separation, other ways have to be applied to separate these flows. The East-bound arrival flow will proceed further North and will be separated horizontally from the West-bound flow. In addition, the flows will follow different glide slopes: the East-bound flow will apply 3.5 deg., the West-bound flow 3 deg.
- East-bound and West-bound traffic is not in balance in principle. Therefore, RWY assignment shall take into account the required balance. Present traffic demand is divided in 42% West-bound traffic and 58% East-bound. To accomplish balanced demand the Southern traffic will be assigned to the appropriate runway and follow STARs to guide them to the designated runway, linked to the designated TMA entry-point, i.e. Tiel or River. RWY assignment is accomplished around 150 to 200 NM out at the same time to establish the sequencing.
- Departure flows are guided in a structured way as much as possible over arrival flows. However, there might be flows that have to be guided partially under CDA arrival flows. Because this might have strong negative effects on fuel efficiency, emissions and noise, this has to be monitored carefully and has to be measured.

- **Schiphol operations based on 4 TMA entry points and 2x2 runway operations**
- **Provides with 4th runway entry-point, a generic model for 2-runway parallel CDA approach operations (North-bound configuration, left-side)**

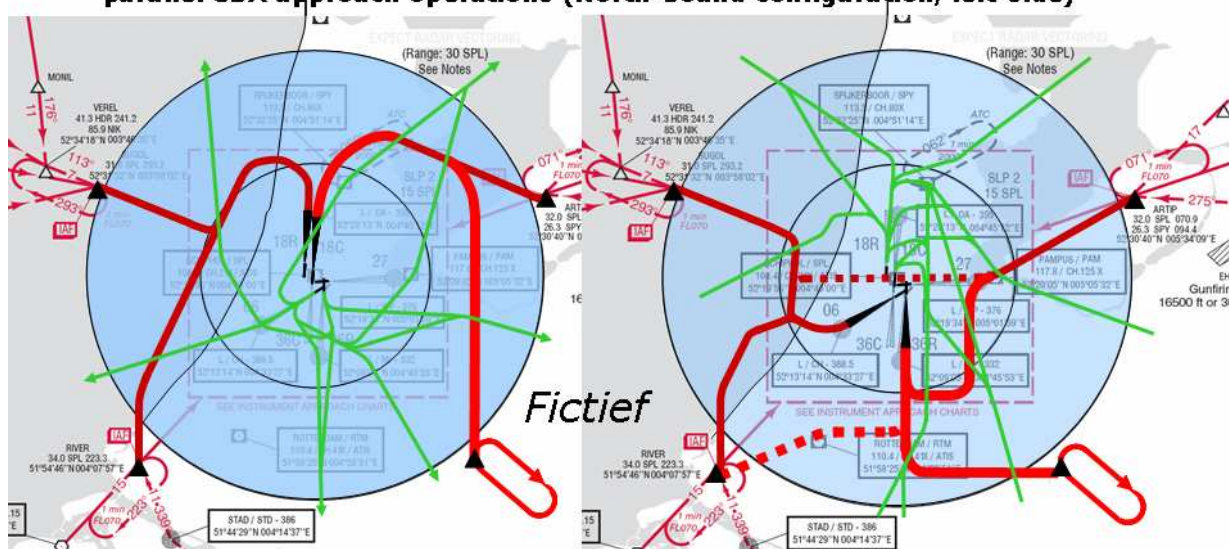


Figure 8 - Advanced procedures for Schiphol TMA operations

ETMA procedures

ETMA traffic flows are addressing:

- **ETMA “dedicated arrival flow corridors”:** Different from today, 2009, long stretched dedicated arrival corridors, i.e. dedicated tunnels in the sky to accommodate arrival flows, are assumed that allow providing ATM service provision to arrival flows for hub airports with maximum efficiency, following continuous descent profiles, while metering and sequencing is applied using RNAV techniques.

Because benefits due to operations by appropriately dimensioned departure and arrival sectors can be measured only when the airports of interest are serviced in all



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directions and when arrival management is performed on the joint flows of traffic for each airport of interest, the ETMA arrival airspace volumes are created in all directions for the airports of interest. These airspace volumes cannot be associated with traditional sectors because they are occupying too much airspace with a too complex interdependent structure. These volumes have to be considered therefore as airspace volumes that are controlled by different controllers, possibly belonging to different organisations and coordinating with each other in order to achieve their ATM objectives. Typically, these volumes will stretch out up to deep into en-route airspace. The arrival flows of traffic using these volumes of airspace will intercept the arrival flow corridors at the most suitable points, keeping their flight profile as flight efficient as possible. After interception of the arrival flow corridor, each flight will descent using a calculated and assigned RNAV track. Very high altitude flights will descent from their TOD to intercept the start of the dedicated arrival corridor as appropriate. The airspace volumes of these flow corridors will be monitored and measured in order to assess workload associated with management of dense arrival flows following CDA-like procedures whilst being sequenced at the same time. An intertwined collection of arrival flow corridors for all hub airport operations in the area will span the airspace available, leaving as much remaining airspace to other users, such as departure traffic, regional airport flows and Military operations. The “dedicated arrival flow corridors” are feeding the TMAs (see Figure 9). In this respect, there are two types of TMA entry-points:

- **TMA entry-points, dedicated to one runway** and feeding (part of) one arrival flow to one runway.
- **TMA entry-points, feeding more than one runway** and accommodating (parts of) arrival flows for several runways and possibly several airports.

“Dedicated Arrival Flow Corridors” Advanced CDAs through ETMA airspace

• AMS-DUS airspace:

- Generic 3D inbound flow representation
- Top view

A future view on required airspace for dedicated arrival flow corridors, comprising airspace organisation and routings.

- Amsterdam: EHAM
- Düsseldorf area: EDDL, EDDK, EDLW
- Brussels: EBBR
- One flow to the London area through the Netherlands

(Red: ~FL 350, Blue: ~FL 120)

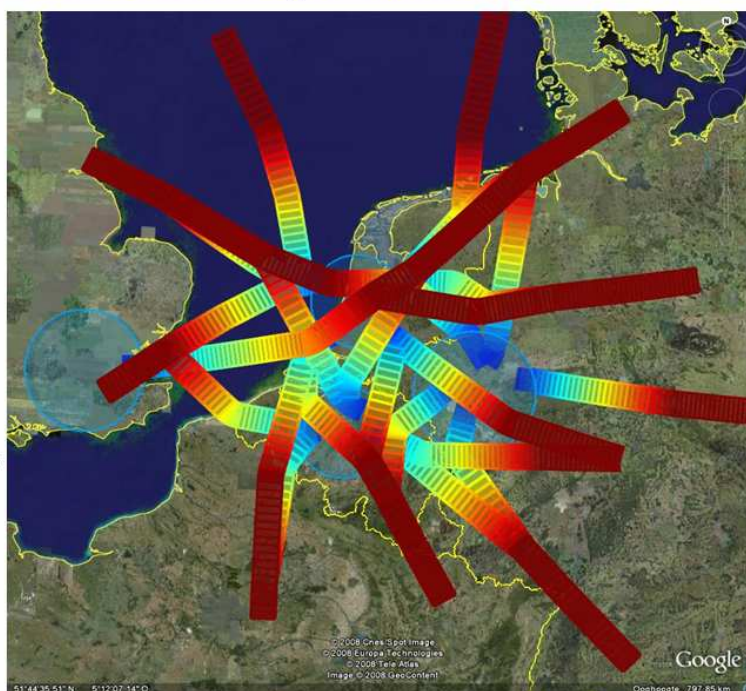


Figure 9 - Rough estimated design of airspace volumes dedicated to service provision to arrival flows for the airports of interest in the area



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- **ETMA departure sectors:**

ETMA departure sectors have to accommodate departure flows from the hub airports in the area. The airports served are: EHAM, EDDL, EDDK and EBBR. These sectors/volumes of airspace will be kept separated from the previously defined "dedicated arrival flow corridors".

2.5.4 Traffic Information

This section describes traffic demand and presently available scenarios. Some assumptions about the traffic or required adaptations are included.

There are several traffic demand scenarios that can be used for simulation:

- **Present-day** traffic, **traditional** scenario (2007 traffic demand, confirmed by ANSP),
- **Growth scenario**, **traditional** forecast (2020 traffic demand, confirmed by ANSP's growth expectations),
- **Present-day** traffic, STATFOR scenario by Episode 3 (2006 traffic demand, confirmed by EUROCONTROL specified reference **scenario of SESAR**),
- **Growth scenario**, STATFOR scenario by Episode 3 (2020 traffic demand, confirmed by EUROCONTROL specified **scenario of SESAR**).

Traditional scenarios

The table below specifies the traditional scenarios, present-day, 2007, and growth scenario, 2020, with 6052 flight and increased linear by cloning to 8204 flights (+35%). In detail: 887 flights (70%) in level flight and not departing or landing in ED*, ET* EH* and EB* (4-letter ICAO Code) were added. To identify these flights, they are marked in the Excel sheet (see scenario files), Column "MV Type" = 2 and in the ACF File "O_" in front of the Call sign. Time offsets range from minimal 10 min to maximal 60 min, to follow the traffic characteristics. Flights marked with "A_," are departures or arrivals in ED* and ET*. An average of ~20% has been added. Time offsets range minimal 10 min to maximal 30 min to follow the characteristics of traffic demand.

The table below lists German airports and their expected growth figures. Only flights are selected that have an impact on the Düsseldorf area and/or the BENELUX. Traffic through Belgian and the Netherlands are listed separately. It should be noted that EDLW has got 0% projected growth, its growth figures are comprised already in the figures for EDDL, because of the interconnection between EDDL and EDLW.

The total growth of traffic volumes of EHAM and EBBR are estimated at +40%, relative 2005. Based on experience of German Airport's growth expectations, German air traffic to and from EBBR is assumed to increase with 10% and to and from EHAM to increase with 7%. Missing traffic to EHAM and EBBR has been added by cloning.



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ICAO Code	percentage	Departure		Arrival	
		Movements	increase	Movements	increase
EDDB	50	23	12	24	12
EDDC	70	10	6	10	7
EDDE	70	3	2	6	4
EDDF	50	152	76	206	104
EDDG	70	44	31	38	26
EDDH	30	81	25	81	25
EDDI	50	21	11	26	13
EDDK	50	240	120	200	100
EDDL	50	350	174	358	182
EDDM	30	157	49	153	48
EDDN	30	32	10	31	10
EDDP	70	14	10	20	14
EDDR	70	6	4	8	6
EDDS	70	45	31	44	30
EDDT	50	68	34	73	37
EDDV	70	40	28	47	33
EDDW	70	20	14	22	15

Table 9 - Summary of departure and arrival operations in the reference scenario of simulated part of German airspace

Advanced SESAR scenarios

The traffic scenarios of SESAR are obtained in a fully different way, received from data available in Episode 3 scenarios, received from WP2.4.1. Again, there is a “present-day” and an “advanced” growth scenario. The present-day scenario represents 2006 air traffic, the growth scenario represents 2020 traffic. The core area traffic is selected from ECAC-wide traffic scenarios, simulated under different conditions of applying SESAR enhanced operational concepts. The difference is that the traffic conditions around TOD have to be different in order to reflect advanced DCB conditions. In the advanced scenarios there is more stability of demand than in the baseline scenarios.

Simulations with long-term advanced scenarios make sense only if the conditions are fulfilled to play their role in the validation process. The basic requirements are:

- There is balance between demand and capacity within the simulated airspace/airport environment. Airports are able to accommodate the traffic through acceptable use of available runway capacity and airspace can be dimensioned in such a way that traffic can be controlled by a control process which is supported by advanced automation support within the scope of the experimental set-up.
- There are scenarios available that allow to process DCB in a way that reflects appropriately the working of DCB mechanisms now and in the future. It is mandatory specifically that the variability on TOD conditions are managed in such a way as required by the advanced concept of arrival management validated by the current experiment.
- The scenarios of this experiment have to fulfil the need of an appropriate structuring as part of the required airspace design adaptation rules of this experimental plan. (See section 3.5.3). In dense areas like the core area, air traffic has to be structured in clearly identified and manageable traffic flows.

Therefore, the use of STATFOR 2020 scenarios make sense only if there is support to generate the effects that are outside the scope of the present experiment, and if they



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represent air traffic in a way compliant with the experimental requirements. Appropriate scenarios are required, reference as well as advanced scenarios, but when these scenarios can be made available these can contribute to the realism of the validation results.

2.5.5 Additional Information

Additional information relates to simulation conditions such as weather conditions, ATC information, on-board information and scenario assumptions.

The simulated scenarios are stable scenarios without wind, without disruption, without delays caused by external factors outside the scope of ATM operations. Therefore, the results are representing ATM performance under ideal conditions. The most important assumption on the quality of the scenarios is the requirement for flow stability at the start of the arrival management process, because this determines the performance of ATM as well as the airspace needed.

2.5.6 Equipment scenario requirements

This section specifies the scenario assumptions on specific equipment availability. The changes are described to equipment capability requirements, such as specifically 4D capabilities.

The simulations are run with 100% equipment levels. When sufficient specific modelling is implemented to assess the impact of equipment differences, also scenarios with mixed equipage will be simulated. However, it is time and effort dependent how much research will be invested in the effects of mixed 4D-equipment levels.

As discussed in the TMA Expert Group of WP5, mixed 4D-equipment levels will have an impact on workload and control in the executive phase in the first place. Assumed mixed levels of equipment require not only some changes in executive functionality of the guidance and control process, but will have also an impact on awareness and interoperable effort needed. These impacts have to be modelled carefully if the outcome of specific experimental sessions with mixed equipment levels is aiming to generate relevant and valid results.

2.6 EQUIPMENT REQUIRED TO CONDUCT THE EXERCISE

This section describes the tools, techniques and/or platforms to be used. References are provided as applicable.



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Network Analysis Model (NAM)

Petri-net model:

- Nodes are airports and sectors (Capacity)
- Flows are determined by: Flights (demand)

• Purpose:

To measure throughput through the Network

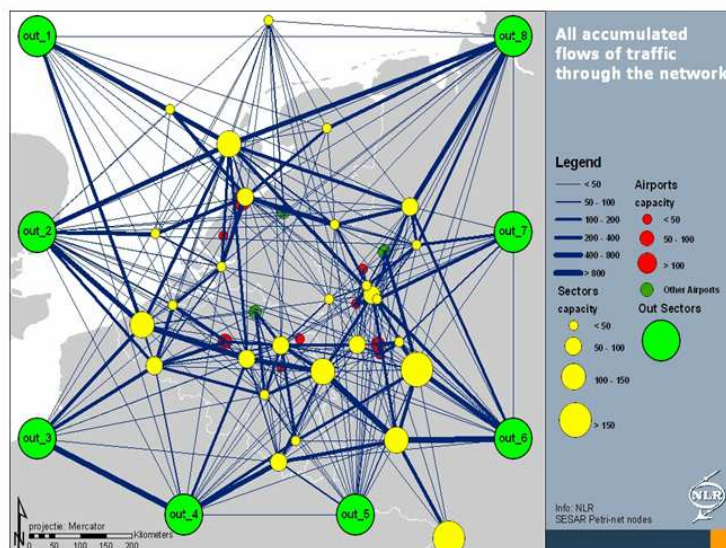


Figure 10 - Example of network of interest to be analysed with Network Analysis Model

The following models and tools are applicable to this performance assessment experiment:

• Network Analysis Model (NAM):

There is a need to be able to judge the balance between air traffic demand in terms of scheduled air traffic flows from departure airport to destination airport through specified routings and the capacity provided in terms of declared capacities per airport and per airspace volume, i.e. a sector. Capacity deficiencies can be assessed by this model by accumulating delay in each node that will cause this delay.

An example of the network of interest is given for a present-day structuring of the network (see Figure 10). This tool is developed by NLR in support of research on network balancing. More information can be found in specific reports on ATM network analysis, SESAR Performance assessment, Ref. [20], and NLR reporting on performance assessment of the ATM network of operations, Ref. [21] and [22].

• Optimising Collaborative Traffic Flow Management (CTFM) and Refined Flow Management (RFM):

The SESAR concept identifies the need for optimum utilisation of network resources. Optimising the throughput through bottlenecks, in particular TMA and Airport nodes, offers a strategy to mitigate congestion and to achieve the efficiency objectives of the operational concept. There is a need in addition to adjust departure planning to meet optimised arrival slots for congested arrival flows. The benefits are assessed as reduced arrival sequencing delays.

A prototype module for CTFM to achieve traffic synchronisation at pre-departure level can be used to provide scenarios with low variability of traffic demand for the TMAs and airports of interest. A second module for RFM provides refinement of (part of) the planned departure traffic, which fits into the ideas of convergent layered planning to meet accurately precision departure times that will mitigate congestion problems of congested arrival flows.

The applicable scenarios of the experiment are all covering an area that will not reach beyond core area limits. This scope is insufficient to apply a DCB process, requiring an ECAC-wide scope. Therefore, it is not sure if there are ways to apply CTFM and/or RFM in service of providing the required DCB performance. Maybe there are other



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means to adapt incoming traffic flows to the required stable demand conditions, necessary to accomplish advanced AMAN with high stability and limited use of airspace, whilst still being realistic in flight performance behaviour. Scripting the scenario is the feasible way out. In that case, arriving traffic is “regulated” by managing the incoming arrival flow on remaining flight time and an equalised flow distribution. Some “natural” uncertainty will be introduced by spreading the estimated arrival times by applying random variations on the ideal distribution of arrivals.

- **Total Airspace and Airport Modeller (TAAM@):**

TAAM is the actual fast-time simulation facility that allows to simulate the large volumes of traffic according to a planned scheduling. Different planned schedules of different scenarios will be simulated in fast-time. The outcome and analysis of TAAM simulation results serves to validate the performance of the DCB and traffic synchronisation processes, executed by the simulated and emulated modules in this experiment.

TAAM is widely used for assessment of airspace and airport performance behaviour. In this experiment, TAAM is used only to assess ATM performance at airspace level. No Airport operations and no ground movement operations are simulated. NLR has broad experience to use TAAM to validate ATM performance under varying operational conditions, see global and airport fast-time simulations results in Gate-to-Gate, Ref. [23] and [24]. Also, in this experiment different FTS-sensitive effects will be investigated:

- Optimising airspace routing, i.e. horizontal and vertical profiles,
- Optimising speed and descent profiles, i.e. simulating and emulating CDAs,
- Optimising planning of arrival sequences (mainly by emulation),
- Optimising flight executive processes such as applying PRNAV tracks, advanced conflict detection and minimising workload.

2.7 LINKS TO OTHER VALIDATION EXERCISES

The relationships or dependencies are specified in this section between this and other planned validation exercises, i.e. internal stakeholders. It is indicated for which exercises the present results serve as input and which output from other exercises will be used as input.

The objective of this fast-time exercise is to validate that the ATM capability of ETMA/TMA airspace in a multi hub-airport environment is sufficient to cope with increased demand in each airport, taking into account the forecast capacity of each of the airports, WP5 validation strategy, Ref. [14].

Input:

- **WP5.3.1: Expert Group on TMA**, the expert group is expected to advise on critical aspects of operations in TMA and ETMA airspace:
 - In TMA airspace, on stability and optimal separation of CDAs,
 - In TMA airspace, on safety related to exception handling for CDA operations at parallel runways,
 - In TMA airspace on staggered approaches for CDAs in order to maximise throughput,
 - In ETMA airspace on optimised sequencing in support of arrival flows for several airports and runway, arriving over one IAF,
 - In ETMA airspace on minimised use of airspace while optimising efficiency during synchronisation and sequencing.
- **Description of the TMA related aspects of the SESAR Concept of Operations:**



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- The concepts of operations are derived from the SESAR Con. Ops., Ref. [8] and the DOD E5, Ref. [12].
- **Assumptions and hypothesis necessary to run the Fast Time Simulation exercises:**
 - Each element of the fast-time simulation experiment is modelled based on knowledge derived from detailed simulation experiments and real-life experience. However, advanced conceptual elements are often not validated at a sufficient level of confidence to know exactly under which conditions the benefits are perceived, how many benefits are perceived and at which costs. Either, advanced conceptual elements are ignored, assuming that they have not a significant impact on the assessment issues raised, i.e. advanced planning can benefit arrival operation at hub airports executed within an appropriate organisation of airspace but without advanced executive support, or advanced conceptual elements are emulated, assuming that an inaccurate modelling by emulation will not influence performance assessment results in a significant way.
- **From WP2.4.1: data needed for extrapolation to ECAC wide level:**
 - The applicable scenarios for all experiments are defined by WP2.4.1.
 - These scenarios are balanced by assessment with a static model (FAP) to ensure that traffic demand is roughly in balance with available capacity throughout the network.
 - A dynamic network balancing process was previously foreseen, but not anymore, to be executed to assess balance in the Network at a more accurate level. This process can be compared with a long-term network balancing process to obtain a seasonal scheduling for all airspace users.
 - More short-term network balancing and traffic synchronisation is applicable and needed to synchronise the traffic flows to and from the large airports in the area of interest at pre-departure level. This process can be compared with short-term traffic balancing, although all event-driven delays and incidental planning deviations are not yet incorporated in this planning process.
 - All these steps at the level of DCB are necessary inputs to the experiment, because they contribute to deliver stable arrival traffic demand flows to the airports of interest, prepared at pre-departure level. The result is the advanced scenario that contributes to deliver the expected benefits.
 - There is no evidence anymore how to accomplish equivalent inputs, and scripting or emulation is probably the only applicable last resort solution.

Output:

- **External, to stakeholders of ATM:** Results shall be produced on the required quality of operations in ETMA/TMA airspace for a multi-hub airport environment. The expected outcome is an indicator that clarifies the potential of CDA operations for airports in the core area with sufficient capacity to accommodate the traffic demand expected by SESAR.
- **To WP5.3.1, TMA Expert Group:** The TMA Expert Group will use the results of the FTS experiment to assess the validity of earlier visions and to use results for their final report. In particular, the so-called “Story-board” is a condensed view on the results of discussions within the Expert Group, and this results can be compared with experimental experience.
- **To WP2.3, Validation Management:** The Validation Management group will receive results and monitor progress on the preparation, execution and analysis of results of the experiment.



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- **WP2.4.4 (Environmental impact)** has the objective to look into ECAC-wide effects on the environment. Although this experiment considers a limited number of airports and a limited area only, it still may give insight in beneficial effects of several OIs in the departure/arrival phase on environmental sustainability. Required data will be communicated as specified by EP3 WP2.4.4, see their document: ENV_Assessment_Input_Data_Requirements, Episode-3 environment assessment, Ref. [19].

In addition, existing expertise and knowledge is adopted from other projects, prototyping and validating advanced scenarios in the environment of Schiphol airport.

The **OPTIMAL project** has executed validation experiments on Advanced CDAs (ACDAs) in the environment of Schiphol. The OPTIMAL deliverables, Ref. [15], [16] and [17], are reporting on:

- **Arrival Procedures:**
 - The OPTIMAL project has accomplished fast-time and real-time simulation experiments on CDA and ETMA/TMA approach procedures. The OPTIMAL project simulated a concept of CDA, supported by 4D planning in ETMA/TMA airspace, applying ASAS sequencing in TMA airspace.
- **Airspace design:**
 - The OPTIMAL project simulated CDA approaches partly in a present-day environment, partly in a future or experimental environment. The TMA of Schiphol Airport was largely kept as operated at present, although a fourth TMA entry-point, South-East of Schiphol, was added. The approach paths were present-day lateral profiles, although adapted to CDA patterns.
 - The ETMA airspace was applied in an unrestricted way, making use of airspace up to 120 NM out of the Airport. However, it was not the objective of the project to investigate in-depth the airspace needs, and therefore no sectorisation requirements were derived from the OPTIMAL experiments.
- **Safety and hazards:**
 - The achievable spacing of arriving flights is critical for the success of flying CDAs under high throughput conditions. The OPTIMAL project performed a safety assessment study analysing the stability of queues and the safely achievable separations at the start and at the end of a CDA. A general summarising statement declared a safe minimum time-based separation at the initial CDA point of more than 60 seconds, see Optimal Stroeve, Ref. [15].

2.8 CONCEPT ASSUMPTIONS

This section describes the assumptions concerning the problem and concept to be analysed. Applicable assumptions were discussed and concluded by the WP5 Expert Group on TMA operations during their meetings. The guidelines for these discussions were series of questions on critical issues concerning the concept and the scenarios. The concluding assumptions are listed below, followed by a summary of series of questions and their replies. The ultimate result was a condensed view on a possible implementation of the concept within the applicable operational environment and how this would operate. This view was laid down in the so-called "Story-board" and this view is added as annex 2.1. Finally, the issue of required low variability of demand at the start of the arrival management process was the most critical issue. The list of statements to support this assumption is added as annex 2.2.

Part of the discussions in the Expert Group were devoted to the airborne-side operations of the concept, i.e. the interoperability of ground operations with airborne 4D planning, guidance and control capabilities, supported by advanced 4D FMS. Although the fast-time simulations with TAAM are not well positioned to simulate airborne behaviour in full detail, the answers by Airbus are relevant to understand the possibilities and limitations of the role of airborne 4D FMS and precision navigation capabilities in operating advanced arrival management with support of 4D. The questions and answers are added in annex 2.3.



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The following assumptions are applicable on the **operational concept** and the implementation of the concept:

- Because noise-friendly approaches are mandatory for any increase of capacity, the gain in environmental benefits cannot be compromised, unless this is required to maintain the noise-friendly character of departure operations.
- Because efficiency of operations is a major driver for SESAR and because inefficiency of operations can hardly be solved better than before departure, the simulations of advanced scenarios depend on Demand and Capacity Balancing achieved before departure.
- Sequencing and spacing is assumed to start from 60 min. before landing (~200 NM out) in order to reach maximum efficiency of operations approximately. However, the precise measure of time/distance is dependent on local conditions as well; e.g. arrival management makes sense only if most of the traffic is airborne.
- Sequencing and high precision 4D-guidance leads to high precision arrivals over the TMA-entry points, allowing a high degree of CDAs (from 120 NM to TMA-entry-point) and full CDAs from 7000 ft (IAF) to touch-down. This is applicable for example at least for Schiphol but local conditions may lead to other distance/altitude preferences.
- CDAs are applicable from 7000 ft, but that implies also the assumption to be able to apply CDAs for all traffic arriving at the airport. No alternative approach procedure can be accommodated.
- The CDAs are feasible due to an assumed high RNP capability of all traffic, however for reasons of realism accepting different levels of RNP capabilities as well.
- The highly accurate planning of arrivals by CDAs is assumed to be realised by planning and control by time-based separations.
- A feasible implementation of a high-capacity arrival concept requires a highly systemised approach. It is assumed that highly accurate predictions are obtained by Air-Ground exchanges, sequencing by AMAN based on down-linked 3D unconstrained trajectories, continuous monitoring on 4D performance and interoperable planning, guidance and control.
- The automation is assumed to be highly interoperable and human centred.

Assumptions are applicable also on accomplishing **feasible scenarios**:

- The SESAR growth scenario (+70% of air traffic demand in the 2020 reference scenario) is deemed not possible in the area, therefore growth scenarios are limited to the acceptable growth estimates of the applicable airports in the area.
- The advanced scenarios are addressing a time horizon set by SESAR, but hard constraints such as airport growth figures are respected.
- The National boundaries are ignored, allowing the creation of ideal arrival sectors/airspace control volumes for the airports and TMAs of interest, but also assuming other traffic to be adaptable to these requirements.
- Stability of demand/capacity is assumed. This is assumed to be achievable by balancing capacity and by applying CTFM on advanced scenarios, but otherwise the scenarios have to provide stability in a different way.
- The scenarios are respecting noise abatement regulations, because these regulations are enforced by law and these constraints will not vanish. Populated areas are to be considered as critical and persistent constraints.
- The scenarios shall address not only 100% equipage levels, but also mixed equipage levels in order to cope with sufficient realism.

Several assumptions are applicable to performance assessment by this fast-time simulation experiment. The scenarios as well as the applicable models are simplified compared to reality. This leads to assumptions on **approximations of performance measurements**:

- All flights in the scenarios are single independent flights without knowledge of any connectivity to other flights, such as deploying the same aircraft, the same crew, or transporting transfer passengers with implicit connectivity between flights. Therefore,



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no reactionary delays, no incidental delays and no company-induced delays are measured.

- The scheduling of future scenarios are obtained by “cloning”-techniques, i.e. by multiplying flights. Even after corrections, this is far inferior to the process applied by negotiations between ATM stakeholders to make up their scheduling of coming seasons. For that reason, pre-departure DCB delays have to be interpreted as delays to repair the scheduling. Nevertheless, the amount of delays is representative and indicative for the measure of saturation of the network or parts of the network.
- The obtainable benefits of the concept are dependent on accurate planning, achieved by information supply by Airlines in the first place. The benefits regarding efficiency, i.e. flight duration, fuel consumption and airspace requirements, are mainly dependent on departure ground holdings. It is assumed that all stakeholders are willing ultimately to maximise the achievable benefits by selecting a planning, optimised towards ATM efficiency and otherwise at least optimised towards their own most economic resources deployment criteria.
- The benefits achieved by optimised planning depend on execution as planned. It is assumed that departure management acts as an enabler and will allow high precision departures to congested arrivals with sufficient precision to reach the start of the arrival management process on-time.
- The modelling of executive services will be modelled according to expectations of achievable performance. It is assumed that this can be accomplished in a sufficient realistic way.

A set of assumptions are derived from questions formulated to identify those topics that are critical to bring the operational concept successfully into operation. The questions and the most appropriate ways to address these topics, are identified below.

1. How **to approach the IAF** in a structured way through a stretched arrival sector applying performance based navigation?

- Flight performance objectives are presented to the pilot and the aircraft's FMS through arrival management and A-G data communication.
- The guidance and control loop performed by ATC/pilot are considered capable to achieve the CTA within a defined tolerance.
- The quality of navigation and the achievable accuracy in time is determined by aircraft navigational performance characteristics. The levels of navigation performance that are required, and possibly also achievable in 2020, are deferred to be determined by technical evaluation.
- An achievable quality factor of [+2,-3 min.] is assumed when aircraft enter the 60 min. (200NM) arrival management horizon.
- A typical quality factor of ± 30 sec at IAF is assumed to be required for issuing CDAs to tightly sequenced sequences of aircraft. It should be noticed, however, that advanced 4D-equipped aircraft will perform with better performance characteristics and will achieve a tolerance of ± 10 s probably. This level of performance might be a requirement even in order to allow ATC to cope with that part of the fleet that is not yet fully equipped.

2. How **to improve planning, guidance and control** by A-G exchange of 4D-planning and use of FMS?

- 4D downlink prior to start of AMAN process is assumed, specifying a fully unconstrained arrival by nominal arrival procedure.
- An AMAN target time is agreed (the CTA) and the aircraft's FMS follows the CTA, unless significant deviations occur. If the expected efficient Estimated Time of Arrival differs above a threshold, a delta is normally down-linked and re-sequencing may be accomplished.



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- Targets for IAF are defined, taking complexity and traffic volumes into account; a typical value of 2 min. between arrivals is applicable. However, these flights may arrive over different TMA entry-points, merging during descent inside the TMA.
 - A procedure is assumed to start with 4D downlink, followed by uplink of a ground system constraint, resulting in an efficient CTA usage to ensure pre-sequencing on IAF.
3. How to deal with **CDAs of dense flow** over one IAF to one runway, merging with a second flow over a second IAF (**converging flows**)?
- Smooth merging is dependent amongst others on tight sequencing and applicable equipment levels. Dependent on equipment levels the workload induced by the operations might be different. Therefore, time constraints need to be assumed in TAAM, implying controller procedures and workload being differentiated according to applicable equipment levels.
 - In case of merging inside the TMA, CDAs are assumed to be split in two parts with the merge(s) to be accomplished under control of ATC.
 - Different equipment levels are applicable in real-life and therefore also during simulation.
4. How to deal with **CDAs of dense flow** over one TMA entry-point diverging to several runways/airports (**diverging flow**)?
- Lateral separation is preferred if possible, second is time difference and third is level separation. However, if the distance to be flown from TMA entry-point to airport is significantly different for two flows, also the flights will enter the TMA at different altitudes, making a split of flows at vertical levels attractive.
5. How to ensure **undisturbed departure operations during initial climb**, while operating the airport(s) with several dense departure and CDA arrival flows?
- Departure constraints of today, 2009, are to be respected.
 - A departure and arrival route structure of “cones and tubes” is assumed to be developed for 2020 scenario.
 - The preference is to guide departure flows over the arrival flows. Nevertheless, it is anticipated that departure flows have to be split sometimes, respecting the CDA paths and keeping both flows separated at a structural level. Part of the departure flows may have to stay below the arrival flow.
6. How to service and to control non-4D equipped, 4D-equipped and mixed equipped traffic in ETMA and in TMA airspace (**Mixed equipment and CDAs**)?
- Figures for equipment level are to be determined in compliance with forecast estimates.
 - Different spacing requirements are assumed for different equipment levels, resulting in capacity loss and increased ATC workload.
 - FTS has to address workload increase resulting from e.g. 15% level 2 aircraft.
7. How to cope with **stacking** as well as high precision sequencing on IAF?
- Holdings are not expected during normal operations, but may be a result of unexpected shortage of capacity in the tactical phase.
 - It can be investigated which aircraft capabilities are applicable to support on-time operations for timely leaving of the holding pattern and to meet downstream time constraint.
 - Holdings are assumed to be allocated sufficiently far from IAF to allow to accomplish a sequenced arrival flow over the IAF.
8. A flight **deviating during CDA**, extending the flight path, how to cope with deviations, which impact on the sequence and the capacity, and how to anticipate? And the same



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questions for flights **aborting the CDA** and rejoining the sequence later on? And the same question for **overshoots**, and how to re-join the sequence again?

- Deviating or non-compliant aircraft need to be re-inserted into the sequence; delay for others may be the inevitable result.
- Some headroom might be required to cope with frequently occurring deviations.

11. How to operate CDAs on parallel runways in a safe way?

- RNP will bring high precision navigation.
- Approach paths could provide slowly converging tracks, avoiding head-on conditions.
- Monitoring/responsibility can be provided by the flight-deck (CDTI).

2.9 SUMMARY

The simulation steps are summarised and presented in a scheme; Annex A provides a summary and overview of the exercise scope.

The experiment will be executed by incremental steps, including iterations. The resulting achievements are consolidated as a set of end-state simulation results for each year. These end-states permit to assess intermediate results and to assess the quality of results by comparing different steps with each other.

The reference runs are executed on traditional airspace organisation, the advanced runs on advanced airspace organisation. Both sets of runs are executed with and without the SESAR OIs to improve the performance (see Table 10 and Figure 11).

Run		Year 2006/2007	Year 2015	Year 2020
1.1	Ref. Bal.	Throughput ass.	Throughput ass.	Throughput ass.
1.2	Ref. Do nothing	Efficiency reference	Efficiency reference	Efficiency reference
1.3	Ref. Synch.	Benefits by SESAR	Benefits by SESAR	Benefits by SESAR
2.1	Adv. Bal.	Throughput ass.	Throughput ass.	Throughput ass.
2.2	Adv. Do nothing	Efficiency reference	Efficiency reference	Efficiency reference
2.3	Adv. Synch.	Ben. SESAR+airspace	Ben. SESAR+airspace	Ben. SESAR+airspace
2.4	Incl. Adv. Exec.	Additional benefits	Additional benefits	Additional benefits

Table 10 - Overview of simulation runs to execute the performance assessment experiment



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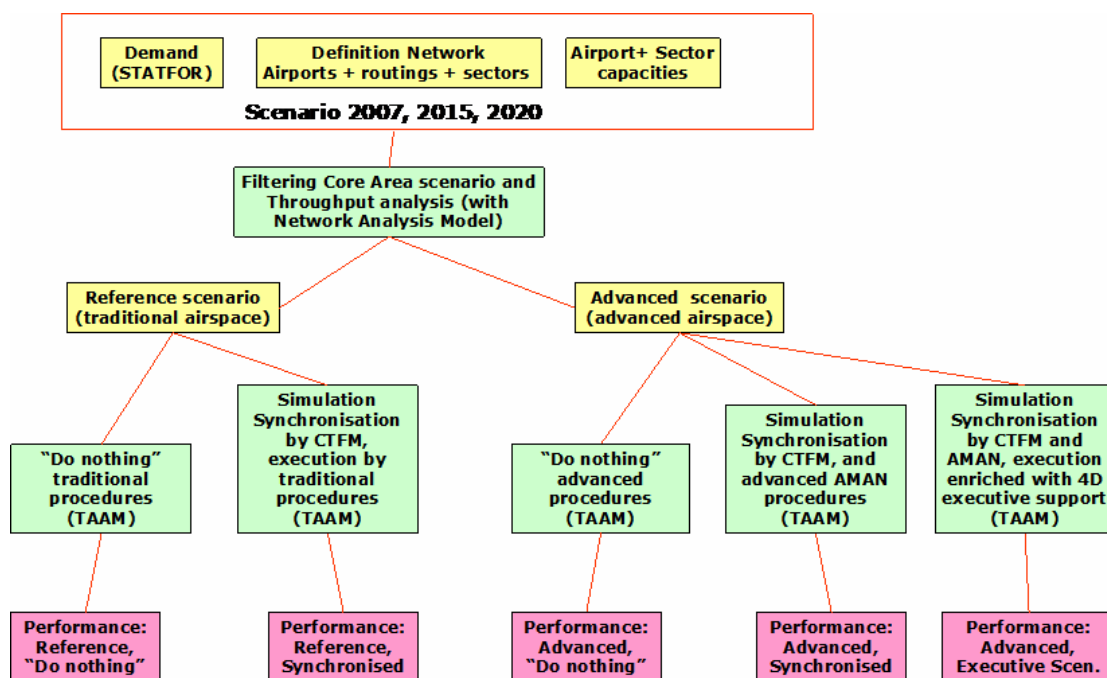


Figure 11 - Overview of simulation runs and comparison of results

3 PLANNING AND MANAGEMENT

3.1 ACTIVITIES

This section gives an outline of the tasks that need to be performed in the preparatory, execution and post-exercise phase. The deliverables that will be prepared are indicated and described briefly.

The simulation experiment consists of the following steps:

1. Defining the Experimental Plan and receiving approval and agreement.
2. Preparation of the experiment: Organising the scenarios, preparing the simulation facilities and emulation/simulation modules, defining and preparing analysis facilities.
3. Conduct of the simulation experimental runs, collect simulation results and perform initial analysis. This step is performed over a considerable large period in an iterative way, keeping control on the impact of each scenario change on the operational results.
4. Final analysis and writing the FTS simulation report.

Each step of the simulation experiment is elaborated below in more detail:

1. Defining the Experimental Plan:

The experimental plan is described after consultations of partners, including adherence to DOD E5, Ref. [12] and the WP5 Validation strategy, Ref. [14].

2. Preparation of the experiment:

Preparation of the experiment consists mainly in:



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- Verifying correctness and realism of applicable scenarios,
- Verifying correctness and realism of applicable modelling by emulation of Arrival Management in TAAM and appropriate performance assessment with the Network Analysis Model, NAM,
- Development of tools for model development and analysis, i.e. available facilities are used, but new options are added to improve 3D-visualisation of airspace design and simulation results,
- In other respects, existing facilities are applied.

3. Conduct of the simulation experiment:

Fast-time experiments are conducted by sets of experimental runs, performed often in an iterative way. Most important is to start from a traditional scenario with present-day levels of traffic and to add new element in the scenarios step-by-step. The following experimental runs are executed, all simulating a core area scenario, including at least traffic to and from the Düsseldorf area, the airport of Amsterdam, Schiphol and Brussels airport, Zaventem:

1. Simulation of baseline scenarios with 2006/2007 and 2015/2020 levels of air traffic demand (Present-day airspace organisation, present-day routing and procedures and present-day concept of operations). These scenarios serve as reference scenarios to compare with more advanced scenarios and to allow assessment of benefits.
2. Simulation of airspace-advanced scenario with 2006/2007 and 2015/2020 levels of air traffic demand (Extended arrival sectors/dedicated volumes of airspace to allow continuous descent procedures, however planning and control are still organised in a traditional way, missing 4D planning, guidance and control precision and missing advanced AMAN support and Air-Ground datalink exchanges.) These scenarios are used to evaluate airspace usage, feasibility to separate arrival flows from other traffic (except the military), and to get first results on benefits due to stretched arrival procedures, not yet optimised towards minimised sequencing delays.
3. Simulation of scenarios including modelling of advanced operational elements of SESAR, although the traditional elements will not include enhanced pre-departure planning. That is foreseen to be included only by applying advanced SESAR scenarios⁷.

4. Final analysis and reporting:

The analysis will be performed using NLR's simulation analysis toolkit, consisting of simulation post-processing software, e.g. to process workload figures, and a set of Analysers that can be adapted if required for specifically emerging analysis needs.

An Episode 3 template shall guide the reporting. Further, the Final report shall include those parts of the experimental plan needed to allow to read the report as an independent document. Sections will be added to present the result, the analysis on results and conclusions and recommendations.

3.2 RESOURCES

This section gives the expected resources and describes the expertise, skills and knowledge required from all participants involved in preparing and conducting the exercise:

- **NLR:** The simulation experiment is prepared, executed and analysed by NLR.

⁷ It should be noted that scenarios including appropriate application of DCB to ensure sufficient low variability of traffic demand, can be applied only if they are available. If not available, a possible way out is scripting and/or emulation.



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- **DFS:** DFS provides the traditional airspace organisation, provides detailed information how operations in the Düsseldorf area can be improved by enhanced operations, and DFS will contribute in operational analysis and final reporting.
- **LVNL:** LVNL provides detailed information how operations in the Schiphol area can be improved by enhanced operations, and LVNL will contribute in operational analysis and final reporting.
- **NATS:** NATS will assist in expert judgement on the interface between UK and the Netherlands.
- **Other partners:** LFV and DLR will contribute by Expert Judgement and by reviewing the reports.

Activities	Detail	Effort (mm)
Preparatory	Exp. Plan	2.5
	Prep. and Analysis tools	4.0
	Val. of scenarios	2.0
Execution	Trad. Airsp. scenarios	2.0
	Adv. SESAR scenarios	4.0
	Final runs	2.0
Post-Exercise	Analysis Trad. Airsp. scenarios	1.5
	Analysis adv. SESAR scenarios	3.5
	Final report	2.0
TOTAL (mm)		23.5

Table 11 - Expected effort

3.3 RESPONSIBILITIES IN THE EXERCISE

This section describes the responsibilities of the participants involved in preparing and conducting the exercise.

NLR has the lead in the conduct of the experiment. NLR has also the responsibility to organise the experiment, to inform consortium partners involved in the experiment and to organise the meetings that are required to define, to manage and to execute the experiment.

NLR has the responsibility to document the experimental plan and the conduct of the experiment, the analysis and the results of the experiment. In addition, NLR shall execute the experiment and perform the analysis of results.

Partners, with a high interest in the experiment and its results, DFS and LVNL, shall participate in defining, organising, analysing the results of the experiment. In addition, they shall evaluate the operational relevance of experimental results, and will participate in the dissemination of results. DFS will provide also traditional scenarios of civil flight operations in the area of interest as a reference for final evaluations by SESAR scenarios.

Other partners, LFV, NATS and DLR, will participate by small contributions and by reviewing.



3.4 TRAINING

The experiment is a fast-time simulation activity, using TAAM by experienced staff. No training is applicable.

3.5 TIME PLANNING

This section gives indications for the start and end date of the activities and the expected delivery date of the result report.

There are three critical Milestones defined:


1. Delivery of Experimental Plan (31 December 2008)
2. Delivery of early results (26 February 2009)
3. Final results and delivery final report (25 March 2009)

3.6 RISKS

This section summarises possible risks in achieving the aimed results.

Risk <1>:	<Advanced SESAR scenarios>		
Description:	There is risk that traffic of advanced SESAR scenarios are inappropriate to be flown as planned within high density areas, presumably operating with a complex structuring of traffic flows and a structural de-confliction imposed.		
Impacted Area:	X <input type="checkbox"/> Own Exercise	<input type="checkbox"/> Other Exercise	<input type="checkbox"/> WP
Level:	<input type="checkbox"/> Low	<input type="checkbox"/> Medium	X <input type="checkbox"/> High
Possibility of occurrence:	<input type="checkbox"/> Low	<input type="checkbox"/> Medium	X <input type="checkbox"/> High
Contingency Actions	-		
Mitigation Actions:	Time and effort permitting the flightplans can be adapted to follow routings of an acceptable structuring of airspace.		
Responsible party:	NLR		

Risk <2>:	<DCB and low variability of traffic demand>		
Description:	Advanced scenarios will provide the expected benefits only if traffic is sufficiently managed before departure and en-route. Most important is a refined DCB process based on trajectory-based planning ensuring on-time departures of traffic to congested destinations, arriving on-time for traffic synchronisation.		
Impacted Area:	X <input type="checkbox"/> Own Exercise	<input type="checkbox"/> Other Exercise	<input type="checkbox"/> WP
Level:	<input type="checkbox"/> Low	<input type="checkbox"/> Medium	X <input type="checkbox"/> High
Possibility of occurrence:	<input type="checkbox"/> Low	<input type="checkbox"/> Medium	X <input type="checkbox"/> High
Contingency Actions	-		

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Mitigation Actions:	The mitigation is to adapt demand to variability limits within acceptable and described tolerance limits. This may induce, however, unnatural side-effects and it may give less confidence in the achievable results.
Responsible party:	NLR

Table 12 - Risk identification



4 ANALYSIS SPECIFICATION

4.1 DATA COLLECTION METHODS

The fast-time experiment makes use of two tools: Total Airport and Airspace Modeller (TAAM) and Network Analysis Model (NAM). Both tools are generating data.

TAAM has as input airspace and airport environment description data and a time table, comprising the scheduling of air traffic. Experimental runs are compared by varying these input data and comparing the differences in generated output data. For example, the time tables can be modified by off-line calculating pre-departure time constraints, and comparing the effects of these time constraints on the simulation of air traffic and measuring their performance.

TAAM will record all significant events in principle, and the analysis takes place by filtering the relevant events. In addition, several post-processing runs will be applied to calculate summary results and derived results. For example, average delays are calculated over each run and collected in tables, also derived quantities are processed off-line such as workload, derived from conflict counts.

In detail, the Fast-time simulation (TAAM) considers (See SESAR, the Performance Framework, D2, [5]):

- **Traffic Load** is measured as an overall quantity characterising the traffic load per hour (KPI_CAP_OVERALL).
- **Throughput** is measured by the fast-time experiment at airport level and at sector level, but at sector level without preserving the sector load to remain realistic regarding the capacity available (KPI_CAP_THROUGHPUT).
- **Delays** are measured at several levels of flight planning and execution, as far as defined, observed and measured in the experiment. Not all delays are observables: Airline and Airport induced delays are not observed. Also, turn-around and reactionary delays are unknown due to the lack of knowledge on connectivity of flights. Other delays consist of Flow Management delays, departure planning and execution delays, en-route delays and in-flight arrival sequencing delays. The delays are all measured in seconds and minutes, but without a threshold. This is required in order to measure operational effects with sufficient accuracy and in order to be able to accumulate correctly partial delays of a flight. Only in the concluding summary, the results will be scaled to the required KPIs, taking into account a threshold of 3 minutes, see SESAR D2, Ref. [5] (KPI_EFF_DEPDELAY_OCC, KPI_EFF_DEPDELAY_SEV, KPI_PRED_ARRDELAY_OCC, and KPI_PRED_ARRDELAY_SEV, KPI_EFF_DURATION_OCC, KPI_EFF_DURATION_SEV).
- **Workload** is calculated from simulated traffic entering, passing and exiting the sector. The experienced workload in the sector is the sum of workload calculated from event detection of individual flights, while taking into account traffic complexity. The measured workload can be compared with the sector capacity, derived from the Heavy Workload Threshold (HLT), representing a value of 70% of maximum possible workload (2520 s per hour). The average workload per sector is monitored as well as possible excess of maximum acceptable workload per sector, while also the number of flights through the sector is measured; N.B., it should be noted that workload assessment is limited to the busy hours from 07:00 to 22:00 (KPI_CAP_WORKLOAD, KPI_CAP_ELEMENTARY).
- **Flight duration and fuel consumption** are recorded during flight simulation. The recorded value comprises the total flight duration per flight or the part of the flight



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within the area of interest, being a measure of flight efficiency and being sensitive in particular for changes in arrival sequencing procedures. The fuel consumption is derived from a simple point-mass modelled parameterised flight execution model. Nevertheless, the model is sensitive enough to discern highly efficient from less efficient procedures (KPI_EFF_FUEL_OCC, KPI_EFF_FUEL_SEV).

The NAM tool is used only to evaluate the balance in that part of the European network that is subject of interest, i.e. the Benelux and the Düsseldorf area. The NAM tool, based on Petri-net modelling, considers:

- **Throughput** is measured by running the Petri-net model at sector and airport level. Flights are observed only to pass a sector or airport when there is capacity available, and whenever no capacity is available, delays are imposed and recorded. The measured throughput represents therefore the effective throughput of the network in a (selected) stage of saturation obeying the rules to respect capacity constraints of airports and sectors (KPI_CAP_THROUGHPUT).
- **Delays** are observed and measured at the point where they are created by lack of capacity. They are measured as delays, upholding the transition of the flight from departure to the first sector, from a sector to each consequent sector, as defined by the flightplan, and finally from the last sector to the destination airport. Only pre-departure and in-flight pseudo-flight-executive delays are measured. These delays are measured without thresholds, because the delays are quantifying the occurrence of hotspots in the system rather than flight performance characteristics, and because delays may be partial to a flight and have to be accumulated yet. The summary will provide some statistics with an overview of distribution of total delay per flights, taking into account the applicable defined threshold of 3 minutes (KPI_EFF_DEPDELAY_OCC, KPI_EFF_DEPDELAY_SEV, KPI_PRED_ARRDELAY_OCC, and KPI_PRED_ARRDELAY_SEV).

4.2 OPERATIONAL AND STATISTICAL SIGNIFICANCE

This section describes the likely operational and statistical significance levels of the experiment, with an explanation of the reasons why these levels were chosen.

All experimental runs are performed on scenarios representing 24 hours of traffic. The selected sample is a normal sample, derived from a representative day operated under nominal conditions. The variations in operational conditions are assumed to be fully included in this one-example traffic sample, because it represents all periods of the day, including nightly hours, peak hours and more relaxed periods of the day. In addition, the traffic will be followed and evaluated for four airports, each operating its specific procedures within a specific airspace context of operations.

From the point of view of relevance, the weakest points are the simplifications in operations and simplifications in modelling. Operations are simplified because flights are following a pre-defined adherence to the scheduling and no exception handling cases will occur. Also, no deviations will occur that stem from a systematic delaying nature of ATM involvement. For example, PRR reports are showing systematic increase of delays over the day, caused by knock-on effects and by connectivity of the planning of flights. This connectivity is ignored.

Another weak point is the modelling of ground and airborne behaviour. Fast-time simulations derive their force from processing large volumes of flights and producing high statistics. On the other hand the applied modelling is relatively simple. Therefore, the confidence level of fast-time simulations relies on simulating a very large number of events occurring in slightly different circumstances, but the relevance of each event is determined by the modelling of the detection mechanism and the experience leading to the selected modelling.

The modelling is sometimes strongly simplified, such as e.g. the modelling of the aircraft. This implies that fast-time simulations with tools like TAAM are not appropriate to validate dynamic



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flight behaviour and human behaviour, but rather to collect statistical relevant data from a relatively large scope of simulation.

In summary:

- Fast-time simulation takes place over 4 airports, giving large variation in operational context.
- Fast-time simulation takes place over 24 hours giving large variation in traffic density conditions.
- Fast-time simulation takes place using present-day traffic (2006/2007: busy, but very well feasible) and very dense traffic situations (2015/2020: at saturation level of the applicable airports).
- Processing more than one day of traffic will not overcome the problems of modelling simplifications and lack of non-nominal behaviour in the scenarios.
- Statistical significance comes from the number of flights processed during one day of operations and the number of events that take place under slightly varying conditions.

4.3 ANALYSIS METHOD

The analysis method is based on a step-by-step incremental process to bring the experiment to its final stage. Data loggings of each experimental run are collected processed and stored for further analysis.

NLR has a large set of analysers available to evaluate simulation results. NLR will make use of them in this experiment in a selective way. Given the objective of the present experiment, the focus will be on analysing the performance of arriving flights from 60 min before landing (200 NM out), starting the measurements on flights from a selective set of waypoints until the landing under varying conditions. The main focus in analysing experimental results will be laid on assessment of the difference between present-day scenario by levelling off and vectors, and the advanced scenario by CDAs.

The following scheme of evaluation of simulation results will be followed by comparison of present-day scenario with advanced scenario:

- **Horizontal and vertical profiles of individual flights and flows:**
 - Comparing scenarios 1.2 and 2.2, sufficient throughput capacity is assessed by changing airspace (part of **Hypothesis 2**)
- **Flight duration and fuel consumption of individual flights and flows:**
 - Comparing scenarios 1.2 and 2.2, improved flight efficiency is assessed by changing airspace (part of **Hypothesis 2**).
- **Performance of arrival management under present-day and future conditions, and the associated amount of enhanced flight efficiency:**
 - Enhanced 4D planning and traffic synchronisation applied on traditional airspace organisation, scenario 1.3, (**Hypothesis 3**) and on advanced airspace organisation, scenario 2.3, (**Hypothesis 4**), and to assess the expected effectiveness of combining advanced airspace organisation and enhanced 4D planning and traffic synchronisation.
- **And to include optimisation by systematic use of PRNAV tracks on CDA performance:**
 - The previous advanced scenario, 2.3, is extended with enhanced flight executive guidance and control functionality. This scenario, 2.4, is expected



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to provide enhanced throughput and enhanced flight efficiency (**Hypothesis 5**).

- **Performance of DCB and the effects on arrival management and the efficiency of flight operations:**
 - The best moment to analyse the opportunities to improve flight efficiency by early anticipation on traffic synchronisation and to minimise airspace requirements is after completion of test on the improvement of planning and executive, although the need for iteration can not be excluded. Throughput optimisation and flight efficiency improvement by low variability of demand is analysed now (**Hypothesis 1**).
- **Evaluation of achieved balance in the network, associated sector capacities and workload:**
 - The balance in the network (only part of the ECAC network being analysed during this experiment) and sensitivity for capacity changes is the concluding issue. Is the network appropriate under stable nominal operational conditions and under the assumptions of this experiment? (**Hypothesis 1**)
 - Also, overall effects can be evaluated now regarding throughput, flight efficiency, predictability and environmental load.

4.4 DATA LOGGING REQUIREMENTS

Each experimental run is identified by the applicable scenario and its associated description of airport and airspace environment, and in addition, by its time table (scheduling) and year of reference. Altogether there are a maximum of 21 runs if all runs are completed as planned, derived from three original time tables (2006/2007, 2015 and 2020).

Data logging takes place per flight, per airport/runway of interest, per sector or volume of airspace of interest. Often quantities of interest can be determined only afterwards by post-processing. A standardised procedure will be followed to produce the relevant data, achieved by direct logging as well as by post-processing.

For each experimental run the following data is collected:

- Average delay overview of each element of delay of flows and traffic of interest,
- Average fuel, pax.nr. and flight duration of flows and traffic of interest,
- The performance per airport/runway of interest in terms of delay and throughput over the day,
- Average performance of sectors over the day,
- The performance per sector/airspace volume of interest in terms of delay and throughput over the day,
- The performance per sector/airspace volume of interest in terms of workload and throughput over the day,
- Monitored statistics of sector overloads over the day, and
- Flight plan and actual performance of flight per individual flight, including data concerning flight delaying events.



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4.5 OUTLINE REPORTING PLANS

The results of the experiment will be described in a report with the title: “Multi Airport TMA and CDA FTS Report”, deliverable D5.3.4-02. This report will become an independent document. Further, the report will be structured in agreement with the template delivered by the project.

The reporting shall be based on the present Experimental Plan. The intention is to perform the fast-time simulation experiment as planned and to use those parts of the Experimental plan that outline the contents of the experiment as the basic inputs to the Final Report of this experiment.

The following structure of contents of the Final Report is proposed:

- Executive Summary,
- Introduction,
- Objectives and Hypothesis,
- Operational Concept Elements,
- Experimental Design,
- Experimental Model,
- Dependencies, Inputs and Outputs,
- Scenarios,
- Metrics,
- Conduct of Experiment and Experimental Runs,
- Results and Analysis,
- Conclusions, and
- References Abbreviations Appendices.

The concluding chapter may yield statements and recommendations for further concept development, in particular for the DODs E5 and possibly also M2, Ref. [12].



5 DETAILED EXERCISE DESIGN

5.1 DEPENDENT AND INDEPENDENT VARIABLES

This section clarifies the key variables introduced in Validations Scenarios and how they are varied. Also the contextual variables are identified, how they are controlled and how they are counterbalanced or normalised.

The simulation exercises are conducted on two scenarios: 2007 and 2015/2020, different by traffic densities. The interest is in 2015/2020 results, the reference is the 2007 result. To limit the number of runs and the amount of data to be analysed, only those 2007 runs are simulated that are required to understand the progress in achieving FTS results, The first and last run with 2007 data is mandatory, intermediate steps can be skipped if there are no problems to understand 2015/2020 results.

The concept of interest addresses early and extended advanced arrival management through “dedicated arrival flow corridors”. Because parts of these flows are independent from other parts, these flows of traffic can be simulated and analysed independent of each other, in first instance. However, each step ends only if all air traffic can be simulated by one run, dealing with all air traffic of that simulated scenario. This principle is applied by testing each time consequently:

- Traffic flows for EHAM,
- Traffic flows for EDDL and EDDK,
- Traffic flows for EBBR.

In principle, these flows are almost identical in behaviour, in practise more differences in operations have to be covered. For instance, TMA-entry levels are different, number and allocation of IAFs are different, merging operations on incoming flows are different and problems with departure flows have to be treated separately.

All airports/runways receiving inbound arrival flows in the simulations will deal with these flows as much as possible in segregated way. The reason is that optimisation towards wake vortex separation works in the best way on segregated flows. In mixed-mode operations, wake vortex separations can be planned and realised as well, however, it is difficult in a simulated process to cope with mixed-mode operations in a different way than an alternating way. In “real-life” operations, groups of flights and alternating use of the runway will be applied as appropriate, but in a simulated environment it is difficult to formulate an efficient strategy.

The FTS experiment is conducted in this way by five major steps:

Step	Identification	Rationale	Key variables
1.	Baseline org.	The Baseline org. is characterised by existing STARs, operating from national boundaries. Tactical arrival management is applicable after TMA entry, including levelling-off and vectoring.	To measure: effective throughput, distance flown per flight, delay time by arr.proc., fuel and workload per sector
2.	Future org.	Horizontal and vertical profiles are changed in 3D (unconstrained, no separations applicable): ETMA routing, starts far out to reach TMA-entry point by pseudo-CDA STAR from TMA entry-point after IAF by CDA to touch-down	Objective is optimal flight profiles through advanced airspace. Key var.: Distance flown and fuel These runs give absolute achievable minima by ideal



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Step	Identification	Rationale	Key variables
			sequencing.
3.	Future with AMAN	In ETMA Advanced AMAN, sequencing on TMA entry-point, performing CDA after passing IAF, including separations.	Objective is successful application of CDAs in a feasible way. Key var.: minimum delay, less fuel and maximum throughput (compare 3 with 1 and 2)
4.	Future DCB balanced AMAN	An assumed partitioning of airspace around volumes of air traffic is applied in order to be able to assess workload effects. In addition, DCB is applied on volumes of incoming traffic, determining the load on airspace and controllers as well.	Objective is to determine operational conditions under SESAR concept of operations applying trajectory-based operations. Key var.: throughput, delay and workload (compare 4 with 3)
5.	Future opt.exec.	Flight executive improvements are simulated by emulation. Use of efficient RNAV tracks, early speed adjustments according to 4D planning and guidance support by 4D-FMS have an effect on accurately reaching a planned waypoint with minimal airspace requirements.	Objective is to assess increased efficiency. Key. var.: throughput, delay and workload (compare 5 and 4)

Table 13 - Step-wise scheme to perform fast-time experiment

Some remarks should be noticed, related to Table 13:

The steps define intermediate simulation results. It should be noted that the question if all intermediate steps are operationally feasible and safe is not relevant. The question is to add advanced functionality in an incremental way and to be able to validate that each incremental step provides a certain expected improvement in operations forthcoming from that specific change in operations.

Ad 1): The performance of the Baseline organisation is expected to operate with similar performance characteristics as real life. It is a reference. The most important difference with real life is that there are no connectivity and reactionary delays. The 2007 scenario is the reference that link present-day operational efficiency to the efficiency experienced by the simulations. The 2015 scenario sets the scene for a “do-nothing” development of operations, whilst demand will increase.

Ad 2): The profiles are perfect, there is no vectoring or delay absorption etc., because there is no separation. The result can be used therefore to create a reference of optimal flight trajectories, given the applicable organisation of airspace. This result can be compared with other results to invent how different results might be compared to the most plausible assumptions. It should be noted that the results of this step are very artificial and therefore very **UNREALISTIC**.

Ad 3): During AMAN sequencing in ETMA airspace, pseudo CDAs are applicable. The flights are following a quite realistic descent path, while flights have to be vectored also. This is achieved by applying traditional vectoring, but executed in ETMA airspace instead of TMA airspace; also, speed advisories are applicable.

If advanced AMAN, based on 4D technology, is applicable, this will operate off-line by pre-processing 4D planned trajectories. The initial flight times of newly entering flights are not adapted, because the AMAN can not influence traffic conditions outside the 200NM working



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area. AMAN has to assign a strategy to influence flight execution at an early stage to arrive on-time as planned. This shall be emulated.

The appropriate sequencing with 10 to 30 seconds precision is met on the TMA entry-point. This early sequencing is assumed to be sufficient to allow CDAs when passing the IAF, and to be sufficiently separated to establish final sequencing and to accomplish merging if necessary.

It should be noted that advanced sequencing is applied, in first instance, on traffic performing a traditional executive process to accomplish the sequencing. This implies that the sequencing is accomplished by continuous vectoring (during a continuous descent process).

Ad 4): A DCB process ensures a low variability of demand of arriving traffic flows. That determines the load on airspace requirements and on ATM service provision. Therefore, workload and airspace usage can be determined only when there is sufficient control on demand regulation.

Once the regulation of demand is in compliance with expected SESAR performance levels, it is possible also to assess how much airspace is needed to sequence the arrival flows in ETMA airspace by traditional speed adjustment and vectoring and how much workload this creates within applicable volumes of airspace.

Ad 5): All improvements in the Executive flight phases are aiming to perform the executive process in a more efficient way better addressing planned target settings with less interaction and less involvement of pilot and controllers. No matter what is simulated, the simulation must show enhanced planning by 4D, enhanced adherence to this planning by 4D guidance support of the aircraft with its 4D-FMS to meet a planned waypoint with high accuracy, and simplified execution of this 4D planned process to achieve less instructions to meet the target waypoint on-time.

Airspace efficiency may benefit from use of RNAV tracks, and flight efficiency might benefit from applying RNAV tracks to achieve sequences in a staggered way, reducing the dependencies and the reacting dynamic effects of aircraft navigation operations on each other.

Finally, the result of 2007 and 2015/2020 scenarios of the Baseline organisation can be compared with the 5th organisation, comprising future airspace organisation and DCB-balanced AMAN support for planning and advanced executive support. For the 2007 scenario, this provides a view on the achievable benefits if advanced operational concepts could be made operational on present-day traffic conditions. For the 2015/2020 scenario, this provides a view on achievable benefits for future operational conditions accommodating increased demand.

A summarising overview of dependent and independent experimental variables is added in the following table.

Independent variable	Control on this variable	Dependent variables	Dependent KPIs
Traffic density	Used to differentiate between present-day and future scenarios	Flow densities, bottlenecks and queuing quantities	Throughput, delay, fuel, workload, environmental load
Airspace and flight profiles	Used to differentiate between "traditional" and "advanced" scenarios	Flow densities, bottlenecks and queuing quantities	Throughput, delay, fuel, flight duration, flight efficiency, environmental load
Traffic flows	DCB measures to ensure low variability	Flow densities, bottlenecks, queuing quantities and airspace usage	Throughput, delay, fuel, flight duration, flight efficiency, environmental load, predictability



Independent variable	Control on this variable	Dependent variables	Dependent KPIs
The planning of individual flights	Traffic synchronisation, sequencing, flight planning and 4D A-G data exchange	Flow densities, bottlenecks, queuing quantities and airspace usage	Delay, fuel, flight duration, flight efficiency, environmental load, predictability
4D guidance by FMS and advanced ATM automation support	Flight executive guidance and control measures	Bottlenecks, queuing quantities, workload and achievable separation	Throughput, delay, fuel, flight duration, flight efficiency, environmental load, predictability

Table 14 - Overview of independent and dependent variables applicable to the differentiation of scenarios

5.2 LENGTH AND NUMBER OF RUNS

The simulation runs are performed in an iterative and accumulative way (see section 2.5). An acceptable result on one validation scenario, initiates the next step to validate a valid result of this step, changing experimental variables one-by-one and in a controlled way. First, results are obtained by running and analysing all validation scenarios, 1.1 to 1.3 and 2.1 to 2.4, with a traditional traffic scenario, then advanced SESAR traffic scenarios are used to assess the consequences of a transition to SESAR operational conditions.

The steps 1.3 and 2.3 will not include DCB improvements for a traditional scenario, but even for SESAR advanced scenarios this will be the case only if available, and if the data deserve a sufficient level of confidence.

5.3 TIME PLANNING FOR THE EXERCISE

The table below lists main activities and Milestones. The Milestones are identified synchronisation points by expected WP2.3 (Validation Management) and WP5 TMA EG meetings, held to present and discuss intermediate results.

Activity	Review meeting WP2	TMA EG meeting 28/29 Jan	TMA EG meeting March 09	Review meeting WP2
Experimental Plan	Dec 08			
Results on airspace, traditional and advanced		Jan 09		
Results on optimised profiles		Jan 09		
Results on AMAN processing +RNAV			March 09	
Results on DCB and Workload			March 09	
Final reporting				April 09

Table 15 - Detailed time planning




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6 REFERENCES AND APPLICABLE DOCUMENTS

Ref.	Document	Name	Status
[1]	EP3 / Proposal 037106 / V3.0/ Contract Amendment N°3	Episode 3 DoW	Applicable
[2]	E-OCVM	E-OCVM Version 2.0	Applicable
[3]	E3-WP2-D2.0-03-RQT	Performance Framework cycle 1	Applicable
[4]	E3-WP2-D2.3-01-WKP	Guidance Material for identification of Validation issues at WP and programme level: steps 0.1 to 1.7 of the E-OCVM	Applicable
[5]	DLM-0607-001-01-00	SESAR D2: Air Transport Framework, The Performance Target	Applicable
[6]	RPT-0708-001-01-01	The SESAR Performance Booklet	Applicable
[7]	DLM-0612-001-02-00	SESAR D3: The ATM Target Concept	Applicable
[8]	DLT-0612-222-01-00	SESAR Concept of Operations	Applicable
[9]	DLM-0706-001-01-00	SESAR D4: ATM Deployment Sequence	Applicable
[10]	DLT-0707-008-01-00	9 Scenarios illustrating the SESAR CONOPS	Applicable
[11]	E3-WP2-D2.3-03-WKP	Guidance Material for identification of Validation issues at WP and programme level: steps 2.1 to 2.6 of the E-OCVM	Applicable
[12]	E3-D2.2-027, version 3.0, 29/07/2008	SESAR DOD – Arrival and Departure – High and medium/Low density Operations – E5	Applicable
[13]	E3-D2.2-033, version 0.02, 01/12/2008	SESAR DOD – Medium/Short Term Network Planning – M2	Applicable
[14]	E3-D5.2.1-01, version 0.11, 29/10/2008	WP5 Validation Strategy	Applicable
[15]	OPTIMAL, S.H. Stroeve et al., D7.1.1-3, Approved, December 2007.	Safety aspects of ACDA approaches at Schiphol	Applicable
[16]	OPTIMAL, R.J. de Muynck et al., D2.4-6, Approved, December 2007.	Optimised Procedures and Techniques for the Improvement of Approach and Landing	Applicable
[17]	OPTIMAL, R.J. de Muynck, D2.2.1-1, Approved, August 2008.	Aircraft Procedures Definition, ACDA	Applicable
[18]	E3-D5.3.1-01, version 0.4, 15/02/2008	WP 5.3.1 TMA Expert Group Plan	Applicable
[19]	EP3-WP2.4.4 (to be published)	ENV assessment input data requirements specifications	Applicable
[20]	SESAR Definition Phase, Task 2.3.1/D3, DLT-0612-231-00-02, Toulouse, June 2007.	Compute and Map Operational Concepts & Airspace KPIs based on identified available Tools and Methodologies	Information
[21]	Seljee, R.R., NLR-CR-2008-047, Amsterdam, August 2008.	A generic transformation model extended with prioritisation for optimising flows in route networks	Information

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Ref.	Document	Name	Status
[22]	Jonge H.W.G. de, Seljée, R.R., Beers J.N.P., NLR-CR-2008-047, Amsterdam, August 2008.	Flow Management and Airspace Management impacting Schiphol operations, Validation Strategy on Demand and Capacity Balancing	Information
[23]	Jonge H.W.G. de, Beers J.N.P., Seljée R.R., NLR-CR-2006-795, Amsterdam, December 2006.	The simulation report of global fast-time simulations in Gate-to-Gate, Gate-to-Gate Flow and Departure management	Information
[24]	Jonge H.W.G. de, Dronkelaar J.H., Beers J.N.P., NLR-CR-2006-796, Amsterdam, December 2006.	The simulation report for fast-time simulations at airport level for Gate-to-Gate, Gate-to-Gate Flow and Departure management	Information
[25]	CASSIS, LFV, D-LFV 2008-056339, version 1.0, December 2008.	CTA/ATC System Integration Studies (CASSIS), Concept of Operations	Information

Table 16 - References and applicable documents



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1 Annex: Applicable Operational Improvements

The following list of Operational Improvements (OIs) are addressed by the experiment of “Multi-airport TMA operations in the core area”, and are adopted from the Detailed Operational description (DOD) E5, version 2.0, Ref. [12].

Line of Change	OI Step	Description	Rationale	Related Processes
L02 Moving from airspace to trajectory based operations	Advanced Continuous Descent Approach (ACDA) [AOM-0702]	This improvement involves the progressive implementation of harmonised procedures for CDAs in higher density traffic. Continuous descent approach procedures are used from Initial Approach Fix (IAF) or transition altitude to the runway. New controller tools and 3D trajectory management enable aircraft to fly, as far as possible, their individual optimum descent profile (the definition of a common and higher transition altitude would be an advantage).	Clean environmental approach paths, reduced noise level and emissions (although the accuracy with which paths are flown may exacerbate the impact for those directly under the route).	Implement Arrival Queue Implement Separation in Terminal Area
L03-01 Collaborative Layered Planning Supported by Network Operations Plan	SWIM enabled NOP [DCB-0103]	The NOP is in fact a 4 dimensional virtual model of the European ATM environment. It is a dynamic, rolling picture that provides a relational image of the state of the ATM environment for past, present and future. The user, via the appropriate applications, is able to view this image, moving the window along the timeline and focusing on any particular aspect or aspects he or she is interested in.	The plan itself is the result of the complex interactions between the trajectories shared into the system, the capacity being offered, the actual and forecast MET conditions, resource availability, etc. and the automatic and manual negotiations that have been carried out. While a user will only need to see the part of the picture he is concerned with together with its broader implications in order to carry out an action on and with the plan, the applications themselves always use the totality of the information available in the	(virtually all Queue Management and separation provision – related processes in E5)



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Line of Change	OI Step	Description	Rationale	Related Processes
			SWIM environment.	
L01-05 Airspace User Data to Improve Ground Tools Performance	Use of Predicted Trajectory (PT) to Enhance ATM Ground System Performance through TMR [IS-0303]	The trajectory sharing process is automatic and transparent to the crew and the controller unless the update results in a new interaction for the aircraft. RBT revision is triggered at air or ground initiative when constraints are to be changed (modified by ATC, or cannot be achieved by a/c)	The objective is to improve ground trajectory prediction by use of airborne data.	Implement Terminal Area Exit Queue Optimize Arrival Queue Implement Arrival Queue Detect and Solve Conflicts Implement Separation Solution
L07-01 Arrival Traffic Synchronization	Arrival Management Supporting TMA Improvements (incl. CDA, P-RNAV) [TS-0102]	Arrival Management support is improved to facilitate the use of PRNAV in the terminal area together with the use of CDA approaches. Sequencing support based upon trajectory prediction will also enhance operations within the terminal area thus allowing a mixed navigation capability to operate within the same airspace and provide a transition to eventual 4D operations.	Improved arrival management in combination with optimised runway utilisation procedures and infrastructure will assure the capability to build a safe, continuous, expeditious and optimised flow of arriving aircraft towards, on and vacating the airport runway(s). This enhanced AMAN will help to smooth throughput, and will, in fact, provide consistent spacing – even in very windy weather – because it looks at aircraft-to-aircraft relationship rather than just fixed spacing requirements.	Optimise Arrival Queue
L07-01 Arrival Traffic Synchronization	Controlled Time of Arrival (CTA) through Use of Datalink [TS-0103]	The CTA (Controller Time of Arrival) is an ATM imposed time constraint on a defined merging point associated to an arrival runway. The CTA (which includes wake vortex optimisation) is calculated after the flight is airborne and disseminated to the relevant controllers, arrival airport systems, user systems and the pilot. All partners in the system work towards achieving the CTA.	When initially issued the CTA represents the current optimised sequence that can still be changed if circumstances dictate. For a short flight the CTA should be very close to the pre-take-off Target Time of Arrival (TTA) and is calculated as soon as the flight is airborne. For longer flights the CTA must be available well before	Optimize Arrival Queue Implement Arrival Queue



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Line of Change	OI Step	Description	Rationale	Related Processes
			planned Top-of-Descent and is calculated when the flight passes the AMAN sequencing horizon.	
L07-01 Arrival Traffic Synchronisation	Arrival Management into Multiple Airports [TS-0303]	The system provides support to coordination of traffic flows into multiple airports in the vicinity to enable a smooth delivery to the runways.	Assistance to Multiple airport arrival management in the terminal area environment is becoming increasingly necessary especially in view of the emerging use of secondary airports which are located in close proximity to major airport hubs. In a complex terminal airspace environment there may be significant interaction between traffic flows into a number of these airports. The interaction of such traffic flows in relation to arrival management must be analyzed.	Optimize Arrival Queue
L07-01 Arrival Traffic Synchronisation	Arrival Management Extended to En Route Airspace [TS-0305]	The system integrates information from arrival management systems operating out to a distance of up to 200 NM to provide an enhanced and more consistent arrival sequence. The system helps to reduce holding by using speed control to absorb some of the queuing time.		Optimize Arrival Queue Implement Arrival Queue



2 Annex : Inputs by WP5 TMA Expert Group

2.1 Story-Board

This storyboard attempts, in a simple visual way, to present proposed procedures/methods to be used in a forthcoming SESAR/EP3 Fast-Time Simulation validation exercise [WP5.3.4], covering the management of arrival traffic into busy TMAs, in the core area of Europe, in the medium term timeframe [approx. 2020]. The area of interest for the WP5.3.4 simulation includes one TMA managing an airport with high-density traffic (Schiphol) and a second TMA, handling a number of large interacting airports within the TMA (Düsseldorf area).

It should be noted that for the simulation, and for the SESAR operation itself, Arrival Manager (AMAN) functionality should be considered to be operating within a horizon (time or distance to destination) that would allow minimum flight-efficiency impact on flights that have a time constraint at their destination. This would imply AMAN operating to horizons above its current use, and also operating seamlessly across ACC borders. This simulation does not consider how these processes/improvements will be put in place.

It is assumed, for the simulation and for the context of operations in SESAR, that a degree of 'smoothing' of traffic will be achieved by DCB, such that arrival traffic will enter the AMAN Horizon smoothed to approx. +2/-3 minutes, in relation to their planning. It is also assumed that this 'degree of smoothing' will allow adequate time for further smoothing and control of the flights by application of an AMAN constraint at the IAF, without major flight inefficiency or loss of arrival capacity – Assumptions A, B, C.


On 'capturing' the flight, the AMAN will downlink the trajectory projection [based on unconstrained arrival] from 4D capable aircraft, and will process and present a planned sequence. AMAN sequencing will rely on the aircraft capability of meeting the IAF with an accuracy of +/- 30 sec. - Assumption D. 4D aircraft will fly autonomously to their given constraint, while ground system will provide trajectory management support to non-4D equipped aircraft to achieve this accuracy.

In the en route and E-TMA sectors arrival flows will follow dedicated routes towards each TMA entry point. In each flow there will exist mixed-equipped traffic. Some aircraft will be 4D capable and will 'self-manage' their time constraint, and others will be managed by ATC, with system support, to meet their AMAN-planned time and sequence. It is assumed that system support will be in place, and of a level, to allow ATC to cater for this mixed-equipped traffic without significant workload impact – Assumption E.

After TOD aircraft will be facilitated, to as large a degree as possible, with a flight efficient descent, constrained only by other traffic (inbounds or crossings). The ATC ground system will continuously monitor flights with regard to them meeting their time constraints. If aircraft appear to be deviating significantly from their times, the ground system will alert the controller, in order for appropriate action to be taken – Assumption F.

Flights will be spaced to allow a continuous CDA for the portion of the flight from FL70 to touch-down. If aircraft are to be left 'unconstrained' in this final portion of flight a spacing of approx. 2min will be required at around 30NM DTG – Assumption G. This is supported by previous OPTIMAL studies in Amsterdam. A spacing of less than 2min [but still respecting normal separation criteria] may be considered however, if a portion of the CDA is 'prescribed', which would reduce aircraft performance/speed variability in this arrival segment – Assumption H.

Exception handling by ATC for missed approaches/go-arounds would be routine in nature, and aircraft would be reinserted in the sequence where/when appropriate. An element of headroom in the capacity figure would reduce the impact these cases would have on

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following traffic. No headroom in the capacity would have a more significant impact on following traffic – Assumption I.



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2.2 Assumptions and explanations concerning the Story-Board

Assumption A/C: Low variability of demand, 200NM out / 60 min.

Benefits:

- **Airspace utilisation:** With low variability there is control on the amount of airspace needed to accomplish the sequencing, without such control the required airspace for dedicated arrival flows cannot be limited to narrow tubes without including at least the use of holding stacks.
- **Capacity:** Without ensured low variability there will be dips in demand resulting in loss of capacity.
- **Efficiency:** Low variability ensures limited deviations from the ideal CDA profile to accomplish the required sequencing at TMA entry-point, no control on variability may result in unconstrained loss of flight efficiency.
- **Safety:** Low variability ensures control on traffic complexity during descent operations, lack of control on variability of demand may result in otherwise avoided tactical manoeuvring.
- **Environment:** All non flight-efficient manoeuvring in the descent will cost extra fuel, and is preferable avoided on the condition that low variability of demand will not be accomplished by flight inefficient manoeuvring in the en-route flight phase.

200 NM out / 60 min.:

- **Time-based or distance based:** Both, flight planning and the AMAN, operate on time and therefore time is the preferred dimension, and 200NM out equals roughly 60 min. However, AMAN operational conditions will often be determined by local geographical constraints. If such constraints are applicable, the effective range will be less than 200NM, corresponding with less than 60 min.
- **AMAN operational range:** AMAN is an interoperable tool; AMAN is able to update an arrival sequence continuously and can make use of planning information with different levels of uncertainty without restrictions to processing but with restrictions to operational relevance. The controller, however, has an interest to assess the planned sequence only if there is operational relevance:
 - The accurate flightplan information is complete or fairly complete,
 - The managed arrival sequence is stable and deserves sufficient confidence to uplink planning constraints to 4D-equipped flights and to coordinate with neighbouring control centres, and
 - The applicable flights are preferably all, or almost all, before their Top-of-Descent (TOD).
- **Therefore:**
 - All or almost all flights have to be airborne before establishing the arrival sequence. The under limit can be laid therefore roughly at 40 min. because flights with shorter flight times tend to be replaced by high speed trains.
 - If there are flights incidentally not yet airborne and within the applicable time zone, AMAN can reserve an arrival slot based on the planned departure time, accepting the need to re-sequence as soon as the aircraft is airborne; in that case a 4D re-planning is received and the planning uncertainty is suppressed.

Managing low variability of demand:

- **Flow control, information supply:** The flow of arriving traffic 200 NM out / -60 min, is as large as the flow of traffic arriving at the airport of interest. It is sufficient therefore to apply accurate flow regulations on airport arrival flows during periods of congestion, which are determined by the declared airport arrival capacity. The Airport



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and ANSP have a direct interest to provide accurate arrival capacity information if that ensures a well-dimensioned and continuous arrival flow. The Airline provides an accurate and up-to-date 4D RBT, allowing meaningful regulations with a tolerance of minutes, and has an interest in a flight-efficient approach procedure.

- **Flow control, management of information:** In order to accomplish low variability of arrival demand without disrupting en-route flight operations, the requirement is to determine high precision departure times (take-off) for all flights with less than ~4 hours flight time:
 - Long-haul flights are considered as constraining conditions and are outside the scope of departure regulations.
 - Before planning a departure sequence all pre-departure flights will have a planned departure uncertainty of roughly -5, +10 min. This uncertainty has to be reduced to -2, +3 min. for those flights heading to a congested destination, which requires prioritisation by high-precision departure.
 - All ECAC airports may have to contribute to reduce variability of arrival demand during a period of congestion of arrival demand for an airport and all airports going through a period of arrival congestion deserve to receive priority departures for their flights as needed.
 - All ECAC airports going through a period of arrival congestion have to provide the TTAs and associated TTOTs to inform departing airports of high-precision requested departure times, and Airlines and concerned airports have to provide high-precision departure services.
- Therefore:
 - SWIM has to ensure the appropriate information gathering and distribution.
 - Short-term DCB has to comprise a process that determines constraints (no delays) for those flights that require high-precision departures, based on already available 4D RBT information.
 - The departing airport has to be able to accommodate high-precision departure operations, if necessary with support of a DMAN.
- **Flow control, execution:** Low variability of arrival demand, 200NM out / -60 min, can be realised by high-precision departures mainly:
 - Most airports, but even hub airports must be able to accommodate high-precision departures as long as pre-departure DMAN provides an accurate and reliable planning and as long as there are sufficient facilities to overtake at the **holding** point or to service priority departures by an extra runway entry-point.
 - Low variability can be realised when most flights are departing within a narrow time window and will arrive within the same time window. Outliers departing outside their time window can proceed unimpeded because they are not challenging the objective of low variability as long as there is feedback on the statistical performance of the achieved variability of demand.
 - It is not compulsory to provide en-route ATC services guiding all traffic of congested arrival flows on-time to their designated arrival-flow interception waypoint, because that was not the requirement. However, it is required to guide them to their designated waypoint as good as possible “on-time”, however in acceptable balance with flight-efficiency objectives.
 - The Airline (FOC) is able, thanks to SWIM, to monitor the expected arrival demand on the destination airport and is able to decide on the trade-off of optimal cost-index, optimal flight efficiency and possible draw-backs of anticipated congestion problems. The FOC, the flight dispatcher, can decide therefore to change an RTA and to agree on a modified TTA (at destination, modifying estimates over planned waypoints), coordinating with the pilot. The pilot may agree a modified CTA with ATC.
- **Flow control, performance monitoring:** There is no need to monitor the performance of individual flights regarding their success in meeting their agreed time window, because low variability of arrival demand has performance targets with



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statistical relevance only, and because the outcome of performance of each individual flight is determined now by a complex and coherent process with many actors involved. However, it is relevant to monitor statistics on performance, which implies a task for the Performance Review Report services. The objective of this task is to provide the information to improve the process in such a way that low variability is achieved when and where needed. Monitoring information may comprise:

- Statistical information on the performance of all airports going through periods of congestion of arrival traffic regarding predictability and punctuality of arriving traffic.
- Statistical information on the performance of departure traffic of all airports servicing high-precision departures regarding predictability and punctuality of these flights.
- Information on the dependency of predictability and punctuality of other operations on high-precision departures and the percentage of these operations.

Step 5: Unconstrained 4D arrival prediction by the aircraft

4D prediction:

- 4D-equipped flights: The confidence level of planning is higher than for non-4D flights, but down-linked planning and ground-based planning have to be compared and decisions on CTA agreements have to be taken at the level of planning tasks. This cost effort.
- Non-4D-equipped flights: Ground-based tools will accomplish the planning of the sequence with not too-much human interaction, however:
 - The agreement is missing and has to be accomplished by clearance instructions, and this might be labour intensive,
 - The work is moved from short-term planning to executive phase,
 - The confidence level of planning is not as high as for equipped traffic.

4D execution, making a CTA:

- **Workload:** Presumably the workload during descent is not much different under nominal conditions between flying an agreed CTA for 4D flights (monitoring rather than giving any instructions) and non-equipped flights giving one or two clearance instructions, based on advisories from available automation support tools (assumption). However, the workload may increase significantly if complexity increase and flights may deviate more than expected from their planned slot in the arrival sequence.
- **Workload:** Another possible effect on workload is that non-equipped flights must be advised similarly to 4D flights, but monitored more. There will be probably an increase of workload, because the monitoring tools will not support very well the Controller due to the lower quality of available data information. These effects are to be evaluated in more detail.

Step 9a/9B: Reaching a TMA-entry-point/IAF

30 sec. precision over the TMA-entry-point/IAF:

- **Navigation precision:** 4D-equipped flights can do better and can realise 10 s. precision. Probably that is needed to operate CDAs, however, their guidance process should be as independent as possible from non-equipped flights, which can be achieved by “staggering” (see below).
- **Workload:** Less than 30s precision may introduce unfavourable workload and flight inefficiency; however, exact optima can not be determined without experimental validation.



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2 min. interval between succeeding flights:

- **Achievable minimum distance:** This minimum is derived from Monte-Carlo simulation on a simplified model under simplified conditions. Experimental validation has to show which minimum distance is feasible and safe.

Step 10: Applying prescribed CDA

Prescribed CDA:

- **Universal procedure:** CDA procedures can be defined that can be flown by most aircraft feeding the arrival flows. The prescribed procedure will satisfy the requirements:

- To be within the flight envelope of most aircraft, at least jets,
- To be flight-efficient, safe and environmental friendly, and
- To allow as high throughput as achievable.

First the SOURDINE project, later OPTIMAL, have specified feasible and appropriate procedures that can be flown from 6000/7000 ft by most aircraft types. These procedures will be adopted.

- **Staggering:** Staggering after TMA-entry-point towards a merge point can contribute to maximised capacity. The flight guidance during CDA has two objectives:
 - Flights are guided towards their planned landing time, and
 - Flights are required to maintain separation from the preceding flight.

"Staggering" has the objective to avoid dependence on preceding flights as long as possible. The last option for final merging is on the cross-wind leg, or engaging an inbound turn at an altitude of 3000/4000 ft or above.

Staggering is accomplished by alternative selection between two PRNAV tracks. The selection is based on planned traffic feeding the dedicated arrival flows and can be accomplished in an early stage by AMAN.

- **Merging on inbound turn:** The controller will have to decide on successful merging at IAF. Either the flight is within the acceptable time-window and the CDA-clearance can be submitted or a non-nominal procedure is initiated.
- **Parallel runway operations:** CDAs on parallel runways have to be safe, whilst continuous flows have to be facilitated on both runways, independent of each other, at the same time. An option is to separate inbound turns by lateral separation and to descend by different glide-paths (e.g. 3 and 3.5 degrees).

Exception handling:

- **Stacking:** There is one arrival flow at Final and somewhere there are stacks, probably one per TMA entry-point. Exception handling will make use of one of those stacks, or possibly even a specific overshoot stack area. Headroom capacity has to be ensured in order to be able to feed stacked flights in the regular traffic flow. (A complete design of exception handling procedures is clearly outside the scope.)

2.3 Answers from Airbus on questions on advanced CDA arrival procedures

The following questions and answers are collected in order to support the modelling of fast-time simulations in establishing stable arrival sequencing procedures for advanced CDAs in the most realistic way, given the applicable simplifications and assumptions of fast-time simulation. The questions are addressing 4D airborne support to 4D ground planning and execution of flights, and the questions were answered by Airbus representative: Jean-Louis de Menorval (JLM).

➤ **First series of questions:**



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How to approach IAF in a structured way through a stretched arrival sector applying performance based navigation?

- JLM: Airbus vision for mid term (2013-2015) using Initial 4D, is to use PRNAV (RNAV-1) procedure merging on IAF, with a CTA/RTA at merging point with a precision of 10s at 95%.

How to improve by A-G exchange of 4D planning and use of FMS?

- JLM: With Initial 4D the ground should have access to the complete trajectory predictions coming from the FMS (on the active FPLN).

How to deal with CDAs of dense flow over one IAF to one runway, merging with a second flow over a second IAF (converging flow)?

- JLM: From IAF to FAF you can use "merge point" type of structure proposed by EUROCONTROL, which is mature. You can use ASAS spacing (ASPA). You can potentially use the 4D trajectory prediction from I4D A/C to support ground tool to deliver the A/C at precise time on the FAF. On Airbus side we also think we could also use another RTA set on FAF with a precision of 10s at 95%, but we have not done sufficient validation up to now (we do not know until which density of traffic this is possible).

How to deal with CDAs of dense flow over one IAF to several runways/airports (diverging flow)?

- JLM: You can use the lateral RNAV-RNP capability of A/C with a performance down to RNP=0.1NM at 95%. The separation between two flows (10-5 error assumption) would be from 4xRNP (RNP SAAR) to approximately 6 times the level of lateral performance for a RNAV procedure. You can also use the vertical navigation capabilities, where the A/C performance goes from 200ft at 10-5 (RNP SAAR with VEB) down to 300ft at 10-5 (for RNAV) procedures. This would require vertical separation from two flows (for 10-5 error assumption) of around 400ft (RNP SAAR) to 600 ft (for RNAV).

How to ensure undisturbed departure operations during initial climb, while operating the airport(s) with several dense departure and CDA arrival flows?

- JLM: You can use a combination of the 4D trajectory downlink from the Initial 4D capable A/C to anticipate conflict (through MTCD). More over, you can use a set of window altitude constraints in climb segment to define a "tunnel". However, no performance demonstration exist up to now, but you can assume that the Altitude constraint be satisfied with a maximum error of 500 ft at 10-5 with some specific pilot procedure.

How to service and to control non-4D equipped, 4D equipped and mixed equipped traffic in ETMA and in TMA airspace (CDA)?

- JLM: You can use previously described Initial 4D capabilities for 4D equipped A/C, and for non 4D aircraft, you can assume RNAV-1, with a speed advisory from a ground tool.

How to cope with stacking as well as high precision sequencing on IAF?

- JLM: Following airline inputs, on Airbus side we do not support the idea of A/C automation to deal with these scenarios.

A flight, deviating during CDA, extends the flightpath; how to cope with deviations, which impact on the sequence and the capacity, and how to anticipate?

- JLM: Probability in case of significant deviation from CDA, flight path (assuming slope is limited, and no ATC unplanned speed change request) should be reduced.

Non-nominal conditions:



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- A flight, deviating, aborting the CDA and how to rejoin the sequence?
- A flight, making an overshoot, and how to rejoin the sequence?
- How to operate CDAs on parallel runways in a safe way?
- JLM: Using previously described navigation capabilities you can reduce the constraints linked to parallel runways to a certain extent.

➤ **Second series of questions:**

Is it feasible to follow ATC-instructions and use 4D guidance capability of advanced aircraft to meet planned times? I.e. by re-planning and re-issuing 4D plan to FMS?

- JLM: At 200 NM from runway using Initial 4D on A320 we have a time guidance control authority of 5min (approximately +2/-3 min depending on Cost index).

What is the best way to deal with guidance, given mixed equipment and differences in predictability?

- JLM: We propose to use Initial 4D capabilities for better equipped A/C and PRNAV with speed advisory from ground tool for other aircraft.

What is best achievable performance at IAF (today's state-of-the art aircraft), and how much airspace to be comply with time constraints?

- JLM: On Airbus A/C the theoretical performance of RTA on existing A/C is 30s down to FL100. We do not have the values in real operation with the uncertainty on winds. We believe the value is around 40 to 50s at 95%. This precision is quite independent from the time horizon at which the RTA is entered. When two in trail A/C are flying a RTA, the order of magnitude of the distance reduction is inferior to 10NM (from cruise level to FL100) and maximum value is near top of descent.

What is achievable with all aircraft in operation at present and coming years?

- JLM: With Initial 4D aircraft we target to have a 10s 95% precision on RTA.

Will aircraft capability better be served by systematically separating flights: e.g. by offsets over PRNAV tracks in ETMA airspace, and is there any alternative?

- JLM: Our vision is rather to use the offset solution only when the 10NM distance reduction discussed before is an issue.

Is it possible to formulate a generally applicable procedure/strategy (all A/C types) to reduce speed, to save time by lateral offset, to save time by quitting CDA profile?

- JLM: You need to give more precision on the scenario you have in mind.

What is the opinion from aircraft's/pilot's perspective on critical distance during descent to preceding aircraft and following aircraft?

- JLM: We do not have any typical value for this yet. The use of the downlink of the 4D prediction by Initial 4D A/C could support this.

What is the opinion on risk of instability due to differences in type and performance (old-new, light-heavy-super-heavy, AC-type differences)?

- JLM: The use of the downlink of the 4D prediction by Initial 4D A/C could support this. The FMS prediction in open loop (without time guidance) is fairly good. It is mainly the uncertainty on meteo effect that cause error in predictions.

Is the price a high one to give up vectoring and to switch to fly one continuous CDA profile in tight sequence from perspective of flight efficiency? And from the perspective of capacity/safety? Are there attractive alternatives, e.g. staggered approaches, late merging and to which price?



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- JLM: Airbus considers that it would be more efficient to use "modern techniques" previously described.

Late merging? What is feasible latest merging point? Which separation is to be maintained between 3 merging flights? Which separation achieved after merging operation?

- JLM: Late merging at FAF or IAF could be possible using RTA at merging point thanks to "Fan arrival" but we do not know if it is possible in high density areas.

Is it possible to operate late merging without creating extra noise problems when operated at low altitude?

- JLM: Late merging using techniques with a guidance loop on speed (ASAS) or time (RTA) will necessarily make more noise than open loop descent.

Suppose CDA operated from 6000/7000 ft, how well is it possible to keep crossing departures separated from arrival flows without adverse effects on noise abatement? Which spectrum of departure profiles have to be respected given the performance ranges of all aircraft operated at hub airport in the coming years?

- JLM: A specific study is necessary to answer this question.

How much distance is needed for stacking operations to join a CDA flow at IAF and safely and accurately intercept a flow? How much is the gap required to safely merge an (advanced) aircraft into a flow?

- JLM: A specific study is necessary to answer this question.

Giving exception handling (by late vectoring and overshoot) how difficult is it to merge CDA flow and how much buffer space required?

- JLM: A specific study is necessary to answer this question.

Giving inbound turning CDA approaches to two sufficiently separated parallel runways, how to ensure safety? Is it possible to rely on aircraft's RNP performance?

- JLM: To a certain extent the A/C navigation performance previously described should enable this type of operations.

Is it possible to define inbound turning exception handling procedures that ensure that overshoots and other exception handling procedures can be operated well-defined enough to be separated from other arriving and departing traffic, making use of advanced aircraft navigation capabilities?

- JLM: Thanks to existing RNAV and RNP SAAR capabilities you can define a corridor with high probability of confidence the A/C is going to remain within the limits. For RNP SAAR the probability to exit the corridor of 2xRNP is above 10⁻⁵ and close to 10⁻⁷ (depending on the assumptions).



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Annex A Exercise Overview Table

The following table provides a summary and overview of the exercise scope.

Validation Scenario	Summary/ Purpose	Hypothesis	Metrics/ Indicators	SESAR OI	SESAR KPI	DOD References
1.1 Reference, Balanced	Assess balance of the network, optimise network capacity	Are the capacities of the traditional network in the core area in balance?	NAM	DCB-03-01	Throughput and Waiting time	DOD-E5 and M2/M3
1.2 Reference, “Do Nothing”	Assess throughput and efficiency through network	How much throughput and how efficient is air traffic operating?	TAAM	-	Throughput and delay	DOD-E5
1.3 Reference, arrival synchronised	Assess optimised throughput by CTFM and advanced arrival management and synchronisation	Is pre-departure planning and enhanced arrival sequencing improving the efficiency and effective use of available capacity?	Opt.Synchr.-CTFM, / TAAM	DCB-0103, IS-0303, TS-0102	Throughput and delay Fuel efficiency and workload	DOD-E5
2.1 Adv., Balanced	Adapt airspace organisation and assess balance of the network by optimising capacity	Are the capacities of the advanced network in the core area in balance?	NAM	DCB-03-01	Throughput and Waiting time	DOD-E5 and M2/M3
2.2 Adv. “Do nothing”	Assess throughput and efficiency through network	How much throughput and how efficient is air traffic operating?	TAAM	TS-0305, AOM-0702	Throughput and delay	DOD-E5



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Validation Scenario	Summary/ Purpose	Hypothesis	Metrics/ Indicators	SESAR OI	SESAR KPI	DOD References
2.3 Adv. arrival synchronised	Assess optimised throughput by CTFM and advanced arrival management and synchronisation	Is pre-departure planning and enhanced arrival sequencing improving the efficiency and effective use of available capacity?	Opt.Synchr.-CTFM / TAAM	DCB-0103, IS-0303, TS-0102, TS-0303	Throughput and delay Fuel efficiency and workload	DOD-E5
2.4 Adv. including 4D-guidance	Assess optimised throughput by adding 4D guidance	Gives 4D-guidance an improvement of throughput and thus effective use of available capacity?	Opt.Synchr.-CTFM / Enhanced Exec. Performance / TAAM	TS-0103	Throughput and delay Fuel efficiency and workload	DOD-E5

Table 17 - Overview exercise scope

N.B. SESAR ids are: Throughput (KPI_CAP_THROUGHPUT), delay (KPI_EFF_DEPDELAY_OCC, KPI_EFF_DEPDELAY_SEV, KPI_PRED_ARRDELAY_OCC, and KPI_PRED_ARRDELAY_SEV, KPI_EFF_DURATION_OCC, KPI_EFF_DURATION_SEV), flight duration and fuel efficiency (KPI_EFF_FUEL_OCC, KPI_EFF_FUEL_SEV) and workload (KPI_CAP_WORKLOAD, KPI_CAP_ELEMENTARY).

Note that “waiting time” measured with the NAM tool is not a SESAR KPI, because it is an artificial quantity to detect and measure throughput bottlenecks in an ATM network.

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