



E-OCVM Version 3.0 Volume I

**European Operational Concept
Validation Methodology**



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The Systems Engineering process is a discovery process that is quite unlike a manufacturing process. A manufacturing process is focused on repetitive activities that achieve high quality outputs with minimum cost and time. The **Systems Engineering process** must begin by **discovering the real problem** that needs to be solved; the biggest failure that can be made in systems engineering is finding an elegant solution to the wrong problem. Once the problem is discovered and defined, a solution that provides the appropriate mix of cost, schedule and performance metrics, based on the **stakeholders' expectations**, must be discovered. In keeping with addressing the **solution's life cycle**, other discoveries have to address the development, manufacturing, training, deploying, refinement, and retirement of the system.'

(INCOSE Guide to the Systems Engineering Body of Knowledge)

CONTENTS

FOREWORD	v
PART I – ATM SYSTEM DEVELOPMENT – ROLE OF VALIDATION PROCESSES AND THE E-OCVM METHODOLOGY	1
1 INTRODUCTION	3
1.1 Scope	3
1.2 Intended Audience	3
1.3 Structure of the E-OCVM Version 3.0	4
2 ROLE OF OPERATIONAL CONCEPT VALIDATION IN ATM SYSTEM DEVELOPMENT	5
2.1 Operational Concept Validation	5
2.2 Assumptions on the Role of Validation in ATM System Development	5
2.3 ATM Concept Lifecycle Phases	6
2.4 E-OCVM and Concept Development	7
2.5 Managing Progress through the Lifecycle	7
2.6 E-OCVM and the Verification Process	8
2.7 E-OCVM and a Performance Framework	8
3 ORGANISING VALIDATION IN LARGE-SCALE CONCEPT DEVELOPMENT	9
4 RISKS AND CHALLENGES TO VALIDATION	10
PART II – OVERVIEW OF THE E-OCVM	11
5 PRINCIPLES OF THE E-OCVM	13
5.1 Scope	13
5.2 Evidence-Based	13
5.3 Scalable	13
5.4 Configuration Control and Change Management	13
5.5 Transparency	13
5.6 Ensure Overall Coherency	13
5.7 Balancing ‘Generic’ and ‘Local’ Assessment	14
5.8 Use	14
6 THE E-OCVM – A PROCESS OF SEVERAL PARTS	15
6.1 Concept Lifecycle Model & Maturity Assessment	15
6.2 Structured Planning Framework (SPF)	20
6.3 Case-Based Approach	21
7 DOCUMENTING THE VALIDATION PROCESS	23
7.1 Validation Strategy: Organising the Work of Validation	23
7.2 Operational Concept Description	24
7.3 Validation Exercise Plans	24
7.4 Validation Exercise Reports	25
7.5 Performance Framework	25
7.6 Validation Maturity Map	25
7.7 Consolidated Validation Results	25

PART III – E-OCVM - DETAILED DESCRIPTION	27
8	CONCEPT LIFECYCLE MODEL (CLM) 29
8.1	V0: ATM Needs 30
8.2	V1: Scope 30
8.3	V2: Feasibility 32
8.4	V3: Pre-Industrial Development & Integration 33
9	MATURITY ASSESSMENT AND LIFECYCLE TRANSITION CRITERIA 35
9.1	Lifecycle Phases and Key Decisions 36
9.2	Scope 36
9.3	General Characteristics 36
9.4	Transition Criteria 38
10	STRUCTURED PLANNING FRAMEWORK 43
10.1	Summary of the SPF 43
10.2	SPF Steps and Sub-Steps 44
10.3	Impact of Current Validation Phase (V1, V2, V3) on the SPF 47
10.4	Guidance on Selection of Validation Techniques and Tools 48
11	CASE BASED APPROACH 50
11.1	Case development along the CLM 50
11.2	Typical case output 51
11.3	Business Case 51
11.4	Safety Case 51
11.5	Human Factors Case 52
11.6	Environment Case 52
11.7	Standards and Regulation Case 52
11.8	Relationship between the Cases 53
11.9	Implementation of Case-Based Approach within the SPF 54
12	GLOSSARY & TERMINOLOGY 56
13	ABBREVIATIONS & ACRONYMS 60
14	INFORMATION & FURTHER READING 63
14.1	Validation Forum Website 63
14.2	Reference Material on ATM Concept Validation 63
14.3	Examples of 'Validation' Projects 63
14.4	Reference Material on Software Engineering and Requirements Management 64
14.5	Reference Material on Maturity Assessment 64
14.6	Reference Material on Performance Assessment 64
14.7	Reference Material on SESAR 64
14.8	Reference Material in Support of Standardisation and Regulation 64
14.9	Reference Material in Support of Cases 65

mid 90s	Recognition that lack of Business Case to support decision making
2000	
2001	
2002	EUROCONTROL makes the Validation Data Repository available (April) MAEVA provides first version of the Validation guide handbook. (June)
2003	
2004	MAEVA project completed (April) CAATS project started (April) First meeting of the Joint Programme Board (JPB) (Oct)
2005	JBP endorses E-OCVM for collaborative projects with EC and EUROCONTROL (Jan) Validation Forum Supervisory Board set up (May) Release of E-OCVM v1.0 (June) First meeting of Validation Forum Supervisory Board (Nov)
2006	CAATS project completed (March) CAATS II project started (Nov)
2007	Release of E-OCVM v2.0 (March) Episode 3 project started (April)
2008	
2009	CAATS II project completed (Nov) Episode 3 Project completed (Dec)
2010	Release of E-OCVM v3.0

FOREWORD

Since the mid-1990s ATM research in Europe has been striving towards a coherent approach to create a basis for clear and understandable information (i.e. a business case) in order to support efficient transfer from R&D and effective decision making on implementation of new operational concepts and ATM systems. This effort led to the development of the European Operational Concept Validation Methodology (E-OCVM) presented in Version 3 in this document. The timeline opposite summarises key events in that development.

E-OCVM was created as a framework to provide structure and transparency in the validation of air traffic management (ATM) operational concepts as they progress from early phases of development towards implementation. Its aim is to achieve consistency in the collaboration of independent R&D organisations, aiming at a coherent approach and comparability of results across validation activities and projects, while leaving freedom to define the most practical planning and execution of individual activities. It provides validation practitioners, as well as experienced programme and project managers, with both a common understanding of what is required to perform validation and the framework necessary to collaborate effectively. Since 2005 it has been mandatory to apply the E-OCVM in collaborative ATM R&D projects of the European Commission and EUROCONTROL.

Version 3 of the E-OCVM continues to be a framework for carrying out R&D rather than a strict set of rules. It complements the principles of earlier versions based on real experiences of applying the methodology. The Validation Supervisory Board, comprises representatives of the diverse stakeholders of ATM, namely AT-One representing the European ATM Research And Development Association (EATRADA), Deutsche Flugsicherung representing the Air Navigation Service Providers in Europe, Indra as an ATM ground system manufacturer, Isdefe representing the European Commission project CAATS II, and representatives from the European Commission and EUROCONTROL. It was responsible for supervising the development of Version 3. The development work itself was carried out within European Commission and EUROCONTROL projects. The principal changes from Version 2 are in two important areas:

- the necessary management of stakeholder expectations and information requirements through ‘transversal cases’, such as the Safety, Business, Human Factors and Environment Cases;

- the assessment of the maturity of the concept, and the management of concept development transitions, from the initial identification of the problem through to transfer of the concept development from R&D to industry for implementation.

The target audience for the E-OCVM includes, but is not restricted to:

- managers setting up development programmes;
- programme managers;
- project managers;
- system developers;
- validation practitioners.

In 2007 the European Commission and EUROCONTROL set up a public-private partnership called the SESAR Joint Undertaking (SJU) to represent the principal stakeholders of the ATM system. The role of the SJU is to ensure the modernisation of the European air traffic management system by coordinating and concentrating all relevant R&D efforts in the Community.

Version 3 of the E-OCVM is timely in view of the many validation activities currently being initiated in the SESAR Development Phase. Principles of the E-OCVM have contributed to the SJU’s approach to validation, which is embodied in the System Engineering Management Plan (SEMP) and the SESAR Validation and Verification Strategy.

While the Validation Supervisory Board has maintained a close relationship with the SJU, it has kept the description of the E-OCVM in Version 3 as a standalone document, applicable to ATM validation activities in general. Nevertheless, any future developments of the E-OCVM are expected to be assured by the SJU.

This version is an evolution on Version 2 and will be used in the context of the SESAR JU work programme by nearly 300 R&D projects. Lessons learned will be fed back into daily use and may lead to an update of the methodology in the future.

The E-OCVM Validation Supervisory Board thanks you for your future contributions and hopes that you find E-OCVM Version 3.0 of value in your work.

PART I

ATM SYSTEM DEVELOPMENT

ROLE OF VALIDATION PROCESSES AND THE E-OCVM METHODOLOGY

Part I explains the position of validation and the E-OCVM in the wider context of ATM System Development.

Part I is relevant to anyone involved in the Research and Development (R&D) of new Air Traffic Management (ATM) operating procedures, human-machine interactions and supporting technologies. It is intended to support both small and large-scale validation activities.

It is targeted directly at:

- managers setting up development programmes;
- the managers of those programmes and their constituent projects;
- ATM system developers who need guidance to support operational concept development and evaluation;
- practitioners involved in evaluation of performance and behavioural capabilities including evidence gathering, evidence preparation (possibly as 'cases') and the description of concept of operations.

The methodology also helps the broader stakeholder community to understand the mechanisms of ATM R&D and their own participation. These stakeholders include system users, system providers, standardisation and regulatory bodies, and supporting technology providers.

Ultimately, the E-OCVM helps decision makers by identifying key decisions and structuring the evidence on which implementation and operational decisions can be based.

1 INTRODUCTION

1.1 Scope

Successful development of a system depends on having adequate methods to ensure that the planned system is achievable and will be fit for purpose. This need was recognised by European Air Traffic Management (ATM) Research and Development (R&D) and the discipline of ‘operational concept validation methodology’ emerged.

This document is Version 3.0 of the European Operational Concept Validation Methodology (E-OCVM), to be applied in European Commission (EC) and EUROCONTROL ATM R&D collaborative projects. In particular, this includes Single European Sky ATM R&D (SESAR) projects within the SESAR Joint Undertaking (SJU).

E-OCVM was originally created as a framework to provide structure and transparency to the validation of operational concepts as they progress from early phases of development towards implementation. Its aim was to achieve consistency in the collaboration of independent R&D organisations while leaving freedom for the execution of activities. It provides experienced programme and project managers as well as practitioners with a common understanding of what is required to perform validation and the framework necessary to collaborate effectively.

The methodology continues to be a framework for R&D conduct rather than a strict set of rules. Within that framework, each project or programme must develop working methods and practices adapted to the scale of the operational concept under validation. Version 3.0 does not change the principles of the earlier versions. Rather, it extends them, based on experience of application of previous versions, to better address larger scale validation activities that involve complex concepts with established performance targets, multiple partnerships and the need to construct a sound basis for decision-making. Further, this upgrade to Version 3.0 provides additional guidance material in two key areas:

- in the management of stakeholder expectations and information requirements through “transversal cases” (e.g. cases for, Safety, Environment, Business Case, Human Performance, and Standardisation and Regulation). Transversal cases consolidate the evidence from

assessments across the concept validation process from a particular perspective having a special significance to the stakeholders. Some of these may even be established as legal or regulatory requirements, e.g. safety cases, environmental impact assessments;

- in the assessment of concept maturity and the management of concept development transitions from initial problem identification through to transfer of the concept development from R&D to industry for implementation.

1.2 Intended Audience

The methodology is relevant to anyone involved in the ATM R&D of new operating procedures, human-machine interactions and supporting technologies. It is intended to support both small and large-scale validation activities.

It is targeted directly at:

- managers setting up development programmes;
- the managers of those programmes and their constituent projects;
- ATM system developers who need guidance to support operational concept development and evaluation;
- practitioners involved in evaluation of performance and behavioural capabilities including evidence gathering, evidence preparation (possibly as ‘cases’) and the initial description and further detailing of the concept of operations.

The methodology also helps the broader stakeholder community understand the mechanisms of ATM R&D and their own participation. These stakeholders include system users in general, system providers, standardisation and regulatory bodies, and supporting technology providers.

Ultimately, the E-OCVM helps decision makers by identifying key decisions and structuring the evidence on which implementation and operational decisions can be based.

1.3 Structure of the E-OCVM Version 3.0

The present document is **Volume I of the E-OCVM Version 3.0** and is divided into three principal parts:

- Part I explains the position of validation and the E-OCVM in the wider context of ATM System Development;
- Part II gives an overview of the principal elements of the E-OCVM and the relationship between them;
- Part III discusses the individual elements of the E-OCVM in detail and provides guidance on their application.

These three parts are complemented by:

- Glossary and Terminology sections;
- Acronyms and Abbreviations;
- A list of further reading providing background and reference material for many of the topics addressed in this document and closely related ATM system development.

A companion document, **Volume II of the E-OCVM Version 3.0** contains annexes and support material to the application of E-OCVM. Dedicated elements provide:

- a brief introduction to requirements development;
- an explanation of the relationship between the E-OCVM Concept Lifecycle Model (CLM) Phases and NASA Technical Readiness Levels (TRLs);
- support material for the application of the Structured Planning Framework (SPF) at programme, project and exercise levels;
- a categorisation of Research and Development needs;
- transition criteria through the concept lifecycle;
- guidance on the development and incorporation of different transversal cases;
- guidance material on Validation Support to Standardisation and Regulation as an annex.

It is anticipated that programme managers should find sufficient information in Vol I, Part I to understand the significance and role of validation and the E-OCVM. Vol I, Part II will allow project planners and managers to understand the activities that may need to be integrated and managed in their projects. Vol I, Part III and the supplementary material of Vol II, are intended to provide practitioners with information and understanding in support of their activities.

2 ROLE OF OPERATIONAL CONCEPT VALIDATION IN ATM SYSTEM DEVELOPMENT

ATM system development requires the concerted execution of many activities – one of which is operational concept validation, the subject of this document. The interplay of operational concept validation with the other activities (concept development, verification, etc.) needs to be established, depending on the specific development strategy. While these other activities lie largely outside the scope of this document, the current Section 2 seeks to place E-OCVM within the proper context in order to better identify and manage the necessary cooperative interfaces.

One essential for system development is the establishment of requirements, again in cooperation with other activities, including operational concept validation. The role of requirements needs to be understood by the reader of this document. An outline of requirements development is provided in Vol II.

2.1 Operational Concept Validation

Validation is an iterative process by which the fitness for purpose of a new system or operational concept being developed is established. The E-OCVM focuses on providing evidence that the concept is “fit for purpose” and answers the question, “Are we building the right system?”

2.2 Assumptions on the Role of Validation in ATM System Development

There are some key assumptions, which underlie the E-OCVM:

- Validation with E-OCVM is concerned both with the identification of the operational needs of the ATM stakeholders and the establishment of appropriate solutions (the operational concept). It follows an iterative process to ensure that the needs are properly understood, the solution is well adapted (the right system is being developed) and adequate supporting evidence has been gathered.
- E-OCVM is intended to support every scale of validation activity: from a single study to prepare for a local operational change to multi-national programmes. Consequently, it cannot simply be followed like a cookery book recipe but must be intelligently applied to develop a validation process adapted to both the scale and complexity of the activity and operational concept under development.
- Validation (and hence E-OCVM) is part of a larger system development/engineering process. It takes its place together with other important processes such as requirements management, concept refinement (solution development), verification, development of a performance framework, etc.

The remainder of Part I looks more closely at how validation and E-OCVM integrate into this larger system engineering process, highlighting the relationships of the greatest importance.

2.3 ATM Concept Lifecycle Phases

The E-OCVM adopts three different but related perspectives to organise validation activities: the Concept Lifecycle Model (CLM), the Structured Planning Framework (SPF) and the Case Based Approach (CBApp). All three are introduced more fully in Part II. The CLM describes the evolution of an operational concept through a number of phases from the initial recognition of need for change, concept development, validation and verification to implementation and operations. For historical reasons these are known as 'V' for Validation phases. This is NOT a reference to the 'V' diagram often used to describe the software development lifecycle!

The original six-step CLM described in E-OCVM V2.0 has been extended to provide a finer description of the later deployment, operational and decommissioning activities.

This lifecycle model is considered generally appropriate for all ATM concept lifecycle modelling, and hence it is assumed for use in all applications of the E-OCVM. Some sectors of manufacturing industry are accustomed to using 'Technology Readiness Levels' (TRLs) as initially proposed by NASA instead of the V-Phases. The TRLs provide a finer structure but can be easily related to the V-Phases, see Vol II, Annex 2.

The complete lifecycle is subdivided into eight 'V' phases. Concept development proceeds from left to right. Viewed very simply, the boundaries between phases can be considered as transitions or milestones where the

understanding of the operational concept and the body of evidence associated with it must provide enough information to decide that additional investment and transition to the next stage are justified. The decision is based on a Business Case that presents the range of stakeholder interests (and not simply the economic case).

E-OCVM and validation are mainly concerned with lifecycle phases V1, V2 and V3 but are also concerned with V0 to ensure that the correct initial conditions have been met. Validation activities in V3 must have sufficient understanding of V4 to ensure that the correct information is available to manage the V3 to V4 transition. The remaining phases V5, V6 and V7 fall outside the scope of E-OCVM.

Figure 1 emphasises that different processes may dominate at different stages in the lifecycle. Expressed simply, in the early stages problem identification and the establishment of targets and requirements for solutions will lead, then solution development and clarification (concept development) will predominate, this will be followed by assessment of the candidate solutions against the requirements (validation) and assessment of the technical achievability of the solutions (verification).

This lifecycle view provides the means to explore the relationship between E-OCVM and other key system engineering processes. The remainder of Section 2 describes these relationships.

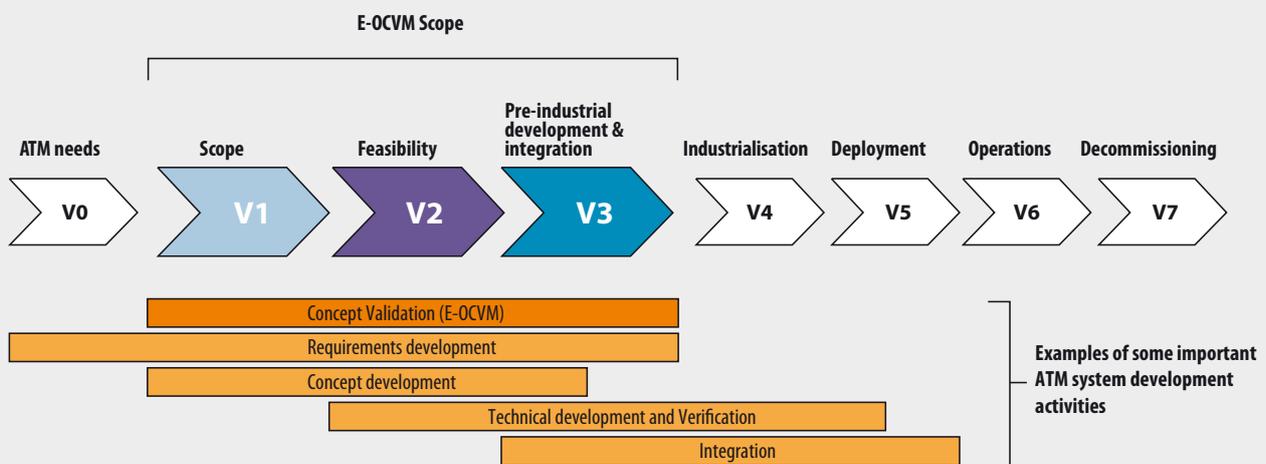


Figure 1: The Lifecycle V-Phases, validation and other ATM system development activities

2.4 E-OCVM and Concept Development

Following the expression of needs (in V0), one or more candidate solutions are identified and proposed. In ATM these solutions generally take the form of an operational concept, a proposal for a way in which the ATM system (people, procedures, technology) will behave (or operate) to meet the needs. When first developed, the concept will be expressed in relatively general terms, and there will be only limited information available on its potential to satisfy the requirements. As the concept proceeds through the different steps of the concept lifecycle, it will be detailed and refined in terms of its operations and its applicability to different operational contexts.

Figure 1 shows the close relationship between concept development and validation, the latter helping drive the former. The concept has to be clarified and modified in order to be able to respond to the demands of requirements and to the questions posed by validation. Initially some aspects of the concept will be clear, others less well defined and a significant effort must be invested in concept development in order to arrive at the homogeneous level of detail that allows effective and complete validation. However, as the concept progresses it becomes increasingly stable and effort focuses more on the collection of validation evidence. Ideally, by the end of V3 the concept should be stable, except for changes in requirements or new possibilities brought about by technical innovation.

2.5 Managing Progress through the Lifecycle

Managing progress through the concept lifecycle depends on understanding the state of maturity of the concept or “concept element” under study and on knowing what additional information and evidence is required to justify additional development at both the technical level and the project management level. The term ‘concept element’ is used in a general sense to describe a component of a larger concept, which can be the subject of individual development, validation and testing.

The E-OCVM explains how to assess the maturity level using a formal **Maturity Assessment** process (Section 6.1.2, Section 9). Maturity assessment is based on lifecycle phase transitions. To decide on V-phase transitions, **Lifecycle Transi-**

tion Criteria (See Vol II, Annex 4) are used as the basis for the maturity assessment. They define when the activities that should have been performed in a lifecycle phase can be considered complete.

Maturity assessment is important both at the programme management level and for the detailed management of the validation process itself.

At a **programme management level** the maturity assessment can steer an R&D programme from a strategic view point through regular monitoring and review cycles. It analyses the results obtained in projects relevant to a given operational concept, asking where the programme is in the lifecycle, what has been achieved during the last period, and what the implications of the obtained results are regarding the strategic objectives and performance targets. On this basis, the remaining **research needs** can be identified.

At **project and validation exercise levels**, maturity assessment is important in **steering the activities of the validation process** itself, within lifecycle phases as well as between them. By reviewing the maturity and coverage of validation content (the quality of understanding of the concept, how and where, it delivers performance) each time new data are obtained, it is possible to identify gaps and set validation objectives and priorities for the validation data that must be collected through appropriate exercises if the concept development is to progress and continue.

The other key ‘factor’ in focussing and steering development of a concept is the priorities, expectations and concerns of the stakeholders. In E-OCVM this is managed through the Case-Based Approach (Section 6.3)) and in particular through the **Business Case**, which plays a special role. The Business Case is considered as more than an economic case and cost-benefit analysis. It presents a balanced synthesis of the critical issues from the other cases (Safety, Human Factors, etc) to reflect the decision-making priorities of stakeholders in a particular validation activity. The content and complexity of a Business Case will reflect both the scale of the validation activity and the maturity of the concept under development.

2.6 E-OCVM and the Verification Process

The primary focus of E-OCVM is on concept validation. However, verification is also of great importance, and the two are often recognised in a single Systems Engineering process as Validation & Verification.

Whereas “validation” deals with the question, “Are we building the right system?” “verification” deals with answering the question, “Are we building the system right?” In order to answer either question, there must already be a well-defined concept for the system to be built. There are established standards and practices to deal with verification of such a well-defined system. However, in the early stages of concept development, such as V1 to V3 to which E-OCVM applies, these standards and practices are not applicable because the concept and system are not yet sufficiently mature. Hence the need for verification and the required degree has to be decided on a case by case level. The nature and credibility of assumptions need to be considered in this context.

It is important to establish in the early stages of system development that the necessary technology is available or will be available when needed. There may be different technology choices with different impacts on the current system environment, achievable performance and cost and time to deploy. Verification during V1 to V3 will be focussed on these issues as well.

The E-OCVM synchronises “validation” and “verification” by means of the Lifecycle Maturity Assessment process. At each lifecycle phase, the maturity criteria are used to examine both concept and system-related aspects. The maturity criteria for both concept and system-related issues must be sufficiently satisfied before advancing to the next lifecycle phase.

2.7 E-OCVM and a Performance Framework

Most proposals for the modification or redesign of ATM systems are driven by the need to improve performance in one form or another. ICAO has provided a Global Performance Framework, which serves as a general reference for performance assessment (see Section 14, Information & Further Reading).

In an ATM system development process the performance framework documents the Key Performance Areas (KPA), such as capacity, efficiency, etc., the Key Performance Indicators (KPIs), the performance targets, metrics and measurement-related assumptions that are used to assess the effectiveness of a concept.

In the case of small scale validation activity it may be sufficient to identify specific targets for the system and validation metrics for an assessment, but in the case of larger-scale performance-focused validation, the performance framework has the additional role of ensuring that all performance validation activities and exercises make measurements in a way which allows integration and comparison of results. In validation of very large concepts, it may also link performance targets at global and local level i.e. to establish the link between local performance in specific operational contexts and overall system performance. This means that a performance framework must be in place at a very early stage to ensure that it is taken into account in the planning of the validation programme and exercises.

The performance framework may be enhanced to support the understanding of how benefit is produced and delivered and for the examination of performance trade-offs.

3 ORGANISING VALIDATION IN LARGE-SCALE CONCEPT DEVELOPMENT

The E-OCVM is intended to be scalable to support a wide range of validation activities from small-scale studies to support local operational change to large ATM system development programmes. It must be interpreted and adapted to establish the validation process that is appropriate to particular activities in their particular contexts.

The ATM Concept Lifecycle Model introduced in Section 2.3 is easily applicable to a simple concept with little change to current operations that can be managed in a single work stream. However, in larger projects and programmes, validation will require the organisation of multiple R&D activities. In such cases, it is necessary to find a suitable segmentation of the overall concept into a set of coherent concept elements or clusters of operational adaptations, steps and/or enablers and to organise them into sequences of sub-programmes, projects and exercises. In project management terms, this corresponds to establishing an appropriate work breakdown structure.

Having broken the work down into an effective structure, the principal challenges are in ensuring coherence, and from the validation perspective, ensuring that the results of all the different validation activities can be re-integrated to build a clear view of the concept's fitness for purpose. This can only be achieved if the re-integration is anticipated and considered in the building of the work breakdown structure by establishing the necessary common principles and practices across the project or programme and implementing them as a suitable validation management process.

More generically, the E-OCVM supports this in a number of ways:

- the Concept Lifecycle Model and the Maturity Assessment process, complemented by the development of the Business Case, provide the means of controlling and synchronising progress of the different activities and work streams through the lifecycle.
- the Structured Planning Framework identifies key activities to be undertaken at the appropriate stages at exercise, project and programme level, e.g. sharing of high-level strategic principles, timely establishment of the performance framework and metrics (Section 2.7); documentation of key assumptions.

- the Case-Based Approach and the different cases help identify the key information required by stakeholders throughout the validation process again using the criteria for the maturity assessment.

4 RISKS AND CHALLENGES TO VALIDATION

Managing validation effectively, especially in a very large project or programme can be very challenging. Many different factors can have a negative impact on the ability to obtain good validation results.

Experience from completed validation-centred projects, e.g. FP5 Gate-to-Gate Project, FP6 Episode 3, and from analysis of material from the EUROCONTROL Validation Data Repository (VDR) has identified some of the 'classical' pitfalls to be avoided:

- lack of strategic focus and coordination of R&D activities. Exercise planning not driven by R&D and validation needs. Alternative solutions not identified and considered;
- failure to adequately assess maturity resulting in the execution of inappropriate validation activities. Typically assuming a level of maturity that is too high;
- tendency to validate what is easy and to leave the hard problems for later. While quick-wins can be useful, the hard problems often take longer to solve. So to keep to schedule the hard problems should possibly be addressed earlier, especially if they are potential show-stoppers;
- failure to adequately document an exercise and particularly the assumptions associated with it. This can severely limit the use of the data;
- failure to anticipate the needs for integration of data from different exercises. If the integration of data from different exercises is not considered during the identification of their assumptions and metrics (so that these can be shared where necessary), there is little chance that the results can be combined later;
- failure to use past project results leading to the unnecessary repetition of work;
- failure to conduct key activities in time, i.e. the high level validation strategy and the performance framework must be available early enough to be correctly incorporated in more detailed project and exercise planning;

- validation being driven by the capabilities of methods, tools and platforms instead of the converse. Validation exercises should be designed to achieve the validation objectives, so planning must ensure that the requirements for the correct methods and tools can be established in time.

There are particular risks when problems fall between the responsibilities of the different actors involved in the validation process. Consequently, programme, project and validation experts must all remain vigilant, and in communication to detect and mitigate such risks.

PART II

OVERVIEW OF THE E-OCVM

In order to best understand Part II “Overview of the E-OCVM” the reader should be familiar with the content of Part I “ATM System Development – Role of Validation processes and the E-OCVM Methodology”. Part I explains the position of validation and the E-OCVM in the wider context of ATM System Development.

Part II provides readers with an overview of how the E-OCVM is structured and used. It explains the key principles underlying the E-OCVM. It explains the three main components of E-OCVM, as already introduced in Part I, in more detail: the Concept Lifecycle Model (CLM) and Maturity Assessment Framework; the Structured Planning Framework (SPF); and the Case-Based Approach (CBApp). Finally, it describes the key documents and data associated with the application of the E-OCVM.

Part II is relevant for anyone who is more deeply involved in the ATM R&D of new operating procedures, human-machine interactions and supporting technologies e.g. on programme management level or below.

It is targeted directly at:

- the managers of programmes and their constituent projects;
- system developers who need guidance to support design and evaluation;
- practitioners involved in evaluation of performance and behavioural capabilities including evidence gathering, evidence preparation (possibly as ‘cases’) and the description of the concept of operations.

5 PRINCIPLES OF THE E-OCVM

5.1 Scope

The E-OCVM is concerned with validation of operational concepts following initial identification of ATM needs in V0 and preparing for Industrialisation in V4. Principally it focuses on the R&D issues around concept definition, feasibility assessment, pre-industrial development and integration within V1 to V3.

The E-OCVM recognises the need for a close coupling between validation and verification. Activities are identified to support integration of validation and verification through the CLM.

Note that an operational concept can be alternatively expressed as “Concept of Operations” or “ConOps”. The ConOps is a more detailed expression of an operational concept.

5.2 Evidence-Based

Support for a concept to be developed through to implementation is based on the provision of evidence. Evidence is built by demonstrating ‘fitness for purpose’ whereby stakeholders can judge if the concept is capable of being fit for their own purposes. Practically, this requires grouping results within a ‘Case Based Approach’ where a “case” is a structure for grouping evidence about critical validation aspects such as business, safety, human factors, environment, and standardisation.

5.3 Scalable

The E-OCVM is scalable depending on the scale and scope of the concept being assessed. Different organisational breakdowns may be applied, but they should recognise:

- overall programme level, addressing the whole of a complex operational concept;
- one or more concept element levels clustered into a ‘logical’ group on the basis of associated operation or the planning of implementation;
- project or exercise level.

Thus, the E-OCVM can be applied to validation of an individual airspace change or a complete programme, such as SESAR. When used for a large-scale programme it allows subdivision of the overall programme into intermediate and small-scale validation projects.

However, the guidance provided by E-OCVM (Section 6.2.2) cannot necessarily be directly applied to the highest levels of very large programmes. Additional influences such as international political constraints and social and, intercultural issues have to be considered. Their resolution lies largely outside the scope of E-OCVM.

5.4 Configuration Control and Change Management

The ATM needs (i.e. requirements) and operational concept will often evolve during R&D due to knowledge gained as well as potentially due to the evolving operational environment. Hence, the body of evidence that accumulates must be reviewed and managed to ensure its continuing relevance and applicability to the updated concept. This will be achieved by controlled review and revision of the entire system development documentation.

5.5 Transparency

The evidence must be developed through appropriate exercises and transparent processes. Performance must be measured in an objective manner using a **performance framework**. In particular, critical assumptions must be clearly documented.

5.6 Ensure Overall Coherency

The validation process must establish the evidence to demonstrate the interoperability of concept elements, which may be implemented together. This is necessary to ensure integration in a system-of-systems environment. Standardisation and Regulation is a particularly important driver for interoperability (see Part III).

5.7 Balancing 'Generic' and 'Local' Assessment

The E-OCVM recognises validation both for generic and locally adapted versions of operational concepts. When designing the validation strategy and project work plan, the requirements for both must be identified and planned if needed. Furthermore, in programmes anticipating widespread implementation there will be a need for assessment on both local costs and benefits and those on the wider scale.

The performance framework has an important role to play both in decomposing global targets to a local level to support assessment but also in understanding how results obtained at a local level can be used to construct wider performance assessments.

Similarly, assumptions about airspace organisation and traffic demand and behaviour need to be clearly understood and well documented if data from different exercises are to be related.

5.8 Use

The E-OCVM provides a framework to support collaborative validation of a concept in the European ATM R&D environment. It requires intelligent interpretation and application in order to achieve the most effective validation results.

6 THE E-OCVM – A PROCESS OF SEVERAL PARTS

Section 2.1 introduced operational concept validation as a part of the larger system development activity specifically concerned with ensuring that the system eventually developed will be fit for purpose.

The current section explains more fully how the proposed methodology brings three different perspectives together to structure operational concept validation and concept development:

The **Concept Lifecycle Model (CLM)** provides a model for the progression of a concept through various phases to full use in an operational system. The CLM structures the lifecycle into phases with clear transition criteria to separate lifecycle phases. This enables the monitoring of the progress of concept development towards performance goals and the control of resources, e.g. by redistributing priorities, starting additional work or stopping the concept development.

The **Structured Planning Framework (SPF)** structures the work to be carried out within the individual CLM phases so that exercises are designed, planned and conducted to meet the specific validation objectives.

The **Case-Based Approach (CBApp)** focuses on consolidating evidence from different CLM phases to build a consistent source of material on areas of special importance to the stakeholders, e.g. safety, environment, etc. It also provides guidance on the design of suitable exercises to obtain the evidence required.

6.1 Concept Lifecycle Model & Maturity Assessment

The validation process is structured around the Concept Development Model (CLM). The model defines a phased approach to R&D (V0-V3) where concept validation is conducted, but also covers the subsequent industrialisation and implementation steps (V4-V7). This phased approach to R&D aims to reduce uncertainties before unnecessary engagement of more resources/budget. The CLM introduces a decision point at the end of each phase.

Maturity Assessment supports the underlying decision making process. It analyses key results from concept validation activities to assess progress through the concept lifecycle. This enables decisions to be taken on what validation activities remain to complete the current lifecycle phase. It also provides a basis for decisions on whether to stop or to continue an R&D activity, depending on the results obtained so far.

An initial maturity assessment is conducted at an early stage in a concept validation project or programme to identify within what phase a concept element is situated and what work remains to be done. Maturity assessment is then conducted systematically to incorporate emerging validation results and to monitor progress. This allows both the development of effective validation planning and the basis for estimating investment required to completion. The latter may be necessary to support the Business Case for decision making at both project and programme levels.

6.1.1 The Structure of the Concept Lifecycle Model

The CLM aims to structure understanding and expectations on what evidence should become available and when. It shows how the different system development processes relate to one another within a common framework and provides the structure around which the Case Based Approach and the Structured Planning Framework are organised.

It supports the setting of appropriate validation objectives based on the R&D needs, reflecting the achieved maturity and the quality of existing evidence.

Concept development is the process of designing, describing, constructing and testing of working procedures and human technology integration. This is achieved with the support of models, hardware and software capabilities that mimic the behaviour of the potential end system.

An ATM concept takes time to develop into application and the validation process must allow for, and ideally accelerate, this ‘maturation’. Phases V1 to V3 of CLM in particular, create a structure for the concept validation that also accounts for the concept development needs. Throughout, CLM describes milestones in the development of a concept where fitness-for-purpose should be examined to avoid continued development without an indication of clear benefits or progress.

Figure 2 shows the lifecycle progression through all eight phases from the identification of a need to improve ATM

performance (V0) through to operational use (V6) and eventual decommissioning (V7).

During each of the phases where validation is conducted, the validation scope is likely to be refined in line with the advancing maturity of the concept. As the concept becomes more mature, the validation activity must become more focussed, rigorous and directly relevant to real world operations. As risk is decreasing, investment in larger validation exercises may be justifiable, where the scope and objectives of these exercises are sufficiently mature.

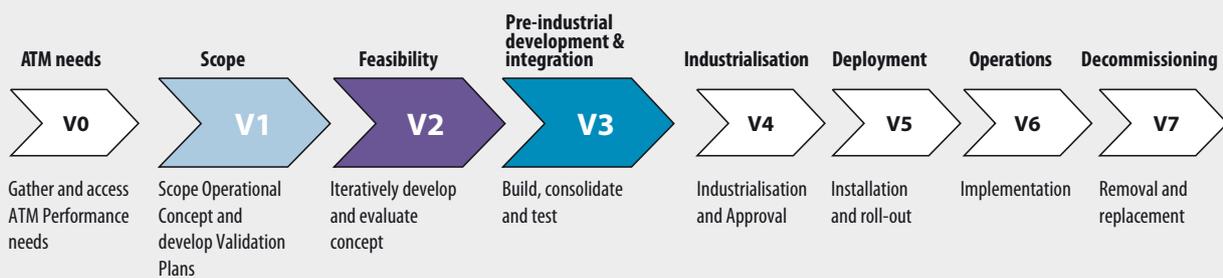


Figure 2: Concept Lifecycle Model

The phases of the Concept Lifecycle Model are:

- V0 ATM Needs** – The objective of this phase is to establish and quantify the need and drivers for change. The current and potential future situation should be analysed and the improvement areas and objectives identified and performance targets established.
- V1 Scope** – This phase identifies the operational/technical solutions for meeting the target performance identified in phase V0. The proposed operational concept(s) and associated technical solution(s) should be defined in sufficient level of detail to enable the establishment of an appropriate performance/assessment framework, the identification of potential benefit mechanisms, scope of potential applicability and initial cost estimates (order of magnitude) to justify R&D.

The identification of major research and development issues/needs (R&D needs) is also done during this phase to plan the corresponding R&D activities and establish the validation objectives. The “cases” relevant for these validation objectives are identified and established.

An important activity in this phase is to develop a validation strategy and planning, setting high level validation objectives and priorities and covering activities for V1 in detail, and V2 and V3 in outline. At the end of V1, this strategy/plan will be updated to cover V2 in detail and V3 in outline, taking the increasing validation knowledge into account.

V2 Feasibility – The main objective of this phase is to develop and explore the individual concept elements and supporting enablers until the retained concept(s) can be considered operationally feasible or it can be established that further development is no longer justified. To elaborate the concepts/enablers and to establish if they are feasible, this phase depends heavily on analysis, modelling and simulation (fast and real time), and may include some initial functional prototyping.

The definition of the concepts and supporting enablers is typically defined to be as open and as broadly applicable as possible thus the modelling and simulation should expose the concepts/enablers to a range of representative operational contexts to establish the actual applicability. This should help to demonstrate potential fitness for purpose across European environments. The **common performance framework** will play an important role in supporting the integration and comparison of results from different environments. However, in a small-scale validation activity, which is specifically targeted at a local change, the objective will be to define the concept(s) and validate in a local context as similar as possible to that of application.

Performance, operability and the acceptability of operational aspects should be the primary concerns. It is during this phase that operational procedures and requirements should become stable. One or more iterations may be needed depending on the complexity of the concept and the effort required to validate its performance/behaviour. In this phase, the human and technology integration, the operating procedures (for normal and important abnormal conditions) and the phraseology/communications requirements should be analysed and tested for the individual concept elements.

This stage will mainly establish the feasibility from the operational and transitional view point and provide initial elements for technical feasibility.

V3 Pre-industrial development & integration – The objective of this phase is threefold:

- firstly, to further develop and refine operational concepts and supporting enablers to prepare their transition from research to an operational environment;
- secondly, to validate that all concurrently developed concepts and supporting enablers (procedures, technology and human performance aspects) can work coherently together and are capable of delivering the required benefits;
- thirdly, to establish that the concurrent packages can be integrated into the target ATM system.

The main type of validation exercise conducted in this phase is thus concerned with integration, and establishing that the performance benefits predicted for individual concept elements in V2 can be realised collectively. It requires integration of pre-industrial prototypes in representative system platforms. This could include the use of real-time simulations and shadow mode/live trials, allowing exposure to different representative operational context environments.

At this stage the operational concept descriptions, applicable operational scenarios, operational procedures, benefit mechanisms, illustrative human-machine interfaces etc., should be stable and documented to a level which will support transfer to industry. V3 should provide adequate information, evidence and documentation to permit decision making and planning of further deployment.

This stage will complete feasibility from the operational and technical integration perspectives. It will identify costs and benefits clearly to allow decision making towards industrialisation and deployment and deliver the materials required to support industrialisation.

V4 Industrialisation – In this phase the applicable specifications are submitted, approved and published as Standards by the ATM community (e.g. through European Standards Organisations, namely European Telecommunications Standards Institute (ETSI), Comité Européen de Normalisation (CEN), European Committee for Electrotechnical Standardisation (CENELEC)). The need for regulation (e.g. to assure coordinated deployment) will be reviewed and if needed the regulatory mechanism will be used to develop implementing rules using the standards as means of compliance. “Pioneer” live operations may be started to build consensus and to gather further evidence to determine whether regulation is required. Another purpose of this phase is to develop approved (certified) product/procedure designs that comply with all applicable technical/operational specifications and standards as mandated by applicable regulatory/legislative provisions related to System Deployment and Operations.

The activities such as development of guidance/guidelines or any supporting material (e.g. training package) for the support of the Deployment Phase V5 are also carried out in V4.

V5 Deployment – During this phase the supply industry builds, installs, integrates and validates on-site systems/facilities/infrastructure. Individual users and service providers acquire such systems/facilities/infrastructure, locally adopt and deploy procedures, recruit, train and license their operational and support staff, purchase insurance, organise validation and acceptance, and receive permission (where required) to start operations.

Deployment may be pan-European or local. It may be plan-driven or market-driven (with or without incentives). Deployment may be based on voluntary application of standards or, if necessary, may be driven by regulation (e.g. through publication of Implementing Rules).

V6 Operations – Users and service providers operate in accordance with the deployed concepts and supporting enablers. This includes planning and management of day-to-day operations, as well as maintenance, recurrence training, performance monitoring and review, and operations monitoring and feedback to enable continuous improvement. It is during this phase that performance improvements and benefits are realised. In this phase the actual benefits can be measured and compared with the expectations and predictions from the validation process.

V7 Decommissioning – This phase serves to plan and execute the termination of the use of concepts and enablers by users and service providers. This normally takes place, as a final transition step, when they are no longer required due to evolution in operational requirements and operational solutions.

E-OCVM mainly addresses V1, V2 and V3 of the CLM. V0 is concerned with necessary pre-validation activity. During the later phases of Industrialisation (V4), Deployment (V5) and Operations (V6) different methodologies than those proposed here will be used (e.g. system-development “V” model). At the V3 to V4 transition the R&D community hands over advancement of the development process to industry. Consequently, effort must be invested to make certain that the outputs of V3 are prepared and packaged to ensure the effective transmission of all critical system information. This also applies to the validation infrastructure and can be very valuable in V4 if it proves necessary to revise work in order to clarify emergent issues identified in the later phases.

6.1.2 Maturity Assessment and Lifecycle Transition Criteria

Maturity assessment analyses result from concept validation activities in the context of the system development to assess progress through the concept lifecycle. At the programme level, it is used to steer the R&D from a strategic viewpoint through regular review cycles. It also has the potential, at the project and exercise levels, to identify gaps in understanding of concept behaviour and help focus the detailed planning of validation exercises.

The assessment analyses the results obtained in relevant system development activities on a specific operational concept element, (i.e. where is it in the lifecycle? What other work is ongoing? How well are the benefit mechanisms understood? What are the implications of recently obtained results for the strategic objectives and performance targets?), to provide recommendations for next steps in concept clarification and validation. This assessment should always include results from other projects, programmes and from the general literature.

Maturity assessment is a monitoring activity but is different from classical project progress monitoring. In programme and project monitoring the focus is on timely execution of agreed activities and on the provision of required deliverables/results. In maturity assessment, the focus is on to what extent, and with what reliability, the validation results confirm that the concept will achieve the target performance objectives. Maturity assessment develops and maintains the description of the maturity of the different concept elements in their different operational contexts (the **validation maturity map**). It provides recommendations on future R&D activities to initiate, to modify or to stop concept element/enabler related work. This feedback is then used to update programme, project and validation exercise planning.

Within a programme, it is quite frequent to find several projects contributing to the validation of the same operational concept and/or supporting enablers. It is therefore essential that the maturity assessment is also addressed at programme level. Under these conditions, it is also quite common to have an independent steering group to review results/proposals from projects/programmes and to make recommendations for the next phase. However if a project is not part of a larger programme, the initial maturity assessment will be done on the project level itself by conducting an early survey of the current maturity of the underlying subject concept based on related information coming from other research.

Lifecycle transition criteria are used in the maturity assessment. They define how to identify when a lifecycle phase's activities can be considered complete. The transition criteria and their application are specified in Section 9.4.

For effective concept validation, it is important to have a good, well-documented understanding of both:

- what is already known from work up to the point of the assessment (detailed concept description, performance model status, understanding of benefit mechanisms, etc.) and;
- what the "gap" R&D needs are: those aspects that need further investigation and definition. These remaining R&D needs are broken down within specific operational contexts to become validation objectives at the more detailed project and exercise levels.

It is also important that the key R&D results are reported in a form that is coherent with those R&D needs so their impact can be understood. Maturity assessment will be concerned with the completeness, consistency and confidence in the validation results.

The expectation is that each ATM R&D project addresses one or more of the R&D needs.

Maturity assessment addresses the following elements:

- consolidation of results obtained by several projects;
- identification of position and progress within the lifecycle phase;
- analysis of the impact of results on target objectives and recommendations for revision of the work programme (e.g. starting/stopping/repeating validation activities, revision of concept & supporting enablers to achieve feasibility or better performance, etc.);
- identification of the remaining R&D needed to complete the current and following phases until the end of V3.

The maturity assessment delivers and maintains the concept-level **validation maturity map** (Section 7.6) and provides recommendations for the decision making process.

6.2 Structured Planning Framework (SPF)

The Structured Planning Framework (SPF) is the process for planning and conducting R&D validation activity, such as programme, project or exercise, in a particular CLM phase.

The SPF comprises a number of steps relating to the planning, conduct and reporting of the R&D validation activity. Each step is divided into sub-steps that detail the particular tasks involved in that step.

6.2.1 The SPF and the CLM

The application of the SPF depends on the particular CLM V-phase in progress.

For CLM phase V0, the only SPF activity that has to be conducted is “Capture ATM Needs” (part of Step 0).

For CLM phases V1, V2 and V3, the SPF should be performed fully (Steps 0-5), at least once for each V-phase. The SPF may be repeated more than once for a given phase if the maturity achieved for the concept and the validation evidence is judged insufficient against maturity assessment criteria.

However, if maturity assessment indicates that a concept and the supporting evidence have already reached a higher level of maturity, the appropriate lifecycle phase may be skipped. For example, if a concept and supporting evidence is judged to have reached V2, the run of the SPF for V1 may be missed out.

The SPF is not normally carried out for CLM phases V4 and above, since these relate to industrialisation, deployment, operation and decommissioning. System development methodologies other than E-OCVM exist for these activities.

6.2.2 The SPF and Programme, Project and Exercise Levels

The SPF is concerned with the conduct of work to develop or refine a concept and to produce the supporting evidence that it will meet the identified ATM needs.

A validation programme sets the overall validation strategy, objectives and work plan for validating a concept. Typically, the validation work plan is expressed as a set of sub-tasks or validation projects, each project addressing validation of some element(s) of the overall concept. Each project will comprise

one or more exercises. R&D needs at the programme level must cascade down through project validation objectives to exercise validation objectives.

Exercises correspond to individual assessments, and might employ different techniques such as real-time or fast-time simulations, or expert group or gaming evaluations depending on their objectives. Exercises provide validation results that are fed back up the validation chain to the project and programme levels, with appropriate reviews at each level. These reviews may instigate revision of the validation strategy and validation work plan, as well as detailing the concept itself.

The content of the steps and sub-steps of the SPF depends on whether the SPF user is responsible for a programme, project or exercise. The relationships between the programme, project and exercise levels is shown in Figure 3.

For details of individual steps and sub-steps see Section 10.

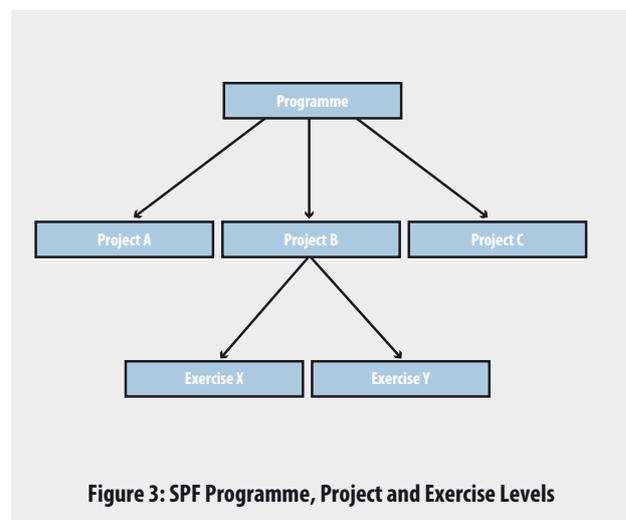


Figure 3: SPF Programme, Project and Exercise Levels

Intermediate levels might also exist between the programme and project levels as a means of sub-dividing the programme (and hence also the validation strategy, validation work plan and validation results) into manageable sub-units. For example, there may be a need for several sub-programmes of work to sit between programme and project levels.

Conversely, a small-scale R&D validation activity may require only a standalone validation project with a few contributing exercises, in which case the programme and project level activities of the SPF are merged.

Thus, the decision on how to structure the overall validation activity must be taken by considering the specifics of the concept itself. In the case of very large programmes with more planning levels as proposed in Figure 3, the guidance provided by E-OCVM may no longer be sufficient. In this case very experienced individuals need to contribute on a case by case basis.

6.2.3 SPF Steps

The SPF comprises six steps. The steps are applied differently according to the lifecycle phase and programme/project/exercise level, but a brief description of each step is provided below. The programme-project view mainly concerns Steps 0, 1, 4 and 5, whilst the exercise view mainly concerns Steps 2, 3 and 4.

Details of individual steps and their breakdown into sub-steps are provided in Section 10.

Step 0 - State Concept and Assumptions

This step identifies the problem, its severity and against what key measures and target performance levels the problem is being assessed. It also concerns development (or refinement) of the solution, or simply understanding the solution where one is already proposed. This step should be re-examined at the beginning of each new concept lifecycle phase.

Step 1 - Set Validation Strategy

This step identifies stakeholders, issues, aims, objectives, indicators, maturity criteria, cost-benefit mechanisms and expected outputs of the validation process. This information is used to develop the validation strategy and validation work plan. At the beginning of each phase of the lifecycle, the information in the validation strategy and validation work plan should be reviewed and possibly modified and refined, taking all levels such as programme, project and exercise into account.

Step 2 – Determine the Exercise Needs

This step plans a validation exercise defined in the validation work plan prepared at the project level. It captures all the detailed exercise needs appropriate to the maturity of the lifecycle phase and the proposed solution.

Step 3 - Conduct the Exercise

This step is where the validation exercises are conducted. This step is repeated for each exercise defined in the validation work plan prepared at the project level with the aim of collecting evidence about feasibility and performance of the proposed solution.

Step 4 - Analyse the Results

An exercise's results are analysed and reviewed against its aims and objectives. The results are passed up to the higher planning level, where they will be collated and passed up to the next level of management of the validation activity, as required by the programme/project structure.

Step 5 - Disseminate Information to Stakeholders

This step processes and collates information from the exercises in order to ensure that information is accessible and understandable to stakeholders. To facilitate understanding, the information may be presented in terms of "cases". Unexpected results with an impact on the concept development or the expected performance or behaviour are interesting results and should be presented. A stakeholder review is conducted to assess concept maturity and to make proposals for revision of the proposed concept, as necessary. If the results show that there are serious problems with the solution, the R&D validation activity may be terminated in extremis.

6.3 Case-Based Approach

This aspect of the concept validation methodology is concerned with providing specific feedback to the concept developers and providing stakeholders with targeted information in an easily understood format appropriate to their needs. The information that serves as evidence should be relevant to the performance objectives and targets (as identified in phase V0 of the Concept Lifecycle Model) that the concept intends to address. The stakeholders' questions concerning the concept and its performance need to be answered.

The application of the Case-Based Approach thus helps to drive information requirements. Together with the application of the performance framework approach, this supports the development of an appropriate validation strategy.

The development of the cases requires specific, relevant expertise and guidance on this aspect is given in several places in the E-OCVM. Apart from this introduction to the Case-Based Approach, Section 11 provides the definition and purpose of the:

- Business Case;
- Safety Case;
- Environment Case;
- Human Factors Case;
- Standards and Regulatory Case.

It also gives some key principles of the relationship between cases. Vol II, Annex 5 describes in more detail how to build the content of those cases and how the cases are related. Detailed material providing best practices and guidance for the first four cases is provided in the CAATS II deliverables; see Section 14, "Information & Further Reading".

6.3.1 The Case-Based Approach and Stakeholder Information Needs

The main objective of using a case is to group diverse information into a clear structure in order to describe the potential of the concept under evaluation and thereby support the stakeholders by providing the evidence they require to make investment and implementation decisions.

The principal cases that should be anticipated are safety and security, human factors, environmental, standards & regulation and technology. Together with an analysis of the economical impacts of implementing and operating the concept, the cases are synthesised into the Business Case as a support to higher-level decision making processes.

When required, a special synthesis of the contents of these cases could be made to address the needs of identified stakeholder groups e.g. operational, safety regulators, ANSP investors, airline investors, technology suppliers etc. As well as the overarching Business Cases constructed to support decision making at programme level, individual stakeholders need information to support decision making within their own business models.

6.3.2 The Case-Based Approach and the CLM

Each case will be developed along the concept lifecycle, see Figure 4. During the earlier CLM phases (i.e. V1), the cases will deliver only preliminary case-related performance based evidence and the focus will be more on providing feedback to the concept developers so that the case aspects of the concept can be improved. During later CLM phases (i.e. V3) and with the benefit of an improved, more stable concept, the focus changes towards providing evidence that the concept is fit for purpose, by means of detailed assessments. The cases and Figure 4 are explained more fully in Section 11.1.

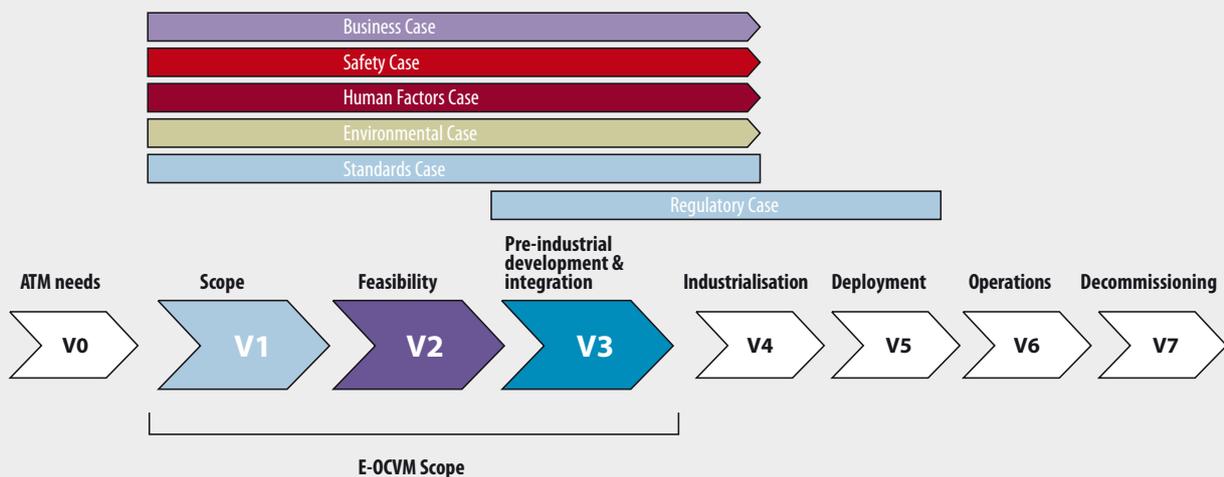


Figure 4: Scope of the different cases along the CLM

(Note that although the development of the Business, Safety, Human Factors and Environment Cases will continue in V4-V7, the E-OCVM provides only guidance on how to build these cases in the R&D phases V1-V3)

7 DOCUMENTING THE VALIDATION PROCESS

The E-OCVM methodology is founded upon a number of key documents. The term “document” is used in a broad sense. For example, some of the documents may be maintained in the form of databases or through the use of Computer Aided Software Engineering (CASE) tools.

First and foremost it takes a strategic approach by organising the work around a **validation strategy** document, which is maintained throughout the R&D activity as a **living document**. As evidence is gathered or the concept changes the validation strategy is revisited and updated under careful **configuration control** and **change management**. This reflects the **iterative and incremental nature** of the methodology. Thus, the validation strategy reflects the current situation, is the basis for planning of future activities and provides the common orientation for coping with uncertainty in the longer-term. Its key role to provide a unified approach throughout validation is described in Section 7.1.

The validation strategy is supported by a number of other key documents described in the following sub-sections.

7.1 Validation Strategy: Organising the Work of Validation

Validation strategy plays a key role in the organisation of the activity of validation. The overall purpose of a validation strategy is to ensure that a validation programme or project fulfils its functions. It does this by ensuring that there is a common understanding of the set of shared principles and practices, which are to be used to structure and organise activities throughout concept development and validation to progress the maturity of the concept through to implementation. Consequently, it encapsulates or identifies (but does not necessarily detail):

- the overall R&D needs/validation objectives of the activity;
- the rationale used to structure and prioritise the more specific validation activities;
- the assumptions about concept, scope and context;
- shared processes, tools, reference material or criteria (assessment of performance, maturity assessment, etc.).

These must be shared or applied by all validation activities covered by the validation strategy to produce the coherent and consistent results needed if an adequate validation of the target concept is to be achieved. To do this it must be developed early in the process of validation (during V1 of the CLM) so that it can be used to drive initial planning. It is then further developed and revised throughout the lifecycle.

As validation activities increase in scale or involve a larger number of actors, the role of the validation strategy becomes more and more important in establishing and documenting those elements that must be shared.

7.1.1 Validation within a Project Management Framework

When validation is organised in the context of large programmes (such as SESAR) it is essential that the first **programme validation strategy** covering the above points at the level of the global activity, is available at an early stage in the project (early in V1). It must be available prior to the elaboration of the detailed work-planning to identify the validation activities and exercises that are needed. Exercises proposed without this guidance may contribute validation results, but these may lack the form and coherence required for effective validation.

This Initial validation strategy will be reviewed and developed further with experience as a programme or project progresses, but it will provide the stable reference and principles which guide prioritisation and re-planning when difficulties are encountered or the operational concept or context evolve.

In simple and easily structured validation activities involving few exercises and a small team, it might be sufficient to capture and document the key assumptions and principles directly in the validation exercise plan.

However, in large or complex concept validations, where the activity is broken down into sub-activities (projects, work-packages, etc.) each containing a number of related validation activities, the practices, principles and assumptions of the initial validation strategy may need to be expanded and detailed more fully as local **sub-activity validation strategies**. These are used to ensure an appropriate and consistent interpretation for the development of validation exercise plans within the sub-activity, while documenting its relation and coherence with the overall validation strategy.

The sub-activity's strategy clarifies how the contents of the validation strategy for the programme should be interpreted and mapped to the sub-activity. It documents additional assumptions and principles as required by the sub-activity (e.g. how performance targets are to be mapped, how traffic demand is to be interpreted in the local context), so that exercises can be developed to be both locally and globally consistent.

7.1.2 Strategy-Driven Validation Work Planning

Once the strategy has been initially developed, there is a number of further steps in developing an appropriate validation work plan. Firstly, the concept may be broken down into convenient elements to make the task more manageable. Then, these different elements must be individually assessed for maturity against the CLM. This is done by referring to available R&D results and by making a judgement of the completeness of the concept description.

Then, to support the development of work plans in line with the initial validation strategy, activities to increase maturity against the validation objectives need to be identified and prioritised. As the necessary activities become clearer, the appropriate sequence of validation exercises is developed into a work plan.

This can be documented as the project management plan and work breakdown structure, reflecting the principles of

the validation strategy (or in the case of a very large project, the more detailed assumptions of the relevant validation strategies of identified elements, see Section 6.2.2).

7.2 Operational Concept Description

The descriptions of the operational concept and the applicable operational contexts are the principal inputs to an operational concept validation process.

This operational concept description combines the relevant results of the entire system development effort. Consequently, it is a common document, which must be managed and updated based on results and experience, to support all the different system development activities.

Depending on the scale of an operational concept, the concept and context descriptions might vary from short textual descriptions to complex data models.

Generally, the initial concept description is expressed in a (relatively) simple form, without detail, and as it proceeds and matures through the concept lifecycle the description is elaborated and refined. One of the key products of a validation process is the maturation of the concept description linked to the validation evidence, which supports and justifies the status of "validated concept". **A suitably documented and updated concept description thus plays a critical role in building and maintaining a shared understanding throughout the validation activity.**

7.3 Validation Exercise Plans

An exercise plan describes the way in which an exercise or activity is to be prepared and executed in order to achieve an objective. This description serves as the specification of an exercise in a way that allows others to reproduce the exercise.

An exercise plan may be more or less detailed depending on the complexity of the exercise, but typically should cover:

- **context** (background assumptions, why the exercise is needed, relationship to other exercises);
- **objectives together with the underlying assumptions and hypotheses** (what the exercise is intended to achieve under which conditions and assumptions, how success can be judged, e.g. against hypotheses);

- description of the exercise **process** (what is to be done);
- description of the **resources** (required to successfully achieve the objective);
- **indicators and metrics** (to be measured in order to achieve and integrate results at the appropriate levels).

In activities with several exercises, there may be value in having common templates to make it easier to ensure that all plans have the necessary information and that they share the same background assumptions.

7.4 Validation Exercise Reports

Exercise report documents describe and interpret the outcomes of exercises with respect to the objectives as described in the corresponding exercise plans. Underlying assumptions and hypotheses are verified and follow-up actions must be identified in the case of any issues which have emerged. The reports also describe any deviations from the anticipated processes and assumptions.

As for exercise plans, there may be an advantage in having common templates for exercise reports, both to ensure that reports cover the appropriate content and also to facilitate comparison and integration of results from different studies. However, templates must not be followed blindly but tailoring to the specific situation should be encouraged.

7.5 Performance Framework

A performance framework documents the KPAs, KPIs, performance targets and low level metrics and measurement related assumptions that are used to assess the effectiveness of a concept in the case of performance-focussed validation. Its role is to ensure that all performance related validation activities are measured in a way that allows integration and comparison of results. In larger validation activities, it may also link performance targets at global and local level i.e. to establish the link between local performance in specific operational contexts and overall system performance. The performance framework may be extended to support the understanding of how benefit is produced and delivered and for the examination of trade-offs between KPIs and between KPAs.

7.6 Validation Maturity Map

A validation maturity map links the description of the different concept elements of the operational concept with the assessment of their validation maturity. It may play an important role especially in large projects or programmes in maintaining a trace of effective progress and in establishing priorities for future validation activities. Individual concept elements must be assessed for maturity at an early stage in a programme/project following the principles and priorities laid out in the programme/project validation strategy. The purpose of this initial assessment is to provide both a baseline for future assessment and to plan the validation work, which will subsequently be required. The result of this assessment may be to identify that the concept elements are in V1, or already in V2 or even V3, in which case the planning will be developed accordingly.

Subsequently, the maturity status of the concept elements can be updated and tracked based on the outcomes of validation exercises which feed the maturity assessment process described in Section 6.1.2.

7.7 Consolidated Validation Results

Validation results are reported in several forms in addition to the reporting through the validation exercise reports:

- validation results, risks and outstanding issues from the perspective of stakeholder communities are captured in the different cases;
- Business Cases represent the most direct support for decision making processes. These not only include cost-benefit analysis and the economic case, but also capture and balance key information from the other cases and summarise validation maturity information. Specific Business Cases may need to be developed to support important local and global implementation decisions.

In addition to support for development related decision making, the validation process also contributes directly to a number of key knowledge-based deliverables supporting development and industrialisation:

- the detailed documentation of the operational concept and its applicability;
- the validation maturity map;
- the performance and influence models capturing the mechanisms whereby the concept provides benefit.

PART III

E-OCVM - DETAILED DESCRIPTION

In order to best understand Part III “E-OCVM – Detailed Description”, the reader needs to be familiar with the content of Part I “ATM System Development – Role of Validation processes and the E-OCVM Methodology” – and of Part II “Overview of the E-OCVM”.

Part I explains the position of validation and the E-OCVM in the wider context of ATM System Development. Part II provides readers with an overview of how the E-OCVM is structured and used.

This final Part III discusses the individual elements of E-OCVM in detail and how to apply them. It is relevant to anyone who is directly involved in the ATM R&D of new operating procedures, human-machine interactions and supporting technologies. It is targeted at:

- system developers who need guidance to support design and evaluation;
- practitioners involved in evaluation of performance and behavioural capabilities including evidence gathering, evidence preparation (possibly as “cases”) and the description of concept of operations.

IMPORTANT INFORMATION

The E-OCVM is a **framework** for validation. Sadly, there is no recognised formula that can be simply followed to ensure the effective validation of ATM Operational Concepts. The guidance and advice presented in the E-OCVM and especially in Part III and the Annexes are based on the experience of many years of concept validation and the current understanding of good practice. However, the advice must be followed critically and adapted intelligently to the concepts and contexts of validation.

8 CONCEPT LIFECYCLE MODEL (CLM)

As introduced in Parts I & II, the Concept Lifecycle Model (CLM) aims to structure expectations on what evidence should become available and at what stage in development. It supports the setting of appropriate research and validation objectives, shows how concept validation interfaces with concept and other system development processes and indicates where the operational concept and associated descriptive mechanisms should be verified.

Figure 5 shows the lifecycle progression through eight phases from the identification of a need to improve ATM performance (V0) through to operational use (V6) and decommissioning (V7). The iterative aspect of the process is not represented in this diagram.

The definition of these phases is provided in Part II. This section will focus on phases V1, V2 and V3 for which the “Concept Vali-

ation Methodology” was mainly developed. Since V0 plays a critical role in preparing V1 and the subsequent validation phases it is also treated in some detail. – Additionally, deliverables from system development activities other than validation are identified to provide a more complete picture.

For each phase, the typical activities will be defined and explained and the expected deliverables will be identified. It is important to note that many of the activities described relate to other concurrent system development processes, such as concept clarification, requirements management, verification, etc. The coordination of these different processes is the responsibility of programme management but is supported by the programme validation strategy. It is also important to note that the typical deliverables are defined at a high level to introduce the CLM as a framework. More detailed deliverables are addressed in the Case Guidance material in Vol II, Annex 5.

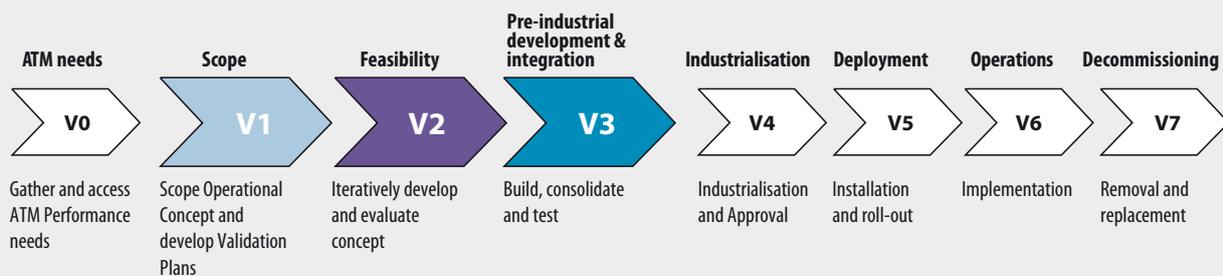


Figure 5: Concept Lifecycle Model

8.1 V0: ATM Needs

The objective of this phase is to establish and quantify the need for change. Major ATM problems and needs are identified by analysing both the current and potential future situations.

The typical activities in V0 are:

- Identification of major ATM problems and needs;
- Definition of performance targets.

8.1.1 Identification of Major ATM Problems and Needs

The current and projected future situation should be analysed to identify ATM problems and needs to be addressed in the targeted period. The projected future situation scenarios should be identified using forecasts and market studies. The performance needs and improvement areas should be identified through representative stakeholder groups and context(s) of use. The threats and opportunities for change should be identified by analysing and identifying the major contributing factors to those current or projected ATM problems and needs. The analysis should be done at a level that allows the identification of key areas that can be further improved and the establishment of high-level strategic objectives.

Deliverables:

- Current and future situation - ATM problems and needs.

8.1.2 Definition of Performance Targets and Strategic Objectives

Quantified performance targets are defined for all KPAs to appropriately address the ATM needs and improvement areas identified above.

Deliverables:

- Performance targets and strategic objectives.

8.2 V1: Scope

This phase identifies the operational and technical solutions for meeting the target performances identified in phase V0. The proposed operational concept(s) and associated technical solution(s) should be defined in sufficient level of detail to enable the identification of potential benefit mechanisms and initial cost mechanisms (order of magnitude) to justify subsequent R&D. The initial development and documentation of the concept, together with the ATM problems needs and targets from V0, make up the principal inputs to the operational concept validation process.

This phase integrates well-justified concepts in a R&D programme and particularly elaborates a validation strategy and work plan covering the R&D activities for the next two phases (V2 and V3). The identification of major research and development issues/needs (R&D needs) is also done during this phase to plan the corresponding validation activities.

The typical activities of V1 are:

- Initial definition of operational concept;
- Definition of initial logical system architecture;
- Definition of benefit and cost mechanism; initial justification for R&D;
- Identification of R&D needs (and high level validation objectives);
- Definition of validation strategy and work plan.

These typical activities and the related deliverables are briefly described below.

8.2.1 Initial Definition of Operational Concept

The operational concept should be defined at a level of detail which allows the development of the benefit and cost mechanisms and the identification of major R&D needs (explained in Section 8.2.4). The major concept options can be defined at this stage to allow planning of relevant validation activities to be conducted in V2. The process of elaborating the concept to this level requires a strong interaction between the operational concept development activities and the concept validation activities. In small scale developments/projects these activities may be conducted by the same team.

Deliverables:

- Initial operational concept.

8.2.2 Definition of Initial Logical System Architecture

The logical system architecture presents the design of the system independently from any physical implementation. It links the operational concept to the services and functions to be provided. The change in the current logical architecture should be identified at a level of detail which allows the development of the benefit and cost mechanisms and the identification of major R&D needs. Once again this will require good coupling between the architectural analysis and the performance analysis.

Deliverables:

- Initial logical system architecture.

8.2.3 Definition of Benefit and Cost Mechanisms: Initial Justification for R&D

The benefit mechanisms should identify KPAs for which benefits are expected, give the rationale for the proposed change and link the benefits to the relevant ATM problems/needs, performance targets and strategic objectives identified in V0.

The cost mechanism should identify potential procurement (including R&D), implementation and operation costs. At this stage, an order of magnitude is sufficient to allow an initial justification.

Potential benefits and costs are provided for representative stakeholder groups and intended context(s) of use.

Alternative concepts that address the same (or similar) ATM needs are identified. Arguments are developed to confirm the need to validate this concept instead of (or in addition to) these alternative concepts.

Deliverables:

- Initial Business Case.

8.2.4 Identification of R&D Needs

Major R&D issues/needs are identified based on high level benefits, risk and impact assessments (including those from transversal cases) covering all relevant KPAs and strategic objectives including safety, human factors, environment, etc. The major operational, technical and transition related feasibility issues are also identified considering the modification to operational procedures, to ATM architecture, required Communication, Navigation and Surveillance (CNS) technologies, standardisation and regulation requirements. The mapping of R&D needs to specific operational contexts and conditions will allow

the identification of more specific validation objectives. The R&D needs and how they can be captured and structured are further explained in Section 9.3.1 and Vol II, Annex 4.

Deliverables:

- High level analysis of benefits and risks for all relevant KPAs and strategic objectives;
- High level analysis of operational, technical and transitional feasibility issues;
- R&D needs.

8.2.5 Definition of Validation Strategy and Work Plan

Integrated validation strategy and complementary work planning are developed. They define all R&D activities to be done in the following two phases (V2 and V3). In keeping with the description in Section 7.1 the validation strategy provides the principles and priorities to organise the work of validation. In large programmes the overall programme validation strategy may be complemented by sub-activity validation strategies. The work planning applies the principles of the relevant validation strategy to identify a sequence of validation activities (e.g. exercises) that will progress the maturity of the concept to achieve the validation objectives.

The validation strategy and work plans do not address industrialisation which is addressed later in V4.

Deliverables:

- Validation strategy;
- Work plan (including planning of validation exercises).

8.3 V2: Feasibility

The main objective of this phase is to develop and explore the concept and supporting enablers until it can be considered feasible. In order to elaborate the concepts/enablers and to prove their feasibility, this phase is heavily based on modelling and simulation (fast and real time), and may include, in the case of a technical enabler, some initial prototyping as well (research prototype).

The definition of the concepts and supporting enablers is in principle performed at a generic level but the modelling and simulations should expose the concepts/enablers to different representative operational contexts. This should help to demonstrate fitness for purpose across European environments.

Performance, operability and the acceptability of operational aspects should be the primary validation concerns. It is during this phase that operational procedures and requirements should become stable. One or more iterations may be needed depending on the complexity of the concept and the effort required to validate its performance/behaviour. At the end of this phase human technology integration, operating procedures (for normal and key non-normal conditions) and phraseology should have been thoroughly tested.

This phase will mainly establish the feasibility from the operational and transitional viewpoints and provide initial elements for technical feasibility.

The typical activities of V2 are:

- Elaboration & validation of the operational concept;
- Preliminary technical feasibility assessment;
- Preliminary transition feasibility assessment;
- Preliminary benefits and risk assessments;
- Intermediate business case;
- Updated validation strategy and work plan.

These typical activities and related deliverables are briefly described below.

8.3.1 Elaboration & Validation of Operational Concept

This is a major and iterative activity of this phase. The concept is elaborated mainly taking into account various validation issues and results, i.e. operational, technical and transition feasibility results, benefit, risk and impact assessment results (including those from transversal cases) for all relevant KPAs.

Deliverables:

- Preliminary Detailed Operational Concept;
- Preliminary operational procedures;
- Validation reports.

8.3.2 Preliminary Technical Feasibility Assessment (research prototype)

If the concept requires introducing, or changing a technical enabler, it is specified, prototyped and tested in a research environment. The research prototype is integrated into the validation platforms and used in the operational concept validation activities.

Deliverables:

- Preliminary logical system architecture;
- Preliminary technical system architecture;
- Preliminary technical specification (including performance, interoperability and CNS technologies requirements);
- Research prototype;
- Validation reports.

8.3.3 Preliminary Transition Feasibility Assessment

The transition covers all the changes required for the implementation of the concept including institutional changes, infrastructure changes, re-allocation of people, training, etc. Major transition issues identified in the previous phase (Section 8.2.4) are checked for their feasibility and associated risks. This activity will rely heavily on the Case-Based Approach, e.g. for standards and regulation, human factors, safety, etc.

This assessment shall include the necessary identification of the further needs of regulation/legislation (V2/V3).

Deliverables:

- Preliminary transition phases definition;
- Preliminary transition feasibility report.

8.3.4 Preliminary Benefits and Risk Assessments

The benefits and risks are assessed for all relevant KPAs and strategic objectives. The major issues found during these assessments and requirements derived from them are provided as feedback to the operational concept elaboration and validation activity.

Deliverables:

- Preliminary safety and performance requirements;
- Preliminary benefits and risks assessment reports for all relevant KPAs and strategic objectives.

8.3.5 Intermediate Business Case

The key results from performance assessments (for all relevant KPAs) and from operational, technical and transition feasibility assessments are analysed from the business perspective. This includes not only monetary indicators from the Cost-Benefit Analysis (CBA) but also qualitative and quantitative results including those derived from the other transversal cases. Implementation scenarios are identified and their cost/impact estimated. Interdependencies and trade-offs are identified. Alternatives and options are compared. The affordability for the representative stakeholder groups is analysed.

Deliverables:

- Intermediate Business Case report.

8.3.6 Updated Validation Strategy and Work Plan

The R&D needs and corresponding validation objectives for the next phase are reviewed and further developed on the basis of the results obtained and experience gained. Work plans are revised accordingly. Where experience identifies the need for improvements in methods and tools, these are captured as **validation requirements** and used to drive the necessary improvements. In rarer cases where the validation approach is encountering difficulties or basic assumptions are proven to be inadequate, sub-activity, or even overall, validation strategy may require revision with a correspondingly larger impact on validation work planning.

Deliverables:

- Updated validation strategy;
- Updated work plan (including updated planning of validation exercises).

8.4 V3: Pre-Industrial Development & Integration

There are three main objectives to this phase. Firstly, to further develop and refine operational concepts and supporting enablers, in order to achieve their transition from research to a live environment. Secondly, to validate that all simultaneously developed concepts and supporting enablers (procedures, systems and human performance aspects) work together coherently and are capable of delivering the required benefits. Thirdly, it also validates that they can be integrated into the target ATM system.

One important class of validation exercises conducted in this phase can be identified as “pre-operational validation”. It requires integration of pre-industrial prototypes in representative system platforms to be used in real-time simulations or shadow mode/live trials, allowing exposure to different representative operational context environments.

In this phase the information allowing for decision and planning of further deployment should be clarified (e.g. finalisation of transition feasibility assessment, benefit and risk assessments, Business Case). This information includes the clear identification of necessary standardisation/regulation/legislation.

This stage will complete feasibility from the technical and integration (into the target ATM system) perspectives. It will identify costs and benefits clearly to allow possible decisions concerning industrialisation.

The typical activities of V3 are:

- Integration and validation of operational concept (with all other related concepts);
- Technical specifications and feasibility assessment (pre-industrial prototype);
- Transition feasibility assessment;
- Benefit and risk assessment;
- Final research business case.

These typical activities and related deliverables are briefly described below.

8.4.1 Integration and Validation of Operational Concept (with all other related concepts)

The operational concept is integrated into the target system and validated using realistic scenarios. Its interaction with all related concepts is analysed.

Deliverables:

- Detailed operational concept;
- Operational procedures;
- Operational validation reports.

8.4.2 Technical Specifications and Feasibility Assessment (pre-industrial prototype)

The technical specifications are developed to the level required for the industrialisation and for possible standardisation in the next phase. A pre-industrial prototype is developed on the basis of these specifications and validated.

Deliverables:

- Logical system architecture;
- Technical system architecture;
- Technical specification (including interoperability, performance and CNS technologies requirements);
- Pre-industrial prototype;
- Technical validation reports.

8.4.3 Transition Feasibility Assessment

Transition feasibility assessment is completed to cover the case of impact arising from operational and technical refinements made during this phase.

Deliverables:

- Transition phases definition;
- Transition feasibility report.

8.4.4 Benefit and Risk Assessment

The benefits and risks assessments made at the previous phase are finalised here for all relevant KPAs and strategic objectives. The interactions of all related concepts are analysed.

Deliverables:

- Safety and performance requirements;
- Benefit and risk assessment reports for all relevant KPAs and strategic objectives.

8.4.5 Final Research Business Case

The intermediate Business Case is refined using the results from validation for all relevant KPAs, key results from the other transversal cases, and other decision making criteria. The CBA and the affordability to stakeholders are also refined. Supporting local Business Cases for representative context of use & stakeholders are developed.

Deliverables:

- Final Research Business Case report.

9 MATURITY ASSESSMENT AND LIFECYCLE TRANSITION CRITERIA

The maturity assessment aims to steer a R&D programme from a strategic viewpoint through its regular update cycles. It supports the underlying decision making process. It analyses key results from all relevant projects to provide the following elements/deliverables:

- Updated Validation Maturity Map: the current phase of the CLM is identified by referring and consolidating key results obtained by current and previous projects;
- Recommendations for decision making process: it analyses the impact of results on target objectives to prepare recommendations to stop or to continue (including revision of concept and supporting enablers to reach feasibility/better performance, repetition/extension of some validation activities etc.);
- Updated R&D needs: it identifies the remaining R&D needs to complete the current and remaining phases until end of V3;

For a new R&D programme or project, it would be necessary to make an initial maturity assessment by analysing the results provided by other programmes/projects in that area, if any. This initial maturity assessment will be a prerequisite for the definition of validation strategy and work plan.

The initial and following “regular” maturity assessments are referred in SPF Steps 1.2 and 5.1 respectively.

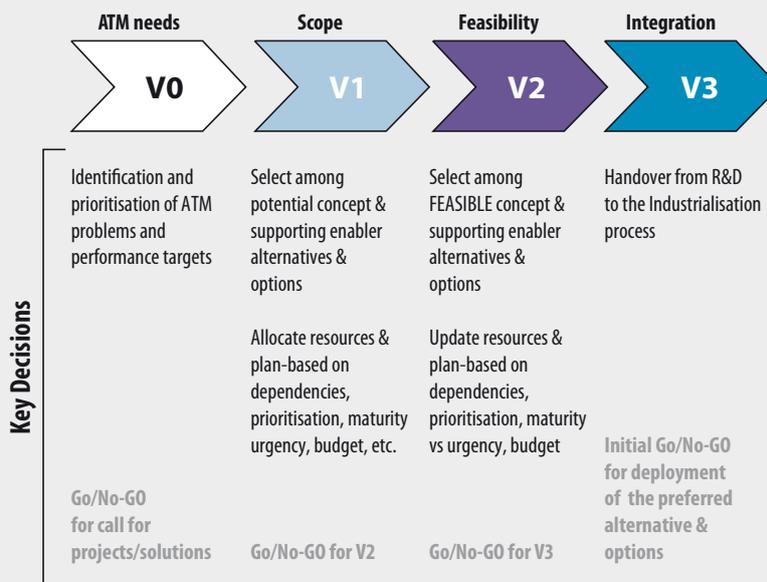


Figure 6: Key decisions per lifecycle phase

9.1 Lifecycle Phases and Key Decisions

Figure 6 shows key decisions to be taken at the end of each lifecycle phase when validating an operational concept and supporting enablers. Depending on the scale of the programme, the decisions might be related to a number of concept elements. The following description centres on the perspective of the individual concept element while taking into account the related options and possible alternative concept elements being investigated in the programme. The maturity assessment is designed to support these types of decision (i.e. Go/No-Go decision; selection of concept element options and/or alternatives). Other decisions that concern the whole programme (e.g. prioritisation, allocation of resources and planning) are not in the scope of the maturity assessment. They are addressed by the programme level Business Case and risk assessment.

9.2 Scope

The maturity assessment will focus on the R&D results obtained in the following areas:

- Operational concept elaboration and feasibility
- Technical enablers elaboration and feasibility
- Transition definition and feasibility
- Performance (benefits and negative impacts), risks and economic justifications
- Work plan and its execution

In those areas, key results will be analysed. They are expected to be reported by relevant projects in respect to the R&D needs.

9.3 General Characteristics

9.3.1 R&D Needs

For an effective planning of R&D and its regular updates supported by the maturity assessment process, it will be important to have:

- a good definition of outstanding R&D needs;
- an adequate coverage of R&D needs by on-going and new projects to avoid gaps and unnecessary redundancies.

	R&D Need Categories
Problem	1. Problem/solution link
Context	2. Context of use on link
Design & Feasibility	3. Processes & Procedures (Business processes/operational procedures and roles) 4. Human-Technology Integration 5. Technical Enabler (Automated system functionality and performance) 6. Transition
Validation of Performance	7. Alternative solutions (Analysis of alternative solutions) 8. Integration (with related concepts and implications) 9. Assessments (of benefits, risks and impact)
Business Case	10. Business Case

Figure 7: R&D Need Categories

R&D needs can be identified using a systematic approach based on R&D categories (see Figure 7). This helps to capture the major questions and uncertainties that R&D should address in each category. This approach has been successfully tested during the SESAR definition phase. More detailed information on the R&D need categories and their use can be found in Vol II, Annex 4.

9.3.2 R&D Results

For an effective maturity assessment it is important that R&D results are reported in the right level of detail with respect to the relevant R&D needs. The level of confidence in results (e.g. high, medium, low) is also useful and should be reported together with the corresponding rationale. This will help to interpret the results and to decide on further actions. It is also to be expected that new R&D needs will be identified during the validation process. These should also be reported by projects.

9.3.3 Lifecycle Transition Criteria

The other key element of the maturity assessment is the set of lifecycle transition criteria. The lifecycle transition criteria support the maturity assessment by defining when work related to each lifecycle phase can be considered complete. They allow the identification of outstanding R&D needs to complete each phase and to prepare recommendations for the decision making process.

The transition criteria are expressed in terms of generic questions. Three types of question are defined to cover different types of assessments:

- Assessment of development level

Example: Have all the closely related concepts been considered in the validation? In the early stages of concept development and refinement, the closely related concepts might be identified and elaborated to mitigate some risks (e.g. major safety hazards, interoperability requirements). In that case, it is important to analyse a concept element together with other “closely related” concept elements that are prerequisite for its potential implementation and use.

- Assessment of results

Example: Is the selected concept option confirmed as operationally feasible when integrated into the target system?

- Assessment of remaining issues

Example: Are there any (new or previously identified) major feasibility issues that need further validation?

These transition criteria questions are structured using R&D need categories.

9.3.4 Maturity Assessment

The maturity of concept development, and in particular validation, will be assessed by asking the relevant transition criteria questions when analysing R&D results corresponding to a specific R&D need. As both the assessment criteria and R&D needs are structured within R&D need categories, the identification of relevant criteria is straightforward.

The following provides an example to illustrate the application of transition criteria questions:

Input to Maturity Assessment

R&D need (SESAR Master Plan - ASAS sequencing and merging - TS-0105-08 -): ...This R&D should study the impact of reduced separation approaches (down to 2NM) on ACAS and should identify if any technical integration is required between ACAS and ASAS application.

R&D results: For illustration purposes, let's consider two possible results:

Possible result 1: The technical integration of ASAS and ACAS is required to eliminate unnecessary Resolution Advisory (RA) messages. The unnecessary RA messages need to be eliminated to reach the required human performance; i.e. to allow controller acceptance and to mitigate major safety risks identified in the safety analysis.

Possible result 2: The technical integration of ASAS and ACAS is not required. Both systems can work together without negative impacts on safety and without negative impacts on pilot and controller work.

In both cases, the assumption is that the confidence in the results was reported as high and the related rationale was explained.

Maturity Assessment

TC [V2.C8.1] *Are the closely related concepts considered in the validation? ...*

Assessment: In both cases, this criterion is satisfied.

TC [V2.C9.1] *Are the benefits and risks assessed for all relevant KPAs and for all identified potential contexts of application? Are the synergies and trade-offs between all relevant KPAs analysed?*

Assessment: In both cases, this criterion is satisfied (i.e. safety and human factors assessments were made).

TC [V2.C9.2] *What are the results? Are the major issues found during these assessments (e.g. assessments showing less than expected benefits, major safety hazards, unresolved human factors and environment issues, etc.) adequately addressed in further concept and supporting technical enabler elaboration and validation activities? In the case that the targeted benefits are shown not to be feasible, what is the impact on the overall (i.e. Implementation Package/Service level) strategic performance objectives/targets?*

Assessment:

In the case of result 1, the results illustrated the need to elaborate a solution (operational and technical) to integrate ASAS and ACAS and to make the necessary validations. This additional work is required to complete V2.

In the case of result 2, from the operational feasibility (i.e. safety and user acceptability) perspective, this criterion is sufficiently addressed and the R&D need can be closed.

9.4 Transition Criteria

The lifecycle transition criteria are defined in Vol II Annex 4 together with lifecycle phase objectives, typical activities and typical deliverables. The present section describes the transition criteria for each of the lifecycle phases. For each transition between phases, the key questions to be answered in support of the transition decision are listed and then used to structure the section. The related analysis and criteria are then explained. If some of the questions are not adequately resolved then there is still work to be done in those areas before the end of the phase can be achieved. The work plan and its execution are also re-assessed in order to identify results which remain outstanding as well as to ensure the adequacy of planning for the next phase.

Please note: the difference of structure between this section and Annex 4 of Vol II. In that Annex, the transition criteria are structured using R&D needs categories while the present section is structured around the key transition questions. For both the V2-V3 and V3-V4 transitions, there is at least one key question relating to each of the five R&D results areas (see Section 9.2) of the maturity assessment. The rationale for using the simplified structure here is to allow for a more concise presentation.

9.4.1 V1-V2 Transition Criteria

The assessment will establish whether the following key questions are adequately answered:

- What are the operational concept/enablers to meet the needs?
- What are the potential contexts of use/application/deployment?
- What are the related operational concepts and their possible implications?
- What are the potential benefits/costs?
- What are the potential alternatives?
- What needs deserve to be validated (R&D needs)?
- What are the potential risks (solution risks)?

What are the operational concept/enablers required to meet the needs?

The assessment will examine whether the operational concept and supporting technical enablers are defined at the level of detail required for the development of benefit mechanisms and for the identification of major feasibility and performance related R&D needs. It will check whether any operational concept and technical enabler options are adequately identified.

What are the potential contexts of use/application/deployment?

The assessment will check whether:

- the context in which the concept should be implemented is defined adequately (e.g. airport, TMA, en-route, traffic density, airspace structure, etc.);
- the target Initial Operational Capability (IOC) date and area of application are identified adequately (e.g. local, regional, pan-European);

What are the related operational concepts and their possible implications?

The assessment will establish whether related concepts are identified. It will also check whether potential impacts (enhancements or negative impacts) between the subject concept and all related concepts are elaborated adequately.

What are the potential benefits/costs?

The assessment will focus on whether the potential benefits are identified adequately and fit with the performance targets and strategic objectives identified in lifecycle phase V0. It will also check that the potential cost has been adequately identified (order of magnitude).

Initial comparison with alternative concepts?

The assessment will focus on whether alternative concepts/enablers are adequately identified. It will also assess whether the potential benefits/costs are compared with the potential (or known) benefits/costs of alternative concepts/enablers to justify R&D work in that area.

What needs deserve to be validated (R&D needs)?

The assessment will address whether the major operational, technical and transition related feasibility issues are identified adequately. It will also check whether the need to assess these feasibility issues is justified (i.e. do all available results indicate feasibility or are there contra-indications?). Further, the assessment will address whether the major performance related issues (R&D needs) are identified adequately, covering all relevant KPAs. It will also look at whether potential solution risks are identified.

Work plan

The assessment will verify whether the work plan for the next period adequately covers all the major feasibility and performance related R&D needs/issues that are identified.

9.4.2 V2-V3 Transition Criteria

The assessment will establish whether the following key questions are adequately answered:

- Operational feasibility (user acceptance, safety)?
- Technical feasibility (preliminary assessment based on research prototypes)?
- Transition feasibility (including institutional issues)?
- Potential benefits validated for concept options?
- Affordability for stakeholders?
- Alternative solutions compared?

Operational feasibility (user acceptance and safety)?

Development and validation level: The level of development of the operational concept (business processes, operational procedures, phraseology, roles of actors and their tasks, human and technology interaction) will be assessed. The coverage of feasibility results will be analysed in respect to different concept options that may have been identified and that have possibly evolved during the project execution. The expectation is that the preferred option is fully developed and validated together with the closely related concept elements (i.e. its prerequisites).

Operational feasibility & human factors & safety analysis results:

The expectation is that major operational and human factors feasibility issues and possible show-stoppers should be identified during this phase. The assessment will examine the outcome in each of those areas to check whether major issues are identified, analysed and whether solutions to overcome them are elaborated and validated. The focus will also be to check whether any show-stopper is identified that influences any future recommendations. In the case that a modification or selection of a specific concept option was made, the adequacy of the justification will be analysed from the feasibility perspective. In the case of a show-stopper or of limitations in human acceptance/performance, has the question of whether it is possible to resolve the problem by re-orienting the concept been adequately addressed?

Technical feasibility (preliminary assessment)?

Development and validation level: The level of development (technical system architecture, technical specifications, performance requirements, interoperability requirements, research prototype) achieved for the technical enablers will be assessed. The coverage of the feasi-

bility results will be assessed with respect to the different technical enabler options identified. The expectation is not to assess the feasibility of all technical enabler options in V2. What is expected is to confirm that there exists at least one feasible option, if this is the case. The feasibility assessments at that stage are preliminary as they are done using research prototypes/simulation platforms. The assessment of performance and interoperability will be completed in V3.

Feasibility results: The assessment will address whether the initial technical feasibility is analysed using research prototype(s) and check whether any show-stopper or critical performance issue can be identified. The assessment will also check whether the research prototype/platform is consistent with the preliminary technical specifications and with the selected operational concept option.

Transition feasibility (including institutional issues)?

The maturity assessment in V2 will cover:

Development and validation level: The extent to which possible transition options/scenarios/issues were elaborated will be analysed. It is expected that the transition feasibility is mainly addressed in V2 and further refined in V3.

Feasibility results: The transition scenario material will be analysed for any existing open critical transition issues or possible show-stoppers.

Potential benefits validated for concept options?

Development and validation level: The assessment will focus on whether the potential benefits and negative impacts, identified through the benefit mechanisms in V1, are further refined and validated. The interdependencies and trade-offs between all relevant KPAs are elaborated. It will also check whether those performance assessments addressed all feasible concept options to support a justified selection among them.

Performance assessment results: The assessment will check whether the potential benefits identified in V1 are confirmed. In case the potential benefits are shown not to be feasible or only partially feasible, the questions (1) whether it is possible to re-orient the concept? (2) what is the impact on the programme level performance objectives/targets? Are they adequately addressed?

Intermediate Business Case?

Development and validation level: The assessment will look at whether the implementation scenarios are identified and if their costs are estimated for representative stakeholder groups. It will check whether the various feasibility results, namely the performance assessments results, the alternative solutions and the solution risks related to operational concept options and supporting enablers are taken into account in the Intermediate Business Case.

Business Case results: The assessment will check whether the affordability is adequately confirmed for all representative stakeholder groups. It will also check whether the preferred concept option is sufficiently justified among other options and also in respect to the alternative concepts (i.e. at least with major ones).

Work plan and its execution?

Execution level: The aim is to check whether all the planned activities are completed and to identify possibly missing/delayed ones.

Next phase coverage of identified major/critical issues: This step will check whether outstanding R&D needs are all planned to be addressed by one or more projects in the next phase of the lifecycle.

Readiness: The assessment will establish whether the remaining time for the completion of maturity level V1, V2 or V3 activities is identified adequately. In case of significant deviation from the initial planning and/or potential delivery risks in the proposed time period these elements will be flagged.

9.4.3 V3-V4 Transition Criteria

The assessment will establish whether the following key questions are adequately answered:

- Operational feasibility when integrated into the target system with other concept elements?
- Pre-industrial feasibility?
- Transition feasibility: Possible refinements?
- Potential benefits for alternatives/options sufficiently validated?
- Affordability for stakeholders: possible refinements?
- Availability of mature specification material to enable standardisation & regulation, if so intended?

Operational feasibility when integrated into the target system with other concept elements?

Development and validation level: In V2, the integration was addressed only for closely related concept elements. In V3, the integration with all related concept elements is expected to be addressed. The material developed in V2 for the selected concept option will be validated and if necessary refined during this phase. At the end of V3 the expectation is to have fully developed and validated material.

Operational feasibility & human factors & safety analysis results: When analysing the integration into the end system with all related concept elements, additional major operational and human factors feasibility issues and possible show-stoppers could be found. The assessment will examine the outcome in each of those areas to check whether major issues are identified, analysed and whether solutions to overcome them are elaborated and validated. The focus will also be to check whether any show-stopper is identified that influences any future recommendations. In the case that a development of the previously selected concept option was necessary, the adequacy of the justification will be analysed from a feasibility perspective. In the case of a show-stopper or of limitations in human acceptance/performance it must be verified that the question of whether it is possible to resolve the problem by re-orienting the concept has been adequately addressed.

Pre-industrial feasibility?

Development and validation level: Limited development and validation was made in V2 principally to identify possible show-stoppers. The main technical enabler development and validation work is to be done in this phase. At the end of this phase, one expects to have fully developed and validated technical material (i.e. technical system architecture, technical specifications, performance requirements, interoperability requirements, design, human machine interaction, pre-industrial prototype) taking into account the integration of all relevant target system elements.

Feasibility results: An initial/partial selection of the technical enabler options may have been undertaken in V2. The final selection is expected to be done in V3. The assessment will address whether the technical feasibility is analysed using a pre-industrial prototype and check whether any show-stoppers or critical performance and interoperability issues are identified. It will analyse whether these issues are adequately addressed in the further elaboration of technical enabler options and whether the selected technical enabler option is adequately justified. The assessment will also check whether the pre-industrial prototype/platform is consistent with the final technical specifications and with the possibly refined operational concept option.

Transition feasibility – possible refinements?

Development and validation level: The transition feasibility addressed in V2 should be reviewed in V3 to take into account the selected technical enabler option and possible refinements to the operational concept during this phase. The assessment will check if the transition analysis is refined accordingly.

Feasibility results: The transition scenario material will be analysed for any existing open critical transition issue or possible show-stopper.

Potential benefits for alternatives/options sufficiently validated taking into account integration to the target system?

Development and validation level: The assessment will focus on whether the potential benefits and negative impacts are further refined and validated, taking into account the relation of concepts to each other. It will

check whether the interdependencies and trade-off analyses are extended accordingly.

Performance assessment results: The assessment will check whether the potential benefits are further confirmed in this phase. In case the potential benefits shown not to be feasible or only partially feasible, the questions (1) It is possible to re-orient the concept? (2) What is the impact on the programme level performance objectives/targets? will be looked at. In the case that they are not adequately addressed, then recommendations will be made on those areas.

Business Case

Development and validation level: The assessment will examine whether the intermediate Business Case developed in V2 is refined using the results of more detailed feasibility and performance assessments undertaken in this phase. The assessment will also consider whether the benefits are compared with all alternative concept elements.

Business Case results: The assessment will check whether the affordability is adequately confirmed for all representative stakeholder groups. It will also check if the selection of this concept is adequately justified in respect to all relevant alternative concepts.

Availability of mature specification material to enable standardisation and regulation, if needed?

The assessment will establish whether the needs for standardisation and regulation are adequately justified and whether material is sufficiently developed and mature to support the standardisation and regulation process in V4.

Work plan and its execution

Execution level: The aim is to check whether all the planned activities are completed and to identify possibly missing/delayed ones.

9.4.4 Possible Flexibilities

The maturity assessment and the transition criteria are defined for a general case not taking into account programme level priorities and constraints. Therefore they need to be applied in a flexible manner. The following examples aim to illustrate the required adaptation of the transition criteria to the programme level priorities and constraints:

- Budget limitations may not allow elaboration and validation of all alternative solutions simultaneously. In that case, the criterion which requires all alternative solutions to be validated in parallel and compared for cost, benefits and risks will not be applied as such. It will be applied to justify the initial (a priori) selection of alternative solutions to be validated and the final (a posteriori) selection following their validation results.
- The urgent need for performance improvements in a particular operational context of use may dictate the validation of a proposed solution with some priority unique to that context of use. In that case, the criterion, which requires the validation of all potential context of use, will not be applied.
- The initial benefit evaluations may confirm limited benefits in certain KPAs while illustrating important benefits in some other KPAs. The future evaluations may be planned only in major benefit areas to accelerate the programme and to take into account budget limitations. The criterion, which requires benefits to be evaluated in all relevant KPAs will not be applied as such but will be limited to the major benefit areas.

10 STRUCTURED PLANNING FRAMEWORK

As introduced in Part II Section 3.2, the Structured Planning Framework (SPF) is the process followed to manage R&D concept validation in individual CLM phases V1, V2 and V3.

The SPF consists of six steps (labelled “x.0”) necessary to conduct validation in a controlled and stepped approach, each step having a number of sub-steps (labelled “x.n”).

The detail of the tasks carried out in the steps and sub-steps depends on the “level” of the activity (i.e. programme, project or exercise) and their order and content may need to be adapted critically and intelligently to the context of the validation.

10.1 Summary of the SPF

Figure 8 and Figure 9 provide an overview of the SPF as applied at programme, project and exercise levels expressed as flows of activities. The three levels are each expressed as a set of steps and sub-steps

Figure 8 shows that applying the SPF at the programme level develops an approach to validation based on stakeholder priorities and performance objectives. This is expressed as a programme level validation strategy applicable to all subsequent programme activities. This includes validation objectives and a work plan, which comprises a series of projects. The identification of projects will depend on the breakdown of the concept into concept elements. The SPF is then applied to each of these projects.

Figure 9 shows the application of the SPF at project level. The validation objectives applicable to each project are used to develop an exercise plan, which comprises one or more exercises (expert groups, modelling, simulations, trials etc.). The results of these exercises are integrated at project and then programme level. At programme level decisions can then be taken on how to progress validation to mature the proposed concept and supporting evidence.

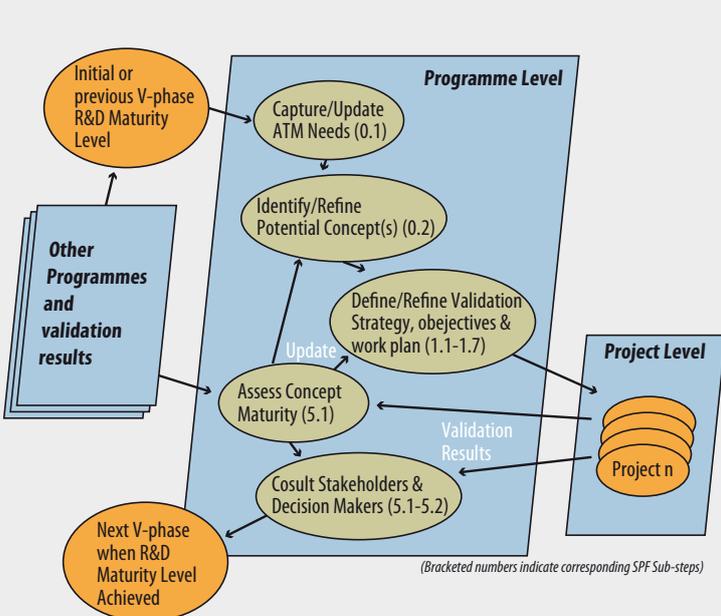


Figure 8: SPF Programme-to-Project Level

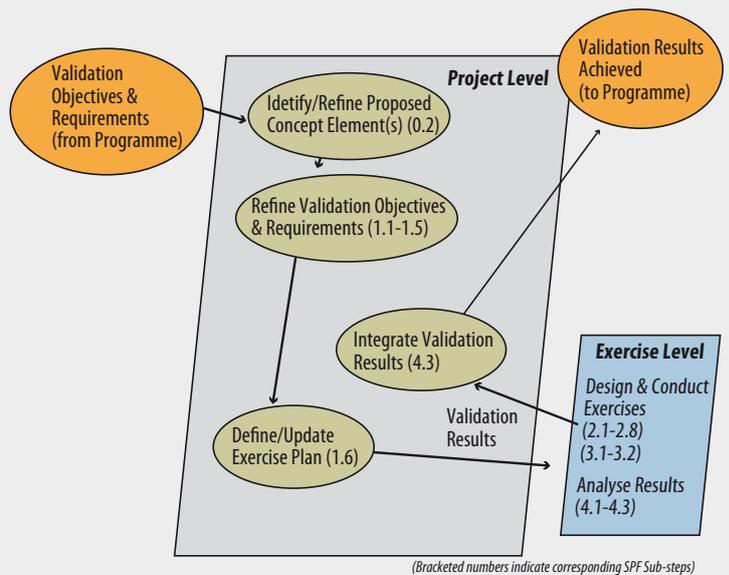


Figure 9: SPF Project and Exercise Levels

10.2 SPF Steps and Sub-Steps

The SPF is presented in the following pages in a tabular format identifying tasks that should be carried out for each step and sub-step. The tasks depend on the activity level (programme, project or exercise).

The tasks and their sequence must be carried out with analysis and reflection. Continuous assessment of the particular circumstances of the concept validation and the particular situation of the validation practitioner is required. Amongst the factors to consider are the:

- scope/size of the concept under assessment;
- current CLM phase of the concept (i.e., V1, V2 or V3);
- concept maturity – in early CLM phases validation will concentrate on concept definition and refinement whereas in later CLM phases the emphasis moves to gathering performance data;

- validation level (high level programme management, project management, or validation exercise planning);
- stability of the validation activity – results gathered so far, recent significant changes to the problem statement, stakeholders, assumptions, or the concept.

These and other factors will influence which steps and sub-steps are followed. It is possible that within a step, one or more sub-steps can be omitted, and one of the skills of the validation practitioner is to make appropriate choices.

A detailed description of the steps is provided in Vol II, Annex 3.

It should be noted that an empty cell in the tables indicates that no task or output has been identified that is appropriate to that sub-step for the activity level concerned.

Applying the SPF at Programme/Project/Exercise Level to V1-V2-V3					
Step	Sub-Step	Name	Activities – Programme Level	Activities – Project Level	Activities – Exercise Level
0. State Concept and Assumptions	0.1	Capture or update the ATM needs.	<p>Survey stakeholders to gather and analyse information on the ATM problem.</p> <p>Identify Key Issues, KPAs and existing performance levels in context of performance framework.</p> <p>Define ATM needs, performance targets and concept performance objectives.</p>		
	0.2	Identify or refine the proposed solution(s).	<p>Draw up and review proposed operational concept(s).</p> <p>Draw up typical operational scenarios and context.</p> <p>Assess alternative solutions.</p>		

Applying the SPF at Programme/Project/Exercise Level to V1-V2-V3

Step	Sub-Step	Name	Activities – Programme Level	Activities – Project Level	Activities – Exercise Level
1. Set Validation Strategy	1.1	Identify or refine: a) stakeholders; b) the cost and benefit mechanisms.	Formally identify participating stakeholders. Identify potential cost and benefit mechanisms, including the definition of performance objectives.		
	1.2	Identify R&D needs and carry out the initial maturity assessment for each concept.	Carry out the initial maturity assessment to identify the current and target levels of maturity of the concept(s) or concept elements: assess whether at V1, V2, V3... for each starting point. Deliver the R&D needs.		
	1.3	Define the objectives for the validation activity.	Identify what the validation activity is expected to achieve. Will include any case requirements.	Review validation objectives defined for the project and review any ambiguity with the programme management.	
	1.4	Refine the performance objectives.	Refine performance objectives in KPAs, KPIs, and high-level indicators and metrics.	Refine or update detail of indicators at level of project, and show how they relate to the indicators identified by the programme.	
	1.5	Define the validation requirements.	Identify how the validation objectives will be assessed in general terms (e.g. validation infrastructure available, policies).	Identify how the project will conduct its validation activities (i.e. which validation tools and techniques will be applied to which aspects of the problem).	
	1.6	Define or refine the validation work plan.	Break programme into projects and provide project work plan. The breakdown of the operational concept into elements may provide a basis for this activity.	Break project into exercises and provide exercise work plan.	
	1.7	Consolidate the validation strategy (in one document).	Deliver or update the validation strategy.		

Applying the SPF at Programme/Project/Exercise Level to V1-V2-V3

Step	Sub-Step	Name	Activities – Programme Level	Activities – Project Level	Activities – Exercise Level
2. Determine the Exercise Needs	2.1	Identify the acceptance criteria and performance requirements for the exercise.			Identify what is expected of the exercise by the project and how the exercise result contributes to the project result – what does success look like?
	2.2	Refine the validation objectives.			Add detail to the exercise objectives defined by the project, where necessary.
	2.3	Refine exercise validation requirements.			Add detail to the exercise environment defined by the project and specify in detail the methods, platforms etc. that will be used and how. Record assumptions made.
	2.4	Identify indicators and metrics.			Prepare the detailed list of Indicators and metrics, showing how they relate back to the project indicators, if applicable.
	2.5	Develop the validation scenarios.			Specify the detailed operational scenarios and justify that they will fulfil the exercise objectives as defined by the project.
	2.6	Produce the validation exercise plan.			Deliver final exercise-level validation plan. Includes analysis specification and detailed exercise design.
	2.7	Prepare material for the exercise.			Prepare exercise environment (exercises, scripts, models, platform, etc.).
	2.8	Conduct pre-exercise testing and training.			Confirm exercise environment. Identify and remove unexpected behaviours and artefacts of study. Confirm that key experimental assumptions seem justified. Train participants (where required).
3. Conduct the Exercise	3.1	Carry out the validation exercise.			Collect “raw” data. Observe for unexpected behaviours not already addressed pre-exercise.
	3.2	Examine unexpected behaviour or results, and reports of problems.			Study any problem reports, challenges to assumptions and emergent behaviours to determine if they relate to the concept.

Applying the SPF at Programme/Project/Exercise Level to V1-V2-V3					
Step	Sub-Step	Name	Activities – Programme Level	Activities – Project Level	Activities – Exercise Level
4. Analyse the Results	4.1	Analyse the data as planned.			Analyse exercise data.
	4.2	Prepare analysis contributions.			Prepare exercise analysis contributions.
	4.3	Prepare the validation report and cases.	<p>Integrate results of projects.</p> <p>Build programme-level cases reports.</p> <p>Consolidate project validation reports.</p>	<p>Integrate results of exercises.</p> <p>Build cases.</p> <p>Produce project validation report.</p> <p>Pass results up to programme level.</p> <p>Train participants (where required).</p>	<p>Identify validation exercise shortcomings.</p> <p>Produce exercise validation report(s).</p> <p>Pass results up to project level.</p>
5. Disseminate Information to Stakeholders	5.1	Review maturity and validation results with stakeholders.	<p>Carry out maturity assessment of the concept(s) or concept elements, when required.</p> <p>Stakeholder review of consolidated programme-level validation results, including case reports.</p>		
	5.2	Draw conclusions and decide on actions, feedback to the validation strategy.	<p>Identify changes to operational concept(s) and validation strategy.</p> <p>If maturity transition criteria achieved for the operational concept (or a specific sub-element), proceed to next V-phase. If not, revise validation plans, e.g. repeat current CLM phase or stop.</p>		

10.3 Impact of Current Validation Phase (V1, V2, V3) on the SPF

In managing the application of the SPF, the project manager and validation practitioner must take account of the context of the R&D activity. In particular, the emphasis of the SPF will evolve as work progresses through the CLM. This evolution in emphasis is shown in Figure 10, the number of “tick” marks indicating the relative weight of effort that might be expected to be placed on the SPF steps. No hard-and-fast rule is proposed, so this table must be taken as general guidance.

	V1	V2	V3
Step 0 – State Concept & Assumptions	✓ ✓	✓	✓
Step 1 – Set Validation Strategy	✓ ✓ ✓	✓ ✓	✓
Step 2 – Determine Exercise Needs	✓ ✓	✓ ✓ ✓	✓ ✓ ✓
Step 3 – Conduct the Exercise	✓ ✓	✓ ✓ ✓	✓ ✓ ✓
Step 4 – Analyse the Results	✓ ✓	✓ ✓ ✓	✓ ✓ ✓
Step 5 – Disseminate Information	✓ ✓ ✓	✓ ✓ ✓	✓ ✓ ✓

Figure 10: Selection of SPF Steps to Perform

If an R&D activity is at a low level of maturity, assessed to be at V1, stakeholder needs and the high-level concept should be available as inputs. Work in V1 will then concentrate on developing this concept further (Step 0), setting the validation strategy (Step 1) and conducting initial exercises using techniques appropriate to V1 such as expert groups and prototyping (Steps 2-4). Dissemination (Step 5) will take a high profile.

At V2, the concept will be revisited in the light of new information and the results of V1 (in Step 0), but this should not be an extensive rework since V1 should settle most of the key concept issues. The validation strategy will be reviewed and updated (Step 1). Significant effort will then be placed on experimentation (using techniques appropriate to V2 such as modelling and real-time simulation) and dissemination (Steps 2-5), see Section 10.4.

Finally, at V3, the concept should require little reworking as it should be mature, but attention must be paid to other parallel developments that might impact on it (Step 0). The validation strategy is mature and well defined so should not require modification (Step 1). Effort will, again, be placed on experimentation (using techniques appropriate to V3 such as shadow-mode trials) and dissemination (Steps 2-5).

10.4 Guidance on Selection of Validation Techniques and Tools

As part of the SPF, it is necessary to consider and select the appropriate validation techniques and tools for exercises. The choice will depend on the maturity of the concept assessment and the type of evidence that is sought. The validation practitioner should always ask what technique or tool is most appropriate to the exercise needs and objectives. Potential techniques and tools are reviewed in this section.

Literature Study

Literature study involves identifying documents relevant to the proposed concept and making a critical assessment of the concept using a structured approach. In particular, relevant previous research should be used. This technique should be applied when a proposed concept is very immature and it should permit rapid identification of strengths, weaknesses and outstanding issues challenging the proposed concept.

Executive summaries of the selected documents provide a background for the information obtained from the documents. It is also important to record assumptions in the surveyed documents.

The output data from a literature study are a list of qualitative statements, and possibly numerical results, from relevant documents providing the “evidence material” for testing the hypotheses.

Judgemental Techniques

Judgemental techniques involve having a team of subject matter experts participate in a structured review of a proposed concept. Well-known techniques exist, such as Delphi Methods. This technique should be used particularly to review immature concepts.

A typical assessment would involve eliciting and recording the opinions from a representative group of experts – opinions

will be recorded in accordance with the plans. The exercise could be in the form of a meeting, at which the validation team facilitates the discussions or it could be purely paper based, circulating specific information and questionnaires e.g. by mail or e-mail to the experts.

Fast-Time Modelling

Fast-time techniques involve using models of ATM systems, several of which exist for both airspace and airport operations. These models are highly dependent on the data used to drive them, and hence this must be carefully validated in order to assure realistic outputs.

Fast-time validation exercises are typically structured as a series of runs with randomised variations of a representative validation scenario. The output data are numerical and require careful analysis and interpretation to take account of the effects of the underlying model, data and scenarios.

They are best used to test the sensitivity of a proposed concept to different assumptions and scenarios.

Gaming

Gaming techniques are appropriate to exploration of real-life situations where two or more parties must interact with a choice of action in order to meet their objectives. Gaming helps validation practitioners gain insight into real-life situations where the outcome depends on human interactions with each other. In particular, it can reveal hidden, implicit or otherwise unexpected behaviours of the participants, and thereby help understanding of the drivers affecting a real situation.

Players are assigned roles, employing the aims, motivations and doctrine that are expected of the role. Gaming can be played in real time or in rounds (where players' actions are carried out simultaneously). Gaming may be performed with little more than some players, a simple scenario and rule set, and recording medium, although an automated gaming facility may help increase realism.

Real-Time Simulation

Real-time simulation techniques are important in providing human-in-the-loop experience of a proposed concept in a relatively controlled and repeatable environment. Extensive training of participants is necessary to reach levels of expertise and familiarity with the proposed concept and simulation tools.

Data collected may include simulator data logs, observer notes, video recordings, questionnaires and debriefing

sessions. Insights may also be gained from sophisticated techniques such as eye movement tracking and heart rate monitors.

Real-time simulation validation exercises can provide both objective and subjective outputs.

A variant of real-time simulation is to adopt a more prototyping approach with repeated short and small-scale exercises to rapidly evolve a proposed concept. This is particularly useful to build understanding in an immature concept and to develop it to the stage where more extensive exercises are appropriate.

Shadow Mode Trials

Shadow mode trials involve the use of prototypes of operational tools to assess the effectiveness of a proposed concept. The prototypes are integrated with live operational systems and run in the background in parallel.

Shadow mode trials are generally not closed-loop in that the prototypes are not able to easily feed back into the live operation. Furthermore, they are not carried out in controlled environments (although they may be in "typical" operational conditions). Hence, in experimental terms they do not generally provide repeatable results.

Shadow mode trials are mostly be of use to inform potential users about a proposed concept and to gain experience of prototypes with live operational data feeds.

Live Trials

Live trials involve the deployment of prototypes of operational tools and/or the use of proposed procedures in live operation. They have the advantage of exposing the proposed concept to reality but inevitably place high demands on rigorous safety assessment and understanding the effects (positive and negative) on impacted traffic.

To gain maximum assessment benefit, a live trial should be run for an extended period of data collection. It must be understood that in experimental terms a live trial takes place in an uncontrolled situation, so experiments and data collections are often not easily repeatable or comparable with pre-trial operations.

Live trials will generally be very expensive to set up and run, and hence they should only be carried out when justified by a high level of confidence in the proposed concept.

11 CASE BASED APPROACH

As explained in Part II, the objective of using a “case” is to group information into a clear structure in order to describe the potential of the concept under evaluation and thereby provide pertinent feedback to the concept developers and support the key stakeholders by providing evidence as they make the investment and implementation decisions.

This section gives the definition and purpose of the Business, Safety, Human Factors, Environment, and Standardisation and Regulation Cases and describes on a high level how a programme/project should develop these as part of an R&D or validation programme. Detailed guidelines for each case are given in Vol II, Annex 5.

Although other cases (e.g. security, technology) may and should be developed within a validation programme/project, at present the E-OCVM provides only guidance for the five cases identified above.

11.1 Case Development along the CLM

The Case Based Approach should start as early as V0 with the identification of case-specific performance needs. The main establishment of the cases is done in V1 with the scoping and planning of the case’s work (e.g., level of analysis, methods to be used, coordination with other assessment processes), based on the stakeholders needs and always with the objective of supporting the stakeholder decisions through the life-cycle of the programme/project. It will also establish the “case baseline” (existing concept material and evidence) relevant to the validation activity and the case reports being targeted for development.

During the further development of a case along the concept lifecycle, its focus evolves as illustrated in Figure 11. In the earlier CLM phases the cases will deliver only preliminary case-related performance based evidence and the focus will be more on providing feedback to the concept developers so that the case aspects of the concept can be improved. During later CLM phases and with an improved, more stable concept, the focus changes towards providing evidence that the concept is fit for purpose, by means of detailed assessments.

The background to this shifting in focus is that changing and improving concepts is generally easier and less costly at an early stage of a development process. At a late stage of development, issues with any of the case-related aspects of a concept are likely to be more complicated, more expensive or even impossible to mitigate.

During the validation process, maturity assessments are carried out at least at the end of each phase of the concept lifecycle, addressing both the concept and evidence. If the programme/project starts at a more advanced stage there must be a check to ensure that all activities that would have been covered in earlier phases are actually completed. Case maturity assessment is a contributor to the overall maturity assessment. Detailed criteria have been developed for each case to enable validation projects to review the maturity of validation material case-by-case (see Annex 5).

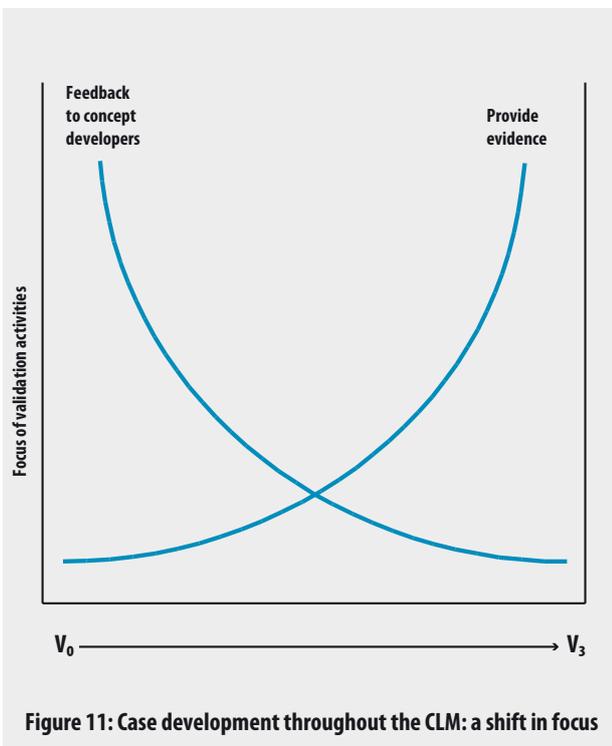


Figure 11: Case development throughout the CLM: a shift in focus

11.2 Typical Case Output

The R&D Cases will typically deliver case reports which reflect this shifting of focus. Early phase (intermediate) case reports will be mainly directed to the concept developers. Any assessment to be carried out will become more detailed as the concept matures and consequently the case reports will progressively build the evidence needed by the case stakeholders to make the correct decision on selecting concepts or their alternatives for further development, for redesign, or for further research.

11.3 Business Case

11.3.1 What is a Business Case?

The Business Case is a structured way to prepare the required evidence for decision makers (stakeholders) on the advantages and disadvantages of the different concepts under consideration. It represents an overarching position relative to the other cases: it brings them together, balancing the positive and negative aspects of each, and presents the underlying economic assessment to enable decision makers to make informed trade-offs. A Business Case is therefore a collaborative process involving a multi-disciplinary team aiming to ensure the ownership and buy-in of all stakeholders.

As such, the Business Case includes, but goes beyond a cost-benefit analysis because it may include funding analysis, multi-criteria decision analysis (MCDA) techniques, and proposal of the implementation plan for a more comprehensive explanation of the investment situation. It is evidence-based, and a tool to support planning and reporting.

11.3.2 Why a Business Case?

The purpose of a business case is to facilitate and support better informed decision making for key investment issues. It evaluates the project value, which can be qualitative (including intangible benefits) and quantitative (monetary). Decisions are taken by multiple stakeholders (not necessarily only those that invest resources but any group that can have a significant impact on the investment decision) and the potential impacts are evaluated from a multi-criteria perspective; economics is only one of the aspects.

11.4 Safety Case

11.4.1 What is a Safety Case?

Whereas the development of a Safety Case by an individual ANSP for regulatory approval of a change to its ATM system has already become common practice, Safety Case development in R&D has been subject of a lot of recent research and experiences is just building-up. Consequently, several new, complementary approaches have recently been developed that aim to address emerging needs for Safety Case development for advanced developments.

The Safety Case in R&D is a means of grouping validation results about safety, such that it supports all stakeholders and decision makers as they consider investment and implementation options. The development of such a Safety Case aims to provide them with timely information as evidence concerning the potential of a concept to meet defined safety goals.

11.4.2 Why a Safety Case?

The purpose of a Safety Case in R&D is to provide information on safety aspects of a concept under development, based on evidence that supports:

- decision makers with respect to selection of concepts for further development or redevelopment of a concept;
- concept developers and system engineers in effectively developing a safe concept

The development of a safe concept is best supported by a validation process in which safety is considered from the start. This way, problems regarding the safety of a concept can be identified at an early stage, and stakeholders can readily be informed whether concept options are promising for eventually delivering the desired level of safety. If problems with the safety of a concept are discovered at a late stage of a development process, mitigation may not anymore be possible, or only at the cost of expensive redesign.

In each of the R&D phases, the output of the Safety Case is focused on describing the potential of a concept to meet defined safety goals. One particularly important aspect is concerned with the explanation to the concept development process and the decision makers of why the evaluated concepts may not yet be safe enough. Such knowledge is vital in R&D to enable operational concept developers to improve on the weakness in concepts. For a concept that is

selected after V3 for implementation, the Safety Case from R&D can become the evidence based foundation for a Safety Case in support of regulatory approval.

11.5 Human Factors Case

11.5.1 What is a Human Factors Case?

The Human Factors Case is a means to give systematic attention to the complex and critical way in which human and non-human parts of the system must work together to deliver safe, cost-effective performance. It ensures that people-related issues are explicitly addressed and incorporated within the planning and decision making process for a proposed ATM concept.

11.5.2 Why a Human Factors Case?

The purpose of the Human Factors Case is to collate and present information about how a concept under evaluation affects the roles of people in the system (taking account of human capabilities and characteristics) and about their contribution towards expected system performance and behaviour. This information is used in order to inform the key stakeholders and decision makers as they consider the investment and implementation options. It is the means by which the human factors attributes of an operational concept can be validated, and assurance given that the people-related aspects of the development of the proposal have been effectively managed. Therefore, any project from which the results may impact the way humans work with technological systems should have a Human Factors Case. It will identify at an early stage how to develop the human factors analysis of the proposed concept and will contribute towards considerations of potential design options by operational analysts.

11.6 Environment Case

11.6.1 What is an Environment Case?

An Environment Case is a structured way to provide information on the environmental potential and performance of a concept, relative to set criteria. The information should include the evidence that provides a convincing and valid justification that the concept can and will continue to perform at that level.

11.6.2 Why an Environment Case?

The purpose of an Environment Case is to help the programme/project manager to plan, identify and analyse environmental impacts that any ATM system proposal is likely

to bring. An Environment Case can, at an early stage, identify how to develop the environmental analysis of the proposal and will support the operational analysts in considering the potential design options available. Appropriate tools can be identified and used to model various scenarios with the results then compared to relevant criteria which are applicable for the ATM concept proposal.

During the early stages of concept validation it will be necessary to consult the relevant stakeholders to understand their needs and their expectations of the content of the Environment Case. Airlines are increasingly lobbying ANSPs to provide a more fuel efficient service, minimising their route length, fuel burn and CO₂ emissions. The military's requirements can be significant in some European Union (EU) states and so their input is important. In addition, local communities and the wider public are among the key stakeholder groups. Ultimately, it is usually the national regulator who reviews an Environment Case to ensure it meets with national environmental legislation.

11.7 Standards and Regulation Case

11.7.1 What is Standardisation & Regulation?

Standardisation is the process of developing and agreeing technical and operational standards. A standard is a document that establishes uniform engineering and technical specifications, criteria, methods, processes or practices. Standards are developed and approved by a number of different organisations. Ideally stakeholders will implement a standard voluntarily on the basis of the benefits offered.

Regulation is the process of putting in place and applying a legal instrument to compel implementation of specific requirements. This is done particularly when coordinated deployment is required, and normally depends on a consensus being achieved amongst a majority of stakeholders that the change is necessary.

11.7.2 Why a Standards and Regulation Case?

The purpose of the Standards and Regulation (S&R) Case is to provide content and evidence that will help S&R stakeholders to produce the new or modified standards and regulations that will be needed to implement concept elements. The S&R Case draws on material developed for other cases but is targeted at meeting the specific priorities and needs of the S&R stakeholders. The aim of the S&R Case is to encourage faster deployment by improving the focus of R&D.

Interoperability is essential in a system-of-systems such as is implemented in a complex ATM operational concept. Standards are the principal enablers of interoperability, specifying how systems should be implemented to ensure that they work together. Regulations provide a legal obligation to implement particular standards, assuring that all appropriate systems meet the interoperability requirement.

these different specialist perspectives (cases) comes however with the risk of fragmentation, which can lead to incoherent/inconsistent results.

To overcome this separation there are several commonalities between cases that need to be understood for a successful outcome to the project. Figure 12 shows the four main connections:

11.8 Relationship between the Cases

Each case brings the benefit of a different specialist view to the assessment of the concept. This includes understanding of the problem it is intended to solve, and the benefits it should bring, as well as the costs (not just monetary) of implementing and operating it within the ATM system. At all early stages of the concept lifecycle, there will also be outstanding issues, which will benefit from the different specialist perspectives to identify them, and to understand their likely implications.

- the **key outputs**, which are the evidence to support the stakeholders in the decision process;
- the **main body of evidence** supporting the key outputs, that can be scrutinised (mainly by experts);
- the **processes** used during the project to create the evidence (and also to influence concept evolution in a favourable direction);
- the **case teams** within each speciality, which are responsible for applying the processes and producing the results.

The separate viewpoints operate in parallel throughout the process of concept development and evaluation, each producing its own focused case output. The benefit of having

For each connection there are common topics which should be considered in order to facilitate the integration of elements from the different cases. Details about these relational aspects and topics can be found in Vol II, Annex 5, Section 7.

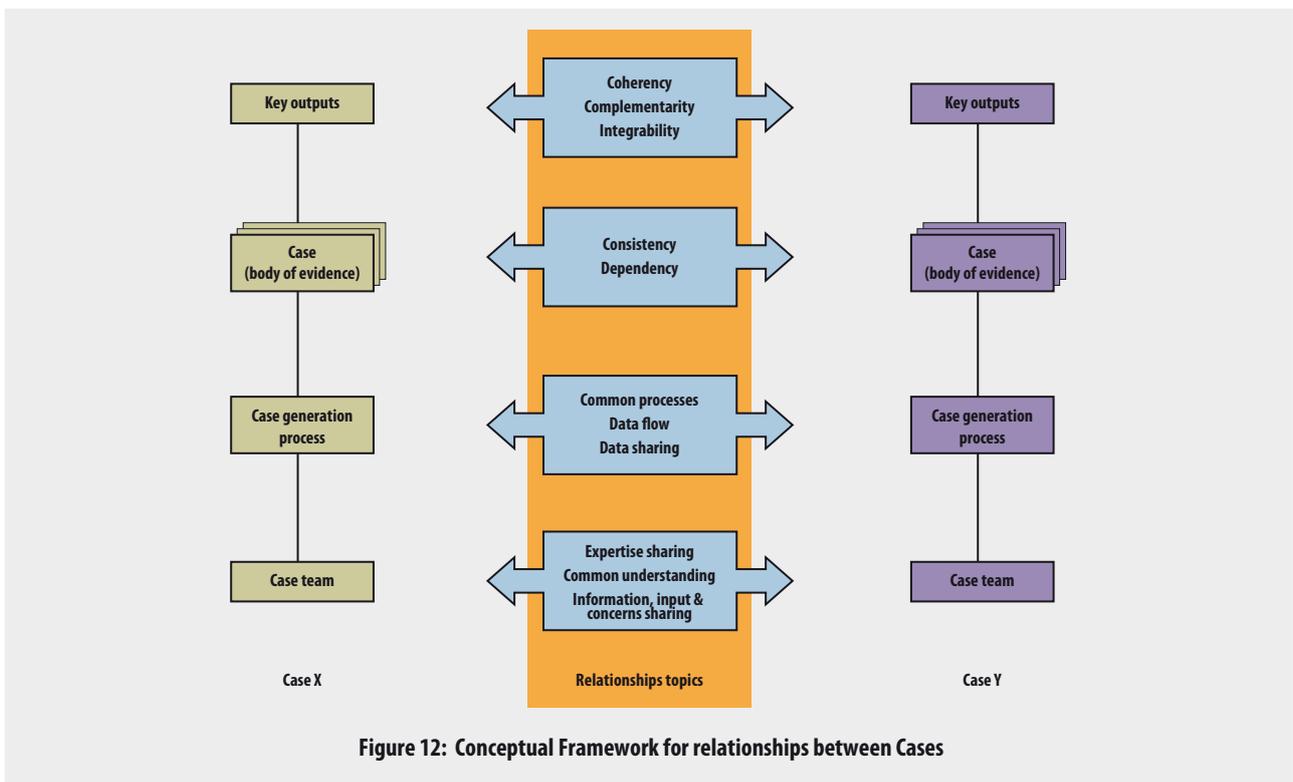


Figure 12: Conceptual Framework for relationships between Cases

11.9 Implementation of Case-Based Approach within the SPF

The SPF and cases are closely interlinked, with the cases being multiple parallel strands of R&D within the SPF process. The benefit of including the cases is to ensure focus in the collection of information and evidence appropriate to the stakeholders' needs and also to ensure continuity of management of this data between phases V1-V3 of the CLM.

Step 1 of the SPF takes a view over all lifecycle phases, in the light of which individual projects refine and elaborate their contribution to the overall validation strategy. First, in Sub-Step 0.1, and more particularly in detail in Sub-Step 1.1, the validation project team must establish which cases (or "impacts") the stakeholders require to prove to them that the concept will have sufficient impact to make it worth investing resources. This will take account of criteria such as those expressed in overall ATM needs, the performance framework, and implementation roadmaps.

In Sub-Step 1.3 the details of case requirements will be specified. This may involve specifying for which cases information is required for particular concept elements. For example, for some concept elements a detailed CBA and Safety Case may be required whereas for others these may be of lesser importance while still feeding general results into an overall Case Assessment for the concept. This will allow an overall trade-off between validation resources and validation needs, and will refine the existing case baseline relevant to the validation activity and establish the case reports to be targeted for development.

The case requirements will be fed into the Validation Work Plan developed in Sub-Step 1.6 and the Validation Strategy consolidated in Sub-Step 1.7.

Step 2 determines the needs for exercises. Exercise objectives (Sub-Step 2.2) will be based around delivering the case results that are a key element of the acceptance criteria (Sub-Step 2.1) as detailed in the Validation Strategy. Assumptions made must be recorded and coordination made between exercise teams to ensure that the assumptions are consistent and coherent (Sub-Step 2.3) so that the cases have a consistent and coherent baseline for assessment.

During Step 2 the progressive detailing and clarification of case needs will lead to further inevitable trade-offs between the needs of different cases. This will particularly take place during the finalisation of exercise plans. Potential areas of overlap and inter-dependency will have been highlighted to identify synergies between cases in the provision of data and analysis. The results will be re-integrated during exercise planning (Sub-Step 2.6) to complete plans for production of feedback to the concept developers or evidence to the stakeholders.

Step 3 is concerned with carrying out the exercises planned in Step 2. The case teams will participate in exercises and monitor outputs to respond to unexpected results from the case perspectives. Once exercises are completed, **Step 4** will draw together the results which will on the one hand be fed back to the project team itself to refine exercise needs and on the other hand be formatted appropriately for the stakeholder needs, that is, as the required case reports. The case reports will then be fed back to the concept developers or to stakeholders to contribute to decision making (**Step 5**).

Figure 13 illustrates the information loop between cases and exercises as described above. More specifically it shows:

- cases are a key input for deciding priorities in exercise design, planning and analysis;
- the use of a common validation repository for the storage and integration of data and results from other projects;
- how case results feed back into the refinement of exercise needs.

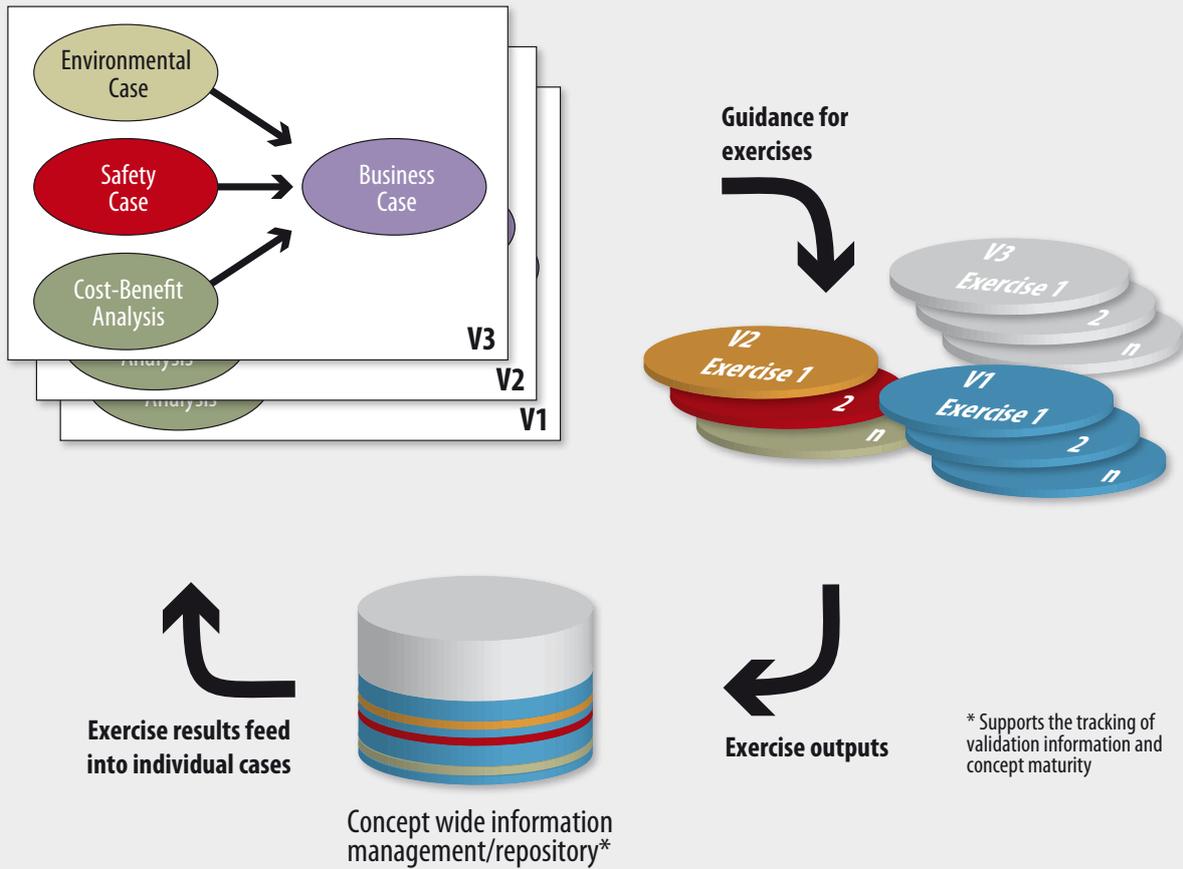


Figure 13: Cases, Exercises and the development of information to provide evidence

12 GLOSSARY & TERMINOLOGY

The E-OCVM is based on the following key terminology. As this terminology is important for the methodology, it is elaborated here for improved comprehension and consistent use.

Activity

In this document, the term activity is used in the general sense to describe purposeful activity to meet objectives. It is the basic unit of action. Consequently a validation activity is an activity whose purposes are related to validation; a verification activity is pertinent to verification, etc.

Architecture

An architectural description is a formal description of a system, organised in a way that supports reasoning about the structural properties of the system. It defines the system components or building blocks and provides a plan from which products can be procured, and systems developed, that will work together to implement the overall system. This may enable management of investment in a way that meets business needs.

Depending on the specific area of interest architectures may focus on specific characteristics, e.g.

- a system architecture or systems architecture is the conceptual high-level design that defines the structure of a system;
- ATM architecture focuses on ATM systems;
- **Technical system architecture** focuses on the technical infrastructure, whereas the **logical system architecture** focuses on “logical” issues, such as data, data flows, roles and responsibilities.

Assumption

An assumption is a proposition that is taken for granted, as if it were true, for the purposes of performing demonstrations or assessments in specific context. (For the results to be subsequently used in another context, the assumption must be applicable in that context).

ATM Needs

ATM needs are the combination of a description of the ATM problem, and the broad targets that a solution to that problem must meet. The description of ATM needs should identify the problem and its cause or causes, quantify the problem, and identify constraints.

Baseline Performance

See Performance.

Benefit Mechanism

A description of the way in which improved performance is delivered within the ATM system. The benefit mechanism should demonstrate logically and clearly how the benefits are achieved, perhaps using influence diagrams to show how different ATM functions and processes contribute (positively or negatively) to the delivery of benefit.

Case

A “case” is a means of structuring and presenting evidence about critical aspects of validation recognised as important by key stakeholders. Common examples include, but are not limited to, aspects such as business, safety, human factors, environment, and standardisation.

Concept Element

To facilitate the development of a concept the concept may be split up into more basic ‘concept elements’.

Concept of Operations (ConOps), Operational Concept

An **Operational Concept** is seen as a high-level description of ATM system elements that address a high-level set of user requirements. Depending on the use of an operational concept description, it may include/exclude a description of user-related information on system interoperability, data and information flows, actors with roles and responsibilities and operational procedures which would support the system requirement capturing process. Such a (more detailed) description is referred to as **Concept of Operations (ConOps)**. Consequently a ConOps is a detailed description of how an operational concept works. It identifies and details the functions and processes, and their corresponding interactions and information flows, concerned actors, their roles and responsibilities.

Hence Operational Concept Validation starts from an Operational Concept and arrives at a Concept of Operations. (NB. Despite this distinction, the term Operational Concept Validation Methodology is used generally for the entire E-OCVM as a matter of convenience.)

The ConOps serves as bridge between Operational Concept Validation and System Detailed Definition and Design. Recommendations for the outline and content of ConOps documents are available in the industry literature.

Constraint

In general terms, a constraint sets limitations on behaviour (the ability to do something). In ATM system development there may be several types of constraint deriving from operational, environmental, technical, legal, institutional or other conditions. Constraints need to be identified and carefully documented.

Enabler

In general terms, an enabler provides adequate power, means, opportunity, or authority to allow something to be done. In ATM system development, identifying the necessary enablers and ensuring that they will be in place to allow the system to achieve its performance targets is an important activity. Different classes of enabler can be identified, e.g. procedural, technical, human, institutional, regulatory etc.

Evidence

Evidence is verifiable information based on established fact or expert judgement, which is presented to show that an argument or hypothesis to which it relates is valid (i.e. true).

Exercise

The term exercise is used to describe an activity intended to improve understanding and progress some elements of the concept further through the CLM. An exercise may have different foci depending on where the activity is within the lifecycle. An exercise may exploit different techniques in order to achieve its objectives, i.e. analysis, modelling, fast-time simulation, etc.

Hypothesis

A hypothesis is a prediction to be confirmed or rejected by means of validation activity.

Indicator

See Key **Performance Indicator**.

Influence Diagrams

Influence diagrams are directed graphs used as an alternative to decision trees for modelling decision situations. They can represent both probabilistic and decision information. They have become popular in ATM R&D through their use to describe and elaborate benefit mechanisms.

Key Performance Area (KPA)

Key performance areas are broad categories that describe different areas of performance of an ATM system. The performance framework published by ICAO has 11 categories, such as safety, efficiency, interoperability and security. (See **Performance Framework**)

Key Performance Indicator (KPI)

Key performance indicators measure performance in key performance areas and are identified once the key performance areas are known. A key performance indicator is a measure of some aspect of a concept or concept element, for example, 'the total number of runway incursions per year', 'mean arrival delay per week at airport X'. (See **Performance Framework**)

Lifecycle

In systems engineering terms, the lifecycle is a description of an actual or proposed system that addresses all phases of its existence including system design and development, production and/or construction, distribution, operation, maintenance and support, retirement, phase-out and disposal. In E-OCVM the lifecycle is based on the Concept Lifecycle Model (CLM), consisting of the phases V0, ..., V7, (see E-OCVM V3.0, Volume1, Sections 6.1 & 9).

Maturity Assessment

Maturity assessment analyses key results from concept validation activities to assess progress through the CLM. This enables decisions to be taken on what validation activities remain to complete the current lifecycle phase.

Metric

A metric is an agreed parameter in which a (key performance) indicator is measured. Examples are 'tonnes of CO₂ per flight', 'minutes', 'decibels'. Each key performance indicator has an associated metric. (See **Performance Framework**).

Operational Concept

An Operational Concept is a description of a set of ATM concept elements and the manner in which they are configured and operated. A statement of the operational concept should provide information on the actors involved and their high level tasks and responsibilities, enablers, events and the drivers of the events, processes and their relation to each other, airspace organisation, information flows and procedures.

Generally, the initial concept description is expressed in lifecycle phase V1 in a simple form, with limited detail so as to

not unnecessarily constrain the concept development. As it proceeds and matures through concept lifecycle the description is elaborated and refined.

One of the key products of a validation process is the matured concept description with linked validation evidence used to support and justify the 'validated concept'. See **Concept of Operations**.

Operational Concept Scenario

Tells the story of how the concept will operate to meet operational requirements. It is shared by operational experts and system designers and plays an important role in driving the elaboration, development and validation of the concept, becoming increasingly specific and detailed as system development matures.

Operational Requirement

An Operational Requirement is a statement of the operational attributes of a system needed for the effective and/or efficient provision of air traffic services to users. Operational Requirements are used to build the Operational Concept.

Performance

There are several definitions under this entry, all of which are related.

Baseline Performance

A specific level of some aspect of system performance that serves as a reference.

Performance Objective

An aspect of system performance that is to be improved.

Performance Target

A specific level of some aspect of system performance that is to be achieved.

Target Performance

The level of system performance to be achieved (in a general sense). Compare with the notion of a specific performance target.

Performance Framework

A performance framework is used to document and establish the framework for performance assessment. It typically consists of key performance areas (KPAs), key performance indicators (KPIs), performance targets, metrics and measurement-related assumptions which are used to validate a concept.

For large-scale, performance-focussed validation the performance framework has the additional role of ensuring that all performance validation activities and exercises make measurements in a way in which allows integration and comparison of results. In validation of very large concepts, it may also link performance targets at global and local level, i.e., to establish the link between local performance in specific operational contexts and overall system performance.

The performance framework may be enhanced to support the understanding of how benefit is produced and delivered and for the examination of performance trade-offs.

(See also **Key Performance Areas** and **Key Performance Indicators**)

Pre-Industrial

Pre-industrial is used to refer to (validation) activities which consider the functional, performance, usability, interoperability or other aspects of the concept which are addressed by the research community prior to direct consideration of the issues associated with the technical production and implementation. The technical production and implementation are addressed by industry in V4.

Pre-Operational

Pre-operational is used to refer to all system development products and procedures which are not yet approved and accepted as ready for operational use.

Prototyping

Prototyping is a process where an early and simplified version of a potential design solution is used to further explore requirements, problem characteristics or the applicability of solutions. Prototyping can be applied using a variety of techniques and can focus on a wide range of aspects such as requirements (operational, technical, HMI, etc), interactions, processes or technology.

Requirements

Requirements are characteristics that identify the accomplishment levels needed to achieve specific objectives for a given set of conditions. Requirements are statements that prescribe a function, an aptitude, a characteristic or a limitation to be met by the ATM/CNS system in a given environment.

Research and Development Needs (R&D Needs)

R&D needs state major questions and open issues to be addressed during the development, validation and verifica-

tion of a concept/concept element and supporting enablers. They correspond to (or at least enable) the definition of the programme level development, validation and verification objectives.

System Operability

Covers all aspects of the way that people are designed into the system, which to a large degree is about how well the rest of the system is designed around the people.

Target Performance

The level of system performance to be achieved (in a general sense). Compare with the notion of a specific **Performance Target**.

Transition Criteria

Transition criteria are used in the maturity assessment. They define the scope and level of information and evidence which must be available to demonstrate that a lifecycle phase's activities can be considered complete.

Transversal Areas

In order to manage the work of concept validation and system development, an operational concept will generally be segmented in a way which allows specialisation in the development of solutions. The term transversal is used to refer to aspects of system development which are applicable across the segmentation boundaries. Some examples are related to the need for a shared validation and integration framework such as the high level validation strategy, the performance framework and the maturity assessment process, but others are topic related such as safety, human factors, environment, etc. The latter are often consolidated as **transversal cases** to present key validation information to stakeholders.

Validation

Validation is an iterative process by which the fitness for purpose of a new system or operational concept being developed is established. The E-OCVM focuses on providing evidence that the concept is "fit for purpose" and answers the question, "Are we building the right system?"

Validation Maturity Map

The validation maturity map maintains the description of the maturity (established by the **maturity assessment** process) of the different concept elements in their different operational contexts. It may play an important role especially in large projects or programmes in maintaining a trace of effective progress and in establishing priorities for future validation activities.

Validation Objectives

The validation objectives for a project should be set as part of the project planning process and will then be decomposed and linked through definition of the work plan and the individual exercise plans. In the case of a larger programme the validation objectives of the project will be derived from the Programme R&D Needs and from the high level validation strategy.

Validation Requirements

Validation requirements are the requirements to achieve validation, e.g. the enablers; the timely availability of a performance framework, availability of suitable modelling tools, platforms, reference data etc.

Validation Scenario

A validation scenario is a specific scenario developed for the purposes of undertaking validation activities and to gather evidence relevant to the validation objectives. It is used to analyse the performance and interactions described or expected in the operational concept scenarios. It is necessarily derived from, and compatible with, the operational concept but is designed to focus on aspects of system behaviour which are of interest or concern and lie at the heart of the design of validation exercises. It should also be consistent with the eventual, intended contexts of use.

Verification

Verification provides proof that technology components are feasible and can be safely and economically implemented. Verification can be defined as focusing on the technology and answers the question; "*Are we building the system right?*"

Additionally in a "system of systems" Verification becomes even more important as the performance of one system potentially affects the performance of other systems or may not be able to realise its full performance due to constraints from the other systems. Interoperability of the individual systems with one another must be ensured. Verification therefore needs to be conducted in parallel with validation. This will help to discover problems early and to resolve them before costly deployment.

Having this in mind validation and verification are not considered in isolation by the E-OCVM but are combined in Validation & Verification, one of the Systems Engineering processes.

13 ABBREVIATIONS & ACRONYMS

ACAS	Airborne Collision Avoidance System
AEEC	Airlines Electronic Engineering Committee
AMC	Acceptable Means of Compliance
ANSP	Air Navigation Service Provider
AP5	FAA/EUROCONTROL Action Plan 5: Validation and Verification
AP15	FAA/EUROCONTROL Action Plan 15: ATM Safety Techniques and Toolbox
ASAS	Airborne Separation Assurance System
ATM	Air Traffic Management
CAATS II	Cooperative Approach to Air Traffic Services II, EC FP6 project to support E-OCVM development.
C-ATM	Cooperative Air Traffic Management (ATM R&D project)
CBA	Cost-Benefit Analysis
CBApp	Case-Based Approach
CEN	Comité Européen de Normalisation
CENELEC	European Committee for Electro-technical Standardisation
CLM	Concept Lifecycle Model
CNS	Communication, Navigation, Surveillance
CO	Carbon monoxide
CO ₂	Carbon dioxide
ConOps	Concept of Operations
CREDOS	Crosswind Reduced Separation for Departure Operations (ATM R&D project)
CS	Certification Specification (EASA)
CS	Community Specification (EC)
DG-TREN	General Directorate Transport and Energies of the EC
DOD	Detailed Operational Description
EASA	European Aviation Safety Agency
EATMP	European Air Traffic Management Programme
EC	European Commission
ED78a	Guidelines for Approval of the Provision and Use of Air Traffic Services Supported by Data Communications – as provided by EUROCAE
EIA	Environment Investigation Agency
E-OCVM	European Operational Concept Validation Methodology
EPISODE3	ATM R&D project
ERASMUS	A new Path towards ATM Automation (ATM R&D project)
ERAT	Environmentally Responsible Air Transport (ATM R&D project)
ESARR	EUROCONTROL Safety Regulatory Requirement
ESO	European Standards Organisations
ETS	Emission Trading Scheme
ETSI	European Telecommunications Standards Institute
EUROCAE	European Organisation for Civil Aviation Equipment
Eurolift	Efficient high-lift Design (Aeronautics R&D project)
FASTI	First ATM Support Tool Implementation (EUROCONTROL programme)
FP5, FP6	5 th /6 th EC Framework Project
FOC	Full operational capability
HMI	Human-Machine Interface
ICAO	International Civil Aviation Organisation
iFLY	Safety, complexity and responsibility based design and validation of highly automated air traffic management (ATM R&D project)

INTEROP	Interoperability Standard
IOC	Initial Operational Capability
IP	SESAR Implementation Step – namely IP1, IP2, IP3
IPR	Intellectual Property Rights
IR	Implementing Rule
KPA	Key Performance Area
KPI	Key Performance Indicator
L_{den}	A noise assessment indicator that represents the sound level corrected according to the period of the day. L stands for “level”, d for “day”, e for “evening”, and n for “night”.
L_{eq}	International and National Standards and Guidelines use A-weighted equivalent continuous sound pressure levels to describe the noise impact at residential areas: L_{eq} levels
LoM	Level of Maturity
LTO cycle	Landing and Take Off cycle
MASPs	Minimum Aviation System Performance Standards
MCDAs	Multi Criteria Decision Analysis
MCDMs	Multi Criteria Decision Making
MOPs	Minimum Operational Performance Standard
NASA	National Aeronautics Space Agency of the United States of America
NFDPS	New Flight Data Processing System (at UAC Maastricht)
NO_x	Nitrous Oxides (NO and NO_2).
NPV	Net Present Value
NUP2+	NEAN Update Programme (ATM R&D project, NEAN: North European ADS-B Network, ADS-B: Autonomous Dependant Surveillance – Broadcast)
N70	Noise events louder than 70 A-weighted Decibels (dB(A))
OPTIMAL	Optimised Procedures and Techniques for Improvement of Approach and Landing (ATM R&D project)
OSD	Operational Service and Environment Description
PANS	Procedures for Air Navigation Services
PM _x	Particulate Matter, size less than x μ m
QoS	Quality of Service
R&D	Research and Development
RA	Resolution Advisory (for TCAS)
RESET	Reducing Separation Standards (ATM R&D project)
RIA	Regulatory Impact Assessment
S&R	Standards and Regulations
SAFMAC	SAFety validation for MAJOR Changes
SAM	Safety Assessment Methodology
SAME	Safety Assessment Made Easier
SARPS	Standards and Recommended Practices (ICAO)
SEA	Strategic Environmental Assessment
SEL	Sound Exposure Level
SESAR	Single European Sky ATM R&D
SJU	SESAR Joint Undertaking
SME	Subject Matter Expert
SoR	Statement of Requirement
SO_x	Sulphurous oxides (where x takes different values, SO_2 SO_3 etc.)
SPF	Structured Planning Framework
SPR	Operational, Safety and Performance Requirements Standard

SUPPS	Supplementary Procedures (ICAO)
SWOT	Strengths, Weaknesses, Opportunities, Threats
TC	Transition Criteria
TMA	Terminal Manoeuvring Area
TRL	Technology Readiness Level
TOPAZ	Traffic Organization and Perturbation AnalyZer
UNESCO	United Nations Educational, Scientific and Cultural Organisation
V1, 2, ... 7	CLM Phases V1 to V7.
ValFor	Validation Forum (of the E-OCVM)
VDR	Validation Data Repository
VOCs/HC	Volatile Organic Compounds/Hydrocarbons
WBS	Work Breakdown Structure

14 INFORMATION & FURTHER READING

14.1 Validation Forum Website

Users of this methodology who have questions or a need for explanations or further support should first visit the ValFor web site at <http://www.eurocontrol.int/valfor>. Various forms of support are available including:

- E-mail contact with EUROCONTROL validation staff;
- Guidance material to support the understanding and application of the E-OCVM;
- Useful web links;
- Useful documents.

Additionally European Commission projects support application of the E-OCVM and other aspects of validation. Contact points for those projects can be found on the ValFor Web Site.

Training packages have been developed and can be provided on request. The actual details can be found on ValFor web pages.

14.2 Reference Material on ATM Concept Validation

- [1] European Operational Concept Validation Methodology Version 2.0, March 2002.
http://www.eurocontrol.int/valfor/gallery/content/public/E-OCVM_v2_Small.pdf
- [2] The “Master ATM European VALidation Plan (MAEVA)”:
[Validation Guidance Handbook Part I: http://www.eurocontrol.int/valfor/gallery/content/public/MAEVA_VGH_Part1.pdf](http://www.eurocontrol.int/valfor/gallery/content/public/MAEVA_VGH_Part1.pdf)
[Validation Guidance Handbook Part II: http://www.eurocontrol.int/valfor/gallery/content/public/MAEVA_VGH_Part2.pdf](http://www.eurocontrol.int/valfor/gallery/content/public/MAEVA_VGH_Part2.pdf)
- [3] FAA EUROCONTROL cooperative R&D Action Plan 5 Validation and Verification Strategies: www.eurocontrol.int/valfor
- [4] FAA EUROCONTROL cooperative R&D Action Plan 5: Validation and Verification Strategies: “Operational Concept Validation Strategy Document”, Annex B, FAA/EUROCONTROL.
http://www.eurocontrol.int/valfor/gallery/content/public/AP5_FinalReport_31March08_signatures%20KB_dp_de.pdf
- [5] NASA Technology Readiness Levels http://en.wikipedia.org/wiki/Technology_readiness_level
- [6] SJU: SESAR Validation and Verification Strategy Document, Version 1.0, 2nd June 2009.
- [7] Validation Data Repository (VDR): <http://www.eurocontrol.int/vdr>.
- [8] Improvement of E-OCVM Transition V3 -> V4 Study Report
http://www.eurocontrol.int/valfor/gallery/content/public/report_V01_001.pdf

14.3 Examples of ‘Validation’ Projects

- [1] http://www.eurocontrol.int/eec/public/standard_page/SSP_gate_to_gate.html - for the Gate to Gate project.
- [2] <http://www.episode3.aero/> - for the Episode 3 project.
- [3] <http://www.optimal.isdefe.es/> - for the Optimal project.
- [4] http://www.eurocontrol.int/eec/credos/public/subsite_homepage/homepage.html - for the CREDOS project

14.4 Reference Material on Software Engineering and Requirements Management

- [1] INCOSE Guide to the Systems Engineering body of knowledge (G2SEBoK)
<http://g2sebok.incose.org/app/mss/menu/index.cfm>.
- [2] Roles of Requirements in ATM Operation Concept Validation (RORI-OCV)
http://www.eurocontrol.int/valfor/gallery/content/public/NLR-CR-2007-702_RORI-OCV_D3_Final_Report.pdf

14.5 Reference Material on Maturity Assessment

- [1] Strategic Assessment of ATM R&D Results (SARD), Assessment Process and Criteria, v1.0, EUROCONTROL, 2008.
- [2] Strategic Assessment of ATM R&D Results - ASAS Concept: Airborne Spacing Applications v.1.0, EUROCONTROL, May 2008.
- [3] Strategic Assessment of ATM R&D Results - ASAS Concept: Airborne Self-Separation Applications v.1.0, EUROCONTROL, June 2008.

14.6 Reference Material on Performance Assessment

- [1] ICAO (2008) "Manual on Global Performance of the Air Navigation System: Part I & II", Doc 9883, edition 1.0, February 2008.
- [2] Performance Review Report (PRR 2008), Performance Review Commission, 7 May 2009:
http://www.eurocontrol.int/prc/gallery/content/public/PRR_2008.pdf
- [3] Episode 3, D2.4.1-04, "Performance Framework", Version 3.06, November 2009:
<http://www.episode3.aero/public-deliverables>

14.7 Reference Material on SESAR

- [1] All publicly available documentation on the SESAR Definition Phase is to be found on the ATM Portal.
<http://www.atmmasterplan.eu/> (This includes the Deliverables D1 to D6 and supporting documents).
- [2] All publicly available information on the SESAR Development Phase is to be found on the SESAR JU website <http://www.sesarju.eu/>

14.8 Reference Material in Support of Standardisation and Regulation

- [1] EUROCONTROL (2008) "Guidelines for the Development and Maintenance of the SESAR Standardisation Roadmap".
- [2] European Commission (2007) "Guide to European Community legislation in field of civil aviation, European Commission", June 2007.
- [3] European Commission (2009) "Second strategic review of better regulation in European Union", January 2009
- [4] European Commission (2005) EC Impact Assessment.

14.9 Reference Material in Support of Cases

Business Case

- [1] CAATS II D19, "Business Good Practices", version 1.0, CII-WP1.4-ISD26-V1.0-DE-PU, June 2009.
- [2] CAATS II D20 "Guidance material for a typical business case", version 1.0, CII-WP1.4-BRT33-V1.0-DE-CO, June 2009.

Safety Case

- [1] CAATS II D13, "Good practices for safety assessment in R&D projects," in two parts: CII-WP1.2-DBL-D13P1-v3.6-DE-PU & CII-WP1.2-NLR-D13P2-v3.6-DE-PU, October 2009.
- [2] CAATS II D14 "Guidance document for a typical safety case," CII-WP1.2-NLR-006-V1.91-DE-PU, October 2009.
- [3] FAA/EUROCONTROL, ATM Safety Techniques and Toolbox, Safety Action Plan 15, Issue 2, October 2007.
- [4] EUROCONTROL, Air Navigation System Safety Assessment Methodology (SAM), SAF.ET1.ST03.1000-MAN-01, Edition 2.1, 2007.
- [5] ED-78A/DO264 - "Guidelines for approval of the provision and use of Air Traffic Services supported by data communications" EUROCAE, December 2000. (This document is identical to the US RTCA DO-264)
- [6] H.A.P. Blom, S.H. Stroeve, H.H. de Jong, Safety Risk Assessment by Monte Carlo Simulation of Complex Safety Critical Operations, Eds: F. Redmill & F. Anderson, Proc. 14th Safety critical Systems Symposium, Bristol, UK, February 2006, Springer.
- [7] EUROCONTROL (2009). Safety Assessment Made Easier (SAME) Part 1 - Safety Principles & Introduction to Safety Assessment', v0.94 (agreed), 10th July 2009

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NOTES



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