E-OCVM Version 3.0
Volume II Annexes

European Operational Concept Validation Methodology

EUROPEAN COMMISSION

EUROCONTROL

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Integration and publication were managed by EUROCONTROL.

'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)

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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.

mid 90s Recognition of lack of Business Case support to decision making

2000

2001

2002 EUROCONTROL makes the Validation Data Repository available (June)

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 JPB endorses E-OCVM for collaborative projects for EC and EUROCONTROL (Jan)

Validation Forum Supervisory Board set-up (May)

Release of E-OCVM v 1.0 (June)

First meeting of Validation Forum Supervisory Board (Nov)

2006 CAATS project completed (March)

CAATS II project started (Nov)

2007 Release of E-OCVM v 2.0

Episode 3 project started (April)

2008

2009 CAATS II project completed (Nov)

Episode 3 project completed (Dec)

2010 Release of E-OCVM v 3.0

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, and 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.

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 Concept LifeCycle Model (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 by which a (key performance) indicator is measured. Examples are 'tonnes of CO_2 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 verification 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 will 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.

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
MCDA	Multi Criteria Decision Analysis
MCDM	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)
NOx	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)
OSED	Operational Service and Environment Description
PANS	Procedures for Air Navigation Services
PMx	Particulate Matter, size less than x µm
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

INFORMATION & FURTHER READING

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.

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Validation Guidance Handbook Part I:
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

[3] FAA EUROCONTROL cooperative R&D Action Plan 5 Validation and Verification Strategies: www.eurocontrol.int/valfor

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Examples of ‘Validation’ Projects

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[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

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[1] Strategic Assessment of ATM R&D Results (SARD), Assessment Process and Criteria, v1.0, EUROCONTROL, 2008.

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[3] Strategic Assessment of ATM R&D Results - ASAS Concept: Airborne Self-Separation Applications v.1.0, EUROCONTROL, June 2008.

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[1] ICAO (2008), "Manual on Global Performance of the Air Navigation System: Parts 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

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/

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[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

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[5] EUROCAE, ED-78A/DO264 -“Guidelines for approval of the provision and use of Air Traffic Services supported by data communications”, December 2000. (This document is identical to the US RTCA DO-264)

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[2] CAATS II D17, “Guidance for Human Factors Case within E-OCVM Programmes and Projects”, CII-WP1.3-DBL-D17-V2.0-DE-PU, May 2009.

[3] EUROCONTROL “The Human Factors Case: Guidance for Human Factors Integration”, Version 2, EUROCONTROL, June 2007, http://www.eurocontrol.int/humanfactors/public/standard_page/HF_Case.html

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[1] CAATS II D22, “Environmental good practice,” CII-WP1.5-ICL-D22-V2.0-DE-PU, October 2009.

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ANNEXES

ANNEX 1: REQUIREMENTS DEVELOPMENT

At the heart of the E-OCVM are the validation of a concept and the development of the Operational Concept. Validating a concept means answer the question: “Are we building the right system?” The answer requires an interactive and incremental approach to capturing and validating the requirements that emerge from R&D activities In particular, capturing these requirements runs in parallel to Operational Concept Development. The initial stakeholder requirements that come from the early stages of the operational concept development gradually evolve as a result of further validation activities and continuous requirements review and re-specification. The result will be clear, consistent, and stable requirements that can be used as the basis for implementation and deployment activities.

Operational concept development, validation and requirements engineering are closely interlinked. Validation of the Operational Concept, however, does not explicitly embrace validation of the requirements. Developers, namely requirements engineers, will have to extract requirements from the information captured within the Operational Concept and associated descriptive material (e.g. scenarios and use cases) using interactive participative techniques (e.g. brainstorming, gaming, trade-off analysis, live demonstrations) to support the capture of requirements. These are the same techniques used to build the Operational Concept. Thus, the requirements specification and the Operational Concept specification will be closely related. The Operational Concept is a useful way of communicating the developing concept with stakeholders. As such, Operational Concept validation activities will also provide a powerful means of testing and validating the emerging requirements.

The E-OCVM does not give requirements engineering practices because they are documented elsewhere (INCOSE Guide to the Systems Engineering Body of Knowledge (G2SEBoK) http://g2sebok.incose.org/app/mss/menu/index.cfm). In E-OCVM terms, normally the initial capture of requirements and their analysis will provide input to Concept Lifecycle Model (CLM) phases V0 and V1, whilst the result of requirements management will provide input to later phases. The output from requirements engineering will be particularly important as input to the validation process during Structured Planning Framework sub-steps 0.2 and 1.1 (these sub-steps should be conducted at least once per CLM phase).

Initially, **requirements capture** is conducted to identify stakeholder needs and transform them into raw system requirements. The system requirements describe the services that users and other stakeholders need in a defined environment. A requirements development team identifies the stakeholders of the system throughout its lifecycle, and their needs and desires. Based on the outcome of this process the concept development team produces a high-level concept description to specify the environment and the system components that play a role in this environment. A technology development team (technology development may run in parallel with concept development) should contribute to the description of the real world environment by proposing technical solutions for the operational needs that have been identified.

The following information (commonly contained in a single document), should be the outcome of the requirements capture process:

- documented stakeholder needs;
- documented applicable regulations and legislation;
- documented raw requirements based on the stakeholder needs;
- a high-level concept description including a description of the real world system environment;
- specification of the system characteristics that are required, and the constraints on a system solution.

The process of capturing requirements should comprise the following activities:

- identification of stakeholders: this includes, but is not limited to, organisations involved in the development, qualification, operation, and approval of the system;
- identification of stakeholder needs: this involves the identification of needs, obtained by consulting with the stakeholder;
- translation of needs into raw requirements: formulation of raw requirements based on stakeholder needs and identified organisational requirements due to regulation and legislation processes, including consultation with regulators and stakeholders;
- identification and definition of system constraints: specific constraints can apply, such as minimum operational performance standards and minimum system performance standards, or other issues concerned with legislation (e.g. on safety and security);
- specification of other non-functional requirements, such as performance related requirements.

Requirements capture is followed by the **requirements analysis** process. This transforms stakeholder needs for operational service into a technical view of the system hat could deliver those services. This process builds a representation of a future system that will meet the requirements of the stakeholder and that, as far as constraints permit, does not imply any specific implementation. It results in measurable operational and technical requirements that specify the characteristics that the system needs to possess to satisfy the stakeholder requirements. Requirements analysis should also give numerical targets for the requirements, where possible.

The common set of operational requirements must describe the intended interaction between the system and its operational environment. This set will then be the reference against which each resulting operational service is validated to confirm that the system fulfils the identified needs.

Finally, ongoing **requirements management** must be carried out. This will maintain the operational and technical requirements (including possible organisational requirements due to compliance with regulations for approval, certification, safety etc.) of the services provided by systems and system components and identify inconsistencies between those requirements. Requirements management must take place throughout the CLM phases and must track the rationale and supporting documentation for each of the changes made to a requirement. To improve the requirements management process and the consistency of system development, the central role of a programme manager is recommended in order to supervise all the sub-activities of the overall system development activity (supported by managers on each system and domain level).

ANNEX 2: NASA TRLS VERSUS E-OCVM CLM

Industrial maturity assessment is based on the TRL (Technology Readiness Level) concept derived from initial NASA definitions, which can be applied to technologies, functions, architectures, or methods & tools. The definition of the TRLs is still evolving. A frequently used version is depicted below.

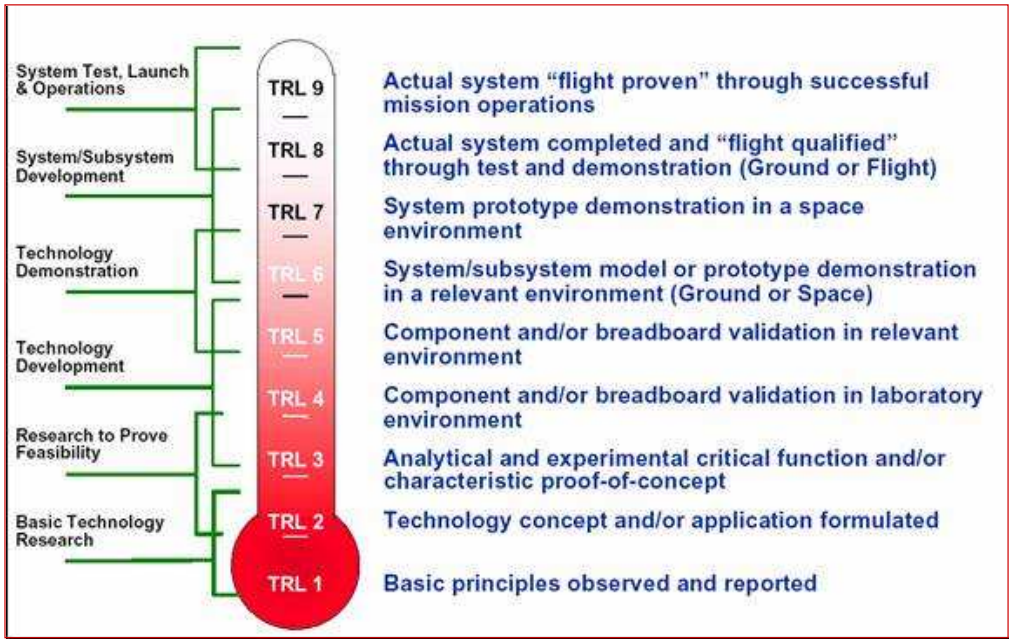

Figure 1: NASA TRLs – Overview (Figures 1 & 2 after Episode 3, WP6)

The principal relation between the TRLs and Concept Lifecycle Model (CLM) phases is shown in the figure below. However interdependencies (deliverables and schedule) between E-OCVM and TRL still need to be defined (operational concept, procedures, standardisation needs, system prototypes, equipments, lab and flight tests…).

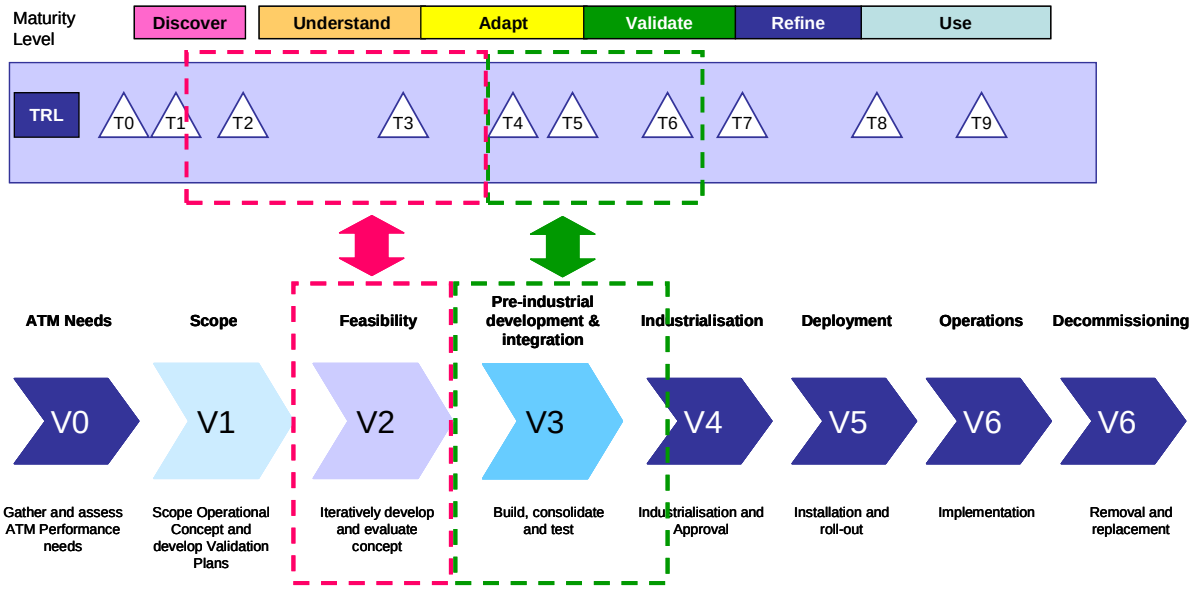

Figure 2: Principal relationship between the NASA TRLs and the E-OCVM CLM phases.

A more detailed presentation is provided at
http://en.wikipedia.org/wiki/Technology_readiness_level .

ANNEX 3: DETAILED DESCRIPTION OF THE STRUCTURED PLANNING FRAMEWORK

1 INTRODUCTION

1.1 Overview

The Structured Planning Framework is introduced in Vol I, Section 3.2 and discussed in Vol I, Section 10 of the E-OCVM. Part III provides a table that summarises the steps and sub-steps of the Structured Planning Framework by programme, project and exercise. The table is sufficiently generic to apply equally well to V1, V2 and V3 of the Concept Lifecycle Model (CLM), that is, the three phases of validation. This annex provides detailed guidance for the application of this table.

This annex presents the application of the Structured Planning Framework at three 'levels' – programme, project and exercise – which is a generic structure for managing validation activity. In fact, the number of levels will depend on the nature of the validation activity itself. For a large scale validation activity (such as SESAR, for example) there could be more than three levels. On the other hand a small and simple concept may only require a validation project with a couple of exercises (that is, no programme level). In the latter case, it would be likely that the project would need to bring in some of the programme level sub-steps into the project.

Guidance in this annex deliberately falls short of providing detailed instructions for a given sub-step. The aim is to provide enough information to be helpful, but not too much such that the Structured Planning Framework becomes a 'recipe book' to follow unthinkingly. The framework is there to help the programme manager, the project manager and the exercise planner (amongst others) to carry out the validation of a concept.

Finally, the larger and more complex the validation activity, the more useful the Structured Planning Framework (and indeed the E-OCVM) will be.

1.2 Target Audience

The target audience for this guidance material is anyone who wishes to have detailed information on what is expected in the sub-steps of the Structured Planning Framework. Thus, the target audience for this annex:

- stakeholders;
- programme managers;
- project managers;
- exercise planners.

1.3 How to Read This Document

The information in this annex is supplementary to that given in Vol I, Section 10 of the E-OCVM.

A step or sub-step will be missing if a particular level has no need of that step or sub-step. Furthermore, if two levels have the same sub-step the description for each will be different, that is, specific to the particular level. Thus, in the first instance, if a programme manager wishes detailed guidance on the Structured Planning Framework he should read the programme level part. Similarly, the project manager and exercise planner should read the project and exercise parts, respectively, if detailed guidance is sought.

The programme manager may also find it helpful to read the project part. Similarly, the project manager may find it helpful to read both the programme and exercise level parts; and the exercise planner may find benefit in reading the project level part. The choice is up to the reader.

Whether at programme, project or exercise level, the information given within a sub-step is deliberately generic to apply to V1, V2 or V3 validation phases. **For specific information on deliverables for a given V-phase please refer to the E-OCVM Vol I, Section 8**.

Finally, no matter the level at which the Structured Planning Framework is to be applied, the framework must be **used intelligently to support the particular validation activity.** The framework should be flexible enough to cope with validation activities of different size and complexity.

1.4 The Structured Planning Framework

1.4.1 Programme Level

STEP 0 STATE CONCEPT AND ASSUMPTIONS
Sub-Step 0.1 Capture or Update the ATM Needs
Description The ***ATM needs*** must be known before validation can start. What are ATM needs? ATM needs are the combination of a description of the ATM problem, and the broad targets that a solution[1] to that problem must meet. This sub-step is about capturing or updating the ATM needs. This sub-step is first applied in phase V0 of the Concept Lifecycle Model. In V1 and subsequent phases the purpose will be to update the ATM needs to capture the evolution of the problem or changes in the operational system constraints. To capture or update the ATM needs the following tasks need to be done: • **Identify the Problem;** broadly state the nature of the problem, if possible, using Key Performance Areas (KPAs) such as safety, capacity, environment. Is the problem now, or in the future? Where and when does the problem occur? These and other simple questions will help to identify the problem; • **Identify the cause;** where does the problem lie? What part or parts of the ATM system contribute to the problem? Which parts are the most important? • **Quantify the problem;** carry out an analysis to quantify the problem. This will help to benchmark the current situation, and will assist the validation activity. It may be that quantitative information already exists, in which case it should be used if possible; • **Identify the constraints;** the problem will be bound by certain constraints, such as time, geographical location, environment and cost of solution. Constraints should be identified. Imagine a given problem has a time constraint – an urgent solution is needed. Given this constraint a lengthy development programme would be unsuitable; • **Set broad targets;** the solution must meet these broad targets. The broad targets will be interpreted and decomposed into more specific targets (called 'performance objectives'). For a large scale programme (like SESAR) a ***performance framework*** is an essential programme tool. It is therefore necessary for the programme manager to ensure that a performance framework is in place on the first encounter of this sub-step, and that it is available and shared by the projects within the programme. Even a *basic* performance framework will help the programme manager to describe the ATM needs.
Expected Outputs • The ATM needs, which consist of: o a description of the ATM problem; o performance framework; and o the broad targets that a solution must meet.

[1] A *concept* is a *solution* to the problem. These two terms are used interchangeably in this annex.

STEP 0 STATE CONCEPT AND ASSUMPTIONS

Sub-Step 0.2 Identify or Refine the Proposed Solution(s)

Description

There are two parts to this sub-step. First, identify one or more proposed solutions to the ATM problem. Second, describe each proposed solution. It may help to provide operational scenarios for illustration.

Each proposed solution to the ATM problem should be described. The list of bullets below will help. Whilst the bullets provide a good starting point, the list is not exhaustive.

- **Describe the proposed solution;** start with a general description;
- **What are the benefits to expect?** Which KPAs will see benefit? Are all ATM needs met, or just some? Will the ATM needs be met in stages or all at once?
- **How will the expected benefits be realised?** Describe how the proposed solution will resolve the ATM problem;
- **What are the enablers?** Does the proposed solution rely on other existing systems or proposed developments?
- **What are the constraints**? – Are there constraints imposed on the solution? In V1 these constraints are likely to be very similar to the constraints described in sub-step 0.1, but as the concept matures through V2 and V3 the constraints may become more specific.
- **Are there legal implications?** If so, describe them briefly. An example: is certification required?
- **What are the assumptions?** What has been assumed in developing the proposed concept? (Validation will need to verify that these assumptions are correct).
- **Are there any limitations?** Is the proposed concept limited in some way? For example, will it only work in certain environments, or does its effectiveness deteriorate in poor weather?
- **New problems;** what problems could be created if the proposed solution becomes operational? Are any likely to be critical, which could affect the success of the solution?
- **Areas of special attention;** perhaps it is already clear that some areas of the proposed concept will require special attention in the validation process. If so, these should be listed.
- **Risks;** the proposed solution will have some risks in terms of current maturity, the required level of development, the required level of investment, the impact on the baseline system, the complexity of the solution, etc. Each risk should be quantified and mitigated where possible.

The proposed operational concept(s) and associated technical solution(s) should be defined in sufficient detail so that: (a) benefit mechanisms can be identified, and (b) costs can be estimated to justify research and development (R&D) activity.

Comparing and contrasting ***several*** proposed solutions may increase the chances of finding a good solution to the ATM problem.

The first time this sub-step is encountered (probably in V1, but not necessarily) the task will be to *identify* the proposed solution(s). On subsequent encounters the task will be to *refine* the description or descriptions.

Expected Outputs

- A description of each proposed solution, perhaps with some operational scenarios for illustration.

STEP 1	SET VALIDATION STRATEGY
Sub-Step 1.1	**Identify or Refine a) Stakeholders, and b) the Cost and Benefit Mechanisms**

Description

There are two parts to this sub-step.

The first part of the sub-step relates to stakeholders. Anyone that has any input to, or is in any way affected by the implementation of the proposed concept is a stakeholder. The co-operation and advice of stakeholders is vital to ensure that a good operational concept is brought into service. Thus, stakeholders must be consulted throughout the validation process.

The first stage is to perform a **stakeholder analysis**. A stakeholder analysis identifies all the parties that have an interest (stake) in the ATM problem or the proposed solution. Their interests are assessed, and also the ways in which their interests affect the development of the proposed concept or concepts.

The second stage is to discuss with stakeholders what participation they wish to have (if any), and what outcome or 'final product' they want to see from validation (**stakeholder expectations**). Stakeholders may have conflicting views and interests.

The second part of this sub-step is to define the cost and benefit mechanisms for each concept. This will need performance objectives to be defined for each concept.

The first time this sub-step is encountered (probably in V1, but not necessarily) the task will be to gather the information. On subsequent encounters the task will be to check that the information is still correct.

Expected Outputs

- Stakeholder analysis;
- Stakeholder expectations;
- Cost and benefit mechanisms.

STEP 1	SET VALIDATION STRATEGY
Sub-Step 1.2	**Identify R&D Needs and Carry Out the Initial Maturity Assessment for Each Concept**

Description

Before proceeding, an explanation of maturity with respect to a concept is required. A concept that is well documented whose performance characteristics are well known and quite certain is more mature than a concept that has little detail and is without any measured performance. The more detail, more quantification, less risk and less uncertainty about the viability and performance of a concept, the more mature the concept is.

The first purpose of this sub-step is to assess the maturity of the concept or concepts, thus identifying which particular V-phase the concept or concepts are in. The more mature the concept the more likely it is to belong to a higher V-phase.

The first occasion this sub-step is encountered the maturity of the concept will be assessed. On subsequent encounters the concept may well have been broken down into **concept elements**. If a concept has been segmented (split up) into several concept elements a maturity assessment will be required for each concept element. Different concept elements need not be at to the same V-phase. Segmentation occurs in sub-step 1.6, where a brief explanation can be found.

The second purpose of this sub-step is to identify what the maturity levels of the concept (or concept elements) should be for the current and subsequent validation V-phases. These are called the **target levels of maturity**. The target levels of maturity will be described by **transition criteria**, which are the individual targets that the concept (or concept element) must attain if the concept (or concept element) is to pass on to the next V-phase.

If a concept (or concept element) does not satisfy the target level of maturity for the current V-phase there will be three alternative outcomes. Another round of validation work is required on the troublesome concept (or concept element) to ensure that it passes in future, or, the concept (or the concept element) is modified, or it is withdrawn. If the concept or concept element is modified, it will need to be subject to further validation activity.

Expected Outputs

- Description of the current and target levels of maturity;
- Set of transition criteria to describe each target level of maturity (that is, for each validation V-phase) for each concept (or concept element).

STEP 1 SET VALIDATION STRATEGY

Sub-Step 1.3 Define the Objectives for the Validation Activity

Description

The purpose of this sub-step is to define the ***validation objectives*** for the programme level. These will be created with reference to three different sources of information:

- the stakeholder expectations expressed at the programme level (sub-step 1.1);
- any programme level case-based material that already exists;
- information coming in from the validation related research needs at the level of the programme maturity assessment.

Validation objectives determine the scope, direction and design of the validation activity, and so are a vital component of any validation activity.

Before defining the validation objectives it may be helpful to consider the following questions:

- What is the aim of the validation process during each V-phase of the Concept Lifecycle Model?
- What can be realistically achieved in the validation process during each V-phase?
- What do stakeholders expect from validation during each V-phase?
- What would be an acceptable output of the programme at the end of each V-phase?
- What specifically will validation address?
- What are the transition criteria for the concept(s) or concept elements to progress to the next V-phase?

Each time this sub-step is encountered the validation objectives will need to be restated and revised, if necessary.

Defining the validation objectives should help to identify the cases (such as Safety and Human Factors) that are needed at the programme level. It will be helpful to establish the shared rules for when projects should consider certain cases, and the fact that projects have the right to identify the need for them.

Expected Outputs

- Validation objectives for the programme level.

STEP 1	SET VALIDATION STRATEGY
Sub-Step 1.4	**Create Performance Objectives**

Description

Starting from the broad targets for a concept in sub-step 0.1, performance objectives are first derived in sub-step 1.1. Performance objectives *must* be consistent with these broad targets. The decomposition of the broad targets into appropriate performance objectives is part of the work of the performance framework (a performance framework is necessary for large scale validation activities). Thus, the performance framework that began in sub-step 0.1, V0, continues in sub-step 1.4.

In sub-step 1.4 performance objectives are refined, each one described in terms of KPA-KPI-metric combinations.

Expected Outputs

- List of KPIs and their metrics;
- List of performance objectives for the programme.

STEP 1 SET VALIDATION STRATEGY
Sub-Step 1.5 Define, or update the Validation Requirements
Description 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, realism required, etc. These requirements should be gathered and detailed here. It is preferable to keep these requirements at a similar level to the level that the problem and solution(s) have been described. Enough information should be gathered to at least enable an initial estimate of the number of projects and validation exercises required with perhaps even enough information to recommend appropriate tools and techniques. The first time this sub-step is encountered (probably in V1, but not necessarily) the task will be to define the validation requirements, and on subsequent encounters to review and update it.
Expected Outputs • The current requirements for validation

STEP 1 SET VALIDATION STRATEGY

Sub-Step 1.6 Define or Refine the Validation Work Plan

Description

The purpose of this sub-step is to organise the validation activity. A large validation activity (like SESAR) needs to be broken up into smaller, manageable activities. This process is called **segmentation**. The purpose of segmentation is to make the validation of the concept easier. There is no single approach to segmentation, as it will depend on the nature of the concept itself. However, segmentation should aim to produce segments (**concept elements**) that are broadly self-contained building blocks of the concept. Very experienced persons should lead this difficult activity.

The **Validation Work Plan** describes how the validation activity from V1 through to V3 is organised into manageable pieces of work. If segmentation has occurred, the Validation Work Plan will follow this structure.

For a large validation activity (like SESAR for example) the Validation Work Plan should go into detail *down to* the project level. The programme should give validation objectives for each project. In addition, it will be useful to describe the relationship between different projects, for instance, whether they run in series or parallel. The Validation Work Plan should describe validation activities for the current V-phase in detail, and subsequent V-phases in outline.

The first time this sub-step is encountered (probably in V1, but not necessarily) the task will be to write the Validation Work Plan from scratch. On subsequent encounters the task will be to review and update it.

Expected Outputs

- The Validation Work Plan.

STEP 1	SET VALIDATION STRATEGY
Sub-Step 1.7	**Consolidate the Validation Strategy (in One Document)**

Description

Sub-steps 1.1 to 1.6 are the separate parts of the validation strategy. Together they make the validation strategy. This sub-step brings the parts together in one document.

The first time this sub-step is encountered (probably in V1, but not necessarily) the task will be to bring together the various texts that have already been written. On subsequent encounters the task will be to review and update it.

The programme manager must ensure that the programme level validation strategy is available to all validation projects *before* the projects reach sub-step 1.3. This will allow projects to agree their validation objectives with the programme, and to inherit working methods and assumptions.

Expected Outputs

- The validation strategy presented in one document or one set of documents.

STEP 4	DETERMINE THE RESULTS
Sub-Step 4.3	**Prepare the Validation Report and Cases**

Description

A programme level validation report will give an overall view of the validation activity (of its constituent projects) at a certain point in time. How often these reports are required within the current V-phase will be set at the programme level, but may also depend on the implications of the results from the ongoing validation exercises.

The target audience will be senior managers. With this in mind, the report should provide an overview of progress to date without being too technical. Items to include will be a presentation and discussion of important results, problems encountered, conclusions and recommendations. The report should focus on validation activity that has occurred since the last programme level validation report.

At the same time, programme level cases will be filling up with the results from project validation activities. Because cases and the programme level validation report draw from the same pool of validation results they should (and must) be consistent.

Expected Outputs

- A report that summarises the validation activity to date;
- Programme level cases are updated with results from validation activities.

STEP 5	DISSEMINATE INFORMATION TO STAKEHOLDERS
Sub-Step 5.1	**Review Maturity and Validation Results with Stakeholders**

Description

The programme level validation report and the cases are presented to the stakeholders. The purpose is to provide stakeholders with enough relevant information to see what progress has been achieved, and to compare the progress against what was planned, and to explain discrepancies, if any exist.

Depending on the validation strategy, there may be several occasions within the same V-phase when validation results are presented to the stakeholders. It may not be necessary to **asses the maturity** of the concept or concept elements unless at the end of the V-phase. If an assessment of the maturity of the concept or concept elements is required, the assessment will use the **transition criteria** to decide if the **target level of maturity** has been met for the concept or for each concept element. Recall that if the concept is broken down into concept elements, the concept elements need not be in the same V-phase. If required, the results of the maturity assessment will be presented to the stakeholders with the cases and or programme level validation report

Expected Outputs

- Possibly, but not necessarily, an assessment of the maturity of the concept or concept element.

STEP 5	DISSEMINATE INFORMATION TO STAKEHOLDERS
Sub-Step 5.2	**Draw Conclusions and Decide on Actions: Feedback to the Validation Strategy**

Description

Having evaluated the evidence presented before them in sub-step 5.1, the stakeholders are ready to make decisions on the future direction of the validation activity.

The stakeholders will decide if the concept or each concept element can progress to the next V-phase. This particular decision may not be necessary, depending on whether the validation activity is at the end of the V-phase or not.

If either the concept or concept element fails to satisfy the target level of maturity for the current V-phase, there will be three alternative outcomes: another round of validation work is required on the troublesome concept (or concept element) to ensure that it passes in future, or, the concept (or the concept element) is modified, or it is withdrawn. If the concept or concept element is modified, it will need to be subject to further validation activity.

Finally, the stakeholders will also decide what changes are required for the operational concept and for the validation strategy.

Expected Outputs

- A decision to proceed or not to the next V-phase for each concept or concept element (if applicable);
- A decision on the changes needed for the operational concept and for the validation strategy.

1.4.2 Project Level

STEP 0	STATE CONCEPT AND ASSUMPTIONS

Sub-Step 0.2 Identify or Refine the Proposed Solution(s)

Description

The main purpose of this sub-step is to describe the parts of the concept or concepts that are within the scope of the project. It may help to provide operational scenarios for illustration.

On the first encounter of this sub-step the project manager should look to the programme level description of the concept(s) to extract the parts of the concept(s) that are within the scope of the project. Only a vague description may be available, in which case the project manager will be responsible for proposing and fleshing out details of the concept(s) himself. Indeed, describing the concept(s) is the beginning of validation (V1).

On sub-sequent encounters of this sub-step (whether in later V-phases, or a different cycle within the same V-phase) the parts of the proposed solution(s) that are within scope of the project will need updating to take account of the latest information from validation activities. The starting point for revising the description should be the latest description available at programme level.

Whether the task is to describe the concept(s) from scratch or to revise an existing description or descriptions, reference to the following bullets may help. The list is not exhaustive.

- **Describe the proposed solution;** start with a general description of the solution that lies within the scope of the project;
- **What are the benefits to expect?** Which KPAs will see benefit? Are all ATM needs met, or just some? Will the ATM needs be met in stages or all at once?
- **How will the expected benefits be realised?** Describe how the proposed solution will resolve the ATM problem;
- **What are the enablers?** Does the proposed solution rely on other existing systems or proposed developments?
- **What are the constraints**? – Are there constraints imposed on the solution? In V1 these constraints are likely to be very similar to the constraints described in sub-step 0.1, but as the concept matures through V2 and V3 the constraints may become more specific.
- **Are there legal implications?** If so, describe them briefly. An example: is certification required?
- **What are the assumptions?** What has been assumed in developing the proposed concept? (Validation will need to verify that these assumptions are correct).
- **Are there any limitations?** Is the proposed concept limited in some way? For example will it only work in certain environments, or does its effectiveness deteriorate in poor weather?
- **New problems;** what problems could be created if the proposed solution becomes operational? Are any likely to be critical, which could affect the success of the solution?
- **Areas of special attention;** perhaps it is already clear that some areas of the proposed concept will require special attention in the validation process. If so, these should be listed.
- **Risks;** the proposed solution will have some risks in terms of current maturity, the required level of development, the required level of investment, the impact on the baseline system, the complexity of the solution, etc. Each risk should be quantified and mitigated where possible.

Expected Outputs

- A description of each proposed solution, perhaps with illustrative operational scenarios

STEP 1	SET VALIDATION STRATEGY
Sub-Step 1.1	**Identify or Refine a) Stakeholders, and b) the Cost and Benefit Mechanisms**

Description

There are two parts to this sub-step.

The first part of the sub-step relates to stakeholders. Anyone that has any input to, or is in any way affected by the implementation of the proposed concept within the scope of the project is a stakeholder for the project. The co-operation and advice of stakeholders in the project is vital to ensure that a good operational concept is brought into service. Thus, stakeholders must be consulted throughout the validation process.

The first stage is to perform a **stakeholder analysis**. A stakeholder analysis identifies all the parties that have an interest (stake) in the ATM problem or the proposed solution within the scope of the project. Their interests are assessed, and also the ways in which their interests affect the development of the proposed concept or concepts within the scope of the project.

The second stage is to discuss with stakeholders what participation (if any) they wish to have, and what outcome or 'final product' they want to see from validation (**stakeholder expectations**). Stakeholders may have conflicting views and interests.

The second part of this sub-step is to define the cost and benefit mechanisms for each concept within the project's scope with respect to the context of operations being considered that project and how they contribute to the programme level. Similarly programme level performance objectives for each concept will need to be translated into the operational context of the project.

The first time this sub-step is encountered (probably in V1, but not necessarily) the task will be to gather the information. On subsequent encounters the task will be to check that the information is still correct.

Expected Outputs

- Stakeholder analysis;
- Stakeholder expectations;
- Cost and benefit mechanisms for the project.

STEP 1 SET VALIDATION STRATEGY

Sub-Step 1.3 Define the Objectives for the Validation Activity

Description

The purpose of this sub-step is to ensure that the project has appropriate **validation objectives**. Validation objectives determine the scope, direction and design of the project. Validation objectives for the programme level will already have been defined and possibly the programme will already have interpreted and refined its validation objectives for each project. If this is the case the task for the project manager will be to ensure that these validation objectives are correct and complete. If not, the project manager will be responsible for interpreting and refining the programme level validation objectives for his project. These will need to be confirmed with the programme manager.

In the later case it may be helpful to consider the following questions:

- What is the aim of the project during each V-phase of the Concept Lifecycle Model?
- What can be realistically achieved in the project during each V-phase?
- What do stakeholders expect from the project during each V-phase?
- What would be an acceptable output of the project at the end of each V-phase?
- What specifically will the project address?
- For the concept(s) or concept elements that lie within the scope of the project, what are the transition criteria to advance the project to the next V-phase?

Defining the validation objectives for the project should identify the programme level cases (such as Safety and Human Factors) into which the project will provide results. It may also help to identify cases that are specifically required for the project.

It will be important to check regularly that the project's validation objectives are still consistent with the programme level validation objectives.

Expected Outputs

- Validation objectives for the project.

STEP 1	SET VALIDATION STRATEGY

Sub-Step 1.4 Create Performance Objectives

Description

The purpose of this sub-step is to ensure that the project has identified appropriate **performance objectives** for the project's exercises.

Programme level performance objectives will already have been defined (in sub-step 1.1 and 1.4) by programme managers, and possibly these will have already been decomposed into project level performance objectives. If this is the case the task for the project manager will be to ensure that the performance objectives allotted to the project are correct and complete (are consistent with meeting the project's validation objectives from sub-step 1.3). If this is not the case the project manager will be responsible for decomposing (interpreting and refining) the programme level validation objectives for his project, ensuring that these are consistent with meeting the project's validation objectives from sub-step 1.3). (The exercise planners will then decompose the project level performance objectives down to the specific exercises).

It will be important to check regularly that the project's performance objectives are still consistent with the programme level performance objectives and the project's validation objectives from sub-step 1.3.

Expected Outputs

- List of KPIs and their metrics useful for the project;
- List of performance objectives for the project.

STEP 1 SET VALIDATION STRATEGY
Sub-Step 1.5 Establish Validation Requirements
Description The validation requirements specific to the project (e.g. particular requirements related to the scope of the project – operational context, assumptions to be shared by exercises, etc.) should be gathered and detailed here. Validation requirements are the requirements to achieve validation, e.g. the enablers; the timely availability of a performance framework, availability of suitable tools, techniques, reference data, realism required, etc.
Expected Outputs • The requirements for validation for the project.

STEP 1 SET VALIDATION STRATEGY

Sub-Step 1.6 Define or Refine the Validation Work Plan

Description

The purpose of this sub-step is to organise the validation activity that is within the scope of the project. The project level **Validation Work Plan** describes how the validation activity from V1 through to V3 is organised into exercises. The project manager is responsible for giving validation objectives to each exercise. These should be derived from the validation objectives of the project (sub-step 1.3).

Exercises may be carried out in series and or parallel. Therefore, the plan should show how the exercises relate to each other. The project level Validation Work Plan should describe the exercises for the current V-phase in detail, and subsequent V-phases in outline.

The first time this sub-step is encountered (probably in V1, but not necessarily) the task will be to write the Validation Work Plan for the project from scratch. The programme level Validation Work Plan may contain information on how the project is decomposed into exercises. In this case this will be a good starting point for writing the Validation Work Plan for the project. On subsequent encounters the task will be to review and update it.

Expected Outputs

- The Validation Work Plan for the project.

STEP 4	DETERMINE THE RESULTS

Sub-Step 4.3 Prepare the Validation Report and Cases

Description

A project level validation report will give an overall view of the validation activity within the scope of the project at a certain point in time. How often these reports are required within the current V-phase will be set at the programme level, but may also depend on the implications of the results from the ongoing validation exercises.

The target audience will the programme manager, those managing the cases and the stakeholders. The report should provide an overview of progress to date within the exercise without being too technical. Items to include will be a presentation and discussion of important results, problems encountered conclusions and recommendations. The report should focus on the validation activity that has occurred in the project since the last project validation report.

At the same time, programme level cases will need information from the project. In addition, the project itself may have its own specific cases. Cases will need to be kept up to date with the latest validation results from the exercises. Programme level and project level cases and the project level validation report all draw from the same pool of project validation results, so they should (and must) be consistent.

Expected Outputs

- A report that summarises the validation activity within the project to date;
- Cases are updated with results from the project's validation activities.

1.4.3 Exercise Level

STEP 2	DETERMINE THE EXERCISE NEEDS
Sub-Step 2.1	**Identify the Acceptance Criteria and Performance Requirements for the Exercise**

Description

Briefly describe what the project expects from the validation exercise in terms of project level validation objectives, and describe how the results of the validation exercise will be useful to the project. In other words, this is about ensuring that those planning the exercise know *why* the exercise is worth the trouble by having to justify it themselves.

Describe what success would be for the exercise[2]. This may help the exercise planner to understand what will bring about success (and failure) of the exercise. This is likely to ensure a greater chance of success for the exercise itself.

Outputs

- A short text to justify the need for the exercise, and what the project expects from it. A description of what success for the exercise looks like.

[2] *Success* is not the affirmation of a hypothesis, and *failure* is to reject it.

STEP 2	DETERMINE THE EXERCISE NEEDS
Sub-Step 2.2	**Refine the Validation Objectives**

Description

The purpose of this step is to ensure that the exercise has appropriate validation objectives. The project may already have proposed validation objectives for the exercise. If so, these may need to be refined to ensure they are appropriate for the exercise (one criterion of appropriateness is that the validation objective can be achieved in the exercise!). If not, the exercise planner will need to decompose (interpret and refine) the project level validation objectives to create validation objectives for his exercise.

The E-OCVM is a top-down methodology, and so an exercise's validation objectives should be described through the performance framework. However, there may be occasions where an exercise identifies validation objectives that are unconnected to the performance framework. These will need the agreement of the project manager.

Validation objectives are an essential ingredient of an exercise because they determine its scope, direction and design.

Outputs

- A list of validation objectives for the exercise.

STEP 2 DETERMINE THE EXERCISE NEEDS

Sub-Step 2.3 Refine Exercise Validation Requirements

Description

The purpose of this sub-step is to describe in detail how the exercise will meet its validation objectives. A description should already be available in documentation at the project level, but it is unlikely to be detailed enough. The description will cover the method to achieve the exercise's validation objectives, which will itself cover the technique(s) and tool(s) in support of the method.

The exercise should be designed to address the validation objectives of the exercise (sub-step 2.2). Each validation objective will have at least one hypothesis to test during the course of the exercise. There may be assumptions made during the design of the method, in which case these should be captured.

Outputs

- A detailed description of how the exercise intends to meet its validation objectives;
- The hypotheses;
- The assumptions.

STEP 2	DETERMINE THE EXERCISE NEEDS
Sub-Step 2.4	**Identify Indicators and Metrics**

Description

The purpose of this sub-step is to describe the KPIs and metrics for the exercise's validation objectives (given in sub-step 2.2). There may already be a description of these in project level documentation. If not, the KPIs and metrics can be chosen from a list in the performance framework.

There may be occasions when the exercise identifies indicators that are not KPIs within the performance framework. Such indicators might be useful for the exercise, but not for a direct evaluation of the concept(s). For example, exercise planners may want to measure the correctness of an algorithm in a new validation model.

Outputs

- List of indicators and metrics for the exercise.

STEP 2 DETERMINE THE EXERCISE NEEDS

Sub-Step 2.5 Develop the Validation Scenarios

Description

The purpose of this sub-step is to develop validation scenarios for the exercise. A **validation scenario** provides the setting (context) in which all or part of the concept can be validated.

Operational concept scenarios may already have been created by others to describe the concept to stakeholders. These scenarios might be a good starting point for developing the **validation scenarios** for the exercise.

The choice of validation scenarios should be driven by the hypotheses which will be tested in the exercise. Recall that in sub-step 2.3 the hypotheses are derived from the exercise's validation objectives.

Output

- Validation Scenarios.

STEP 2 DETERMINE THE EXERCISE NEEDS

Sub-Step 2.6 Produce the Validation Exercise Plan

Description

The purpose of a validation exercise plan is to ensure that those responsible for carrying out the exercise will have thought about and planned their exercise sufficiently to ensure that the exercise will be successful.

However, the plan is not just for those who will carry out the exercise. The project manager needs to review the plan and approve it. The plan can be thought of as a contract between the project manager and those who will carry out the exercise. Others who may be interested in the validation exercise plan are: other project managers, programme managers, those responsible for building cases, the stakeholders.

The validation exercise plan should be **structured** in a **logical** fashion and **short**. This will help the reader make sense of the document. The validation exercise plan should be **useful**, a document to refer back to during the setting up of the exercise and during the exercise itself. It may also assist with writing the validation exercise report. If the validation exercise plan is sitting on a shelf gathering dust this could be a sign that there will be problems ahead with the exercise. **Keep the plan to hand**, and update it if need be.

Each validation exercise plan is different, and will depend on the particular circumstances of the validation activity. However, most plans will include some or all of the following topics (the choice is best left to the discretion of those planning the exercise, with the agreement of the project manager):

- where the validation exercise fits in with other work;
- some background information on the subject, but ideally not too much;
- the aims of the exercise (i.e., the validation objectives);
- how the exercise links back to project level KPAs and KPIs;
- how the exercise will be carried out (i.e., the experimental design);
- hypotheses, and their acceptance/rejection criteria;
- the assumptions;
- a description of how the data will be analysed;
- roles and responsibilities of everyone in connection with the exercise;
- time planning (a Gantt chart can be useful here);
- how the validation exercise will be reported.

If your exercise sits within a large validation programme, a validation exercise plan template may be provided. With luck the format of the template will provide some flexibility to adapt the plan to the particulars of the exercise.

Finally, some **symptoms of a badly written validation exercise plan** are:

- excessive use of jargon, abbreviations and acronyms (even if given in a glossary);
- verbosity;
- it is long;
- poorly structured;
- difficult to understand;
- repetition.

If your validation exercise plan shows several of these symptoms it is likely to be badly written. This might be because you have not thought clearly and deeply enough about your exercise. In

any case, the plan should be rewritten.
Output • The validation exercise plan.

STEP 2	DETERMINE THE EXERCISE NEEDS
Sub-Step 2.7	**Prepare Material for the Exercise**

Description

The purpose of this sub-step is to prepare for the exercise. The validation exercise plan may have discussed particular traffic samples, or platforms, or scripts, or training aids, for example. In this sub-step these are made ready so that the exercise can begin.

Output

- All the material necessary for the exercise to begin.

STEP 2	DETERMINE THE EXERCISE NEEDS
Sub-Step 2.8	**Conduct Pre-Exercise Testing and Training**

Description

Once the material for the exercise is ready, **it is important** to test the method, prepared material, platform (if there is one), organisation, etc., **together**. This can be carried out by the planners of the exercise, perhaps with the help of volunteers or with the actual participants of the forthcoming exercise (if there are any). The aim of such testing is to confirm that the method described in the validation exercise plan works, and to identify glitches in the setup of the exercise, procedures, platform, etc. Subsequent to testing, any problems that were observed should be corrected before the exercise begins, and the validation exercise plan updated accordingly.

If the validation method describes the need for participants, this sub-step will provide a good opportunity for them to get acquainted with the method, and platform (if one exists). The advantage will be that come the start of the real exercise, the participants should require less training time.

Output

- A tested platform and experimental approach;
- Trained participants for the forthcoming exercise (but some exercises may not have participants).

STEP 3	CONDUCT THE EXERCISE
Sub-Step 3.1	**Carry Out the Validation Exercise**

Description

The purpose of this sub-step is to carry out the exercise in accordance with the validation exercise plan.

Note any unexpected behaviour or results during the course of the exercise. Participants may report problems too, perhaps in relation to the platform or with assumptions. However, sub-step 2.8 should have identified some or all unexpected behaviours and problems beforehand.

Output

- Saved data;
- Details of unusual or unexpected data or behaviour during the course of the exercise.

STEP 3	CONDUCT THE EXERCISE
Sub-Step 3.2	**Examine Unexpected Behaviour or Results, and Reports of Problems**

Description

This sub-step is carried out in parallel with the previous sub-step. The purpose of sub-step 3.2 is to examine unexpected behaviour or results, or problems raised by the participants (if there are any) in the exercise. Unexpected results may not necessarily be bad because they may reveal important information about the concept. An example of an unexpected result would be the failure of an algorithm under certain unforeseen but real conditions.

An assessment may conclude that the exercise should either carry on, be modified, or be stopped.

Output

- An assessment of any unexpected behaviour or results or reported problems.

STEP 4	ANALYSE THE RESULTS
Sub-Step 4.1	**Analyse the Data as Planned**

Description

The purpose of this sub-step is to carry out the analysis of the results in accordance with the validation exercise plan. There may be occasions when the analyst sees benefit in analysing the data in a different way to that described in the validation exercise plan. This should be done only if there is a good reason to do this, **and with the consent of the project manager**. Recall that the purpose of producing results and analysing them is to address the validation objectives of the exercise.

Outputs

- An analysis of the data.

STEP 4 ANALYSE THE RESULTS
Sub-Step 4.2 Prepare Analysis Contributions
Description The purpose of this sub-step is to understand the operational significance of the results (note, a result may be statistically significant but not necessarily operationally significant). Group the results into meaningful groups (analysis contributions) so that the impact in a particular group is clear. Grouping could be by KPA, or perhaps by project level validation objective. The analyst should state the results, compare them to the exercise's hypotheses, determine the operational significance of the results, and summarise them in meaningful groups. Within an exercise no conclusions should be drawn about the success or failure of the concept or concept element itself, which should be the role of the stakeholders.
Outputs • Analysis contributions.

STEP 4 ANALYSE THE RESULTS

Sub-Step 4.3 Write the Validation Exercise Report

Description

The purpose of the validation exercise report is to summarise the validation exercise and its results in a clear and succinct way.

The validation exercise report is the formal deliverable of the exercise to the project. Thus, the report is written primarily for the project manager, and the language and style should be chosen accordingly to suit him or her. However, think who else is likely to read the report. The report must be written ***clearly*** for all readers.

Each validation exercise report is different, and will depend on the particular circumstances of the validation activity. However, most reports will include some or all of the following topics (the choice is best left to the discretion of those writing the report, with the agreement of the project manager):

- executive summary (this is a short, standalone summary of the validation exercise report);
- aim of the report;
- where the validation exercise fits in with other (current and previous) work in the project or programme;
- some background information on the subject, but ideally not too much;
- how the exercise links back to project level KPAs and KPIs;
- description of what was done during the exercise;
- assumptions;
- results;
- discussion of results;
- conclusions;
- glossary.

If your exercise sits within a large validation programme, a validation exercise report template may be provided. With luck the format of the template will provide some flexibility to adapt the report to the particulars of the exercise.

Finally, some ***symptoms of a badly written validation exercise report*** are:

- excessive use of jargon, abbreviations and acronyms (even if given in a glossary);
- verbosity;
- it is long;
- poorly structured;
- difficult to understand;
- repetition.

If your validation exercise report shows several of these symptoms it is likely to be badly written. The report should be rewritten.

Outputs

- A validation exercise report.

ANNEX 4: MATURITY CRITERIA

1 R&D CATEGORIES AND THEIR USE

The R&D needs (i.e. programme level development, validation and verification objectives) state major questions and open issues to be addressed during the R&D phases of the Concept Lifecycle Model (V0-V3).

The R&D need categories present a checklist of areas to be inspected for the systematic identification of research and development needs per concept element.

They are defined in four groups: (1) problem, (2) context of use, (3) design and feasibility, and (4) validation of performance,. There is no one to one relationship between these groups and the lifecycle phases. The proposed R&D need categories aim to allow a unique classification for each R&D need. They can be applied easily to formulate new R&D needs whereas the mapping of the existing R&D needs to the R&D needs categories might be more challenging in some cases. Some tips are provided at the end of this annex to ease that process.

1.1 Problem/Solution Link

Is there a need to deepen the understanding of the ATM problem and its contributing factors in order to develop or further elaborate the concept for its improvement? If the answer is yes, this element is normally in the lifecycle phase V0. A better understanding of the ATM problem, its contributing factors and their importance needs to be created before a potential solution can be further elaborated. The link between ATM problem and the solution should be clarified through the use of a performance influence diagram,.

1.2 Context of Use

Is there a need to investigate further the understanding of the specific context of use (airspace, airports, en-route, TMA, traffic complexity)? Up to the end of lifecycle phase V1 this could be the situation. An initial definition of the operational concept is in that case available. The specific context of use still needs to be described in more detail in direct relationship to the ATM problem. The performance influence diagram should allow illustration of the benefits in the problem context. If these links cannot be established, the problem has to be investigated further or the initial concept definition needs to be improved.

1.3 Design & Feasibility

The R&D categories in this group address typical feasibility questions to be answered during the elaboration of an operational/transversal improvement, its supporting enablers and transition scenarios/issues.

Processes & procedures (business processes/operational procedures and roles):

Is there a stable and validated definition of the new or modified business processes, operational procedures, maintenance procedures, civil military coordination/ cooperation, etc. that are required to implement this concept element? Are the possible needs for new actors and/or modification of the role of existing actors understood (e.g. controllers, supervisors, pilots, maintenance staff, etc)? If these questions cannot be answered fully, there is a need for further R&D (normally in the lifecycle phase V2).

Human-technology interaction:

In the case that the concept requires new system automation or the modification of an existing system, are the human-technology interaction and its implications understood or do they need further investigation (in the lifecycle phase V2 for initial elaboration/validation or V3 for pre-industrial product developments/validation)?

Technical enabler (automated system functionality and performance):

In the case that the concept requires new system automation or the modification of an existing system, it is important to understand the development and validation of the automated system(s). The following states are possible:

- detailed technical specifications have been developed and validated using realistic scenarios and a pre-industrial prototype integrating all related concept elements and all supporting technical enablers. For this particular state, all R&D activities are normally completed.
- or, the development is in phase V3 but the R&D work has not yet been completed meaning that one or more of the following R&D needs can be identified:
    - development of a pre-industrial prototype integrating all related concept elements/supporting enablers and compliant with the technical specifications;
    - development of realistic scenarios;
    - validation of technical feasibility using realistic scenarios and a pre-industrial prototype integrating all related concept elements.
- or, the development is in phase V2, which requires development of initial technical specifications, development of research prototypes and an initial technical feasibility assessment.

Transition issues (for feasibility and risks):

The transition covers all the changes required for the implementation of the concept element including institutional changes, infrastructure changes, re-allocation of people, training, etc., In the first phases (V1-V3) of the lifecycle, major transition issues should be identified (V1), their feasibility and associated risks should be checked (V2) and the analysis should be refined by taking into account evolution of the operational concept and supporting enablers (V3). The extent to which these questions have already been answered will help to identify remaining R&D needs as indicated above.

1.4 Validation of Performance

The validation related R&D needs categories are important for the decision making process. The R&D needs categories already identified, focus mainly on the feasibility and on the assessment of show-stoppers. Additional aspects of validation are considered in the remainder of this section, addressing the assessment of benefits and risks in more detail.

Alternative solutions:

Are there potential alternative solutions to the ATM problem addressed by this concept element? Were these alternative solutions identified and analysed? In case alternative solutions exist (and have been identified as another concept element), but have not yet been analysed comparatively, there is a need to make a comparative benefit assessment (in V2) and to further refine it (in V3). The results should thus be used to make a comparative cost-benefits analysis in V2 and to further refine it in V3. The alternative solutions should be identified in V1 and the related work for V2 and V3 phases should be planned there.

For example, the application of continuous descent with curved approaches, the application of very advanced arrival management functions and the application of the ASAS sequencing and merging concept can be compared.

Integration with related concepts and implications:

For each concept element, what are the related concept elements? Have they been identified? Have their respective interactions and implications been analysed? If these questions cannot be answered in a satisfactory way, there is a need for further R&D (in V2 for the validation of the most closely related concept elements and in V3 for the validation of any remaining ones). An example would be the analysis of interaction between the basic arrival manager and the ASAS sequencing and merging concepts which are closely related concept elements and so should be be addressed in V2. The impact of the ASAS sequencing and merging concept on Airport concepts (e.g. impact on ground system efficiency) can be addressed in V3.

Benefits and risks (operational, safety, environment, human factors):

Firstly there must be an assessment to identify if performance influence diagrams have been established for each concept element. This might be true in most cases but not for all. If the ATM problem needs to be further investigated and the context of use needs to be further analysed, the performance influence diagrams, even if they exist, may need to be reviewed as well.

Where a credible performance influence diagram exists, it needs to be verified that the achievable benefits and potential risks are assessed for all relevant KPAs including safety and environment, as well as in other transversal areas like human performance.

In lifecycle phase V2, a preliminary benefit assessment and a preliminary risk assessment should be available. In lifecycle phase V3, a validated benefit assessment and a validated risk assessment should have been produced. The difference between these two phases is that in V2, the benefit and risk assessments are made during the elaboration of the concept using research prototypes/simulation platforms, mostly in isolation from other related concept elements. In V3, the concept is stable and the assessments are made by considering all related concepts, using realistic scenarios and pre-industrial prototypes.

An important part of these risk assessments will be safety assessments (a preliminary Safety Case – initial version in V2 and a preliminary Safety Case – final version in V3) and human factors assessments.

A critical review of the specific concept element may reveal additional benefit and risk assessments to be addressed.

1.5 Business Case

The Final Research Business Case is the concluding activity in V3. An intermediate Business Case (BC) is prepared in V2. It is further refined in V3.

The intermediate Business Case provides implementation scenarios, cost estimations, return on investments for representative stakeholder groups taking into account all potential contexts of application. It analysis the key results from feasibility and performance assessments (for all relevant KPAs) from the business perspective. This includes not only monetary indicators from the Cost-Benefit Analysis but also other qualitative and quantitative results. It provides an initial comparative analysis with all alternative concepts and supporting enablers.

The intermediate Business Case is further refined in V3. Implementation scenarios, cost estimations and return on investments are refined for representative stakeholder groups. Supporting local Business Cases for representative contexts of use and stakeholders are developed. The impact of the integration of the improvement in the target system needs to be discussed. The comparison with all alternative concepts and supporting enablers needs to be refined and completed.

For each concept element, it needs to be verified whether a Business Case exists and whether it covers the points listed above. If not, there is a need for further R&D.

1.6 Tips for Mapping R&D Needs to R&D Needs Categories

The potential challenge of mapping an already defined R&D need to only one R&D need category may be simplified by splitting the R&D need into parts relevant to each category and/or by classifying them along the main question addressed by the need.

From the initial application of this categorisation, at least one potential difficulty has been observed. It is sometimes difficult to select between the benefit and risk assessment category and one of the design categories. In the design categories, the elaboration of the concept and related enablers and their feasibility should be addressed as a principal activity. In some cases, it may also include elements of benefit/risk analysis (e.g. for the transition category). In the benefit and risk assessment category, the benefits and risk assessment is the principal activity covering all KPAs and risk areas.

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2 LIFECYCLE PHASE OBJECTIVES & ACTIVITIES & DELIVERABLES & TRANSITION CRITERIA

Lifecycle Phase/Objectives	Typical activities	Typical Deliverables	Analysis Criteria for Lifecycle Transitions - **Typical Generic Questions** for each R&D Need Category[3]
V0: Identification of Needs The objective of this phase is to establish and quantify the need for change. The current and potential future situation should be analysed and the improvement areas and performance targets should be identified.	**Identification of major ATM problems/needs** *The current and projected future situation should be analysed to identify ATM problems and needs to be addressed in the targeted period. This includes performance needs and blocking point analysis, forecasting and market studies.* **Definition of performance targets and strategic objectives** *The performance and improvement needs should be analysed and prioritised. Performance targets and strategic objectives should be established.*	**Current & Future Situation – ATM problems and needs** *Analysis of current situation and its projection into the future using forecasts, market studies. Identification of opportunities and threats for change. Identification of performance needs and improvement areas per representative stakeholder group and context(s) of use (e.g. SESAR D1).* **Performance Targets and Strategic Objectives** *Quantified performance targets over time for all KPAs and links to the improvement areas identified (e.g. SESAR D2).*	**Problem/Solution link** *[V0.C1.1] Are the (current and future) ATM problems and their contributing factors analysed, clearly identified and explained? Are the future needs, opportunities and requirements captured, analysed and understood?* *[V0.C1.2] Are the performance targets quantified for all KPAs to address the identified ATM problems?* *[V0.C1.3] Is the (current/future) context and its potential impact on ATM analysed? Are the related results used when defining the performance targets?*
V1: Scope This phase aims to identify the operational/technical solutions for meeting the target performances and to produce the (initial) description of the target Operational Concept and associated initial logical system architecture description. It also aims to provide benefit mechanisms for the proposed concepts and to link them to the relevant ATM problems/needs in V0 to illustrate the strategic fit. 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. This phase aims to develop a validation strategy and associated work plan covering the R&D activities	**Initial definition of operational concept** *The operational concept should be defined at the level of detail required for the development of the benefit and cost mechanisms and for the identification of major R&D needs.* **Definition of initial logical system architecture** *The changes in the current logical architecture should be identified at the level of detail required for the development of the benefit and cost mechanisms and for the identification of major R&D needs.* **Definition of benefit and cost mechanism** *The benefit mechanisms should identify KPAs for which benefits are expected, give the rationale in respect to the proposed change and link them to the relevant ATM problems/needs identified in V0 (to illustrate strategic fit).* *The cost mechanism should identify potential procurement, implementation and operational cost. 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.*	**Initial Operational Concept** *Including definition of business processes requirements, operational services, actors, their main characteristics, constraints and context of use. (e.g. SESAR ConOps, high level OSED).* **Initial logical system architecture** *Identification of required system functionality independent of how it is implemented.* **Initial Business Case (Benefit & Cost Mechanism and initial justification for R&D)** *Definition of expected benefits and rationale.* *Definition of potential cost (order of magnitude) and rationale.* *Comparison with alternative concepts and supporting enablers, if any.* *Draft description of the reference scenario and the baseline.*	**Processes & procedures** *[V1.C3.1] Is the operational concept defined at the level of detail required for the development of the benefit mechanisms and for the identification of major R&D needs?* *[V1.C3.2] Are different concept options (variants) defined, if any?* Note: In case of a supporting technical enabler, we should consider the human–technology integration and the technical enabler elements below: **Human-technology integration** *[V1.C4.1] Have the relationship and interaction between human and machine been defined for all concept options, at the level of detail required for the development of the benefit mechanisms and for the identification of major R&D needs (related to socio-technical issues)?* **Technical enabler** *[V1.C5.1] Are the supporting technical enablers defined at the level of detail required for the development of the benefit mechanisms and for the identification of major R&D needs?* *[V1.C5.2] Are different technical enabler options defined, if any?* **Context of use** *[V1.C2.1] Is the potential context of application (e.g. airport, TMA, en-route, traffic density, airspace structure, etc.) defined and adequate?* *[V1.C2.2] Is the potential deployment context (local/regional/pan European use) defined and are they adequate?* **Problem/Solution link** *[V1.C1.1] Are the potential benefits identified for representative stakeholder groups and intended context(s) of use as well as adequate (benefit mechanisms/relevant KPAs/contribution to performance targets/rationale)?*

[3] There is one generic question that needs to be asked for each R&D category in V2 and V3: Are there any major (new or already) identified issues in that category that needs further validation/elaboration/etc.? This question aims to address explicitly new validation issues (R&D needs) that could have been identified during V2 and V3 phases as well as the need to repeat or to complete some validation exercises to improve the quality and/or the completeness of results. This question, although implicitly covered by those included in the table might be useful to be addressed systematically.

Lifecycle Phase/Objectives	Typical activities	Typical Deliverables	Analysis Criteria for Lifecycle Transitions - Typical Generic Questions for each R&D Need Category[3]
for the next two phases (V2 in detail and V3 in outline).	**Identification of R&D needs** *Major R&D issues/needs are identified based on high level benefits, risks and impact assessments covering all relevant KPAs including safety and human factors, etc. The major operational, technical and transition related feasibility issues are also identified considering:* • *the modification to operational procedures,* • *to ATM architecture,* • *required CNS technologies,* • *standardisation and regulation requirements.*	**High level analysis of benefits and risks for all relevant KPAs** *(e.g. High level safety analysis, high level human factors analysis, etc.)* *Major benefits and risk issues to be addressed in R&D are identified from different KPA view points.* **High level analysis of operational, technical and transitional feasibility issues** *Modification to operational procedures, to ATM architecture, required CNS technologies, standardisation and regulation requirements and impact on human aspects are defined (enablers). Major feasibility issues to be addressed in R&D are identified.* **R&D needs** *R&D needs identified above are consolidated.*	**Alternative solutions** *[V1.C7.1] Are the alternative concepts and supporting enablers adequately identified for each context of application?* *[V1.C7.2] Is the need to validate the subject concept instead of (or in addition to) these alternative concepts justified?* **Integration** *[V1.C8.1] Is the potential impact of the concept on the target system identified? Have all related concepts been identified and are the relationships adequately defined?* **Assessments** *[V1.C9.1] Are the major performance related issues (R&D needs) identified based on high level benefits, risks and impact assessments covering all relevant KPAs?* *[V1.C9.2] Are the major operational, technical, socio-technical, and transition related feasibility issues (R&D needs) and standardisation/regulation needs and issues adequately identified? Are the need to assess these feasibility issues justified (i.e. there are not any know results showing non feasibility)?* **Development and validation plan (planning level)** *[V1.C11.1] Does the development and validation plan adequately cover all major performance, feasibility and standardisation/regulation related R&D needs/issues?*
	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). The validation strategy and work plans do not address industrialisation which is addressed later in V4.*	**Validation strategy** *Definition of the validation approach, principles, steps and necessary validation means (type of activities/tools). It addresses all the R&D needs identified and defines the R&D activities to be performed.* **Work plan** *Definition of a work plan including resources, specific development and validation tools/platforms, development of necessary validation scenarios.*	
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	**Elaboration & validation of Operational Concept** *This is a major and iterative activity in this phase. The concept is elaborated mainly by taking into account a range of validation results in this phase (i.e. operational, technical and transition feasibility results, benefits and risk assessments results for all relevant KPAs).*	**Preliminary detailed Operational Concept** *Initial operational concept is further developed and refined using various validation results.* *(e.g. OSED, DOD, etc).* **Preliminary operational procedures** *Procedures and phraseology are developed and used in the validation activities. They are refined during this phase.* **Operational validation reports** *Allowing understanding of the validation characteristics, the information captured during the validation, the analysis of the information and the consequent results –e.g. the acceptability/operability/suitability, the resulting revisions to the Concept/Procedures.*	**Processes & procedures** *[V2.C3.1] Have the various operational concept options been adequately assessed (operational feasibility and safety)?* *[V2.C3.2] Is there a viable/preferred concept option that is shown to be operationally feasible (showing by prototyping that interaction between people is viable and that preliminary human performance and safety requirements can be met)? In case of several feasible concept options, is the selection of this concept option justified?* *[V2.C3.3] Are the business processes, operational procedures, roles and responsibilities of actors and their tasks, and human performance requirements needed to implement this concept option developed?* Note: In case of a supporting technical enablers, we should also consider the human–technology integration and the technical enabler parts below*:* **Human-technology integration** *[V2.C4.1] Have the relationships and interactions between human and machine been defined, prototyped and shown to be adequate?* *[V2.C4.2] Have the relationships and interactions between people, and technology, been shown to be operationally feasible, and consistent with (preliminary) human performance requirements?* **Technical enabler** *[V2.C5.1] Have the different technical solutions been adequately explored for the selected concept applications?* *[V2.C5.2] Is there a viable/preferred technical/technology solution(s) shown to be feasible (i.e. working research prototype showing that preliminary technical performance requirements can be met)?* *[V2.C5.3] Do we have a validated preliminary architecture, preliminary HMI design, preliminary technical specification?*
	Preliminary technical feasibility assessment (research prototype) *If the concept has a new technical enabler or one subject to change, 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.*	**Preliminary logical system architecture** *The logical system architecture is further refined to a level of detail to support development of the preliminary technical specification and to incorporate validation results.* **Preliminary technical system architecture** *To the level of detail required to develop the technical specification and the research prototype.* **Preliminary technical specification (including performance, interoperability and CNS technology requirements)** *To the level of detail required to build a research prototype and validation scenarios* **Research prototype** *To the level of detail required to validate operational concept and some technical issues (e.g. some performance issues). It is integrated into the validation platforms.*	

Lifecycle Phase/Objectives	Typical activities	Typical Deliverables	Analysis Criteria for Lifecycle Transitions - Typical Generic Questions for each R&D Need Category[3]
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 be thoroughly tested. **Principally, this phase will establish the feasibility from operational and transitional view points and provide initial elements for technical feasibility.**		**Technical validation reports** *Allowing understanding of the validation characteristics, the information captured during the validation, the analysis of the information and the consequent results – e.g. the feasibility of technical functionality, the performance results, the resulting change in the Technical specifications.*	*[V2.C5.4] Are the preliminary technical performance requirements, interoperability and CNS requirements identified and validated on a research prototype/platform?* **Transition** *[V2.C6.1] Are the major transition issues analysed for their feasibility and risks, and possible options identified and assessed?* *[V2.C6.2] Is the transition shown to be feasible?* **Alternative solutions** *[V2.C7.1] Are the alternative solutions for each context of application, analysed for feasibility and risks, and are results available for comparison?* **Integration** *[V2.C8.1] Are the closely related concepts considered in the validation? In the early phase of concept development and refinement, the closely related concepts might be elaborated to mitigate some risks (e.g. major safety hazards, interoperability requirements).* **Assessments** *[V2.C9.1] Are the benefits and risks assessed for all relevant KPAs and for all identified potential contexts of applications? Are the synergies and trade-offs between all relevant KPAs analysed?* *[V2.C9.2] What are the results? Are the major issues found during these assessments (e.g. assessments showing less then expected benefits, major safety hazards, unresolved human factors and environment issues, etc.) adequately addressed in further concept and supporting technical enablers elaboration and validation activities? In case the targeted benefits are shown to be unfeasible, what is the impact on the overall strategic performance objectives/targets?* *[V2.C9.3] All major issues related to safety regulation (such as transfer of responsibility, delegation of verification of compliance to third parties and/or approved organisations, etc.) have been assessed and shown to be compliant with current safety regulation or regulation is subject to change.* **Business Case** *[V2.C10.1] Are the implementation scenarios identified and their cost estimated for representative stakeholder groups?* *[V2.C10.2] Does the Intermediate Business Case cover all relevant KPAs, other decision-makers' criteria and all potential contexts of application? Does the intermediate Business Case take into account synergies and trade-offs between all relevant KPAs?* *[V2.C10.3] Does the intermediate Business Case provide an initial comparison of all alternative concepts and supporting enablers across the different criteria (KPA, CBA, feasibility etc.)?* *[V2.C10.4] Are the subject concept and supporting enablers shown to be cost beneficial?* *[V2.C10.5] Are the implementation and operation affordable for representative stakeholder groups?* **Work plan** *[V2.C11.1] Does the work plan for the next phase adequately cover all major performance, feasibility and standardisation/regulation related R&D needs/issues?* *[V2.C11.2] Are the time and potential risks for the completion of the next phase activities adequately identified?*
	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 transitional issues identified in the previous phase are checked for their feasibility and associated risks.* This assessment shall include the necessary identification of the further needs for Regulation/Legislation (V2/V3).	**Preliminary transition phases definition** *Definition of transition steps and supporting activities.* **Preliminary transition feasibility report** *Assessment of potential difficulties and risks for major transition issues. Definition of means to avoid or to mitigate them.*	
	Preliminary benefits and risk assessments *The benefits and risks are assessed for all relevant KPAs. The major issues found during these assessments, and requirements derived from them, are provided as feedback to the operational concept elaboration and validation activity.*	**Preliminary safety and performance requirements** *Definition of the overall operational requirements, including capacity, safety security and other performances, characteristics, constraints, and attributes.* **Preliminary benefit and risk assessment reports for all relevant KPAs** *(e.g. Preliminary safety analysis – FHA report, SAM PSSA report level 1, Preliminary human factors analysis, etc.)*	
	Intermediate Business Case *The key results from performance assessments (for all relevant KPAs) and from operational, technical and transitional feasibility assessments are analysed from the business perspective.* *This includes not only monetary indicators from the CBA but also qualitative and quantitative results.* *Implementation scenarios are identified and their cost estimated.* *Interdependencies and trade-offs are identified. Alternatives and options are compared.* *The affordability for the representative stakeholder groups is analysed. Stakeholders take part in the development of the Business Case.*	**Intermediate Business Case report** *A report describing and comparing feasible alternatives through trade-off analysis; identifying the most critical – from a quantitative and possibly monetary perspective - uncertainties of the project. From this analysis recommend update of R&D needs; do recommendations for the next phase, including the budget to spend on final R&D tasks. Includes also a more developed Cost-Benefit Analysis using influence diagrams for costs and benefit mechanisms, sensitivity analysis, probabilistic risk analysis, and all the scenarios (e.g. reference, alternatives, and options).*	

Lifecycle Phase/Objectives	Typical activities	Typical Deliverables	Analysis Criteria for Lifecycle Transitions - Typical Generic Questions for each R&D Need Category[3]
V3: Pre-industrial Development and 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	**Integration and validation of the 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.*	**Detailed Operational Concept** *The operational concept is fine tuned using a range of validation results.* *(e.g. OSED, DOD, etc).*	**Processes & procedures** *[V3.C3.1] Is the selected concept option confirmed to be operationally feasible when integrated into the end system, (showing that all interaction between people is viable based on prototyping of a realistic environment?* *[V3.C3.2] Following its integration into the end system, do we have a stable and validated definition of business processes, operational procedures, roles and responsibilities of actors, their tasks, and human performance elements required to implement (and if so intended to regulate) this concept option?* Note: In case of supporting technical enablers, we should consider the human–technology integration and the technical enabler elements below. **Human–technology integration** *[V3.C4.1] Have the relationships and interactions between human and machine been defined and validated in an operationally realistic environment using a pre-industrial prototype?* *[V3.C4.2] Have the relationships and interactions between people and technology been confirmed to be operationally feasible, and consistent with agreed human performance requirements?* **Technical enabler** *[V3.C5.1] Do we have a validated system architecture, HMI design, & technical specification ready to be used for industrialisation (and for standardisation if so intended)?* *[V3.C5.2] Are the interoperability requirements, the refined technical performance requirements, and the refined CNS requirements validated on a pre-industrial prototype and platform integrating all relevant target system elements?* *[V3.C5.3] Is the technical enabler shown to be feasible (i.e. working pre-industrial prototype showing that interoperability and performance requirements can be met)?* **Transition** *[V3.C6.1] Are there any impacts on the transition steps and supporting activities identified in the previous phase coming from operational and technical refinements made during this phase? Is the transition analysis refined accordingly?* *[V3.C6.2] Is the transition confirmed to be feasible?* **Integration** *[V3.C8.1] Are the related concepts considered in the validations?* **Assessments** *[V3.C9.1] Are the benefits and risk assessments refined (i.e. by a quantitative analysis and considering the impact of all related concepts to each other) for all relevant KPAs and for all contexts of applications? Is the trade-off analysis extended accordingly?* *[V3.C9.2] What are the results? Are the major issues found during these assessments (e.g. assessments showing less then expected benefits, major safety hazards, etc.) adequately addressed in further concept elaboration, integration and validation activities? In case the targeted benefits are shown to be unfeasible, what is the impact on the overall (i.e. IP/Service level) strategic performance objectives/targets?*
		Operational procedures *The operational procedures are fine tuned using validation results.*	
		Operational validation reports *Allow understanding of the validation characteristics, the information captured during the validation, the analysis of the information and the consequent results –e.g. the acceptability/operability/suitability, the resulting changes to the Concept/Procedures.*	
	Technical specifications and feasibility assessments (pre-industrial prototype, technical specifications ready for possible standardisation) *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.*	**Logical system architecture** *The logical system architecture is fine-tuned reflecting possible impacts from validations and changes to the operational concept and supporting technical enabler(s).*	
		Technical system architecture *Is developed to the level of detail required for industrialisation and for possible standardisation in the next phase .It will be used for the development of the pre-industrial prototype and for its integration into the representative system platform for validation.*	
		Technical specification (including interoperability, performance and CNS technologies requirements) *To the level of detail required for industrialisation and for possible standardisation in the next phase (e.g. INTEROP, outline SARPs, MOPs etc).*	
		Pre-industrial prototype *To the level of detail required to complete the technical validations (performance, interoperability, CNS) and to integrate into a live environment.*	
		Technical validation reports *Allow understanding of the validation characteristics, the information captured during the validation, the analysis of the information and the consequent results – e.g. the feasibility of technical functionality, the performance results, the resulting changes to the Technical specifications.*	
	Transition feasibility assessment *Transition feasibility assessment is completed in case of impact coming from operational and technical refinements made during this phase.*	**Transition phases definition** *Preliminary transition phase's definition is refined.*	
		Transition feasibility report *Preliminary transition feasibility report is refined.*	
	Benefits and risk assessment *The benefits and risk assessments done in the previous phase are finalised here for all relevant KPAs. The impact of all related concepts is analysed in both directions. Benefits and impact are quantified.*	**Safety and performance requirements** *Preliminary safety and performance requirements are refined using various assessment/validation results.*	
		Benefits and risk assessment reports for all relevant KPAs *(e.g. Safety analysis including refined FHA reports and SAM PSSA Reports level 1, Human factors analysis, etc.)*	

Lifecycle Phase/Objectives	Typical activities	Typical Deliverables	Analysis Criteria for Lifecycle Transitions - Typical Generic Questions for each R&D Need Category[3]
documented to a level which will support transfer to industry. **This phase will complete feasibility from technical and integration (towards the target ATM system) perspectives. It will clearly identify costs, benefits and risks to allow decision-making for industrialisation**	**Final Research Business Case** *The intermediate Business Case is refined using the results from validation for all relevant KPA and other decision-maker criteria. The CBA and the affordability to stakeholders are also refined. Supporting local Business Cases for representative contexts of use & stakeholders are developed.*	**Final Research Business Case report** *Consolidates the output of the previous phases and the current phase. It includes: a trade-off analysis comparing the feasible options and a detailed Cost-benefit Analysis for the selected alternative/option.*	**Business Case** *[V3.C10.1] Is the Business Cases refined for representative stakeholder groups?* *[V3.C10.2] Is the Business Case refined using the results of more detailed benefit and risk assessments as well as trade-off analysis between all relevant KPAs?* *[V3.C10.3] Does the Business Case provide a complete comparison for all alternative operational concepts and supporting enablers across all criteria and representative stakeholder groups?* *[V3.C10.4] Is the Business Case for the operational concept and supporting enabler(s) confirmed in an integrated and realistic environment?* *[V3.C10.5] Is the affordability analysis refined and confirmed taking into account the benefit and cost refinements for representative stakeholder groups?* **Work plan** *[V3.C11.1] Does the work plan for V4 adequately cover all relevant activities (industrial product developments, standardisation, regulation, certification, further development of case material for specific local deployment contexts and individual stakeholders, if so required).* *[V3.C11.2] Are the time and potential risks for the completion of the next phase activities adequately identified?*

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.

Additional important tasks within the V4 phase are the development of manufacturing and end user documentation, the development of the required training programmes and facilities, development/acquisition/construction of (mass) production tools and facilities (factories) with appropriate staffing, establishing (mass) production capacity at sufficient deployment volumes, preparation of maintenance support, the production of a deployment (V5) plan where required, and/or the development of a communication/marketing strategy towards the customers/end users.

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.

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ANNEX 5: GUIDE TO INCORPORATION OF CASES IN ATM R&D PROJECTS

1 INTRODUCTION

This Annex is based on the Best Practices and Guidance material for the Safety Case, Human Factors Case, Business Case and Environment Case as developed within the CAATS-II project[4] (see "Further Reading", Section 0). The objective of the CAATS II guidance material (which started on the basis of E-OCVM Version 2.0) is to provide project managers with sufficient information about each of the above areas to determine why a case is needed and how each supports the validation process throughout the R&D phases especially in terms of communication with key stakeholders. Each of the cases is important and must be considered at the design phase of a project to determine the most appropriate methodology for the project, within the E-OCVM framework.

2 THE CASE-BASED APPROACH IN THE E-OCVM

The Case-Based Approach is concerned with providing key stakeholders with evidence constructed from targeted information in an easily understood format appropriate to their needs. The 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 as well as the questions that the stakeholders will need answers to concerning the concept and its performance.

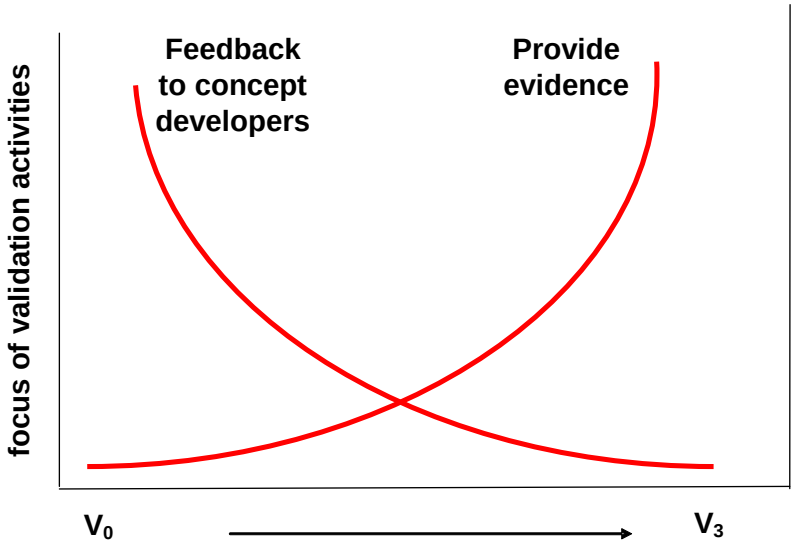

Figure 3: Case development throughout the Concept Lifecycle Model: a shift in focus

Each case will be developed along the concept lifecycle. The case activities should start as early as in V0 with the identification of case-specific performance needs. The actual 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 stakeholders' decisions through the lifecycle of the programme/project. It is also necessary to establish the "case baseline" (based on existing concept material and evidence) relevant to the validation activity and the case reports being targeted for development. During the further

[4] 6th Framework DG-TREN Programme project funded by the European Commission

development of a case along the concept lifecycle, its focus evolves. This is schematically illustrated in Figure 3.

During 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 related 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. Together with an analysis of the economical impacts of implementing and operating the concept all cases are then synthesised into the Business Case as a support to higher-level decision-making processes, see Figure 4.

The background to this shift 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.

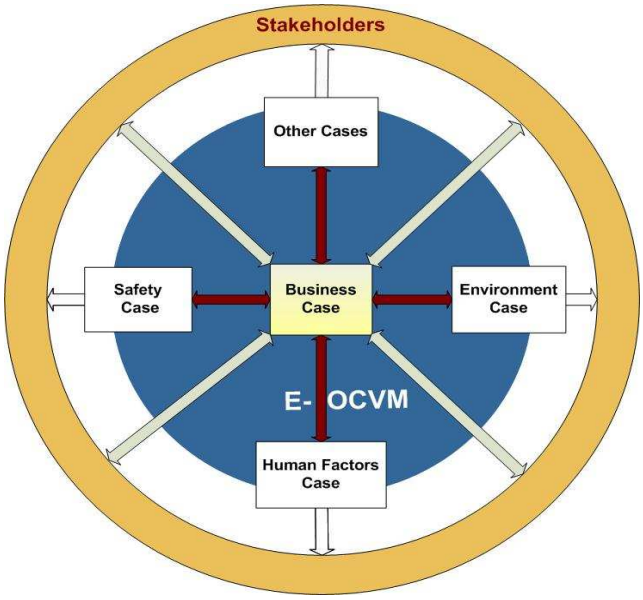

Figure 4: The Business Case as focal point in the decision making process

During the validation process maturity assessments are carried out as a minimum, 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, an initial maturity assessment should be performed.

Case maturity assessment is facilitated by transition criteria. Detailed criteria have been developed to allow evaluating case-by-case whether the validation objectives of a specific phase of the Concept Lifecycle Model have been reached (see Appendix A: Case Maturity Criteria pp104).

3 BUSINESS CASE

3.1 Introduction

3.1.1 Business Case Definition and Purpose

The Business Case is a structured process that helps to prepare the required evidence for decision-makers and impacted stakeholders on the advantages and disadvantages of different options under consideration. This is done by assessing the potential impacts from a multi-criteria perspective (i.e. typically economic, performance, safety, environment.), including synergies and trade-offs.

The decision is 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 is evaluated using multiple criteria (e.g. economics and finance are just one part of it).

The Business Case goes beyond the CBA because it includes funding analysis, multi-criteria decision analysis/making (i.e.: MCDA/MCDM), study of the implementation plan and a more comprehensive explanation of the investment situation. It is an evidence-based instrument and a tool to support planning and reporting.

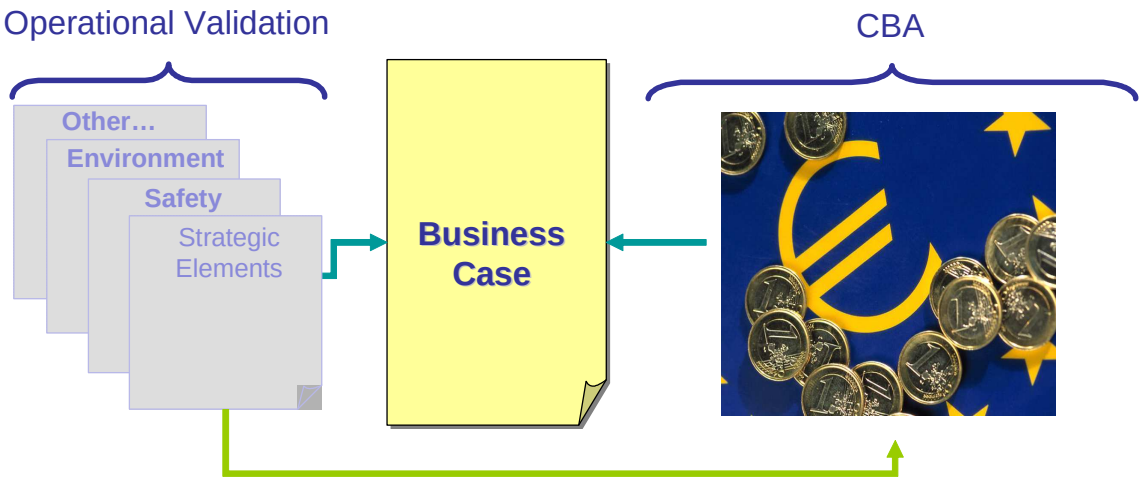

Figure 5: Business Case - the focus to support decision-making

The main principles of a Business Case are:

1. **Transparency and Partnership with a Collaborative Development Process**
   Involving stakeholders and multi-disciplinary experts is the best way to ensure process ownership and final buy-in.
2. **Risk Management**
   A progressive and iterative process to manage and reduce risk and uncertainty.
3. **Consistency by following a Common Framework for Business Cases**
   Follow a standard approach to assessment contributing to consistent decision making.
4. **Proportionality of the Business Case Analysis**
   Balanced approach between the cost of the Business Case analysis and expected benefits ("Value for Money").

The purpose of a Business Case is to facilitate and support better informed decision-making for key investment decisions. This is achieved by:

- ensuring stakeholders' involvement and buy-in;
- enabling R&D to be focused on significant issues;

- ensuring that different concept options are identified and properly assessed.

3.1.2 Scope of the Business Case

The aim of an ATM Business Case is to evaluate the programme/project value through the lifecycle phases; the programme/project value can be qualitative (including intangible benefits), and/or quantitative (monetary). The decision is multi-stakeholder and multi-criteria due to the programme/project organisations and the complexity of the concept under study; economics and finance are part of it. This activity is needed to ensure that not only the costs and benefits for all projects are weighed before a commitment of resources is made but also that multiple perspectives are considered. It also ensures that the projects where investment is made bring the greatest value to the organisation and that there is adequate justification to raise funds when necessary.

3.1.3 Typical Stakeholders for the Business Case

Owing to its overarching, multi-stakeholder and multi-criteria character, it is not possible to define a “typical” Business Case stakeholder. Any ATM stakeholder that is in some way involved in the decision making process, especially where related to investment, can be considered a Business Case stakeholder.

It is more important to note that a Business Case is a collaborative process involving a multi-disciplinary team. The key participants involved in the Business Case are:

- Business Case practitioners;
- project and programme team members;
- validation and case experts (those in charge of assessing the different performance impacts);
- Impacted stakeholders: the decision makers.

3.2 Business Case and Concept Maturity

3.2.1 Integration with Concept Lifecycle

The Business Case should start as early as possible in V0 and should support throughout all phases of the E-OCVM Concept Lifecycle Model of the project or programme. Figure 6 shows how the Business Case fits along the Lifecycle as a continuous process. V0 is a preparation phase focusing on the business view of the ATM needs to be addressed during the next phases. In V1 an initial Business Case presents a first sketch of benefit and cost mechanisms as well as very rough assessments in terms of scoring, ranking, eventually orders of magnitude for quantities. In V2, a Business Case is issued to check whether or not the project is on the right track and some decisions of re-orientation can still be taken at this stage. In V3, a final R&D Business Case is presented to the decision makers in order to take the Go/No-Go decision to industrialisation and deployment.

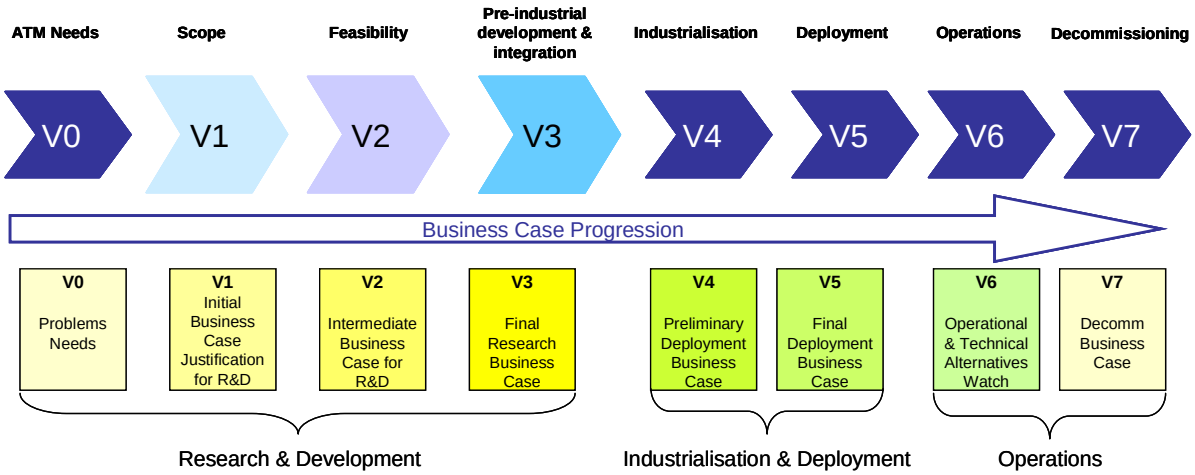

Figure 6: Business Case progression during the E-OCVM Concept Lifecycle Model

If the project or programme is already at a more advanced phase (e.g. V3) the Business Case process steps will have to be rolled out in full to ensure that all the activities that would have been covered in earlier phases are completed. It always starts with the scoping and planning of the Business Case's work (e.g. level of analysis, methods to be used, coordination with other assessment processes).

3.2.2 Transition Criteria

The Business Case transition criteria are focussed on evaluating the appropriate level of the (business) impact assessments of each phase, based on the general transition criteria. The Business Case specific transition criteria are included in the Appendix at the end of this Annex (see, A.1).

3.3 Business Case Methodology

Figure 7 illustrates the Business Case Methodology key steps. An important principle is that the steps are taken in an iterative way in each lifecycle phase. In keeping with the E-OCVM principles, this means that the process may have to return to previous steps based on the outcome of the current step.

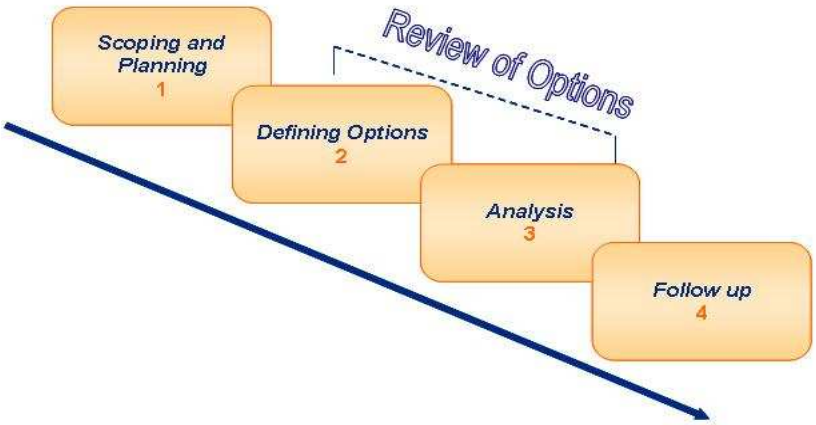

Figure 7: Business Case Key Steps

Figure 8 describes the steps of the Business Case Methodology. These steps are performed in every lifecycle phase.

4 STEPS	General Description
Scoping and Planning (Including needs and problems analysis, stakeholders, lifecycle phase…)	Framing the decision to be supported by the Business Case, including the scope of the performance assessment and the planning (time and resources), coordination with the other case areas. Identify the stakeholders to be involved in the activities.
Defining Options (Alternatives and options against "business as usual", dependencies)	Identification of the criteria that will be used by decision makers to make a decision on this project/programme. Draw the alternatives/options and dependencies to propose the solution and support evidence of the concept. Assessment process Collaboration with other areas of expertise (e.g. Human Factor, Environment, Safety, etc.).
Analysis (Including criteria/evaluation of impacts, comparison of options, consolidation and recommendations)	Core of the Business Case with the analysis of the combined alternatives/options and the assessment by experts: a description of the main impacts (benefits, disbenefits and costs), and an assessment of their magnitude (results). Develops recommendations in a report.
Follow Up (Monitoring and learning through continuous improvement)	The results of the assessment are consolidated for all criteria and across the stakeholder groups. Indicators for post monitoring are developed and lessons are learned.

Figure 8: Business Case Methodology Overview

3.4 Documentation of a Business Case

The Business Case Report is the documentation that presents the Business Case results to the stakeholders/decision-makers. All the work performed previously has been summarised in this document with the objective of serving as a support tool for decision making on the continuity of the Operational Concept development. **Figure 9** provides the recommended outline that all Business Cases should follow. Each outline element is identified to provide an overview of required content.

Business Case Outline
1.0 Executive Summary (Presentation)
2.0 Framing (Context)
2.1 Goals, Purpose, Needs, Participants, Stakeholders, Used Processes
2.2 Functional Performance and Metrics to be used
2.3 Baseline/Alternatives Considered
2.4 Key Assumptions
2.5 Business Model Definition (e.g.: Influence Diagram)
3.0 Analysis (Discussion of the Alternatives, the Impacts and the Results)
3.1 Alternatives
3.1.1 Functional Process Description
3.1.2 Performance Impact and Metrics (e.g.: NPV/IRR/Payback)
3.1.3 Cost Projections
3.1.4 Benefit Projections
3.2 Risk Assessment (e.g.: Probabilistic) and Trade-offs (e.g.: Sensitivity Analysis and MCDA)
4.0 Conclusions, Recommendations and Issues
5.0 Annexes

Figure 9: Outline structure of a typical Business Case Report

4 SAFETY CASE

4.1 Introduction

Whereas it is already good practice for ANSPs to develop a Safety Case for certification and/or approval of changes to their ATM system (including humans, procedures, and technical equipment), much less experience exists for Safety Case development for advanced concepts in R&D. Here, the focus is on supporting the development process and informing all stakeholders affected about safety aspects of yet immature advanced concepts.

Safety Case development in R&D has been the subject of a lot of recent research and it can be stated that:

- experiences with developing a Safety Case in E-OCVM are just building up;
- SESAR and other reviewed sources identified several complementary emerging needs for Safety Case development for advanced concepts, for which established approaches fall short; and
- several new, complementary approaches are emerging that aim to address the identified emerging needs.

This section provides guidance on Safety Case development in ATM R&D against the background of the above situation.

4.1.1 Safety Case Definition and Purpose

In the literature, a Safety Case is defined as '*the documented assurance of the achievement and maintenance of safety*'. Strictly speaking, such a definition does not apply to concepts in R&D, as concepts in R&D are typically not yet mature, cannot yet be stated to be safe, and need further development or redevelopment before being optimised with respect to all key performance areas. Therefore, in R&D, the development of a Safety Case serves the broader objective of providing the information key stakeholders and decision-makers need about the safety aspects of concepts under evaluation as they consider investment and implementation options along the phases of E-OCVM. Eventually, if a concept appears to be

successful, such a Safety Case from R&D may become the foundation for Safety Cases in support of certification and implementation.

Purposes of Safety Case development for advanced concepts in R&D are o provide information on safety aspects of the concepts that supports:

- decision-makers in taking informed decisions on further development or redevelopment of concepts; and
- concept developers and system engineers in effectively developing a safe concept.

4.1.2 Scope of the Safety Case

Safety Case development in R&D is limited in scope to the validation of concepts with respect to the ICAO KPA 'Safety'. In the R&D phases, the scope of a Safety Case should be sufficiently broad for all stakeholders affected by the proposed concept to retrieve the information needed for decision-making. This should also enable identification and analysis of safety risks emerging from the dependencies and interactions between different elements (e.g., ground-based and airborne).

4.1.3 Typical Stakeholders for the Safety Case

All stakeholders potentially affected by the proposed concept should be addressed in a Safety Case in R&D. Typical stakeholders to be addressed are: ANSPs, airspace users, airports, regulators, policy makers, human operators, associations, human society, and other service providers.

The results of the Safety Case in an R&D phase of development should be of principal value to decision-makers amongst these stakeholders, and to the operational concept development process. Furthermore, the results should be taken into account by the project manager and/or the programme manager in managing the development and validation processes effectively.

4.2 Safety Case and Concept Maturity

4.2.1 Integration with Concept Lifecycle

The focus of development of a Safety Case evolves with increasing concept maturity. The emphasis changes while moving towards a more consolidated concept. This is represented in Figure 10 where emphasis shifts:

- *from* providing early feedback for major design improvement and preliminary evidence that the concept could be safe,
- *to* collecting sufficient information that the concept as finally developed and to be implemented, is indeed acceptably safe.

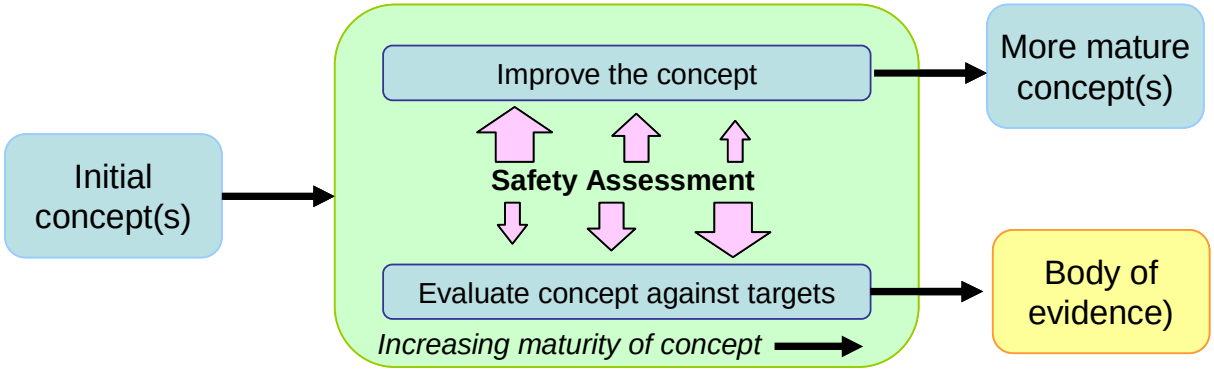

Figure 10: Focus of safety assessment during the concept lifecycle

The background to this shift 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. Accordingly, especially in the early phases, safety feedback to developers plays an important role.

In later phases the availability of a more mature version of the concept allows for the collection of more evidence, for example when prototypes may cost-effectively be developed. Then, the feedback to design may also be on a more detailed level.

Any validation process is to be supported by analysis; this also holds for safety validation. This is also reflected in **Figure 11**, which summarises the safety validation activities needed in each CLM phase.

CLM Phase	Safety validation activities
V0: ATM needs	Identification of ATM safety performance needs (e.g., safety targets). Supporting the identification of ATM barriers that need to be alleviated to reach the ATM needs.
V1: Scope	Safety analysis to: • Determine an appropriate validation strategy. • Provide safety feedback to the development process.
V2: Feasibility	Safety analysis to: • Determine feasibility of the concept. • Provide safety feedback to the development process.
V3: Integration	Safety analysis to: • Provide evidence for the safety of the further detailed concept. • Provide safety feedback to the development process.

Figure 11: Safety validation activities in the R&D phases of CLM

Organising iterations between concept development and safety analysis is an effective way to support the development of a concept ready for being transferred to a next phase. Such iterations are as follows: The concept development process delivers an improved and/ or more detailed version of the operational concept. The safety analysis provides feedback to the concept, which the development process can next use to improve the concept.

4.2.2 Transition Criteria

Safety Case specific transition criteria serve to evaluate whether the safety validation objectives of a specific phase of the CLM have been reached. Two independently developed sets of Safety Case specific criteria are available:

- the Safety-Case specific criteria as given in Appendix A of this Annex;
- the Safety-Case specific transition criteria developed as part of the 'SAME' approach [7].

Practical experience with the use of these Safety-Case specific transition criteria and with their differences remains to be built up.

4.3 Safety Case Methodology

Safety analysis plays a crucial role in Safety Case development in each of the R&D phases. In Section 4.3.1 it is explained how the objective of safety analysis can be determined in line with E-OCVM, and hence dependent on the maturity of a concept. Section 4.3.2 explains the main activities to be part of any safety analysis. Section 4.3.3 describes identified needs for

Safety Case development of advanced development. Finally, Section 4.3.4 describes the use of methods to reach the determined objective of safety analysis.

4.3.1 Defining the Objective of Safety Analysis in line with E-OCVM

The objective of safety analysis is to be tailored to the maturity of the concept under evaluation. For selecting the phase of the CLM to be tackled, the following steps can be followed:

Step I. Identify previous safety analysis results for the concept under consideration. Databases such as EUROCONTROL's Validation Data Repository (VDR) may be checked for this. Re-use of previous safety analysis results may be possible, and the results may provide valuable information, as one can learn e.g., why previous concept versions were not yet sufficiently safe.

Step II. Determine the concept maturity in terms of the phases of the CLM, using the generic transition criteria (see Vol1, Part III).

Step III. Review the safety analysis results from step I to determine for which phases of the CLM the objectives of Safety Case development have indeed been reached using the Safety Case specific transition criteria (see Section 4.2.2). It is recommended to consider to which extent the existing safety analysis results have addressed the emerging needs in safety analysis of advanced concepts introduced in Section 4.3.3.

Step IV. Select the phase of the CLM in which the Safety Case is to be (further) developed. This should be straightforward as long as Safety Case development is aligned with concept maturity and the objectives of previous phases have indeed been reached according to Step III).

Step V. Determine the objective of safety analysis in the selected phase according to **Figure 11**.

4.3.2 Use of Safety Analysis to Reach Objectives

The activities to be part of any safety analysis are presented in Figure 12, as agreed upon by FAA, EUROCONTROL and other involved organisations in FAA/EUROCONTROL Action Plan 15: ATM Safety Techniques and Toolbox [3]**,** which is "the first major attempt to evolve a common inter-operable safety approach".

One or more cycles of safety analysis may need to be performed to reach the objectives of the selected phase of CLM.

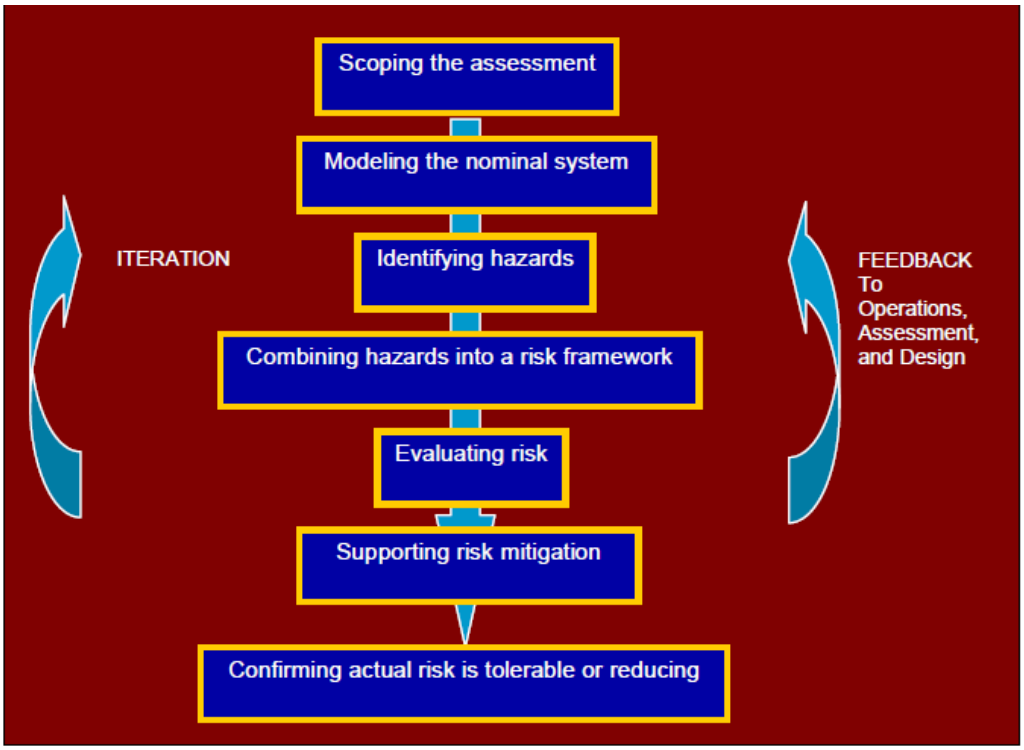

Figure 12: A generalised Seven-Stage Safety Assessment Process, plus a key eighth stage of organisational learning (from [3])

4.3.3 SESAR-identified emerging needs

Figure 13 provides an overview of the SESAR-identified emerging needs with respect to safety validation of advanced concepts.

Id	Description of emerging need
A.	The need for a 'macro' Safety Case
B.	The need to address safety regulations
C.	The need to address the multi-stakeholder nature of advancing air traffic operations
D.	The need to address the success side of a change
E.	The need to cover the human operators in the ATM system
F.	The need to identify unknown 'emergent' risks
G.	The need to be compliant with E-OCVM
H.	The need to assess concept maturity
I.	The need for managing relations between cases

Figure 13: Overview of SESAR-identified emerging needs for Safety Case development in R&D for advanced concepts

4.3.4 Use of Methods

The main approaches currently in use for safety assessment in R&D projects are:

- Air Navigation Services Safety Assessment Methodology, SAM [4];

- EUROCAE's "Guidelines for approval of the provision and use of Air Traffic Services supported by data communications", ED78a [5];
- TOPAZ accident risk assessment methodology [6].

These three methods cover the eight AP15 stages of Figure 12 rather well. Nevertheless there are some interesting differences for stages 4, 5, and 8. ED78a falls short in combining hazards (stage 4). TOPAZ on the other hand stands out in a positive way on evaluating both positive and negative contribution to safety risk (stage 5). For stage 8, ED78a and SAM focus on feedback in the form of safety requirements, whereas TOPAZ provides feedback with the focus on understanding the main sources of safety risk, and on sensitivity of risk to changes in parameter values. These sensitivity values allow system design experts to see how changes in safety requirements affect safety risk.

Each of the safety analysis process stages may be supported by complementary techniques. The detailed Safety Case Guidelines document provides an overview of both established techniques for such support, and of needs for supporting techniques for use for advanced concepts. The emerging needs for safety validation of advanced concepts of Section 4.3.3 were identified by SESAR relative to SAM, the most commonly used approach in safety assessment. In [1] established and new approaches that aim to address these emerging needs are identified. Many of these approaches are still in development, and their integration so far is limited. Example features of emerging approaches in support of SESAR type changes are (See [2] for more details):

- extension of SAM by considering also the positive contribution of a concept under investigation to aviation safety, in addition to the negative contribution to risk (SAME);
- early identification of the main challenges of a new concept development regarding safety regulation, safety performance, operational safety, and safety management;
- process regarding the active roles and collaboration of multiple stakeholders during the development and safety validation of air transport operations.

Ref. [2] provides an overview, and presents guidance for the integration of approaches. It is recommended to continue the integration of these complementary emerging approaches to take advantage of their strengths.

4.4 Precedents

No publicly available examples of E-OCVM compliant Safety Cases for advanced concepts in the R&D phases V1, V2, and V3 have yet been identified. A number of example of plans addressing E-OCVM compliant Safety Case development for advanced concepts in these phases are however available:

- The R&D projects RESET and iFLY (V1);
- SAFMAC describes a planned approach for Safety Case development in phases V0 to V3;
- SESAR Safety Management Plan – SMP (V0 to V3);
- SAME (V0 to V3).

4.5 Documentation of a Safety Case

Safety Case development should support both concept development and decision-making by stakeholders. Therefore, the focus in Safety Case documentation for phases V0 to V3 should be on explaining to concept developers and decision-makers *why* immature concepts evaluated are not (yet) safe enough. Such knowledge is vital in R&D to enable operational concept developers to improve the weaker aspects of concepts.

Together with the views of concept developers on further improvement of the concept, such results provide the appropriate decision-making information for stakeholders.

To enable proper use of the Safety Case by stakeholders, programme managers, concept developers, and (e.g., future) validation teams, the following should be clearly documented:

- the phase of E-OCVM that has been tackled in the safety analysis;
- exactly which version of which concept(s) of operations have been analysed;
- the assumptions that have been adopted;
- how the conclusions of the Safety Case are supported by convincing arguments;
- how the arguments in the Safety Case are supported by evidence;
- detailed description of approach and results of individual safety analysis activities as hazard identification, hazard combination and risk evaluation; and
- supportive argumentation for the methodology and techniques that have been selected.

5 HUMAN FACTORS CASE

5.1 Introduction

"... The provision of ATM services today depends heavily upon the performance of humans at all levels within ... the ATM system from which the services are delivered."[5] The Human Factors Case gives 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.

5.1.1 Human Factors Case Definition and Purpose

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, 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. The objective of the Human Factors Case should be tailored to the maturity of the concept being examined.

5.1.2 Scope of a Human Factors Case

Using a Human Factors Case will help the project manager to plan, identify and analyse the likely people-related impacts that a proposed ATM system concept will have. 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. Appropriate tools and techniques are available to analyse, model, evaluate and influence the design for people within the system, looking at the system from a human-centred point of view, in the context of criteria relevant criteria to the proposed ATM system concept. The specific function of the Human Factors Case is to ensure that people-related issues are explicitly addressed and incorporated within the planning and decision making process for a proposed ATM system concept, and specifically that:

- the roles of people in the system will be consistent with human capabilities and characteristics, and
- the contribution of people within the system will support the expected system performance and behaviour.

5.1.3 Typical Stakeholders of the Human Factors Case

At the broad level the overall conclusions of the Human Factors Case will be of interest to most ATM stakeholders, including ANSPs, investors, operators, airspace users, regulators, unions, etc, because the human component of the system plays a dominant role in its performance, cost and safety. More detailed interest in, and scrutiny of, the Human Factors Case will come from stakeholders who have specialist interests within these organisations, including controllers, pilots, maintainers, trainers, operational mangers, personnel managers, etc.

[5] SESAR Definition Phase D1 – Air Transport Framework, The Current Situation, July 2006

5.2 Human Factors Case and Concept Maturity

5.2.1 Integration with Concept Lifecycle

At each lifecycle phase, the Human Factors Case process identifies people-related issues, based on what is currently known about the (partly mature) concept, and it seeks to explore and resolve them. The focus through all phases is on the way that people fit into, and contribute to, the overall system, but the way this is explored, and the type of evidence that is generated to give confidence in the concept, varies according to the constraints (of both resources and information) at each phase. **Figure 14** gives a summary of the human factors validation focus in different R&D lifecycle phases.

Phase	Concept development	Human Factors validation focus
V0	**ATM Needs**: Identify needs, constraints and potential concepts	Ask questions to view the problem from a people-centric, as well as a system and technology-centred perspective.
V1	**Scope**: Describe concept(s) in enough detail to identify potential benefit mechanisms (system changes that may help meet needs).	Develop descriptive models that account for the people affected by the concept, and relate them to other system models being developed. Ensure that they make explicit what the people do and how their performance will contribute to the expected benefits. Identify side effects that could compromise human performance.
V2	**Feasibility**: Develop and explore concept(s) to point where they are considered operationally feasible. Use system prototypes (not fully developed technology). Iterate as required to explain unexpected findings. Establish new system behaviours	Use prototypes and mock-ups to explore all aspects of human interaction and operability. Contribute to all human-aware[6] aspects of design. Supplement human in the loop experiments with walk-throughs where full interaction isn't possible, and use predictive performance models where full experimentation isn't practicable. Track all side effects and secondary issues.
V3	**Integration**: Integrate required functionality in pre-industrial prototypes. Explore engineering processes to develop experience for building the end system. Establish standards/regulations necessary to build and operate the required technical infrastructure.	Use fully representative prototypes to test all aspects of human interaction and operating procedures in relevant, realistic scenarios, at all relevant levels. Ensure all human-aware aspects of design are adequate. Gather realistic human performance information. Supplement this with modelling where experimental results are not possible. Track and resolve all primary and secondary issues. Ensure full integration of human factors results.

Figure 14: Focus of human factors at different CLM phases

[6] The term 'human-aware' is used to denote any aspect of a system design, whether visible or not, that has a significant effect on the way people perceive, understand and carry out their work. This includes all HMIs, as well as for example, the sequence in which related events occur, the delay between stimuli and responses, the way in which information is organised and accessed, the grouping of tasks and responsibilities.

5.2.2 Transition Criteria

The maturity of a conceptwith respect to human factors is assessed using three sets of criteria:

- concept definition criteria – how well defined are the people-related aspects of the concept?
- people-related issue criteria – how well are the people-related issues understood? How significant are the remaining issues (i.e. can they be acceptably resolved and managed)?
- human factors process criteria – is the human factors work underlying the evidence sound?

Structured lists of these criteria, with guidance on what to expect at each level of maturity, are in Appendix A. As well as feeding into the overall aggregate decision to move the concept between maturity levels, these criteria also indicate any specific aspects where the human factors maturity is not in line with the overall maturity, and hence where special attention is needed to 'catch up' to avoid undue risk that the concept will later be found deficient in terms of human performance, effectiveness, cost or wellbeing.

The Strategic Assessment of ATM R&D results (SARD) which describes the criteria to be used in SESAR for the assessment of the maturity of ATM concepts in line with the Concept Lifecycle Model of E-OCVM, includes transition guidance specific to the Human Factors Case.

5.3 Human Factors Case Methods and Processes

Human factors work within a project applying E-OCVM draws on a combination of pre-existing human factors methods and processes, adapted to apply to different phases of the CLM, to work within the SPF, and to produce an objective body of evidence in support of validation.

5.3.1 Methods and Tools

Human factors work is structured on two levels. At one level are the technical activities (analysis, model building, interviewing, prototyping, walk-throughs, experimentation, measurement, and so on). They will vary between projects, and are normally performed by human factors practitioners. Above these are the integration processes that relate the technical work to the needs of the wider ATM problem space, coupling the work to the project's main plan and objectives. These integration processes require a blend of human factors expertise and broad systems/management skills.

Stage	Title	Description
1	Fact finding	Identify what will change, who will be affected, how they will be affected.
2	Issue analysis	Use workshops and interviews to identify potential HF issues, assess their impact, and determine priorities.
3	Action plan	Identify actions, mitigation strategies and monitoring arrangements in response to the issues.
4	Actions implementation	Conduct the planned studies, analysis, evaluation, etc and check that issues are dealt with.
5	HF Case review	Review effectiveness of the process, with lessons learned for improvement.

Figure 15: Stages in EUROCONTROL Guidance for Human Factors Case process

The process used to identify, assess and prioritise people-related issues is based on the EUROCONTROL Guidance for Human Factors Case [3], which is summarised in **Figure 15**.

This is interpreted in the context of the relevant lifecycle phase, and prioritised in terms of the concept objectives.

Pre-project (i.e. programme level) engagement with human factors concerns is essential in order to ensure that the plan (which will constrain the project's scope of action) adequately caters for three key aspects of human factors work:

- **Resource level** - To allocate sufficient effort, with the right type of experience to do the required work effectively;
- **Integration** – To ensure that the results produced will be compatible with what is done in other parts of the project;
- **Timing** – To ensure that information is available when it is needed to inform project decisions, and to feed into other project activities.

This pre-project engagement may be subject to resource and effort constraints, so the process is not prescribed. It provides preliminary insights broadly equivalent to stages 1-3 in **Figure 15**.

Lifecycle tailoring of the human factors process mainly concerns the choices and depth of the technical activity, with the emphasis shifting from modelling and analysis in early phases, to experiment and simulation in later phases.

The inputs to the human factors process reflect the breadth and variability of issues associated with the concept, and it is not sensible to pre-specify them. Key inputs to almost all human factors work include access to representative users and Subject Matter Experts, with sufficient time available to participate in activities like workshops, focus groups and experiments/simulations.

5.3.2 Human Factors and SPF

There is a broad mapping[7] between the human factors work and the SPF.

Step 1 of the SPF is mainly a programme responsibility, and takes a view over all lifecycle phases, in the light of which individual projects refine and elaborate their part of the overall strategy.

The human factors validation needs are derived from a combination of:

- system level stakeholder concerns (typically expressed through the KPAs);
- human factors concerns from current operation (identified by issue analysis);
- change-driven human factors concerns (identified by issue analysis);
- exercise[8] constraints (driven by lifecycle considerations of cost, risk and uncertainty).

Step 2 of the SPF is a project level activity, inheriting decisions about priorities and resources, taken at programme level. The activity to determine the needs for Human Factors exercises includes:

- interpretation of the project's overall validation objectives from a people-related perspective;
- identification of any specific people-related evidence required by other disciplines (e.g. Safety Case);

[7] In the more detailed human factors guidance.

[8] The term 'exercise' covers any activity that can be used at various phases of the lifecycle to generate or present evidence to stakeholders. The aim is to use whatever type(s) of exercise can cost effectively generate evidence appropriate to the uncertainties and expectations at each phase.

- translation of identified issues relating to operability and human performance;
- balancing priorities of the above within the available resources and lifecycle constraints in order to satisfy the highest priority needs;
- selection of suitable exercises (or of suitable incremental value that can be added to exercises planned for other project purposes);

Human factors value can be added to:

- stakeholder workshops – Added topics to focus on the effects on people and relationships;
- fast time modelling – Review of assumptions about human function and performance within models;
- human-in-loop simulation – Observational protocols to assess for workload, situation awareness, etc.;
- performance prediction – Assumptions about people, and/or data on human behaviour & performance.

Human factors specific exercises may include:

- role and relationship modelling – Descriptive models to support understanding;
- task, workload and communication modelling – Various analytical and descriptive models to facilitate reasoning about people's work;
- process walk-throughs – To learn from users 'talking their way through' processes;
- part task experiments – Small scale human-in-loop exploration of critical areas.

Step 3 of the SPF does what was planned in Step 2, with progress monitored to cope with any unexpected result, e.g.: major discrepancies of user expectation or observed user performance, emergent user behaviours, operability failures, or ineffective observation or measurement.

Step 4 of the SPF draws together and interprets the human factors data to generate coherent results for the Human Factors Validation Case (and other cases, where appropriate).

Step 5 of the SPF is owned at programme level, but may partly be delegated to the project. More detailed human factors dissemination to specialists and interested stakeholders may be needed.

5.3.3 Building Evidence for System Operability

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.

- analysis is needed to understand the effect that the system (changes) will have on the people;
- design intervention is needed to obviate its adverse effects and enhance positive effects;
- evaluation is needed to produce evidence that the overall effect (on the people) will be acceptable;
- operability evaluation must consider the complementary perspectives shown in Figure 16.

Operability perspective	Detail studied	Issues arising
Individual human role	Responsibilities assumed	Overload, underload, situation awareness, task complexity, comprehensibility, ambiguity, coherence and acceptability, motivation.
	Goals to be achieved (by the role)	
	Expected tasks	
	Associated procedures	
Collective aspects of human activity and relationships	Team members' roles	Functional teams [9], role boundaries, communication, team transparency.
	Communication processes	
Relationship with the system	Function allocation between human & machine	System boundaries, human-machine boundary, function allocation, system transparency, trust.
	Working logic of system perceived by human	
Interface with the system	Format and content of information	Information, interaction
	Lay-out and handling (actions) of interface	

Figure 16: Complementary perspectives of system operability

During CLM V1, input to the process consists mainly of descriptions, models and experience carried over from existing system(s). There is an aspiration for what the concept will do, but little hard evidence about how it will do it, or whether it will even work. Work on operability will draw extensively on generic knowledge about how people interact with systems, interpreted in the context of the current concept. Conceptual designs can be 'tested' by review and structured walk-through with representative subjects.

During CLM V2, there will be richer descriptions and models (inherited from V1 and created during V2). They will be supplemented by various sorts of prototype. Many aspects of operability can be tested by people doing quasi-real tasks in real time. Even aspects that can't be so tested can benefit from much greater realism and interactivity in non-real-time walk-throughs.

During CLM V3, substantial prototypes can be integrated into meaningful scenarios. The results of V2 should ensure that their user interfaces are fairly mature in respect of all localised tasks and interaction, thus enabling a focus on more widespread interaction between people and teams in realistic scenarios.

5.3.4 Building Evidence for Human Contribution to System Performance

This requires understanding, and being able to quantify, the mechanisms that link human performance to desired system performance, in order to make appropriate people-related contributions to system performance models.

- all models of the overall system must expose the human contributions explicitly, in a way that enables them to be reasoned about within the overall system context;
- models of the technical system must expose human interfaces explicitly in a way that enables the influence of the human link to be reasoned about in the context of the technical system;
- system functional models must be linked to credible human models (of tasks, jobs, relationships, etc) that can explain human behaviour and performance within the system context;

[9] The network of all people with whom an individual needs to interact in order to do his/her job

- System performance models must be based on supportable evidence about human behaviour and performance (capacity, reliability, variability, etc.);
- Economic and business performance models must be based on realistic evidence about human costs, and the sustainability of human resources.

The ICAO KPAs are used to define system performance. They are quite broad, and cover widely different aspects of 'performance'. **Figure 17**, shows the human factors contribution to performance in the three groups of KPAs.

'Visibility'	KPA	Human Factors Support
High (Societal outcome)	Safety, Security, Environmental sustainability	Understanding dependencies on human behaviour, reliability, vigilance, etc, plus related evidence, e.g. about error likelihood, error management and attitudes.
Medium (Business effects on users & operators)	Cost effectiveness, Capacity, Efficiency, Flexibility, Predictability	Human task effectiveness and efficiency, task integration, rest cycles, etc, plus evidence about human work rates, task organisation, etc.
Low (Not direct interest to airspace users and customers)	Access & equity, Participation	Processes for effective stakeholder involvement.
	Interoperability	Understand impact of human inter-operability.

Figure 17: Human factors support to different Key Performance Areas

Support to the 'business' (medium visibility) KPAs is a major validation activity. System functional models show how the different parts, including people, interact. So it is essential to identify which parts of the model will change with the proposed concept, and which parts can safely be assumed to be the same (for small scale incremental concepts). In the changed areas, a new model must be developed or adapted and tested against known human characteristics. Any concept design changes needed to accommodate the people can then be explored.

System performance models typically use influence diagrams as a framework, with other models of various relationships plugged in. The human factors contribution to model building must ensure that models:

- Include all relevant people (not just the most obvious ones).
- Include all of their relevant activities (not just the primary ones).
- Take account of the performance they are actually likely to deliver (not just their theoretical performance based on function alone).

Initially models will be qualitative, but quantitative models will be progressively needed in order to validate quantitative goals. Proper planning (within the SPF) should enable the generation of human factors data and sub-models for this purpose. Where phase constraints prevent the provision of all the desired (reliable[10]) human performance data, then the human factors and system performance specialists must work together to determine how best to use the data and insights that can realistically be obtained, in order to build an appropriate degree of confidence in the concept.

[10] Human performance is variable and very context dependent. Data obtained from unrepresentative samples, or in non-matching contexts may not be reliable predictors of actual performance.

5.4 Precedents

The human factors validation process, as defined within E-OCVM, is a synthesis of existing methods and good practice, drawn from many sources, across ATM and other industries. The fully integrated approach across all phases of the lifecycle has not yet been applied, but there are precedents for all aspects, and some component parts have been applied.

- The EUROCONTROL Human Factors Case process, which provides the underlying method, has been applied in several R&D projects, including: CREDOS, ERASMUS, CORA, FASTI and NFDPS Maastricht.
- The phase-based tailoring is a direct interpretation of E-OCVM principles into human factors terms.
- The structure of the evidence to be produced for the Human Factors Validation Case is modelled on the generic structure of a Safety Case, as used in several industries.
- Human Factors Claim 1, about how well the human is integrated into the system, is based on the primary goal of human factors across all industries.
- Human Factors Claim 2, about the human contribution to overall system performance is a necessary adjunct of the performance based approach of E-OCVM, and in particular the use of KPAs.

5.5 Documentation of a Human Factors Case

The body of a Human Factors Case report should include the main sections listed in **Figure 18**.

Section	Description	Comment
Reference model	Defines the scope of the system (including people) about which the claims are made.	Make clear 'what' HF validation relates to. Enable all stakeholders (and case builders) to be sure they are talking about the same thing.
People-related issues	Lists people-related issues identified so far (with supporting evidence about how they were identified and assessed).	Give confidence that the problem has really been understood.
Actions taken	Lists actions already taken in the emergent concept design that resolve (some of) the issues.	Demonstrate value added in terms of reducing concept risk and uncertainty.
Actions outstanding or planned	Lists further action needed to refine and/or complement what has been done. May indicate phase or time scale.	Make clear what still needs to be done (before operation) to develop sufficient confidence in (people-related aspects of) the concept.
HF Case summary	Short, high level, itemised list of statements summarising the overall case, with links to the supporting detail.	Capture the key issues in a short enough form for decision makers to absorb, alongside information from other cases.

Figure 18: Sections of Body of Evidence for Human Factors Validation Case

6 ENVIRONMENT CASE

6.1 Introduction

6.1.1 Environment Case Definition

The purpose of an Environment Case is to collate environmental information together in order to describe the potential of a concept under evaluation and inform the key stakeholders and decision-makers as they consider the investment and implementation options. It is essentially the means by which the environmental attributes of an operational concept can be validated and assurance given that the development of the proposal has been effectively managed. The objectives of the Environment Case should be tailored to the maturity of the concept being examined.

6.1.2 Scope and Purpose of Environment Case

Using an Environment Case will help the project manager to plan, identify and analyse the likely environmental impacts that any ATM system proposal is likely to bring. It will, 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 system proposal. The function of the Environment Case specifically is to ensure that environmental considerations are explicitly addressed and incorporated within the planning and decision making process for an ATM system proposal.

6.1.3 Typical Stakeholders for the Environment Case

The principal target audience group for the Environment Case is programme managers - people who establish or manage programmes to validate proposed improvements to ATM system performance. There is a large number of stakeholders who have an interest in the content of the Environment Case. Airlines are increasingly lobbying ANSPs to provide a more fuel efficient service, minimising their fuel burn and emissions. Government regulators may review an Environment Case to ensure it meets with environmental legislation. The military are also a stakeholder of the Environment Case – as they seek to ensure their airspace user requirements are met. In addition, the wider community is a key stakeholder. Any individual who feels they may be affected by a change to the airspace operation should be considered a stakeholder. These individuals may represent themselves or have their interests represented through a number of groups such as community organisations, Non Governmental Organisations or elected representatives.

6.2 Environment Case and Concept Maturity

6.2.1 Integration with the Concept Lifecycle

The Environment Case follows the same outline as the validation process for the overall project. A range of initial possible solutions should be outlined and subject to a level of evaluation to test their scope and appraise their likely environmental outcomes. The Environment Case is focused on the specific aspects and stakeholders. This is true for all cases and enables a validation process with balanced information on all cases, built upon the same base and level of maturity. Figure 19 details the expected environmental content at each CLM lifecycle phase.

Phase	Concept development	Environmental validation focus
V0	**ATM Needs**: Identify stakeholder needs, ATM system constraints and potential concepts	The environmental impacts of the part of the ATM system under consideration may be identified. Environmental regulations and targets for the effected part of the ATM system should be investigated.
V1	**Scope**: Describe concept(s) in enough detail to identify potential environmental benefit mechanisms	At this phase, there should be greater understanding of the potential environmental impacts. This enables the scope of the environmental assessment to be identified. Consultation requirements should be being developed.
V2	**Feasibility**: Develop and explore concept(s) with appropriate tools and modelling	Much of the quantitative environmental assessment should be undertaken during this phase. The tools and models used for this assessment are determined by the type of environmental impact being assessed. Environmental consultation with various stakeholders should be included in V2. Where different options are being considered the environmental trade-offs should be assessed.
V3	**Integration**: Test concept's behaviour and performance to determine how it will interact with other elements of the ATM system	The environmental assessment will focus on the potential solution. The assessment will be fully documented within the Environment Case. The results of the Environment Case may be used by the Business Case. Environmental and Stakeholder consultation will continue.

Figure 19: Focus of Environment Case at different CLM phases

6.2.2 Transition Criteria

Given the number, scope and range of ATM system projects, studies, initiatives and proposals in Europe, it is difficult to prescribe specific rules on how and when it can be determined that a concept should transition from one V phase to the next in the E-OCVM framework based on the Environment Case. However, it is recognised that some form of general environmental guidance on transition criteria may be valuable and which can, in turn, be interpreted and/or tailored by project managers for their individual concept on a project by project basis. As such, transition questions should be defined by both high level targets and by local constraints. Furthermore, there are regional, national, and local constraints or regulatory requirements that might affect the development of the concept. It is important that these targets and requirements are identified and understood in the early phases of the development lifecycle. The environmental assessment and case will then be developed based on them as the project matures. The Strategic Assessment of ATM R&D results (SARD) which describes the criteria to be used for the assessment of the maturity of ATM concepts, in line with the Concept Lifecycle Model of E-OCVM includes transition guidance specific to the Environment Case, see Appendix A.

6.3 Environment Case Methodology

The appropriate context of the Environment Case is determined by including an initial appraisal of the scope of the exercise to be undertaken. Following the development of an outline plan, the individual steps outlined in the following sections are completed as appropriate to the concept's maturity. Each environmental assessment will feed into the Environment Case. The assessments themselves will become more detailed as the concept matures. It is expected that with a more mature concept there will be a greater understanding of the expected ATM operation. This will enable a more detailed and quantitative environmental assessment to be undertaken. This, in turn, will result in a more mature

Environment Case. Determining the scope is a key activity in deciding what type of analysis is required.

6.3.1 Assessments and Tools

Assessment of noise impacts

Noise analysis is usually confined to that arising from aircraft flying in the terminal airspace and typically below 3,000 ft. Depending on the scope of the proposal, the noise assessment should include the use of mapping and quantitative data to show L_{DEN} contours, and may include other combinations of L_{eq}, SEL, frequency of events, Noise Above (NA), Time Above (TA), assessments of likely numbers of people and geographic area subjected to noise above certain values from the current system and the system proposed after the change. N70 contours, average noise exposure indices and operational diagrams can graphically show the number of aircraft expected to use the individual elements of the changed ATM system and assist in the evaluation of the proposal.

Assessment of local air quality impacts

Air quality analysis is usually confined to that arising from aircraft climbing or descending in the terminal airspace and typically below 3,000 ft. The assessment should make use of mapping and quantitative data to illustrate the scope of the impacts.

Where the change proposed is likely to change local air quality, i.e. the level of fuel burn, or the nature, volume or composition of combustible products, or cause changes to local air quality; it should be evaluated in terms of CO, VOCs/HC, NOx, PMx and SOx emissions.

Assessment of climate impacts

The baseline track distance and the track distance following the airspace proposal should be calculated. An estimate of the baseline total annual fuel burn/ mass of CO_2 emitted should also be compared with that of the proposed scenario. The assessments should be made for a range of future traffic scenarios. CO_2 emissions analysis is usually calculated for en-route emissions only as those occurring in the LTO cycle only represent a small percentage of the total.

The EU Emmissions Trading Scheme for aviation is likely to prescribe a suite of metrics to complement that of CO_2 measured in tonnes. For climate change assessment, it may also be possible to estimate non-CO_2 emissions such as NOx for the proposed airspace change. Additionally, other non-CO_2 impacts are also potentially highly significant and include contrail induced cirrus cloud. No method or metric has yet been agreed to measure contrail coverage or frequency.

Assessment of tranquillity and privacy impacts

This should include a consideration of the likely impacts of the proposed change of the over-flight of tranquil areas and other sensitive buildings and areas in the terminal airspace. Consideration is usually confined to that arising from aircraft in the Landing and Take-Off cycle and in particular should focus on whether the proposal allows low-level operations that might be perceived as invading the privacy of people in those areas. Sensitive regions may include residential areas, educational facilities, hospitals, religious centres, civil/military installations and other designated sites. The use of mapping and quantitative data to highlight the number and nature of settings subject to over-flight is recommended.

Assessment of natural environment and recreation impacts

An assessment of the impacts on natural environment, recreational areas and other areas of national significance including National Parks, Special Areas of Conservation, Outstanding Areas of Natural Beauty, other sites falling under the EU Natura 2000 network, UNESCO World Heritage Sites, national heritage properties and areas of high cultural value in the terminal airspace should be undertaken. Consideration is usually confined to that arising from aircraft in the LTO cycle. The use of mapping and quantitative data to highlight the number and nature of settings subject to over-flight is recommended.

Assessment of wildlife, biodiversity and habitats

How the proposed ATM system change is likely to result in interactions with biodiversity, habitats, soil and water resources is an important factor in terms of wider environmental assessment. Consideration is usually confined to that arising from aircraft in the LTO cycle and in terminal airspace. The assessment should focus on potential interactions (including exposure to noise and vibration) with birds, animals, migratory species and wildlife in their natural states, in addition to possible changes to biodiversity, habitats, and soil and water resources. The use of mapping and quantitative data to highlight the scope of potential interaction with the natural environment and species is recommended.

Tools and Checklist

There are many environmental models and assessment tools which can potentially be used to investigate, quantify and refine airspace proposals during the planning stage, by calculating the effect of a concept on one or more environmental impacts. A range of regulatory references, standards and guidelines for the array of environmental impacts identified in the checklist are discussed in D22 Chapters 2 and 5 ([1]).

A standardised checklist of environmental aspects to be considered as part of the environmental assessment process of ATM design has been developed in D22 Chapter 5 ([1]). The checklist incorporates the assessment of direct and indirect environmental effects resulting from a proposed change. The nature of the particular concept will determine the exact level of environmental assessment required as the entire checklist may not be relevant & applicable to every project. In particular, the phase of flight with which the proposal is concerned with will dictate the scope of evaluation and the impacts to be considered.

6.3.2 Risk Assessment

A risk assessment and evaluation of uncertainties and errors should be undertaken. This should cover both the operational concept of the proposal and the results of the modelling and analysis.

6.3.3 Identify Environmental Indicators and Metrics

There are many available ways in which the environmental performance of existing and proposed ATM systems can be assessed. The indicators and metrics available for the assessment of the environmental performance of the ATM system in addition to the validation strategy are an important element of the design process.

6.3.4 Disseminate Information to Stakeholders

A number of issues and points raised may need to be addressed following the dissemination process. This is an inevitable and legitimate requirement of the process and should be seen as an opportunity to make it more transparent and understandable to the various stakeholders and airspace users. The process can also be an information gathering opportunity.

Some of the issues raised may be able to be dealt with at this stage of the process - for example, a more comprehensive justification for some of the design options chosen or making design choices where multiple options exist, based on the consultation feedback. If there are significant issues raised which were not previously considered, it may be necessary to alter elements of the proposed ATM systems and repeat the exercise. It may also be the case that substantial concept changes are required following considered raised objections, which would have to go through the assessment procedure again.

6.3.5 Public Consultation

The objective of the consultation exercise with public and other stakeholders is to ensure the change proposal meets their expectations and needs. This is different to the separate follow-up exercise where the proposal is validated by others.

A consultation process is usually required when implementing new rules, operating procedures, airspace or related changes. The nature, depth and scope of consultations however, vary considerably between States. In some States the ANSP and/or regulator may consult with the major users of controlled airspace, while in others the ANSP and/or regulator engage in a wider formal public consultation. The differences in consultation processes are likely to be due to a number of different reasons including the cultural, historical and political context and the resources and time available.

It is beyond the scope of this project to recommend a particular type of consultation. However, it is likely that development of EU rules – especially those in the environment domain will result in a harmonised approach across Europe. Furthermore, the principals of consulting as widely as possible already feature in the Environment Investigation Agency (EIA) and Strategic Environmental Assessment (SEA) and may become mandatory. It can be beneficial to include representatives of the public from early on the concept to provide opportunity to direct the development of the concept based on their key concerns.

6.4 Precedents

There are few examples of ATM Environment Cases to date. A number of projects are therefore highlighted which have a clearly defined environment scope and can be expected to be among the first users of an Environment Case.

6.4.1 OPTIMAL

OPTIMAL was an air-ground co-operative project, which aimed at defining and validating innovative procedures for the approach and landing phases of aircraft and rotorcraft, as well as new ATC tools and airborne functions to support these new procedures. The goal of OPTIMAL was to increase the ATM capacity maintaining and even improving safety while minimising external aircraft/rotorcraft noise nuisance.

Several examples can be extracted from the OPTIMAL project, which helps understand/clarify the different parts contained in the environmental validation process[11].

The main environment-related steps were:

1. Based on the Environment High Level Objectives (maintain or decrease the level of impact) ”noise level” and “emissions” were identified as indicators.

2. Metrics related to the low-level objectives for both noise and emissions were identified. (Noise: Sound Exposure Level (SEL), $L_{A\ MAX}$ (for Rotorcraft) and Day/Evening/Night Average Sound Level (L_{DEN}), Emission: Kg of emitted CO_2 per year).

3. Environmental analyses were carried out with the metrics from step 2, using different scenarios for the new approach and landing procedures.

[11] OPTIMAL is one of the first projects that used the E-OCVM for its validation programme. However, since the first version of the E-OCVM was issued after the project began, the validation within OPTIMAL was more or less adapted to the E-OCVM and therefore some aspects, like the maturity levels, were not taken sufficiently into account.

The procedures designed and used in the OPTIMAL project had varying levels of maturity: many of the procedures would still require further improvement and testing before they could be implemented. At the end of the project, the global maturity level of the OPTIMAL procedures was V2/V3.

6.4.2 ERAT

The ERAT project aims to identify operational initiatives, develop concept elements, integrate them and validate a concept of operations that reduce the environmental impact of the air transport operation in all phases of flight in the extended terminal area. The potential benefits of several initiatives are known from earlier research such as the Sourdine projects, NUP2+, C-ATM and Eurolift (ERAT 2009). The Sourdine projects devised an implementation strategy for environmental mitigation and were V1/V2 projects. ERAT is in turn derived from Sourdine and other projects and is in the V3 phase.

The project's objectives also include developing concept of operations that will minimise noise, emissions and the impact on local air quality in the airport TMA, whilst assuring an increase of or at least no adverse effects on airport capacity. The validation approach being taken is in line with the devised Environment Case methodology.

6.4.3 Episode3

Episode3 is responsible for assuring that the SESAR CONOPS satisfies the required levels of environmental performance of the future European ATM system – defined by SESAR. It is focusing on environmental validation and the E-OCVM approach. Episode3 is a validation project and fall within the scope of a V1/V2 project.

6.5 Documentation of an Environment Case

The deliverable of guidance for a typical Environment Case takes the form of the template shown in **Figure 20** for the drafting of a case to support an ATM system proposal.

Section	Title
1	**Environment Case executive summary**
2 2.1 2.2 2.3 2.4 2.5	**Introduction** Aim Background & purpose Scope What constitutes an ATM System change Document structure & layout
3 3.1 3.2	**E-OCVM and Environment Case methodology** E-OCVM outline and context Building the Environment Case
4	**Context & justification**
5	**ATM system description**
6 6.1 6.2 6.3 6.4 6.5	**Argument & basis of claim** High level claim Identifying the environmental performance criteria Constructing the argument Principal arguments High-level assumptions
7 7.1 7.2 7.3	**Evidence** Gathering and presenting evidence Evidence – Determination of environment requirements Developing an environment plan
8 8.1 8.2	**Assumptions, caveats and limitations** Uncertainties, risk and unexpected effects Limitations
9	**Miscellaneous Issues**
10	**Conclusion**

Figure 20: Structure of a typical Environment Case Report

7 RELATIONS BETWEEN CASES AND INTEGRATION OF RESULTS

7.1 The Need to Relate Cases

As explained in the previous sections each case brings the benefit of a different specialist view to the assessment of the concept. This includes understanding the problem the concept 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 potential implications.

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

- diverging assumptions for the cases' simplified representations of the concept under consideration;
- specialist language, not always understandable to non-specialists nor to the specialists of other cases;
- individual case priorities that reflect the specialist case perspectives on the problem may diverge in inconsistent ways, unless explicitly linked back to the overall concerns of the programme/project stakeholders;
- separate, one to one contact between a case team and particular groups of stakeholders to identify their concerns and insights can lead to fragmented, and not fully consistent, stakeholder input.

Overcoming this fragmentation and making the different outputs fit together is essential if (non-case specialist) stakeholders are to be able to understand the overall picture, and use it as a basis for making decisions. Ensuring that the different case contributions will fit together (coherency) and, moreover, in a cost-effective way is a responsibility shared by all the case teams, throughout the life of the programme/project, not just at the end.

7.2 Case Framework

To meet this requirement there are several aspects of the relationships between cases that need to be understood for a successful outcome to the project[12]. Figure 21 shows the four main aspects of this relationship (between two cases, in this instance) and for each aspect identifies some common topics. Note that no chronological order or sequencing of the relationships should be implied from this figure.

The following sections describe the four aspects of this relationship between cases. However, this description is not exhaustive; the nature of the relations will vary with the specifics of the particular cases and with the overall project context and maturity. Although some relation topics are universal (e.g.: the need for different teams to understand each other's approach and concerns), many will need to be developed on an application by application basis. In other words, since no two programmes/projects are the same, a particular dependency between case A and case B in one project might not be applicable in another project.

[12] The need for particular relationships between cases should be identified in the validation strategy, establishing an overall process for evidence production. This should ensure compatibility between the different cases, avoiding possible problems such as the use of different methodologies to investigate the same issue (e.g., Human Factors Case by human factor experts and Human Assurance Level by safety experts).

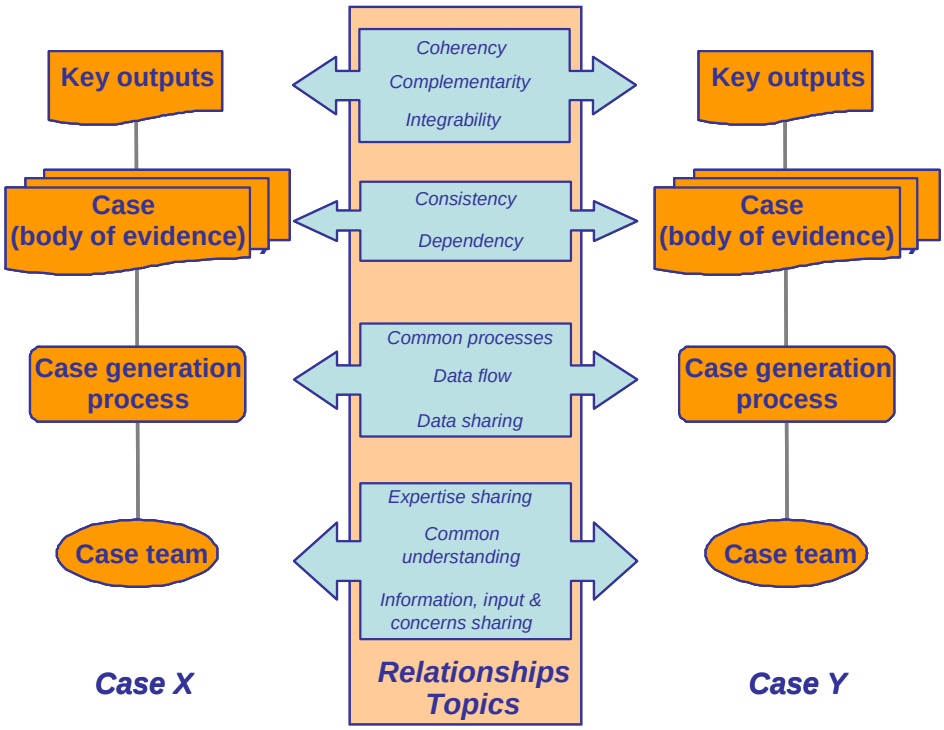

Figure 21: Conceptual Framework for relations between Cases

7.2.1 Key Outputs

The 'headline output' of each case is a summary of key findings. These are the case results that stakeholders will expect to pick up and fit together. They should be coherent and they should complement each other. If the results of different cases conflict with each other in any way, they should be presented coherently in a way that enables stakeholders to see what compromise or trade-off is needed to resolve them.

For example, if the Environment Case shows that a complex new procedure is necessary to meet pollution or noise targets, and the Human Factors Case shows that such a procedure is unlikely to be reliable in practice, without excessive training and management overheads, then both cases should present their results in a way that allows stakeholders to see clearly the choice they have to make, and to be sure they are not asked to compare apples with oranges.

Integration of heterogeneous results is never easy, especially if the conclusions of different cases tend to point in different directions. The best way to integrate or aggregate the results of the cases will depend on the type of information that they produce, which in turn will vary through the lifecycle. There are various ways of combining and weighting quantitative results to take account of incompleteness, reliability, relative weight, and so on. Qualitative results should also be factored in, and there are techniques for relating them to each other and to common objectives within the KPAs.

Finally, the key results of all cases, and their integrated outcome, should be communicated effectively to all stakeholders. The presentation and emphasis may differ to meet their different needs, but if they are all to own the eventual solution, they should all understand where it came from, and how any underlying conflicts were resolved.

7.2.2 Body of Evidence

Underlying each set of key findings is a body of substantive evidence. The evidence in each case will of course be different, but it should be structured in a way that permits scrutiny to ensure it is consistent, i.e. it is based on the same (or compatible) assumptions, models and tests. This is particularly important if there are any conflicts of interest, as with the example of an unsustainable environmental mitigation procedure. Also, it is necessary to ensure that the case priorities are derived from the overall concerns reflected in the KPAs, and that all results and conclusions are similarly linked clearly to appropriate KPAs (and where possible KPIs).

7.2.3 Case Generation Process

Behind each output is a process. Partly this is the E-OCVM, but mainly it is the set of specialist techniques used internally by each case. These techniques are different (by definition) though they will have some common elements. For example, when more general issues or cross-disciplinary issues are being discussed with the stakeholders, it can be more cost effective (and less confusing for stakeholders) for two or more case teams to work together with stakeholders.

The cases can only be as good as the information fed into them. Some of this information will be completely specific to an individual case, but much of it will affect more than one case, and its use should be co-ordinated in order for the end results to integrate reliably. Where two different cases use similar data sets, small adjustments may make sharing possible. Their needs are likely to be slightly different, so the need is to ensure that the two subsets remain consistent. One case may produce an output for another to use as an input. That is a good way to link cases together, but it requires co-ordination to ensure that the right information, in the right form, is produced at the right time. Where processes cannot share the same data, there is still merit in tracking key information to ensure that results do not diverge.

Also, the foundations on which all the cases are built should be agreed with all stakeholders. This means they should be involved in critical decisions about underlying assumptions, about the relative importance to be attached to each case, and about the priority of different KPAs, and specific KPIs within them. If the case teams cooperate within the same exercise from which both intend to derive results, (see also the Human Factors – Environment example above), the team of the driving case should then lead the activity. The other case team would contribute to its scoping, planning and running.

7.2.4 Case Teams

Even more fundamental to each output is the specialist team (or individual) that undertakes the exploratory and analytical work, and produces the result. Quite properly, each team has its own culture, through which it adds value. But in order to work towards a coherent set of outputs, each team needs also to understand the others – not just their general viewpoint, but the specific aspects of the concept under study about which they are particularly concerned. Using the example of the need for a complex environmental mitigation procedure, the best time for the human factors team to know about the procedure is when it is actually being considered, not when the case teams review each others' final reports.

Teams should maintain their independent view, as well as understanding each other, so there is a balance to be struck. In the example used, it might be possible for the teams to work together to resolve, or partly resolve the conflict, but equally they might conclude that it cannot be resolved, and should be presented to stakeholders.

Finally, it is recognised that there is no single 'owner' of the relationship between teams. In some projects top-down central direction may work. In others the development of bottom-up relationships between teams may be more effective. But if the relationships do not develop,

then the results produced, and hence the basis on which stakeholders make decisions about the concept, are less likely to be coherent.

7.3 Case Specific Relations

The relationships of each case with other cases will of course differ, reflecting their unique perspectives. They may also differ from project to project, depending on the overall concerns of stakeholders, and the specific issues raised by the concept under consideration.

Furthermore, cases can impose indirect relationships upon each other, because cases evolve during a project. Issues are uncovered and potential ways of resolving them are conceived. Often the most effective way to resolve them is to influence the still-evolving concept. Indeed it can be suggested that there is more value in influencing a concept change in order to remove its defects than there is in producing proof of what defects it does or does not have, in a report available only at the end.

Each case may (and should) interact with the concept in this way, but when the concept changes, it may significantly alter the baseline on which the other cases are working, thus giving them a 'moving target'. Managing such changes is a normal system engineering activity, but case teams should not take the easy option and put all the responsibility on the concept developers to ensure that they are aware of change. It is likely to be more effective in practice if each team is aware of the influence that the others are having, or likely to have, on the evolving concept, while always retaining its independent view.

The list of specific relationships provided below is only intended to give a flavour of some typical relationships. More specific relationships can be found in the respective guidelines (see "Further Reading").

The **Business** Case is concerned with the value (not necessarily monetary) accrued by stakeholders and derived from the introduction and operation of the systems under study. It compares all aspects of performance, and so needs to co-ordinate with all other cases that assesses different aspects of performance. It also provides the justification and economic impact that will support stakeholder decisions about the concept(s). It therefore needs to work with all cases whose results may influence costs, see Figure 22.

The **Safety** Case is a primary contributor to the Business Case, since safety mitigation is often a key driver of concept costs, and safety gains or losses should be factored into the overall benefit equation. Wherever human performance or behaviour affects safety (either as a risk or as part of its mitigation) then there should be close co-operation with the Human Factors Case.

The **Human Factors** Case focuses on the capability, needs and interfaces of a key system component (the human) rather than on a single area of performance like Safety or Environment (or Security). Since human performance and behaviour influences virtually all KPAs, human factors will have inherent overlaps of subject matter that require cooperative working with the other case disciplines. For example:

- Safety – Human error is a major cause of accidents, and human resourcefulness is a powerful means of preventing accidents. Human performance and behaviour are very dependent on context, and on how well people are integrated into the system. Human factors is an essential complement to safety, and there are many practical ways for the two cases to cooperate.
- Environment – Although some aspects of environmental performance are 'designed in', some aspects rely on procedural defences, and hence on human performance. There should thus be a link between the two cases.
- Security – Security relies on combined solutions of people supported by technology, hardly ever on technology alone. The Security Case should properly account for human capabilities, limitations and performance.

- Business – It is not uncommon for people-related costs to exceed other costs in ATM, and business benefits always rely on some element of human performance. It is thus an important contributor to the Business Case. Likewise, the human factors contribution to concept development is likely to be more effective with an understanding of the Business Case.
- Technology – All technology requires human support and maintenance, and most technology has an impact on the way that people perform their operational tasks. The case for technological change should therefore be made with an awareness of what these impacts are, and how they will influence the system's ability to meet its objectives. In practice, the link between the Human Factors and Technology Cases will be very dependent on the specific situation.
- System engineering – This is not a case-producing discipline, but the all-embracing discipline within which systems are conceived, developed and validated. The human is a fundamental component of all ATM systems, but many aspects of human factors work are quite different from those of mainstream engineering disciplines. It is therefore important to develop an understanding between the 'soft' people-related discipline and the 'hard' mainstream systems disciplines.

The **Environment** Case is a key contributor to the Business Case, since environmental mitigation can be a key cost driver, and environmental gains are important benefits.

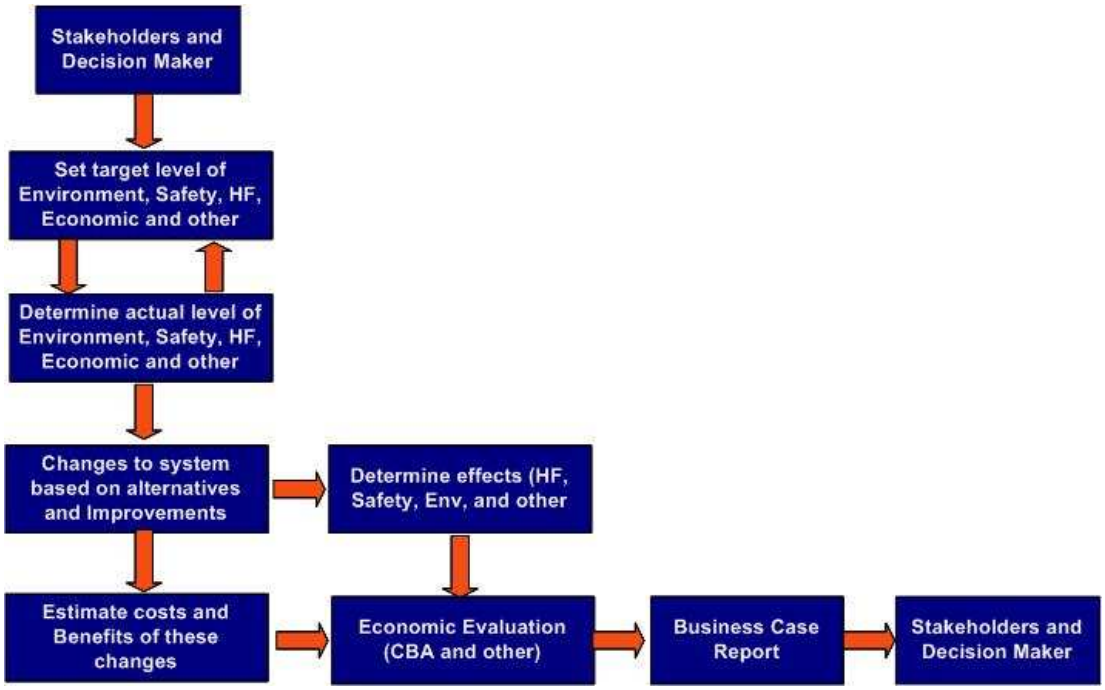

Figure 22: Collaborative assessment of the Business Case with the other cases

APPENDIX A: CASE SPECIFIC CRITERIA

A. MATURITY ASSESSMENT

As explained in Vol 1, Section 9, the Maturity Assessment (MA) aims to steer an R&D programme from a strategic viewpoint through regular update cycles. However, the maturity of the concept could well be different when seen from each specialist perspective. It cannot be assumed that because the concept overall is judged to be at level X the maturity is uniform across all cases. Any difference in maturity across cases should be recognised by both project planners and stakeholders and should be reflected in the type and amount of activity undertaken to develop each separate case.

This Appendix provides the case specific transition criteria (i.e. questions to be evaluated) for the Safety Case, Human Factor Case, Business Case and Environment Case and where necessary guidance is added. The criteria are based on the general R&D need categories; however case specific questions and guidance are given only when necessary to extend the generic questions and guidance. In other words, where no case specific questions/guidance is given the general questions and guidance for maturity assessment are applicable and sufficient for developing Safety, Environment, Human Factors and Business Case related planning for next phase(s). Further case-specific guidance can be found in the respective guidelines (see “Further reading”)

The structure of this Appendix is as follows:

A.x: Vi-Vj Transition Criteria

A.x.y: R&D need category

A.x.y.1: Typical generic questions

A.x.y.n: case specific questions and/or guidance

A.1 V0-V1 Transition Criteria

A.1.1 Problem/Solution Link

A.1.1.1 Typical Generic Questions

[V0.C1.1] Are the (current and future) ATM problems and their contributing factors analysed, clearly identified and explained? Are the future needs, opportunities and requirements captured, analysed and understood?

[V0.C1.2] Are the performance targets quantified for all KPAs to address the identified ATM problems?

[V0.C1.3] Is the (current/future) context and its potential impact on ATM analysed? Are the related results used when defining the performance targets?

A.1.1.2 Safety Case Specific Questions

[V0.Saf1.1&3] Are the (current and future) related ATM safety performance needs and constraints identified? Are the user requirements with respect to safety identified together (with other user requirements, e.g. capacity, efficiency, economy, environmental, etc)?

[V0.Saf1.2] Are the safety performance targets quantified to satisfy the identified safety-related ATM needs in an operational environment?

A.1.1.3 Safety Case Guidance

An assessment of the current and future ATM operational environment may be undertaken at this early phase to determine the performance needs and constraints, with a focus on the safety perspective. Constraints that already exist and those that are foreseen in the future ATM context are of importance.

The involvement of all relevant stakeholders in this assessment is crucial for major changes (e.g. SESAR). The aim is to identify major constraints (e.g., geographical location, costs associated with the proposed solution, compliance with regulation, etc.) to develop possible solutions.

In addition, the assessment may also include a description of the ATM operational environment (which can differ from the actual operational environment) in which the solution (new or modified concept) is intended to be employed. This information may help, for instance to set appropriate safety targets.

A.1.1.4 Environment Case Guidance

The environmental impacts of the part of the ATM system under consideration should be identified. For example, if the change is to an airport, the key environmental impacts will be different to that of en-route.

A high level environmental assessment may be undertaken at this stage to understand the environmental performance in the current situation. There is also opportunity to gain a view on the future performance based on the future situation.

Environmental restrictions are in place for airports across Europe which determine environmental limits of operation particularly with respect to noise and local air quality. Regulators in many states specify the requirements for environmental performance. In addition, consideration needs to be given to European wide performance targets. For example SESAR is aiming to improve environmental performance by 10%. These targets and rules should be fully considered when setting KPAs.

A high level environmental assessment may be undertaken at this stage to understand the environmental performance in the current situation. There is also opportunity to gain a view on the future performance based on the future situation. The assessment should aim to compare expected future performance with current performance.

From a Safety and Environment Case perspective it is important to understand the regulations and restrictions which determine what is an acceptable level of performance within the ATM system.

A.2 V1-V2 Transition Criteria

A.2.1 Processes and Procedures

A.2.1.1 Typical Generic Questions

[V1.C3.1] Is the operational concept defined at the level of detail required for the development of the benefit mechanisms and for the identification of major R&D needs?

[V1.C3.2] Are different concept options (variants) defined, if any?

A.2.1.2 Human Factors Specific Questions

[V1.H3.1] Have all affected human roles, responsibilities and tasks been defined, together with any changes of procedure, team structure and communication, at the level of detail required to identify people-related issues relevant to all KPAs and hence major HF R&D needs

[V1.H3.2] If different concept options (variants) are defined, is the human component, role, etc of each defined to the level of detail needed above?

A.2.1.3 Human Factors Case Guidance

In parallel with analysis work, the human factors effort in V1 should have identified and tracked human factors issues, to provide a broad picture of all people-related issues in the proposed concept, and should have sought to resolve any that do not require the wider activities of V2, V3, or industrialisation. The associated people-related risks should have been clearly considered and made explicit.

The human factors fact finding and analysis in V1 should go beyond a functional description of the proposed processes and procedures, in order to understand how they will affect the people who carry them out. The analysis should include factors such as potential over or under load, how the redistribution of tasks will affect the social system, i.e. inter-role communication, the ability of all roles to maintain the necessary situation and state awareness, and the effect on job integrity (how well different tasks and responsibilities fit together). It should also identify where existing issues might be aggravated by the changes. The analysis should be supported by human factors models that describe the human role within the system, and adequately account for the identified issues. The results should be endorsed by relevant stakeholders and SMEs who would be affected by the change (based their on comprehensive input and involvement).

A.2.2 Human Technology Integration

A.2.2.1 Typical Generic Questions

[V1.C4.1] Have the relationship and interaction between human and machine been defined for all concept options, at the level of detail required for the development of the benefit mechanisms and for the identification of major R&D needs (related to socio-technical issues)?

A.2.2.2 Human Factors Specific Questions

[V1.H4.1] <identical to V1.C4.1> Have the relationship and interaction between human and machine been defined for all concept options, at the level of detail sufficient for the development of the benefit mechanisms and for the identification of major R&D needs (related to socio-technical issues)?

[V1.H4.2] Are the supporting technical enablers defined at the level of detail required for the potential impact on human performance and wellbeing to be identified?

[V1.H4.3] If different technical enabler options are defined, are they defined in a way that permits the above assessment to be made for each option?

A.2.2.3 Human Factors Case Guidance

Integration of people within the overall system is about more than HMI. It requires an understanding of the effect on people and their performance of different ways of dividing the work between people and machines. Is this understanding evident from the results produced?

Is there evidence of integrated thinking, for example technical models of the system that explicitly represent the human component in ways that make it possible to reconcile them with the human factors models of human characteristics, capability and performance?

Where there is more than one option, there is a need to understand the human implications of all combinations under consideration, not just the core option in isolation.

A.2.3 Context of Use

A.2.3.1 Typical Generic Questions

[V1.C2.1] Is the potential context of application (e.g. airport, TMA, en-route, traffic density, airspace structure, etc.) defined and adequate?

[V1.C2.2] Is the potential deployment context (local/regional/pan European use) defined and are they adequate?

A.2.3.2 Safety Case Specific Questions

[V1.Saf2.1] Is the potential context of application (e.g. airport, TMA, etc) well defined and adequate to permit the identification of the safety issues?

[V1.Saf2.2] Is the potential deployment context (local/regional/pan European use) well defined and adequate to permit the identification of the safety issues?

A.2.3.3 Safety Case Guidance

A proper description of the proposed ATM system is needed for identifying its potential impacts. In addition, a description of the current ATM environment, and a description of the future ATM environment are helpful to analyse the potential effects on safety. This will all serve to analyse the new ATM system with respect to its safety performance, including potential positive contribution to safety (i.e. extinguish some of the existing hazards) and negative contribution to risk (e.g. related to new hazards). This way, the potential effects on safety are identified. Optionally, more detailed safety targets (e.g. safety objectives) can be identified for parts of the operational concept.

A.2.3.4 Human Factors Specific Questions

[V1.H2.1] Is the potential context of application (e.g. airport, TMA, en-route, traffic density, airspace structure, etc.) defined and adequate to permit the identification of the different required human performance envelopes?

[V1.H2.2] Is the potential deployment context (local/regional/pan European use) defined and adequate to permit identification of cultural and other regionally related human aspects?

[V1.H2.2] Is the potential impact of the concept on the human roles, tasks and responsibilities of the target system(s) identified? Has there been an adequate identification and description of potential human interoperability issues?

A.2.3.5 Human Factors Case Guidance

The definition of deployment contexts must be supported by an assessment of which particular contexts will stress which particular aspects of the people involved, in order to understand the required human performance envelope.

A.2.3.6 Environment Case Guidance

The context of application determines the requirements of an environmental assessment and case. It should also be noted that a change to the one part of the ATM operation may result in changes to other aspects of the operation. The indirect effects of an application should be captured within the Environment Case. In terms of the Environment Case, the area of potential deployment will influence the requirements for environmental assessment. Local, regional and pan European regulation and guidance on the environment vary.

A.2.4 Problem/Solution Link

A.2.4.1 Typical Generic Questions

[V1.C1.1] Are the potential benefits identified for representative stakeholder groups and intended context(s) of use; as well as adequate (benefit mechanisms/relevant KPAs/contribution to performance targets/rationale)?

A.2.4.2 Safety Case Specific Questions

[V1.Saf.1.1] Have the potential effects on safety been identified for all relevant stakeholder groups? Is the potential impact of the concept shown to be adequate to satisfy the expected safety performance targets?

A.2.4.3 Human Factors Specific Questions

[V1.H1.1] Is the human contribution to the potential benefits identified, along with any people-related risks and is it adequate (for all relevant KPAs)?

A.2.4.4 Environment Case Guidance

In terms of the Environment Case, consideration should be given as to whether a stakeholder consultation will be required. This requirement will be determined by local legislation. Keeping stakeholders (including representatives of the public) involved from an early phase of the project may allow issues to be resolved prior to the consultation.

The environmental impacts modelled in V0 should be reviewed based on the more mature concept. The assessment should take two forms. First it is important to ensure the correct

environmental issues are being considered (for a given ATM change). A more detailed environmental assessment may be possible when the understanding of the concept has been developed. The result of this assessment should be compared to the relevant KPAs.

A.2.5 Assessment

A.2.5.1 Typical Generic Questions

[V1.C9.1] Are the major performance related issues (R&D needs) identified based on high level benefits, risks and impact assessments covering all relevant KPAs?

[V1.C9.2] Are the major operational, technical, socio-technical, and transition related feasibility issues (R&D needs) and standardisation/regulation needs and issues adequately identified? Are the need to assess these feasibility issues justified (i.e. there are no results which show the concept to be unfeasible)?

A.2.5.2 Safety Case Specific Question

[V1.Saf9.1] Are the major safety issues (and associated R&D needs) identified based on a high level analysis of the potential safety benefits, safety risks and also impact assessments covering all relevant KPAs?

[V1.Saf9.2] Are the major safety-related operational, technical and transition related feasibility issues (R&D needs) and standardisation /regulation needs and issues identified and adequate? Is the need to assess these feasibility issues justified (i.e. there are no known results showing non-feasibility)? Has the concept been deemed feasible (from the safety perspective) by all relevant stakeholders or not?

A.2.5.3 Safety Case Guidance

The purpose of these safety assessments is to ensure that all the main safety issues relevant to the proposed concept are identified and well understood, including:

- expected safety benefits and concerns;
- assumptions;
- impact on safety regulation (these may obstruct healthy safety innovations. Where needed, revision of or amendments to safety regulations may be proposed.);
- new hazards emerging from the joint behaviour of the changed elements;
- human performance issues;
- interactions and relations between multiple operational changes;
- more detailed consideration of safety targets.

A.2.6 Work Plan

A.2.6.1 Typical Generic Questions

[V1.C11.1] Does the development and validation plan adequately cover all major performance, feasibility and standardisation/regulation related R&D needs/issues?

A.2.6.2 Safety Case Specific Question

[V1.Saf11.1] Does the development of the safety validation plan adequately cover all major safety R&D needs and issues? To what extent is the development & validation plan based on evidence collected from an initial safety analysis?

A.2.6.3 Safety Case Guidance

The initial assessment of the safety implications of the operational concept, will serve to form the basis for a validation plan. As part of this, a dedicated Safety Plan may be developed. The Safety Plan addresses the allocation of safety responsibilities, resources and schedule of activities and also a detailed performance framework with safety targets and objectives, for at least the next phase of E-OCVM to be tackled.

A.3 V2-V3 Transition Criteria

A.3.1 Processes and Procedures

A.3.1.1 Typical Generic Questions

[V2.C3.1] Have the various operational concept options been adequately assessed (operational feasibility and safety)?

[V2.C3.2] Is there a viable/preferred concept option that is shown to be operationally feasible (showing by prototyping that interaction between people is viable and that preliminary human performance and safety requirements can be met)? In case of several feasible concept options, is the selection of this concept option justified?

[V2.C3.3] Are the business processes, operational procedures, roles and responsibilities of actors and their tasks, and human performance requirements needed to implement this concept option developed?

[V2.C3.x] Are there any (new or previously identified) major feasibility issues that need further validation?

A.3.1.2 Human Factors Specific Questions

[V2.H3.1] Have all affected roles, responsibilities, team structures and relationships, together with related tasks, interfaces, and human performance criteria been adequately defined and adequately assessed?

[V2.H3.2a] Is the human performance needed to achieve desired system performance for the preferred concept option consistent with human capability?

[V2.H3.2b] Is the preferred concept option viable in terms of operability and human performance? Was its selection justified in terms of operability and human performance?

[V2.H3.3] Has the development of business processes, operational procedures and roles of actors, required to implement this concept option been based on engagement with end users, including testing under realistic conditions?

[V2.H3.x] Are there any major people-related issues that need further validation?

A.3.1.3 Human Factors Case Guidance

The simulations and experiments conducted in V2 should have been designed and monitored to explore the human task, job and team issues identified in V1. Typically they will resolve some issues and discover some more. There must be a clear view of what people-related aspects of processes and procedures have and have not been validated so far. Any critical areas not covered by simulation should have been covered by supplementary human-the-in-loop experiments or perhaps by detailed performance modelling.

A.3.2 Human Technology Integration

A.3.2.1 Typical Generic Questions

[V2.C4.1] Have the relationships and interactions between human and machine been defined, prototyped and shown to be adequate?

[V2.C4.2] Have the relationships and interactions between people and technology, been shown to be operationally feasible, and consistent with (preliminary) human performance requirements?

[V2.C4.3] Does the preliminary technical system specification incorporate people-related Requirements?

[V2.C4.x] Are there any major (new or previously identified) socio-technical issues that need further resolution?

A.3.2.2 Human Factors Specific Questions

[V2.H4.1] <<identical to V2.C4.1>> Have the relationships and interactions between human and machine been defined, prototyped and shown to be adequate?

[V2.H4.2] Have human information and interaction needs been defined, and a preliminary HMI design shown to be feasible in use by representative users performing realistic tasks? Are they consistent with (preliminary) human performance requirements? Is the chosen option (combination of processes and technical enablers) shown to be adequately operable?

[V2.H4.3] Does the preliminary technical system specification incorporate people-related Requirements?

[V2.H4.x] <<Same as V2.C4.x>> are there any major (new or previously identified) socio-technical issues that need further resolution?

A.3.3 Transition

A.3.3.1 Typical Generic Questions

[V2.C6.1] Are the major transition issues analysed for their feasibility and risks, and possible options identified and assessed?

[V2.C6.2] Is the transition shown to be feasible?

[V2.C6.x] Are there any major (new or previously identified) transition issues that need further analysis?

A.3.3.2 Human Factors Specific Questions

[V2.H6.1] Have the major people-related transition issues been analysed and potential means to resolve them been identified?

[V2.H6.2] Can the people-related aspects of transition be managed?

[V2.H6.3] Do any major people-related transition issues need further analysis?

A.3.3.3 Human Factors Case Guidance

Consideration of transition should include the social system (organisation, team structure, responsibilities, management, etc) as well as the technical system.

A.3.4 Assessments

A.3.4.1 Typical Generic Questions

*V*2.C9.1] Are the benefits and risks assessed for all relevant KPAs and for all identified potential contexts of applications? Are the synergies and trade-offs between all relevant KPAs analysed?

[V2.C9.2] What are the results? Are the major issues found during these assessments (e.g. assessments showing less then expected benefits, major safety hazards, non solved human factors and environment issues, etc.) adequately addressed in further concept and supporting technical enablers elaboration and validation activities? In case the targeted benefits are shown to be unfeasible, what is the impact on the overall strategic performance objectives/targets?

[V2.C9.3] All major issues related to safety regulation (such as transfer of responsibility, delegation of verification of compliance to third parties and/or approved organisations, etc.) have been assessed and shown to be compliant with current safety regulation or regulation is subject to change.

[V2.C9.4] Are there any additional works (i.e. concept elaboration, assessment, comparison) to be done?

A.3.4.2 Safety Specific Questions

[V2.Saf9.1] Have the safety benefits and constraints been assessed in all identified potential contexts of application? Are the synergies and trade-offs between all KPAs analysed?

[V2.Saf9.2] Have all major safety-related issues found during the assessments been adequately addressed, by modifying the concept and/or supporting technical enablers and validating the results? Have all relevant stakeholders been taken into account in the assessments? Is the scope of the assessment sufficiently wide?

[V2.Saf9.3] All major issues related to safety regulation such as transfer of responsibility, delegation of verification of compliance to third parties and/or approved organisations, etc have been assessed and shown to be compliant with current safety regulation or regulation is subject to change?

[V2.Saf9.4] Is any more work needed to address major safety issues, (e.g. further safety assessments, to ensure all safety assumptions are valid)?

A.3.4.3 Safety Case Guidance

There is a need to ensure that all safety issues are addressed, so a comparative analysis of safety-related issues should be undertaken for each alternative operational concept in each assumed operating context (including its interfaces) based on safety targets and the support of all relevant stakeholders.

This analysis should provide feedback to developers and input to stakeholders for their decisions on retaining some options and rejecting others. It is recommended to consider a wide scope of all the inputs subject to assessment to ensure that safety issues have been identified and analysed, including:

- expected safety benefits and concerns;
- assumptions;
- impact on safety regulation;
- new hazards emerging from the joint behaviour of the changed elements;
- human performance issues;
- interactions and relations between multiple operational changes.

If the current concept cannot achieve a safety target, then its most critical shortcomings with respect to safety shall be identified to analyse which hazards can best be alleviated to reduce risk. The aim is to deliver best safety feedback to developers, e.g., realistic and appropriate safety requirements or explanations of safety shortcomings that enable developers to improve the concept.

All the safety-related issues or assumptions that need further assessments and validation should be adequately addressed (e.g. how the system could recover from an internal failure, if the system could react to an abnormal situation in its operational environment, etc) Stakeholder information to be delivered should include information on concepts that have been redeveloped and still shown to have unacceptable risk level, and information on whether realistic mitigations may still be identified or not.

In parallel, potential trade-offs between KPAs (and their KPIs) may be analysed, e.g. increasing airport safety might imply less airport capacity.

Changes to concepts made for safety reasons (including safety requirements) may have both positive and negative effects on other KPAs. (e.g. cost increase, flight efficiency increase, reduction in emissions).

A.3.4.4 Human Factors Specific Questions

[V2.H9.1] Have the human contributions to benefits and risks for all relevant KPAs been assessed in all identified potential contexts of application? Are people-related aspects included in analysis of synergies and trade-offs between KPAs?

[V2.H9.2] Have all major people-related issues from the assessments been adequately resolved by modifying the concept and/or supporting technical enablers? Has the result been validated?

[V2.H9.3] Have the human implications of compliance with, or changes to, safety regulation been adequately considered? The need is to ensure that all human issues related to concept

success (the KPAs) are adequately understood, so that investment in V3 HF R&D can be properly prioritised.

[V2.H9.x] Is any more work needed to address outstanding people-related issues, (e.g. further elaboration, assessment, comparison of how the human component will integrate and perform within the overall solution)?

A.3.4.5 Business Case Guidance

The Business Case uses the outcome of benefit and risk assessments from other activities. A comparison with all alternative concepts is also provided in terms of respective costs and benefits. The analysis should cover all relevant KPAs for representative stakeholder groups and context(s) of use.

The assessments show less than expected benefits, etc. If the targeted benefits shown not to be feasible the assessment has to expose consequences for the target.

A.3.4.6 Environment Case Guidance

The environmental KPAs should be fully understood and the reasoning behind them documented. For example, the source of the target (e.g. SESAR, local regulation). The environmental focus will vary depending on the context of the change. En-route environmental issues are different from airport related environmental issues and therefore the focus of the assessment will be dependent of the scope of the change.

Potentially conflicting KPAs should be identified. For example, is it possible to satisfy both the capacity and environmental KPAs? Within environmental KPAs trade-offs may be required. A decision may be required on whether to focus on minimising CO2 and minimising noise. But it is recommended that this is managed through close consultation with the stakeholders, particularly the regulator. Synergies should also be identified. For example - reducing CO2 equates to a reduction in fuel burn and thus a potential cost-benefit to airline customers.

Environmental results should be presented to the decision maker. Consultation with the stakeholders and regulator may be required if the KPA targets are not feasible. If additional environmental assessment is required (potentially requested by stakeholders or regulators) it should follow the assessment guidance already noted.

A.3.5 Business Case

A.3.5.1 Typical Generic Questions

[V2.C10.1] Are the implementation scenarios identified and their cost estimated for representative stakeholder groups?

[V2.C10.2] Does the Intermediate Business Case cover all relevant KPAs, other decision-makers' criteria and all potential contexts of application? Does the intermediate Business Case take into account synergies and trade-offs between all relevant KPAs?

[V2.C10.3] Does the intermediate Business Case provide an initial comparison of all alternative concepts and supporting enablers across the different criteria (KPA, CBA, feasibility etc.)?

[V2.C10.4] Are the subject concept and supporting enablers shown to be cost beneficial?

[V2.C10.5] Are the implementation and operation affordable for representative stakeholder groups

[V2.C10.x] Are there any additional analyses to be done?

A.3.5.2 Safety Specific Questions

[V2.Saf10.1] Are the implementation scenarios identified and their costs estimated for the different stakeholder groups?

[V2.Saf10.2] Does the Intermediate Business Case take into account all relevant safety aspects in all potential contexts of applications?

A.3.5.3 Safety Case Guidance

The impact of the concept with respect to safety can be measured in terms of positive impacts (i.e. benefits) and negative impacts (i.e. costs) to the stakeholders. Evidence is preferred where possible, but also assumptions and expert judgment may be needed. Important items to be taken into account in a Business Case are:

- estimated changes in accident and incident risk, and the corresponding value;
- foreseen costs for identified changes to the operational concept and implementing safety requirements

A.3.5.4 Human Factors Specific Questions

[V2.H10.1] Do the implementation scenarios account for all people-related costs?

[V2.H10.2] Does the Intermediate Business Case account for all human contributions to all relevant KPAs (in all contexts)?

[V2.H10.3] Does the Intermediate Business Case comparison of alternatives take adequate account of differing human contributions to respective costs and benefits?

A.3.5.5 Human Factors Case Guidance

Since people in ATM are the largest cost, and also the critical element in the provision of the service, the Business Case should adequately represent the human component. In particular, it should give due weight to important non-quantifiable attributes, alongside those that can be readily quantified.

A.3.5.6 Business Case Guidance

The economic analysis in the Business Case report has to describe the identified scenario for developing the concept and the costs estimated for representative stakeholder groups.

The Business Case Report has to identify and consider all relevant KPAs for the study and describe all the potential contexts of applications

The Report and the economic model (Influence Diagram) built should show the comparison of all the alternative concepts and are customised by enablers in terms of respective costs and benefits

Financial Metrics show if the result of the Business Case study is cost beneficial.

A.3.5.7 Environment Case Guidance

The Business Case should include the environment assessment detailed in V2.C9

A.3.6 Work Plan

A.3.6.1 Typical Generic Questions

[V2.C11.1] Does the work plan for the next phase adequately cover all major performance, feasibility and standardisation/regulation related R&D needs/issues?

[V2.C11.2] Are the time and potential risks for the completion of the next phase activities adequately identified

A.3.6.2 Safety Specific Questions

[V2.Saf11.1] Does the development of the safety validation plan adequately cover all major safety R&D needs and issues for the next phase?

A.3.6.3 Safety Case Guidance

As the concept matures and more detailed information is available, the safety validation plan shall be updated accordingly.

A.3.6.4 Human Factors Specific Questions

[V2.H11.1] Does the development and validation plan for the next phase adequately cover human performance, operability and related issues?

A.3.6.5 Human Factors Case Guidance

Is there a clear view of what will need to be done in V3? Plans for Human Factors in V3 should build on what has been learned about people-related aspects of the concept in V2, and extend the coverage to aspects that require proving in a more widely integrated context. They should give strong priority to issues with high impact, issues that could be costly to address if not resolved prior to industrialisation and any aspects of the concept that are less mature than expected at the end of V2

A.4 V3-V4 Transition Criteria

A.4.1 Processes and Procedures

A.4.1.1 Typical Generic Questions

[V3.C3.1] Is the selected concept option confirmed to be operationally feasible when integrated into the end system, (showing that all interaction between people is viable based on prototyping of a realistic environment?

[V3.C3.2] Following its integration into the end system, do we have a stable and validated definition of business processes, operational procedures, roles and responsibilities of actors, their tasks, and human performance elements required to implement (and if so intended to regulate) this concept option?

[V3.C3.x] Are there any (new or previously identified) major operational feasibility issues that need further validation?

A.4.1.2 Human Factors Specific Questions

[V3.H3.1] Are there stable and validated definitions of all roles, responsibilities, tasks, procedures, team structures and communication mechanisms, required to implement this concept in the end system? Has the interaction between people been validated in a realistic environment?

[V3.H3.2] Are there stable and validate definitions of all roles, responsibilities, tasks, procedures, team structures, communication mechanisms, and human performance requirements needed to implement this concept in the end system?

[V3.H3.x] Are there any major operability issues that need further validation?

A.4.1.3 Human Factors Case Guidance

The integrated simulations & experiments conducted in V3 should have been designed and monitored to explore all aspects of human tasks, jobs and teams outstanding from V2. If they were not, or if they discovered new issues, there must be a clear view of how they can be resolved. The aim should be for all people-related aspects of processes and procedures to have been explored and resolved.

A.4.2 Human Technology Integration

A.4.2.1 Typical Generic Questions

[V3.C4.1] Have the relationships and interactions between human and machine been defined and validated in an operationally realistic environment using a pre-industrial prototype?

[V3.C4.2] Have the relationships and interactions between people and technology been confirmed to be operationally feasible, and consistent with agreed human performance requirements?

[V3.C4.x] Are there any major socio-technical issues that need further resolution?

A.4.2.2 Human Factors Specific Questions

[V3.H4.1] Have human information and interaction needs been explored, and HMI designs been shown to be operable by representative users performing realistic tasks in an operationally realistic environment using a pre-industrial prototype?

[V3.H4.2] Has human performance needed to achieve desired system performance been shown to be feasible on a pre-industrial prototype integrated with all relevant end-system elements?

[V3.H4.x] <<same as V3.C4.x>> Are there any major socio-technical issues that need further resolution?

A.4.2.3 Human Factors Case Guidance

The system design and specification should include a comprehensive set of people-related requirements (PRR) covering: Context of Use, Organisation Characteristics, User Characteristics, Team/Role/Job/Task Design, Training, Allocation of Functions, HMI, Equipment designed for People, and Environment designed for People

A.4.3 Transition

A.4.3.1 Typical Generic Questions

[V3.C6.1] Are there any impacts on the transition steps and supporting activities identified in the previous phase coming from operational and technical refinements made during this phase? Is the transition analysis refined accordingly?

[V3.C6.2] Is the transition confirmed to be feasible?

[V3.C6.x] Are there any major transition issues that need further analysis?

A.4.3.2 Human Factors Specific Questions

[V3.H6.1] Does the transition plan take account of all people-related issues arising out of operational & technical refinements made during this phase?

[V3.H6.2] Can the people aspects of transition be managed?

[V3.H6.x] Are there any major people-related transition issues that need further analysis?

A.4.3.3 Human Factors Case Guidance

The evidence should confirm the acceptability of all human implications of the transition. Organisation, team structure, responsibilities, etc) with the same degree of confidence as for the transition of the technical system.)

A.4.4 Assessments

A.4.4.1 Typical Generic Questions

[V3.C9.1] Are the benefits and risk assessments refined (i.e. by a quantitative analysis and considering the impact of all related concepts to each other) for all relevant KPAs and for all contexts of applications? Is the trade-off analysis extended accordingly?

[V3.C9.2] What are the results? Are the major issues found during these assessments (e.g. assessments showing less then expected benefits, major safety hazards, etc.) adequately addressed in further concept elaboration, integration and validation activities? In case the targeted benefits are shown to be unfeasible, what is the impact on the overall (i.e. IP/Service level) strategic performance objectives/targets

[V3.C9.x] Are there any additional works (i.e. concept elaboration, assessment, comparison) to be done?

A.4.4.2 Safety Specific Questions

[V3.Saf9.1] Have the safety benefits and constraints been assessed and refined, in all identified potential contexts of application? Are the synergies and trade-offs between all KPAs analysed?

[V3.Saf9.2] Have all major safety-related issues found during the assessments been adequately addressed, by modifying the concept and/or supporting technical enablers and validating the results?

[V3.Saf9.x] Is any more work needed to address major safety issues, (e.g. further safety assessments, to ensure all safety assumptions are valid)?

A.4.4.3 Safety Case Guidance

Based on safety analysis, which should as much as possible be supported by evidence, (e.g. real data from simulations, trials, related operations, equipment data) the minimum performance and functionality features associated to the logical architecture should show to be feasible by the system as built, under all expected normal and abnormal operational conditions in the potential context of use.

The safety requirements derived for each element of the logical architecture should not only have been shown to be adequate to ensure the safety of the overall system but also shown to be achievable in the implementation of the operational concept.

A.4.4.4 Human Factors Specific Questions

[V3.H9.1] Has the human contribution and impact been made explicit in all benefit and risk assessments and tradeoffs for all relevant KPAs and for all contexts of applications?

[V3.H9.2] Have all major people-related issues found during the assessments been adequately addressed, by modifying the concept and/or supporting technical enablers, with the results validated?

[V3.C9.x] Is any more work needed to assess and resolve any outstanding people-related issues?

A.4.4.5 Human Factors Case Guidance

The need is to ensure that all human issues related to concept success (the KPAs) have been addressed, and the results are acceptable.

A.4.4.6 Environment Case Guidance

During this phase of the project, information should be available to undertake a comprehensive quantitative assessment. The results of the individual assessments will need to be compared in a qualitative manner. E.g. noise results compared to emissions results. The assessment should build on assessments undertaken in earlier phases of the concept.

The results of the analysis should form part of the Environment Case. The case should document any issues identified and the resulting actions taken.

A.4.5 Business Case

A.4.5.1 Typical Generic Questions

[V3.C10.1] Is the Business Cases refined for representative stakeholder groups?

[V3.C10.2] Is the Business Case refined using the results of more detailed benefit and risk assessments as well as trade-off analysis between all relevant KPAs?

[V3.C10.3] Does the Business Case provide a complete comparison for all alternative operational concepts and supporting enablers across all criteria and representative stakeholder groups?

[V3.C10.4] Is the Business Case for the operational concept and supporting enabler(s) confirmed in an integrated and realistic environment?

[V3.C10.5] Is the affordability analysis refined and confirmed taking into account the benefit and cost refinements for representative stakeholder groups?

[V3.C10.x] Are there any additional analyses to be done?

A.4.5.2 Safety Specific Questions

[V3.Saf10.1&2] Has the Business Case been updated using the results of more detailed costs/benefits assessments for the different stakeholder groups?

[V3.Saf10.3] Are the operational concept and supporting enabler/s confirmed to be operable and acceptable to users in an integrated and realistic environment?

[V3.Saf10.x] Are there any additional analyses of safety contribution to costs and benefits required?

A.4.5.3 Safety Case Guidance

The elements identified in V2 will be refined based, now on more realistic results obtained from the simulations/ assessments and less on assumptions and expert judgment. The Safety Case may give input to a more realistic estimation of benefits/ costs of implementing the operational concept when all safety requirements are fulfilled.

A.4.5.4 Human Factors Specific questions

[V3.H10.1] Is the Business Case adequately refined to represent the interests of stakeholders directly affected by people-aspects of the concept, notably end users?

[V3.H10.2] Do the more detailed benefits and risks assessments in the refined Business Case reflect underlying analysis of people-related aspects comparable to the analysis of other aspects?

[V3.H10.x] Does the Business Case account for all human contributions to all relevant KPAs (in all contexts)?

A.4.5.5 Human Factors Case Guidance

The need is to ensure that the Business Case adequately represents the human component, (including appropriate weight for non-quantifiable people-related attributes) and that the concept will be operable and acceptable.

A.4.5.6 Business Specific Questions

[V3.B10.1] Verify that the identified scenario for developing the concept and the costs estimated and Net Present Value calculation were refined for representative stakeholder groups.

[V3.B10.2] The Business Case Report has to take into account results of more detailed benefits and risk assessments from relevant KPAs for the study and to be used in the contexts of applications. Is it possible to analyse and measure other cases impacts on the Business Case?

[V3.B10.3] The Report and the economic model (Influence Diagram) built should compare broadly all the alternative of the concepts and support enablers in terms of respective costs and benefits.

[V3.B10.4] After a full final analysis the financial metrics have to determined if the Business Case study for the OC and enablers is cost beneficial or not.

[V3.B10.5] What should be all the proposed sources of funding?

[V3.B10.X] The final report identifies additional opportunities or problems for the Business.

A.4.5.7 Business Case Guidance

Results have to show and demonstrate to representative stakeholder groups that implementation and operation are affordable. The Business Case report has to determine tangible results about the relationship between cases and the best possible scenario through mitigation actions. It also has identified and proposed all the possible sources of funding.

A.4.5.8 Environment Case Guidance

There are many stakeholder groups who may wish to be consulted on with regards to the environmental impacts of an ATM change. The environmental assessment and case should feed into the Business Case. Some form of environmental analysis should be undertaken for potentially feasible operational concepts to allow a valid environmental comparison.

Environmental impacts should be included in the affordability analysis. There are potential costs related to the Environment Case. For example - will additional insulation/double glazing need to be purchased for residents?

ANNEX 6: VALIDATION SUPPORT TO STANDARDISATION AND REGULATION – GUIDANCE MATERIAL

1 INTRODUCTION

1.1 Overview

This guidance material explains how the European Operational Concept Validation Methodology (E-OCVM) may support standardisation and regulatory (S&R) processes. The purpose of this guidance is to assist the R&D Community and validation practitioners in particular, to provide information needed by S&R bodies to develop standards and regulations to achieve full and timely implementation of a concept being validated. The guidance provides advice on how the three E-OCVM aspects (Concept Lifecycle Model, Case-Based Approach and Structured Planning Framework) should be applied to deliver information to meet the common S&R requirements and processes.

The **Concept Lifecycle Model (CLM)** provides a framework to express the maturity of the S&R for a concept element throughout the lifecycle. A description of the CLM phases in terms of S&R is given, covering the most important/relevant S&R activities, S&R needs and evidence that can be produced during each cycle.

The **Case-Based Approach (CBApp)** provides a formal interface to the S&R bodies. The CBApp provides justification material to support the development of regulations and standards: S&R Case Reports draw this information together. A description of how to build S&R Case Reports is given in these guidelines. This is followed by an explanation of how to apply the CBApp through application of the third aspect of the E-OCVM - the Structured Planning Framework (SPF).

The **Structured Planning Framework (SPF)** is the series of sub-steps that detail how to apply the E-OCVM to projects and exercises. The SPF provides guidance on how to generate evidence during the CLM V-phases. While the CLM captures the maturity of the S&R, the SPF is applied within each CLM phase to gather evidence to build the S&R Case.

The guidance material is for general use as part of E-OCVM Version 3.0. In addition, specific considerations relating to SESAR and the Single European Sky (SES) are identified.

1.2 Target Audience

The target audience for this guidance material is validation project team members and validation practitioners. The material therefore addresses the needs of this audience, i.e.:

- It simplifies otherwise complex S&R issues;
- It identifies how validation processes, inputs and outputs (with which the validation practitioner should be familiar) map to S&R processes, inputs and outputs;
- It enables validation practitioners to ‘apply’ the E-OCVM to S&R.

The material is not aimed at the S&R bodies as they are considered stakeholders and will not apply the material directly.

1.3 Standards

Standardisation is the process of developing and agreeing technical and operational standards. A standard (or “norm”) is a document that establishes uniform engineering or technical specifications, criteria, methods, processes, or practices. The following issues should be borne in mind:

- Formal standards initiation requires a certain level of maturity of both the operational concept and underlying technology;
- Standards are developed throughout the concept and technology development lifecycle;
- Draft standards can be produced within the R&D community prior to the formal initiation of standards development (e.g. to demonstrate the level of maturity);
- Draft standards need to be validated. The level of validation varies considerably and may rely solely on inspection by experts or involve detailed simulations or trials;
- The R&D community is traditionally involved in the preparation and acceptance of standards.

Validation teams will provide information for input to draft standards. This information will include contributions both to the content and the supporting evidence. Furthermore, the needs of the standardisation bodies for certain information must be reflected in the validation planning. Once a validated draft has been prepared, it can be proposed for formal endorsement by standardisation bodies.

There are many types of standards. For the purposes of these guidelines the terminology used in EUROCAE ED-78A (such as SPR and INTEROP standards) is used in the text. However, this is not intended to imply that these are the only standards that can be addressed, and these guidelines are applicable to all standards development.

1.4 Regulations

A regulation is a legal instrument to achieve a political objective. It may be that there is sufficient consensus or motivation for a concept that implementation goes forward voluntarily on the basis of standards only, without external intervention. On the other hand, it may be considered that implementation should be obligatory or that coordinated deployment is necessary to achieve feasibility, effectiveness and/or adequate return on investment: in these circumstances the typical solution is to apply regulation.

In general terms a regulation sets out:

- the service to be provided;
- the scope of applicability (in terms of aircraft, airspace etc);
- the performance target agreed with the stakeholders.

Regulations are developed when implementation is required. This means that regulations are only developed for mature concepts (i.e. those operational concepts that pass E-OCVM CLM V3 and beyond).

When developing regulations, regulators require clear evidence of assessment of the impact of the change. This is described in a Regulatory Impact Assessment for which standard approaches exist and will address the economic, safety, environmental and social implications of the proposed measure and the evidence for these claims. This evidence can be derived from the E-OCVM R&D validation cases, provided the R&D validation plans are appropriately designed. For example, the evidence should not be limited to a particular region. Consequently, the regulators have specific needs for evidence gathering that need to be reflected in the validation process.

1.5 Standardisation and Regulatory Bodies

Regulatory and standardisation activities have historically been based on:

- National legislation;
- International Civil Aviation Organisation (ICAO) standards and recommended practices, accompanied by appropriate guidance material for global application;

- Industry standards - produced on a voluntary basis of consensus within the industry by European Organisation for Civil Aviation Equipment (EUROCAE), RTCA (the American equivalent of EUROCAE) and the Airlines Electronic Engineering Committee (AEEC) amongst others.

Today, regulatory activities for European Air Traffic Management (ATM) are increasingly conducted in the context of Single European Sky (SES) legislation, which is established in accordance with the European Community framework for standards and regulation. Under this framework the European Commission establishes applicable rules and standards, mandating as appropriate suitably qualified organisations such as EUROCONTROL and EUROCAE to carry out their development and formal approval of standards through European Standards Organisations (ESOs). In addition the European Aviation Safety Agency (EASA) has been created by the EU and develops regulations and standards within the EU regulatory framework to support airworthiness; the EASA responsibilities will be extended to the safety of ATM and airports.

To support the technical evolution of the SES, the European Commission has established the Single European Sky ATM Research (SESAR) programme that will set the future regulatory and standardisation agenda within ATM and conduct the R&D necessary to provide the technical grounds for the new standards and rules.

Figure 23 summarises key organisations involved in European ATM standardisation and regulation and the current types of regulatory and standardisation material they produce.

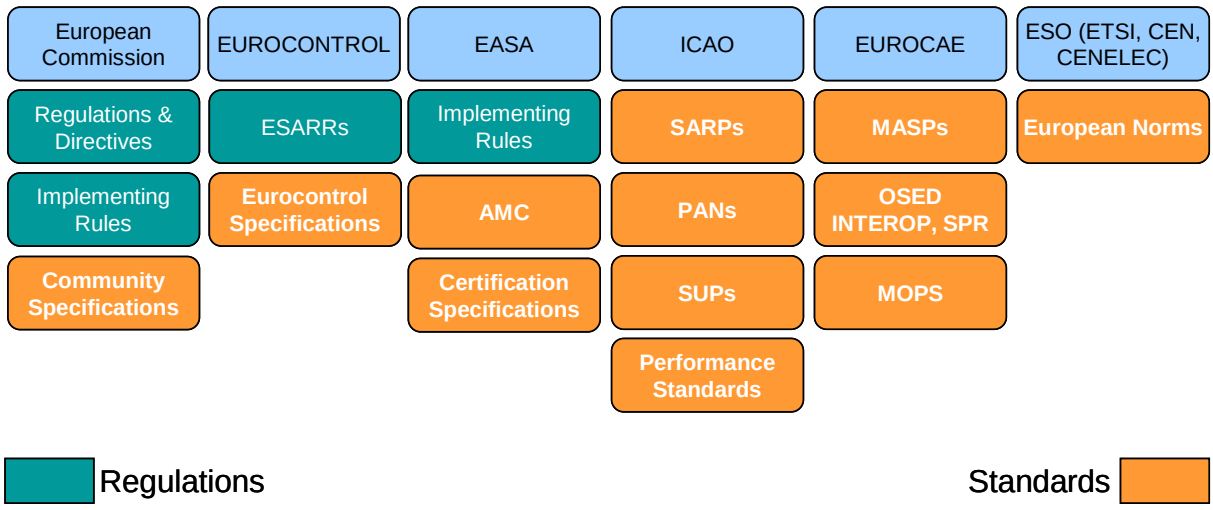

Figure 23 - S&R Bodies and material required

1.6 Standards and Regulation in SESAR, the SJU, the Single European Sky (SES) and the European Aviation Safety Agency (EASA)

Standardisation and Regulation are key elements of the approach followed in SESAR and the SES.

The SESAR approach to S&R is that R&D in SESAR will result in proposals issued by the SJU for standards (or “norms”) that can be put forward by SES for adoption by **standardisation bodies** and implemented directly by stakeholders on a voluntary basis or, if needed, be taken up by the **SES** as the basis for regulation.

SJU proposals for standards and norms will define uniform technical and operational specifications, procedures and practices, and aim at ensuring the interoperability of ATM

systems in Europe and at enhancing ATM capabilities in Europe (that is, safety, capacity, security, and environment).

Ideally stakeholders will implement standards directly but if regulation is necessary, this will be implemented through European Community Regulations and Directives, principally by Implementing Rules (IRs) associated with the Single European Sky (SES) Regulations.

The SES regulatory approach is performance based. Rules focus on "what" an ATM stakeholder must do and define the required level of service. The detail of “how” a particular solution (e.g. technology and/or procedure) will deliver the required performance are set out in standards called Community Specifications (CS) which draw together material (normally by reference) from other standards and indicate an acceptable means of compliance for the corresponding Implementing Rule.

Implementation may also be based on standalone Community Specifications and/or voluntary industry standards.

The SESAR ATM Master Plan (ATM-MP) will establish concrete planning for the development of standards, and this will give validation practitioners a better basis for preparing plans for collecting evidence. Of particular importance will be the chapter of the ATM-MP detailing the SESAR Standardisation Roadmap which will allow ATM stakeholders to anticipate and coordinate their efforts and to facilitate the adoption of SESAR technical proposals as standards and norms by the relevant standardisation bodies. The Standardisation Roadmap will be augmented by a detailed Standards Development Plan and supporting process, methods and tools.

The deployment phase of SESAR consists of a succession of three Implementation Packages (IPs) to put in place the proven Operational Improvements. The deployment of these IPs will be supported by the SES legal framework of Implementing Rules and Community Specifications. A Regulatory Roadmap will be developed for the ATM-MP to detail where regulation is expected to be used to support the IPs.

The Standardisation and Regulatory Roadmaps would also give indication of the timing at which information is required, providing inputs to the R&D schedule.

Standards and Regulations developed through SES may address air-ground, ground-ground and airborne segments of the operating environment. At the same time EASA is concerned with aviation safety, currently of the air-ground and airborne segments, and following EASA’s Total System philosophy, in the future extended to airports and ATM. Within the scope of these responsibilities, EASA is also developing regulations and means of compliance, applicable through the Community regulatory framework. Furthermore, EASA is also concerned with certain environmental issues, as are other EU agencies.

1.7 Practical Issues in Standardisation and Regulation

It is necessary to be realistic about the complexity facing R&D teams supporting S&R stakeholders, and to plan validation accordingly.

Since R&D may address **multiple S&R stakeholders**, their different needs and processes must be identified. In the context of SJU projects, validation practitioners should seek to understand the different demands and to build these into the validation plans.

In developing material for S&R stakeholders, R&D teams should consider the **approach to compliance** required for the concept element. For example, where SES follows a self-declarative approach (so-called “Global” or “New” Approach), a provider of a product may demonstrate compliance using their own standards or specifications where these are shown to be equivalent to requirements identified in the regulation being applied (such as in a Community Specification). Hence different sets of standards or specifications may, potentially, be used as compliance baselines for the same concept element for different implementations.

The range of standards relevant to a proposed concept element may be very wide and dependent on the S&R stakeholder. An Implementing Rule or Community Specification may call up a dozen or more interlinked and overlapping standards. These may be drafted by the R&D team or, in many cases, come from external sources. Standardisation and regulatory roadmaps will help to guide R&D teams in this complex picture, but in order to deliver effective validation proposals R&D teams will need to develop their understanding of relevant standards and rules as part of the concept element description.

The SES approach depends on acceptance by users of increased standardisation as the way to achieve performance improvement. However, and particularly at the stages V2, V3 and V4, it will be difficult for stakeholders to commit to particular technologies and there will in general be a reluctance to accept prescription of a single solution and a desire for many exemptions and special cases reflecting local and supplier preferences. It is **normal for several means of compliance to be acceptable** in order to subdivide a complex problem into smaller independent elements, to manage dependencies with external sources of requirements and to permit alternative solutions. This issue will be reinforced when developing regulatory material implying an eventual legal compliance obligation.

In these circumstances of an **uncertain baseline**, it will be difficult for R&D teams to obtain evidence on which to prepare case assessments, such as for cost-benefit assessment or the Business Case. The response of the R&D team must be to identify the confidence that can be placed in individual data, and to attempt to find a way to reflect this uncertainty in the results. Approaches to handling this type of risk vary, but may include modelling best, worst and most probable instances when producing evidence.

1.8 Identifying the Need for S&R at Project Level

During project preparation it is necessary is to identify the need for R&D to support regulation and/or standardisation. This will depend both on external inputs (e.g. the Standardisation Roadmap) and the project's own assessment of the need for formalisation to enable correct and timely implementation of concept elements and/or enablers. Thus a two-way approach should be adopted to identifying S&R needs, combining top-down programme-level assessment and the bottom-up project-level assessment. This task is addressed explicitly in the SPF (see Section 3.3.2.2 of this annex).

1.9 Standards and Regulations Case Reports

The E-OCVM describes how the Case-Based Approach (CBApp) provides key stakeholders with targeted information and how the Structured Planning Framework (SPF) is applied throughout the concept lifecycle in order to produce the 'evidence' required for cases.

S&R Case Reports are the deliverables from the E-OCVM S&R Case R&D.

The objective of the S&R Case Reports is to enable validation practitioners and project managers to ensure that their R&D activity will first, support standardisation bodies in developing and validating the required standards and secondly, will support regulators in drafting rules that govern the way the concept is implemented and the level of service it should deliver, and the supporting evidence for impact assessment. Much of the information that makes up S&R Case Reports is already produced in R&D projects and contributes to other E-OCVM cases. The S&R Case Reports takes this information and ensures it is available at the right time, and in the right format.

Although there are strong similarities between the information required by regulators and standardisation bodies there are also differences in terms of scope and timing. Considering the S&R Case Reports separately:

- **Standards Case Report** – concentrates on the technical details of the how a service is provided and may address one or more eventual candidate standards. The standards material matures with the concept in terms of scope, with technical detail

progressively available in the latter phases of the CLM. Depending on the type of standard (such as SPR, MOPS, INTEROP defined in EUROCAE ED-78A and for convenience used as the main reference in these guidelines), the Standards Case Report will contain information about:

- Principles of operation;
- Operational Services Description;
- Operational Requirements (including Interoperability Requirements);
- Safety and Performance Requirements;
- System Requirements (including functional and Quality of Service (QoS) requirements);
- System Description (Architecture);
- Equipment Specifications (hardware and interface requirements);

- In SESAR the **Standardisation Roadmap** will identify the overall anticipated standardisation needs and the Standardisation Case document lays down the need for one or more standards to deliver SESAR OI steps or enablers. A **Standards Development Plan** will provide a detailed plan for development of each new or updated candidate standard. The relevant **Standards Case Report** will progressively collect the R&D information needed to prepare candidate standards as foreseen in the Standardisation Case and Standards Development Plan, in preparation for formal initiation of development or update of one or more candidate standards.
- **Regulatory Case Report** – in support of a Regulatory Case this output concentrates on the costs and benefits (operational, environmental, safety and social) of a proposed service and may address one or more rules and associated standards. The Regulatory Case matures significantly with the operational concept. In the early phases, the Regulatory Case Report 'stores' the information that the S&R stakeholders can use to monitor the concept development and performance. In the latter phases the Regulatory Case Report is the justification material for a specific regulatory option. A Regulatory Case Report will typically include information on the following:
  - Interoperability and performance requirements;
  - Economic and environmental impact;
  - Safety requirements;
  - Quality of service requirements;
  - Assessment of the 'Acceptable Means of Compliance (AMC).
- In SESAR the three **Implementation Packages** will form the basis of a **Regulatory Roadmap** developed for the **ATM Master Plan**. Regulatory-related action will consist of analysing the need for regulation and then drafting appropriate legal instruments (IR, CS etc) for subsequent implementation as legal instruments by the SES. The **Regulatory Case Report** will progressively collect the information from R&D to feed these draft legal instruments and their supports such as Regulatory Impact Assessments.

Figure 24 illustrates the evolution of the content of Standards and Regulatory Case Reports throughout the E-OCVM CLM process. In V1 of the Concept Lifecycle Model, the emphasis is on supplying information about the concept design, while still providing some information on the likely performance of the concept. In later phases the emphasis shifts and by the time the concept is ready for implementation (and regulation), the need is primarily for evidence that the concept can deliver the required ATM performance.

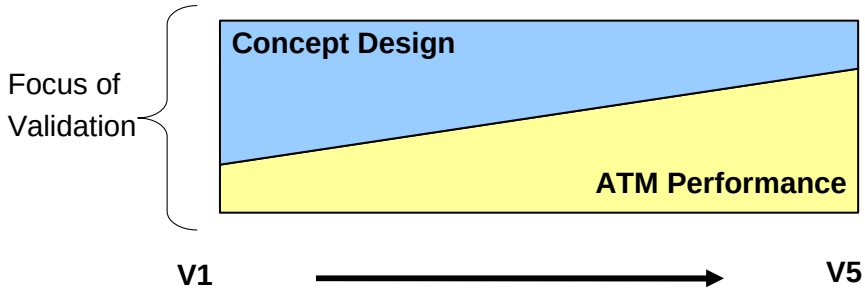

Figure 24 - Content of S&R Case throughout the E-OCVM Concept Lifecycle

2 S&R CASE AND CONCEPT MATURITY

2.1 Concept Lifecycle Model

Figure 25 shows the E-OCVM Concept Lifecycle Model. The E-OCVM focuses mainly on the R&D phases of V1, V2 and V3. However, this guidance material also recognises the important role of the Standards and Regulation Case in subsequent phases, considering V4 in some detail and acknowledging its role in V5 to V7.

Information for the Standards Case is mainly developed during V1 to V4. Information for the Regulatory Case is developed informally using information gathered during R&D stages V1 to V4 for use mainly in V4/V5.

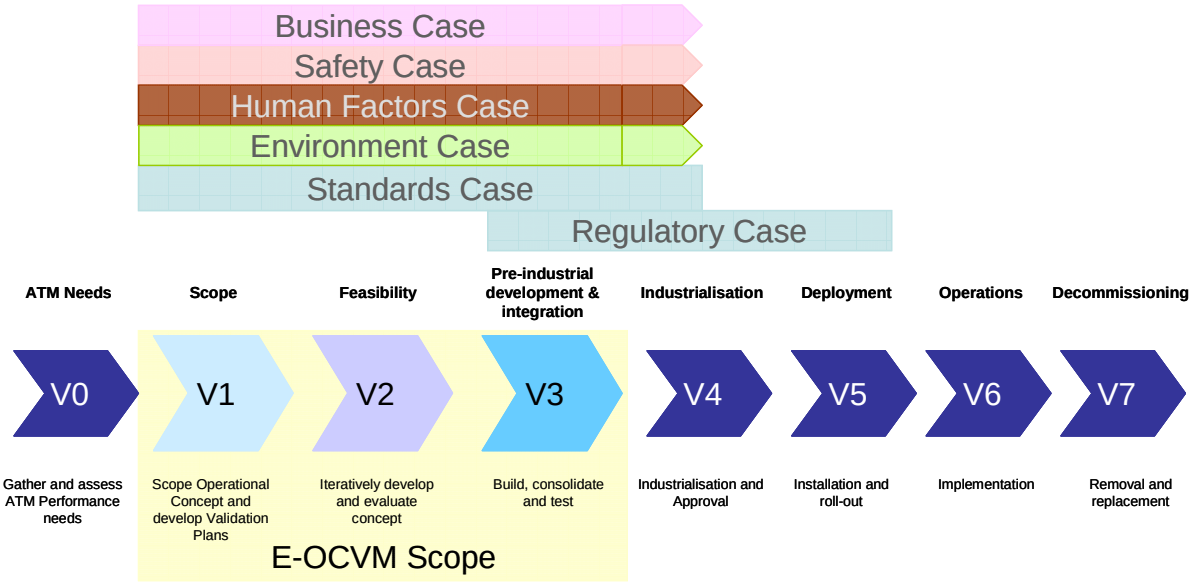

Figure 25: E-OCVM Concept Lifecycle Model, including SESAR CLM phases

2.2 Links between R&D and Standards and Regulations

The following artefacts are used to define the S&R and R&D activity for each CLM phase:

- Standardisation Roadmap – a top-down review of expected standardisation needs arising from different sources balancing those needs into one coherent view of what standards will be needed and by when. The Standardisation Roadmap will be a part of the SESAR ATM Master Plan;
- Standardisation Case – a document prepared at ATM Master Plan level identifying and justifying the need for one or more standards to achieve a particular SESAR OI step or enabler;
- Standards Development Plan – detailed description of the type and required development cycle of standards required for implementation of the concept, developed from the Standardisation Roadmap;
- Regulatory Requirement – statement of the required end state that may be enabled by regulation. The regulatory requirements for all elements of the SESAR ATM Master Plan make up the Regulatory Roadmap;
- Regulatory Evidence – evidence to support Regulatory Impact Assessment (RIA) and IR development;

- Implementing Rule (IR) – a regulation supporting the uniform implementation of a concept;
- Community Specification (CS) – a formal means of compliance to the proposed IR and/or a standalone standard for voluntary application;
- R&D Documents – the result of R&D into the concept element or enablers studied by the project. This will range from Principles of Operation to System Requirements and even Equipment Specifications.

In addition, OSED, SPR, INTEROP, MOPS and SARPS are included as the generic standards types that are most likely to be required. Additional types of standards material may also be identified.

2.3 Concept Maturity Criteria

Taking a concept from first idea to implementation will involve transition through different states of maturity corresponding to the transitions between V-stages in the CLM. The following table identifies the S&R issues that must have been addressed successfully as preconditions to progressing from one V-stage to the next, and can be used as a checklist by projects for S&R maturity assessment.

Transition	S&R-related Maturity Criteria
V0⇨V1	To reach the level of maturity for **V0->V1**, the project must have reviewed existing S&R material and gaps to understand any pre-existing regulatory or standardisation requirements relating to or driving **ATM Needs**. This will typically involve project contact with S&R stakeholders (e.g. through the Programme Manager).
V1⇨V2	To reach the level of maturity for **V1->V2**, the project must have reviewed any regulatory or standardisation requirements that affect the scope of their activity. To the extent that a **Standardisation Roadmap** exists, this will identify the potential need for new standards and hence the requirement for supporting material and evidence. Similarly, regulatory intentions expressed in a **Regulatory Roadmap**, where one exists, need to be reviewed and likely regulatory requirements and the need for supporting material and evidence understood. Together these will provide S&R input for the initial Validation Strategy.
V2⇨V3	To reach the level of maturity needed for **V2->V3**, the project must have taken account of standardisation and regulatory issues applicable to the operational concepts and enablers concerned and have developed material that will provide core content and evidence for envisioned future or updated Standards and Regulations supporting the operational concepts and enablers. At this stage the work will concentrate on the concepts and enablers being studied, rather than their relation to other concepts. The Standardisation Roadmap will have been reviewed to understand the expected need for new and updated Standards. The validity of this expected need will be reviewed in the light of the clarification of the operational concepts and enablers during the V2 activity. If necessary, the result of this analysis will be fed back to the Standardisation Roadmap WP manager to further inform the standardisation strategy. Regulatory expectations will also be reviewed to establish what deployment scenario is envisioned at this time, if any. If a vision has been developed based around regulation, account will be taken of the evidence that is expected to be needed when developing the validation plan. Generally, Standardisation and Regulatory needs may raise requirements for production of specific evidence or types of validation exercise which must be taken into account in the V2 validation plan. Validation exercises will have been conducted that mainly contribute to the **content** of the **Specifications** that will be used as the core of the future planned Standards, along with the supporting evidence. In particular preliminary OCD (e.g. OSED), SPR and interoperability (e.g. INTEROP) requirements will be prepared along with evidence justifying the results and the level of confidence. Furthermore, statements of requirement for development of more detailed Standards (e.g. MOPs, SARPs) may be prepared when expected to be needed (e.g. when described in the Standardisation Roadmap) so they can be allowed for in validation plans. The fulfilment of each criterion should be reviewed from the S&R perspective with reference to the Generic Analysis Criteria for Transitions presented in **E-OCVM V3 Vol 1, Section 9.4.** **Processes & procedures** Has the preliminary operational concept been developed to a sufficient level of maturity and justification to prepare a mature description (e.g. OSED)? Is there sufficient evidence to support this operational concept if taken forward to standardisation bodies? Does the preliminary operational concept align with the expectations of the Standardisation Roadmap or are different/additional standards required? **HMI** Are particular Standards implied by the HMI strategy and are these taken into account in the Standardisation Roadmap? **System** Have preliminary SPR & interoperability requirements been developed? Are there standardisation/ regulatory issues linked to the technical/ technology solution: for example, should the Standardisation Roadmap take account of additional Standards? **Transition** What are the implications of the transition issues/scenarios associated with the concept for S&R Roadmaps and is transition feasible? For example, should the Standardisation Roadmap take account of additional Standards? Should the Regulatory Roadmap take account of a scenario requiring coordinated deployment or will voluntary compliance be sufficient? **CBA** Do the preliminary economic assessments adequately answer the issues that must be addressed in a Regulatory Impact Assessment, and with what level of confidence? What do the assessments of the alternative solutions indicate: for example, one solution might lend itself to voluntary deployment based on standards whereas another might depend on a coordinated deployment based on a regulatory mechanism? The development, deployment, performance and compliance assurance costs of the scenarios should have been examined. Also, is there sufficient information to address a “Do Nothing” scenario? **Development and Validation Plan (planning level)** Have the development and validation plans adequately taken account of the expected needs for completion of S&R material and, if needed, for additional material?

Transition	S&R-related Maturity Criteria
V3⇨V4	To reach the level of maturity needed for **V3->V4**, the project must have taken account of standardisation and regulatory issues applicable to the operational concepts and enablers concerned. It must have developed material that will be sufficient to provide the justified and detailed content of envisioned future or updated Standards supporting the concepts and enablers. It must have developed material that will be sufficient to provide core content and evidence for envisioned Regulations. The work will have developed further the material relating to the concerned concepts and enablers drafted during V2, and will also have addressed issues relating to their coherent operation. The Standardisation Roadmap will be re-reviewed to check the expected need for new and updated Standards, and the inter-relation with other new or existing Standards. The validity of this expected need will be reviewed in the light of the clarification of the concept and enablers during the V3 activity. If necessary, the result of this analysis will be fed back to the Standardisation Roadmap to further inform the standardisation strategy. Regulatory expectations will also be re-reviewed to check what deployment scenario is envisioned at this time, if any. If a vision based on regulation has been developed, account will be taken of the evidence that is expected to be needed in the V3 validation plan. Any changes to Standardisation and Regulatory needs may have resulted in updated requirements for providing specific evidence or types of validation exercise in the V3 validation plan. *Validation exercises will be conducted that mainly contribute to the validation of the Specifications that will be used as the core of the future planned Standards, along with the supporting evidence. In particular detailed complete OCD (e.g. OSED), SPR and interoperability (INTEROP) requirements will be prepared along with evidence justifying the results and the level of confidence. Drafts of more detailed Standards (e.g. MOPs, SARPs) will be prepared when expected to be needed (e.g. when described in the Standardisation Roadmap).* Validation exercises will also have been conducted that contribute to the *content* of material that will be used in any Regulatory activity applicable to the operational improvement(s). This might include, for example, data for the Regulatory Impact Assessment. The fulfilment of each criterion should be reviewed from the S&R perspective with reference to the Generic Analysis Criteria for Transitions presented in E-OCVM V3 Vol 1, Section 9.4: **Processes & procedures** Does the operational concept description exist in a sufficient level of maturity, detail and justification for adoption by Standardisation bodies (e.g. fully-completed OSED)? Does the operational concept align with the expectations of the Standardisation Roadmap? **HMI** Are particular Standards implied by the HMI strategy and are these available with sufficient maturity, detail and justification for adoption by Standardisation bodies? **System** Have SPR & interoperability and other relevant requirements been developed in a sufficient level of maturity, detail and justification for adoption by Standardisation bodies (e.g. fully-completed SPR, INTEROP documents)? Do these requirements align with the expectations of the Standardisation Roadmap or are different/additional Standards required? **Transition** What are the implications of the transition issues/scenarios associated with the concept for S&R Roadmaps and is transition feasible? For example, what is the status of the required standards? Is the assessment material available to meet the needs of the regulatory scenario, if voluntary compliance is not deemed to be sufficient to assure deployment? **Integration** Have interoperability requirements been identified to a sufficient level of maturity, detail and justification, and knock-on effects assessed? If needed, has material been produced to develop or update Standards, and has this information needs to be taken into account in the Standardisation Roadmap? **CBA** Do the economic assessments adequately answer the issues that must be addressed in a Regulatory Impact Assessment, and with what level of confidence?
V4⇨V5	To reach the level of maturity needed for **V4->V5**, significant S&R activity must have taken place. While V4 (Industrialisation) is, however, beyond the scope of R&D, the R&D S&R results are now exploited fully. The Standards Case developed for required standards identified as necessary within the Standards Development Plan and relevant SoWs will be transformed into *Specifications.* The applicable *Specifications* are then reviewed, approved and published as Standards by the ATM community (e.g. through ESOs). 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 (IR) 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 which comply with all applicable technical/operational specifications and standards as mandated by applicable regulatory/legislative provisions related to system Deployment and Operations.
V5⇨V6	The transition **V5->V6** does not require R&D activity to have taken place. However, monitoring of operations should be conducted ensure that the published S&R material is adequate to ensure the long term stability of the operation. This monitoring is likely to require reuse of R&D facilities.
V6⇨V7	This transition is not relevant to R&D.

3 S&R CASE REPORT METHODOLOGY

3.1 Introduction

This section provides guidance on the methodology for how the three aspects of E-OCVM (CLM, SPF and CBApp) can be integrated to provide support to S&R bodies. The way in which the aspects integrate is as follows:

- The CLM is the main aspect, taking the concept from idea to industrialisation and beyond;
- The steps of the SPF are applied at least once during each phase of the CLM;
- The CBApp is achieved through applying the steps of the SPF during each phase of the CLM, building up a body of evidence as the concept matures.

The following sections describe how the S&R Case is built through application of the Concept Lifecycle Model and the Structured Planning Framework.

3.2 S&R Case-Based Approach

The CBApp initially required stakeholders to state their expectations of the required end-state for the concept's performance. In S&R terms this means identifying the expected standardisation and regulatory requirement. This expectation should not be expected to be static and the project may also identify a need for standardisation or regulation to propose to stakeholders. The CBApp takes these expectations (as Case-Based Information Requirements) and uses R&D processes to gather results which are delivered to meet these expectations. Decisions to progress are then based on the information supplied.

As standards are developed during the R&D process, many people are involved in the development lifecycle, the validation process and the standardisation process. The CBApp should support the development of standards by ensuring evidence is packaged for the working groups of the standardisation bodies.

Similarly, the CBApp should support the collation and packaging of evidence to support teams drafting regulatory material on behalf of regulatory bodies.

3.3 Building S&R Case Reports with R&D Information by Applying the CLM

Figure 26 shows the use of R&D information being used to produce S&R outputs for S&R stakeholders. R&D validation activity will produce the "Information Required" for S&R Case-building in project Validation Reports. Different classes of information will be produced, for example addressing Principles of Operations, System, Safety and Performance Requirements. The information becomes available progressively as the concept matures through the V-stages.

Most **information required for standardisation** is provided in the earlier phases (in V0 to V3, and particularly V2-V3), emphasising the link between the R&D process and the standards development process. The need for standardisation-related information by the S&R Stakeholders is expressed through the Standardisation Roadmap and Standards Development Plan. The actual information required by the S&R Stakeholders – the draft principles of operation, operational services descriptions, safety and performance requirements, system description/architecture – is output that the R&D process generates, and constitutes the Standards Case Report. The Standards Case Report can be used to build the drafts for one or more standards identified by the Standardisation Case and Standards Development Plan (the "S&R Output") for proposal to the S&R Stakeholders who would ultimately endorse the SESAR output.

The **information required for regulation** is not required by the S&R Stakeholders until the concept is more mature (mostly V4 onwards) and after the main R&D phases (V2-V3). The Regulatory Roadmap will give information on the likely regulatory approach and schedule. Regulations are based around standards, and therefore much of the information required at the time of regulatory activity is incorporated in the standards produced as a result of work in V0 to V3. However, standards-specific information would typically need to be supplemented by specific information to constitute evidence to support justification for regulation and the impact assessment. This may place additional requirements on the R&D activity, particularly during V2 and V3[13]. The resulting combination of information ("Regulatory Case Report") can be provided by SESAR R&D projects to help the "S&R Stakeholders" draft regulatory material ("the S&R Output") at the appropriate V-phase (V4 and V5).

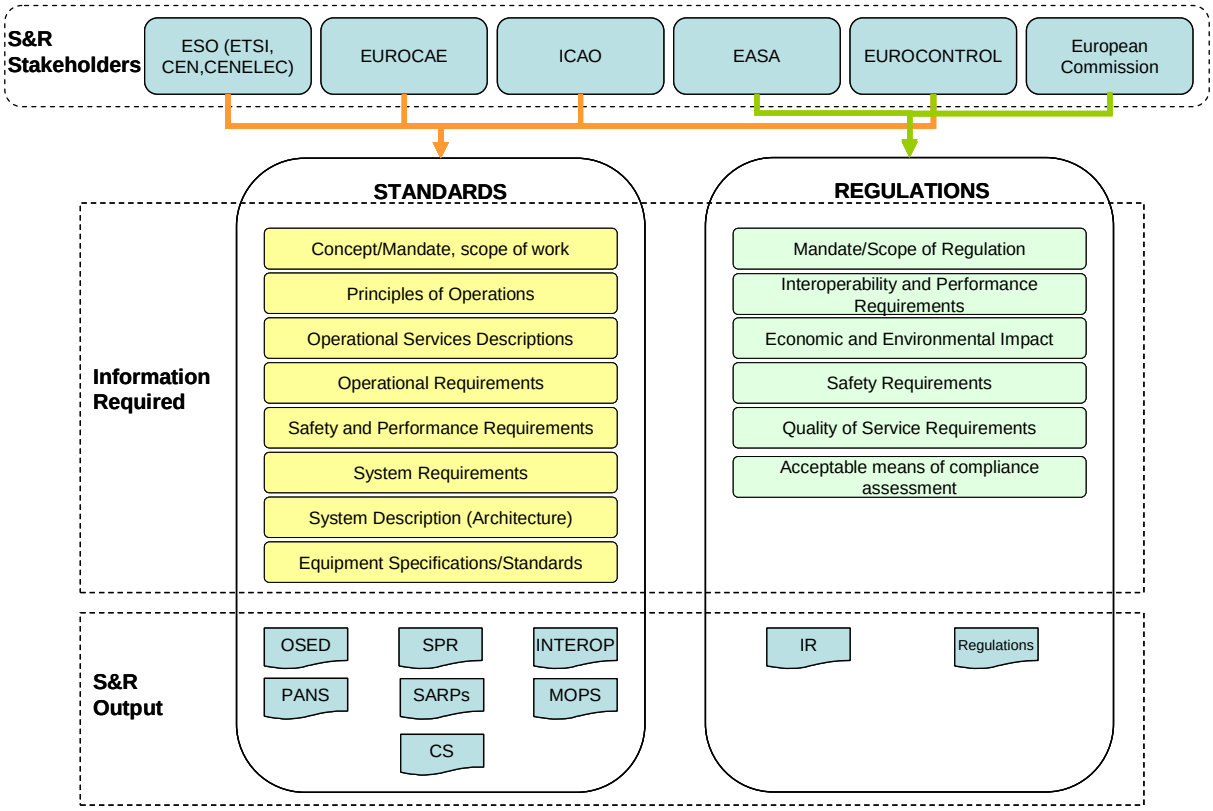

Figure 26 - Common S&R Information Requirements and Outputs

The links between the CLM and Standards and between the CLM and Regulations can be further simplified into the following separate overviews.

CLM and Standards

Figure 27 illustrates the links between the phases of the CLM and the information requirements for developing standards, with most links during V1 to V4.

The E-OCVM states that early stages of development should concentrate on scope and operability, before moving onto performance and technical requirements. The process for developing standards is no different.

[13] For example, regulatory impact assessment will need to look at the impact of different traffic mixes on the effectiveness of an operational improvement.

The standards process begins with the generation of operational information (Principles of Operation, OSEDs, Operational Requirements) in V1 to V3. Once this information starts to become available, the Operational, Safety and Performance Information (SPR) should be provided to the stakeholders. The SPR work can begin in V1 as initial drafts and continues through to V4 to cover the pre-operational system. As the concept matures, the Interoperability Requirements can be extracted (mainly V2 to V4) before the process focuses on Technical Performance. The technical performance information requirements include the system requirements, system architecture descriptions and equipment specifications and standards. Typically this is the last set of information required for standards and can be addressed during V3 and V4.

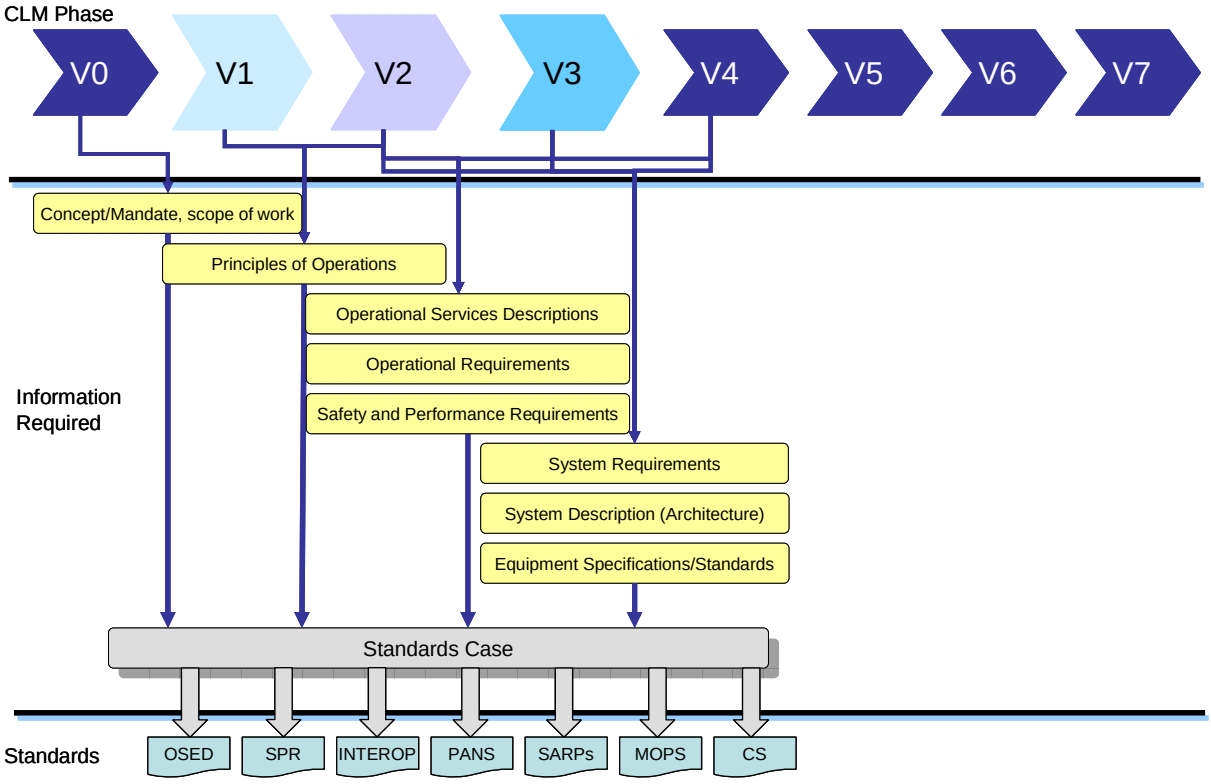

Figure 27: CLM and Standards

As can be seen in **Figure 27** although the requirements basically follow the CLM, overlap between the phases can exist. For example, a draft OSED will allow the SPR to be initiated, or the Interoperability Requirements and Equipment Specification may be worked on in parallel.

Figure 27 also shows that the process is iterative (through the CLM) and that the majority of the information required for all aspects of the Standards Case should be delivered prior to V5.

3.3.1 CLM and Regulation

Figure 28 illustrates the links between the phases of the CLM and the information requirements for building a Regulatory Case, with the major outputs in V4 and V5.

Despite regulations being developed for mature concepts only, it is important that the information that will ultimately be required for the Regulatory Case is gathered throughout the concept lifecycle.

Much of the information required for regulations is the same as the information required for standards (operational performance, Safety, Interoperability, etc) but with a specific

emphasis on benefit of implementation in terms of performance improvement. It is this sharing of information that provides a clear link between the E-OCVM S&R processes.

The first major difference is that while the standards development process develops and uses this information along the CLM, the regulations process only begins to use it in V4 and beyond. Therefore it is important that R&D is designed and planned with these later requirements in mind.

The other main difference is that regulations are traditionally developed by a separate community to the R&D community. The ATM Master Planning process will play a key role avoiding any gap between the people responsible for developing standards and those who develop regulations, and to ensure the information gathered is suitable for both parties.

As with the process for standards, there may be overlap between the types of information required and the CLM phases.

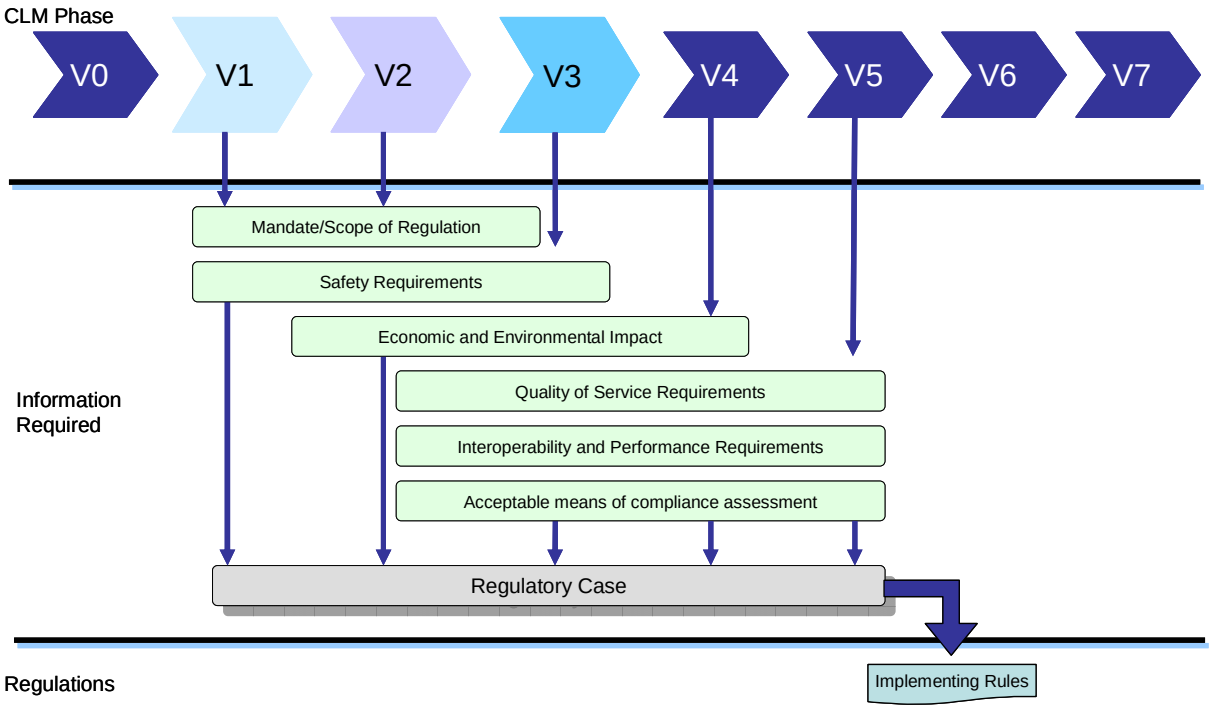

Figure 28: CLM and Regulation

3.4 Building S&R Case Reports through Application of the Structured Planning Framework

The S&R Case is built through repeated application of the SPF. The SPF is applied one or more times at each V-stage of the CLM. As explained in Section 3.3 much of the required R&D information is gathered at the earlier V-stages, particularly V2 and V3.

This section provides guidance on applying the SPF to the Standards and Regulations Case. It should be used in conjunction with the main E-OCVM Structured Planning Framework guidance material.

The material does not provide guidance on how to develop the S&R themselves. Guidance on this topic is available elsewhere and applies to the S&R bodies more than the validation practitioners who are the target evidence for this guidance.

Validation practitioners, in consultation with the programme bodies which are themselves in contact with S&R organisations, review the information currently contained in R&D documents. They then plan a validation process to generate more information for the R&D documents. These documents are used by the S&R stakeholders to complete their own key

outputs. It is not the role of the validation practitioner to draft S&R documents. The role of validation (through the larger R&D process) is to supply the correct information in the correct format.

3.3.2 Step 0 – State Concepts and Assumptions

3.3.2.1 Sub-step 0.1 - Understand the problem

The project should initially identify where the need for or lack of standards and/or regulations may be a factor, cause or driver behind an ATM problem or an ATM performance need. Key sources for this information are the Standardisation and Regulatory Roadmaps, but other sources should be considered. An example could be the lack of suitable S&R leading to interoperability issues.

3.3.2.2 Sub-step – 0.2 – Understand the proposed solutions

The purpose of this sub-step is for the validation practitioner to gain an understanding of the proposed solutions and their potential impact on S&R. The project should identify where there is a need for regulation and/or standardisation at the project level, so that the practitioner can plan a validation process that contributes successfully to S&R development.

For this activity the project will use information produced by the concept developers, R&D and the S&R bodies. The project will have to critically analyse this information to develop its own view of the S&R to which it may contribute or on which it may depend. The S&R Roadmaps associated with the ATM Master Plan will provide critical information to ensure that this is an efficient process, and the project may also feed information back to the Roadmaps.

Issues to consider at project level include:

- Standardisation and regulatory path foreseen in the Roadmaps relating to the particular performance objectives and operational improvement to which the project relates;
- Existence of existing relevant standards and/or regulations. These will have to be applied in the R&D activity, but they may need revision or replacement to achieve the performance improvement foreseen;
- Gaps in existing standards and/or regulations identifiable from consideration of the proposed solutions and comparison with the Roadmaps;
- Potential clustering of S&R needs amongst projects. Coordination with other projects will be needed in order to understand where they are carrying out R&D that addresses related S&R needs. The goal should be a coordinated approach to developing appropriate material;
- Analysis by the project of the concept element or enabler that indicates S&R will most likely be needed to realise a feasible solution. For example, domain specialists working on the project may identify that a particular technology is the most effective technical approach;
- Consensus through a bottom-up process may more efficient than a top-down process in identifying the best approach to standardising an element of a solution.

This analysis of the solutions in terms of S&R will enable the project to define the typology and rough content of standards and regulations for which they will have to support development. Different types of standard require specific considerations. For example, standards for operational procedures or services, interoperability standards and "simple" equipment specifications have different needs for information.

This will enable identification of the information that will have to be captured in the 'R&D documents' (that record the concept description and concept performance produced by R&D). **Figure 29** shows how these different 'R&D documents' (Principles of Operation etc.) map to an example of the typical S&R outputs (OSED etc.) that will be used by the S&R bodies.

	OSED	SPR	INTEROP	SARPs	MOPS
Principles of Operation	X	X	x	x	
Operational Services Description	X	X	x		
Safety and Performance Requirements	X	X			x
Operational Requirements	X			x	
System Description (Architecture)	X	X	x	x	x
System Requirements			x	x	x
Equipment Specifications/Standards				x	x

Figure 29: Mapping of R&D Documents to S&R outputs

The validation practitioner should use this analysis to develop a list of open S&R issues (or update the list if it can be carried over from earlier V-stages).

3.3.3 Step 1 – Set Validation Strategy

3.3.3.1 Sub-step 1.1 - Identify the Stakeholders, their needs and involvement

Identify Stakeholders

The S&R stakeholders to involve may change depending on the concept itself and the maturity of the concept. Typically Standardisation bodies are involved earlier than Regulatory bodies. **Figure 23** of this guidance material listed the main S&R bodies. It is likely that the S&R stakeholders involved in the programme will come from those shown in the diagram and the validation practitioner should become familiar with each of them and their roles.

Stakeholder expectations

The E-OCVM addresses Concept Objectives and Concept Concerns. The S&R stakeholders' objectives and concerns will depend on the level of maturity of the solution and where it is in the concept lifecycle. At the beginning of the lifecycle, they will require information on the concept scope and design. Their expectations will then develop according to the maturity and ultimately be focused on provision of concept performance information.

Exact Information Needs

All the above information is used to derive a list of exact information needs for the validation process. The information needs should summarise:

- The open issues the S&R stakeholders require answered at this E-OCVM phase;
- When this information is required;
- Information non-S&R stakeholders require to be able to understand the impact of S&R on their work.

From this point onwards, the validation strategy will be designed around meeting these stakeholder information needs.

3.3.3.2 Sub-step 1.2 – Identify the Current and Target Levels of Maturity

Current Level of Maturity

The current **level of maturity** is a measure of what CLM phase the solution is currently at, in terms of what information exists about the concept and what the S&R bodies have been able to produce. A framework for assessing the current level of maturity through **transition criteria** (with regard to S&R issues) was provided in Section 2.3.

Target Level of Maturity

Work in Sub-Step 1.1 to establish Stakeholder Expectations will give the validation practitioner information the target level of maturity sought for the concept improvement. Most likely, this will be expressed in terms of the information required by the S&R stakeholders at the end of the project, and the validation practitioner will need to use the approach in Section 2.3 to identify deliverables.

3.3.3.3 Sub-step 1.3 Describe Validation Objectives

The Validation Objectives for S&R will describe what information will be delivered during the validation process, when it will be delivered, what format and what "R&D concept" document or description it will feed into. Collectively these will contribute to the S&R Case-Based Information Requirements.

The formulation of these objectives will in general follow the pattern shown in **Figure 24** of these guidelines – a focus on concept description and technical design issues in the early V-phases, followed by performance information in later stages.

3.3.3.4 Sub-step 1.4 Identify Concept Performance Objectives in KPAs, KPIs and High-Level Indicators and Metrics

This step is not applicable to the S&R Case.

3.3.3.5 Sub-step 1.5 – Establish Validation Requirements

The validation practitioner should analyse each of the Programme S&R Validation Objectives and identify what is required in order to address them. The output of this analysis will be a prioritised list of S&R Validation Requirements with an identified means of gathering the specified information.

No specific tool types or techniques are identified specifically for gathering S&R information: the validation practitioner will find it necessary to select from the full range of techniques applicable to all cases.

3.3.3.6 Sub-step 1.6 – Define Validation Work Plan

At this stage, the set of validation exercises identified in Sub-Step 1.5 are integrated and if necessary prioritised based on the overall context of programme or project constraints and all case requirements.

The compatibility of the resulting Work Plan with the S&R Roadmaps must be reviewed. The Work Plan development should consider the content of the Roadmaps: the timing, information needs and activities specified in it. In turn, the Roadmaps should be ready to receive updates from the Validation Work Plan to reflect feasibility and prioritisation choices.

3.3.3.7 Sub-step 1.7 – Define Validation Strategy

This step is the consolidation of the results of Sub-Steps 1.1-1.6 for all cases.

3.3.4 Step 2 – Determine Exercise Needs

3.3.4.1 Sub-step 2.1 - Identify Stakeholder Acceptance Criteria

The purpose of this Sub-Step is to identify what the S&R Stakeholders will consider an acceptable outcome *for each exercise dealing with S&R.*

The validation practitioner should consult the S&R stakeholders again to discuss acceptance criteria and performance requirements for the exercise. Practically this would involve input from S&R experts in the programme, contact with the S&R organisations or use of guidance produced by these entities.

In early phases of the CLM the focus is on concept design and operability rather than on performance. Therefore it is likely that in V1 and V2 (there are not usually any concept

validation exercises in V0) the Stakeholder S&R Acceptance Criteria for validation exercises in V1 and V2 will probably be information based. The role of the validation practitioner is to work with the S&R stakeholders to understand what information in particular this exercise *must* provide, bearing in mind that there may be other validation exercises addressing S&R information needs.

In later phases of the CLM (V3 and V4) the focus turns more to performance assessment. The Stakeholder S&R Acceptance Criteria for validation exercises in V3 and V4 are likely to be information based *and* performance based.

3.3.4.2 Sub-step 2.2 – Identify Project and Exercise Validation Objectives

As described in the main E-OCVM SPF description.

3.3.4.3 Sub-step 2.3 – Refine Validation Strategy

As described in the main E-OCVM SPF description.

3.3.4.4 Sub-step 2.4 – Identify Indicators and Metrics

As described in the main E-OCVM SPF description.

3.3.4.5 Sub-step 2.5 – Specify Validation Scenarios

In early phases of the CLM the S&R stakeholders expect information related to concept design and operability. They need information in concept description documents (e.g. principles of operation) in order to have information to use in S&R outputs (e.g. OSED). Therefore validation scenarios should be designed to test the concept design and help elicit and establish requirements for the concept design. In later phases the focus is on assessing the performance of the concept so validation scenarios will be designed accordingly. By V4 and beyond, concept design and performance should be mature and so validation scenarios should help elicit and test technical requirements and functional requirements to assist the S&R stakeholders with V4 tasks such as completing SARPs and MOPs.

3.3.4.6 Sub-step 2.6 – Produce the Validation Exercise Plan

As described in the main E-OCVM SPF description.

3.3.4.7 Sub-step 2.7 – Prepare the Platform or Facility

As described in the main E-OCVM SPF description.

3.3.4.8 Sub-step 2.8 – Conduct Pre-exercise Testing and Training

As described in the main E-OCVM SPF description.

Step 3 – Conduct the Exercise

3.3.4.9 Sub-step 3.1 – Conduct the Validation Exercise

As described in the main E-OCVM SPF description.

3.3.4.10 Sub-step 3.2 – Assess Unexpected Results or Behaviours

As described in the main E-OCVM SPF description. Within the specific context of S&R, the assessment for unexpected results could entail the rejection of certain standards or procedures or highlight the need for previously unforeseen standards and regulations.

3.3.5 Step 4 – Determine Results

3.3.5.1 Sub-step 4.1 – Perform Analysis as Specified in the Analysis Specification

As described in the main E-OCVM SPF description.

3.3.5.2 Sub-step 4.2 – Prepare Analysis Contributions

The structure of the S&R Case-Based **analysis contribution** will be based on the S&R Case-Based **information requirements**.

An S&R Case-Based analysis contribution should provide feedback on the concept design and technical issues, thus contributing to the advancing maturity of the operational concept. It should also inform the stakeholders how the concept performed, thus giving an indication of the concept's fitness-for-purpose. This information will contribute to the R&D concept documents described in Sub-Step 0.2 for compilation and dissemination to the S&R stakeholders, leading to the production of draft standards and regulatory material.

3.3.5.3 Sub-step 4.3 – Prepare and Review Validation Report

As described in the main E-OCVM SPF description.

3.3.6 Step 5 – Disseminate Information to Stakeholders

3.3.6.1 Sub-step 5.1 – Disseminate information for stakeholders and decision makers' review

The purpose of this Sub-Step is to compile the S&R Case-Based Analysis Contributions at key project milestones (at least at the end of each phase in the CLM) and disseminate this information to the S&R stakeholders in the S&R Case Reports.

Using a CBApp to prepare the Analysis Contributions should make the compilation at this stage easier. As stated in Sub-Step 4.2, the structure of the S&R Case-Based Analysis Contribution will depend on the S&R Case-Based Information Requirements. Since the information requirements were based on what information was required in the R&D concept documents, the analysis contributions should provide information in a format suitable to fill the open gaps in the R&D concept documents.

To disseminate the information, the validation practitioner should first develop or update the R&D concept documents. When the R&D concept documents have been updated they can be disseminated to the S&R stakeholders in the S&R Case Reports. This 'processing' of results ensures the S&R stakeholders only receive information that is relevant to them.

3.3.6.2 Sub-step 5.2 – Draw conclusions and decide on actions/feedback

The purpose of this Sub-Step is to use the validation results to decide on feedback into the Case-Based Information Requirements and/or Validation Strategy. The process to follow for this Sub-Step is the same as described in the E-OCVM.

The S&R stakeholders will have received information in Sub-Step 5.1. The final task in the SPF is for the validation practitioner to assess if this information has met the Stakeholders' S&R Needs and S&R Case-Based Information Requirements by taking feedback from the S&R Stakeholders.

If some information needs have not been addressed, then these must be addressed in subsequent phases of the validation activity. If all needs are met, then no further action is necessary and the validation process is complete.

4 INTERACTION WITH OTHER CASES

The S&R Case will have strong interactions with the other cases, since much of the information needed to support the elements of the S&R Case will be based on that provided for the Business, Environment, Human Factors and Safety Cases. They will share information requirements and the Validation Strategy will address more than one case in a given validation exercise. The validation exercises then produce a common pool of information based on all the requirements.

The interactions can be summarised as follows:

Business. There will be two main interactions between the business and S&R Cases. First, the Business Case must reflect specific costs or requirements arising from S&R, such as the cost of compliance and compliance monitoring. Conversely, the S&R Case should take account of the assumptions or trade-offs made in the Business Case, such as the minimum equipage levels necessary for cost effectiveness.

Environment. The S&R Case must take account of the conclusions reached in the Environment Case concerning environmental requirements, and embed these conclusions in the S&R proposals. For example, the Environment Case may identify requirements for airspace design around airports to mitigate noise or emissions that must be included in a regulation set up to implement the corresponding concept element.

Human Factors. Human factors requirements may arise that need to be taken into account in the S&R Case. For example, the Human Factors Case may identify minimum standards for operating or building equipment that are an integral part of a successfully-validated concept element.

Safety. Safety requirements are key parts of standards and regulations. In the ED-78A model used in this guidance, there are specific safety standards (SPR). In the regulatory material, maintenance or improvement of safety will have to be justified and safety requirements will be expressed.

In addition to these links to the cases established in E-OCVM, the S&R Case will draw on material from the **systems engineering** stream. Validation and verification R&D work will produce draft content for standards and evidence justifying the content. This should be maintained and brought together when building the S&R Case to provide integrated information for the S&R stakeholders.

5 STRUCTURE AND CONTENTS OF S&R CASE REPORTS

5.1 Standardisation Case Report

The **Standardisation Case Report** is the key deliverable of R&D in support of the **Standardisation Case**. The objective of the **Standardisation Case Report** will be to accumulate and present the results of R&D up to the V-stage reached so far by the R&D activity. The Standardisation Case Report will evolve as the R&D proceeds through the V-stages of the CLM.

In SESAR the Standardisation Case Report will draw heavily on the Standardisation Roadmap as expressed through the **Standardisation Case** and **Standards Development Plans** produced in the context of the ATM Master Plan. The Standardisation Case Report will respond to the need for Standards-related information identified in these documents, but will also review the identified need and, if appropriate, propose modifications of the statement of need. The Standardisation Case Report should be usable as a basis for a *Specification* to be proposed by the SJU to the SES.

The Standardisation Case Report will in no way be a replacement for the formal work of the standards bodies, but it is intended to provide an accumulation of the R&D information that will be reused by them as part of their processes.

Typically a Standardisation Case Report will be needed for each standard proposed by the Roadmap, whether new or updated.

The following provides an outline template for a Standardisation Case Report:

1. Introduction

This should explain the context of the Standardisation Case Report, the nature of the standard it concerns, why this standard is needed, what it shows and a summary of the conclusions and recommendations. The Report may address the modification of an existing standard, as well as the creation of a new standard.

It should also include any recommendations concerning the future R&D and standards development process for this standard. It should also detail any recommendations for changes to the relevant Standardisation Case arising from the R&D activity.

2. Need for the Proposed Standard

This should address the following, based on the relevant Standardisation Roadmap, Case and Standards Development Plan where these exist:

- Description of the objective and scope of proposed new or modified standard;
- The requirement (i.e. Standardisation Case/Standards Development Plan (if they exist)) which the Standardisation Case Report addresses;
- How the Standardisation Case Report addresses the requirement (i.e. Standardisation Case/Standards Development Plan (if they exist));
- Deviations from the requirement (Standardisation Case/Standards Development Plan (if they exist));
- Relationship of the standard to achieving OI Steps;
- Role of standard in meeting performance parameters in the performance framework;
- Expected benefits of the standard.

Supplementary information may also be provided on the standard(s) body(-ies) likely to be concerned; the typology of the standards document (e.g. Safety, Performance,

Interoperability etc.); the segment(s) to which the standard applies (air-ground, ground-ground, airspace etc.) and to which actors; scope of requirements for the standard (e.g. monitoring) and any recommended method(s) for drafting requirements; exception cases to be considered specifically.

It is also important to capture the dependencies of the proposed standard on other standards and regulations. New dependencies may have evolved or appeared during the R&D activity.

3. Summary of R&D Conducted

A summary of the R&D activity on which the Standardisation Case Report is based should be provided, addressing at least:

- Summary of the validation plan, particularly identification of standard-related objectives;
- Description of the operational and technical environment on which the validation work was based, to provide the context for the standards developers;
- Description of the scenarios applied;
- Analysis of alternative approaches examined, possibly supplementing the initial analysis made in the Standardisation Roadmap;
- Summary of R&D information gathered and used in the draft standards;
- Summary of open issues, problem areas, ideas on the implementation scenario and applicability of the proposed standard, impact of non-implementation of the proposed standard etc.

4. Evidence

Description of how evidence was gathered

This section will summarise the validation strategy followed to collect the data, including a description of the exercises carried out, the operational and technical environment employed, the scenarios used, exercise participants and other relevant information.

Justification of why the evidence is reliable

This section will present the argument as to why the evidence is likely to be correct. Attention should be paid to demonstrating the justification of key items in the evidence.

Presentation of evidence

This section will present draft proposed standard material.

This material will be based on the R&D information gathered during the validation work. Largely this will consist of the R&D information annexed to the Report. However, so far as possible the format followed should be appropriate to the type of standard for which material will be used: for example guidance in ED-78A will be of help for OSED, Safety, Performance and Interoperability standards. However, it is clear that the focus is on providing the technical results and not on presentation exactly as would be in the final published version of a standard.

The justification for each requirement in the proposed standard should be identified, so that when the R&D material is taken forward for approval by a standards body, it can be validated.

The R&D information presented may be incomplete. This will be true particularly in the earlier V-stages. Such gaps should be identified as a reminder for R&D in later V-stages.

Uncertainties, risks and unexpected effects

Any parts of the R&D information being presented that are subject to some doubt should be identified and the reasons explained. Such weaknesses might subsequently be resolved through repeated or modified experiments in the same or other projects: at this stage it is sufficient to identify the problems recognised.

Limitations

Any limitations identified during the R&D information being presented must be expressed. Such limitations may arise from the scope or conception of the exercises conducted, the exercise tools used, the results gathered or the analysis conducted. This helps to assess the validity of the results.

5.2 Regulatory Case Report

The **Regulatory Case Report** will be the key deliverable of the R&D in support of the **Regulatory Case**. The Regulation Case does not require the same level of development as the Standardisation Case during the R&D V-stages, V2 and V3: it is only required later in the E-OCVM CLM and the detailed regulatory approach will not be decided until a point during the later stages of V4 or early in V5. The Regulatory Roadmap will be defined at a higher level than the Standardisation Roadmap, and hence there will be less detail available to guide the validation practitioner on the specific needs for the Regulatory Case Report.

Nevertheless, the Regulatory Case Report should be developed where regulation is foreseen within the Regulatory Roadmap.

When an IR is drafted, it has to be accompanied by a variety of supporting information including justification, impact assessment and means of compliance material.

Regulatory requirements for evidence will have had an impact on the stakeholder needs captured for the validation planning (e.g. whether local/regional scenarios should be studied in exercises; what level of equipage is necessary for the benefits to be realised).

The Regulatory Case Report should address the following:

1. Introduction

This should explain the context of the Regulatory Case Report and refer to where the Regulatory Roadmap raises the likely need for regulation. It should give an overview of the R&D material presented and describe how it addresses the expected regulatory need.

The document should also include any recommendations concerning the future R&D and regulatory process for this standard, such as where additional R&D is expected to be required.

2. Need for the Proposed Regulation

This section should describe the validation team's understanding of the need for the regulation. Partly this will come from the Regulatory Roadmap but will also be supplemented by conclusions drawn from the R&D activity.

3. Summary of R&D Conducted

This section contains a summary of the R&D activity on which the Regulatory Case Report is based, addressing at least:

- Summary of the validation plan;
- Description of the operational and technical environment on which the validation work was based, to provide the context for the regulation drafting team;
- Description of the scenarios applied;
- Analysis of alternative approaches examined;
- Summary of R&D information gathered and used in the Report;
- Summary of open issues, problem areas, ideas on the implementation scenario and applicability of the proposed standard, impact of non-implementation of the proposed regulation etc.

4. Evidence

This section should present a summary of the evidence gathered that, it is expected, will support the preparation of regulatory material. Largely this will consist of a reference to the Standards Case Report material (see Section 5.1), since any new regulation will largely be based on the newly draft standards.

5. Outline Impact Assessment

This section will start to build a draft of the information for an Impact Assessment that would be needed to support the regulatory proposal. Essentially it must be shown that the new regulation is safe, cost-effective and not environmentally damaging prior to its approval.

Even at the early V-stages, first information on the impact assessment of a proposed regulation should be provided as it becomes available. The aim is to identification at an early point the gaps in the available information and to redirect R&D accordingly.

Guidance on impact assessment development is included in the Annex material addressing the Business Case Guidance (Annex 5, Section 4).

6 STANDARDS AND REGULATION GLOSSARY

The following terms are given in this document and are in addition to the terms used in the main E-OCVM.

STANDARD: A standard is a document that establishes uniform engineering or technical specifications, criteria, methods, processes, or practices.

STANDARDISATION: Standardisation is the process of developing and agreeing upon technical and operational standards.

STANDARDS AND REGULATIONS CASE: The S&R Case is used to enable the S&R bodies to assess and ensure that a concept is being developed in the right way (i.e. to certain agreed standards), to enable standardisation bodies to develop and validate the relevant standards and to enable the regulators to define rules (Implementing Rules) that govern the way the concept is implemented and the level of service it should deliver.

R&D CONCEPT DOCUMENTS: The set of documents containing information needed to build as input to the S&R Case. These include Principles of Operation, Operational Service Description, Safety and Performance Requirements and Equipment Specifications. They are developed during the E-OCVM R&D validation process.

REGULATION: A regulation is a legal instrument to achieve a political objective. In terms of European ATM, a regulation refers to European Commission (EC) Regulations and Directives, principally the Single European Sky (SES) Regulations and associated Implementing Rules (IRs).

S&R OUTPUT: The set of documents needed by standardisation and regulatory bodies for standards and regulations. These include OSEDs, SPR, INTEROP, MOPS, CS. They are developed from the information in the R&D Concept Documents.