WP5 Final Report
Validation

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The present deliverable summarizes the work done in the context of ASCOS Work Package 5: Validation. This WP comprised four sub-WPs—Validation Strategy (WP5.1), Validation Plan and Scenarios (WP5.2), Validation Exercise Execution (WP5.3), and Validation Results and Recommendations (WP5.4). This deliverable reports on the objectives, work done, and outcomes of these WPs.

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Grant Agreement No.	314299
Document Identification	D5.5
Status	Approved
Version	1.1
Date of Issue	24-09-2015
Classification	Public

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DOCUMENT CHANGE LOG

Version	Author(s)	Date	Affected Sections	Description of Change
1.0	S. Rozzi	05-08-2015	All	Version for approval by PMT
1.1	S. Rozzi, L.Save	24-09-2015	All	Integration of NLR comments

REVIEW AND APPROVAL OF THE DOCUMENT

Organisation Responsible for Review	Name of person reviewing the document	Date
NLR	A.L.C. Roelen	04-09-2015
CAAi	T. Longhurst	30-07-2015
JRC	W. Post	30-07-2015
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TU Delft	H. Udluft	30-07-2015
Thales Air Systems	F. Kaakai	04-09-2015
Avanssa	N. Aghdassi	04-09-2015
APSYS	S. Bravo Munoz, J.P. Heckmann	04-09-2015
Organisation Responsible for Approval	Name of person approving the document	Date
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NLR	L.J.P. Speijker	25-09-2015

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ACRONYMS

Acronym	Definition
ANSP	Air Navigation Service Provider
ATM	Air Traffic Management
ATCMS	ASCOS Tool for continuous safety monitoring
AVG	Average
CAA	Civil Aviation Authority
CATS	Causal model for Air Transport Safety
CMA	Continuous Monitoring Approach
CNS	Communication, Navigation, Surveillance
CPS	Certification Process study
CS	Certification Specifications
D	Deliverable
DOW	Description of Work
EASA	European Aviation Safety Agency
ECCAIRS	European Coordination Centre for Accident and Incident Reporting Systems
ECF	ECCAIRS Common Framework
ECR	European Common Repository
E-OCVM	European Operational Concept Validation Methodology
ESD	Event Sequence Diagram
EU	European Union
FAA	Federal Aviation Administration
FAST	Future Aviation Safety Team
FDM	Flight Data Monitoring
FT	Fault Tree
GPWS	Ground Proximity Warning System
ICAO	International Civil Aviation Organisation
KPA	Key Performance Area
KPI	Key Performance Indicator
NASA	National Aeronautics and Space Administration
RIMCAS	Runway Incursion and Collision Avoidance System

SESAR	Single European Sky ATM Research
SPI	Safety Performance Indicator
TAS	Total Aviation System
TCAS	Traffic Collision Avoidance System
UG	User Group
WP	Work Package

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Executive Summary

This report provides an overview of the work done in the context of ASCOS Work Package 5. ASCOS is an EU-funded project aimed at the development of enhancements for the certification of products and services of the Total Aviation System. ASCOS Work Package 5 deals with the validation of the proposed enhancements, by establishing their fitness for purpose. In other words, the WP establishes the extent to which the ASCOS products can deliver their expected added value to their application domain: certification.

In particular, ASCOS WP5 is composed of five sub-WPs:

- **WP5.1** developed the **Validation Strategy** and covered the following aspects: the identification of the stakeholders and their expectations, the definition of the domain problem addressed by ASCOS, the identification of the proposed ASCOS solutions, with a determination of their maturity levels, the definition of the validation objectives, and the performance framework. These outcomes established the framework for the following WP5.2
- **WP5.2** developed the **Validation Plan**, in which the different components of the validation strategy were translated into three concrete validation exercises. These exercises consisted of three validation workshops in which data were collected by means of questionnaires and focus group discussions. The three exercises addressed:
    - The outcome of ASCOS WP1, i.e. the ASCOS proposed ASCOS certification process (Exercise1),
    - The main outcomes of ASCOS WP2, i.e. the framework for continuous safety monitoring and the ASCOS Tool for Continuous Safety Monitoring (Exercise 2), and
    - The main outcomes of ASCOS P3, the ASCOS Risk Model and the ASCOS Tool for risk assessment.
- **WP5.3** executed the three **Validation Exercises** defined for the project and reported on the results of each specific exercise. This sub-WP was the core of the validation work and absorbed the majority of the effort of WP5. It allowed gaining in-depth insights about the evaluated ASCOS products.
- **WP5.4** illustrated the overall **Validation Results** and delivered corresponding set of recommendations for improvement. These recommendations took into account both the results achieved in WP5.3 and those collected in the parallel WP4.5 (Evaluation of Results), based on the experience of implementing the ASCOS products in the four WP4 certification case studies. Note that among these recommendations, only those addressing the ASCOS proposed certification process are specifically being addressed within ASCOS WP1.5 (Consolidated New Certification Approach); while the other recommendations are made available for further perspective improvements beyond the scope of the ASCOS project.

One distinctive trait of the WP5 validation activities is their compliance with EUROCONTROL E-OCVM, a standard framework for planning validation activities to be carried out in R&D projects.

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1 Introduction

1.1 Objective

The objective of this deliverable is to summarize the work done in the context of ASCOS Work Package 5 (WP5).

1.2 ASCOS Projects Background

ASCOS is an EU funded project aiming at bringing improvements in the certification practices of aeronautical products, operations and systems. The project delivers novel processes, supporting software tools and methodologies that are expected to increase the efficacy and efficiency of certification practices. More specifically, ASCOS should make the certification of (new) operations, systems and products safer, more cost-effective, more flexible, and more integrated across the different domains of the Total Aviation System [1]. Collectively, such enhancements are expected to result in a reduction of fatal accidents due to e.g. loss of control in flight, aircraft system or component failure or malfunction, aircraft ground handling damage, and Air Traffic Management related incidents and accidents.

In previous Work Packages (WPs) the ASCOS project team worked on the following topics:

- WP1: An analysis of the existing European certification and rulemaking process, followed by a proposal for adaptations in the certification approach to ease certification of safety enhancement systems and operations.
- WP2: The development of a process and supporting tools for continuous safety monitoring, using a baseline risk picture for all the parts of the total aviation system. This included the development of a safety performance indicator framework and the baseline risk picture, i.e. the establishment of the current risk level of the various parts of the total aviation system.
- WP3: The development of a total aviation system safety assessment method and supporting tools that can be used for safety based design of new systems, products and/or operations. This included the development of a risk model based on accident scenarios and an approach to assess future and emerging risks.

1.3 ASCOS Work Package 5

ASCOS WP5 is dedicated to the validation of ASCOS products. ASCOS adopted the definition of validation defined by E-OCVM, a standard reference framework defined by EUROCONTROL for supporting ATM R&D projects during the validation of novel operational concepts. E-OCVM defines validation as “the iterative process by which the fitness-for-purpose of a new system or operational concept being developed is established” [2]. According to this definition validation investigates whether and to which extent a new system, product or service satisfies the originally intended purpose for which it was designed. In other words, validation answers the question “have we built the right system?”[2].

ASCOS WP5 consisted of four work packages:

- WP5.1 Validation Strategy;
- WP5.2 Validation Plan and Scenario;
- WP5.3 Validation Exercises and Execution;
- WP5.4 Results Analysis and Reporting.

To date, these WPs have been completed and their results are available in the following deliverables:

- D5.1 : Validation Strategy [2],
- D5.2: Validation Plan and Scenarios [3],
- D5.3: Validation Exercises Execution respectively [4],
- D5.4: Validation Results [5].

Deliverable D5.1 applied the seven steps promoted by E-OCVM[6]. Deliverable D5.2 further refined this strategy by breaking it down into three validation plans for three different validation exercises. For each exercise, the document reported aspects such validation objectives, methodology, roles, etc. Essentially, D5.2 completed the preparatory phase of the ASCOS validation exercises, while D5.3 reported on the results of these exercises. The three validation exercises collected feedback about the fitness-for-purpose of the main ASCOS products by mean of structured group discussions and questionnaires administered to selected experts external to the ASCOS project. D5.4 presented a summary version of the D5.3 validation results, developed a corresponding set of recommendations, and presented these recommendations to WP1 together with the recommendations developed in WP4. This made the D5.4 a single repository of the recommendations developed within the project, including those intended for the consolidation of the new certification approach in ASCOS WP1.5 and those useful for future development of the ASCOS outcomes externally to the ASCOS project.

1.4 DOCUMENT STRUCTURE

This document is organized as follows:

- Section 2 reports the work done and main outcomes for WP5.1;
- Section 3 reports the work done and main outcomes for WP5.2;
- Section 4 reports the work done and main outcomes for WP5.3;
- Section 5 reports the work done and main outcomes for WP5.4.

2 WP5.1 Validation Strategy

2.1 Overview and Objectives

The objective of this work package was to define the validation strategy for the ASCOS project.

2.2 Work done

This work package was executed over the period from March to June 2014. The validation strategy was developed following the guidelines from E-OCVM. E-OCVM is a standard validation framework developed and maintained by EUROCONTROL [6]. E-OCVM provides a structured framework for planning and conducting validation activities, which is suitable for both projects and programmes. A distinctive aspect of the framework is the concept lifecycle model, which facilitates the selection of validation objectives appropriate for specific lifecycle development phase and maturity level of a novel concept.

Although E-OCVM was developed for the validation of innovative ATM operational concepts, it was chosen as a reference standard because its validation principles and guidance can apply also to other R&D contexts. In compliance with E-OCVM, WP5 entailed the execution of the following phases:

- **Problem statement and need.** This phase reviewed previous project deliverables in order to consolidate the problem addressed by ASCOS.
- **Stakeholders' analysis and expectations**. This phase identified the stakeholders of the project and their expectations in the area of certification of novel aeronautical products and systems, continuous safety monitoring, and safety risk assessment. Expectations were identified based on a review of the deliverables from other ASCOS WPs, on a review of the minutes of previous ASCOS project meetings (in particular the meetings attended by the ASCOS User Group members), and on the results of questionnaire that was circulated among the UG members and returned to the WP5 team.
- **Identification of the ASCOS proposed solutions and determination of their maturity levels.** In this phase, first the WP5 team familiarized with the main ASCOS outcomes to be evaluated, which came from WP1, WP2, and WP3. The WP5 team reviewed the relevant deliverables in which these outcomes were described, and organized, in the context of the WP5 KOM (March 2015), dedicated sessions in which the WP leaders of these WPs were invited to present their respective products This made possible to identify, for each product, the overall concept, the expected benefits, the involved roles, the enablers and the limitations. Secondly, the WP5 team determined the maturity level of each ASCOS product. The purpose of doing so was that of ensuring that the validation plan was compatible with the actual maturity level of the ASCOS products. As a matter of fact, omitting to assess the maturity level of the products would have resulted in planning inappropriate validation activities, especially in case the maturity level is lower than assumed [6]. Eventually, the maturity of the ASCSOS products was determined to be in the range V1 (scope) and V2 (feasibility). This result has been considered acceptable, if we take into account the research nature of ASCOS: At the time the maturity assessment was made, ASCOS was still at the stage of developing preliminary concepts in the area of certification [2].

- **Determination of the validation objectives.** Based on the maturity levels determined in the previous phase for the ASCOS outcomes, it was decided that the ASCOS validation should be exploratory and oriented to the collection of qualitative feedback for improvement by domain experts, rather than based on a pure testing and measurement approach. In particular, it was decided to focus on the identification of possible issues associated to each ASCOS outcome and relevant from an end-user view point. Issues could then be addressed in improved versions of the ASCOS approach.
- **Development of the ASCOS performance framework.** The stakeholders' expectations collected in the previous phase of the work were reviewed in order to identify relevant areas in which to assess the value of the ASCOS outcomes. This phase lead to the development of three separate performance evaluation frameworks, one for each ASCOS outcome to be validated. Each framework came together with its own set of Key Performance Areas (KPA) and Key Performance Indicators (KPI). Besides a review of the user expectations, the development of the framework was based also on: (i) a review of public project materials; (ii) a review of D1.1 (the ASCOS deliverable dealing with current limitations in certification practices [7]); and on (iii) a review of current certification challenges expressed in the technical literature [8].
- **Definition of the validation requirements.** Based on its expert judgment, the WP5 team defined a set of validation requirements. These requirements pointed out important issues that had to be considered during the preparation of the validation exercises for a successful validation. (Note that the *Validation Requirements* are defined by E-OCVM as the "enablers" for the validation activities).

2.3 OUTCOME: VALIDATION STRATEGY

As mentioned above, three main elements resulted as an outcome of the validation strategy: (a) the choice of a qualitative approach, (b) the identification of the validation framework, (c) the identification of the validation requirements.

2.3.1 Qualitative approach

It was determined that ASCOS validation exercises had to focus mainly on qualitative methods based on collection of feedback from domain experts in dedicated familiarization and validation workshops. This orientation of the validation strategy was deemed appropriate for the maturity level of the ASCOS products, which was estimated to be between V1 and V2.

2.3.2 Validation Framework

Based on a review of different materials, including an analysis of the end-user expectations, the strategy included an initial version of the performance evaluation framework. The framework included a set of Key Performance Areas (KPAs), Key Performance Indicators (KPIs) and metrics. The KPAs are:

1. Soundness of the certification safety assurance documentation,
2. Efficiency of the certification process,

3. Cross domain integration
4. Harmonization
5. Accommodation of innovation
6. Operability of ASCOS processes and tools
7. Flexibility.

The KPAs reflected high-level ambitions and expectations of the stakeholders and were intended to 'measure' the "fitness for purpose" of the ASCOS results in each specific area. Associated to them, a set of KPIs and metrics were identified and specified for each of the three ASCOS 'products' under validation, corresponding to the 'products' developed respectively in WP1, WP2 and WP3 .

2.3.3 Validation Requirements

A list of validation requirements was identified to ensure a successful execution of the validation plan to be defined in the following D5.2. Three important requirements are summarized below:

- The ASCOS User Group (UG) represents different stakeholders in the aviation industry and in certification domains. The involvement of UG member was deemed essential for a successful validation. For this purpose, it was considered important to timely contact UG members to secure their participation in the validation exercises. It was agreed that the experts need to be contacted prior to each workshop to clarify aspects such as their expected role and contribution, the required expertise, the planning and set-up of the workshops and the required effort.
- The validation has to take into account the experiences and results from the application of the ASCOS results in the WP4 case studies. It was therefore agreed that the WP5 partners had to regularly exchange information with the WP4 case studies developers, in order to gather feedback regarding the fitness for purpose and assessed performance/benefits of ASCOS results. Also these results had to be collected and categorized using the WP5 performance framework illustrated before.
- The participation of relevant ASCOS partners from WP1, WP2, and WP3 was deemed necessary to provide technical and logistic assistance during the preparation and execution of the exercises, in relation to both ASCOS software tools and methodologies.

The Validation Strategy document concluded with a list of key validation activities, an initial validation planning and a template for the validation plan, to be further developed in the following WP5.2.

3 WP5.2 Validation Plan and Scenarios

3.1 Overview and Objectives

The objective of this work package was to translate the validation strategy developed in the previous phase into a feasible validation plan. The plan had to specify the actual validation exercises and products to be evaluated, preparatory activities and the scenarios necessary to validate the fitness for purpose of three ASCOS outcomes. The selection of ASCOS outcomes actually evaluated is presented in Table 1 (section 3.3).

3.2 Work Done

This work package was executed over the period June–September 2014. It included the following activities:

- **Selection of possible research methods compatible with the requirements set by the validation strategy.** This phase consisted of defining a suitable research methodology that was consistent with the qualitative objective set on the validation strategy: exploring the fitness for purpose of the ASCOS solutions considering their maturity level. Two possibilities were considered: evaluating the ASCOS product by means of qualitative case studies applied retrospectively to an existing product that was certified already, or validating the ASCOS product by mean of focus group discussions with experts. The decision about which method to select was reached by means of a cost-benefit analysis (which is included under appendix B of D5.2 [3]). It was decided that the focus group discussions would best provide the input required for WP1.5 given the constraints in the project.

- **Selection of the ASCOS product to be evaluated.** ASCOS comprises a total of 10 products. However, it was not feasible to validate all of them considering the project scope and resources. Therefore, the WP5.2 had to select which specific ASCOS product could be addressed by the ASCOS exercises. As a result of this phases, five ASCOS products were selected for inclusion in the ASCOS validation exercises. Table 1 (in §3.3) lists the ASCOS products selected for the evaluation. The applicable selection criteria for inclusion were the following:
    - It was feasible to evaluate the product during a one day exercise. This criterion essentially excluded products that were too complex, as a one day exercise would have not allowed participating experts to gain a sufficient familiarisation level. Because of this criterion, for instance, it was decided to exclude the ASCOS process for continuous safety monitoring from the evaluation;
    - The description of the product was sufficiently complete. This criterion excluded products that were still under development at the time the validation plan was developed. Because of this criterion the Total Aviation System safety standard improvement process was excluded for instance.

- **Definition of the validation scenarios.** This phase consisted of identifying suitable scenarios to demonstrate the value of the proposed ASCOS outcomes. For exercise 1, such scenarios consisted of the four selected certification cases that demonstrated the application of the ASCOS certification

approach. These scenarios exploited the four scenarios developed by WP4. For exercise 2, scenarios consisted of four safety monitoring scenarios: In each scenario a safety analyst had to use the ATFCSM to determine how selected SPIs—their occurrence data being retrieved from ECCAIRS—varied following the introduction of predefined changes to the Total Aviation System. For exercise 3, scenarios consisted of two risk assessment scenarios in which an analyst had to determine changes in risk levels in the total aviation system following the introduction of predefined changes.

- **Refinement of the performance evaluation framework**. This phase consisted on refining the initial performance evaluation frameworks that were defined in the previous part of the work (validation strategy).

- **Definition of the exercise-preparation activities.** This phase of the work involved (i) the definition of the training activities, i.e. the activities needed to let the participating experts to achieve an adequate familiarization level with the evaluated products; (ii) the definition of the recruiting strategy, so to ensure an adequate participation of experts to the exercises; and (iii) the definition of the list of materials to be developed prior to each exercise.

3.3 Outcome: Validation Plan

The main outcome the validation plan consisted of the identification of the ASCOS products to be evaluated and the definition of the validation plans.

3.3.1 Selection of the Products to be evaluated

Table 1 shows the five products were selected for inclusion in the ASCOS validation exercises based on the criteria described earlier.

Table 1. ASCOS products included in the scope of the WP5 validation exercises.

#	ASCOS PRODUCT		Addressed by WP5
1	**Proposed ASCOS certification approach**	**WP1.3**	**X**
2	**Framework Safety Performance Indicators (SPIs)**	**WP2.1**	**X**
3	Process safety improvement monitoring	WP2.3	
4	**Tool for Continuous Safety Monitoring (ATCSM)**	**WP2.4**	**X**
5	**Risk Model**	**WP3.2**	**X**
6	**Tool or risk assessment**	**WP3.3**	**X**
7	Safety Assurance Process in Operation	WP3.5	
8	Lessons Learnt Requirement process	WP3.5	
9	Overall Safety Impact Assessment Method	WP3.4	
10	E-learning environment	WP1.5	

3.3.2 Definition of the ASCOS Validation Exercises

The validation plan delivered by WP5.2 identified three evaluation exercises.In particular:

(i) Exercise 1 addressed the proposed ASCOS certification approach [9];
(ii) Exercise 2 addressed the ASCOS SPI framework and the ASCOS Tool for Continuous Safety Monitoring (ATCSM) [10]; and
(iii) Exercise 3 addressed the ASCOS Risk Model and the accompanying ASCOS Risk assessment tool [11],[12].

Each exercise came with its specific objective, exercise description, scenarios, preparatory activities, performance framework and risk and mitigation strategies. From a methodological point of view, the exercises shared the same basic qualitative format: a validation workshop with certification experts comprising a (i) familiarization session, to let participating experts to familiarize with the products to be evaluated by mean of scenario demonstrations (exercise 1, 2, and 3) and interaction with the tool (Exercise 3 only); and a (ii) feedback gathering session, to collect feedback from participating experts by means of controlled group discussions (or focus group) and questionnaires. The plan envisaged to collect feedback from experts in relation to the ASCOS specific Key Performance Areas and Indicators developed in WP5.1 [2] for each ASCOS product. Certification experts were recruited from the ASCOS User Group members. The qualitative nature of the exercise was appropriate to the maturity level of ASCOS products, which WP5.1 estimated to correspond to the phases V1 and V2 of E-OCVM [2].

The aim was to maximize the collection of certification experts' feedback by means of a controlled group discussions and a questionnaire. The combined results of the group of experts working together was expected to be more insightful than talking to them individually. Also, the plan was defined in order to be flexible: it was designed so that each exercise could accommodate 5 to 8 participants (which is a manageable number of participants in focus group research). However, in case attendance exceeded this number of participants, the plan could accommodate for that: Exercise 1 was designed so that the exercise could be run in two parallel groups; Exercise 2 and 3 were self-contained 1 day exercises that could be replicated on different days if required. The validation plan guided WP5.3, i.e. the execution of the validation activities, as described next.

4 WP5.3 Validation Exercises Execution

4.1 Overview and Objectives

This work package included the execution of the validation exercises planned in the previous WP5.2 and the reporting of the results of each specific exercise. The objectives of the work package were:

1. Investigate the value that the proposed certification approach may bring with regard to the certification of novel aeronautical products and services;
2. Investigate the value that the proposed ASCOS SPI Framework and the ASCOS Tool for Continuous Safety Monitoring may bring to the area of continuous safety monitoring, with particular reference to safety monitoring in the context of certification;
3. Investigate the value that the proposed ASCOS Risk Model and the Tool for risk assessment may bring to the area of risk assessment, with particular reference to risk assessment in the context of certification.

4.2 Work Done

The work was executed over the period September 2014–March 2015. The objectives listed above were addressed in three separate validation exercises—each one evaluating selected outcomes of ASCOS WP1, WP2, and WP3. Table 1 below matches each exercise to the corresponding evaluated product, the relevant ASCOS deliverable describing the particular product, the structure of the exercise, and the date of the exercise.

Table 2. Summary table of the three Exercises

Validation Exercises	Evaluated ASCOS Product	ASCOS Reference	Structure of Exercise	Dates of execution
Exercise 1	-ASCOS certification process	D1.2 [9]	-Feedback gathering	10th Oct 2014 (2nd Day of ASCOS UG meeting 3)
Exercise 2	-ASCOS SPI framework -ASCOS software Tool for continuous safety monitoring	D2.1 [13] D2.4 [10]	-Familiarization -Feedback gathering	28th Nov 2014
Exercise 3	-ASCOS Risk Assessment Model -ASCOS Tool for risk assessment	D3.2.3 [11] D3.3 [12]	-Familiarization -Interactive session -Feedback gathering	14th Jan 2015

Although executed at different points in time, the three exercises replicated the same basic data gathering format defined in the previous part of the work (Validation Plan and Scenarios). The format consisted of a one-day validation workshop with selected certification and safety experts and included two main phases:

1. **A familiarization phase.** This phase gave an opportunity to the participating experts to familiarize with the products and solutions under evaluation. The experts were exposed to presentations of the ASCOS solutions and of scenarios demonstrating their application. In the specific case of the Exercise 3, the familiarization phase also included an interactive session in which the experts had a chance to

use the dedicated software tool (in this case, the Tool for Risk Assessment). The familiarization phase was instrumental to prepare experts to the discussion groups and questionnaires used in the second phase, the feedback gathering.

2. **A feedback gathering phase**. This phase represented the core of the workshop. It collected experts' subjective feedback through (i) administration of individual questionnaires and (ii) guided focus group discussions. Both the questionnaires and discussions were structured around the Key Performance Areas of the performance frameworks that were developed in WP5.1 and refined in WP5.2 (for further details see Appendix A).

Each exercise was preceded by a preparatory phase and followed by a data analysis phase. The preparatory phase involved the execution of the following main activities:

- **Preparation of the exercise materials**, including presentations and questionnaires.
- **Recruiting of participating experts**. Certification and safety experts were recruited both from the ASCOS stakeholder list and from contacts of the WP5 team.
- **Software and evaluator protocol preparation (limited to Exercise 3)**. Exercise 3 involved interactive sessions in which the experts could familiarize and interact with the ASCOS Risk assessment tool. For this reason, it was necessary to fine tune some parts of the model available in the software and make sure that the scenarios selected for the testing were fully covered by the tool. At the same time, a set of evaluator protocols was prepared. These protocols included step-by-step instructions to be given by the evaluators to the users in order to follow a pre-set sequence of interaction tasks with the tool that were relevant for the evaluation.

The data analysis phase occurred over the period January-February 2015. This duration was due to the need to combine the data achieved through the questionnaire ratings with an in-depth qualitative analysis of the focus group discussions and of the rationale provided by each participant for their responses to the questionnaires. The data collected during each exercise included: researchers' notes, questionnaire ratings, and audio recordings of the structured focus group discussions. Data were analysed separately for each exercise, and consisted of basic statistical analysis combined with Qualitative Content Analysis (QCA) [14]. Descriptive statistics were used to analyse the questionnaire ratings, including the SUS ratings collected in Exercise 3. The QCA was used to analyse the rationale behind these ratings. This was in fact the most important source of data for this exercise: The questionnaire items, indeed, played mostly the role of useful triggers for reflection and discussions—but the real and important data come from the qualitative description of the reasons behind the experts' ratings.

The QCA entailed three phases:

1. Preparatory phase,
2. First cycle of coding,
3. Second cycle of coding.

The preparatory phase consisted of collecting and aggregating all researchers' notes, on listening the audio files, and on transcribing them. This material was reviewed extensively and provided the basis for the next two data analysis phases.

The first cycle of coding involved searching the transcripts of the focus group discussions in order to look for passages that pointed at problems, attitudes and descriptions of experts' professional experiences relevant for the purpose of the study and useful to understand the value of the proposed ASCOS solutions. Whenever such passages were found, they were marked and assigned a code. This phase allowed to develop a list of initial, first level codes.

In the second coding cycle, the initial codes were searched in order to find similarities and differences between them. The aim was to double check these codes, discard the irrelevant ones, and cluster the relevant ones under higher order categories, i.e. categories that capture relevant key findings.

An intermediate result of this data analysis process was the preparation of the minutes of the meetings. These were instrumental in offering an opportunity to the participating experts to comment and amend what the research team understood from the discussions, prior to finalizing the data analysis phase. In short the minutes were used for the purpose of corroboration.

4.3 OUTCOMES: VALIDATION RESULTS

The main outcomes of this work package consists of the set of validation results that emerged from the three validation exercises. These results reflected the perspectives of the certification and safety experts that took part into the exercises about the potential value that the proposed ASCOS solution can bring to certification and safety management. The following sections will report the summarized version of the validation results in dedicated tables. In each table, the results have been organized according to the KPAs of the ASCOS performance framework. For the full description of these results the reader is referred to deliverable D5.3 [4]

4.3.1 Summary of Exercise 1 validation results

The previous sections have reported the validation results specific to the ASCOS certification approach that have emerged during Exercise 1. The key results of the exercise are summarized in the table below.

Table 3. EXERCISE 1: Summary of the validation results for the proposed ASCOS certification approach.

KPA	Key Results
1. Efficiency	**Time & Effort** - More specialists—in particular, specialists knowledgeable on cross-domain risk assessment—are expected to be involved since the early certification stage in addition to existing domain specialists. This is likely to increase the coordination efforts needed to gain the initial certificate; - The expected increase in interactions between different organizations, as introduced by the

	approach, is likely to increase the effort required for considering legal aspects in certification; - Possible reductions in the overall certification effort are deemed possible when considering the whole system lifecycle, and not only the initial certification approval phase - The approach has the potential to reduce the risk of delays and major reworks later on in the process caused by relevant hazards becoming evident (too) late during the certification process; **Training** - ASCOS requires TAS expertise, therefore both the applicant and the competent Authorities will need to train their personnel accordingly.
2. Soundness	- ASCOS strong focus on cross-domain hazards and safety requirements identification (by means of a formal notation and since the initial certification phase) may reduce the likelihood of relevant hazards and requirements being missed or identified too late; - The effectiveness of the process heavily depends on the expertise of the people involved, rather than solely on the formal steps of process. Roles, processes, process owner, require further specification; - It is not immediately evident how the approach could improve the consideration of human factors aspects in certification.
3. Cross-Domain Integration	- ASCOS has the potential for cross-domain integration, however this depends on the availability of supporting regulation(s) mandating the sharing of safety risk information across the TAS stakeholders involved in a change; - The roles and responsibilities of the TAS architect(s) should be further specified in order to appreciate the potential for improved coordination;
4. Harmonization	- The approach looks compatible with local approaches—either performance or compliance based—used across different domains.
5. Accommodation of Innovation	- It is expected that the ASCOS approach will increase the rate of success regarding the certification of innovative concepts (concepts for which there are no reference standards available); - ASCOS can add clarity and structure to the certification of innovative products;
6. Acceptability	- Acceptability by both applicants and the certifying authorities may be challenged by the perceived significant effort required to adopt the approach; - There is an expectation that national CAAs will see the approach as more helpful (and therefore more acceptable) for airports and ATM, since these domains are more performance based compared to aircraft system certification (which is compliance based); - The wide spread adoption of the approach will be promoted by the acceptance of leading OEMs.

7. Flexibility	- The approach seems more promising for innovative products, while it looks potentially less useful for derivatives changes, i.e. changes for which an initial (pre-existing) certification base applies; - It was difficult to estimate the potential for certifying novel services—e.g. independent de-icing operations—because this type of change is not covered by a dedicated certificate nowadays.

4.3.2 Summary of Exercise 2 validation results

The previous sections have reported the validation results specific to the proposed ASCOS SPI framework and the ATCSM. These results have been collected during Exercise 2, and they are summarized in Table 4 and Table 5 respectively.

Table 4. EXERCISE 2: Summary of the validation results for the ASCOS SPI framework.

KPA	ASCOS Safety Performance Indicator Framework
1. Soundness	- It needs to be further defined how the SPI framework can be adapted/modified/extended for a specific certification case; - As the ICAO view of safety monitoring includes also non-quantitative data sources, it should be made explicit that ASCOS continuous safety monitoring focuses solely on quantifiable safety performance indicators based on reported occurrences (else safety experts would wonder why one should not consider non-quantifiable and non-reportable events); - The SPI framework seems to be oriented mainly towards the consideration of lagging indicators. The framework could be improved by including (leading) indicators that represent safety enhancing activities.
2. Completeness	- To address the variety of Total Aviation System, the SPI framework should include other domains, such as ground handling, maintenance, and airport operations. As an alternative the actual scope of the intended TAS should be better clarified.
3. Standardization	- The link with EASA SPI framework requires further clarification, else there is the risk the ASCOS SPI framework be perceived as a duplication of the former.

Table 5. EXERCISE 2: Summary of the validation results for the ASCOS Tool for Continuous Safety Monitoring.

KPA	ASCOS Tool for continuous safety monitoring
1. Usefulness	- The ATCSM is viewed as a valuable ECCAIRS enhancement, useful for comparative safety assessment to be done by the authority prior to the releasing of the type certificate, and the applicant as part of building a safety case; - ATCSM has been defined as an ECCAIRS enhancement. While this complies with point 4(a) and 4(b) of Art. 7 of EASA regulation 376/2014, it should not be neglected that organizations not having ECCAIRS may have to (re) code their occurrences using ECCAIRS

	to be able to benefit from the tool.

4.3.3 Summary of Exercise 3 validation results

The previous sections have reported the validation results specific to the proposed ASCOS Risk Model and Tool for risk assessment. These results have been collected during Exercise 3, and they are summarized in Table 6 and Table 7 respectively.

Table 6. EXERCISE 3: Summary of the validation results for the ASCOS Risk Model.

KPA	ASCOS Risk Model
1. Soundness	- The risk model appears too generic if compared against local risk models developed by individual stakeholders. Since it is likely that more specific ESDs and FTs will be available at local level, it should be further defined how to connect such models with the generic ASCOS risk model. Such a connection could be obtained by establishing proper hooks between the top even of (local) detailed FT to the relevant ESD or high level FT structure of the ASCOS risk model. - It should be clarified *how* the ASCOS risk model can be used and *by whom* in a TAS risk assessment. Roles and responsibilities associated with the use of the risk model should be further clarified; - The Risk Model creates an expectation that it will serve as support for the identification of novel and unknown risks, while this is not the case. In ASCOS this capability comes from FAST, and therefore it should be clarified how FAST can be used to inform and maintain the Risk Model. - To be a true risk model, the model should have the capability to assess severity levels and consider different probability units.
2. Completeness	- The models appear biased towards the coverage of aircraft operations mainly. ATM operations should have the same level of coverage; - Limiting the model to historic data on the one hand allows quantification, on the other makes the model incomplete with regard to the full range of risks that may occur; - The validity of the Risk Model could be enhanced by feeding it with worldwide safety data, so to cover also third world areas, which notably have working practices (and sources of hazards) very different compared to Europe.
3. Standardization	- The use of the term “emerging risks” associated to the ASCOS Risk Model was criticized for its potential ambiguity and limited compatibility with existing safety management standards.
4. Acceptability	- More information about the staff, expertise, and technological infrastructure needed to use the model would be needed to collect feedback on the acceptability of the risk model.

Table 7. EXERCISE 3: Summary of the validation results for the ASCOS Tool for risk assessment

KPA	ASCOS Risk Tool

2.1 Manipulability	- Perceived as a useful support tool to interact with/modify the elements of the risk model; - Perceived mainly as an editor of the ASCOS Risk Model, rather than a proper risk assessment tool, due to the lack of a severity assessment output/functionality.
2.2 Quantification capability	- It should have the capability to assess severity levels; - It should have the capability to handle different probability units of model elements; - The current lack of confidence data limits the meaningfulness of the probability estimates generated by the model/tool.
2.3 Cross-domain integration	- The wide spread adoption of the tool may help promoting the development of a standard risk language across the various TAS domains; - ECCAIRS data could be used to quantify a portion of the FT model and ESD events; - The use of the tool requires a regulatory requirement to make it obligatory for TAS stakeholders to share risk related information, so that quantitative risk assessment can be integrated (same point made for the certification approach).
2.4 Standardization	- The ASCOS risk model could be, in principle, implemented on different software. Thus, a comparative benchmark with other comparable FT editor is desirable to understand the true potential of the Tool in term of standardization and compatibility
2.5-2.6 Acceptability	- The tool seems acceptable to the user; however, a thorough assessment of acceptability requires an appreciation of the organizational and IT arrangements needed to operate the tool.

Usability	- Overall SUS score was 57, meaning that the tool usability falls in the marginal acceptance range, i.e. some improvements are needed. Identified areas of improvement include:
	  - Providing suggestions for identifying which ESDs/FTs could be affected by a change;
	  - Providing further support for the graphical exploration of the model elements;
	  - Displaying hover boxes next to the selected model's element with information about the element;
	  - Supporting compatibility with other FT software packages (available on the market);
	  - Enhancing the user manual input of probability values;
	  - Integrating an audit trail capability.

5 WP5.4 Results and recommendations

5.1 Overview and Objectives

The purpose of this WP was twofold

1. To develop the full set of **WP5 recommendations**, i.e. the recommendations developed in the context of WP5 and based on the results of the three validation exercises carried out in WP5.3 [4, p. 3]. That deliverable had, in fact, an evaluative purpose only and did not contain yet recommendations for improvement.
2. To present, in an integrated manner, **the full set of recommendations developed by both WP5 and WP4**. This latter work package identified benefits and lessons learnt, as well as specific recommendations for improvement, based on the application of the ASCOS certification approach to four case studies. The four case studies explored the value of the ASCOS approach in the initial phases of certification of innovative changes to the total aviation system (TAS).

The integrated presentation of the complete set of WP4 and WP5 recommendations is intended to provide easy access to all the recommendations developed in the ASCOS project, for use both internal and external to the project. In particular, the recommendations targeting the ASCOS certification approach (WP1) have been addressed by WP1.5, which developed an improved version of the approach. The other recommendations have not been addressed in the scope of the project; they are however available to external stakeholders like the European Commission and the European Aviation Safety Agency, which may consider them in future research and development activities. Also, area of contrast or overlap between the WP4 and WP5 recommendations have been highlighted.

5.2 Work Done

This work package was carried out over the period March 2015–May 2015. It involved the development of the full set of recommendations of the WP5 (based on the results of the validation exercises conducted under WP5.3), and their comparison and integration with the full set of recommendations developed by ASCOS WP4 [15, p. 4]. The WP5 recommendations were elaborated by the WP5 team and were then compared with the full set of the WP4 recommendations during a dedicated WP5-WP4 coordination meeting that took place on the 28th of April 2015 at Deep Blue premises [16]. The meeting provided an opportunity for an in-depth review of the set of recommendations produced by each WP. It allowed the improvement of the same recommendations and the identification of the areas of overlaps and interactions across them.

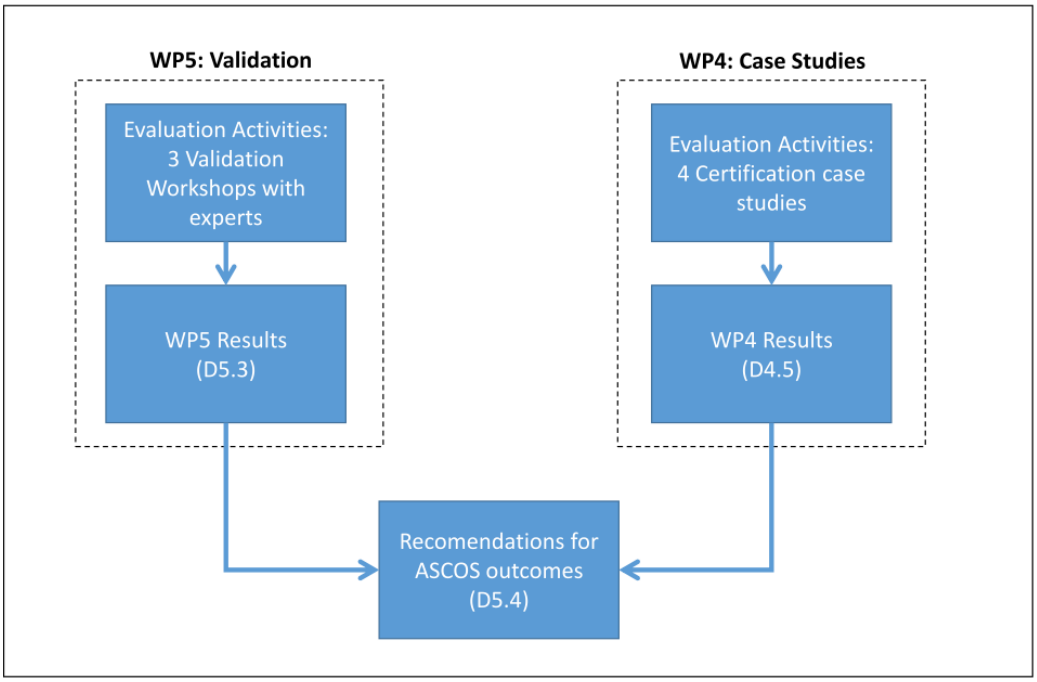

Figure 1. Integration of ASCOS WP4 and WP5.

5.3 Outcome: Set of WP5 recommendations

The main outcome of WP5.4 consisted of the set of recommendations developed based on the outcomes of the ASCOS validation exercises, executed in the previous WP5.3. In particular, the WP5.4 has developed recommendations for the:

1. Proposed ASCOS certification approach;
2. ASCOS SPI framework;
3. ASCOS Tool for Continuous Safety Assessment
4. ASCOS Risk Model;
5. ASCOS Tool for Risk Assessment.

The complete, summarized set of WP5 recommendations developed for these products is reported in the next section. These recommendations will serve the purpose of informing potential future improvements of the evaluated ASCOS products as follows [1]: ASCOS WP1.5 will consider the recommendations presented in this deliverable in relation to the proposed ASCOS certification approach, in order to deliver a more refined and advanced version of it, compared to the initial outline of the ASCOS certification approach documented in deliverable D1.3 [9]. Improvements of other validated ASCOS products, i.e. the SPIs framework, the ASCOS Tool for continuous safety monitoring, the ASCOS Risk Model and the ASCOS Tool for risk assessment, is outside the scope of the ASCOS project (including WP1.5). The recommendations targeting these products, however, will still provide a useful basis for future research and development activities.

It can be noted that six blocks of recommendations have been developed as a result of this phase of work:

1. Recommendations requiring to **further define the context of usage** of the proposed ASCOS products. This kind of recommendations have been highlighted for both the ASCOS proposed certification approach and the ASCOS Risk Model.
2. Recommendations requiring to address some of the **aspects involved in the development of the ASCOS TAS safety argument**. These recommendations address low level issues such as the management of the interfaces of the argument, the definition of an acceptable level or target level of safety across the TAS, the balancing of safety effects across domains.
3. Recommendations about the **integration of the ASCOS approach with specific methodologies**. These recommendations refer, in particular, to human factors related methods (e.g. SESAR Human Performance Case) and organizational assessment methods.
4. Recommendations targeting the **definition of basic terms used in the context of ASCOS**. These recommendations are motivated by the intent to minimize inconsistencies across terms, and also minimize the introduction of novel terms that are unfamiliar to the users of the proposed ASCOS solutions.
5. Recommendations about the **presentation of the ASCOS products**. These recommendations pertain to the way in which the ASCOS products are presented to the end-users: Some products, or their features, may generate erroneous expectations on the user side, depending on how they are presented.
6. Recommendations aimed at **software usability improvements**. These recommendations target essentially the ASCOS Risk assessment tool and aim at improving its usability. Usability recommendations targeting the ATCSM have been already developed in WP2.4.

5.3.1 Set of WP5 recommendations targeting the proposed ASCOS certification approach

REC ID	Contents
1.01	Define the minimum set of roles that should be involved in the use of the ASCOS certification process (WP4-WP5)
1.02	Refrain, whenever possible, from introducing novel ASCOS-specific terminology (WP5-WP4)
1.03	Adopt a consistent definition of “risk”
1.04	Adopt a consistent definition of “hazard”
1.05	Reconsider the definition of the different types of TAS domains (WP5-WP4)
1.06	Use consistently the expression “TAS domain” (WP4-WP5)
1.07	Complement the description of the proposed ASCOS certification approach with references to existing relevant Human Factors methods
1.08	Complement the description of the proposed ASCOS certification approach with reference to organizational hazard assessment methods (WP5-WP4)
1.09	EC or EASA to promote the sharing of safety risk information across the TAS stakeholders involved the use of the proposed ASCOS certification approach
1.10	Define guidance for establishing the team of experts that will have to manage the TAS change
1.11	Define criteria for defining the actual organizations to be involved in the change

1.12	Define criteria for distinguishing changes that require the ASCOS approach from those that do not (WP5-WP4)
1.13	Map WP2 and WP3 products against the ASCOS Certification Process (WP5-WP4

5.3.2 Set of WP5 recommendations targeting the ASCOS SPI framework

2.01	Consider changing the name from "SPI framework for safety monitoring" into "SPI framework for continuous safety occurrence monitoring"
2.02	Provide guidance to adapt the SPI framework to the local context of the change
2.03	Consider the possibility to include positive safety indicators in the SPI framework

5.3.3 Set of WP5 recommendations targeting the ASCOS Tool for Continuous safety monitoring

2.01	Consider changing the name of ASCOS tool from "Tool for continuous safety monitoring" to "Tool for continuous safety occurrence monitoring"

5.3.4 Set of recommendations targeting the ASCOS Risk Model

RECC	
3.01	Further clarify the TAS level purpose of the ASCOS risk model
3.02	Define the connection between the ASCOS risk model and local, in-house risk models
3.03	Ensure that the model covers all of the relevant TAS domains in a consistent manner
3.04	Define guidance that regulate the regular update of the Risk Model
3.05	Further define the structure of roles and responsibilities that will engage with the development and maintenance of the risk model
3.06	Include severity values in the risk model
3.07	Enhance the model with the capability to control different probability units

5.3.5 Set of recommendations targeting the ASCOS Risk assessment tool

RECC	
3.08	Consider to change the name of the "ASCOS Risk Assessment Tool" into "ASCOS Risk Model Editor"
3.09	Provide suggestions for identifying which ESDs/FTs could be affected by a change.
3.10	Provide further support for the graphical exploration of the model
3.11	Display, in the FT and ESD views, model elements descriptions as hover boxes

3.12	Support compatibility with other FT software.
3.13	Enhance user input of probability values
3.14	Further develop the audit trail capability of the tool

6 Conclusions

The present deliverable has reported the work done and the main outcomes of ASCOS WP5. The work in the validation work package was performed in a top down manner, starting with the development of the Validation Strategy (WP5.1), next to the definition of the validation plan (WP5.2), to its execution and reporting (WP5.3), and concluding with the definition of the recommendations for improvement (WP5.4). The validation activities allowed to collect an adequate amount of feedback for all of the KPAs of the products evaluated and to define recommendations for improvement accordingly. This was due to the allocation of adequate resources—time and effort—to the planning and preparatory phases of the validation work, as represented by WP5.1 and WP5.2. In particular, these resources made it possible to prepare and fine tune the validation exercises in a way that was functional to the objective of the work, as demonstrated by the detailed qualitative validation results documented in deliverable D5.3 [4].

The extensive professional knowledge of the experts on the specific topics that were addressed in each exercise (certification for exercise 1, and safety monitoring and safety risk management for exercises 2 and 3) ensured the successful collection of a high quality feedback for each evaluated product. Some difficulties were encountered with the recruitment of experts for the different validation exercises. In particular, it was not possible to have a stable and uniform group of experts coming from the ASCOS User Group that attended all the validation exercises. Working with a stable, uniform group would have allowed the participants to gradually build up knowledge of the ASCOS products under validation and would have ensured that the experts all have a similar level of understanding of the ASCOS concepts and products. For exercises 2 and 3, the heterogeneity of the group required more time than desirable for the initial familiarization phase of each exercise, as some of experts participating in these exercises were being exposed to the ASCOS concepts for the first time.

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Appendix A ASCOS Performance frameworks and Key Performance Areas

The present appendix reports the content of section 3.4 of D5.3 [4], which describes the development of the ASCOS performance framework and the corresponding KPAs.

The validation of a novel product or concept is rarely a matter of evaluating the performance of a system along a single dimension, i.e. based on a single evaluative standard or point of view. Rather, the evaluation of the fitness-for-purpose needs to consider the multiple values, perspectives and viewpoints of the stakeholders that will be affected by the introduction of the novel system. This consideration is particularly relevant to the evaluation of complex products, systems, and concepts such as those proposed by ASCOS. The variety of actors involved in the certification domain, either in the certifier or applicant role, calls for the consideration of multiple view points during the validation process. These include supranational and national civil aviation authorities, manufacturers, airports, air navigation service providers, standard development bodies, etc.

For this purpose, three ASCOS specific performance evaluation frameworks, one for each Exercise, have been designed that captures the key areas of performance (KPA) in which the proposed solutions are expected to deliver their potential. An initial definition of the evaluation frameworks has been provided by the deliverable D5.1 [2, p. 1]. The definition of those frameworks was based on a review of the following sources:

- ASCOS dissemination material (brochures and website [17]);
- ASCOS deliverable D1.1 [7]. This deliverable consists of an analysis of existing regulations and certification processes aimed at identifying potential shortcoming and bottlenecks in current certification processes;
- Minutes of meetings with User Group members. In the ASCOS project a User Group (UG) was established with the intent to represent the relevant stakeholders involved in certification. These expectations of these stakeholders were extracted based on a review of past ASCOS technical meetings in which they participated;
- FAA Certification Airplane Certification Process Study (CPS) [8]. The FAA CPS is the most authoritative reference retrieved from the literature that documents the essential problems and bottlenecks in commercial aviation certification. The study is based on a comprehensive review of the processes and procedures associated with aircraft certification, operations and maintenance, commencing from the initial type certification activities, and extending to the continued operational safety and airworthiness processes. Cross-checking the areas of the framework with the findings of the CPS enabled to further ensure that the framework addresses areas that are of relevance for certification.

Table 8, Table 9, and Table 10 reports the final version of the performance frameworks that have been used during the exercises. These versions represent a refinement of their initial version (proposed under D5.1). In particular, while the initial versions were defined over the period Feb-May 2014, the refined versions were prepared immediately prior to each exercise, keeping into account the practical, logistics of the exercise

(mostly available time for discussion and number of participants) which were not yet defined when the D5.1 was prepared.

KPA	Definition	Metric
1. Efficiency	The extent to which the proposed ASCOS certification approach allows to reduce the effort (cost, time, and training) needed by the applicant to obtain a certificate.	Questionnaire items
2. Soundness	The extent to which the ASCOS certification approach promotes, in certification, the consideration of relevant hazards and safety requirements that today are not or are poorly considered—with specific reference to cross-domain hazards and safety requirements.	Questionnaire items
3. Cross-domain integration	The extent to which the ASCOS approach promotes integration, coordination, and exchange of information across the different stakeholders that may be involved in the certification of a change.	Questionnaire items
4. Harmonization	The extent to which ASCOS looks compatible with the different certification approaches in use in different domains (e.g. ATC vs aviation) and geographical areas.	Questionnaire items
5. Accommodation of Innovation	The extent to which ASCOS makes more likely the certification of innovative products and systems, i.e. products and systems for which no standard are available.	Questionnaire items
6. Acceptability	The extent to which the proposed ASCOS approach looks acceptable to the applicant and the certifying authority.	Questionnaire items
7. Flexibility	The extent to which the proposed ASCOS approach can be applied to a broad range of different types of products, systems, and services, varying in size and complexity.	Questionnaire items

Table 9. KPAs for the proposed ASCOS SPI framework and Tool for Continuous Safety Monitoring (Exercise 2).

Evaluated ASCOS results	KPA	Definition	Metric
ASCOS SPI Framework	1. Soundness	The extent to which the ASCOS SPI framework promotes, in certification, the consideration of relevant hazards that today are not or are poorly considered (with specific reference to the TAS related hazards).	Questionnaire items
	2. Completeness	The extent to which the proposed SPI framework covers the different (certification) domains of the TAS.	Questionnaire items
	3. Standardization	The extent to which the proposed SPI framework can become a standard reference framework in use across the different actors of the TAS.	Questionnaire items
ASCOS Tool for Continuous Safety Monitoring	4. Usefulness	The extent to which the proposed ASCOS is perceived as a tool useful for supporting continuous safety monitoring,	Questionnaire items

Table 10. KPAs for the proposed ASCOS Risk Model and the Tool for risk assessment (Exercise 3).

Evaluated ASCOS results	KPA	Definition	Metric
ASCOS Risk Model	1. Soundness	The extent to which the ASCOS Risk Model promotes, in certification, the consideration of relevant hazards that today are not or are poorly considered (with specific reference to the TAS related hazards).	Questionnaire item
	2. Completeness	The extent to which the ASCOS Risk Model covers, the different hazards of the TAS.	Questionnaire item
	3. Standardization	The extent to which the proposed risk model can become a standard model used by the different actors of the TAS.	Questionnaire item
	4. Acceptability	The extent to which the proposed ASCOS approach looks acceptable to the applicant and the certifying authority.	Questionnaire item
ASCOS Tool for risk assessment	1. Manipulability	The extent to which the Tool for risk assessment promotes a useful means to manipulate—i.e. access, edit, modify— the ASCOS ESDs and FTs.	Questionnaire item
	2. Quantification capability	The extent to which the Tool for risk assessment can calculate the risk quantification.	Questionnaire item
	3. Cross-domain integration	The extent to which the Tool for risk assessment promotes integration, coordination, and exchange of information across the different stakeholders that may be involved in certification.	Questionnaire item
	4. Standardization	The extent to which the proposed tool can become a standard reference framework in use across the different actors of the TAS.	Questionnaire items
	5. Acceptability	The extent to which the proposed ASCOS approach looks acceptable to the applicant and the certifying authority.	Questionnaire items
	6. Usability	The extent to which the proposed risk model provides a usable means for supporting risk assessment.	SUS index

Table 8. KPAs for the ASCOS proposed certification approach (Exercise 1).

KPA	Definition	Metric
8. Efficiency	The extent to which the proposed ASCOS certification approach allows to reduce the effort (cost, time, and training) needed by the applicant to obtain a certificate.	Questionnaire items
9. Soundness	The extent to which the ASCOS certification approach promotes, in certification, the consideration of relevant hazards and safety requirements that today are not or are poorly considered—with specific reference to cross-domain hazards and safety requirements.	Questionnaire items
10. Cross-domain integration	The extent to which the ASCOS approach promotes integration, coordination, and exchange of information across the different stakeholders that may be involved in the certification of a change.	Questionnaire items
11. Harmonization	The extent to which ASCOS looks compatible with the different certification approaches in use in different domains (e.g. ATC vs aviation) and geographical areas.	Questionnaire items
12. Accommodation of Innovation	The extent to which ASCOS makes more likely the certification of innovative products and systems, i.e. products and systems for which no standard are available.	Questionnaire items
13. Acceptability	The extent to which the proposed ASCOS approach looks acceptable to the applicant and the certifying authority.	Questionnaire items
14. Flexibility	The extent to which the proposed ASCOS approach can be applied to a broad range of different types of products, systems, and services, varying in size and complexity.	Questionnaire items

Table 9. KPAs for the proposed ASCOS SPI framework and Tool for Continuous Safety Monitoring (Exercise 2).

Evaluated ASCOS results	KPA	Definition	Metric
ASCOS SPI Framework	5. Soundness	The extent to which the ASCOS SPI framework promotes, in certification, the consideration of relevant hazards that today are not or are poorly considered (with specific reference to the TAS related hazards).	Questionnaire items
	6. Completeness	The extent to which the proposed SPI framework covers the different (certification) domains of the TAS.	Questionnaire items
	7. Standardization	The extent to which the proposed SPI framework can become a standard reference framework in use across the different actors of the TAS.	Questionnaire items
ASCOS Tool for Continuous Safety Monitoring	8. Usefulness	The extent to which the proposed ASCOS is perceived as a tool useful for supporting continuous safety monitoring,	Questionnaire items

Table 10. KPAs for the proposed ASCOS Risk Model and the Tool for risk assessment (Exercise 3).

Evaluated ASCOS results	KPA	Definition	Metric
ASCOS Risk Model	5. Soundness	The extent to which the ASCOS Risk Model promotes, in certification, the consideration of relevant hazards that today are not or are poorly considered (with specific reference to the TAS related hazards).	Questionnaire item
	6. Completeness	The extent to which the ASCOS Risk Model covers, the different hazards of the TAS.	Questionnaire item
	7. Standardization	The extent to which the proposed risk model can become a standard model used by the different actors of the TAS.	Questionnaire item
	8. Acceptability	The extent to which the proposed ASCOS approach looks acceptable to the applicant and the certifying authority.	Questionnaire item
ASCOS Tool for risk assessment	7. Manipulability	The extent to which the Tool for risk assessment promotes a useful means to manipulate—i.e. access, edit, modify— the ASCOS ESDs and FTs.	Questionnaire item
	8. Quantification capability	The extent to which the Tool for risk assessment can calculate the risk quantification.	Questionnaire item
	9. Cross-domain integration	The extent to which the Tool for risk assessment promotes integration, coordination, and exchange of information across the different stakeholders that may be involved in certification.	Questionnaire item
	10. Standardization	The extent to which the proposed tool can become a standard reference framework in use across the different actors of the TAS.	Questionnaire items
	11. Acceptability	The extent to which the proposed ASCOS approach looks acceptable to the applicant and the certifying authority.	Questionnaire items
	12. Usability	The extent to which the proposed risk model provides a usable means for supporting risk assessment.	SUS index

Appendix B Management of safety activities for Total Aviation system

(The present appendix reports the content of section 7 of D3.5a [18]*)*

All the activities described in previous chapters and in relation with the setup of a common safety standard framework and a continuous improvement of safety standard loop are possible only if initiated, promoted, coordinated and monitored from the highest level to the lowest level of a project development.

In complex multi-stakeholder organization, interfaces are often responsible for gaps in safety assessment. It is then necessary to introduce high level organization standards defining interrelations and responsibilities and setting up strict management rules.

Of primary target are Project breakdown structures. These activities should be harmonized and coordinated at the highest level. Of most importance is the identification of safety standards to apply for development. These safety standards should formalize processes for requirement capture, requirement validation, requirement application verification, project organization/documentation, deliverables management, schedule management, process assurance, configuration management. Of most importance are also the "Safety plans" and the safety requirement validation plan, without which there will be no assurance of any safety method application.

Although the operational reliability and the integrated logistic support activities are not strictly speaking part of the safety and certification, these activities can be integrated within the same framework as safety activities

To assure a good interface management between the different stakeholders of a project, a sound and seamless engineering, the continuity of safety assessment practices and the seamless application of the rules, all the activities described in previous chapters should be promoted, initiated, coordinated and monitored at:

- TAS inter-stakeholder level by a central coordination group called here after "TAS Engineering and Safety Group" (TESG)
- TAS stakeholder level by a stakeholder level coordination group called here after stakeholder "Engineering and safety group" (SESG).

The ESG groups are coordination groups that can be under the responsibility of existing bodies or new body as necessary.

At total aviation system the TESG group should include participants from each stakeholder of the total aviation system. It will be the interface with EASA and ICAO

At each stakeholder level the SESG group should include participants from each sub stakeholder in relation with the considered stakeholder. It is the interface with the TESG and local authorities as needed

The organization of the different level ESG groups is illustrated in the following figure:

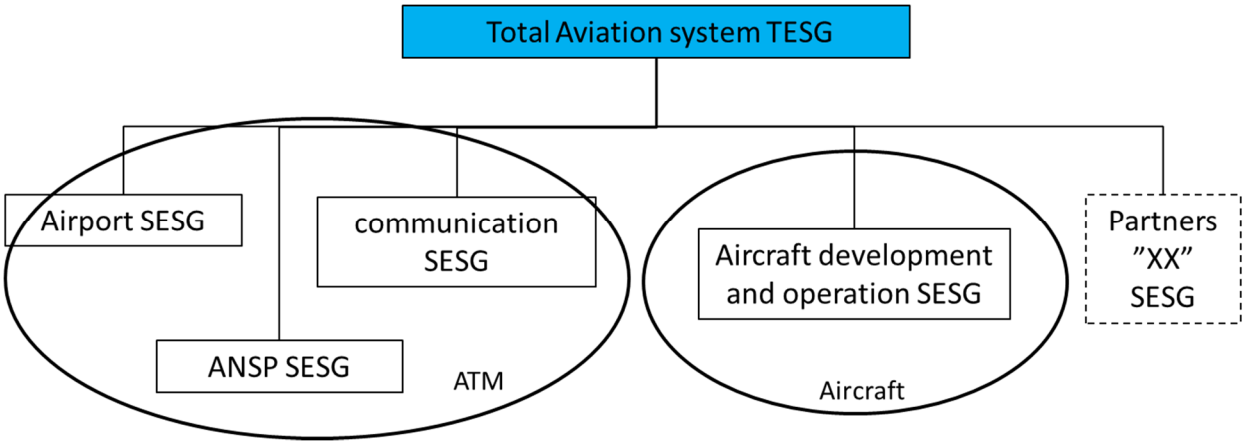

Figure 2. Safety management organization at TAS inter-stakeholder level and at stakeholder level

These Engineering and safety group organization should be implemented in the earliest phase of a development plan. The organization description of these groups, their management activities, their responsibility and the deliverables they should produce should be described in the inter-stakeholder safety plan and in each stakeholder safety plan.

The Total Aviation system "Engineering and Safety Group" (TESG) will be chartered to perform and/or monitor the inter-stakeholder total aviation system safety tasks during development and during operation. To structure product development safety tasks the TESG responsibilities may be to:

1. Identify and promote coherent safety standards framework to apply at inter-stakeholder level and at each stakeholder level for product development, interface management, safety assessment methods, software item development, electronic hardware item development, procedure and services development (including human factor)
2. Develop a safety plan and methods for the inter-stakeholder safety activities
3. Assure coherency between the tools used by the different TAS stakeholders
4. Promote safety culture and assure that safety training courses are available and given to safety involved people
5. Assure that lessons learned processes are established within each stakeholder organization
6. Identify safety lessons learned from previous accidents and provide visibility to each stakeholder
7. Establish and communicate the principles and data to apply to assure coherency between the safety assessments performed by each stakeholder
8. Assure compliance with ICAO SMM and European Aviation Safety Plan (EASP)
9. Identify inter-stakeholder accident scenarios with associated "Event Sequence Diagrams" (ESD)
10. Identify Area of Change to consider with associated future accident scenarios and ESD

11. Establish and allocate the safety objectives and the studies to perform by each stakeholder that contribute to the inter-stakeholder ESD
12. Monitor the completion of each stakeholder contribution to inter-stakeholder ESD
13. Perform inter-stakeholder Common Mode Analyses and evaluate Common Mode Analysis from each stakeholder
14. Issue total aviation system safety results
15. Coordinate with TAS certification authorities
16. Monitor the TAS level lessons learned and standards improvement process

To structure in operation safety assurance task and perform an efficient in operation safety follow up the TESG responsibilities are to set a unifying TAS Safety Management Process guide to allow exchanges of safety information necessary to perform the safety assurance at TAS level. For each organizational activity the management process may be based on the following:

1. A safety assurance plan describing the Safety Management Strategy and associated tasks for in operation safety assurance. This plan should be compliant with the TAS Safety Management Process Guide and with the regulation applicable to each individual organization. The safety assurance plan should particularly identify all the tasks associated to dissemination of safety information between the TAS stakeholders through the TAS level ESG (TESG).

   This plan may be structured around the activities recommended in:
   - **a.** the ARP 5150 for aircraft Safety Assessment in operation
   - **b.** The document “Management of risk: Guidance for Practitioners” (published by TSO (The Stationary Office) on behalf of Office of Government Commerce) applied by some ATM bodies
2. The safety methods to perform the tasks described in the safety plan

If a list of task to perform at TESG level is detailed in the above section, the details on the way the ESG groups will work together and be managed are not detailed further on purpose. This level of detail should be left to the internal decision inside the ESG structure to select the best and simplest way of working together at TAS level and at each stakeholder level.