DFS DEUTSCHE FLUGSICHERUNG GMBH ALIGNING THEIR RESEARCH & DEVELOPMENT NEEDS FOR THE SINGLE EUROPEAN SKY AIR TRAFFIC MANAGEMENT RESEARCH PROGRAMME (SESAR)

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ABSTRACT

This paper analysis the research needs for DFS Deutsche Flugsicherung GmbH derived from the SESAR concept of operations. It focuses on the reasoning for setting up new, SESAR aligned research activities and points out major changes to be faced not only by the German ANSP but by all stakeholders involved in the ATM system. It gives some concrete examples on how DFS R&D supports the operational needs implementing the change, especially by implementing a well settled validation methodology to support the DFS internal decision making process. Finally, it outlines the DFS view on the continuation of the SES process towards a safer and more efficient ATM system for Europe in 2020 and beyond.

1. OVERVIEW

The European process on harmonising the air traffic management provision is known as the Single European Sky process (SES). It started off in the beginning of this decade setting its legislative foundation on a European level. Further, the SESAR programme definition phase was launched in early 2006 to define the target ATM system for Europe in the year 2020 and beyond. The result of this first step in the SESAR context will be a commonly agreed research and implementation roadmap for the activities needed all around Europe. Walking down this roadmap in the coming 15 years will significantly influence the business of all stakeholders involved in the ATM system today and tomorrow.

DFS Deutsche Flugsicherung GmbH (DFS) as the German air navigation provider (ANSP) is affected in many ways by the European SES process. Starting from the need for privatisation of the company – a well known issue in the German aviation community –, this continues through all areas of economical, technical and operational aspects of the service provision.

Currently, the SESAR programme in its two years lasting definition phase is more than half way through. It managed to establish a major cornerstone for building the roadmap: the agreed concept of operations for 2020 and beyond, together with associated more detailed documents. These documents are available in the milestone deliverable D3 of SESAR [6]. The concept describes on a high level the way the service provision all around Europe is to be carried out. Thus, it gives a first view on the needs for further research and development to achieve this target in time.

According to the SESAR concept of operations the DFS R&D strategy is going to change to align with the SESAR vision and concept thus accommodating and preparing the change needed. This demanding task is to be seen on the background of the densest airspace in Europe handling about 3 million flights a year in an always safe and efficient manner. DFS in its R&D effort concentrates on managing the major changes needed to provide SESAR compliant operations in the future. This change management is based on an established validation process and followed on by related implementation activities. Three focus areas are identified in the paper along the main DFS business. These focus areas determine a major part of the DFS R&D activities.

This paper focuses on the reasoning for setting up these new, aligned research activities and points out major changes to be faced not only by the German ANSP but by all stakeholders involved in the ATM system. It gives some concrete examples on how DFS R&D supports the operational needs implementing the change, especially by implementing a well settled validation methodology to support the DFS internal decision making process. Finally, it outlines the DFS view on the continuation of the SES process towards a safer and more efficient ATM system for Europe in 2020 and beyond.

2. THE NEED FOR CHANGE: SESAR

Many analyses have been done in the past two decades on the European ATM system. Many research projects have been started to improve the current system. They were based on European Commission's initiatives as well as on Eurocontrol, multi-national and national funding. European Commission in its research framework programmes ran many ATM related research projects. Acronyms like AVENUE, TORCH, Gate-to-Gate, C-ATM, Episode 3 as one of the sequences launched over more than a decade are well known. Eurocontrol contributed to these activities already in the late 80th with programmes like ODID and PHARE, and it continues on that path with numerous activities up to now. A huge number of national or multi-national initiatives added to this as well, e.g. the French ERATO and ERASMUS programmes or the iTec and Coflight initiatives.

All activities were based on the knowledge (or estimation) that the European ATM system in near future runs in capacity problems as well as efficiency, environmental cost effectiveness and maybe even safety troubles.

Serious capacity shortcomings were experienced already several years ago – and partly overcome up to now.

Most of the initiatives started – as it is a good scientific manner – analysing the current situations' shortcomings and tried to build on that analysis solutions for specific parts of the documented problem. However, most of the activities contributed to the solution only as a "small piece of the mosaic". Fully acknowledging the importance of each of these activities to get an awareness of the overall situation and problems, from a today's, backwards perspective it can be stated that a lot of smaller parts of the mosaic are known today. But it seems like no one really knows the big picture to be formed out of all these mosaic pieces. What is missing is a top-down European approach to the problems of the European ATM system.

It is evident that no initiative started such a comprehensive and strict top-down approach on analysing the European ATM system problems and proposing solutions for the shortcomings than the European Commissions Single European Sky initiative with its Eurocontrol run Single European Sky ATM research programme SESAR. Its main advantages compared to other activities are two-fold: (i) the very strict top-down approach which is mirrored in the list of milestone deliverables and (ii) the fact that nearly all stakeholders of the European ATM system are contributing to the project. One may question the complexity of the milestone and task deliverables, one may disagree to the one or the other detail of the proposed solutions from the individual stakeholders' point of view, one may criticise that the proposed ideas are not ambitious or futuristic enough. But the fact that for the first time all stakeholders – several kinds of airspace users, air navigation service providers, airports, research establishments, regulatory bodies, industry, military and professional's organisations – are contributing jointly to the resulting proposal, is a major step contrasting to previous initiatives. And it is a major success of the SESAR programme.

The European Commission's (EC) expectation for SESAR, expressed by EC Vice-President Jacques Barrot, is that it will deliver a future European Air Traffic Management (ATM) System for 2020 and beyond which can, relative to today's performance, enable up to a 3-fold increase in air traffic movements whilst reducing delays, improve the safety performance by a factor of 10, enable a 10% reduction in the effects aircraft have on the environment and provide ATM services at a cost to the airspace users which is at least 50% less. The challenge facing the air transport community is to meet these expectations and establish a sound, sustainable basis for the industry well into this century.

SESAR analyses that the current ATM system has several strengths, but also some weaknesses. The following strengths are identified:

– The current ATM system is perceived as acceptably safe
– Currently there is no en-route capacity problem
– Civil-military co-ordination improved a lot

On the other hand, some weaknesses are identified as well:

– The ATM system is considered to be expensive
– Interoperability issues hinder an optimum use of the today's airspace capacity
– The ATM system does not sufficiently support achieving and maintaining the airlines' schedules [1]

Considering traffic forecasts for the year 2020 and beyond as well as other estimated effects like changing traffic patterns, passenger demands or environmental constraints together with the identified weaknesses clearly demonstrates that the European ATM system has to be dramatically improved to meet the customers' expectations. This is a fact for the European perspective as well as for an individual stakeholders' point of view. It is doubtless that the system has to be changed to meet future needs. And it is unquestioned that the SESAR definition phase provides more issues to be tackled in research and development than complete, comprehensive and validated elements of the concept of operation ready to implement. Thus, the need for change as well as the need for research and development is obvious – for Europe as well as for DFS German Air Navigation Services. And it seems to become more a radical than an evolutionary change.

3. THE STRATGEY FOR CHANGE: DFS R&D NEEDS

From an ANSP's point of view the ATM system proposed by SESAR can be structured in the following categories:

1) Network Management
2) Trajectory Management
3) Conflict Management, including Separation Provision
4) Airspace Considerations
5) Military Aviation
6) Airport

This structure is not fully in line with the "official" SESAR Concept of Operations structure (which is as follows: Trajectory Management, Trajectory based Operations, Executing and Managing the Business Trajectory, Operations on and around Airports, The Application of Conflict Management and Separation, Collision Avoidance [7, section F]), but it can be easily mapped into this structure. The proposed structure especially emphasises some important issues for DFS R&D, namely on network management, airspace considerations and military aviation.

It is important to note that one of the major and most contentious keywords of the SESAR concept of operations – the "business trajectory" – is of equal importance for DFS as well. However, it is not as much recognised as an R&D issue. Instead, there are several legal, economical and security issues associated with this term, which will be elaborated outside the scope of the R&D area.

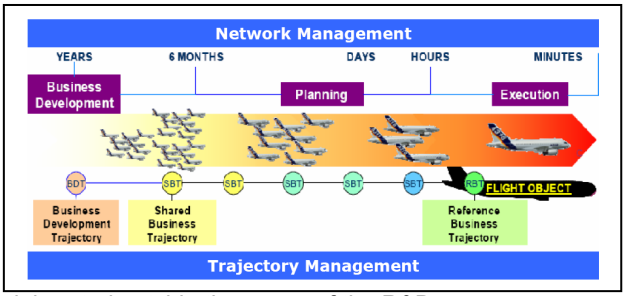


FIG 1. SESAR Concept temporal structure

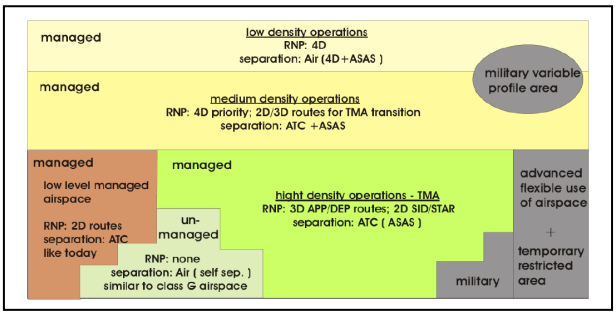


FIG 2. SESAR Concept spatial structure

Within the structure given above there is a temporal as well as a spatial structure of the SESAR proposed solution. The temporal structure is shown in figure 1.

It shows the lifecycle of a trajectory within the ATM system. This temporal structure is important to organise the internal processes of the service provision in an efficient manner. It is also known as the layered planning paradigm.

The spatial structure is shown in figure 2. It shows the applicability of different elements of the concept in different areas of the airspace. Besides elements that are well known today already, several new elements show up especially for the medium and high density operations.

The interdependency of the categories and the structures is shown in figure 3. The darker the colour is, the stronger the interdependency is estimated.

Basically, as DFS currently has the obligation to provide air navigation services according to ICAO for the Federal Republic of Germany, all these categories are equally important to provide a safe, expeditious and orderly flow of air traffic. However, from a DFS business perspective, not all of these categories are in the focus of future considerations. Clearly issues like separation provision and conflict management are at the core of DFS business. Network management is equally important. Others like airport or military aviation may have a different priority depending on the institutional framework set up in the future. This fact is mirrored in the colour coding of figure 3: especially the dark green aspects are of main importance for DFS from a business perspective.

Besides trajectory management, DFS main focus is on network management and conflict management including separation provision. Thus, these three areas form the major R&D needs within DFS for the follow-on activities to

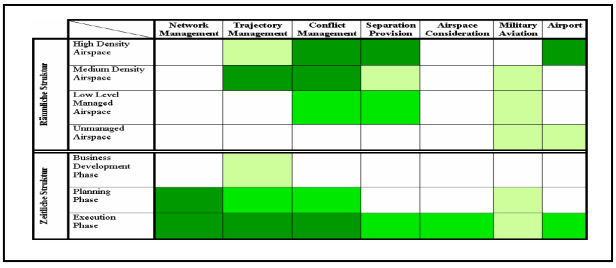


FIG 3. SESAR Concept of Operations: structure – category interdependency

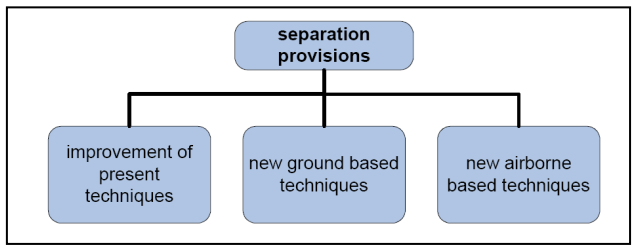


FIG 4. SESAR Categories for Separation Provision [6]

implement SESAR.

Analysing further the issues on separation provision clearly shows a more differentiated view again. SESAR divided the separation provision into three different areas: (i) improvement of present techniques, (ii) new ground based techniques and (iii) new airborne techniques (see figure 4). As the process of improving the present techniques is well underway e.g. in the Eurocontrol triggered LCIP/ECIP process, this is not in the focus of DFS R&D. For the new ground based techniques especially 3D, 4D and 4D-contract techniques are subject to research and validation [7, appendix 2] as well as for the new airborne techniques the cooperative separation provision and especially the proposed self separation provision.

Due to that, three focus areas are identified: (i) en-route service provision with its demanding new concepts of 4D contract and ASAS self separation in mixed environment, (ii) high density E-TMA/TMA operations with highly structured traffic operations and the optimisation of airport capacity including the turnaround process, (iii) layered planning processes and collaborative decision making (CDM) processes for improving the overall ATM system capacity and efficiency. These focus areas form the central DFS R&D needs for the mid term. As they were identified already some time ago, they are already mirrored in the DFS R&D activities on a national (e.g. WFF programme, funded by BMWi) and European (e.g. Episode 3 programme, funded by EC) level.

They also determine the DFS R&D strategy on further developing the validation infrastructure needed to evaluate proposed solutions within these focus areas. An example

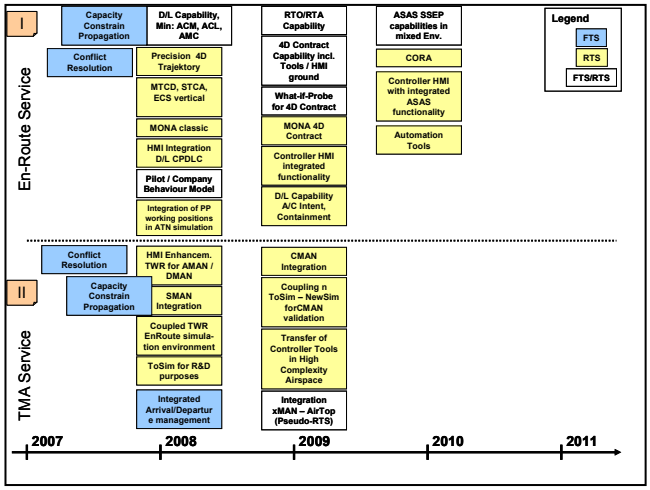


FIG 5. Example for DFS R&D Infrastructure Improvements determined by SESAR Concept of Operations

for this strategy is shown in figure 5. It demonstrates an integrated approach on the overall DFS R&D validation infrastructure – consisting of analytical modelling, fast time simulation, real time simulation and life trial platforms. The strategy takes account of the DFS R&D needs as well as of the proposed SESAR Concept of Operations time frame to implement different parts of the concept. It aims at improving the available validation infrastructure to validate well in time the SESAR ATM capability level 3 requirements at a minimum, which are estimated to take effect as of the year 2020 onwards.

4. THE METHODOLOGY FOR CHANGE: E-OCVM

Taking investment decisions of several 100 M€ asks for solid figures to base on. On the other hand, validating the SESAR concept of operations as a whole or even partly is an ambitious task. Fortunately, in the past decade a validation methodology evolved to produce the figures needed. This process was supported by means of the European Commission sponsored research programmes.

Having done proper validation in the domain of ATM already for several years on a local, mostly national basis, programmes like PHARE demonstrated the need for a common European validation methodology. As a consequence, the development started within two consecutive projects: “Development of EATCHIP/EATMP Validation Methodologies” (DEVAM) [2] and “A Master ATM European Validation Plan” (MAEVA). MAEVA came up with the MAEVA validation guideline handbook [3]. It documents best practise on ATM validation in a structured approach. The handbook is divided in two parts plus an appendix, each part providing more granularity. The annex finally describes in detail all the processes needed for a proper ATM validation activity.

This methodology was further developed in two steps. First, the joined FAA/Eurocontrol activities picked up the MAEVA documents and matched the so far pure European approach with US best practise. This document is the “Operational Concept Validation Strategy Document” (OCVSD) [10], which was developed within the FAA/Eurocontrol action plan 5 in 2003. The next step was to improve this document with some more generic and systematic aspects towards the “European Operational Concept Validation Methodology” (E-OCVM) [4]. E-OCVM is the current state of the art validation methodology jointly used by all partners of the European ATM validation activities.

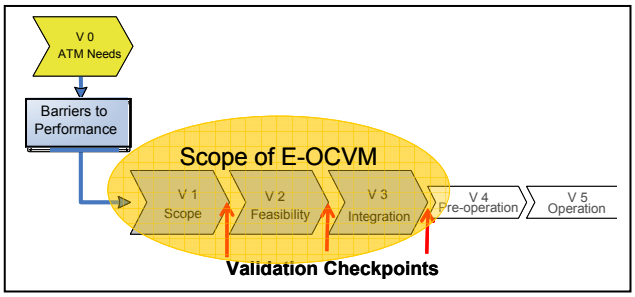


FIG 6. States within the lifecycle of an ATM system (E-OCVM)

E-OCVM identifies five different states to be undergone when developing an ATM system or an ATM system component. These states are considered as the ATM system life cycle:

State 1: Scope of the system/component
State 2: Feasibility of the system/component
State 3: Integration of the system/component
State 4: Pre-operation of the system/component
State 5: Operation of the system/component

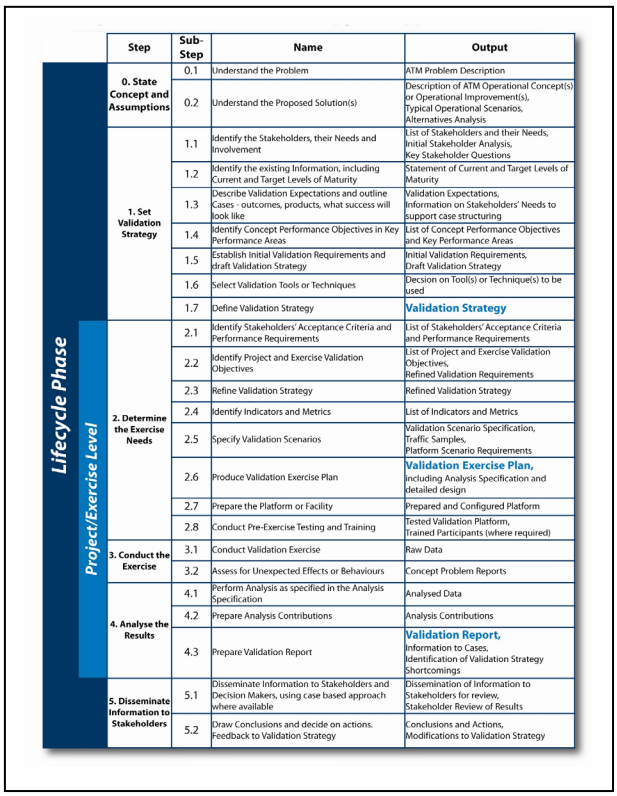
E-OCVM covers state 1-3 of this lifecycle (figure 6). It structures the system development, clarifies availability of evidence and provides check points to consider added value within the validation process – or to stop the validation process well in time if results propose.

E-OCVM also incorporates the well known key performance area approach as facilitated e.g. by Eurocontrol in the performance review reports [5]. Finally, it enables proper stakeholder integration at all stages of the validation process. In addition and based on the MAEVA validation guideline handbook, the E-OCVM provides lots of detailed material as a best practise for each of the steps to be taken within a validation process.

Basically, a validation process is structured in six different steps, each of them comprising of several sub-steps:

0) State Concept and Assumptions
1) Set Validation Strategy
2) Determine Exercise Needs
3) Conduct the Validation Exercises
4) Determine the Results
5) Information for Dissemination

All sub-steps are shown in figure 7. Working through these



Step	Sub-Step	Name	Output
0. State Concept and Assumptions	0.1	Understand the Problem	ATM Problem Description
	0.2	Understand the Proposed Solution(s)	Description of ATM Operational Concept(s) or Operational Improvement(s), Typical Operational Scenarios, Alternatives Analysis
1. Set Validation Strategy	1.1	Identify the Stakeholders, their Needs and Involvement	List of Stakeholders and their Needs, Initial Stakeholder Analysis, Key Stakeholder Questions
	1.2	Identify the existing Information, including Current and Target Levels of Maturity	Statement of Current and Target Levels of Maturity
	1.3	Describe Validation Expectations and outline Cases - outcomes, products, what success will look like	Validation Expectations, Information on Stakeholders' Needs to support case structuring
	1.4	Identify Concept Performance Objectives in Key Performance Areas	List of Concept Performance Objectives and Key Performance Areas
	1.5	Establish Initial Validation Requirements and draft Validation Strategy	Initial Validation Requirements, Draft Validation Strategy
	1.6	Select Validation Tools or Techniques	Decsion on Tool(s) or Technique(s) to be used
	1.7	Define Validation Strategy	**Validation Strategy**
2. Determine the Exercise Needs	2.1	Identify Stakeholders' Acceptance Criteria and Performance Requirements	List of Stakeholders' Acceptance Criteria and Performance Requirements
	2.2	Identify Project and Exercise Validation Objectives	List of Project and Exercise Validation Objectives, Refined Validation Requirements
	2.3	Refine Validation Strategy	Refined Validation Strategy
	2.4	Identify Indicators and Metrics	List of Indicators and Metrics
	2.5	Specify Validation Scenarios	Validation Scenario Specification, Traffic Samples, Platform Scenario Requirements
	2.6	Produce Validation Exercise Plan	**Validation Exercise Plan,** including Analysis Specification and detailed design
	2.7	Prepare the Platform or Facility	Prepared and Configured Platform
	2.8	Conduct Pre-Exercise Testing and Training	Tested Validation Platform, Trained Participants (where required)
3. Conduct the Exercise	3.1	Conduct Validation Exercise	Raw Data
	3.2	Assess for Unexpected Effects or Behaviours	Concept Problem Reports
4. Analyse the Results	4.1	Perform Analysis as specified in the Analysis Specification	Analysed Data
	4.2	Prepare Analysis Contributions	Analysis Contributions
	4.3	Prepare Validation Report	**Validation Report,** Information to Cases, Identification of Validation Strategy Shortcomings
5. Disseminate Information to Stakeholders	5.1	Disseminate Information to Stakeholders and Decision Makers, using case based approach where available	Dissemination of Information to Stakeholders for review, Stakeholder Review of Results
	5.2	Draw Conclusions and decide on actions. Feedback to Validation Strategy	Conclusions and Actions, Modifications to Validation Strategy

FIG 7. Sub-steps of the European Operational Concept Validation Methodology (E-OCVM)

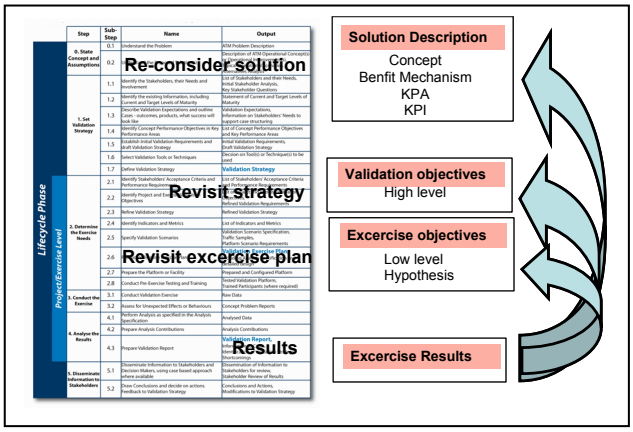


FIG 8. Feedback mechanisms within E-OCVM

steps may last a few months only or several years, depending on the nature and the complexity of the validation process to be performed. Thus it is really beneficial to have one single methodology available describing the necessary steps independent from complexity and duration of the process.

It is important to recognise that steps 2-4 are on the exercise level only. Step 2 provides the exercise preparation, whereas step 3 is about conducting the exercise and step 4 provides analysis and results of the exercise.

Step 0 and step 1 are important to set up a proper exercise starting from step 2 onwards. They are about understanding the problem correctly and set up an adequate validation strategy. The validation strategy includes details of Stakeholders, their needs & questions, searching for existing information on concepts and barriers to performance (the level of maturity), identification of high level validation objectives including target key performance areas (KPA's) and selection of validation tools or techniques to be used.

At the other end of the process, step 5 is about dissemination of results. This is of major importance in a European context due to the experience that lots of validation activities in the past were carried out but not documented and communicated adequately. To overcome this issue, it became mandatory within the process to consider dissemination actions. Additionally, tools like the Eurocontrol validation data repository (VDR) [8] are proposed for use.

As an output, a typical E-OCVM compliant validation process generates three major documents: (i) validation strategy, (ii) validation exercise plan and (iii) validation report.

Another important aspect of the E-OCVM is the implicit and multiple feedback mechanism within the methodology. E-OCVM is explicit about feedback to exercise design, strategy and concept. If a result does not meet expectations, it may be necessary to modify the individual exercise objectives, the overall validation objectives or the concept which describes the proposed solution (figure 8). Thus an iteration and improvement process can start from any of these levels within the methodology depending on its adequateness.

5. THE INITIAL STEPS FOR CHANGE: EPISODE 3 AND SESAR JOINT UNDERTAKING

Currently SESAR is still acting within the definition phase. In milestone deliverable 3 the SESAR Concept of Operations together with related topics like architecture, technology and transition issues was delivered. This includes a number of R&D needs already identified within the process – generated not only within the concept of operations discussion, but also within several other tasks ongoing at the same time [6, annex 3].

As an ongoing task within SESAR, a systematic analysis for validation needs will deliver results in October 2007. In addition it will provide a methodological gap analysis, i.e. indications where the available validation methodology needs to be refined or further developed to be able to serve the validation needs. One example for such a need is the necessity to validate in a complex environment a setting validating the processes from 6 hours prior to a flight event up to the time where the flight leaves the designated airspace. At the moment within the R&D community it is unquestioned that for a validation exercise like this new tools and maybe new methodologies are needed, and effort is taken to provide the necessary support already.

From a SESAR point of view, further validation and development process is subject to the SESAR development phase, lasting from 2008 to 2013. For that purpose the Council of the European Union decided jointly with the European Parliament and the European Commission to establish a Joint Undertaking (JU) which will become effective in 2007. The prime task of this SESAR JU is to organise, monitor and manage the validation and development process needed to implement the new ATM system targeted for 2020 within the final SESAR implementation phase (2014-2020). DFS applied for becoming a funding member of SESAR JU together with other major European ANSP's to enforce the efficient implementation of the SESAR concept of Operations vision of an ATM system capable of the challenges faced in 2020.

As it is estimated that the SESAR JU will not start real work before beginning of 2008, European Commission decided to speed up the validation process by launching an ATM validation project within the scope of its 6th research framework programme. This project is titled "Single European Sky Implementation Support through Validation" (Episode 3). The project started in April 2007 and integrates 26 key partners including DFS, mostly participating in SESAR, covering all technical and system aspects including flow and traffic management, air traffic control, airspace user and airport operations. Prime purpose is to undertake the first concept assessment building on SESAR definition phase performance assessments.

Episode 3 will focus assessment using ICAO key performance areas and the E-OCVM (European operational concept validation methodology). SESAR concept elements specifically address European ATM bottlenecks and are the starting point for Episode 3.

Episode 3 has developed sequences of classical and innovative assessment tools including:

– Expert groups providing initial qualitative assessment against selected key performance areas in relation to operability, safety and human factors whilst also developing validation scenarios
– Gaming exercises providing human assessment of strategic decision making processes feeding fast-time simulation and analytical modelling
– Fast-time modelling assessment of key performance areas, filtering scenarios and options to be evaluated by real-time simulation and trade-off activities
– Real-time simulation providing qualitative operational assessments valuable for developing the concept and building common understanding

Assessment activity will exploit partners' validation capabilities in a European validation infrastructure during two validation cycles covering a generic first assessment followed by local specific validation activities bringing data to the concept performance assessment. DFS is a key partner within this process both to speed up validation as well as to support internal decision making processes on implementation issues related to SESAR.

6. THE TARGET FOR CHANGE: MORE CHANGE

For everybody working in ATM on the European level it is obvious that the change needed will entail more change. For that reason it is vital for any organisation acting in this area to set up an efficient way to deal with this continuous change process. DFS established based on the Single European Sky regulations and serving this need an ISO 9001:2000 compliant, company wide process structure and quality management system. However, this is only one part of the challenge, i.e. to handle changes within the existing organisation.

Thus DFS currently strongly supports national politics in progressing on the path of further privatisation. For now, DFS is corporative but 100% owned by Federal Republic of Germany. Target is to capitalise at a minimum 49% of the shares. Given this step, a re-structuring of the company, e.g. into a holding structure or any other reasonable form, may be considered in the future as an option to implement the change needed not only within the existing organisation but also across different, possibly new organisations. Examples in that direction may be current DFS interests on FCS Flight Calibration Services GmbH in Braunschweig or TTC The Tower Company GmbH in Langen. These examples show: DFS is ready for change already today. And DFS is willing to shape this change together with the European partners.

7. ABBREVIATIONS

3D	3 dimensional
4D	4 dimensional
ANSP	Air Navigation Service Provider
ASAS	Airborne Separation Assistance System
ATM	Air Traffic Management
AVENUE	An ATM Validation Environment for use towards EATMS
BMWi	Bundesministerium für Wirtschaft und Technologie (Federal Ministry of Economics and Technology)
C-ATM	Cooperative Air Traffic Management
CDM	Collaborative Decision Making
ConOps	Concept of Operations
DEVAM	Development of EATCHIP/EATMP Validation Methodologies
DFS	DFS Deutsche Flugsicherung GmbH
EATCHIP	European Air Traffic Control Harmonisation and Integration Programme
EATMP	European Air Traffic Management Programme
EATMS	European Air Traffic Management System
EC	European Commission
ECIP	European Convergence and Implementation Programme
E-OCVM	European Operational Concept Validation Methodology
ERASMUS	En Route Air Traffic Soft Management Ultimate System
ERATO	En-route Air Traffic Organiser
E-TMA	Extended Terminal Manoeuvring Area
FCS	FCS Flight Calibration Services GmbH
ICAO	International Civil Aviation Organisation
ISO	International Standardisation Organisation
iTeC	Interoperability Through European Collaboration
JU	Joint Undertaking
KPA	Key Performance Area
LCIP	Local Convergence and Implementation Plan
MAEVA	A Master ATM European Validation Plan
OCVSD	Operational Concept Validation Strategy Document
ODID	Operational Display and Input Design
PHARE	Programme for Harmonised Air Traffic Management Research in Eurocontrol
R&D	Research and Development
SES	Single European Sky
SESAR	Single European Sky Air Traffic Management Research
TMA	Terminal Manoeuvring Area
TORCH	Technical Economical and Operational Assessment of an ATM Concept achievable from Year 2005
TTC	The Tower Company GmbH
VDR	Validation Data Repository
WFF	Wettbewerbsfähiger Flughafen (Competitive Airport)

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