



# SESAR Human Performance Assessment Process V1 to V3 - including VLD

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# PJ19 CI

## HUMAN PERFORMANCE GUIDELINE

This Guidance Material for Human Performance is part of the SESAR Joint Undertaking methodology, developed in SESAR I and adapted for SESAR 2020.



### Abstract

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# 1 Executive Summary

---

The Human Performance (HP) assessment process serves to ensure that HP aspects are systematically identified and considered in the SESAR operational and technological developments. This document is the main guidance for applying the HP assessment process to **SESAR Solutions for the validation phases V1, V2 and V3 (and V3+/VLD<sup>1</sup>) as well as TRL2, TRL4 and TRL6.**

The HP assessment process is compatible with the approach outlined in the E-OCVM [2]. In this document, the guidance provided is applicable to all validation phases of Research and Development covered by SESAR (i.e. V1 to V3 including ).

HP is one of six Transversal Areas (TAs) included in the development of a Business Case; the other five being Security, Safety, Environment, Cost-Benefit Assessment and Performance. The relationship between HP and the other TAs is described in the present document.

The SESAR HP assessment process uses an ‘argument’ and ‘evidence’ approach. An HP argument is a ‘HP claim that needs to be proven’. The aim of the HP assessment is to provide the necessary ‘evidence’ to show that the HP arguments impacted have been considered and satisfied by the HP assessment process. This includes the identification of HP recommendations and requirements to support the design and development of the concept.

The SESAR HP assessment process consists of four steps, which are: (1) Understand the ATM concept, (2) Understand the HP implications, (3) Improve and validate the concept, and (4) Collate findings and conclude on transition to next V-phase. For each step, objectives, tasks, required input and expected output are described. The description also outlines the link with other SESAR documentation (e.g. SPR-INTEROP/OSED, Validation Plan and Validation Report), in terms of SESAR documents needed as input, and SESAR documents to which each step of the HP assessment process will contribute.

In addition, the support material (namely, the HP argument structure, the HP Log spread sheet, HP assessment plan template and HP assessment report template plus transition questions for finalising the HP assessment process for a given V-phase) is provided

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<sup>1</sup> All V3 related activities are applicable for V3+ and VLD phases)

## 2 Introduction

### 2.1 Purpose of the Document

This document is the main guidance for managing the HP assessment process in the SESAR Solutions that are in phase V1, V2 or V3 (or TRL2, TRL4 or TRL6). Due to the generic nature of the guidance, the document may also be used when conducting HP assessments in ATM developments outside of or following SESAR and in VLDs.

Throughout the document, it will be assumed that a SESAR Solution that applies the present guidance takes into account its specificities related to its given V phase. Moreover, for Solutions in V2 or V3, it is assumed that the Solution has already carried out an HP assessment in the previous phase.

### 2.2 Intended readership

This document is aimed mainly at HP practitioners in SESAR Solutions as well as the project managers of these Solutions. The HP practitioner will ask operational experts and system engineers to participate in certain workshops, interviews, surveys and simulations etc. Therefore operational experts and system engineers might find the document helpful to understand the processes that they are asked to go through.

### 2.3 Acronyms and Terminology

| Term                | Definition                                                                                     |
|---------------------|------------------------------------------------------------------------------------------------|
| <b>A-SMGCS</b>      | Advanced Surface Movement Guidance and Control Systems                                         |
| <b>AIM</b>          | Assessing the Impact of Automation on Mental Workload (Questionnaire for workload measurement) |
| <b>ASAS S&amp;M</b> | <i>Airborne Separation Assistance System Spacing and Manoeuvre</i>                             |
| <b>ATM</b>          | Air Traffic Management                                                                         |
| <b>BC</b>           | Business Case                                                                                  |
| <b>BM</b>           | Benefit Mechanism                                                                              |
| <b>CPDLC</b>        | Controller Pilot Data-link Communication                                                       |
| <b>CTA</b>          | Cognitive Task Analysis                                                                        |
| <b>DMAN</b>         | Departure Manager                                                                              |
| <b>DOD</b>          | Detailed Operational Description                                                               |
| <b>E-ATMS</b>       | European Air Traffic Management System                                                         |
| <b>EGPWS</b>        | Enhance Ground Protection and Warning System                                                   |
| <b>E-OCVM</b>       | European Operational Concept Validation Methodology                                            |

|                         |                                                                                                          |
|-------------------------|----------------------------------------------------------------------------------------------------------|
| <b>HF</b>               | Human Factors                                                                                            |
| <b>HP</b>               | Human Performance                                                                                        |
| <b>HRA</b>              | Human Reliability Analysis                                                                               |
| <b>KPA</b>              | Key Performance Area                                                                                     |
| <b>NASA TLX</b>         | NASA Task Load Index (Questionnaire for workload measurement)                                            |
| <b>SPR-INTEROP/OSED</b> | Safety and Performance Requirements - Interoperability / Operational Service and Environment Description |
| <b>PIR</b>              | Project Initiation Report                                                                                |
| <b>RNAV</b>             | aRea NAVigation                                                                                          |
| <b>RTS</b>              | Real-Time Simulation                                                                                     |
| <b>SA</b>               | Situational Awareness                                                                                    |
| <b>SESAR</b>            | Single European Sky ATM Research Programme                                                               |
| <b>SJU</b>              | SESAR Joint Undertaking (Agency of the European Commission)                                              |
| <b>SME</b>              | Subject Matter Expert                                                                                    |
| <b>TA</b>               | Transversal Area                                                                                         |
| <b>TS/IRS</b>           | Technical Specification / Interface Requirement Specification                                            |
| <b>V-phase</b>          | Validation phase                                                                                         |
| <b>VALP</b>             | Validation Plan                                                                                          |
| <b>VALR</b>             | Validation Report                                                                                        |
| <b>VLD</b>              | Very Large Demonstration                                                                                 |

## 3 The HP Assessment process in SESAR: General Principles & V Phases Specifics

---

Human Performance (HP) is used to denote the human capability to successfully accomplish tasks and meet job requirements. The capability of a human to successfully accomplish tasks depends on a number of variables that are usually investigated within the discipline of “Human Factors (HF)”. These are: procedure and task design, design of technical systems and tools, the physical work environment, individual competences and training background as well as recruitment and staffing. HP also depends on the way in which Social Factors and issues related to Change & Transition are managed. Therefore, adequate considerations of HF and HP in all phases of development and implementation are critical to reach the objectives of SESAR, in terms of achieving the benefits related to the KPAs.

### 3.1 Objectives of the HP assessment process

The purpose of the HP assessment process is to provide assurance that that HP aspects related to SESAR technical and operational developments are systematically identified and managed; all the actions necessary to provide adequate confidence that a product, a service or a system is compatible with human capabilities are conducted.

To achieve this, the HP assessment process:

- describes arguments and necessary evidence to show that airborne and ground ATM actors will contribute to the SESAR expected performance benefits;
- describes arguments and necessary evidence to show that the roles, responsibilities and tasks of airborne and ground ATM actors as developed in SESAR are within the scope of human capabilities and limitations;
- defines the process to ensure HP proactively contributes to building the operational concept and system architecture and describes how results from HP activities should be used in the development process, with the aim of improving the concept and technology;
- defines HP transition criteria for progression from one V-phase to the next V-phase;
- has a clear link with validation by (a) providing an input to the validation plan and (b) using the results of the validation activities in support of the HP arguments;
- is aligned with the other Transversal Area (TA) assessment processes, by (a) using a shared description of the reference, the solution and the assumptions and (b) by identifying overlaps and synergies between HP and other TAs;
- defines interactions and uses synergies with the other TA assessment processes, in particular, the safety assessment process;
- provides data that can feed the SESAR Business Case.

HP assessment processes may be conducted in any V-phase. However, the scope of the SESAR HP assessment processes is the SESAR V-phases (V1-V3).

The HP assessment process provides output on two levels: (a) HP assessments to be used at the level of SESAR Solutions (and possible integration of several solutions) and SESAR Projects or similar; (b) HP cases at the level of solutions and projects that are identified to have significant concept interactions.

## 3.2 The HP assessment process in the SESAR Solutions and Solutions Integration

Applying the HP assessment process to a SESAR Solution and documenting the results of its application yields an HP assessment. The HP assessment process at the Solution level is managed by dedicated HP specialists. The resulting HP assessment can be used as input to the iterative development in the SESAR Solution.

SESAR I had 16.06.05 project that served as HP support and coordination function across SESAR projects and Transversal Areas. Research methodology pertaining to HP was designed by 16.04.03/16.06.05 project members. The current document has been updated and aligned to SESAR2020 principles. The reference material is to be consulted when performing an HP assessment.

The management of the HP assessment process at the level of the SESAR Solution is described in Section 3 of this document.

## 3.3 The HP assessment process and the HP case

HP assessments for SESAR Solutions and Projects will be combined into HP cases which will be done between solutions and/or projects that are identified to have significant concept interactions.

The HP specialists managing the HP assessment process at the level of Solutions shall (a) make the HP assessment available for combination into an HP case, and (b) contribute, if necessary, to the HP case building.

The management of the HP assessment process for HP case building is described in a separate document [1].

At the level of SESAR, the aggregation is done in the context of PAGAR [13], together with all other transversal areas, on the basis of the information available in the PAR (Part V of the SPR-INTEROP/OSED) [14] for each solution.

## 3.4 Relationship with other TA assessment processes

Six TAs are targeted in SESAR2020: Safety, security, cost-benefit assessment, environment, performance and HP. These areas are related to the key objectives of SESAR and are potentially relevant for any SESAR2020 projects.

The assessments in a given TA are consolidated in order to feed the results in the Content Integration process corresponding to PJ19.04. In order to coordinate the exchange between the SESAR TAs and operational and technical development, the consolidated results from different TAs are combined in a Consolidated Performance Assessment Report that will feed into the Business Case.

Making the HP Case available as a basis for the Consolidated Performance Assessment Report is the responsibility of HP Champion in PJ19.4, in coordination with the HP experts responsible for the corresponding solutions/projects.

The relationships between the HP assessment process and the building of the HP Case that would eventually feed into the Consolidated Performance Assessment Report (PJ19.04) together with the results from other TAs is exemplified in Figure 1.

SESAR2020 HP Assessment Methodology/ HP Case

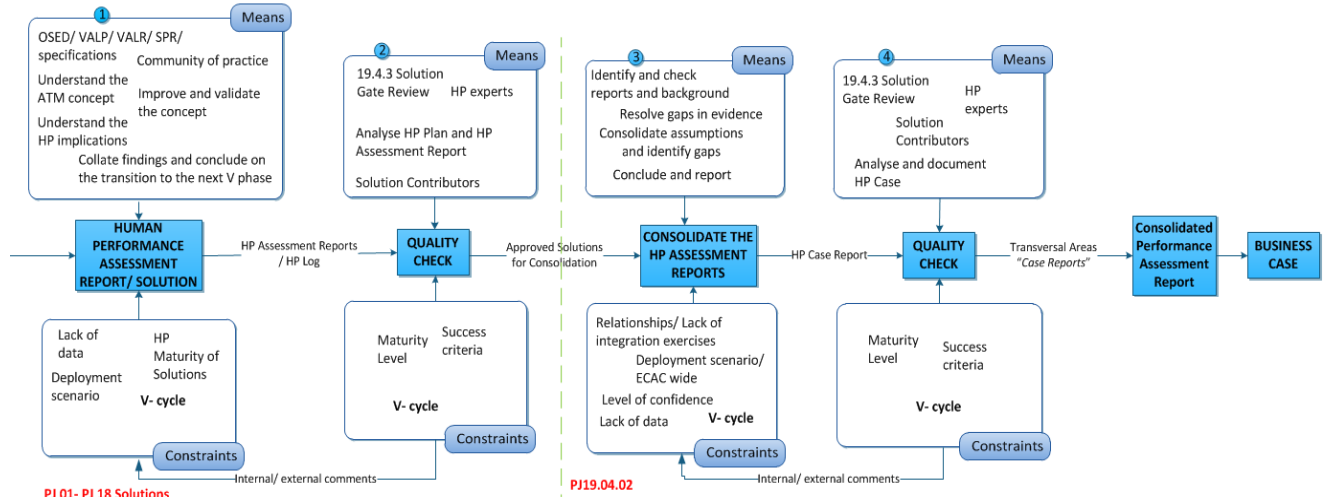


Figure 1: HP Case Building

## 3.5 Relationship between the three V-phases and Very Large Demonstrations (VLDs)

### 3.5.1 The SESAR V-phases

SESAR operational and technical development is structured in three V-phases (V1-V3), in line with E-OCVM [2]:

- **V1 – Scope.** Identifies the operational and technical solutions for meeting the target performance identified in the pre R&D needs phase (V0).
- **V2 – Feasibility.** Develops and explores the individual concept elements and supporting enablers until the retained concept(s) can be considered operationally feasible or it can be established that further development is no longer justified.
- **V3 – Pre-industrial development and integration.** (a) Develops and refines operational concepts and supporting enablers to prepare their transition from research to an operational environment, (b) validates that all concurrently developed concepts and supporting enablers can work coherently together and are capable of delivering the required benefits, and (c) establishes that the concurrent packages can be integrated into the target ATM system.

An additional V-phase – V3+ has been included to support VLDs. It should be noted that it is not officially part of E-OCVM structure.

The V-phases serve to structure development both at the level of Solutions and at the level of the HP Case.

A given V-phase is concluded by establishing, through a maturity assessment, that the lifecycle transition criteria for the given V-phase are satisfied. Details on HP transition criteria are provided as part of the description of Step 4 in the HP assessment process.

### 3.5.2 Details on V1 as defined by E-OCVM

This section provides an outline of the concept development activities that are normally carried out by a Solution in V1.

For a Solution, to be in V1 means that:

- The major ATM problems and needs have been identified and performance targets and strategic objectives have been defined (i.e. activities that are part of the pre R&D V0 needs phase have been carried out and the related documentation is available);
- The Solution has not yet reached V2 (i.e. activities that are part of V1 have not or not completely been carried out and the according documentation is not or not fully available).

According to E-OCVM [2] the main objective of V1 is to identify the operational and technical solutions for meeting the target performance benefits identified in phase V0.

The proposed operational concept(s) and associated technical characteristics should be defined in sufficient level of detail to enable the identification of potential benefit mechanisms and initial cost mechanisms (order of magnitude) to justify subsequent R&D. The initial development and documentation of the concept, together with the ATM problems, needs and targets from V0, make up the principal input to the operational concept validation process.

The focus of the validation activity at this stage is on developing the concept and broadly showing that it can alleviate barriers and enhance ATM performance to the required level [2].

V1 delivers the initial operational concept (CONOPS, high-level SPR-INTEROP/OSED), the initial logical system architecture (specifying the required system functionality independent of the actual implementation) and the initial Business Case.

The typical activities in V1 are:

- **Initial definition of the operational concept:** This is an iterative and major activity in V1. The concept is elaborated through a strong interaction between the operational concept development activities and the concept validation activities. At the end of V1, the operational concept should be defined at a level of detail which allows the development of the benefit and cost mechanisms and the identification of major R&D needs. The major concept options can be defined at this stage to allow planning of relevant validation activities to be conducted in V2.
- **Definition of initial logical system architecture:** The logical system architecture presents the design of the system independently from any physical implementation. It links the operational concept to the services and functions to be provided. The change in the current logical architecture should be identified at a level of detail which allows the development of the benefit and cost mechanisms and the identification of major R&D needs.
- **Definition of benefit and cost mechanism:** The benefit mechanisms should identify KPAs for which benefits are expected, provide the rationale for the proposed change and link the benefits to the relevant ATM problems/needs, performance targets and strategic objectives identified in V0. The cost mechanism should identify potential procurement (including R&D), implementation and operation costs. At this stage, an order of magnitude is sufficient to allow an initial justification. Potential benefits and costs are provided for representative stakeholder groups and intended context(s) of use. Alternative concepts that address the same (or similar) ATM needs are identified.

- **Identification of R&D Needs:** 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.
- **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 provides the principles and priorities to organise the work of validation. In large programs, the overall program validation strategy may be complemented by sub-activity validation strategies. The work planning applies the principles of the relevant validation strategy to identify a sequence of validation activities (e.g. exercises) that will progress the maturity of the concept to achieve the validation objectives.

### 3.5.3 Details on V2 as defined by E-OCVM

This section provides an outline of the concept development activities that are normally carried out by a Solution in V2.

For a Solution, to be in V2 means that:

- The gate between V1 and V2 is already overcome (i.e. activities that are part of V1 have been carried out and the according documentation is available);
- The Solution has not yet reached V3 (i.e. activities that are part of V2 have not or not completely been carried out and the according documentation is not or not fully available).

According to E-OCVM [2] the main objectives of V2 are to develop and explore the individual concept and supporting enablers until it can be considered feasible. In order to elaborate the concepts/enablers and to demonstrate feasibility, this phase is heavily based on modelling and simulation (fast and real-time) and may include some initial prototyping. Performance, operability and the acceptability of operational aspects should be the primary validation concerns. This includes stabilising operational procedures and requirements and thoroughly testing the HMI together with operating procedures and phraseology.

The typical activities in V2 are:

- **Elaboration & validation of the operational concept:** This is a major and iterative activity in V2. 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 technical feasibility assessment (research prototype):** If the concept has a new technical enabler or one that is 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 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. The assessment in V2 shall include the necessary identification of the further needs for Regulation/Legislation (V2/V3).

- **Preliminary benefits and risks 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.
- **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.

### 3.5.4 Details on V3 as defined by E-OCVM

This section provides an outline of the concept development activities that are normally carried out by a Solution in V3.

According to E-OCVM [2] the objectives of V3 are threefold:

- (1) Firstly, to further develop and refine operational concepts and supporting enablers to prepare their transition from research to an operational environment;
- (2) 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; and
- (3) Thirdly, to establish that the concurrent packages can be integrated into the target ATM system.

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

At this stage the operational concept descriptions, applicable operational scenarios, operational procedures, benefit mechanisms, illustrative human-machine interfaces etc. should be stable and documented to a level which will support transfer to industry.

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 and industrialisation.

The typical activities conducted in V3 are:

- **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.
- **Technical specifications and feasibility assessments** (pre-industrial prototype, technical specifications ready for possible standardisations): 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.

- **Transition feasibility assessment:** Transition feasibility assessment is completed in case of impact coming from operational and technical refinements made during this phase
- **Benefits and risks assessment:** The benefit 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 may be quantified.
- **Final Research Business Case:** The intermediate Business Case is refined using the results from validation for all relevant KPAs and other decision-making criteria. The Cost Benefit Analysis and the affordability to stakeholders are also refined. Supporting local Business Cases for representative contexts of use and stakeholders are developed.

### 3.5.5 Details on V3+ as defined by SESAR 2020 Programme Execution Guidance

V3+ phase is technically not part of the E-OCVM structure. The phase has been introduced by SJU specifically to support Very Large Scale Demonstrations (VLDs). An alternative industry maturity assessment framework based on the NASA Technology Readiness Levels (TRLs) is used by SJU to communicate its achievements externally. Compared to the E-OCVM, this framework provides a finer granularity which allows VLD activities to be placed at the crossroads of Validation and Refinement (TRLs 7). In E-OCVM terms VLDs would then be a transition from the Industrial Research & Validation and the Industrialisation/ Deployment and would lie at the border of V3 and V4 (see Appendix C).

Very Large Scale Demonstrations are designed to help bridge the gap between the development and deployment phases and not to replace either type of activity; they aim at assessing the benefits of a SESAR solution.

It should be noted, however, that not every SESAR Solution will be validated in a VLD. At the same time not every VLD will be a natural evolution of Solutions or Projects even though there might be a significant overlap in concepts and approach with the latter.

### 3.5.6 Characteristics of the HP assessment process in V1

In line with the E-OCVM description of typical V1 activities, the HP assessment process for V1 primarily focuses on defining the initial operational concept from an HP point of view.

In particular in V1, the following design/validation activities are supposed to be carried out to investigate and iteratively refine the operational concept(s) options [2].

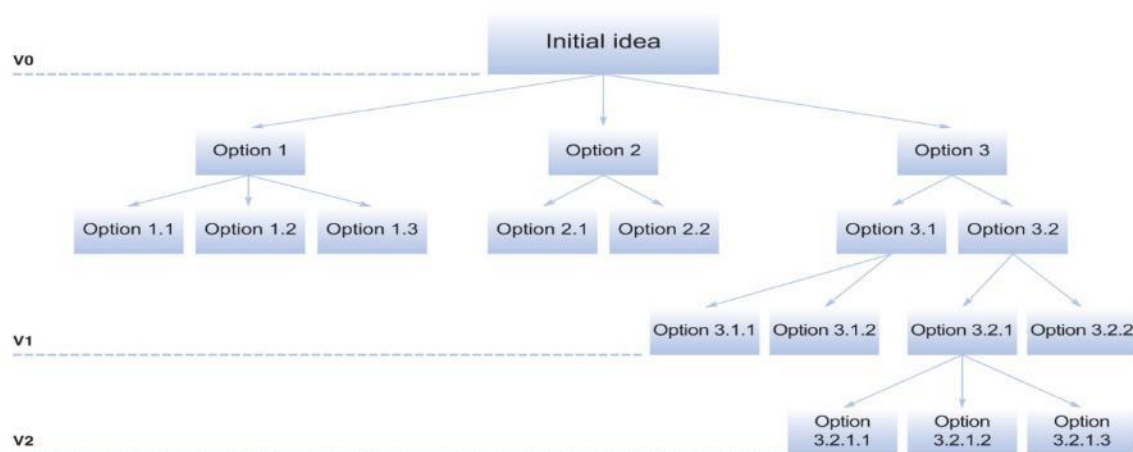
- Develop descriptive models of the human component.
- Make explicit the roles, tasks, constraints and needs of the human actors impacted by the operational concept and how their performance contributes to the system.
- Support the development of the initial operational concept and system architecture
- Identify side effects that could compromise human performance and reveal show stoppers.
- Influence emergent design ideas based on preliminary Human Performance assessment.
- Relate human-centred models to other system models so as to ensure coherence

The iterative V1 process results in the definition of an operational concept that is mature enough to be prototyped and tested at the V2 level. The process carried out at V1 necessarily includes the exploration of different alternatives and the identification of show-stoppers. The HP assessment process is guided by the HP specialist, involves all the stakeholders and requires as a pre-requisite strong cooperation with other actors of the process in particular, operational concept designers and systems designers.

The HP assessment in V1 is based on the application of concept design and evaluation techniques that allow a collective and rapid exploration of the concept. For concept design specific guidance on allocation of levels of automation or the definition of information requirements may be used. For concept exploration, depending on the domain, techniques such as focus groups, HP issue analysis, task analysis<sup>2</sup>, initial use cases, gaming techniques, review of low fidelity prototypes/mock-ups, storytelling etc. can be used.

Figure 2 below provides a schematic representation of the process of concept definition and evaluation carried out at V1. The diagram represents the wide range of design options that can be explored in order to pass from the initial idea to an operational concept that is mature enough to be considered in V2. Ideally all the options should be investigated in order to evaluate the benefits and costs of each one and avoid effects of tunnel vision. Certain design options may be excluded due to 'show-stoppers' identified during the HP assessment process (i.e. problems in concept validity, acceptability and/or feasibility) or because they are found to be less beneficial and appealing for the stakeholders in comparison with other options.

At this stage defining, comparing and contrasting several proposed design options should increase the chances of finding the most effective solutions to the ATM problem.



<sup>2</sup> In V1 a detailed task analysis of the reference scenario is often necessary to fully understand existing tasks and constraints and to enable an HP specialist to support decisions relating to function allocation/automation.

**Figure 2: Schematic representation of the wide range of potential design options that can be explored in V1.**

The following topics are central for an HP assessment in V1:

- *Roles, responsibilities, operating methods and human tasks* (cf. Argument 1 – Appendix A): the application of the HP assessment process for V1 will ensure that the preliminary description of the roles & responsibilities likely to be impacted by the change is clear and non-contradictory and contains all affected actors, and; where appropriate, ensure that initial requirements for operating methods are defined and support the human in carrying out their tasks.
- *Technical support systems and Human-Machine Interface* (cf. Argument 2 – Appendix A): the application of the HP assessment process for V1 will support an appropriate allocation of tasks between the human and the machine (i.e. automation level) and; where appropriate, ensure that the initial design requirements for the human-machine interface are defined and support the human actors in carrying out their tasks.
- *Team structures and team communication* (cf. Argument 3 – Appendix A): the application of the HP assessment process for V1 will ensure that potential effects on the team composition are identified; that initial requirements to ensure an appropriate allocation of tasks between human actors are identified; and that the initial requirements relating to communication between team members are identified and support the human in carrying out their tasks.

Although the actual transition to the proposed concept will only happen in V5, transition issues may be potential ‘show stoppers’ and may impact the operational concept. For this reason, certain HP related aspects of the operational concept that may become impediments for the transition at a later stage will be already identified in V1. Potential issues for the transition will be addressed within the following argument topic:

- *Potential transition factors* (cf. Argument 4– Appendix A): the application of the HP assessment process for V1 will ensure that there is a preliminary identification of factors that need to be considered relating to acceptance and job satisfaction, changes in competence requirements and impact on staff levels and where appropriate that initial needs/requirements relating to such transition factors are identified.

In contrast, the HP assessment process for V1 will not cover any questions related to the specific local implementation of the ATM concept. Thus, specific work place design issues – such as workplace (e.g. OPS room/ flight deck) layout or illumination, noise temperature and humidity levels - will not be addressed in V1.

With regard to proposed HP activities, it is worth considering that in V1 there is no clear view of how to implement the concept. Many aspects of the concept will not have been considered yet and so building high fidelity prototypes is unrealistic. V2 is the first of the E-OCVM life-cycle phases in which the operational concept is detailed enough so as to allow for the application of detailed task analyses techniques (such as Cognitive Task Analysis) and mock-ups, prototypes and simulators can be systematically used for cognitive walkthroughs, usability assessments and performance measurement in real-time simulations. In V1 low-fidelity mock-ups/prototypes are used instead. The techniques to be applied for concept design and evaluation in the V1 phase include focus groups, review of low fidelity mock-ups/prototypes, task analysis, etc. All these techniques allow to, quickly and iteratively evaluate the operational concept(s) under consideration and contribute to its evolution.

### 3.5.7 Characteristics of the HP assessment process in V2

In line with the E-OCVM description of typical V2 activities, the HP assessment process for V2 primarily focuses on improving and validating the operational concept (through an iterative process of design-evaluation-redesign) from an HP point of view. In line with this, the following topics are central for an HP assessment in V2:

- *Roles, responsibilities, operating methods and human tasks* (cf. Argument 1 - Appendix A): building on the work carried out in V1, the application of the HP assessment process for V2 will ensure that roles and responsibilities of human actors are clear and exhaustive; operating methods are exhaustive and support human performance, and human actors can achieve their tasks in a timely and accurate way;
- *Technical support systems and Human-Machine Interface* (cf. Argument 2 - Appendix A): building on the work carried out in V1, the application of the HP assessment process for V2 will support an appropriate allocation of tasks between the human and the machine (i.e. automation level) and will ensure that the high-level design of the human-machine interface supports the human actors in carrying out their tasks;
- *Team structures and team communication* (cf. Argument 3 - Appendix A): building on the work carried out in V1, the application of the HP assessment process for V2 will ensure that effects on the team composition are identified; that there is an appropriate allocation of tasks between human actors; and that the communication between team members supports human performance.

Although the actual transition to the proposed concept will only happen in V5, E-OCVM already requires a preliminary assessment of the transition feasibility in V2. For this reason, HP related aspects of the operational concept that may become impediments for the transition at a later stage will be already identified in V2. Potential issues for the transition will be addressed within the following argument:

- *Potential transition factors* (cf. Argument 4 - Appendix A): the application of the HP assessment process for V2 will ensure that there is a preliminary identification of issues related to acceptance and job satisfaction, changes in competence requirements, impact on staff levels and shift organisation, and the need for re-location of the work force.

The HP assessment process for V2 will not cover any questions related to the specific local implementation of the ATM concept. Thus, specific ergonomic aspects at the place of implementation – such as workplace layout or illumination, noise temperature and humidity levels - will not be covered in V2.

With regard to proposed HP activities, V2 is the first of the E-OCVM life-cycle phases in which;

- the operational concept is detailed enough so as to allow for the application of detailed task analyses techniques (such as Cognitive Task Analysis);
- mock-ups, prototypes and simulators can be systematically used for cognitive walkthroughs, usability assessments and performance measurement in real-time simulation.

Operational trials<sup>3</sup> (such as active shadow-mode trials), in contrast, will usually not take place until V3.

### 3.5.8 Characteristics of the HP assessment process in V3

In line with the E-OCVM description of typical V3 activities, the HP assessment process for V3 primarily focuses on (a) pre-industrial validation: further developing and validating the operational concept and supporting enablers and (b) integration: ensuring that related concepts and supporting enablers can be applied together. Note that, at the end of V3, the SPR-INTEROP/OSED should be mature.

Thus, the following topics are central for an HP assessment in V3:

- *Roles, responsibilities, operating methods and human tasks* (cf. Argument 1 - **Error! Reference source not found.**): building on the work carried out in V2, the application of the HP assessment process for V3 will ensure that (updated) roles and responsibilities of human actors are clear and exhaustive; (refined) operating methods are exhaustive and support human performance, and human actors can achieve their tasks in a timely and accurate way;
- *Technical support systems and Human-Machine Interface* (cf. Argument 2): building on the work carried out in V2, the application of the HP assessment process for V3 will ensure that the (refined) allocation of tasks between the human and the machine (i.e. automation level) is appropriate and the proposed design of the human-machine interface (as specified in pre-industrial prototypes) supports the human actors in carrying out their tasks;
- *Team structures and team communication* (cf. Argument 3): building on the work carried out in V2, the application of the HP assessment process for V3 will ensure that the effects of the (refined) operational concept on the team composition are identified; the allocation of tasks between human actors is appropriate; and that the communication between team members supports human performance.

These topics have been already covered in the argument structure for V2. Different to V2, though, HP activities in V3 will be carried out in a more realistic environment. This means that: (a) the use of low-fidelity mock-ups for HP assessments is not recommended anymore; and (b) operational trials (usually carried out as active shadow mode trials) can be used in addition to Real-Time Simulations.

E-OCVM already requires a preliminary assessment of the transition feasibility in V2. In V3, the transition feasibility assessment will be continued and carried out in a more detailed manner. Aspects related to the transition feasibility will be addressed within the following argument:

- *HP - related transition factors* (cf. Argument 4): the application of the HP assessment process for V3 will ensure that potential issues related to acceptance and job satisfaction are identified, changes in competence requirements are specified, the impact on recruitment & selection is assessed, training needs are assessed, and the impact on staffing requirements & staff levels is identified.

The HP assessment process for V3 will not cover any questions related to the local implementation of the ATM concept. Thus, specific ergonomic aspects at the place of implementation - such as workplace (e.g. OPS room) layout, illumination, noise, or humidity levels - will not be addressed.

### **2.5.9 Characteristics of the HP assessment process in V3+ (VLDs)**

It is highly advisable that those responsible shall consult the outcomes of preceding HP assessments that might feed into the VLD in question to ensure that all the relevant HP issues will have been considered. If the HP assessment was not conducted or finalised (at V3) during the Solution development, any relevant HP activities are at the discretion of those responsible for of the VLD design and conduct.

VLDs will provide a better understanding of the operational environment; they should provide a different perspective of the previously identified HP issues and means to specify potential mitigations. HP-related transition factors are likely to receive special attention. Namely, training needs are foreseen to be specified in sufficient detail; changes in competence requirements and the impact on recruitment and selection are expected to be considered.

## 4 Managing the HP assessment process in SESAR solutions

### 4.1 Overview of the HP assessment process

The purpose of the HP assessment process is to ensure that HP aspects relating to SESAR2020 operational and technological projects are systematically identified and managed within a Solution. The SESAR HP assessment process uses an ‘argument’ and ‘evidence’ approach. An HP argument is a ‘HP claim that needs to be proven’. The aim of the HP assessment is to provide the necessary ‘evidence’ to show that the HP arguments impacted have been considered and satisfied by the HP assessment process. This includes the identification of HP requirements and recommendations to support the design and development of the concept.

This chapter describes the content of each of the four steps of the HP assessment process when applied to the level of a SESAR Solution. The person in charge of the application of the HP assessment process is the Solution HP specialist.

Figure 3 (Chapter 4.2) provides an overview of the four steps of the HP assessment process with the tasks to be carried out and the main outputs: the HP assessment plan [3] (Part IV of the VALP), the HP analysis of the SESAR exercises (that feeds into the VALR) and the HP assessment report [4] (Part X of the SPR-INTEROP/OSED). In addition, an HP Log is recommended to be maintained throughout the lifecycle of the Solution in which all the data/information obtained from all HP activities conducted as part of the HP assessment (Step 1-Step 4) is documented.

It shall be noted that the official deliverable dates are the same for all parts of the VALP and SPR-INTEROP/OSED (e.g. respectively for HPAP and HPAR). However, both the HP Assessment Plan and the HP Assessment Report should feed into Part I of the VALP and SPR-INTEROP/OSED respectively. In this respect, it is the responsibility of the HP Expert to draft the HPAP and HPAR in advance, so that the relevant information is inserted on time in the VALP and SPR-INTEROP/OSED. The HP expert shall draw the attention of the Validation Expert and SPR-INTEROP/OSED leader on this matter and keep them informed on the development of the HP documentation.

For the VALP the official HP deliverable is the HP Assessment Plan (Word Template/ HP Log), while for the SPR-INTEROP/OSED it is the HP Assessment Report (Word Template/ HP Log). The SPR-INTEROP/OSED PART I shall include as well in the requirements section the HP requirements - the HP expert shall ensure the SPR-INTEROP/OSED/SPR leader receives the complete HP input that is appropriately captured. Furthermore, it is the responsibility of the HP Expert to ensure that the HP related information is appropriately analysed and captured in the body text of the VALR. No HP template is available for the VALR as this remains at the discretion of the HP expert to perform the analyses and conclude on SESAR exercises – in collaboration with the Validation Expert.

The HP Log is in the form of a spread sheet (see Appendix B) which is recommended to be used as a living document throughout the lifecycle of the Solution. Following each conducted activity, the HP Log should be updated and reflect the state of the art of the concept, in terms of objectives, conclusions, recommendations and requirements etc. The use of the HP Log is highly recommended as it has been

found to be a thorough tool for the HP experts, ensuring traceability of all activities and representing a detailed register of the findings. The HP Log shall always be used in conjunction with the Word templates of the HPAP and HPAR. In case an HP Log is used, a transfer of information from the Log to the Word documents is required upon submission of the filled in templates to the project management team and the SJU, either through a “copy-paste” process or through detailed referencing to the relevant tabs of the HP Log.

The description of each of the steps detailed in Figure 3 below, consists of the following sections:

- the objective of a step;
- a brief overview of the tasks to be covered in a step;
- the required input;
- the expected output;
- the support material; and
- guidance on how to carry out the tasks in the step.

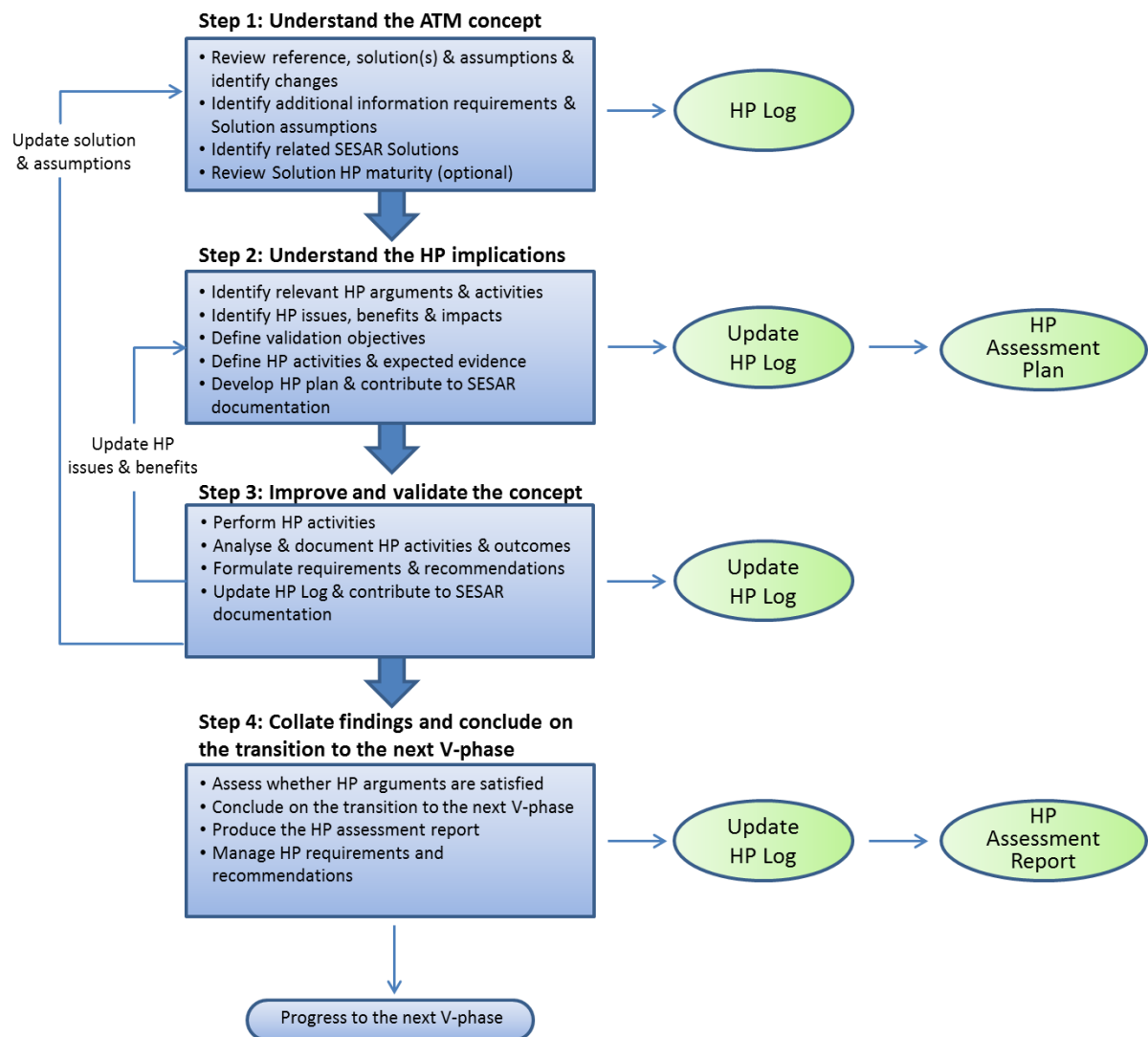


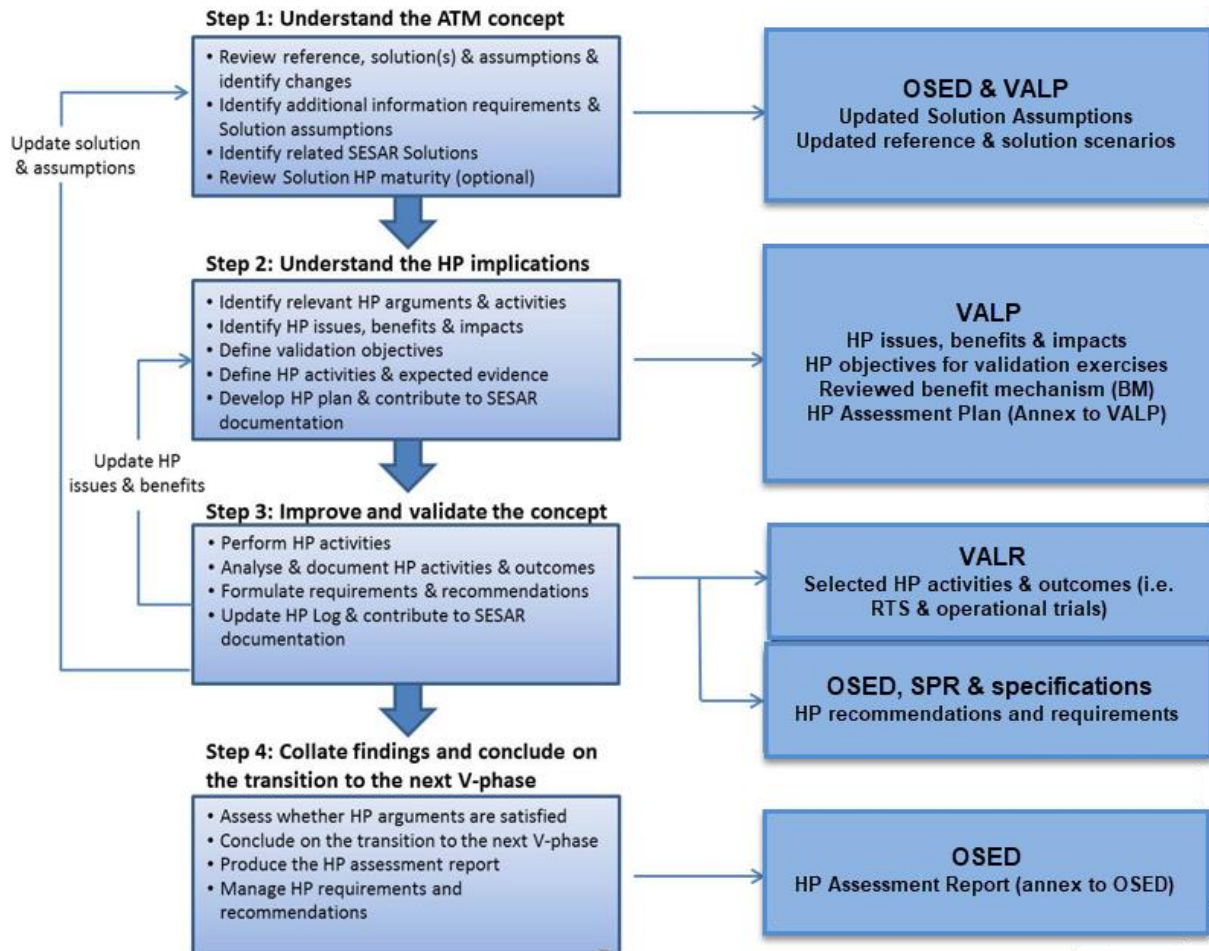
Figure 3: Steps of the HP assessment process

## 4.2 Contribution of the HP assessment process to SESAR Solution documentation

Carrying out an HP assessment for every operational and technical change proposed in SESAR is a requirement by SJU. As outlined above, one of the main reasons is to provide evidence that airborne and ground ATM actors will, in fact, be able to contribute to the SESAR expected performance benefits. Also, HP assessments are needed as the basis for subsequent HP and Business case-building.

In addition, the application of the HP assessment process will generate outputs that can be directly used for other SESAR documentation such as SPR-INTEROP/OSD [5], VALP [6], VALR [7].

Figure 4 shows which parts of the output of the four steps of the HP assessment process can be directly fed into the SESAR documentation.



**Figure 4: Contribution of the HP assessment process to SESAR documentation**

The link between the steps of the HP assessment process and other project documentation is also described in the detailed description of Steps 1 to 4 and the related tasks below. It should be noted, that as illustrated in figure 3 and figure 4, the HP assessment process steps 1 – 3 are iterative and in some cases it may be necessary to iterate certain steps several times during a given V-phase.

## 4.3 Step 1: Understand the ATM Concept<sup>4</sup>

### 4.3.1 Objectives

The objectives of Step 1 are to:

- Understand (a) the ATM system against which the assessment has to be performed (i.e. the reference), (b) the ATM needs and constraints (with a special consideration of the needs of ATM actors) (c) the ATM change proposed by the Solution (i.e. the solution scenario(s)) and (d), the assumptions on which the Solution is based (i.e. context of implementation);
- Ensure that the descriptions of reference, solution(s) and assumptions are complete and consolidated;
- Understand potential interactions of the proposed solution(s) with other Solutions' proposals;
- Confirm the HP maturity of the Solution, if necessary.

### 4.3.2 Tasks to be performed

The following tasks need to be carried out by the HP specialist:

1. Review the ATM needs, constraints, reference, solution(s) and assumptions to understand the ATM changes and the actors impacted; Consult with Safety specialists and perform a "Change and Scope Assessment" ( see Appendix ...).
2. Identify additional information requirements and Solution assumptions; and prepare contribution to SPR-INTEROP/OSED, VALP and, if available the Technical specification;
3. Identify related SESAR Solutions, including Solutions Integrations;
4. If necessary, review the HP maturity of the Solution.

These tasks will be described in more detail in the subsequent guidance section.

### 4.3.3 Input

The following input is required to carry out Step 1:

2. For V1, needs, constraints and opportunities identified in V0 that provided input to start the concept design and evaluation process from SESAR project documentation (as documented in VALP);

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<sup>4</sup> **NB:** It is assumed that for a Solution in V2 or V3, an HP assessment process has been applied in the previous V phase. Therefore, related evidence exists and the HP maturity is in compliance with the beginning of the current V phase. If this is not the case, the HP specialist is responsible for integrating all the HP activities necessary from the previous V-phases in the current V phase in order to meet the requirements of the end of the current V-phase.

3. Description of the reference scenario (from SESAR project documentation e.g. SPR-INTEROP/OSED);
4. Initial list of Solution assumptions (from SESAR project documentation e.g. SPR-INTEROP/OSED);
5. Description of the solution(s) (from SESAR project documentation e.g. SPR-INTEROP/OSED);
6. Information on related SESAR Solutions (from SESAR project documentation).

#### 4.3.4 Output

The following output of Step 1 is expected:

1. Reviewed and, potentially, amended description of the reference and solution scenario(s) (input to SPR-INTEROP/OSED and VALP);
2. Description of ATM actors impacted and the potential changes to their work;
3. Consolidated list of Solution assumptions (input to SPR-INTEROP/OSED and VALP), as well as constraints according to the characteristics of the current V-phase;
4. List of SESAR Solutions to be considered in the HP assessment
5. HP maturity of the Solution (optional)

#### 4.3.5 Support material

- HP Log for capturing Solution background information relating to the reference, solution(s) and Solution assumption, etc., as well as information relating to the changes introduced by the Solution (See Appendix B)
- HP Maturity criteria checklist to determine if all the HP-related information required for a Solution in a given V-phase (V1-V3) is available (See Appendix D). Note that the maturity criteria checklists for each V-phase are in dedicated tabs in the HP Log and may be filled in there.

#### 4.3.6 Guidance on Step 1 Tasks

##### 4.3.6.1 Review reference, solution(s) and assumptions and identify changes

This task will enable the HP specialist to acquire an understanding of the ATM need for the concept(s) as well as the constraints and the change proposed by the Solution. Furthermore, the HP specialist will be able to determine whether an HP assessment is required by the SESAR Solution, or not. If so, the HP specialist will be able to determine whether the description of the reference and solution scenarios as well as the assumptions are sufficient to scope and conduct the HP assessment for the given V-phase.

‘Needs’ refer to ATM problem the Solution intends to ‘fix’. ‘Reference scenario’ refers to the ATM system against which the assessment has to be performed. ‘Solution scenario(s)’ refers to the ATM change proposed by a Solution. ‘Constraints’ refer to limitations on behaviour (or the ability to do something). Finally, ‘assumptions’ relate to the context in which the proposed change will be

implemented as well as, more specifically, from an HP perspective, hypotheses made relating to human behavior either, when using the new systems or that may be impacted by the proposed solution.

When reviewing the description of the ATM needs, reference, the solution(s) and the assumptions, the HP specialist should focus on understanding the type of change proposed by the Solution. To do so, the following questions need to be considered:

- **What** elements of the ATM system are subject to change (e.g. technical equipment, procedures, airspace layout and airspace users)?
- **Who** are the human actors affected by the change?
- **How** will the work of the human actors be impacted?

The 'Description of change' table can be used to help systematically identify and capture the changes proposed by the Solution. This table can be found in the Word template of the HPAP and the HP Log ("Change & Argument Identification" Tab). This table also enables the HP specialist to make a 'go/no-go' decision regarding the HP assessment early on in the HP assessment. If none of the high level HP areas/arguments are impacted and no changes to the ATM actors work are identified, then there is no need to proceed with an HP assessment. Alternatively, traditional task analysis techniques can also be used to help identify and better understand the changes proposed by the Solution compared to the current situation.

Identifying and understanding the changes proposed by the Solution also helps the HP specialist to determine whether the description of the reference and the solution scenarios, as well as the assumptions, are sufficient to scope and conduct the HP assessment given the V-phase of the Solution (see 3.3.6.2).

This task – like the following tasks in Step 1 - is mainly performed in the first V-phase to be covered by an HP assessment. In any subsequent V-phase, the outputs of this and other Step 1 tasks are refined and updated on the basis of newly available data.

The identification of changes shall be performed in collaboration with Safety specialists involved in the Solution, through a "Change and Scope Assessment" process. The activities to be later performed can belong to both Safety and Human Performance [Appendix B]. In this case the specialists should agree upon the categorization of issues under one of the two umbrellas, depending on the concepts or on collaborating in order to achieve a robust result and not to work in isolation on the same concepts.

#### 4.3.6.2 Identify additional information requirements and Solution assumptions

The review of the ATM needs, constraints, reference, the solution(s) and the assumptions may show that there are some gaps (i.e. missing information) that need to be filled in before an HP assessment can be carried out. For instance, an HP specialist might realize that the HP assessment cannot be properly scoped because the change (i.e. the difference between the reference and the solution) is not sufficiently described with regards to its impact on human actors given the V-phase being addressed or that certain constraints relating to HP have not been identified or documented. In such cases, the HP specialist will identify the missing information and, if appropriate, suggest how to fill in the gaps in the SPR-INTEROP/OSED for ATM Solution and TS/IRS for Technological Solution.

Any additional assumptions– as well as any further specification of the reference solution descriptions, constraints, etc. – identified by the HP specialist will be presented to the project manager and the project team to be incorporated in<sup>5</sup>:

- SPR-INTEROP/OSED (Chapter 2 “Summary of Operational Concept”);
- SPR-INTEROP/OSED (Chapter 4.1 “Operational characteristics”);
- VALP (Chapter 3.1 “Validation Plan Context”);
- TS/IRS for Technological solution in particular.

It is recommended to capture the consolidated list of Solution assumptions in the HP Log (“Solution & Concept Information” Tab) in Appendix B.

Note that the information relating to the proposed solution(s) as well as the Solution assumptions will not necessarily be stable over a V-phase. Rather, the description of reference, solutions and the list of Solution assumptions may evolve during the course of the HP assessment. For this reason, it is necessary to revisit, and if necessary update, this information at regular intervals. Regular meetings with the Validation Experts as well as with the SPR-INTEROP/OSED leaders are highly recommended in order to ensure an appropriate level of collaboration and exchange of information.

#### 4.3.6.3 Identify related SESAR Solutions

For the HP assessment in V1 and V2 the identification of related SESAR Solutions serves to detect potential interactions with other Solutions in terms of proposed ATM solutions. Such Solutions can be either aircraft or ground-related. The interaction with other Solutions is essential in V3 since the integration concern is the core of this V-phase. The Solution under investigation can be related to other SESAR Solutions in a number of ways, for instance:

- The results of other SESAR Solutions can provide an input to the Solution’s suggestions;
- Other SESAR Solutions can determine the context of implementation for the proposed solution (i.e. technical projects);
- Other SESAR Solutions can use the output of the Solution under investigation, either as part of their solution description or as part of their context of implementation.

Information on related Solutions, together with other Solution background information, can be captured both in the Word Template as well as in the HP Log (“Solution & Concept Information” Tab), (see Appendix B).

#### 4.3.6.4 Review of Solution maturity

Decision on the Solution HP maturity is typically taken at the end of activities pertaining to a particular V-phase to ensure that the Solution can transit into the next V-phase from an HP point of view. However, if there is a reason to believe that HP maturity does not mirror the overall Solution maturity, it is the responsibility of an HP specialist to verify this. If this is indeed a mismatch in maturity, the HP

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<sup>5</sup> Please note the number references to the chapters in the SESAR documentation provided in this document may have changed since this document was published.

specialist should refer to the HP argument structure for the previous V-phase to identify which HP activities should be carried out before the HP activities of the given project V-phase can be conducted.

The Solution HP maturity can be captured in the HP Log (“Solution & Concept Information”) (see Appendix B) and can be found in the HPAR from the previous V phase.

It should be noted that Appendix D (and dedicated tabs in the HP Log) provides a checklist for all HP related information in each of the three V-phases, V1 to V3.

## 4.4 Step 2: Understand the HP implications

### 4.4.1 Objectives

The objectives of Step 2 are to:

- Understand the proposed change in terms of relevant HP arguments;
- Identify HP issues and benefits associated with the HP arguments;
- Define HP validation objectives, expected evidence and relevant scenarios;
- Plan the HP activities to be carried out as part of the next step.

### 4.4.2 Tasks to be performed

The following tasks need to be carried out by an HP specialist:

1. Identify relevant HP arguments;
2. Identify HP issues/benefits related to the proposed solution(s);
3. Define HP validation objectives;
4. Define HP activities and expected evidence;
5. Develop HP assessment plan and contribute to VALP and other SESAR documentation.

These tasks will be described in more detail in the subsequent guidance section.

### 4.4.3 Input

The following inputs are required to carry out Step 2:

1. HP reviewed description of reference and solution and/or description of potential changes and ATM actors impacted (from Step1)
2. Consolidated list of Solution assumptions (from Step 1);
3. Project Benefit Mechanisms (from SESAR project documentation);
4. Existing previous HP assessment report(s);
5. Existing previous Validation report(s);
6. Existing HP Log;
7. Documentation related to solution (from SESAR project documentation);

8. List of SESAR Solutions to be considered in the project HP assessment (from Step 1);
9. Project planning documents: Project Management Plan, and Safety Plan (from SESAR project documentation);
10. P16.4.2 Repository of HF methods and tools (external input).<sup>6</sup>

#### 4.4.4 Output

The following output of Step 2 is expected:

1. Identification of relevant HP arguments;
2. List of Solution-specific HP issues and benefits together with their impact on HP and KPAs;
3. List of HP validation objectives;
4. List of activities and expected evidence;
5. HP assessment plan and/or input to VALP

#### 4.4.5 Support material

- 16.4.2 Repository of HF methods and tools (with guidance on their use);
- Argument Structure (Appendix A);
- HP Log (Appendix B);
- HP assessment plan template (Appendix B).

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<sup>6</sup> <https://www.eurocontrol.int/ehp/>

#### 4.4.6 Guidance on Step 2 Tasks

A change is addressed when a novelty is introduced in a system, and influences the existing tasks, roles and responsibilities by either modifying them or adding new ones. The understanding of the change begins in Step 1, however, the change is still under analysis in Step 2, through the identification of HP arguments, issues and benefits and their impacts on human performance and KPAs.

##### 4.4.6.1 Identify relevant HP arguments

Based on the changes identified in Step 1, the aim of this task is to identify the HP arguments that need to be addressed by the HP assessment process. The identification of HP arguments relevant for the Solution at a given V-phase can be done using the argument structure itself for a given V-phase (Table 1 Appendix A). The aim is to go through the branches of the argument structure to decide, whether the Solution has an impact on the HP area or topic addressed in the argument.

It should be noted that the argument structure for each V-phase, V1, V2 and V3, builds on the argument structure of the previous V-phase, such that; the V2 argument structure builds on the V1 argument structure, and likewise; the argument structure for V3 builds on the V2 argument structure. The main difference between the argument structures for the different V-phases is the type of evidence that is required to satisfy an argument and hence the activities that need to be performed to obtain that evidence. In V1 the type of evidence required to satisfy an HP argument mainly relates to the exploration of different alternative solutions and the identification of ‘show-stoppers’ as well as the identification of preliminary HP needs or requirements. In V2 and V3 the same arguments may be addressed but more stringent evidence is needed which is obtained by using validation techniques that are considered to be more valid and reliable, e.g. using prototypes to support CTA and RTS.

The arguments identified to be addressed by the HP assessment are documented in the Word template of the HPAP as well as in the HP log (“Issue-Objective-Outcome” Tab) (see Appendix B).

Once the relevant HP arguments have been determined, the HP specialist can, if necessary, identify an initial set of HP activities and evidence that can serve to support an argument using the argument structure for a given V-phase. At this stage, it should be noted only an initial identification of relevant HP activities can be carried out, as the HP activities will be refined based on the HP issues and benefits and impacts identified.

##### 4.4.6.2 Identify HP issues, benefits and impacts related to the proposed solution

In order to select and refine the HP activities to be carried out, Solution-specific HP issues and benefits - together with their impacts both on human performance and system KPAs - need to be identified. For one argument, several HP issues and benefits could be found. On the other hand, it is possible that in the course of the identification of the HP issues/benefits, other HP arguments, not initially selected, may be found to be relevant.

Solution-specific HP issues and benefits along with their impacts are identified by conducting two activities: a literature review/analysis of input documents and if possible; Subject Matter Expert (SME) interviews or workshops:

- *Literature review/ Analysis of input documents*

Previous work on the proposed concept conducted within or outside the Solution needs to be reviewed to identify HP issues and benefits related to the proposed concept already identified through previous validation activities. Therefore, this review must include any available validation reports and HP assessment reports from the previous V-phases. If available, technical specifications or relevant

regulations should also be reviewed to help identify any other potential Solution-specific HP issues or benefits.

As part of the literature review the Solution's Benefit Mechanism must also be used to identify Solution-specific HP issues and benefits. The Business Case requires each Solution to produce a Benefit Mechanism before the Solutions start defining their validation objectives. The Solution's Benefit Mechanism can normally be found in the SPR-INTEROP/OSED and/or VALP. A Benefit Mechanism is a cause-effect description of the impacts of the solution proposed by the SESAR Solution and "describes the positive as well as the negative impacts that the solution is expected/shown to provide" [8]. Impacts – as defined in the Benefit Mechanisms – relate to KPAs and human performance. For this reason, the HP specialist should review the Benefit Mechanism for the Solution with the aim to:

- Check the completeness and correctness of the Solution Benefit Mechanism from an HP point of view;
- Check the completeness of the HP issue, benefit and impact identification from the Business Case point of view (e.g. are all benefits and impacts addressed in the Benefit Mechanism reflected in the HP issues, benefits and impacts?);
- Ensure consistency between the HP issues, benefits and impacts identified in the HP assessment process and the Benefit Mechanism.

At this stage, the Benefit Mechanism can only be reviewed from a theoretical point of view. The actual validation of the expected HP benefits, especially if formulated in a quantitative way, can only be done once the HP activities are carried out.

- *Subject Matter Expert (SME) interviews/workshop*

Following the literature review, a series of interviews or a workshop with a range of different Subject Matter Experts and stakeholders may be conducted to identify Solution-specific HP issues and benefits and their impacts on HP and KPAs. Two information sources are needed to conduct the HP issue, benefits and impacts interviews/workshops:

- (1) the differences between the reference and the Solution's solution scenario, i.e. the changes introduced by the concept and the ATM actors impacted, plus assumptions and constraints (identified in Step1), and;
- (2) the list of relevant HP arguments (identified earlier in Step 2).

The list of relevant HP arguments is used to help structure the interviews/workshop. Standard techniques such as structured analysis and brainstorming are used to help elicit relevant potential HP issues and benefits relating to the changes introduced by the new concept.

HP issues and benefits should be generated on the level of the characteristics of the solutions (i.e. specific operational and technical aspects or situations that need to be considered), and should clearly explain the potential HP impacts and system (KPA) impacts.

According to the V-phase, the HP issues and benefits identified may focus on different topics as well as different levels of detail. In V1 the HP issues and benefits are high level and related to the concept in general. In V2 the HP issues and benefits become more detailed and linked to more precise operational tasks. In V3 potential interactions with related Solutions, as identified in Step 1, should be considered. Potential interactions refer to issues and benefits that arise from the combination of proposed changes in two or more Solutions. To facilitate the identification of interactions, the HP specialist should identify those aspects of the related Solution's suggestions that affect the same

human actors, responsibilities and tasks as the Solution under investigation. In addition, in V3 integration benefits and issues must also be considered, for example, in terms of the integration between on-board and ground; ground and ground, as well as other existing systems, etc. In case an issue or benefit is related to a specific aspect of air/ground integration, one single issue or benefit shall be written.

The HP issues/benefits and impacts can be captured in the HPAP Word template and in the HP log (“Issue-Objective-Outcome” Tab) (see Appendix B).

Some Solution assumptions may influence certain potential HP issues/benefits. In this case these assumptions have to be identified and linked to the related HP issue/benefit.

Therefore, each HP issue and benefit identified must be linked to an appropriate HP argument and if necessary, an assumption.

The benefits of using such interviews/workshop to identify potential HP issues and benefits is that input and knowledge is gained from a range of experts with different backgrounds and experience and this helps to foster commitment and buy-in from the stakeholders.

However, project constraints (e.g. shortage of resources available) may mean that it is not always feasible to conduct such interviews/workshops. If this is the case, and if the HP specialist has a strong understanding and knowledge of the proposed concept, then literature review alone should be sufficient.

Guidance on how to write HP issues and benefits is provided in Appendix A.

It should be noted that additional HP issues/benefits may be identified when the HP activities are carried out (see Step 3). These additional HP issues/benefits will subsequently be added to the HP Log and included in the set of identified HP issues/benefits. Thus, the HP Log represents an HP issues and benefits register which has to be continuously maintained along a project lifecycle.

Following the issue and benefit analysis the HP specialist should provide the safety experts working on the Solution with a list of the issues and benefits identified. The safety experts should integrate the HP safety related issues and benefits in their safety assessment and the list of HP issues consolidated with input from safety (cf. SRM [9]).

#### 4.4.6.3 Define HP validation objectives

Once the relevant HP arguments, issues and benefits have been determined, the HP specialist will be able to identify the HP validation objectives. In V2 or V3, these objectives should complement the HP validation objectives already defined for the previous phase.

For one specific HP argument, issue or benefit, several HP validation objectives could be defined. All HP objectives have to be linked to an HP issue or benefit and hence linked to an HP argument. Furthermore, where possible, scenarios and specific events that need to be investigated as a result of the HP issues and benefits identified, are also defined and linked to the HP objectives.

According to the V phase, as with the HP issues and benefits, the HP validation objectives may address different topics as well as different levels of detail. For example, in V1 the objectives are high level and related to the concept in general, in V2 the objectives are more detailed and linked to more precise operational tasks. In V3, special attention is given to objectives relating to the integration of the concept into the system, such as:

- The integration between on-board and ground;

- The integration between ground and ground;
- The integration between different related SESAR Solutions is done in the context of PAGAR [13] on the basis of the information available in the PAR (Part V of the SPR-INTEROP/OSED) [14] or more in depth performing the HP Case [1].

Guidance on how to write an HP validation objective can be found in Appendix A.

In the case where there are shared air and ground HP validation objectives, a series of non-coupled air and ground exercises plus coupled air/ground exercises may be necessary. In such cases the shared objectives must be broken down into sub-objectives and the scope of the validation objectives (i.e. air and ground objectives plus air/ground interoperability<sup>7</sup> objectives) must be clearly determined. Furthermore, the responsibility for managing each of the sub-objectives over distributed exercises must be clearly defined.

HP validation objectives are registered in the HP Log Tab “Issue-Objective-Outcome” (see Appendix B). The HP validation objectives for SESAR exercises<sup>8</sup> will also be included in the VALP, clustered into more general objectives, remaining that the HP expert closely follows the validation activities, ensuring the detailed HP objectives are included in validation exercises (questionnaires, debrief, interview, logs etc.). As with the HP issues/benefits, the HP validation objectives are continuously maintained along a project.

It should be noted that the HP validation objectives may not necessarily be managed by the HP specialist in isolation, but are also under the responsibility of other project team members and are systematically shared and reviewed before any validation activities. The HP specialist should nonetheless keep on overview on the insertion of these objectives under the management of the team members, if applicable.

#### 4.4.6.4 Define HP activities and expected evidence

The identification of relevant HP arguments early on in Step 2 meant that an initial identification of related HP activities could be made if necessary, before conducting an HP issue and benefit analysis and defining HP validation objectives. However, for a number of arguments, more than one relevant activity is listed in the argument structure and the initial identification of HP activities using just the HP arguments. The decision regarding which particular HP activity/ies will be carried out is made once the specific HP issues and benefits associated to a change have been analysed and the HP objectives together with scenarios and events defined.

It should be noted that:

- A number of HP activities are listed in support of more than one HP argument. This means that the HP activity (e.g. a Cognitive Task Analysis for a specific human actor) only needs to be carried

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<sup>7</sup> The notion of an interoperability as used in this document with regards to air and ground objectives refers to validation objectives derived from HP issues that impact both air and ground operations.

<sup>8</sup> SESAR validation exercises only include, FTS, RTS and operational trials.

out once, albeit with two different foci (e.g. identification of the human actor's information requirements and identification of likely errors).

Example: A Cognitive Task Analysis (CTA) can provide evidence for a number of arguments: it can serve as evidence for showing that the human operator's workload will not be excessive, that the error potential is minimised, and that the human operator is provided with all information necessary to complete a task. Nevertheless, the HP specialist will only have to carry out a CTA once to support the respective arguments.

- Some of the HP activities listed may not need to be carried out by the HP specialist in isolation, but are also under the responsibility of other project members. For instance, the identification of normal operating conditions, abnormal operating condition and degraded modes of the system under investigation will be done in cooperation with the safety specialists.

Conducting an HP activity as such, does not suffice to support an HP argument. Rather, it is the *outcome* of the HP activity that will determine whether or not an HP argument is satisfied. These outcomes are referred to as required "evidence" for an HP argument. HP arguments, associated HP activities and required evidence for each argument are outlined in Appendix A. The HP specialist can use this table to understand which type of evidence is required to support an argument for each of the three V-phases, V1-V3. If evidence, not included in the HP argument structure is thought to be more appropriate for the validation of some objectives, then this 'new evidence' should be documented in the HP Log. It is not necessary to produce all evidence related to an HP argument/ activity, as the evidence depends for example on the validation condition (e.g. certain evidence is formulated in order to compare, whereas comparisons are not applicable for all cases). Note that the concept of "required evidence" in the HP assessment process is equivalent to the notion of "success criteria" as used in SESAR validation.

#### 4.4.6.5 Develop HP assessment plan and contribute to SESAR documentation

The information derived in Step 2, captured in the HPAP Word Template and the HP log in the "Issue-Objective-Outcome" Tab (see Appendix B), in terms of HP arguments, HP issues, benefits and impacts, HP objectives, activities and expected evidence forms the basis of the HP assessment plan. The HP assessment plan provides the Solution with a consolidated description of the HP activities that need to be performed to ensure all relevant HP arguments and their related issues/benefits are adequately addressed within the HP assessment. The HP assessment plan provides the schedule and describes the resources required for each HP activity. When developing the HP assessment plan, the HP specialist should consult the Project Management Plan (PMP) and the Solution's SPR-INTEROP/OSED and VALP. This serves to ensure that HP activities are planned in accordance with Solution activities, deliverables and deadlines.

It should be mentioned in the HP assessment plan if the HP activities are part of SESAR exercises or not. SESAR exercises may be a RTS (Real Time Simulation), a FTS (Fast Time Simulation), or an operational trial. In addition to the "SESAR exercises", other HP activities such as task analysis may be selected to address specific HP issues/benefits. The need for those additional HP activities is at the HP specialist discretion, depending on the type of the validation objectives, and on the agreement of the project manager.

The HP assessment plan is integrated as an appendix of the VALP. A template to support the development of the HP assessment plan can be found in Appendix B.

It shall be noted that for every SESAR Solution HP practitioners should initiate an HP Log and keep it updated throughout the lifecycle of the Solution. The HP log captures complete HP knowledge on a Solution, facilitates detailed follow-up and management of HP knowledge across team member, and ensures traceability on all topics studied. On the other hand, HP plans and HP reports represent a snapshot of the planned HP activity at the moment of the production of the validation plan aligned with the scope of the exercises, hence address a sub-set of the complete HP knowledge on a Solution at this given time. In case a team agrees that for specific reasons no HP log may be required, only HPAP and HPAR are produced (for example in case of a very limited study). In case a team agrees that for specific reasons there is no need for a dedicated HPAP or HPAR (for example in case the HP activity covers only an RTS and no further HP activities already part of the validation documentation), the HP log may be directly used as an attachment to VALP and SPR-INTEROP/OSED.

For simulation exercises (i.e. Real-Time Simulations or trials), the HP specialist needs to closely cooperate with the validation team to ensure that the relevant HP objectives are incorporated into the validation objectives in the validation plan.

For each SESAR exercise, scenarios and events have to be determined and linked to the validation objectives. Scenarios and events are usually derived from the HP issues and benefits identified. The definition of scenarios and events to be evaluated in a specific exercise is a team activity involving HP specialists, safety experts, validation experts, operational experts and/or concept developers (see Step 3).

Specific methods & tools can be selected from the “HP Repository of Tools and Methods”<sup>9</sup> (e.g. NASA TLX or EUROCONTROL’s AIM as specific workload questionnaires).

In order to identify potential overlaps and synergies between HP and safety, it is recommended that the HP specialist and the safety specialist coordinate their plans (e.g. “Scope and Change Assessment” process). Once the HP specialist has decided on the HP activities to be carried out for a Solution, s/he should pass this information on to the Solution’s safety specialist and vice versa.

In addition to the HP assessment plan which forms an appendix of the VALP, the output of Step 2 of the HP assessment process also contributes to the main body of other SESAR deliverables, namely the VALP and SPR-INTEROP/OSED:

→ VALP chapter “Validation objectives”

The HP validation objectives linked to SESAR exercises in the scope of the validation plan will be extracted from the HP Log/ HP Plan- Tab “Issue-Objective-Outcome” (Appendix B) and clustered in the relevant paragraph of the VALP.

The validation objectives have to be linked to hypothesis and success criteria in this paragraph. Hypotheses can be derived from the HP issues, benefits and impacts defined in the HPAP Word Template or the HP Log (“Issue-Objective-Outcome” Tab), (see Appendix B). Success criteria correspond to the ‘evidence’ defined in the HP argument structure.

→ SPR-INTEROP/OSED chapter “Detailed Operational Scenario Use-Cases”

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<sup>9</sup> The SESAR 16.4.2 “HP Repository of Tools and Methods” can be found on <https://www.eurocontrol.int/ehp/>.

The context described in the HP issues and benefits can also be used to be determined whether or not the use cases are complete and correctly defined (SPR-INTEROP/OSD). In addition, the task model, initiated in V1 and refined in V2, is used to detail the use cases accordingly in V3.

## 4.5 Step 3: Improve and validate the concept

### 4.5.1 Objectives

The objective of Step 3 is to conduct the HP activities as they have been specified in the HP assessment plan. The findings obtained from the HP activities will (a) serve to support the arguments and validate the proposed concept or design of solution and (b) form the basis of recommendations and requirements for further analysis and development of the proposed solution in order to improve the proposed concept or solution.

### 4.5.2 Tasks to be performed

The following tasks need to be carried out by the HP specialist:

1. Perform the HP activities as outlined in the HP assessment plan;
2. Analyse and document the HP activities and their outcomes;
3. Formulate recommendations and requirements for further concept and system development;
4. Update the HP Log and contribute to SESAR documentation.

These tasks will be described in more detail in the subsequent guidance section.

### 4.5.3 Input

The following input is required to carry out Step 3:

1. List or register of HP issues/benefits & impacts and recommended HP activities, i.e. HP Log/HP assessment plan, (from Step 2);
2. VALP (SESAR project documentation).

### 4.5.4 Output

The following output of Step 3 is expected:

1. Description of all HP activities conducted and their outcomes (i.e. for SESAR exercises -input into VALR, for non-SESAR exercises (e.g. TA, CTA, stakeholder workshops etc. - reports documenting HP activity conducted and their output );
2. Updated list/register of HP arguments, issues and benefits, validation objectives, with findings from activities conducted (Updated HP Log);
3. Register of HP recommendations & requirements (Updated HP Log).

#### 4.5.5 Support material

- 16.4.2 Repository of HF methods and tools (with guidance on their use);
- Other 16.4/16.5 guidance material (e.g. Updated Generic SESAR Information Presentation guide);
- HP Log (see Appendix B);
- HP assessment report template - ground based Solutions only (see Appendix B).

#### 4.5.6 Guidance on Step 3 Tasks

##### 4.5.6.1 Perform the HP activities as outlined in the HP assessment plan

As part of this task, the HP activities are conducted in accordance with the HP assessment plan/ HP Log. On the level of this process description, no further guidance on the conduct of the HP activities is given. The reason is that (a) any further guidance would depend on the specific HP activities to be conducted, and (b) the set of HP activities in the argument structure (from which the HP assessment plan will be constructed) are standard HP activities that are documented in HP literature.

With respect to the required costs, carrying out the HP activities will be the most time- and effort-consuming task in the HP assessment. Nevertheless, there are some synergies that will help to reduce the effort involved in collecting the required evidence for an argument.

First, a number of HP activities will support more than one HP argument. This mapping of an HP activity onto several arguments was already addressed as part of the HP assessment plan development.

Second, there are a number of activities that may be carried out as shared activities with other TAs or project members, depending on the Solution context. This relates, among others, to:

- *Identification of normal and abnormal operating conditions.* The identification of scenarios and events that need to be covered as part of normal and abnormal operating conditions may be carried out in close co-ordination with safety. The HP assessment will focus on ensuring that human operators can fulfil their tasks under all identified operating conditions. As the technical capabilities of the platform being used in the validation exercise also determines what scenarios and events can be included in a validation exercise, the technical team responsible for the platform should also be involved in this activity.
- *Identification of degraded modes of the system under investigation.* The identification of degraded modes of the proposed ATM system should be carried out in close co-ordination with safety. The HP assessment will focus on ensuring that human operators can fulfil their tasks under all identified degraded modes of the system. Again the technical team responsible for the platform should also be involved in this activity as certain degraded scenarios and/or events may not be technically feasible.
- *Real-Time Simulations and operational trials.* Depending on the Solution the HP specialist may or may not be fully integrated into the validation team. However, whatever the Solution set up, the main role of the HP specialist will be to provide an input to the validation plan, by identifying HP objectives to be investigated in simulation, as well as the success criteria. Also, the HP specialist will advise on setting up a simulation that allows for reliable and valid conclusions (e.g. by helping to specify the experimental design, defining the tools needed to assess human performance related measures).

The goal of the HP validation activities is to collect data and analyse information to address specific HP issues and benefits identified through the HP assessment process. Data can be of qualitative or quantitative nature, e.g. users' debrief comments, feedback from expert interviews, observations, questionnaire responses or system data loggings. The data obtained from the validation activities can either confirm or confute a potential solution.

If not already done as part of the previous step, the planning and conduct of the HP activities are facilitated by the "Repository of HP tools and methods" that was developed within SESAR Project 16.4.2. This repository will help the HP specialist to identify the specific tools (questionnaires, measurement techniques, etc.) to be used within an HP activity, based on standard criteria such as objectivity, validity, and reliability. The "Repository of HP tools and methods" will also provide information and guidance on the usage of these tools and methods.

#### 4.5.6.2 Analyse and document the HP activities & their outcomes

The documentation of HP activities and outcomes includes:

- *A brief description of the activity*

A brief description of the HP activity serves to provide a qualitative indication of the validity and reliability of the obtained outcomes and, thus, the quality of evidence provided in support of an argument. A simulation with a substantial number of experienced end-users, representative study settings and scenarios, and standard measurement tools is likely to provide more valid and reliable outcomes than expert feedback on a limited system mock-up. If the HP activity is described elsewhere (e.g. a Real-Time Simulation will be documented in the validation report in a detailed way, a task analysis should be documented in a separate document which describes the methodology employed and output of the task analysis), then a reference to existing documentation may be sufficient. Information on the conducted HP activities is recommended to be captured in the HP Log "Issue-Objective-Outcome" Tab.

It is important in the case of RTS and operational trials, to point out any discrepancies between the conduct of the validation exercises as described in the VALP and the actual conduct of the exercises in order to give an indication of reliability and validity of the data obtained. These discrepancies are documented in the VALR.

- *Analyse and document the outcomes of the activity*

The outcomes of an HP activity relate to results that can be taken as evidence for a particular issue and hence argument.

If the activity conducted is a SESAR exercise e.g. a RTS or operational trial, then the HP specialist may be required to analyse the data obtained relating to the human performance objectives. However, this analysis may also be performed by the validation team, in this instance the role of the HP specialist is to help the validation team interpret the results and draw conclusions for each of the HP objectives investigated in the exercise. The quality of the raw data, as well as its granularity determines the type of analysis that can be performed, as well as the conclusions that can be drawn. It should be noted that for airborne Solutions in V3, the HP specialist is required to perform a Human Error Analysis (HEA) on all human errors identified in the HP activities conducted (see **Error! Reference source not found.** f or guidance on performing a HEA).

The HP related results from a SESAR exercise are integrated in the VALR and/or SPR-INTEROP/OSED and also summarised in the HPAP Word Template and the HP Log "Issue-Objective-Outcome" Tab (see Appendix B). For other HP activities conducted that are not considered by SESAR as exercise (e.g.:

Cognitive Task Analysis) the HP specialist is responsible for analysing the data and, interpreting and documenting the results. A summary of the HP related results from a non-SESAR exercise are documented in the HPAP Word Template and in the HP Log “Issue-Objective-Outcome” Tab (see Appendix B),

The HP report collates the different HP activities conducted and is attached to the SPR-INTEROP/OSED.

The HP activities may identify new HP issues or benefits not already identified. If so, the new HP issue or benefit must be added to the HP Log under the appropriate related HP argument.

#### 4.5.6.3 Formulate recommendations and requirements for further concept and system development

Based on the outcomes of the HP activities, the HP specialist will formulate a set of HP recommendations and requirements for the development of the proposed ATM concept and its technical system components. It is particularly important to formulate recommendations and requirements for any results that do not support the arguments and point to unresolved or new issues.

**HP recommendations** propose means for mitigating HP issues related to a specific operational or technical change. They require additional analysis, that is, refinement and/or validation before they are mature enough to become a requirement.

**HP requirements** are statements that specify the required characteristics of the solution from an HP point of view. HP requirements should be integrated into the relevant project documentation (e.g., SPR-INTEROP/OSED, or TS/IRS). HP requirements can be seen as the stable result of the HP contribution to the Solution, leading to a redefinition of the operational concept or the specification of the technical elements.

It should be noted that:

- In V1, where the concept is still under definition and there are different possible solutions, it is preferable to produce study items, design actions recommendations and/or requirements in order to drive the design. Recommendations and requirements should be used carefully at this stage because of the poor maturity of the design and concept.
- In V2&V3, an HP recommendation could be formulated for the development of the proposed ATM concept and its technical system components.

HP recommendations and requirements fall into one of several classes, among others:

- Technical system and HMI Design (SPR-INTEROP/OSED or TS/IRS);
- Operating methods and procedures (SPR-INTEROP/OSED);
- Training of end users (SPR-INTEROP/OSED).

In addition, HP recommendations can relate to test and validation activities that need to be conducted in order to investigate issues and potential mitigations in more detail (VALR and/or SPR-INTEROP/OSED).

Guidance on how to write recommendations and requirements can be found in Appendix F.

The “Issue-Objective-Outcome” Tab in the HP Log (see Appendix B) serves to capture the HP recommendations & requirements resulting from all HP activities conducted. For SESAR exercises, the HP recommendations are also documented in the VALR and/or SPR-INTEROP/OSED.

For both ground and airborne Solutions, the HP recommendations and requirements derived from the results of the HP activities conducted need to be reviewed and agreed with the other project members (this is described in more detail in Step 4).

Once generated, all the HP recommendations and requirements are collated and documented in the HP Word Template and the HP Log, as appropriate (see Appendix B).

In addition, the HP recommendations and requirements will also be provided to the safety experts, in order to feed the safety assessment activities and, where relevant, associated requirements.

#### 4.5.6.4 Update HP Log and contribute to SESAR documentation

Once the HP activities, evidence, recommendations and requirements have been captured and documented, conclusions relating to the status of the HP objectives, issues and arguments need to be determined. Conclusions can be derived on four different levels: objectives, HP issues/benefits, arguments and concept/solution:

- Conclusion for **each validation objective**;

The HP specialist has to evaluate if the evidence obtained from the HP activity is sufficient to validate an HP objective. The evidence obtained from an HP activity is compared to the expected evidence as defined in Step 2. Based on the evidence obtained, the status of an objective can either be open, closed or cancelled. If an objective has not been addressed or if the required evidence has not been obtained by the validation activities conducted, then the validation objective is considered to be open. If the evidence obtained from the HP activity is the expected evidence as defined in Step 2 then the objective is considered closed. If an objective has become obsolete i.e. no longer relevant to concept solution, then it is cancelled. It is important to note that the required evidence as described in the argument structure in Appendix A is linked to a given V-phase. On the contrary, objectives are related to a Solution whatever the on-going V-phase.

- Conclusion for each **HP issue and benefit**;

On the basis of the evidence obtained, recommendation(s) and requirement(s) and objective status, the HP specialist has to update the status of the related HP issue/benefit. Several objectives, evidence and recommendations can be associated to a specific issue/benefit. The conclusion relating to an issue or benefit refers to whether or not the HP issue or benefit persists or not. Therefore the status of an issue can either remain open, or be closed or cancelled. New HP issues or benefits may be identified from an HP activity conducted. If so this may result in new HP requirements or recommendations. In addition, if new HP issues or benefits are identified in an HP activity conducted, the new HP issue or benefit must be added to the related HP argument in the HPAR and in the HP Log in the 'Issue-Objective-Outcome' Tab (see Appendix B).

The status of HP issues and benefits allows also to conclude on the status of arguments.

- Conclusion for each relevant **argument**

On the basis of the evidence obtained, the recommendations and requirements identified and status of the specific issues addressed, the HP specialist can then update the status of the arguments. It may be that several HP issues are linked to one HP argument. The HP specialist has to decide if an argument has been sufficiently satisfied, partially or not satisfied for the given V-phase. Whether or not the evidence supports the HP argument for a given V-phase can be determined by comparing it to the description of evidence in the argument structure in Appendix A. For some of the HP activities, the appendix provides more than one set of potential evidence. In this case, the HP specialist needs to

select the evidence that is best suited to the design of and the specific methods/tool used in the HP activity.

- Conclusion at the **concept and solution level**.

The conclusion relating to the concept and solution refers to the conclusion as to whether or not the concept and proposed solution has been successfully validated or not. The conclusion at the concept and solution level will be documented in the core document of the SPR-INTEROP/OSED. In addition, the conclusion with regards to the status of the concept in reference to the V-phase will be concluded in Step 4 of the HP assessment process (see section 3.6).

As mentioned, as well as being responsible for updating the HP Log after each HP activity (i.e. SESAR exercises and non-SESAR HP activities), the HP specialist will be required to contribute to the VALR and/or SPR-INTEROP/OSED:

→ VALR Chapter 3 “Context of the Validation”

This chapter includes information from the VALP, including validation objectives and success criteria, scenarios/events, assumptions, methods and techniques. The HP specialist must ensure the HP aspects are included.

→ VALR Chapter 4 “Validation Results”

This section summarises results of the SESAR exercise(s) conducted. The HP specialist must ensure the HP results obtained for each SESAR exercise are documented in this section.

→ VALR Chapter 5 “Conclusions and recommendations”

This chapter integrates the conclusions and recommendations from all the SESAR exercises conducted. Depending on the Solution, the conclusions and recommendations from non-SESAR exercises (i.e. additional HP activities carried out) may also be recorded in this section. This chapter provides the opportunity to synthesise and present the vision of the concept and solution from an HP perspective. The HP specialist is responsible for ensuring the HP conclusions and recommendations are fully documented in this section.

→ VALR Chapter 7 ‘Validation Exercise reports’

This chapter provides a description of each SESAR validation exercise performed by the Solution. The description of a SESAR exercise includes the scope, objectives, conduct of the validation exercise and results including analysis, the conclusions and recommendations. The HP specialist must ensure that for each SESAR exercise conducted the HP aspects are included.

→ SPR-INTEROP/OSED- Part IV Human Performance Assessment Report

HP activities conducted that are not SESAR exercises (e.g. cognitive task analysis) should be documented and included in the HP report as an appendix. The HP report will form an appendix of the OSED. (The HP Assessment report will be completed in Step 4).

Furthermore, all HP recommendations and requirements should feed into the SPR-INTEROP/OSED and TS/IRS, for example:

- Technical system and HMI Design (SPR-INTEROP/OSED and/or TS/IRS);
- Operational concept and procedures (SPR-INTEROP/OSED);
- Training of end users (SPR-INTEROP/OSED).

However, it should be noted that all recommendations and requirements shall be consolidated and accepted by the project team before they are integrated in the SPR-INTEROP/OSED or TS/IRS.

In case the requirements lead to changes to the SPR-INTEROP/OSED and, thus, the solution description, the modified solution will be subject to validation in this or the next V-phase.

## 4.6 Step 4: Collate findings and conclude on transition to next V-phase

### 4.6.1 Objectives

The objective of Step 4 is to collate the findings from the HP activities conducted to ensure traceability and decide whether all the required HP activities have been carried out to satisfy the HP arguments for the given V-phase. If so, the HP assessment for the given V-phase can be closed and the HP report finalised. If necessary, the HP specialist must also participate in the development of the HP case. Furthermore, the HP recommendations and requirements must be managed to ensure they are used to support the development of the solution/concept.

### 4.6.2 Tasks to be performed

The following tasks need to be carried out by the HP specialist:

1. Assess whether sufficient evidence has been gathered;
2. Conclude on transition to next V-phase;
3. Produce the HP assessment report (update HP Log) and if necessary support the development of the HP case;
4. Manage the HP recommendations and requirements.

These tasks will be described in more detail in the subsequent guidance section (Chapter 4.6.6).

### 4.6.3 Input

The following input is required to carry out Step 4:

1. List of planned HP activities/HP assessment plan (from Step2);
2. Description of HP activities conducted (VALR or HP specific deliverable relating to an HP activity conducted by the HP specialist (from Step 3));
3. Updated HP arguments, issues/benefits & impacts (including newly identified argument, issues & benefits, outcomes of the HP activities) (i.e. the updated HP Log from Step 3);
4. Register of HP recommendations and requirements (i.e. the updated HP Log (from Step 3)).

### 4.6.4 Output

The following output of Step 4 is expected:

1. Completed maturity checklist for the appropriate V-phase (can be found in the HP Log in the dedicated tabs for each V-phase) to document and determine whether the HP assessment for a given V-phase can be finalised and closed;
2. HP assessment report for a given V-phase;
3. Updated HP recommendations and requirements in the HP Log.

#### 4.6.5 Support material

- The HP Log (see Appendix B);
- HP Assessment Plan Template (see Appendix B)
- HP report template (see Appendix B);
- Maturity checklist questions for the relevant V-phase (V1, V2 or V3) to document the decision to complete the HP assessment for a given V-phase (see appendix D or HP Log).

#### 4.6.6 Guidance on Step 4 Tasks

##### 4.6.6.1 Assess whether sufficient evidence has been gathered

The decision of the HP specialist to finalise the HP assessment will be primarily based on the comparison between the HP assessment plan/HP Log (i.e. the list of required HP activities) and the description of conducted HP activities: If all HP activities specified in the HP assessment plan have been carried out and all the required evidence obtained, the HP assessment can, in general, be considered as completed. There are however, additional considerations to be made:

- *An HP activity that was conducted in line with the HP assessment plan may have failed to provide the required evidence.*

For instance, checking the proposed display of visual information against the “Guidelines for effective information presentation” may result in the conclusion that those guidelines have not been followed and that the display is not satisfying from an HP point of view. Likewise, carrying out a Real-Time Simulation on the impact of the new concept on the operator’s workload may have yielded the finding of a significant increase in operator’s workload in certain operational situations.

In case of an HP activity failing to deliver the required evidence, the adverse finding will (a) be highlighted in the description of HP results, and (b) result in recommendations and, possibly requirements for further concept development or validation activities:

- Recommendations, and possibly requirements, relating to further concept development, require iteration between Step 3 (in which the recommendations and requirements are formulated) and Step 1 (by changing the proposed solution in such a way that the requirements and recommendations are reflected in the concept design). To ensure that the recommendations and requirements are sufficiently considered in the future design and development of the concept, they should feed into the SPR and if appropriate, into updating the SPR-INTEROP/OSED, or TS/IRS.
- Recommendations relating to validation activities require iteration between Step 3 and Step 2 (i.e. updating the list of HP issues and benefits along with the list of necessary HP activities recommended).

Once formulated, the recommendations need to be managed and tracked by the HP specialist. To do so, the HP specialist will work with other project members (e.g. project manager, procedures team, designers of the technical system, safety experts) to decide and agree on appropriate actions related to an HP recommendation. For example, the project could decide to perform additional HP activities in the given V-phase in order to gather the required evidence and to complete the HP assessment. Alternatively, the project may decide to address the recommendations for future activities in a later stage of the project. Note that the number of ‘open’ recommendations and requirements and their ‘severity’ provide an important indication on the maturity of the concept which allows the project to transition to the next V-phase or not.

- *HP activities have not been fully conducted as specified in the HP assessment plan.*

In this case, the HP assessment for that given V-phase should – as a general guideline - not be closed. Nevertheless, there may be pressure on the project to transition to the next V-phase, even if not all the HP activities are fully completed. In this case, it is important for the HP specialist to clearly indicate which HP arguments are still ‘open’ and not yet supported by evidence and which remaining HP activities need to be addressed in the following V-phase. As described earlier, the number and severity of ‘open’ HP arguments have an impact on the maturity of the concept and hence whether or not the project can move on to the next phase.

The “Issue-Objective-Outcome” Tab in the HP Log (see Appendix B) and the HPAR Word Template should be used to capture which HP activities have been carried out and the supporting evidence that has been gathered.

#### 4.6.6.2 Conclude on transition to the next V-phase

The goal of this task is to conclude, from an HP point of view, whether or not a concept can transition to the next V-phase, given the evidence obtained from the HP activities conducted. Therefore based on whether sufficient evidence has been produced to support the HP arguments, the HP specialist will conclude whether or not s/he can recommend the Solution’s transition to the next V-phase from an HP perspective.

The decision on whether or not sufficient evidence has been obtained to allow the transition to the next V-phase will be made on the basis of the set of questions on the maturity checklists for each V phase in Appendix D (also in the HP Log). Note that the transition questions in this template are on a higher level of abstraction than the comparison of required and actual evidence described as part of the previous task. Nevertheless, when answering the questions in, Appendix D the HP specialist should base his/ her responses on the comparison between required and actual evidence related to an HP argument. The set of transition questions serves as a final checklist for the HP specialist to decide whether or not to render a positive decision on the finalisation of the given V-phase. For ground based projects this checklist is then inserted into the HP assessment report template and the conclusions from the completed checklist documented (see Appendix B for the HP assessment report template).

#### 4.6.6.3 Produce the HP assessment report

The HP assessment report provides a summary of an HP assessment process and HP activities conducted for the Solution. It also provides a formal documentation of the conclusions drawn relating to HP maturity of the concept and the ‘next steps’ required on the project regarding HP aspects (see HP Assessment Report template in Appendix B).

As described in the introduction of this document, the HP assessments for SESAR Solutions and SESAR Projects will be combined to form HP cases at the level of larger clusters (e.g. operational sub-

packages, deployment packages). It is expected that the HP specialist remains a point of contact to answer any questions regarding the HP assessment conducted at the Solution or Project level.

#### 4.6.6.4 Manage HP recommendations and requirements

Once the HP assessment report is produced, the HP specialist is responsible for managing the follow-up of the HP recommendations and requirements.

The management of the recommendations begins with the production of recommendations. All HP recommendations and requirements identified from the HP activities conducted should be captured in the dedicated Appendix of the HPAR and correspondingly in the dedicated tabs –n the HP Log (see Recommendations and Requirements tabs Appendix B

As soon as a recommendation is incorporated in the HPAR Word Template or the HP Log, it acquires a status. This status of a recommendation depends on the decision made by the project team (including the HP specialist) regarding the related issue and proposed recommendation to mitigate or prevent the issue. The HP specialist will work with other project members (e.g. project manager, safety team, procedures team, designers of technical systems) to decide on appropriate actions related to an HP recommendation or requirement. The decision made by the projects team is based on a negotiation involving all team members to ensure that proposed recommendation is the best and the most feasible solution.

If a recommendation is rejected by the project team a rationale shall be provided and an alternative mitigation means shall be defined. This information is captured in the HPAR Word template and in the HP recommendations in the HP log.

In the same way, requirements have to be considered by all the actors of the project team. If a requirement is rejected by the project team a rationale shall be provided and an alternative mitigation means shall be defined if applicable. Nevertheless, a follow-up is required in order to know when and how the requirement is applied. The way a requirement is applied has to be determined and confirmed by the HP specialist.

The follow up of recommendations and requirements is part of the V&V process and shall be regularly reviewed by the project team throughout the project lifecycle.

## 5 Synergies with other Transversal Areas

Human Performance can, in some way, be seen as an enabler for the other Transversal Areas (TAs), in particular, Safety (e.g. Scope and Change Assessment" Process) and Security. Only if the human actors can fulfill their roles and responsibilities and perform their tasks to an acceptable level, Safety and Security targets can be met.

The HP assessment process includes three types of links with Safety and/or Security assessments:

1. *Inclusion of Safety and Security targets on human tasks in the HP argument structure.* The HP argument structure contains argument branches on the satisfaction of Safety and Security target levels. The reasoning behind these arguments is that Safety or Security assessments may have identified human tasks that – if not carried out to certain accuracy standards – could compromise the Safety or Security of the ATM system. Accuracy standards on human tasks are likely to be formulated in terms of human error. In case Safety or Security have set such targets for certain human tasks, the plausibility of these targets (i.e. the likelihood that human actors will be able to achieve the targets) will be assessed by HP. The activities to assess the plausibility of HP target levels are Cognitive Task Analysis, Human Reliability Analysis, and collection of performance data in Real-Time Simulation and operational trials.
2. *Identification of activities that are shared with other TAs.* A number of the required HP activities will not be under the responsibility of the HP specialist, but will be carried out jointly with other TAs. So far, shared TA activities have been mainly identified for Safety. In order to identify which activities could be carried out as a common activity, it is mandatory that the HP specialist and the Safety specialist coordinate their TA plans (i.e. HP and Safety Plan). Some shared activities concern):
  - *Identification of normal and abnormal operating conditions.* The identification of situations that need to be covered as part of normal and abnormal operating conditions will be carried out in close coordination between HP and Safety. The HP assessment will provide evidence that human operators can fulfil their tasks under all identified operating conditions.
  - *Identification of degraded modes of the system under investigation.* The identification of degraded modes of the proposed ATM system will be provided by Safety. The HP assessment will provide evidence that human operators can fulfil their tasks under all identified degraded modes of the system.
  - *Real-Time Simulations and operational trials.* Real-Time Simulations and operational trials are usually planned and conducted by a validation team. For the specification of simulation objectives, operational scenarios to be used and the data to be collected, though, the validation team will require input from the HP and Safety experts. In order to align their views about what specifically should be investigated in simulation, close coordination between the safety and the HP expert is needed.
3. *Contribution of other TA specialists to HP activities and vice versa.* For some of the HP activities, input from other TAs (in particular, Safety) may be needed. The following relevant inputs to HP activities have been identified:
  - *Identification of HP issues and benefits.* If the HP issues and benefits identification is done in a group workshop, it is recommended to invite a Safety specialist and, potentially, a Security specialist. All identified HP issues and benefits – whether elicited in a group workshop or not

- should be fed back to the Safety specialist. In the same way, issues identified by Safety should be fed back to the HP specialist.
- *Conduct of task analysis.* Although having a somewhat different focus, task analyses (as carried out by HP) and thread analysis (as carried out by Safety) both model information flows between various human and non-human actors. To reduce the effort involved in the conduct of task and thread analyses respectively, it is recommended that information is shared between HP and Safety from the early stages of the activity on.
- *Identification and analysis of human error.* Although the identification of likely human errors - based on an analysis of the cognitive demands associated with a task - is the core expertise of HP specialist, some input from Safety may be needed when analysing human error. This is particularly true if the impact of human error on the Safety of the ATM system is considered. For instance, Safety uses fault trees which model the contribution of human error to accidents and incidents in the current ATM system. These fault trees can facilitate the identification of human error in the proposed ATM concept and the assessment of their impact on accidents and incidents.

## 6 References

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## Appendix A    Appendix Heading

### A.1 - HP Arguments, HP Activities and Required Evidence for V1, V2 and V3

| Top-level Argument: The contribution of the human in the ATM system will support the expected ATM system performance |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                       |
|----------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Arg. 1: The role of the human is consistent with human capabilities and limitations                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                       |
| Arg. 1.1 Roles and responsibilities of human actors are clear and exhaustive.                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                       |
|                                                                                                                      | HP Activity:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Evidence (i.e. Success Criteria):                                                                                                                                                                                                                                                                                                     |
| Arg. 1.1.1: The description of roles & responsibilities cover all affected human actors.                             | Identify/update human actors likely to be impacted by the change & check against the description of roles and responsibilities.                                                                                                                                                                                                                                                                                                                                                                                                                                | <p>V1:<br/>-Preliminary description of roles and responsibilities likely to be impacted by the change has been established to contain all affected human actors.</p> <p>V2&amp; V3:<br/>-Description of roles and responsibilities likely to be impacted by the change has been established to contain all affected human actors.</p> |
| Arg. 1.1.2: The description of roles & responsibilities cover all tasks to be performed by a human actor.            | <p>V1:<br/>-Identify tasks to be performed by the affected human actors using high level Task Analyses to identify potential role changes in the solution compared to roles in the reference scenario &amp; check against the description of roles and responsibilities.</p> <p>V2&amp;V3:<br/>-Identify/update tasks to be performed by the affected human actors using Task Analyses to identify role changes in the solution scenario(s) compared to roles in the reference scenario &amp; check against the description of roles and responsibilities.</p> | <p>V1:<br/>-For each human actor likely to be affected by the change, a preliminary description of roles and responsibilities has been established</p> <p>V2&amp;V3:<br/>-For each human actor likely to be affected by the change, the description of roles and responsibilities and tasks has been established</p>                  |
| Arg. 1.1.3: Roles and responsibilities are clear and consistent (in V1: non-contradictory).                          | <p>V1:<br/>-Review preliminary roles and responsibilities to ensure they are clear and non-contradictory. The review should be carried out with end users, if necessary supported by native speakers/linguistic experts.</p>                                                                                                                                                                                                                                                                                                                                   | <p>V1:<br/>-Preliminary descriptions of roles and responsibilities have been determined to be clear and non-contradictory by end users</p>                                                                                                                                                                                            |



|                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                               | <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Review roles and responsibilities to ensure they are clear and consistent. The review should be carried out with end users, if necessary supported by native speakers/linguistic experts</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                 | <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Roles &amp; responsibilities have been determined to be clear and consistent by end users and linguistic experts.</li> </ul>                                                                                                                                                                                                                                                     |
| Arg. 1.2: Operating methods (procedures) are exhaustive and support human performance.        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|                                                                                               | <b>HP Activity:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <b>Evidence (i.e. Success Criteria):</b>                                                                                                                                                                                                                                                                                                                                                                                                   |
| Arg. 1.2.1: Operating methods (procedures) cover operations in normal operating conditions.   | <p>V1:</p> <ul style="list-style-type: none"> <li>-Identify situations that constitute normal operating conditions in cooperation with the safety and operational specialists</li> <li>-Determine preliminary needs/requirements relating to operating methods</li> </ul> <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Identify/update situations that constitute normal operating conditions in cooperation with the safety and operational specialists &amp; check against the scope of the operating methods.</li> <li>-Liaise with procedure team (operational experts) to define operating methods for normal operating conditions if necessary.</li> </ul> | <p>V1:</p> <ul style="list-style-type: none"> <li>-Normal operating conditions are defined.</li> <li>-Where possible initial needs/ requirements relating to the operating methods for normal operating conditions may be identified</li> </ul> <p>V2 &amp; V3:</p> <ul style="list-style-type: none"> <li>-Operating methods are found to cover identified normal operating conditions</li> </ul>                                         |
| Arg. 1.2.2: Operating methods (procedures) cover operations in abnormal operating conditions. | <p>V1:</p> <ul style="list-style-type: none"> <li>-Define situations that constitute abnormal operating conditions in cooperation with the safety and operational specialists</li> <li>-Identify initial needs/requirements relating to operating methods</li> </ul> <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Identify/update situations that constitute abnormal operating conditions in cooperation with the safety and operational specialists &amp; check against the scope of operating methods.</li> <li>-Liaise with procedure team (operational experts) to define operating methods for abnormal operating conditions if necessary.</li> </ul>      | <p>V1:</p> <ul style="list-style-type: none"> <li>-Provisory abnormal operating conditions are identified where possible</li> <li>-Where possible initial needs/ requirements relating to the operating methods for the abnormal operating conditions may be identified</li> </ul> <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Operating methods are found to cover the identified abnormal operating conditions.</li> </ul> |



|                                                                                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                               |
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| Arg. 1.2.3: Operating methods(procedures) cover degraded modes of the ATM system.                             | <p>V1:<br/>-Define situations that constitute degraded modes of operation in cooperation with the safety and operational specialists -<br/>-Identify initial needs/requirements relating to operating methods</p> <p>V2&amp;V3<br/>-Identify/update situations that constitute degraded modes of operation in cooperation with the safety and operational specialists &amp; check against the scope of operating methods.<br/>-Liaise with procedure team (operational experts) to define operating methods for degraded modes if necessary.</p> | <p>V1:<br/>-Provisory degraded modes of operations are identified.<br/>-Where possible initial needs/ requirements relating to the operating methods for the degraded modes may be identified</p> <p>V2&amp;V3<br/>-Operating methods are found to cover identified operations in degraded modes.</p>         |
| Arg. 1.2.4: The content of operating methods (procedures) is clear and consistent (in V1: non-contradictory). | <p>V1:<br/>-Review operating methods to ensure they are clear and non-contradictory. The review should be carried out with end users, if necessary supported by native speakers/linguistic experts</p> <p>V2&amp;V3:<br/>-Review operating methods to ensure they are clear and consistent. The review should be carried out with end users, if necessary supported by native speakers/linguistic experts.</p>                                                                                                                                   | <p>V1:<br/>-If preliminary operating methods are defined the content has been determined to be clear and non-contradictory by end users.</p> <p>V2 &amp; V3:<br/>-The content of the operating methods has been determined to be clear and consistent by end users and native speakers/linguistic experts</p> |
| Arg. 1.2.5: Operating methods (procedures) can be followed in an accurate, efficient and timely manner.       | See HP activities for Argument 1.3.1<br><i>Not applicable in V1</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | See evidence for Argument 1.3.1<br><i>Not applicable in V1</i>                                                                                                                                                                                                                                                |
|                                                                                                               | See HP activities for Argument 1.3.2<br><i>Not applicable in V1</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | See evidence for Argument 1.3.2<br><i>Not applicable in V1</i>                                                                                                                                                                                                                                                |
|                                                                                                               | See HP activities for Argument 1.3.3<br><i>Not applicable in V1</i>                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | See evidence for Argument 1.3.3<br><i>Not applicable in V1</i>                                                                                                                                                                                                                                                |



| Arg. 1.3: Human actors can achieve their tasks (in normal & abnormal conditions of the operational environment and degraded modes of operation). |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                                                                                                                  | HP Activity:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | Evidence (i.e. Success Criteria):                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Arg. 1.3.1: The potential for human error is reduced to a tolerable level                                                                        | <p><b>V1:</b><br/>-If possible, identify changes to the potential for human error using high level Task Analysis and/or focus groups with end users (e.g. review of low fidelity mock-ups, HP Issue Analysis, HAZOPs) and where appropriate, identify preliminary mitigation.</p> <p><b>V2:</b><br/>-Identify changes to the potential for human error using (Cognitive) Task Analysis and/or focus groups with end users (e.g. review of mock-ups, HP Issue Analysis, HAZOPs) and identify preliminary mitigation</p> <p><b>V2&amp;V3:</b><br/>-Review errors and recovery means in the solution ATM system (e.g. using fault trees of Accident/Incident Models) &amp; compare with likely errors and recovery means in the reference ATM system.</p> | <p><b>V1&amp;V2:</b><br/>- Where possible, potential changes to human error and preliminary mitigation have been identified for consideration by the safety/project team.</p> <p><b>V2&amp;V3:</b><br/>-[GND only] Number of errors in the solution not significantly higher than in reference scenario, taking into account error type &amp; operational impact.<br/>-Number and/or severity of errors in the solution is within tolerable limits<br/>-Recovery means for errors in the solution minimise operational impact.</p> |
|                                                                                                                                                  | <p><b>V2&amp;V3:</b><br/>-Perform Cognitive Walkthrough on prototype with identification of likely errors.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <p><b>V2&amp;V3:</b><br/>-Cognitive Walkthrough did not identify concerns related to the error potential.</p>                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                                                                                                                                                  | <p><b>V2&amp;V3:</b><br/>-Perform or update (Cognitive) Task Analysis with identification of likely errors/error types and recovery means.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <p><b>V2&amp;V3:</b><br/>-[GND only] Less (or the same) potential for errors in the solution than in the reference, taking into account error type &amp; operational impact.<br/>-Potential for errors is within acceptable limits, taking into account error type &amp; operational/safety impact.<br/>-Recovery means for errors in the solution minimise operational impact.</p>                                                                                                                                                |
|                                                                                                                                                  | <p><b>V2&amp;V3:</b><br/>-[GND only] Perform Human Reliability Analysis.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | <p><b>V2&amp;V3: [GND only]</b><br/>-Likelihood of errors in the solution not significantly higher than in the reference</p>                                                                                                                                                                                                                                                                                                                                                                                                       |



|                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                             |
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|                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                          | <p>-Likelihood of errors in the solution is within acceptable limits</p> <p>-Likelihood of errors is reduced as far as possible in the solution.</p>                                                                                                                                                                                                                                                        |
|                                                       | <p>V2&amp;V3:<br/>Assess errors and recovery means in Real-Time Simulation<sup>10</sup> or operational trials <sup>11</sup> :</p> <p>-objective methods: observations, data recordings</p> <p>-subjective methods: interviews, debriefings.</p> <p>&amp; analyse operational impact of errors with safety specialists</p>                                                                                                                | <p>V2&amp;V3:<br/>-[GND only] Number of errors in the solution not significantly higher than in reference scenario, taking into account error type &amp; operational impact.</p> <p>-Number and/or severity of errors in the solution is within acceptable limits.</p> <p>-Recovery means for errors in the solution minimise operational impact.</p>                                                       |
| Arg. 1.3.2: Tasks can be achieved in a timely manner. | <p>V1:<br/>-Identify potential task changes through the use of high level task analysis and/or the use of low fidelity mock-ups with end users</p> <p>V2:<br/>-Identify potential task changes through the use of task analysis and/or the use of mock-ups with end users</p> <p>V2&amp;V3:<br/>-Assess timeliness of actions in Real-Time Simulation or operational trials</p> <p>-objective methods: observations, data recordings</p> | <p>V1&amp;V2:<br/>-Potential changes to the end users tasks are achievable within an acceptable time frame (acceptable can be defined based on end users opinion and good HF practice)</p> <p>V2&amp;V3:<br/>-Tasks are effectively achieved</p> <p>-[GND only] Number of late actions not higher in the solution than in the reference scenario, taking into account the consequence of a late action.</p> |

<sup>10</sup> Whenever Real Time Simulations are listed as HP activity, it is assumed that they are to be carried out with representatives end users and under sufficient realistic operational condition

<sup>11</sup> Whenever Operational trials are listed as HP activity in V2, it is assumed that they are passive shadow mode trials (i.e. active shadow mode trials are not conducted in V2) .



|                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
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|                                                                                                      | -subjective methods: interviews, debriefings.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | -Number of late actions are within acceptable limits, taking into account the consequences of a late action.                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Arg. 1.3.3: The level of workload (induced by cognitive and/or physical task demands) is acceptable. | <p>V1&amp;V2:</p> <ul style="list-style-type: none"> <li>-Identify potential changes to workload/task demands using high level Task Analysis and/or focus groups with end users (e.g. HP Issue Analysis, review of low fidelity mock-up)</li> <li>- Where potential changes in workload/task demands are considered unacceptable, identify preliminary mitigation</li> </ul> <p>V2&amp; V3:</p> <p>Assess workload and underlying factors in Real-Time Simulation and or operational trials:</p> <ul style="list-style-type: none"> <li>-subjective methods: questionnaires</li> <li>-objective methods: data recordings</li> </ul>                                                                                                                              | <p>V1&amp;V2: The potential changes to the level of workload/task demands and the preliminary mitigation identified are acceptable (acceptable can be defined based on end users opinion and good HF practice relating to workload)</p> <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Level of workload not significantly higher in the solution than in the reference scenario.</li> <li>-Level of workload within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment).</li> </ul> |
| Arg. 1.3.4: The level of trust in the new concept/the new procedures is appropriate.                 | <p>V1:</p> <ul style="list-style-type: none"> <li>- If possible, identify factors that will impact upon trust relating to the new concept using focus groups with end users and where possible identify preliminary mitigation</li> </ul> <p>V2:</p> <ul style="list-style-type: none"> <li>-Identify factors that will impact upon trust using (Cognitive) Task Analyses and/ or focus groups with end users e.g. HP Issue Analysis, review of mock-up) and identify preliminary mitigation</li> </ul> <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Assess trust in Real-Time Simulation or operational trials:</li> <li>- objective methods: observations, data recordings (tool usage)</li> <li>- subjective methods: questionnaires.</li> </ul> | <p>V1&amp;V2:</p> <ul style="list-style-type: none"> <li>-Potential issues related to trust and the preliminary mitigation identified are acceptable</li> </ul> <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-[GND only] Level of trust not significantly lower in the solution than in the reference scenario.</li> <li>-Level of trust experienced as sufficient by the end user.</li> </ul>                                                                                                                                        |
| Arg. 1.3.5: Human actors can maintain a sufficient level of situation awareness.                     | <p>V1:</p> <ul style="list-style-type: none"> <li>-Identify factors that will impact upon situational awareness using high level Task Analysis and/or focus groups with end users (e.g. HP Issue Analysis, review of low fidelity mock-up) and where possible identify preliminary mitigation</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                         | <p>V1&amp;V2 :</p> <ul style="list-style-type: none"> <li>-Potential changes to situation awareness and the preliminary mitigation identified are acceptable (acceptable can be defined based on end users</li> </ul>                                                                                                                                                                                                                                                                                                                             |



|                                                                                                                  |                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
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|                                                                                                                  | <p>V2:<br/>-Identify factors that will impact upon situational awareness using (Cognitive)Task Analysis and/or focus groups with end users (e.g. HP Issue Analysis, review of mock-up) and identify preliminary mitigation</p> <p>V2&amp;V3:<br/>-Assess situational awareness in Real-Time Simulation or operational trials:<br/>-subjective methods: questionnaires<br/>-objective methods: situational awareness probes.</p> | <p>opinion and good HF practice relating to situation awareness)</p> <p>V2&amp;V3:<br/>-[GND only] Level of situational awareness not lower in the solution than in the reference scenario.<br/>-Level of situational awareness within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment).<br/>-User is able to perceive and interpret task relevant information and anticipate future events/actions.</p> |
| <p><i>Not Applicable in V1</i></p> <p>Arg. 1.3.6: Human performance satisfies the expected TA target levels.</p> |                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| Arg. 1.3.6.1: Safety requirements on human performance are satisfied.                                            | <p>Check and provide input to Safety Requirements (if any), based on data from:</p> <ul style="list-style-type: none"> <li>- Cognitive Task Analysis (CTA);</li> <li>- Human Reliability Analysis (HRA); or</li> <li>- Real-Time Simulations (RTS).</li> <li>- Operational Trials</li> </ul>                                                                                                                                    | The results of the CTA, HRA and/or RTS are consistent with the safety requirements on human performance.                                                                                                                                                                                                                                                                                                                                                      |
| Arg. 1.3.6.2: Security requirements on human performance are satisfied.                                          | <p>Check and provide input to Security Requirements (if any), based on data from:</p> <ul style="list-style-type: none"> <li>- Cognitive Task Analysis (CTA);</li> <li>- Human Reliability Analysis (HRA); or</li> <li>- Real-Time Simulations (RTS).</li> <li>- Operational Trials</li> </ul>                                                                                                                                  | The results of the CTA, HRA and/or RTS are consistent with the security requirements on human performance.                                                                                                                                                                                                                                                                                                                                                    |



| Arg. 2: Technical systems support the human actors in performing their tasks.                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Arg. 2.1: There is an appropriate allocation of tasks between the human and machine (i.e. level of automation). |                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                   |
|                                                                                                                 | HP Activity:                                                                                                                                                                                                                                                                                                                                                                                                                               | Evidence (i.e. Success Criteria):                                                                                                                                                                                                                                                                                                                                                                 |
| Arg. 2.1.1: The task allocation between the human and the machine is consistent with automation principles.     | <p>V1:<br/>-If possible, identify preliminary task allocation needs/requirements with respect to consistency with deliverable of 16.5.1 'Guidance material for HP automation support '12 and/ or other automation guidelines.</p> <p>V2 &amp; V3:<br/>-Identify or update task allocation with respect to consistency with deliverable of 16.5.1 'Guidance material for HP automation support '12 and/ or other automation guidelines.</p> | <p>V1:<br/>-Preliminary task allocation needs/requirements identified are consistent with deliverables of 16.5.1 "Guidance material for HP automation support ', and/ or other automation guidelines.</p> <p>V2&amp; V3:<br/>-Task allocation is found to be consistent with good deliverables of 16.5.1, 'Guidance material for HP automation support ', and/ or other automation guidelines</p> |
| Arg. 2.1.2: Changes to the task allocation between human and machine support human performance.                 | <p>V1:<br/>-If possible, identify preliminary task allocation needs/requirements with respect to consistency with deliverable of 16.5.2 -Trade-off between planning and flexibility. 12</p> <p>V2 &amp; V3:<br/>Identify or update task allocation with respect to consistency with deliverable of 16.5.2<sup>12</sup> (trade-off between planning and flexibility)</p>                                                                    | <p>V1:<br/>-Preliminary task allocation needs/requirements are consistent with deliverable of 16.5.2.</p> <p>V2&amp;V3:<br/>-The task allocation is consistent with deliverable of 16.5.2.</p>                                                                                                                                                                                                    |
|                                                                                                                 | V1:                                                                                                                                                                                                                                                                                                                                                                                                                                        | V1:                                                                                                                                                                                                                                                                                                                                                                                               |

<sup>12</sup> The SESAR 16.5.x deliverables can be found on Stellar <https://stellar.sesarju.eu/>



|                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
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|                                                                                                                                                                                                                                    | <p>-If possible, perform high level Task Analysis to identify the potential impact of the changes in task allocation on task demands and potential for human error</p> <p>-If possible, review low fidelity mock-ups with end users to identify the potential impact of the changes in task allocation on task demands and potential for human error</p> <p>V2:</p> <p>-Perform (Cognitive) Task Analysis to identify cognitive/ task demands, potential error, and recovery means</p> <p>V3:</p> <p>-Perform or update Cognitive Task Analysis to identify cognitive demands, potential error, and recovery means</p> | <p>-There are no potential adverse effects on human tasks identified in terms of task demand or potential human error</p> <p>V2:</p> <p>-There are no adverse effects on human tasks in terms of an increase in cognitive/ task demand or potential errors.</p> <p>-Task demands and potential errors are minimised and recovery means reduce operational impact.</p> <p>V3:</p> <p>-There are no adverse effects on human tasks in terms of an increase in cognitive demand or potential errors.</p> <p>-Cognitive demands and potential errors are minimised and recovery means reduce operational impact</p> |
|                                                                                                                                                                                                                                    | See HP activities for Argument 1.3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | See evidence for Argument 1.3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <p><i>Not applicable in V1</i></p> <p>Arg. 2.1.3: Transition from automatic to manual modes and vice versa, human-intended or failure induced, can be performed by the human actors in a timely, efficient and accurate manner</p> | <p>V2: Perform (Cognitive) Task Analysis on transition tasks to identify cognitive/ task demands, potential error, and recovery means.</p> <p>V3: Perform/ Update Cognitive Task Analysis on transition tasks to identify cognitive demands, potential error, and recovery means</p>                                                                                                                                                                                                                                                                                                                                   | <p>V2:</p> <p>-There are no excessive cognitive/task demands or potential for error in transition tasks.</p> <p>V3:</p> <p>-There are no excessive cognitive demands or potential for error in transition tasks.</p>                                                                                                                                                                                                                                                                                                                                                                                            |
|                                                                                                                                                                                                                                    | <p>V2&amp;V3:</p> <p>Assess timeliness and accuracy of transition actions in Real-Time Simulation or operational trials with:</p> <p>-objective methods: observations, data recordings</p> <p>-subjective methods: interviews, debriefings.</p> <p>&amp; analyse operational impact with safety specialists.</p>                                                                                                                                                                                                                                                                                                       | <p>V2&amp;V3:</p> <p>-[GND only] Number and/or impact of late actions not higher in the solution than in the reference scenario.</p> <p>-Number and/or impact of late actions is within acceptable limits.</p> <p>-[GND only] Number and/or severity of errors in the solution not higher than in reference scenario.</p>                                                                                                                                                                                                                                                                                       |



|                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
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|                                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | -Occurrence and/or severity of errors is within acceptable limits, taking into account error type & operational impact.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Arg. 2.1.4: The level of workload (induced by the allocation of tasks between the human and the machine) is acceptable. | <p>V1:</p> <ul style="list-style-type: none"> <li>- If possible, identify potential changes to the level of workload/task demands using high level Task Analysis and/or focus groups and/or through the review of (low fidelity) mock-up with end users.</li> <li>- If the identified changes to workload/task load are considered unacceptable identify preliminary mitigation requirements.</li> </ul> <p>V2:</p> <ul style="list-style-type: none"> <li>- Identify potential changes to the level of workload/task demands and/or cognitive demands using (Cognitive) Task Analysis and/or focus groups and/or through the review of mock-up with end users.</li> <li>- If the identified changes to workload/task load are considered unacceptable identify mitigation requirements.</li> </ul> <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Assess workload and underlying factors in Real-Time Simulation or operational trials with:</li> <li>-subjective methods: questionnaires</li> <li>-objective methods: data recordings.</li> </ul> | <p>V1:</p> <ul style="list-style-type: none"> <li>-The potential changes to the level of workload/task demands and the preliminary mitigation identified are acceptable (acceptable can be defined based on end users opinion and good HF practice relating to workload)</li> </ul> <p>V2:</p> <ul style="list-style-type: none"> <li>-The potential changes to the level of workload/task demands and/or cognitive demands and the mitigation identified are acceptable (acceptable can be defined based on end users opinion and good HF practice relating to workload)</li> </ul> <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Level of workload is not significantly higher in the solution than in the reference scenario.</li> <li>-Level of workload within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment).</li> </ul> |
| Arg. 2.1.5: Human actors can acquire an adequate mental model of the machine and its automated functions.               | <p>V1&amp;V2:</p> <ul style="list-style-type: none"> <li>-If possible, identify potential changes to the ability to acquire an adequate mental model using focus groups and/or through the review of low fidelity mock-up with end users.</li> </ul> <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Assess end users' understanding of the technical system's behaviour using think-aloud methods, questionnaires and debriefings in Real Time Simulations or operational trials.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | <p>V1&amp;V2:</p> <ul style="list-style-type: none"> <li>-Where possible, initial needs/requirements to support end-users acquisition of a mental model of the automated function are identified</li> </ul> <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Understanding of the technical system's behaviour is consistent with the operator's task demands.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| Arg. 2.1.6: The level of trust in automated functions is appropriate.                                                   | <p>V1&amp;V2:</p> <ul style="list-style-type: none"> <li>-Identify factors that will impact upon trust relating to the new concept using focus groups with end users and where possible identify preliminary mitigation requirements</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <p>V1&amp;V2:</p> <ul style="list-style-type: none"> <li>-Potential issues related to trust and the preliminary mitigation identified are acceptable (acceptable can be</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |



|                                                                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                         |
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|                                                                                                         | <p>V2&amp;V3:</p> <p>-Assess trust in automated functions in Real-Time Simulation or operational trials using data recordings and observations.</p>                                                                                                                                                                                                                                                                                                                                                                              | <p>defined based on end users opinion and good HF practice relating to workload)</p> <p>V2&amp;V3:</p> <p>-[GND only] Level of trust is not lower in the solution than in the reference scenario.</p> <p>-Level of trust supports the usage of automated functions.</p> |
| Arg. 2.2: The performance of the technical system supports the human in carrying out their task.        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                                                                                                                                                                                                         |
|                                                                                                         | <b>HP Activity:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | <b>Evidence (i.e. Success Criteria):</b>                                                                                                                                                                                                                                |
| Arg. 2.2.1: The accuracy of information provided by the system is adequate for carrying out the task.   | <p>V1&amp; V2:</p> <p>-If possible, identify initial performance needs/requirements of the technical system (accuracy &amp; timeliness of information provided) by performing high level Task Analyses and focus groups with end users.</p> <p>V2:</p> <p>-Perform (Cognitive) Task Analysis comparing system provided information with information requirements of the human.</p> <p>V3:</p> <p>Perform or update Cognitive Task Analysis comparing system provided information with information requirements of the human.</p> | <p>V1&amp;V2:</p> <p>Where possible initial system performance needs/requirements (accuracy of information provided by the system) are identified</p> <p>V2&amp;V3:</p> <p>-The system output is in line with the information needs of the human.</p>                   |
|                                                                                                         | <p>V2&amp; V3:</p> <p>-Assess information accuracy in prototyping sessions or Real-Time Simulation or operational trials with:</p> <p>-objective methods: observations</p> <p>-subjective methods: questionnaires, debriefings.</p>                                                                                                                                                                                                                                                                                              | <p>V2&amp; V3:</p> <p>-[GND only] Information accuracy ratings not lower in the solution than in the reference scenario.</p> <p>-Information accuracy experienced as sufficient by the end user.</p>                                                                    |
| Arg. 2.2.2: The timeliness of information provided by the system is adequate for carrying out the task. | <p>V1&amp;V2:</p> <p>-If possible, identify initial performance needs/requirements of the technical system (accuracy &amp; timeliness of information provided) by performing high level Task Analyses and focus groups with end users.</p> <p>V2:</p>                                                                                                                                                                                                                                                                            | <p>V1&amp;V2:</p> <p>-Where possible, initial system performance needs/requirements (timeliness of information provided by the system) are identified</p> <p>V2:</p>                                                                                                    |



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|                                                                                                     | -Perform (Cognitive) Task Analysis comparing system provided information with information requirements of the human.<br><br>V2&V3:<br>-Perform/update Timeline Analysis.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | -System performance needs (timeliness of information provided by the system) are identified<br><br>V2&V3:<br>-The system provides the information in time for the user to carry out their task.                                                                                              |
|                                                                                                     | V2&V3:<br>-Perform expert-based analytical techniques using digital simulation, mock-up and/or system prototypes.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | V2&V3<br>-Timeliness of information is judged as being sufficient.                                                                                                                                                                                                                           |
|                                                                                                     | V2&V3<br>Assess timeliness of information in prototyping sessions or Real-Time Simulation or operational trials with:<br>-objective methods: observations<br>-subjective methods: questionnaires, debriefings.                                                                                                                                                                                                                                                                                                                                                                                                                                                         | V2&V3<br>-[GND only] Timeliness of information ratings not lower in the solution than in the reference scenario.<br>-Timeliness of information experienced as sufficient by the end user.                                                                                                    |
| Arg. 2.3: The design of the human-machine interface supports the human in carrying out their tasks. |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                                                              |
|                                                                                                     | <b>HP Activity:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | <b>Evidence (i.e. Success Criteria):</b>                                                                                                                                                                                                                                                     |
| Arg. 2.3.1: The type of information provided satisfies the information requirements of the human.   | V1:<br>- If possible, identify initial information needs/requirements of the human by performing high level Task Analysis and focus groups with end users (e.g. HP Issue Analysis, review of low fidelity mock-up)<br><br>V2:<br>Identify information needs/requirements of the human by performing (Cognitive) Task Analysis and focus groups with end users (e.g. HP Issue Analysis, review of mock-up)<br><br>V2&V3:<br>-Perform/update (Cognitive) Task Analysis to identify information requirements of human actors, and check consistency with 16.5.3 'Generic SESAR Information presentation guidelines' <sup>12</sup> for effective information presentation. | V1:<br>-Where possible, initial information needs/requirements are identified<br><br>V2:<br>- Information needs/requirements are identified<br><br>V2&V3:<br>-Information requirements are in line with the information needs of the human.<br>-Information provided allows task achievement |



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|                                                                                                            | <i>Note that within the 16.5.3 guidelines, the style guide itself is applicable to ground only.</i>                                                                                                                                                                          |                                                                                                                                                                                                                                              |
|                                                                                                            | V2&V3:<br><br>-Perform/update Cognitive Walkthrough with early mock-up, system prototype, and simulator to identify information requirements and compare with type of information provided.                                                                                  | V2&V3<br><br>-There is no discrepancy between system-provided information and user-required information.                                                                                                                                     |
|                                                                                                            | V2&V3:<br>Assess Human Performance & Usability during Real-Time Simulation or operational trials with:<br>-subjective methods: questionnaire, debriefings & interviews (feedback on system support)<br>-objective methods: data recordings, observations (task performance). | V2&V3:<br>-[GND only] Usability/Utility rating not lower in the solution than in the reference scenario.<br>-End user perceives usability/utility as sufficient.<br>-End user is able to perform the task in a timely and error free manner. |
| Arg. 2.3.2: Input devices (e.g. keyboard, mouse, touch screen) correspond to HF principles. [V1: AIR only] | Apply HF design principles:<br>FAA HF Design Standards Chap. 9,<br>ISO 9241-400:2007,<br>Eurocontrol Style Guide<br>CS 25 Certification Specification for Large Aeroplanes.                                                                                                  | V1&V2:<br>-Where possible initial input device needs/requirements are identified<br><br>V2&V3:<br>-Input devices are consistent with design standards or regulations. Rationales are provided in case of deviations from standards.          |
| Arg. 2.3.3: Visual displays and other types of output devices adhere to HF principles. [V1: AIR only]      | Apply HF design principles:<br>FAA HF Design Standards Chap. 5,<br>ISO 9241-400:2007,<br>Eurocontrol Style Guide<br>CS 25 – Certification Specification for Large Aeroplanes.                                                                                                | V1&V2:<br>-Where possible initial visual display needs/requirements are identified<br><br>V2&V3:<br>-Visual displays are consistent with design standards or regulations. Rationales are provided in case of deviations from standards.      |
|                                                                                                            | Review interface on the basis of 16.5.3 'Generic SESAR Information presentation guidelines' <sup>12</sup> for effective information presentation.<br><i>Note that within the 16.5.3 guidelines, the style guide itself is applicable to ground only.</i>                     | V1&V2:<br>- Initial HMI needs/requirements are identified<br><br>V2&V3:                                                                                                                                                                      |



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|                                                                                                                                              |                                                                                                                                                                                                           | -HMI is consistent with 16.5.3 'Generic SESAR Information presentation guidelines'.<br><i>Note that within the 16.5.3 guidelines, the style guide itself is applicable to ground only.</i>                                                                                                                                     |
| Arg. 2.3.4: Alarms and alerts have been developed according to HF principles. [V1: AIR only]                                                 | Apply HF design principles:<br>FAA HF Design Standards Chap. 7,<br>ISO 9241-400:2007,<br>Eurocontrol Style Guide<br>CS 25 - Certification Specification for Large Aeroplanes.                             | V1&V2:<br>-Where possible initial alarm/alerts needs/requirements are identified<br><br>V2&V3:<br>-Alarm and alerts are consistent with design standards or regulations (e.g. false alerts or missed detections are minimised and can be recovered from). Rationales are provided in case of deviations from standards.        |
| Arg. 2.3.5: Workstations (e.g. cockpit layout and consoles) adhere to ergonomic principles. [V1: AIR only]                                   | Apply HF design principles:<br>FAA HF Design Standards Chap. 5,<br>ISO 9241-400:2007,<br>Eurocontrol Style Guide<br>CS 25 - Certification Specification for Large Aeroplanes.                             | V1&V2:<br>- Where possible initial workstation needs/requirements are identified<br><br>V2&V3:<br>-Workstations are consistent with design standards or regulations. Rationales are provided in case of deviations from standards.<br>-Tasks are effectively achieved                                                          |
|                                                                                                                                              | V3:<br>-Assess the adequacy of workstations (distances, screen sizes, and seat positions) on a representative prototype.                                                                                  | V3:<br>-Characteristics of the workstation are consistent with ergonomic principles.                                                                                                                                                                                                                                           |
| Arg. 2.3.6: The usability of the user interface (input devices, visual displays/output devices, alarm& alerts) is acceptable. [V1: AIR only] | V1 [Air only],V2,V3:<br>Assess usability with early mock-up, system prototype, and/or simulator:<br>-objective methods: observations, data recording<br>-subjective methods: questionnaires, debriefings. | V1 [Air only],V2,V3:<br>-[GND only] Usability rating for the integrated interface not lower in the solution than in the reference scenario.<br>-End user experiences integrated interface including any new system components as sufficiently usable.<br>-End user is able to perform interaction without noticeable problems. |



|                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
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| <p>Arg. 2.3.7: The user interface design reduces human error as far as possible. [V1: AIR only]</p> | <p><i>V1[AIR only]:</i></p> <ul style="list-style-type: none"> <li>- Identify human error through the review of low fidelity mock-up with end users</li> </ul> <p><i>V2&amp; V3:</i></p> <ul style="list-style-type: none"> <li>-Perform Cognitive Walkthrough with mock-up, system prototype, and/or simulator to identify likely human errors/error types and recovery means.</li> </ul>                                                                                                                                                                                                                                                                           | <p><i>V1[AIR only]:</i></p> <ul style="list-style-type: none"> <li>-Potential for errors is identified, taking into account error type &amp; operational impact</li> <li>-Errors can, in principle, be detected</li> <li>-Recovery means for errors minimise operational impact</li> </ul> <p><i>V2&amp;V3:</i></p> <ul style="list-style-type: none"> <li>-Potential for errors is identified, taking into account error type &amp; operational impact.</li> <li>-Errors can, in principle, be detected.</li> <li>-Recovery means for errors minimise operational impact.</li> </ul>                                                                                                                                                                                                         |
|                                                                                                     | <p><i>V1[AIR only]:</i></p> <ul style="list-style-type: none"> <li>-Perform high level Task Analyses based on proposed or actual interface design to identify likely error detection and recovery means</li> </ul> <p><i>V2:</i></p> <ul style="list-style-type: none"> <li>-Identify changes to the potential for human error using (Cognitive) Task Analysis and/or focus groups with end users (e.g. review of mock-up, HP Issue Analysis, HAZOPs) and identify preliminary mitigation.</li> </ul> <p><i>V3:</i> Perform/update Cognitive Task Analysis based on proposed or actual interface design to identify likely errors, detection and recovery means.</p> | <p><i>V1 [AIR only]:</i></p> <ul style="list-style-type: none"> <li>-Potential for errors is identified, taking into account error type &amp; operational impact</li> <li>-Potential for error detection is maximised</li> <li>-Recovery means for errors minimise operational impact</li> </ul> <p><i>V2:</i></p> <ul style="list-style-type: none"> <li>-Potential changes to human error and preliminary mitigation have been identified for consideration by the safety/project team.</li> </ul> <p><i>V3:</i></p> <ul style="list-style-type: none"> <li>-Potential for errors is identified, taking into account error type &amp; operational impact.</li> <li>-Potential for error detection is maximised.</li> <li>-Recovery means for errors minimise operational impact.</li> </ul> |
|                                                                                                     | <p><i>V2&amp;V3:</i></p> <p>Assess error occurrence and error management in Real-Time Simulation or operational trials:</p> <ul style="list-style-type: none"> <li>-objective methods: observations, data recordings</li> <li>-subjective methods: interviews, debriefings.</li> </ul> <p>&amp; analyse operational impact of errors with safety specialists.</p>                                                                                                                                                                                                                                                                                                    | <p><i>V2&amp;V3:</i></p> <ul style="list-style-type: none"> <li>-[GND only] Number of errors in the solution not higher than in the reference scenario, taking into account the type of error and their operational impact.</li> <li>-Number and/or severity of errors is within acceptable limits.</li> <li>-Recovery means for errors minimise operational impact.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                               |



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| Arg. 2.3.8: The user interface design supports a sufficient level of individual situation awareness. [V1: AIR only] | V1 [AIR only]/ V2<br>-If possible, identify factors that will impact upon situational awareness using Task Analysis and/or focus groups (e.g. through the review of low fidelity mock-up, HP issues Analysis) with end users and where possible identify preliminary mitigation/requirements. | V1 [AIR only]/ V2<br>-Potential changes to situation awareness & preliminary mitigation are identified and acceptable.                                                                                                                                                                                                                                                                              |
|                                                                                                                     | V2& V3:<br>Assess individual situational awareness in Real-Time Simulation or operational trials:<br>- objective methods: observations<br>-subjective methods: questionnaires, debriefings.                                                                                                   | V2&V3:<br>-[GND only] Level of individual situational awareness not lower in the solution than in the reference scenario.<br>-Level of individual situational awareness within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment).<br>-End user is able to perceive and interpret task relevant information and anticipate future events/actions |
| Arg. 2.3.9 The user Interface design supports a sufficient level of team situational awareness. [V1: AIR only]      | V1 [AIR only]:<br>-Identify factors that will impact upon team situational awareness using high level Task Analysis and/or focus groups (e.g. through the review of low fidelity mock-up, HP issues Analysis) with end users and where possible identify preliminary mitigation/requirements. | V1 [AIR only]<br>-Potential changes to team situation awareness & preliminary mitigation are identified and acceptable.                                                                                                                                                                                                                                                                             |
|                                                                                                                     | V2&V3:<br>Assess team situational awareness in Real-Time Simulation or operational trials:<br>- objective methods: observations<br>- subjective methods: questionnaires, debriefings.                                                                                                         | V2&V3:<br>-[GND] Level of team situational awareness not lower in the solution than in the reference scenario.<br>-Level of team situational awareness within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment).<br>-Team is able to perceive and interpret task relevant information and anticipate future events/actions                      |

| Arg. 3: Team structures and team communication support the human actors in performing their tasks.       |                                                                                                                                                                                                                                                                                                            |                                                                                                                                  |
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| Arg. 3.1: Effects on team composition are identified.                                                    |                                                                                                                                                                                                                                                                                                            |                                                                                                                                  |
|                                                                                                          | HP Activity:                                                                                                                                                                                                                                                                                               | Evidence (i.e. Success Criteria):                                                                                                |
| Arg. 3.1.1: Changes to existing roles in the team are identified (including roles that become obsolete). | <b>V1&amp;V2:</b><br>-Identify human actors that are likely to be affected by the change<br><br><b>V3:</b><br>-Identify or update the description of human actors affected by the change                                                                                                                   | <b>V1, V2&amp;V3:</b><br>Affected (or potentially affected) actors are identified                                                |
|                                                                                                          | <b>V1:</b><br>-Perform high level Task Analyses to identify potential role changes in the solution compared to roles in the reference scenario<br><br><b>V2&amp;V3:</b><br>-Perform/review Task Analysis to identify role changes in the solution scenario(s) compared to roles in the reference scenario. | <b>V1, V2&amp;V3:</b><br>Changes (or potential changes) in roles between the solution and the reference scenario are identified. |
| Arg. 3.1.2: The introduction of new roles to a team is identified.                                       | <b>V1:</b><br>Identify potential new actors and their roles in the team<br><br><b>V2&amp; V3:</b><br>Identify/update the description of new human actors and their roles in the team.                                                                                                                      | <b>V1, V2&amp;V3:</b><br>New actors and their roles (or potential new actors and their roles) are identified.                    |
|                                                                                                          | <b>V1:</b><br>-Perform high level Task Analysis to identify potential tasks that have to be covered by a new role.<br><br><b>V2&amp; V3:</b><br>-Perform/update Task Analysis to identify tasks that have to be covered by a new role.                                                                     | <b>V1, V2&amp;V3:</b><br>Tasks (or potential tasks) that have to be covered by new roles are identified.                         |



| Arg. 3.2: The allocation of tasks between human actors supports human performance.                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                                |
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|                                                                                                                | HP Activity:                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | Evidence (i.e. Success Criteria):                                                                                                                                                                                                                                                                                                                                                              |
| Arg. 3.2.1: Changes to the task allocation between human actors do not lead to adverse effects on human tasks. | <p>V1:<br/>-Perform high level Task Analysis or focus groups with end users (e.g. HP Issue Analysis, review of [low fidelity] mock-up) to identify changes to task allocation between human actors and any potential adverse effects on task demands and potential for error</p> <p>V2&amp;V3:<br/>-Perform/update (Cognitive) Task Analysis or focus groups with end users (e.g. HP Issue Analysis, review of [low fidelity] mock-up) to identify changes to task allocation between human actors and any potential adverse effects on cognitive/ task demands and potential for error</p>                    | <p>V1&amp;V2:<br/>-There are no potential adverse effects on human tasks in terms of predicted task demands or human potential for error</p> <p>V2&amp;V3:<br/>-There are no adverse effects on human tasks, in terms of an increase in cognitive demands and/or potential errors.<br/>-Cognitive demands and potential errors are minimised and recovery means reduce operational impact.</p> |
|                                                                                                                | See HP activities for Argument 1.3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | See evidence for Argument 1.3.                                                                                                                                                                                                                                                                                                                                                                 |
| Arg. 3.2.2: The proposed task allocation between human actors is supported by technical systems/the HMI.       | <p>V1:<br/>-Perform high level Task Analysis or focus groups with end users (e.g. HP Issue Analysis, review of (low fidelity) mock-up) to identify preliminary task needs/requirements and review proposed technical systems to ensure that the technical system covers the preliminary/task requirements identified.</p> <p>V2&amp;V3:<br/>-Perform/review Task Analysis or focus groups with end users (e.g. HP Issue Analysis, review of mock-up) to identify task needs/requirements and review proposed technical systems to ensure that the technical system covers the task requirements identified</p> | <p>V1:<br/>-Preliminary task needs/requirements regarding the technical system/HMI are identified<br/>-The preliminary technical system/HMI developed (if available) meets these preliminary needs/requirements identified</p> <p>V2&amp;V3:<br/>-Technical System/ HMI enables human operators to carry out their team tasks.</p>                                                             |
|                                                                                                                | <p>V2&amp;V3:<br/>Perform Cognitive Walkthrough with mock-up, system prototype, simulator to identify task requirements.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | <p>V2&amp;V3:<br/>-Cognitive Walkthrough did not identify areas of concern related to technical system/HMI support.</p>                                                                                                                                                                                                                                                                        |



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|                                                                                        | <p>V2&amp;V3:<br/>Assess Usability in Real-Time Simulation or operational trials:<br/>-subjective methods: questionnaire, debriefings &amp; interviews (feedback on system support)<br/>-objective methods: data recordings, observations.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <p>V2&amp;V3:<br/>-[GND only] Usability rating not lower in the solution than in the reference scenario.<br/>-Usability is judged as sufficient.<br/>-End user is able to perform interaction without noticeable problems.</p>                                                                                                                                                                                                                                                                                        |
| Arg. 3.2.3: The potential for human error in team tasks is reduced as far as possible. | <p>V1:<br/>-Identify changes to the potential for human error, using high level Task Analysis and focus groups with end-users (e.g. HP Issue Analysis, low fidelity mock-up review) and where appropriate identify potential mitigation.</p> <p>V2:<br/>-Identify changes to the potential for human error, using (Cognitive) Task Analysis and focus groups with end-users (e.g. HP Issue Analysis, HAZOP, mock-up review) and identify potential mitigation.</p> <p>V2&amp;V3:<br/>Assess errors and recovery means in Real-Time Simulations or operational trials with<br/>-objective methods: observations, data recordings<br/>-subjective methods: interviews, debriefings<br/>&amp; Analyse operational impact of errors with safety specialists.</p> | <p>V1&amp;V2:<br/>-Changes to the potential for human error and where appropriate potential mitigation are identified for further consideration by the safety/project team.</p> <p>V2&amp;V3:<br/>-[GND only] Number of errors in the solution not higher than in reference scenario, taking into account error type and operational impact.<br/>-Number and/or severity of errors in the solution is within acceptable limits.<br/>-Recovery means exist for errors in the solution minimise operational impact.</p> |
| Arg. 3.2.4: Team tasks can be achieved in a timely and efficient manner.               | <p>V1:<br/>-Identify the main tasks through high level task analysis and/or the use of low fidelity mock-up with end users<br/>-If possible identify initial needs/requirements to ensure main tasks can be achieved in a timely and efficient manner</p> <p>V2:<br/>-Identify/ Review the main tasks through task analysis and/or the use of mock-up with end users</p>                                                                                                                                                                                                                                                                                                                                                                                     | <p>V1&amp;V2:<br/>-Main tasks are achievable within an acceptable time frame and in an efficient manner (acceptable and efficient can be defined based on end users opinion and good HF practice)<br/>-Where possible initial needs/requirements to ensure the main tasks can be achieved in a timely and efficient manner are identified.</p>                                                                                                                                                                        |



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|                                                                                                            | <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Assess timeliness of individual/team actions in Real-Time Simulation or operational trials:</li> <li>-objective methods: observations, data recordings</li> <li>-subjective methods: interviews, debriefings.</li> </ul>                                                                                                                                                                                                                                             | <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-[GND only] Number of late actions not higher in the solution than in the reference scenario, taking into account the consequence of a late action.</li> <li>-Number of late actions are within acceptable limits, taking into account the consequence of a late action.</li> <li>-Tasks are effectively achieved</li> </ul> |
| Arg. 3.3: The communication between team members supports human performance.                               |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                                                                                                       |
|                                                                                                            | <b>HP Activity:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <b>Evidence (i.e. Success Criteria):</b>                                                                                                                                                                                                                                                                                                                                              |
| Arg. 3.3.1: Intra-team and inter-team communication supports the information requirements of team members. | <p>V1:</p> <ul style="list-style-type: none"> <li>-Perform high level Task Analysis and/or review the main tasks through the use of low fidelity mock-up with end users to identify if possible preliminary information needs/requirements within the team/between teams</li> </ul> <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Perform Task Analysis and/or review the main tasks through the use of mock-up with end users to identify information needs/requirements within the team/between teams</li> </ul> | <p>V1:</p> <ul style="list-style-type: none"> <li>-Where possible, preliminary information needs/requirements of team members are identified.</li> </ul> <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Information needs/requirements of team members are identified.</li> </ul>                                                                                          |
|                                                                                                            | <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Analyse intra-team/ inter-team communication in Real-Time Simulation or operational trials:</li> <li>-objective methods: observation, data recordings (R/T, HMI interaction)</li> <li>-subjective methods: interviews, questionnaires &amp; debriefings.</li> </ul>                                                                                                                                                                                                  | <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Observed or recorded communication consistent with information requirements as identified in the task analyses.</li> <li>-Timely communication of task relevant information within the team/between teams.</li> <li>-Team communication is judged as being consistent with their information needs.</li> </ul>              |
| Arg. 3.3.2: The phraseology supports communication in all operating conditions.                            | <p>V1:</p> <ul style="list-style-type: none"> <li>-Perform high level Task Analysis and/or review the main tasks through the use of low fidelity mock-up with end users to identify preliminary phraseology needs/requirements within the team/between teams, if possible</li> </ul>                                                                                                                                                                                                                                           | <p>V1:</p> <ul style="list-style-type: none"> <li>-Where possible preliminary phraseology needs/requirements of the team(s) are identified.</li> </ul> <p>V2:</p>                                                                                                                                                                                                                     |



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|                                                                                        | <p>V2:</p> <ul style="list-style-type: none"> <li>-Perform Task Analysis and/or review the main tasks through the use of mock-up with end users to identify phraseology needs/requirements within the team/between teams</li> </ul> <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Identify/update normal/abnormal operating conditions and degraded modes &amp; check against proposed phraseology.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | <p>-Phraseology needs/requirements of the team(s) are identified.</p> <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Phraseology makes provisions for normal/ abnormal operating conditions and degraded modes.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                                                                                        | <p>V2&amp;V3:</p> <p>Assess the phraseology in Real-Time Simulation or operational trials:</p> <ul style="list-style-type: none"> <li>-objective methods: data recordings, observation</li> <li>-subjective methods: interviews, questionnaires &amp; debriefings.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | <p>V2&amp;V3:</p> <ul style="list-style-type: none"> <li>-Proposed phraseology does not lead to errors related to perception &amp; interpretation of auditory information.</li> <li>-Phraseology is judged as being appropriate for all encountered operating conditions.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Arg. 3.3.3: Changes in communication means & modalities are identified and acceptable. | <p>V1:</p> <ul style="list-style-type: none"> <li>-Perform high level Task Analysis and focus groups with end users (e.g. HP Issue Analysis, review of low fidelity) mock-up to identify if possible potential changes in communication means and modalities</li> <li>-If possible, identify the possible impact of the potential changes identified on workload/task demand, potential for error, situation awareness and where possible identify preliminary mitigation.</li> </ul> <p>V2 &amp; V3:</p> <ul style="list-style-type: none"> <li>-Perform Cognitive Task Analysis and focus groups with end users (e.g. HP Issue Analysis, review of mock-up) to identify potential changes in communication means and modalities,</li> <li>-Identify the possible impact of the changes identified on workload/task demand, cognitive demand, potential for error, situation awareness and where possible identify preliminary mitigation.</li> </ul> | <p>V1:</p> <ul style="list-style-type: none"> <li>-Proposed changes in communication means and modalities and their impact are identified where possible</li> <li>-The proposed changes and preliminary mitigation identified are acceptable (acceptable can be defined based on end users opinion and good HF practice relating to communication means &amp; practices)</li> </ul> <p>V2&amp; V3:</p> <ul style="list-style-type: none"> <li>-Changes in communication means &amp; modalities do not increase cognitive demands</li> <li>-The proposed changes and preliminary mitigation identified are acceptable (acceptable can be defined based on end users opinion and good HF practice relating to communication means &amp; practices)</li> </ul> |
|                                                                                        | <p>V2 &amp; V3:</p> <p>Assess usability of communications means and human performance in Real-Time Simulation or operational trials:</p> <ul style="list-style-type: none"> <li>-objective methods: data recordings, observation</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | <p>V2 &amp; V3:</p> <ul style="list-style-type: none"> <li>-[GND only] Usability rating in the solution not lower than in the reference scenario.</li> <li>-Usability assessed as sufficient by end users.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |



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|                                                                                                                                     | -subjective methods: interviews, questionnaires & debriefings.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | -[GND only] Number of communication errors in the solution not higher than in reference scenario, taking into account error type & operational impact.<br>-[GND only] Number of delayed communication actions in the solution not higher than in the reference scenario, taking into account the consequences of a delayed communication.<br>-Communication means and modalities allow an efficient task accomplishment |
| Arg. 3.3.4: The communication load of team members is acceptable in normal and abnormal conditions and degraded mode of operations. | <p>V1:<br/>-If possible identify potential changes to communication load using high level Task Analysis and focus groups. If the identified changes to communication load are considered unacceptable identify preliminary mitigation.</p> <p>V2:<br/>- Identify potential changes to communication load using Task Analysis and focus groups - If the identified changes to communication load are considered unacceptable identify preliminary mitigation.</p> <p>V2&amp;V3:<br/>Assess communication load in Real-Time Simulation or operational trials (covering normal, abnormal conditions and degraded modes of operations):<br/>-subjective methods: questionnaires<br/>-objective methods: data recordings.</p> | <p>V1&amp;V2:<br/>-Potential changes to the communication load and preliminary mitigation identified are acceptable (acceptable can be defined based on end users opinion and good HF practice)</p> <p>V2&amp;V3:<br/>-Level of communication load in the solution not higher than in the reference scenario.<br/>-Level of communication load experienced as adequate by the end user.</p>                             |
| Arg. 3.3.5: Team members can maintain a sufficient level of shared situation awareness.                                             | <p>V1:<br/>-If possible, identify factors that will impact upon team situational awareness using high level Task Analysis and/or focus groups with end users (e.g. HP Issue Analysis, review of low fidelity mock-up) and where possible identify preliminary mitigation</p> <p>V2:</p>                                                                                                                                                                                                                                                                                                                                                                                                                                  | <p>V1&amp;V2:<br/>-Potential changes to situation awareness and the preliminary mitigation identified are acceptable (acceptable can be defined based on end users opinion and good HF practice relating to team situation awareness)</p>                                                                                                                                                                               |



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|  | -Identify factors that will impact upon team situational awareness using (Cognitive) Task Analysis and/or focus groups with end users (e.g. HP Issue Analysis, review of mock-up) and identify preliminary mitigation |                                                                                                                                                                                                                                                                                                                                                                                                    |
|  | <p>V2&amp;V3:<br/>Assess team situational awareness in Real-Time Simulation or operational trials:<br/>-subjective methods: questionnaires<br/>-objective methods: probe methods.</p>                                 | <p>V2&amp;V3:<br/>-[GND only] Level of team situational awareness in the solution not lower than in the reference scenario.<br/>-Level of team situational awareness within acceptable limits ('acceptable limits' to be defined with regard to the tool used for the assessment).<br/>-Team is able to perceive and interpret task relevant information and anticipate future events/actions.</p> |

| Arg. 4: Human Performance related transition factors are considered                                     |                                                                                                                                                                                    |                                                                                                                                                                                                                                                |
|---------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Arg. 4.1: The proposed solution is acceptable to affected human actors.                                 |                                                                                                                                                                                    |                                                                                                                                                                                                                                                |
|                                                                                                         | HP Activity:                                                                                                                                                                       | Evidence (i.e. Success Criteria):                                                                                                                                                                                                              |
| Arg. 4.1.1: Changes in roles and responsibilities are acceptable to the affected human actors.          | V1,V2&V3:<br>-Discuss description of roles and responsibilities with end users & get feedback on acceptability of the proposed changes.                                            | V1,V2&V3:<br>-End users do not predict negative impact with regard to changes in roles and responsibilities or means for mitigating negative impacts are identified.                                                                           |
|                                                                                                         | <i>Not applicable in V1</i><br>Assess acceptability of the proposed changes in Real-Time Simulation or operational trials:<br>-subjective methods: questionnaires and debriefings. | <i>Not applicable in V1</i><br>-Changes to roles and responsibilities are judged as acceptable.                                                                                                                                                |
| Arg. 4.1.2: The impact of changes on the job satisfaction of affected human actors has been considered. | V1,V2&V3:<br>-Discuss proposed solution with end users & get feedback on potential impact on job satisfaction.                                                                     | V1,V2&V3:<br>-No negative impact with regard to changes in roles and responsibilities is envisaged or means for mitigating potential negative impacts are identified.                                                                          |
| Arg. 4.2: Changes in competence requirements are analysed.                                              |                                                                                                                                                                                    |                                                                                                                                                                                                                                                |
|                                                                                                         | HP Activity:                                                                                                                                                                       | Evidence (i.e. Success Criteria):                                                                                                                                                                                                              |
| Arg. 4.2.1: Knowledge, skill and experience requirements for human actors have been identified.         | V1&V2:<br>-If possible, review new/updated operating methods and tasks to identify potential changes in knowledge, skill and experience requirements.                              | V1&V2:<br>-Where possible, initial knowledge, skill and experience requirements are identified.                                                                                                                                                |
|                                                                                                         | V3:<br>-Identify/update knowledge, skill and experience needs/requirements using the good practice material from 16.4.3 Training And Competence                                    | V3:<br>-Knowledge, skill and experience needs/requirements are identified and in line with 16.4.3 Training And Competence Analysis Tool (TACAT) for Air Traffic Controllers (ATC), Air Traffic Safety Electronic Personnel (ATSEP) and Pilots. |



|                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                   |
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|                                                                                                                                                   | Analysis Tool (TACAT) for Air Traffic Controllers (ATC), Air Traffic Safety Electronic Personnel (ATSEP) and Pilots <sup>13</sup> .                                                                                                                                                                                                             |                                                                                                                                                                                                                   |
|                                                                                                                                                   | V3:<br>-Perform/update Cognitive Task Analysis to identify knowledge, skill and experience requirements.                                                                                                                                                                                                                                        | V3:<br>-Knowledge, skill and experience requirements are identified/consolidated.                                                                                                                                 |
|                                                                                                                                                   | V3:<br>-Perform/update Job Analyses to identify knowledge, skill and experience requirements.                                                                                                                                                                                                                                                   | V3:<br>-Knowledge, skill and experience requirements are identified/consolidated.                                                                                                                                 |
| <p><i>Not applicable in V1</i></p> <p>Arg. 4.2.2: The impact on operator licensing (as defined by the regulating bodies) has been identified.</p> | <p>V2&amp;V3:<br/>-(Preliminary) identification/update list of relevant regulation concerning licensing &amp; check against identified changes in competence requirements.</p> <p>V3:[GND]<br/>-Perform an early Regulatory Impact Assessment (eRIA) by applying the 16.06.05 D04 “Assessment of ATCO Licensing Requirements”<sup>14</sup>.</p> | <p>V2&amp;V3:<br/>-(Preliminary) analysis of (in)consistencies between current licensing regulation and future licensing needs.</p> <p>V3:[GND]<br/>-Determination of regulation and endorsement requirements</p> |

<sup>13</sup> The SESAR 16.4.x deliverables can be found on Stellar <https://stellar.sesarju.eu/>

<sup>14</sup> .

<sup>14</sup>. The SESAR 16.06.05 D04 “Assessment of ATCO Licensing Requirements’ document can be found in Stellar under the HP CoP Folder

## A.2 Explanations on the HP arguments

Note: The table serves to provide further explanations of the concepts and terms used in the arguments. It does not provide a description of the criteria for deciding whether or not an argument is satisfied. These criteria are provided as part of the evidence description in Appendix A.1

| ID         | Argument                                                                                      | Explanation                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------|-----------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Arg. 1     | The role of the human is consistent with human capabilities and limitations.                  | Roles are defined as the position(s) or purpose(s) that someone has in an organisation. Responsibility is defined as a duty or obligation to perform a set of tasks assigned to a specific role.                                                                                                                                                                                                                      |
| Arg. 1.1   | Roles and responsibilities of human actors are clear and exhaustive.                          | The roles and responsibilities for all human actors affected by the proposed project change must be: clearly defined; compatible; complete, in that all roles have been considered and all responsibilities appropriately defined.                                                                                                                                                                                    |
| Arg. 1.1.1 | The description of roles & responsibilities cover all affected human actors.                  | The description of roles & responsibilities is complete and includes all human actors that will be impacted by the proposed project change.                                                                                                                                                                                                                                                                           |
| Arg. 1.1.2 | The description of roles & responsibilities cover all tasks to be performed by a human actor. | The description of roles and responsibilities is complete and all the tasks to be performed by the human operators have been considered and described. This includes the new tasks and modified tasks that may result from the proposed project changes, as well as the former existing tasks that remain unchanged.                                                                                                  |
| Arg. 1.1.3 | Roles and responsibilities are clear and consistent/non-contradictory                         | The defined roles and responsibilities of all human actors affected by the proposed project change are clearly defined, unambiguous, and compatible (and not contradictory).                                                                                                                                                                                                                                          |
| Arg. 1.2   | Operating methods (procedures) are exhaustive and support human performance.                  | Operating methods (Procedures) are the accepted courses of actions to fulfil a certain responsibility. For an ANSP, they are normally laid down in an Operational Manual and need to be in line with ICAO provisions. For the flight deck, operating methods are described in Standard Operating Procedures which are part of Flight Manuals or other aircraft-specific documentation or airlines' operating manuals. |
| Arg. 1.2.1 | Operating methods (procedures) cover operation in normal operating conditions.                | The operating methods developed cover operations in normal operational conditions. <i>Normal operating conditions</i> are the conditions the system is expected to encounter in day-to-day operations and where it delivers full functionality and performance.                                                                                                                                                       |

| ID         | Argument                                                                                                                               | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
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| Arg. 1.2.2 | Operating methods (procedures) cover operations in abnormal operating conditions.                                                      | The operating methods developed cover operations in abnormal operational conditions. <i>Abnormal conditions</i> are those conditions the system may exceptionally encounter (e.g. severe weather, airport closure, etc.) and for which the system needs to be robust against (i.e. can work through), or at least resilient to (i.e. recover easily from).                                                                                                                                                       |
| Arg. 1.2.3 | Operating methods (procedures) cover operations in degraded modes of the ATM system.                                                   | The operating methods developed cover degraded modes of operation. A <i>degraded mode of operation</i> is a reduced level of service invoked by equipment outage or malfunction, staff shortage or procedures becoming inadequate as a knock-on effect of one or several deficient system elements.                                                                                                                                                                                                              |
| Arg. 1.2.4 | The content of operating methods (procedures) is clear and consistent/non-contradictory.                                               | The content of the operating methods developed are clear and consistent. This means they are not open to misinterpretation and not contradictory.                                                                                                                                                                                                                                                                                                                                                                |
| Arg. 1.2.5 | Operating methods (procedures) can be followed in an accurate, efficient and timely manner.                                            | Operating methods for normal operating conditions, abnormal operating conditions and degraded modes of operation can be applied by the end users without significant errors and respecting the sequence and timing of actions.                                                                                                                                                                                                                                                                                   |
| Arg. 1.3   | Human actors can achieve their tasks (in normal & abnormal conditions of the operational environment and degraded modes of operation). | The proposed project changes must not negatively affect human performance and hence the ability of the human actor to perform & achieve their tasks in normal & abnormal operating conditions as well as degraded modes of operation. Several factors can have a significant impact on human performance, these include; subjective workload, error potential, situation awareness, trust, fatigue.                                                                                                              |
| Arg. 1.3.1 | The potential for human error is reduced as far as possible.                                                                           | Human error is a generic term that encompasses all those occasions in which a sequence of mental or physical activities (intended or unintended) result in an undesired outcome. When introducing changes to an existing system, the changes relating to potential for human error must be considered and mitigated as far as possible. Consideration must be given not only with regards to the prevention of human error occurrence, but also with regards to the detection of errors and recovery from error. |
| Arg. 1.3.2 | Tasks can be achieved in a timely manner.                                                                                              | In addition to errors, timeliness of task-related actions is usually taken as an indicator of task performance. Timeliness of an action commonly refers to response speed and latencies, potentially                                                                                                                                                                                                                                                                                                             |

| ID           | Argument                                                                                 | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
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|              |                                                                                          | also to the correct sequencing of actions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Arg. 1.3.3   | The level of workload (induced by cognitive and/or physical task demands) is acceptable. | <p>Subjective workload relates to an individual's perception of the effort expended to perform a task/set of tasks. Subjective workload is induced by cognitive and physical task demand but it varies as a function of ability, skill, training and experience. Objective workload or task load relates to task demands. To understand the impact of project changes on the human actors workload both objective and subjective measures should be obtained.</p> <p>Too low and too high levels of workload may have an adverse effect on human performance.</p> |
| Arg. 1.3.4   | The level of trust in the new concept/the new procedures is appropriate.                 | Trust relates to the level of confidence the human actors have in the new/changed tasks & procedures etc. The human actors' level of confidence in the new concept/new procedures must be appropriate, that is, neither too high nor too low.                                                                                                                                                                                                                                                                                                                     |
| Arg. 1.3.5   | Human actors can maintain a sufficient level of situation awareness.                     | Situation awareness relates to the human actors' perception of what has happened in the past, what is currently happening and therefore what is likely to happen in the near future. The human actors in the system must be able to maintain a sufficient level of awareness of the operational situation under normal & abnormal operating conditions as well as degraded modes of operation.                                                                                                                                                                    |
| Arg. 1.3.6   | Human performance satisfies the expected TA target levels. [not applicable in V1]        | Certain TAs, such as safety and security, may define minimum requirements for human performance on certain tasks, in terms of the required accuracy or speed. In case such minimum requirements (or target levels) are defined, the plausibility of these targets needs to be assessed.                                                                                                                                                                                                                                                                           |
| Arg. 1.3.6.1 | Safety requirements on human performance are satisfied. [not applicable in V1]           | The safety assessment may have identified human tasks that – if not carried out according to certain accuracy standards – could compromise the safety of the ATM system. In case safety has set accuracy targets for certain human tasks, the plausibility of these safety targets needs to be assessed by Human Performance.                                                                                                                                                                                                                                     |
| Arg. 1.3.6.2 | Security requirements on human performance are satisfied. [not applicable in V1]         | The security assessment may have identified human tasks that – if not carried out according to certain accuracy standards – could compromise the security                                                                                                                                                                                                                                                                                                                                                                                                         |

| ID         | Argument                                                                                                                                                                                             | Explanation                                                                                                                                                                                                                                                                                                            |
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|            |                                                                                                                                                                                                      | of the ATM system. In case security has set accuracy targets for certain human tasks, the plausibility of these security targets needs to be assessed by Human Performance.                                                                                                                                            |
| Arg. 2     | Technical systems support the human actors in performing their tasks.                                                                                                                                | In order for the technical systems to support the human in carrying out their tasks, the usability of the technical system must be assured. Usability is the extent to which a system allows people to achieve goals (tasks) in an effective, efficient and satisfactory way (HF Case v2.0).                           |
| Arg. 2.1   | There is an appropriate allocation of tasks between the human and machine (i.e. level of automation).                                                                                                | Allocation of tasks between the human and machine relates to the level of automation introduced, i.e. the extent to which tasks are controlled/performed by the human operator or the machine.                                                                                                                         |
| Arg. 2.1.1 | The task allocation between the human and the machine is consistent with automation principles.                                                                                                      | The level of automation/distribution of tasks between the human and machine must be consistent with HF automation principles. Relevant HF automation principles are mentioned in the list of HP activities and required evidence.                                                                                      |
| Arg. 2.1.2 | Changes to the task allocation between human and machine support human performance.                                                                                                                  | The proposed changes to task allocation must not negatively affect human performance and hence the ability of the human actor to achieve their tasks. The impact of the changes in the task on situational awareness, workload, human error/ performance must be considered.                                           |
| Arg. 2.1.3 | Transition from automatic to manual modes and vice versa, human-intended or failure induced, can be performed by the human actors in a timely, efficient and accurate manner. [not applicable in V1] | The change in mode of operations from automatic to manual and vice versa must be clear to the human actor (to ensure that mode errors are mitigated). Also, the actions required by the human actor in response to the mode change must be easy to perform.                                                            |
| Arg. 2.1.4 | The level of workload (induced by the allocation of tasks between the human and the machine) is acceptable.                                                                                          | Subjective workload relates to an individual's perception of the effort expended to perform a task/set of tasks. Subjective workload is induced by cognitive and physical task demand but it varies as a function of ability, skill, training and experience. Objective workload or task load relates to task demands. |
| Arg. 2.1.5 | Human actors can acquire an adequate mental model of the machine and its automated functions.                                                                                                        | A mental model refers to a human's internal representation/understanding of a system and how it works. As a result, a mental model of a machine and its automated function helps to shape our                                                                                                                          |

| ID         | Argument                                                                                     | Explanation                                                                                                                                                                                                                                                                                                                                  |
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|            |                                                                                              | interactions with a system and define our approach to solving problems and carrying out tasks.                                                                                                                                                                                                                                               |
| Arg. 2.1.6 | The level of trust in automated functions is appropriate.                                    | Trust relates to the level of confidence the human actors have in the automated functions. The human actors' level of confidence in the automation must be appropriate, that is neither too high nor too low.                                                                                                                                |
| Arg. 2.2   | The performance of the technical system supports the human in carrying out their task.       | In order for the technical system to support the human actor(s) in their tasks all the information presented must be: relevant & necessary to the task(s) being performed; accurate; and presented in a timely manner.                                                                                                                       |
| Arg. 2.2.1 | The accuracy of information provided by the system is adequate for carrying out the task.    | Accuracy - reflects the degree of closeness of a measurement to the true value of the measured quantity. All information provided by the technical system should be accurate enough to support task performance.                                                                                                                             |
| Arg. 2.2.2 | The timeliness of information provided by the system is adequate for carrying out the task.  | The system needs to provide information to the human actor in time, that is, when information is required for task performance. Excessive latencies in information provision can yield to disruption in task performance.                                                                                                                    |
| Arg. 2.3   | The design of the human-machine interface supports the human in carrying out their tasks.    | The human machine interface refers to the modes by which the human user and the machine communicate information and by which control is commanded (HF Case v2.0).                                                                                                                                                                            |
| Arg. 2.3.1 | The type of information provided satisfies the information requirements of the human.        | With respect to the type of information, all the information necessary to the task(s) being performed must be provided by the system. Care must be taken not to display task-irrelevant information as this will create clutter and may negatively impact situation awareness.                                                               |
| Arg. 2.3.2 | Input devices (e.g. keyboard, mouse touch screen) correspond to HF principles. [V1:AIR only] | An input device is used to provide data and control signals to an information processing system. Examples are: keyboard, mouse, and touch screen                                                                                                                                                                                             |
| Arg. 2.3.3 | Visual displays and other types of output devices adhere to HF principles. [V1:AIR only]     | <p>A visual display is an output device that presents visual information to the human actor. Information can also be conveyed in a non-visual (e.g. tactile or auditory) way.</p> <p>If the same type of information is provided through different output devices (i.e. different visual displays, or visual displays and speakers), the</p> |

| ID          | Argument                                                                                                                                 | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                         |
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|             |                                                                                                                                          | information should be consistent between information sources.                                                                                                                                                                                                                                                                                                                                                                                       |
| Arg. 2.3.4  | Alarms and alerts have been developed according to HF principles. [V1:AIR only]                                                          | Alarms and alerts alert the human actor to the fact that a problem exists, inform about the priority and nature of the problem, guide the human actor's responses, and confirm in a timely manner whether the response corrected the problem (cf. FAA HF Design Standards).                                                                                                                                                                         |
| Arg. 2.3.5: | Workstations (e.g. cockpit layout and consoles) adhere to ergonomic principles. [V1:AIR only]                                            | A workstation is the assigned location for a human actor to perform his or her job (e.g. cockpit for pilots, console for air traffic controllers). It comprises all input and output devices as well as furniture (seats, worktops, etc.).                                                                                                                                                                                                          |
| Arg. 2.3.6  | The usability of the user interface (including input devices, output devices/displays, and alarms & alerts) is acceptable. [V1:AIR only] | Usability is the extent to which a system allows people to achieve goals (tasks) in an effective, efficient and satisfactory way.                                                                                                                                                                                                                                                                                                                   |
| Arg. 2.3.7  | The user interface design reduces human error potential as far as possible.[V1: AIR only]                                                | Human error is a generic term that encompasses all those occasions in which a sequence of mental or physical activities (intended or unintended) result in an undesired outcome. The interface can reduce human error in various ways: for instance, by ensuring that displayed information is unambiguous or by facilitating the detection of incorrect system inputs.                                                                             |
| Arg. 2.3.8  | The user interface design supports a sufficient level of individual situation awareness. [V1: AIR only]                                  | Individual situation awareness relates to a human actors perception & understanding of what has happened in the past, what is currently happening and therefore what is likely to happen in the near future (cf. Endsley, 1995).                                                                                                                                                                                                                    |
| Arg. 2.3.9  | The user interface design supports a sufficient level of team situational awareness. [V1: AIR only]                                      | Team situation awareness relates to the degree to which every team member has sufficient situation awareness regarding the situational elements they are responsible for. Overall team situation awareness is good if every individual member has good individual situation awareness, so that there is no weak links in the chain. Another important factor in team situation awareness is the team's ability to interact with other team members. |
| Arg. 3      | Team structures and team communication support the human actors in performing                                                            | Teams and communication relates to how people work together and communicate with each other on shared goals and tasks (The HF Case v2.0). Changes                                                                                                                                                                                                                                                                                                   |

| ID         | Argument                                                                                           | Explanation                                                                                                                                                                                                                                                                                                                                              |
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|            | their tasks.                                                                                       | in team structure can include changes to the composition of a team in terms of roles, as well as, changes to the way in which tasks are allocated between the team members. Such changes may impact the communication flow within a team and way tasks are performed.                                                                                    |
| Arg. 3.1   | Effects on team composition are identified.                                                        | Effects of team composition need to be identified in terms of which roles change or become obsolete as well as what new roles emerge as a result of the changes introduced by the project.                                                                                                                                                               |
| Arg. 3.1.1 | Changes to existing roles in the team are identified (including roles that become obsolete).       | See explanation on higher level Argument 3.1.                                                                                                                                                                                                                                                                                                            |
| Arg. 3.1.2 | The introduction of new roles to a team is identified.                                             | See explanation on higher level Argument 3.1                                                                                                                                                                                                                                                                                                             |
| Arg. 3.2   | The allocation of tasks between human actors supports human performance.                           | The allocation of tasks between human actors refers to the way in which tasks are distributed between the different team members.                                                                                                                                                                                                                        |
| Arg. 3.2.1 | Changes to the task allocation between human actors do not lead to adverse effects on human tasks. | The proposed changes to task allocation must not negatively affect human performance and hence the ability of the human actor to achieve their tasks.                                                                                                                                                                                                    |
| Arg. 3.2.2 | The proposed task allocation between human actors is supported by technical systems/the HMI.       | The proposed distribution of tasks between team members needs to be enabled by technical systems. For instance, the distribution of tasks may require the team members to have access to input devices and visual displays and to exchange information digitally.                                                                                        |
| Arg. 3.2.3 | The potential for human error in individual and team performance is reduced as far as possible.    | When introducing changes to the task allocation between human actors, changes relating to the potential for human error must be considered and mitigated as far as is possible. Consideration must be given not only with regards to the prevention of human error occurrence, but also with regards to the detection of errors and recovery from error. |
| Arg. 3.2.4 | Team tasks can be achieved in a timely manner.                                                     | In addition to errors, timeliness of task-related actions is usually taken as an indicator of task performance. Timeliness of an action commonly refers to response speed and latencies, potentially also to the correct sequencing of actions.                                                                                                          |
| Arg. 3.3   | The communication between team                                                                     | Communication can be said to support human performance if it enables the timely and accurate                                                                                                                                                                                                                                                             |

| ID         | Argument                                                                                                                | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
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|            | members supports human performance                                                                                      | passing of all the necessary information between actors so that the communicated information is received and understood by the actor(s) that need it. Communication can be verbal and non-verbal (e.g., using gestures).                                                                                                                                                                                                                                          |
| Arg. 3.3.1 | Intra-team and inter-team communication supports the information requirements of team members.                          | See explanation on higher-level Argument 3.3.                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Arg. 3.3.2 | The phraseology supports communication in all operating conditions.                                                     | Phraseology relates to the use of a standardised words and phrases for verbal communication between human actors. The proposed phraseology needs to make provision for normal operating conditions, abnormal operating conditions and degraded modes of the ATM system.                                                                                                                                                                                           |
| Arg. 3.3.3 | Changes in communication means & modalities are identified and acceptable.                                              | Communication means relate to the technical enablers that support the transfer of information between human actors. Technical enablers are among others phone, R/T, and data link. In case of face-to-face communication, no technical enabler is required. Communication modalities relate to the type of information that is conveyed between actors. These can be verbal (i.e. spoken or written language) or non-verbal (i.e. gestures, symbols or sounds).   |
| Arg. 3.3.4 | The communication load of team members is acceptable in normal and abnormal conditions and degraded modes of operation. | Communication load refers to the part of subjective or objective workload that can be attributed to the requirement of exchanging information with other human actors.                                                                                                                                                                                                                                                                                            |
| Arg. 3.3.5 | Team members can maintain a sufficient level of shared situation awareness.                                             | Team situation awareness relates to the degree to which every team member has sufficient situation awareness regarding the situational elements they are responsible for. Overall team situation awareness is good if every individual member has good individual situation awareness, so that there is no weak links in the chain. Another important factor in team situation awareness is the team's ability to communicate & interact with other team members. |
| Arg. 4     | Human Performance related transition factors are considered.                                                            | Although the transition to the proposed concept will only happen in V5, E-OCVM requires an assessment of the transition feasibility in V3. For this reason, HP related aspects of the operational concept that are crucial for the successful transition at a later stage                                                                                                                                                                                         |

| ID         | Argument                                                                                                           | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
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|            |                                                                                                                    | should need to be identified.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Arg. 4.1   | The proposed solution is acceptable to affected human actors.                                                      | See explanations on lower level Arguments 4.1.1 and 4.1.2.                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Arg. 4.1.1 | Changes in roles and responsibilities are acceptable to the affected human actors.                                 | Acceptance of the proposed changes can be defined as the demonstrable willingness within the end user group to conform to the roles and responsibilities as proposed in the new ATM concept.                                                                                                                                                                                                                                                                                                         |
| Arg. 4.1.2 | The impact of changes on the job satisfaction of affected human actors has been considered.                        | Job satisfaction refers to the feeling or 'affective response' a human actor experiences in a job role.                                                                                                                                                                                                                                                                                                                                                                                              |
| Arg. 4.2   | Changes in competence requirements are analysed.                                                                   | Competence refers to the skill, knowledge & experience required by the human actors to perform their tasks to the required standard/level of required performance.                                                                                                                                                                                                                                                                                                                                   |
| Arg. 4.2.1 | Knowledge, skills and experience requirements for human actors have been identified.                               | <p>Knowledge is the fact or condition of being aware of something, in this case, awareness of task-relevant information.</p> <p>A skill is an acquired ability or capacity to smoothly and adaptively carry out complex activities or job functions.</p> <p>Experience is familiarity with a skill or field of knowledge acquired through actual practice. Experience is a function of the time spent performing a task and the variety of conditions of performance that have been encountered.</p> |
| Arg. 4.2.2 | The impact on operator licensing (as defined by the regulating bodies) has been identified. [not applicable in V1] | Personnel licensing relates to a system of standards, processes and procedures aimed to ensure that personnel undertaking safety related tasks in civil aviation (pilots, air traffic controllers, aircraft maintenance engineers, etc.) are competent to perform their tasks to the prescribed standard.                                                                                                                                                                                            |
| Arg. 4.2.3 | Potential interferences between existing and new knowledge & skills are identified [not applicable in V1]          | Changes to the competencies (i.e. skills, knowledge & experience) required by the human actors to perform their work may interfere each other and affect human performances.                                                                                                                                                                                                                                                                                                                         |
| Arg. 4.3   | Changes in staffing requirements and staffing levels are identified.                                               | Changes to the roles, tasks and responsibilities may impact and change the number of staff required, as well as the composition and organisation of staff within the organisation.                                                                                                                                                                                                                                                                                                                   |

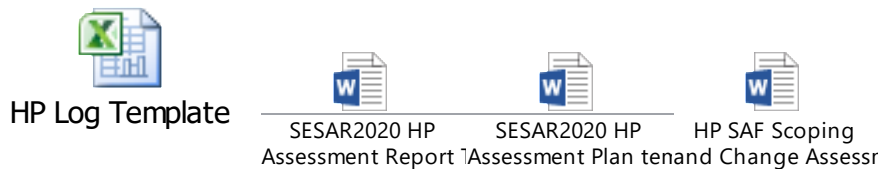
| ID         | Argument                                                                        | Explanation                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|------------|---------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Arg. 4.3.1 | The impact on staff levels is identified.                                       | Changes to the number of staff required (i.e. both increases & decreases) for each role within the organisation must be identified.                                                                                                                                                                                                                                                                                                                  |
| Arg. 4.3.2 | The impact on shift organisation is identified. [not applicable in V1]          | Consideration must be given to: the timing of shifts; duration of shifts; rotation of shifts (fast /slow, retarded/advanced); rest breaks and recovery periods: shift handover requirements. (HF Case v2.0).                                                                                                                                                                                                                                         |
| Arg. 4.3.3 | The impact on workforce (re-)location is considered.[not applicable in V1]      | Issues relating to relocation and transfer that should be considered and include relocation policies, family situation; housing & living; commuting policies & possibilities; social impacts on the partner & family; job issues of partner; communication & social dialogue (HF Case v2.0).                                                                                                                                                         |
| Arg. 4.4   | The impact on recruitment and selection processes has been considered.[V3 only] | Changes to the competencies (i.e. skills, knowledge & experience) required by the human actors to perform their work may have an impact on the strategies and criteria for recruitment and selection of staff.                                                                                                                                                                                                                                       |
| Arg. 4.4.1 | Changes in operator's profiles have been identified.[V3only]                    | Operator's profiles relate to the set of skills, knowledge and experience a human operator needs to possess to successfully perform the job. As such, the argument is tightly connected to Arg. 4.2.1.                                                                                                                                                                                                                                               |
| Arg. 4.4.2 | Changes in selection criteria have been identified.[V3 only]                    | "Selection criteria" relate to the set of criteria against which a job applicant will be assessed. Knowledge and experience requirements are subject to training and job exposure and, thus, do not necessarily need to be present in an applicant at the time of selection. On the other hand, certain skills, abilities, personality traits and behavioural tendencies may be less modifiable and, thus, should be part of the selection criteria. |
| Arg. 4.5   | Training needs are identified for the affected human actors. [V3 only]          | The training needs resulting from the proposed changes to the human actors' roles and tasks must be identified and defined for all affected operators.                                                                                                                                                                                                                                                                                               |
| Arg. 4.5.1 | The content of training for each actor group is specified.[V3 only]             | "Content of training" refers to the type of information that needs to be conveyed to a human operator.                                                                                                                                                                                                                                                                                                                                               |
| Arg. 4.5.2 | The duration of training for each actor group is specified.[V3 only]            | "Duration of training" relates to the length of the training that needs to be provided to a human operator.                                                                                                                                                                                                                                                                                                                                          |

| ID         | Argument                                                                                                  | Explanation                                                                                                                         |
|------------|-----------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| Arg. 4.5.3 | The required types of training (i.e. classroom, simulator, on-the job training) are identified. [V3 only] | “Type of training” relates to the setting in which the training needs to be given (e.g. classroom, simulator, on-the-job training). |

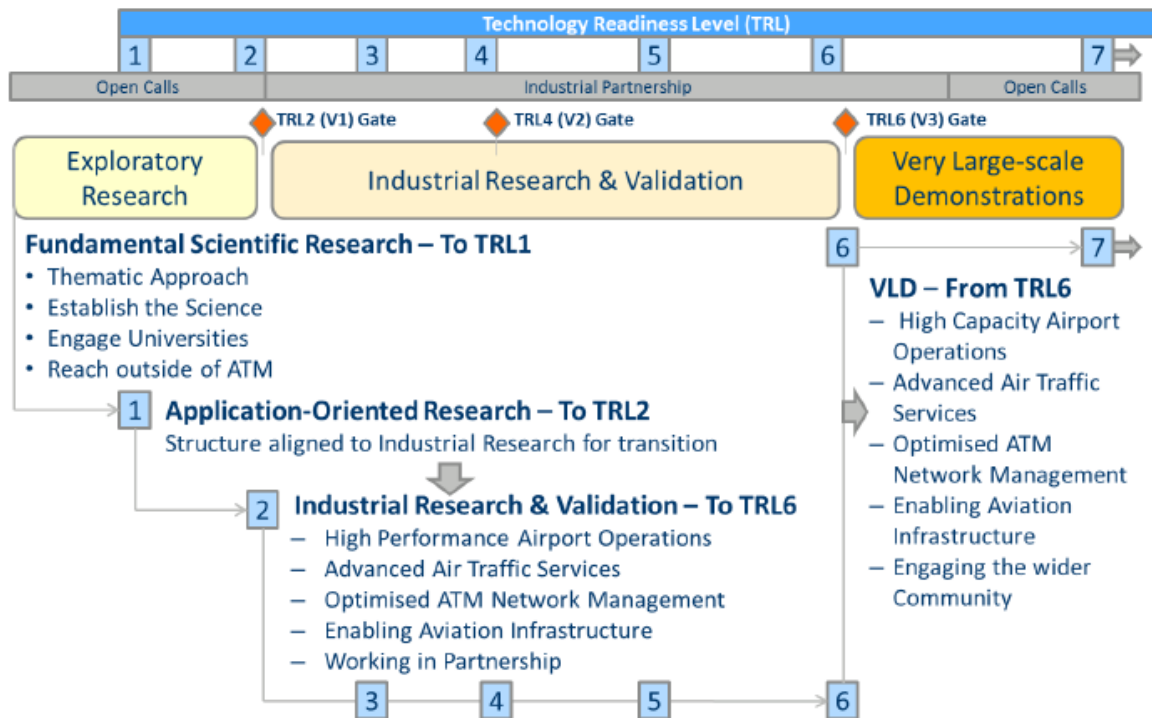
## Appendix B - HP Log and document templates

An HP Log is recommended to be maintained throughout the lifecycle of the project/solution in which all the data/information obtained from all HP activities conducted as part of the HP assessment (Step1-Step 4) is documented. This HP Log is a living document and should be updated and/or added to as the project/solution progresses. Following each validation activity the updated HP Log reflects the current status of the concept at that time in terms of objectives, conclusions, recommendations and requirements etc.

The HP assessment plan and HP assessment report are mandatory deliverables which **have to** be incorporated as annexes to the project/solution's validation plan and validation report respectively. Templates to help structure and develop the HP assessment plan and HP assessment report can be found below.



## Appendix C Mapping NASA Technology Readiness Levels (TRLs) against E-OCVM Concept Lifecycle Model (CL M) phases in SESAR 2020



**Figure 5:** SESAR Maturity Phases: NASA TRLs versus E-OCVM CLM

| Technology Readiness Levels (TRLs) |                                                                                      | (E-OCVM)<br>V phases | E-OCVM Description                                                                                                                                                                                                                                                                                              | HP Activities                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------------------------------------|--------------------------------------------------------------------------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>TRL 1</b>                       | Basic principles observed and reported                                               | V0                   | <ul style="list-style-type: none"> <li>Establish and quantify the need and drivers for change</li> <li>Establish high level requirements</li> <li>Establish performance targets</li> </ul>                                                                                                                      | Review & annotate the HP arguments that may be relevant for the operational concept                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>TRL 2</b>                       | Technology concept and/or application formulated                                     | V1 (early)           | <ul style="list-style-type: none"> <li>Initial definition of the operational concept</li> <li>Definition of initial logical system architecture</li> <li>Definition of benefit and cost mechanism</li> <li>Identification of R&amp;D Needs:</li> <li>Definition of Validation Strategy and Work plan</li> </ul> | <p>The following activities are should be performed t to investigate and iteratively refine the operational concept(s) options</p> <ul style="list-style-type: none"> <li>Develop descriptive models of the human component.</li> <li>Make explicit the roles, tasks, constraints and needs of the human actors impacted by the operational concept and how their performance contributes to the system.</li> <li>Support the development of the initial operational concept and system architecture</li> <li>Identify side effects that could compromise human performance and reveal show stoppers.</li> <li>Influence emergent design ideas based on preliminary Human Factors assessment.</li> </ul> <p>Relate human-centred models to other system models so as to ensure coherence.</p> |
| <b>TRL 3</b>                       | Analytical and experimental critical function and/or characteristic proof of concept | V1 (late)            |                                                                                                                                                                                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |

|       |                                                                                           |                       |                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------|-------------------------------------------------------------------------------------------|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TRL 4 | Component / subsystem validation in laboratory environment                                | V2 (early)            | <ul style="list-style-type: none"> <li>• Elaboration &amp; validation of the operational concept:</li> <li>• Preliminary technical feasibility assessment (research prototype):</li> <li>• Preliminary transition feasibility assessment:</li> <li>• Preliminary benefits and risks assessments:</li> <li>• Intermediate Business Case:</li> </ul> | <ul style="list-style-type: none"> <li>• Roles, responsibilities, operating methods and human tasks will ensure that roles and responsibilities of human actors are clear and exhaustive;</li> <li>• Operating methods are exhaustive and support human performance, and human actors can achieve their tasks in a timely and accurate way;</li> <li>• Technical support systems and Human-Machine Interface will support an appropriate allocation of tasks between the human and the machine (i.e. automation level) and will ensure that the high-level design of the human-machine interface supports the human actors in carrying out their tasks;</li> <li>• Team structures and team communication ensures that effects on the team composition are identified; that there is an appropriate allocation of tasks between human actors; and that the communication between team members supports human performance.</li> <li>• Identify potential transition factors related to acceptance and job satisfaction, changes in competence requirements, impact on staff levels and shift organisation, and the need for re-location of the work force.</li> </ul> |
|       | System / subsystem/ component validation in relevant environment                          | Completed by V2(late) |                                                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|       | System/ subsystem model or prototyping demonstration in a relevant end-to-end environment | V3                    | <ul style="list-style-type: none"> <li>• Integration and validation of the operational concept</li> <li>• Technical specifications and feasibility assessments</li> <li>• Transition feasibility assessment</li> <li>• Benefits and risks assessment</li> <li>• Final Research Business Case:</li> </ul>                                           | <p>HP activities in V3 will be carried out in a more realistic environment.</p> <ul style="list-style-type: none"> <li>• Ensure that roles and responsibilities of human actors are clear and exhaustive; (refined) operating methods are exhaustive and support human performance, and human actors can achieve their tasks in a timely and accurate way;</li> <li>• Technical support systems and Human-Machine Interface will ensure that the allocation of tasks between the human and the machine (i.e. automation level) is appropriate and the proposed design of the human-</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |



|       |                                                                                                              |                                |                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------|--------------------------------------------------------------------------------------------------------------|--------------------------------|-------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TRL 7 | (ground space) or                                                                                            |                                |                                                       | <p>machine interface (as specified in pre-industrial prototypes) supports the human actors in carrying out their tasks;</p> <ul style="list-style-type: none"> <li>Team structures and team communication ensures that the effects of the operational concept on the team composition are identified; the allocation of tasks between human actors is appropriate; and that the communication between team members supports human performance.</li> <li>HP - related transition factors (Argument 4): ensures that potential issues related to acceptance and job satisfaction are identified, changes in competence requirements are specified, the impact on recruitment &amp; selection is assessed, training needs are assessed, and the impact on staffing requirements &amp; staff levels is identified.</li> </ul> |
|       | System demonstration in an operational environment (ground, airborne or space)                               | V3+                            | <ul style="list-style-type: none"> <li>N/A</li> </ul> | <ul style="list-style-type: none"> <li>HP activities depend on the outcomes of preceding HP assessments. If the HP assessment was not conducted or finalised (at V3) during the Solution development, relevant HP activities shall be carried out prior to the VLD execution.</li> <li>HP-related transition factors: training needs are foreseen to be specified in sufficient detail; changes in competence requirements and the impact on recruitment and selection are expected to be considered.</li> </ul>                                                                                                                                                                                                                                                                                                          |
| TRL 8 | Actual system completed and "mission qualified" through test and demonstration in an operational environment | Beyond the scope of SESAR 2020 | <ul style="list-style-type: none"> <li></li> </ul>    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |



|       |                                                                                        |                                |   |  |
|-------|----------------------------------------------------------------------------------------|--------------------------------|---|--|
| TRL 9 | (ground or space)                                                                      |                                |   |  |
|       | Actual system "mission proven" through successful mission operations (ground or space) | Beyond the scope of SESAR 2020 | • |  |



## **Appendix D HP Maturity criteria checklist for each V-phase (V1, V2 and V3)**

Note that the following checklists are integrated and to be updated in the HP log (Tabs: “Maturity-V1”, “Maturity-V2”, “Maturity-V3”).

The output of the Maturity evaluation shall be used to populate the Maturity tool on Stellar, at solution level.

| Maturity checklist for finalising the V1 assessment |                                                                                                                                                                                      |                          |                                                                                                                                                                                                                                             |
|-----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ID                                                  | Question                                                                                                                                                                             | Answer<br>'yes' or 'no'. | Comments<br><i>Please substantiate your answer.</i>                                                                                                                                                                                         |
| 1                                                   | Have relevant arguments for V1 been addressed and appropriately supported?                                                                                                           |                          | <i>Refer to relevant sections of the HP table, e.g.</i><br><i>-Arguments addressed and associated evidence</i><br><i>-Outcomes of the HP activities</i>                                                                                     |
| 2                                                   | Are the benefits and issues in terms of human performance and operability related to the proposed solution sufficiently assessed (i.e. on the level required for V1)?                |                          | <i>Refer to relevant sections of the HP table, e.g.:</i><br><i>- Arguments addressed and associated evidence</i><br><i>- Identified HP benefits and issues</i><br><i>- Outcomes of HP activities</i>                                        |
| 3                                                   | Have potential interactions with related projects/concepts been identified?                                                                                                          |                          | <i>Refer to relevant sections of the HP table, e.g.:</i><br><i>- List of related projects</i><br><i>- Identified HP benefits &amp; issues concerning the interaction with other projects</i><br><i>- Outcomes of specific HP activities</i> |
| 4                                                   | In case of different options of the proposed solution, are the decisions for selecting specific options for further assessment based on the consideration of HP benefits and issues? |                          | <i>Refer to the relevant sections of the HP table, e.g.:</i><br><i>- Identified HP benefits and issues</i><br><i>- Outcomes of specific HP activities</i>                                                                                   |
| 5                                                   | Is the level of human performance needed to achieve the desired system performance for the proposed solution consistent with human capabilities?                                     |                          | <i>Refer to relevant sections of the HP table:</i><br><i>- Outcomes of HP activities on HP related measures (workload, situational awareness, human error, task efficiency)</i>                                                             |
| 6                                                   | Have the preliminary proposed solutions been preliminary assessed with expert/end users input?                                                                                       |                          | <i>Refer to relevant sections of the HP table:</i><br><i>- Description of HP activities (in particular, validation activities), including details on participants and test conditions/operational scenarios</i>                             |
| 7                                                   | Are the outcomes of the preliminary assessments in V1 based on the solution assessment mature enough to start V2?                                                                    |                          | <i>Refer to the conclusion in VALR and all conclusions in HP deliverable</i>                                                                                                                                                                |
| 8                                                   | Have all relevant SESAR documentation been updated according to the HP activities outcomes (SPR-INTEROP/OSD, VALR)?                                                                  |                          | <i>Compare the HP table and last version of SPR-INTEROP/OSD and SPR</i>                                                                                                                                                                     |
| 9                                                   | Have the major factors been addressed that can influence the transition feasibility (e.g. changes in automation level)?                                                              |                          | <i>Refer to relevant sections of the HP table, e.g.:</i><br><i>- Arguments on task allocation human-machine, on impacts on the organisational level</i><br><i>- Requirements and recommendations for concept implementation</i>             |
| 10                                                  | Has the next V-phase sufficiently been prepared (open HP issues to be addressed)?                                                                                                    |                          | <i>Refer to relevant sections of the HP assessment report, e.g.:</i><br><i>- List of open issues/benefits and associated validation objectives not yet validated;</i><br><i>- Recommendation for further research.</i>                      |

| Maturity checklist for finalising the V2 assessment |                                                                                                                                                                            |                                         |                                                                                                                                                                                                                                     |
|-----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ID                                                  | Question                                                                                                                                                                   | Answer<br><i>Fill in 'yes' or 'no'.</i> | Comments<br><i>Please substantiate your answer.</i>                                                                                                                                                                                 |
| 1                                                   | Have relevant arguments for V2 been addressed and appropriately supported?                                                                                                 |                                         | Refer to relevant sections of the HP table or HP assessment report, e.g.:<br>-Arguments addressed and associated evidence<br>-Outcomes of the HP activities                                                                         |
| 2                                                   | Are the benefits and issues in terms of human performance and operability related to the proposed solution sufficiently assessed (i.e. on the level required for V2)?      |                                         | Refer to relevant sections of the HP table or HP assessment report, e.g.:<br>- Arguments addressed and associated evidence<br>- Identified HP benefits and issues<br>- Outcomes of HP activities (including validation exercises)   |
| 3                                                   | Have potential interactions with related projects/concepts started to be considered?                                                                                       |                                         | Refer to relevant sections of the HP table or HP assessment report, e.g.:<br>- List of related projects<br>- Identified HP benefits & issues concerning the interaction with other projects<br>- Outcomes of specific HP activities |
| 4                                                   | In case of different options of the proposed solution, is the decision for a specific option(s) based on the consideration of HP benefits and issues?                      |                                         | Refer to the relevant sections of the HP table or HP assessment report, e.g.:<br>- Identified HP benefits and issues<br>- Outcomes of specific HP activities                                                                        |
| 5                                                   | Is the level of human performance needed to achieve the desired system performance for the proposed solution consistent with human capabilities?                           |                                         | Refer to relevant sections of the HP table or HP assessment report:<br>- Outcomes of HP activities on HP related measures (workload, situational awareness, human error, task efficiency)                                           |
| 6                                                   | Are the assessment results in line with what is targeted for that concept? If not, has the impact on the overall strategic performance objectives/targets been analysed?   |                                         | Refer to relevant sections of the HP table or HP assessment report:<br>• - Arguments addressed and associated actual evidence                                                                                                       |
| 7                                                   | Has the proposed solution been tested with end-users and started to be tested under sufficiently realistic conditions, including certain abnormal and degraded conditions? |                                         | Refer to relevant sections of the HP table or HP assessment report:<br>- Description of HP activities (in particular, validation activities), including details on participants and test conditions/operational scenarios           |
| 8                                                   | Are the outcomes based on the solution assessment mature enough to start V3?                                                                                               |                                         | Refer to the conclusion in VALR and all conclusions in HP deliverable                                                                                                                                                               |
| 9                                                   | Have all relevant SESAR documentation been updated according to the HP activities outcomes (SPR-INTEROP/OSED)?                                                             |                                         | Compare the HP table and last version of SPR-INTEROP/OSED                                                                                                                                                                           |



|    |                                                                                                                                                                                                                                                      |  |                                                                                                                                                                                                                                          |
|----|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 10 | Have the major factors that can influence the transition feasibility (e.g. changes in automation level, changes in staff requirements, such as competence, staffing levels) been considered? Are there any ideas on how to overcome any such issues? |  | <i>Refer to relevant sections of the HP table or HP assessment report e.g.:</i><br>- Arguments on task allocation human-machine, on impacts on the organisational level<br>- Requirements and recommendations for concept implementation |
| 11 | Have any impacts been identified that may require changes to regulation in the area of HP/ATM? This includes changes in roles & responsibilities, competence requirements, or the task allocation between human & machine.                           |  | <i>Refer to relevant sections of the HP table or HP assessment report e.g.:</i><br>- Arguments on roles & responsibilities, task allocation human-machine, impediments to implementation                                                 |
| 12 | Has the next V-phase sufficiently been prepared (additional testing conditions, open HP issues to be addressed)?                                                                                                                                     |  | <i>Refer to relevant sections of the HP assessment report, e.g.:</i><br>- List of open issues/benefits and associated validation objectives not yet validated;<br>- Recommendation for further research.                                 |

| Maturity checklist for finalising the V3 assessment |                                                                                                                                                                           |                                         |                                                                                                                                                                                                                                                                                                                                                  |
|-----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| ID                                                  | Question                                                                                                                                                                  | Answer<br><i>Fill in 'yes' or 'no'.</i> | Comments<br><i>Please substantiate your answer.</i>                                                                                                                                                                                                                                                                                              |
| 1                                                   | Has a Human Performance Assessment Report been completed?<br>Have all relevant arguments been addressed and appropriately supported?                                      |                                         | <i>Refer to relevant sections of the HP table or HP assessment report, e.g.</i><br><i>-Arguments addressed and associated evidence</i><br><i>-Outcomes of the HP activities</i>                                                                                                                                                                  |
| 2                                                   | Are the benefits and issues in terms of human performance and operability related to the proposed solution sufficiently assessed (i.e. on the level required for V3)?     |                                         | <i>Refer to relevant sections of the HP table or HP assessment report e.g.:</i><br><i>- Arguments addressed and associated evidence</i><br><i>- Identified HP benefits and issues</i><br><i>- Outcomes of HP activities (including validation exercises)</i>                                                                                     |
| 3                                                   | Have all the parts of the solution/concept been considered?                                                                                                               |                                         | <i>Refer to the relevant sections of the VALP, SPR-INTEROP/OSED and of the HP table or HP assessment report e.g.:</i><br><i>- Description of the solution/concept and related assumption</i><br><i>- List of assumption that have a link with the HP issue/benefits</i><br><i>- List of issues/benefits and associated validation objectives</i> |
| 4                                                   | Have potential interactions with related projects/concepts been considered and addressed?                                                                                 |                                         | <i>Refer to relevant sections of the HP table or HP assessment report e.g.:</i><br><i>- List of related projects</i><br><i>- Identified HP benefits &amp; issues concerning the interaction with other projects</i><br><i>- Outcomes of specific HP activities</i>                                                                               |
| 5                                                   | Is the level of human performance needed to achieve the desired system performance for the proposed solution consistent with human capabilities?                          |                                         | <i>Refer to relevant sections of the HP table or HP assessment report e.g.:</i><br><i>- Outcomes of HP activities on HP related measures (workload, situational awareness, human error, task efficiency)</i>                                                                                                                                     |
| 6                                                   | Are the assessments results in line with what is targeted for that concept? If not, has the impact on the overall strategic performance objectives/targets been analysed? |                                         | <i>Refer to relevant sections of the HP table or HP assessment report:</i><br><i>- Arguments addressed and associated actual evidence</i>                                                                                                                                                                                                        |
| 7                                                   | Has the proposed solution been tested with end-users and under sufficiently realistic conditions, including abnormal and degraded conditions?                             |                                         | <i>Refer to relevant sections of the HP table or HP assessment report e.g.:</i><br><i>- Description of HP activities (in particular, validation activities), including details on participants and test conditions/operational scenarios</i>                                                                                                     |
| 8                                                   | Do validation results confirm that the interactions between human and technology are operationally feasible, and consistent with agreed human performance requirements?   |                                         | <i>Refer to relevant sections of the HP table or HP assessment report:</i><br><i>- Arguments addressed and associated actual evidence</i><br><i>- Outcomes of the validation exercises</i>                                                                                                                                                       |



|    |                                                                                                                                                                                                                                                                                      |  |                                                                                                                                                                                                                                            |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 9  | Have all relevant SESAR documentation been updated according to the HP activities outcomes (SPR-INTEROP/OSED)?                                                                                                                                                                       |  | <i>Compare the HP table and last version of SPR-INTEROP/OSED</i>                                                                                                                                                                           |
| 10 | Do the outcomes satisfy the HP issues/benefits in order to reach the expected KPA?                                                                                                                                                                                                   |  | <i>Refer to relevant sections of the HP table or HP assessment report e.g.:<br/>- Arguments addressed and associated evidence<br/>- Identified HP benefits and issues<br/>- Outcomes of HP activities (including validation exercises)</i> |
| 11 | Have HP recommendations and HP requirements correctly been considered in HMI design, procedures/documentation and training?                                                                                                                                                          |  | <i>Refer to relevant sections of the HP table or HP assessment report e.g.:<br/>- Outcomes of HP activities (including validation exercises)</i>                                                                                           |
| 12 | Have the major factors that can influence the transition feasibility (e.g. changes in competence requirements, recruitment and selection, training needs, staffing requirements, and relocation of the workforce) been addressed? Are there any ideas on how to overcome any issues? |  | <i>Refer to relevant sections of the HP table or HP assessment report e.g.:<br/>- Arguments on task allocation human-machine, on impacts on the organisational level<br/>- Requirements and recommendations for concept implementation</i> |
| 13 | Have any impacts been identified that may require changes to regulation in the area of HP/ATM? This includes changes in roles & responsibilities, competence requirements, or the task allocation between human & machine.                                                           |  | <i>Refer to relevant sections of the HP table or HP assessment report e.g.:<br/>- Arguments on roles &amp; responsibilities, task allocation human-machine, impediments to implementation</i>                                              |
| 14 | Has the next V-phase sufficiently been prepared (additional testing conditions, open HP issues to be addressed)?                                                                                                                                                                     |  | <i>Refer to relevant sections of the HP table or HP assessment report e.g.:<br/>- List of open issues/benefits and associated validation objectives not yet validated;<br/>- Recommendation for further research.</i>                      |

## Appendix E - Guidance for writing HP benefits, issues and objectives

### E.1 Guidance for writing HP benefits

#### Guidance on HP benefit writing:

An HP benefit relates to those aspects of the proposed ATM concept that are likely to have a positive impact on human performance.

An HP benefit should be written defining:

- The potential source (cause) of the impact, including a brief description of the concerned system (part of the system/function)
- The potential HP impact (consequence on the human operator if the benefit occurs),
- The concerned actors (pilots, controllers, others) with a recall of his or her role if relevant in the scope of the benefit.
- The potential impact on system performance in terms of KPAs (e.g. efficiency, capacity, safety).

*Note: An HP benefit should be matched to the corresponding argument. If the benefit could be equally related to several arguments, it should be logged once and referred to if it matches other arguments too (e.g. "See Arg. 1.3.1", or "See issue I-1.3.2-3.1"). On the other hand, an HP practitioner might decide to combine several benefits that are too similar. HP benefits should not be duplicated.*

#### Example for a benefit (air & ground):

The ASPA-IM-S&M Procedures are expected to reduce the controller's workload and to increase the flight crew's situation awareness in the arrival sequence. In turn this will bring a benefit for safety.

*Analysis: The source of the benefit is the ASPA-IM-S&M procedure and the related impact is the decreased workload for the controller and increased situation awareness for the flight crew. Safety constitutes the affected KPA*

### E.2 Guidance for writing HP issues

An HP issue relates to those aspects in the ATM concept that need to be resolved before the proposed change can deliver the intended positive effects on Human Performance. An HP issue is likely to have a negative impact on human performance.

An HP issue should be written as a potential problem defining:

- The potential source (cause) of the problem, including a brief description of the concerned system (part of the system/function)
- The potential HP impact (consequence on the human operator if the problem occurs),
- The concerned actors (pilots, controllers, others) with a recall of his or her role if relevant in the scope of the issue.

- The potential impact on both human performance and system performance in terms of KPAs (e.g. efficiency, capacity, safety etc)

*Note: An HP issue should be matched to the corresponding argument. If the issue could be equally related to several arguments, it should be logged once and referred to if it matches other arguments too (e.g. “See Arg. 1.3.1”, or “See issue I-1.3.2-3.1”). On the other hand, an HP practitioner might decide to combine issues that are too similar. HP issues should not be duplicated.*

Example for an issue for air on the topic of CPDLC (Controller Pilot Data Link Communication)(air):

Change in communication channel from auditory to visual may negatively impact ‘team’ situation awareness of the flight deck crew, which may negatively impact human performance and increase the risk for human error. This in turn would have a negative impact on safety”

*Analysis: The source of the problem is the change of communication channels and the related HP impact is the decrease of team-situation awareness and an increased risk of human error. Safety constitutes the affected KPA*

Example for an issues for ground on the topic of CPDLC (Controller Pilot Data Link Communication (ground):

The controller issues a CPDLC message and does not receive a response in time; s/he receives a time out message. The controller has to refer to voice communication. The change from CPDLC to voice communication and the delay of the controllers action caused by the time out message may lead to an increase in controller workload, reduce the human performance and increases the risk of human error This in turn would have a negative impact on safety and capacity.

*Analyses: The source of the problem is the time out message (no response from the pilot) in the first place forcing a change of communication channels resulting in the HP impact which is an increase in workload and an increased risk of human error.*

### **E.3 Guidance for writing HP validation objectives**

Please consult the SESAR 2020 Requirements and Validation Guidelines [12]

## Appendix F - Guidance for writing HP recommendations and requirements

Please refer to Chapter 4.5.6.3 and the SESAR 2020 Requirements and Validation Guidelines [12].

## Appendix G - Guidance for Human Error Analysis (V3 only)

In V3, the HF specialist has to identify behaviours which have to be classified as human error. According to AMC 1309: “*Error is an omission or incorrect action by a crewmember or maintenance personnel...*”. They stem either from “paper” analysis subject to evaluations (e.g. based on procedures analysis and Functional Hazard Analysis conducted by the safety team) or from observations collected during exercises.

The human errors related to an HP assessment are matter of a qualitative study (HEA).

HEA are performed in a systematic way. The HF specialist has to determine different aspects such as:

- Error type, i.e.:
  - *Detection error*: The crew did not pick the suitable information that would allow properly understanding, planning and executing as expected.
  - *Interpretation error*: Despite having in mind all the useful information, the crew did not understand the situation and what to do.
  - *Planning error*: Despite having in mind all the useful information and having understood the situation, the crew elaborated a wrong plan of actions.
  - *Execution error*: Despite having elaborated a correct plan of actions, the crew did not apply it properly.

*The understanding of the nature of errors allows finding the appropriate mitigation means (e.g. among design changes proposal or training) by defining their:*

- Cause(s),
- Consequence(s)
- Associated safety criticality of the human error
- Mitigation means

HEA should be registered in the HP log.

## Appendix H - Guidance for managing HP interoperability issues in Air/Ground coupled validation exercises

Projects in which the operational concept affects both ground and air operations may not only require independent air and ground validation exercises but also coupled air/ground validation exercises which investigate specifically how the interoperability between air and ground could affect HP. This section focuses on the additional activities that the HP specialists need to perform to investigate the HP issues relating to interoperability between air and ground to ensure harmonisation of the results. If the teams performing the HP assessment for ground and air aspects are different the management of these additional activities require cooperation and coordination between the two teams. The activities that need to be performed are described below:

### 1. Preparation of the validation exercise(s) (corresponding to steps 2 and 3 of the HP assessment process)

The air and ground teams in charge of the HP assessments shall:

- establish a shared understanding of the HP issues identified from the Air and Ground HP assessment processes conducted to date, focusing on the interoperability issues, in order to **determine a common set of air/ground HP interoperability issues**. It should be noted that additional air/ground interoperability issues may be identified during this step;
- define **interoperability related validation objectives** for the common set of air/ground interoperability issues identified and allocate the objectives to the couple air/ground validation exercise(s);
- define the **scenario context and specific air and ground events** to be implemented in the coupled exercise to investigate and address the HP interoperability issues and objectives;
- define a set of **indicators and metrics** together with the related **success criteria** to ensure the human performance interoperability objectives are adequately assessed. Where possible and appropriate, the same indicators and metrics for air and ground will be used to assess the air/ground interoperability objectives. It is also strongly recommended that as well as collaborating to define a set of indicators and metrics the air and ground teams should also collaborate when developing the required tools and techniques, e.g. questionnaires, debriefs, used to assess the HP issues.

The output from these activities will be included in the validation plan that is finalised at the end of this exercise preparation phase.

### 2. Execution of the validation exercise(s) (corresponding to step 3 of the HP assessment process).

The air and ground teams in charge of the HP assessment shall:

- **train and brief the air and ground participants** involved in the coupled air/ground exercise;

- **collect the interoperability related data** necessary to address the specific validation objectives for air and ground respectively according to the performance framework and the validation plan;
- Organise **collective air/ground debriefings** to complement the opinions, experiences and viewpoints of air and ground actors respectively.

3. **Post-execution of the validation exercise(s)** (corresponding to step 3 and 4 of the HP assessment process)

The air and ground teams in charge of the HP assessment shall analyse the data collected and provide the results of the validation exercises related to interoperability. This implies that they will:

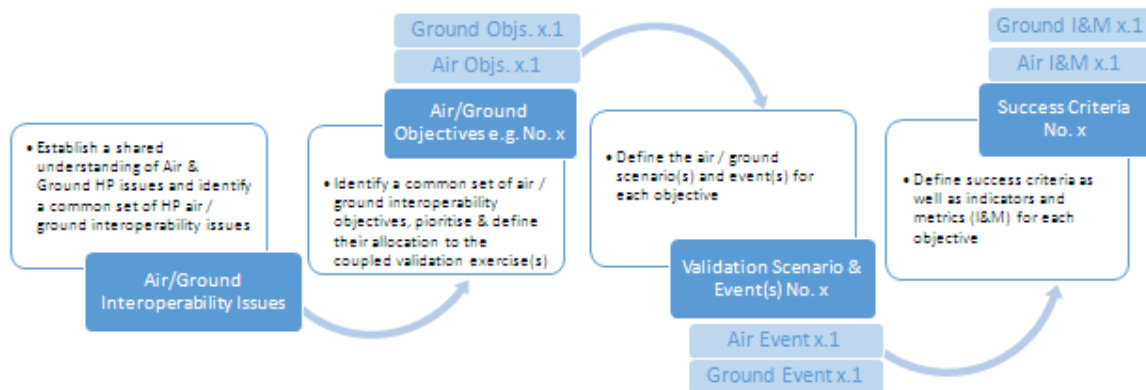
- Cooperate in **selecting and analysing interoperability related data**. The organisation of a convergence meeting is advisable at this stage in order to allow the HF specialist involved in air and ground HP assessment to compare the interoperability data selected and the initial results achieved, as well as validate the conclusions with the participants of the validation exercise to ensure the results have been properly understood and correctly interpreted;
- Collaborate to produce **recommendations and requirements** related to interoperability and affecting air, ground or both to ensure the recommendations and requirements produce by air and ground teams do not contradict each other. Responsibility for managing the HP recommendations and requirements produced from the validation exercise must be clearly assigned between the air and ground teams;
- Produce a set of **integrated results and conclusions** concerning the interoperability issues investigated in the validation exercise(s). The conclusions should include a joint decision regarding the status of the each HP objective and issue addressed in the coupled air/ground exercise.

The output of these activities will be included in the validation report.

The following diagram provides a graphical representation of the additional tasks to be performed for the HP assessment relating to air/ground interoperability issues. Representing the process described above, the graph focuses on interoperability aspects only and does not include the activities that are carried out on air and ground side individually applying the HP assessment process.

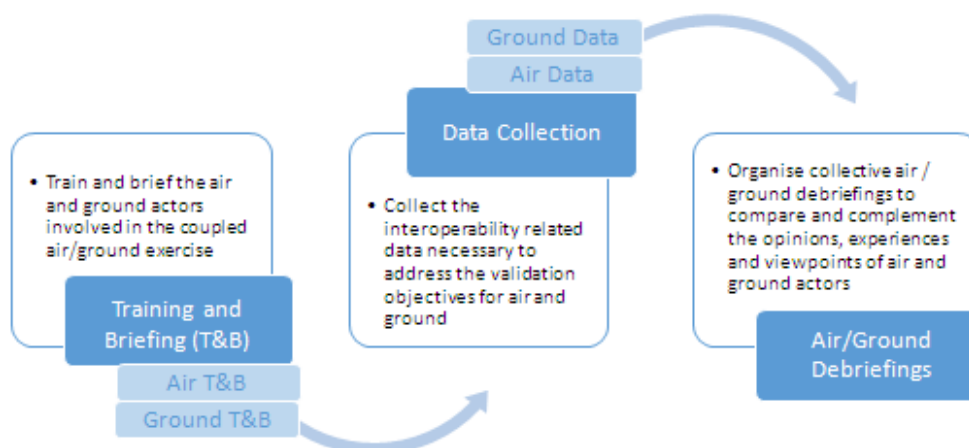
## PREPARATION OF THE VALIDATION ACTIVITIES

Develop a common validation plan for coupled Air/Ground exercises



## EXECUTION OF THE VALIDATION EXERCISE

Collect interoperability related data as specified in the validation plan



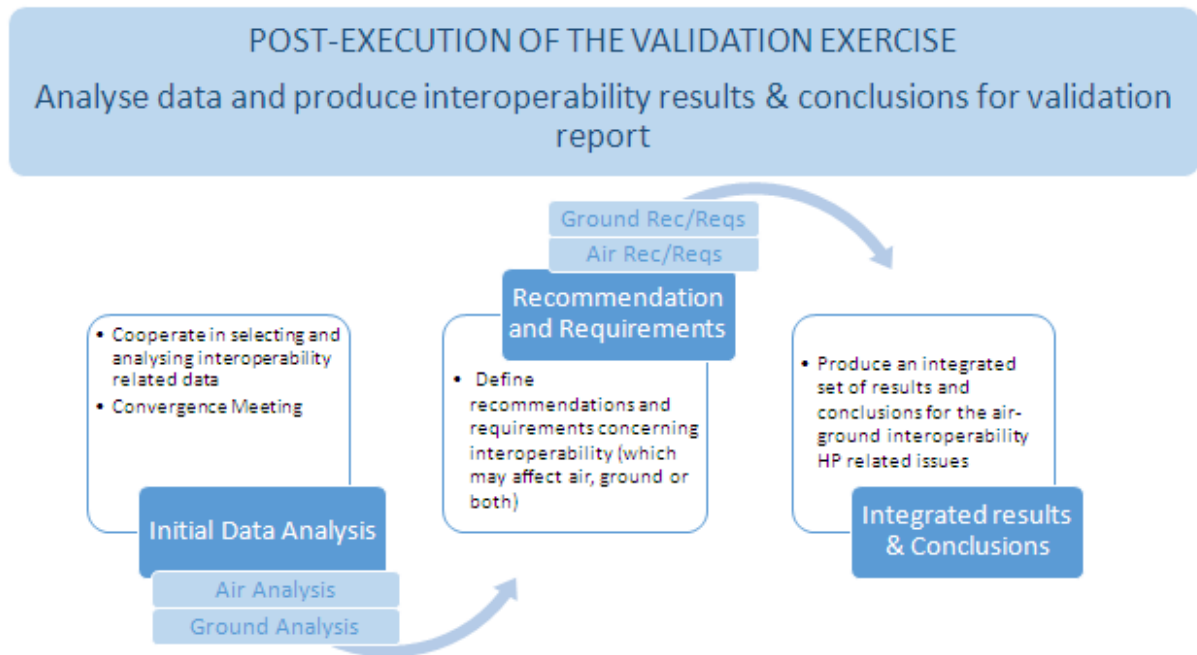


Figure 6: Guidance for managing HP Interoperability issues in Air/Ground coupled validation exercises

## Appendix A Glossary

| <i>Term</i>            | <i>Description</i>                                                                                                                                                                                                                                                                                                                                                                                                                              |
|------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Assumptions            | An assumption is a proposition that is taken for granted and relate to the context in which the proposed change will be implemented. In addition and more specifically, from an HP perspective, assumptions relate to the hypotheses made relating to human behaviour when using the new systems or that may be impacted by the proposed solution.                                                                                              |
| Constraints            | In general terms, a constraint sets limitations on behaviour (the ability to do something). In ATM system development there may be several types of constraints deriving from operational environmental, technical, legal institutional or other conditions. Constraints need to be identified and carefully documented.                                                                                                                        |
| 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). The concept of “required evidence” in the HP assessment process is equivalent to the notion of “success criteria”                                                                                                                                         |
| Human Factors (HF)     | HF is used to denote aspects that influence a human’s capability to accomplish tasks and meet job requirements. These can be external to the human (e.g. light & noise conditions at the work place) or internal (e.g. fatigue). In this way, “Human Factors” can be considered as focussing on the variables that determine Human Performance.                                                                                                 |
| Human Performance (HP) | HP is used to denote the human capability to successfully accomplish tasks and meet job requirements. In this way, “Human Performance” can be considered as focussing on the observable result of human activity in a work context. Human Performance is a function of Human Factors (see above). It also depends on aspects related to Recruitment, Training, Competence, and Staffing (RTCS) as well as Social Factors and Change Management. |
| HP activity            | An HP activity is an evidence-gathering activity carried out as part of Step 3 of the HP assessment process. An HP activity can relate to, among others, task analyses, cognitive walkthroughs, and experimental studies, RTS, operational trials.                                                                                                                                                                                              |
| HP argument            | An HP argument is an HP claim that needs to be proven through the HP Assessment Process                                                                                                                                                                                                                                                                                                                                                         |
| HP assessment          | An HP assessment is the documented result of applying the HP assessment process. When applied at the SESAR project-level it is a                                                                                                                                                                                                                                                                                                                |

|                         |                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                         | <p>partial HP assessment. When applied to an Operational Focus Areas is a complete HP assessment.</p> <p>HP assessments provide the input for the HP case.</p>                                                                                                                                                                                                                                                                                            |
| HP assessment process   | <p>The HP assessment process is the process by which HP aspects related to the proposed changes in SESAR are identified and addressed in the concept design, development and validation process. The development of this process for SESAR constitutes the scope of Project 16.04.01. It covers the conduct of HP assessments on the project-level as well as the HP case building over larger clusters of projects.</p>                                  |
| HP benefit              | <p>An HP benefit relates to those aspects of the proposed ATM concept that are likely to have a positive impact on human performance.</p>                                                                                                                                                                                                                                                                                                                 |
| HP case                 | <p>An HP case is the documented result of combining HP assessments from projects into larger clusters (e.g. operational sub packages, deployment packages) in SESAR.</p>                                                                                                                                                                                                                                                                                  |
| HP issue                | <p>An HP issue relates to those aspects in the ATM concept that need to be resolved before the proposed change can deliver the intended positive effects on Human Performance. An HP issue is likely to have a negative impact on human performance.</p>                                                                                                                                                                                                  |
| HP impact               | <p>An HP impact relates to the effect of the proposed solution on the human operator. Impacts can be positive (i.e. leading to an increase in Human Performance) or negative (leading to a decrease in Human Performance).</p>                                                                                                                                                                                                                            |
| HP validation Objective | <p>An HP validation objective describes a goal of a validation exercise or activity (e.g. workshop, task analysis, RTS, trial) from a human performance perspective. It relates to the impact that a concept and/ or a system (or part of the system) may have on human performance. One validation activity may be driven by several HP validation objectives.</p>                                                                                       |
| HP recommendations      | <p>HP recommendations propose a potential means for mitigating or preventing HP issues related to a specific operational or technical change. HP recommendations are proposals that require additional analysis (i.e. refinement and validation). Once this additional analysis is performed, HP recommendations may be transformed into HP requirements.</p>                                                                                             |
| HP requirements         | <p>HP requirements are statements that specify required characteristics of a solution from an HP point of view. HP requirements should be consolidated and accepted by the project team before they are integrated into the, SPR-INTEROP/OSED, or TS/IRS. HP requirements can be seen as the stable result of the HP contribution to the project, leading to a redefinition of the operational concept or the specification of the technical systems.</p> |

|                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                | Requirements can be verified through inspection, analysis, review of design, or test (mainly for System Projects);                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Operating methods (procedures) | Operating methods refer generally to procedures and are the accepted working methods. In the ATM environment, operating methods can be characterised as a set of activities or course of actions performed by each person intervening in the process, according to pre-established rules to enable a successful operation (e.g. operating methods for the flight deck are described in the Standard Operating Procedures, for an ANSP they are normally laid down in an operational manual and need to be in line with ICAO provisions |
| Responsibilities               | Things that are your job or duty to deal with. Have responsibilities means to have a duty to make certain that particular things are done.                                                                                                                                                                                                                                                                                                                                                                                             |
| Role                           | The position(s) or purpose(s) that someone has in an organisation. The typical or characteristic function performed by someone relating to the tasks that have been assigned to them.                                                                                                                                                                                                                                                                                                                                                  |
| Success criteria               | A success criteria is a means of establishing that a validation objective has been achieved. The concept of “required evidence” in the HP assessment process is equivalent to the notion of “success criteria”                                                                                                                                                                                                                                                                                                                         |
| System                         | A set of functions designed to meet a goal or set of related objectives. Key components of automated systems are hardware, software, people and operating methods (procedures).                                                                                                                                                                                                                                                                                                                                                        |
| Task                           | A task is a set of actions / activities which can be performed alone, or together with other tasks, to achieve a goal.                                                                                                                                                                                                                                                                                                                                                                                                                 |

- END OF DOCUMENT -