Validation Plan and Scenarios

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Acronyms

Acronym	Definition
ANSP	Air Navigation Service Provider
AoC	Area of change
ASCOS	Aviation Safety and Certification of new Operations and Systems
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
COS	Continuous Operational Safety
CPS	Certification Process study
CS	Certification Specifications
D	Deliverable
DOW	Description of Work
EASA	European Aviation Safety Agency
EASp	European Aviation Safety plan
EC	European Commission
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
RVT	Remote Virtual Tower
SESAR	Single European Sky ATM Research
SPI	Safety Performance Indicator
TAS	Total Aviation System
TCAS	Traffic Collision Avoidance System
UG	User Group
UPRT	Upset Prevention and Recovery Training
WP	Work Package

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Executive Summary

This document presents the validation plan for the validation activities to be conducted in the context of ASCOS Work Package 5. The plan establishes the background and specific activities necessary for validating the fitness-for-purpose of the ASCOS proposed certification improvements. Based on EUROCONTROL E-OCVM [1], this means exploring how these improvements can perform in an actual certification context, i.e. what (added) value these products bring to the current certification process of aeronautical products and services.

The plan is composed of three evaluation exercises, one for each set of the ASCOS products to be validated: (i) the ASCOS logical argument framework referenced to the Total Aviation System, presented in the ASCOS Deliverable (D) 1.3 [2]; (ii) the ASCOS Tool for continuous safety monitoring, presented in the D2.4 [3]; and (iii) the Safety risk assessment model and the accompanying software tool, presented in D3.2.3 [4], and D3.3 [5] respectively.

Each exercise comes with its specific objective, exercise description, scenarios, preparatory activities, performance framework and risk and mitigation strategies. From a methodological point of view, the exercises share 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. Feedback from experts will be sought in relation to the ASCOS specific Key Performance Areas and Indicators; these have been defined by the D5.1 [6] specifically for each ASCOS product. Certification experts will be recruited from the ASCOS User Group members. The qualitative nature of the exercise is appropriate to the maturity level of ASCOS products, which was estimated to correspond to the phases V1 and V2 of E-OCVM [6].

At the core of the selected format is the intent 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 will be more insightful than talking to them individually. At the time of writing the number of experts taking part into the exercise is unknown; however, estimated minimum attendance is expected between 5 and 8 experts. In focus group, this number maximizes opportunities for discussions while making sure the group remains manageable. At the time of writing no definitive list of attendants is available; for this reason the exercises have been designed in order to adapt to an higher participants number: Exercise 1 is designed so that the exercise can be run in two parallel groups; Exercise 2 and 3 are self-contained 1 day exercises that can be replicated on different days if required.

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1 Introduction

1.1 Background

ASCOS is an EU funded project aiming at bringing improvements in the certification 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 programmes. 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 [7]. Such enhancements are expected to translate on a reduction of fatal accidents due to loss of control in flight, aircraft system or component failure or malfunction, aircraft ground handling damage, and Air Traffic Management related failure. These are the five top commercial air transport accident categories that include the higher number of fatal accidents.

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

- 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, an approach to assess future and emerging risks, and a methodology to improve current safety standards.

The present work package, ASCOS WP5, is dedicated to the validation of ASCOS products and consists 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, the WP5.1 Validation strategy has been completed and approved by ASCOS and is available in ASCOS D5.1 [6]. That document covers the seven steps advocated by E-OCVM for defining a validation strategy of novel concepts, from the definition of the current problems and constraints involved in current certification practices, to the initial definition of validation objectives, requirements, and performance framework. This material has provided the foundations for the development of the validation exercises that are described by the present deliverable.

1.2 Purpose of this Document

The objectives of this task are:

- To develop a validation plan for (selected) methods and tools;
- To identify and plan a set of validation exercises;
- To describe all aspects necessary to run the exercises: such as exercise objectives, indicators and metrics, scenarios and the roles of the different stakeholders, the activities to be undertaken the method(s), technique(s) and tool(s) to be used (also for the posterior data analysis).

This document presents the validation plan and scenarios that have been defined in the scope of ASCOS WP5.

1.3 Validation of ASCOS products

The objective of the validation is to establish the fitness-for-purpose of the certification improvements delivered by ASCOS. Validation may mean different things to different people. A useful document to clarify its meaning is E-OCVM [1], a common approach defined by EUROCONTROL for supporting ATM R&D projects during the validation of novel concepts and systems. 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”. Validation is an issue of establishing if a product satisfies the originally intended purpose for which it was designed and if it delivers the expected benefits to the user. In short validation answer the question “have we built the right system?”. In this way it differs from verification: this latter focuses in fact on answering the question “have we build the system right, i.e. according to the initial specifications?”.

The evaluation of fitness for purpose of ASCOS products has to be considered in the context of certification, i.e. how ASCOS products may change existing certification practices and which added value they may bring to these. For instance, ASCOS may increase the consideration of hazards related to the Total Aviation System, rather than the single domain in which the change takes place; may improve the cost-effectiveness of existing certification practices, especially for innovative products and services; may streamline the process of gaining acceptance by an authority.

Focusing the validation exercises on these areas of performance comes natural for evaluating the outcome of WP1. The proposed ASCOS Logical argument framework affects directly the practice of certification. The same does not apply to the products developed in the context of WP2 and WP3. Such products consist of models, methodologies and supporting software tools intended to support safety analysis relevant for specific phases of the WP1 certification process; however, these improvements could also support safety analysis non-certification related. So, it is important to stress that the evaluation of the WP2 and 3 products will be considered in the context of certification with reference to the ASCOS proposed certification approach.

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 fit for purpose needs to be conducted considering 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 organizational actors involved in certification either in the role of certifier or applicant 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 a performance evaluation framework has been designed that captures the areas of performance in which each ASCOS product is expected to bring an improvement in certification practices. The performance framework has been developed in the course of WP5.1, and is currently documented by the D5.1 [6]. The performance framework identifies some broader areas of performance, also called Key Performance Areas (KPA), each containing more specific indicators, i.e. the Key Performance Indicators (KPI). While a KPA summarizes broader areas of improvement, KPIs are specific to each product that has to be evaluated instead.

2 Validation Plan Overview

2.1 Description of the Plan

The ASCOS validation plan comprises three distinct validation exercises:

- Exercise 1: Validation of the logical argument framework referenced to the Total Aviation System. This product has been developed in the context of ASCOS WP1 and its description is available in ASCOS deliverable D1.2 [2];
- Exercise 2: Validation of the software tool for continuous safety monitoring. This product has been developed in the context of ASCOS WP2 and its description is available in ASCOS deliverable D2.4 [3];
- Exercise 3: Validation of the safety risk assessment model and the supporting software tool. These products represent part of the outcome of ASCOS WP3; their descriptions are available on ASCOS deliverables D3.2.3 [4], and D3.3 [5] respectively.

Each plan specifies the exercise, objective, validation scenario, roles and responsibilities, and preparatory activities specific for the validation of each ASCOS product to be validated in the context of WP5. From a methodological stand point, the three exercises share the same basic qualitative format: a validation workshop with selected certification experts from the ASCOS UG group. This format includes two phases:

1. **A familiarization phase,** which gives an opportunity to the participating experts to familiarize with the product to be validated by means of a demo illustrating specific scenarios (all three exercises) and user trials (Exercise 3 only). The familiarization phase is instrumental to prepare experts to the discussion groups and questionnaires envisaged in the second phase;
2. **A feedback gathering phase**. This phase represents the core of the workshop. It collects experts' subjective feedback through guided group discussions (i.e. focus group) and questionnaires. Feedback is collected on the ASCOS defined Key Performance Areas (KPA) and Indicators (KPI). KPAs and related KPIs have been developed for each specific ASCOS product in WP5.1 (see [6]); they represent important areas of certification in which these products are expected to bring an improvement.

Table 1. Summary table of the three Exercises

Validation Exercises	ASCOS Product Under Evaluation evaluated	Format	Structure of the day	Dates
Exercise 1	TAS Level Logical Argument framework	1 Day Validation Worksop	-Feedback gathering	10th Oct 2014 (2nd Day of ASCOS UG meeting 3)
Exercise 2	ASCOS software Tool for continuous safety monitoring	1 Day Validation Worksop	-Familiarization + -Feedback gathering	Nov 2014 *(tentative)*
Exercise 3	Risk Assessment methodology, method and supporting software tool	1 Day Validation Worksop	-Familiarization & User trials -Feedback gathering	Jan 2015 *(tentative)*

Although all of the three exercises share the same common qualitative format some differences can be observed regarding duration and specific activities envisaged for the familiarization session. Regarding duration, it can be noted that Exercise 1 will last one day and will include only the Feedback Gathering session. This is the case because this exercise will occur during the second day of the ASCOS UG meeting 3. The first day of this meeting serves the evaluation purposes of the WP4, which concern the application and evaluation of the proposed approach in the context of four case studies regarding the introduction of novel aeronautical systems and services. Thus, during Day 1 of the UG meeting 3 participating experts will take part in group discussions aimed at evaluating the quality of the certification materials developed for each case. Because of that, participants will have had an opportunity to understand in depth the proposed certification approach, so that no familiarization is needed during day 2. In short, day 1 of the UG meeting 3 will serve both the goals of the WP4 and the familiarization goal of Exercise 1.

It is important to stress at this point that Exercise 1 does not duplicate the evaluation conducted by WP4. Exercise 1 uses the cases prepared by the WP4 as a basis for broader discussions on the value of the ASCOS approach in different certification contexts than those exemplified by the WP4 case studies. The focus of Exercise 1 is on the value of the concept of the logical argument framework. From Exercise 1 perspective, the WP4 cases are instantiations of the concept useful to let experts understand the approach and envisage how it could work in real life, and hence express a judgement about its potential and limitations. On the contrary, the cases developed by the WP4 have a more specific focus on the quality of the certification material as developed by each WP4 case.

Regarding familiarization, it can be noted that the Exercises 2 and 3 entail the evaluation of software products also. Therefore, their respective familiarization sessions include also interactive demo sessions to show the working details of these software. Further, limited to the Exercise 3 only, it is also foreseen to conduct a software trial with expert participants: these will use the tool to perform predefined tasks so it will be possible to collect feedback about the tool functionalities and usability aspects.

2.2 Rationale of the Plan

The format of the Validation Workshops is justified by the following considerations:

1. Consideration of constraints in accessing experts.
2. Adequacy to ASCOS Maturity Level.

2.2.1 Consideration of constraints in accessing experts.

The planning and the choice of the validation activities is constrained by the availability of the certification and safety experts to involve in the exercise. ASCOS certification and safety experts have to be recruited from the members of the ASCOS User Group. Such members are active professionals whose availability is constrained by the job demands of the different organizations they work for. So it is envisaged that it is more feasible to request UG members to attend three short 1-day events organized over the period October 2014 to January 2015, allowing about 1 month interval between each other, rather than a single event lasting 3 days. For these reasons it has been chosen to hold an evaluation exercise that allows to condensate UG attendance on a few dates.

2.2.2 Adequacy to ASCOS Maturity Level.

It must be noted that the validation plan presented here has mostly a focus on learning and improvement rather than on demonstrating the validity of the ASCOS approach quantitatively. This is because validation activities are inevitably influenced by the maturity of the concept under evaluation. During the WP5.1 the maturity level of ASCOS products was estimated to be between phases in V1-Scope and V2-Feasibility of the E-OCVM (see D5.1, p.42). This is because ASCOS is an innovative project and consequently many aspects of how its proposed solutions have to be used in a real life certification context are to be explored. In particular, to date there is no description of how the proposed concepts deliver improved performances within a certification context. In fact no evaluation activity of their fitness-for-purpose has been initiated prior the initiation of WP5. Because of this knowledge gap, it was decided that WP5 validation should be qualitative-explorative, rather than quantitative-confirmative.

This decision is reflected in the format chosen for the validation exercises, which emphasizes (in the feedback gathering session) the elicitation of knowledge and insights from selected experts through controlled group discussions, i.e. focus groups. Because of their professional experience, experts have a unique insider view about the certification life and its inner working logics, existing barriers, and multiple (conflicting) demands and constraints. Their insider view places them in a unique position to see the pros and cons of ASCOS products.

The focus group method is suited to the collection of feedback from experts. The combined results of the whole group working together will be more insightful than talking to experts individually. The focus group is a qualitative research method that is based on the elicitation of knowledge from a homogeneous small group of participants through a controlled group discussion in a relaxed environment [8]. Participant number usually varies between 6 and 12. In a typical focus group a moderator prompts discussion and elicits beliefs, opinions, and critiques from a group of participants on a theme that is of interest to the researcher. Compared to other qualitative research methodologies—such as interviewing, direct observations and questionnaire—, the need to conduct controlled group discussion is one of the most distinctive feature of focus group. This requires the consideration of issues such as having one or several individuals dominating the discussion and the likelihood of groups dynamics obscuring the discussion of the topic of interest, such as the tendency to reproduce normative discourse [9]. These dynamics are not normally encountered by alternative data collection methodologies which instead entail interactions with one or a few research participants at time.

2.2.3 Rationale for the sequence of the Exercises

The specific sequence of the validation workshops has been defined considering that the WP1 product, i.e. the TAS logical argument framework, is the main product developed by ASCOS. Consequently it has a high priority for the consortium. Also, focusing on the evaluation of the WP1 first ensures that the evaluation of the WP2 and WP3 products is made with consideration of their role in context of certification and the use of the TAS logical argument framework. This is because by the time of Exercise 2 and 3 will occur, UG members will be already familiar with the proposed certification process, having encountered it already during Exercise 1. On the other hand, focusing on the outcomes of WP2 and WP3 prior the WP1 would risk to assess their value as

standalone non-certification related items, rather than as contributory processes and tools to the WP1 product.

The high priority given to Exercise 1 explains why this exercise has been specified more in detail in the remaining of this deliverable. The definition of logistic arrangements for Exercises 2 and 3 are still on going at the time of writing this deliverable.

3 Exercise 1: Validation of the ASCOS TAS Level Argument Framework (WP1)

3.1 Objective

The objective of Exercise 1 is to evaluate the value that the ASCOS Logical argument approach brings with regard to the certification of novel aeronautical products and services. In particular the focus is on understanding to which extent the approach meets the expectation of certification stakeholders.

3.2 Exercise description

Exercise 1 consists of a one day Validation Workshop with certification experts recruited from the ASCOS UG member group. The Workshop is organized around two controlled group discussion sections aimed at collecting UG members' views on the new certification approach. In particular, each section is moderated by a facilitator that will seek participants' response about the potential impact of ASCOS proposed certification approach on a set of predefined ASCOS Key Performance Areas and related Key Performance Indicators, as defined by D5.1. The full list of the KPAs and KPIs used for the focus group discussions is available under section 3.5. Experts' response will be sought from both an applicant and a certifier (or certifying authority) perspective. Participant feedback will be collected in the form of questionnaire ratings. The group discussion sections are followed by a third and last session in which the list of the main findings of the day are presented by the research team to the audience for the purpose of corroboration.

The Workshop is organized in the context of the UG Meeting 3. The first day of this meeting is intended for familiarization purposes: it will provide an opportunity for demonstrating in detail the use of the approach to the UG members in the context of four certification scenarios. As part of this exercise plenty of time (about 1h) is left to participants for in depth discussions about each case. Having a full day dedicated to familiarization explains why the planned validation focus group does not has an initial training or familiarization session as for the other Exercises.

It has to be noted that the consortium has also considered an alternative validation plan for the evaluation of the Logical Argument Approach: the retrospective application of the ASCOS Logical Argument Framework in the context of an existing real life certification case. This option appeared appealing because it would have provided a realistic baseline against which to compare ASCOS performances. On this basis, a comparative assessment of the relative strengths and limitations of the proposed approach and the retrospective case study methodologies was made by the WP5. The assessment is available under appendix B. It has concluded that the retrospective application of the ASCOS approach in the context of an existing case would have encountered problems of both (i) feasibility and (ii) generizability. Regarding feasibility, it was acknowledged both (i) the difficulty of accessing property certification material not available in the public domain, and (ii) the lack of adequate managerial arrangements, resources and time in the WP.5. Regarding generizability, it was acknowledged that the produced insight would have been difficult to generalize besides the context of the specific case. On the other hand the chosen format is not limited to a single case but aims at eliciting feedback from a wide range of certification experiences known to the experts taking part in the study.

Furthermore, one strong assumption behind the feasibility of the alternative plan was that cost figure of current certification programmes are available in the literature. Such costs could then be used for baseline comparison, i.e. to see how the costs of the ASCOS approach compare with existing certification costs. For this reason a literature review was conducted in the context of WP5.2 to search for data on costs of current certification programs (the review is available under Appendix E of this document). The review has identified some references that provide numerical indications of costs of various types of certification programs [e.g. Boeing, Nickum, Thomas, AeroStrategy]. However, in using these indications it is important to note they are case specific: professional experience suggests that safety assessments may require a few days up to many months of work, depending on the scope, complexity of the case, regulatory requirements, means of compliance etc.; therefore, it is impossible to provide a cost estimate generally applicable beside the specific case in which it has been estimated—its value is too case specific.

3.3 Validation Scenarios

Exercise 1 will make use of validation scenarios exemplifying the application of the ASCOS Logical argument framework in a certification context. The scenarios have been developed as part of ASCOS WP4. They exemplify the execution of the first three steps of the ASCOS proposed logical argument framework.

3.3.1 Identification of the Scenarios

The selected scenarios are appropriate to ASCOS because they represent certification situations in which improvement in current certification practices is desirable. They represent changes concerning the introduction of innovative technological systems and services. This is a sensitive area of improvement in current certification practices due to factors such as high costs, length of the process, and domain and lifecycle compartmentalization.

3.3.2 Scenario 1.1: Certification of RPAS Failure Management System

This scenario demonstrates the application of ASCOS proposed approach to the certification of a change involving the introduction of a novel system for a Failure Management System for a Remotely Piloted Aircraft System (RPAS). The RPAS is conceived as an adaptation of a (generic) existing civil fixed wing cargo aircraft with flight crew on board. The RPAS definition includes the aircraft, the ground station used to pilot the aircraft and the communications link between aircraft and ground station. It shall cover the specific aspects of training and maintenance and maintenance of RPAS product.

3.3.3 Scenario 1.2: Certification of an Automated Aircraft Recovery System

This case demonstrates the application of ASCOS proposed approach to the certification of a change involving the introduction of a novel on-board Automatic Aircraft Recovery system (AARS). This system is intended as remedy against loss-of-control accidents, which are often triggered by insufficient situational awareness on the crew's side in combination with rare failure modes. The purpose of the AARS is to restore automatically the aircraft safe flight condition after the occurrence of any potential upset or any deviation from a normal control regime. In other words, whenever any system failure or any other flight disturbing event leading to loss of crew's situational awareness occurs, this system will bring the a/c to a stable flight condition, within the normal flight envelope of the aircraft. The system will be in control of the restored situation for a sufficient period of time to permit the crew to diagnose the potential problem and to restore situational awareness.

3.3.4 Scenario 1.3: Certification for Ground De-Icing operations

This case demonstrates the application of ASCOS proposed approach to the approval of a change involving a transfer in responsibility for Anti-Icing/De-Icing ground operations from airlines to an individual Anti-Icing/De-Icing service provider external to the airline. Today, airlines are responsible for establishing procedures for ground de-icing and anti-icing and related aircraft inspections to allow the safe operation of the aircraft. The air operator may provide a ground de-icing and anti-icing service itself, or contract out the service to an

external provider. In both cases, responsibility for safety and for compliance with applicable regulations remains with the airline operator.

The change considered in this Scenario entails that an individual de-icing/ anti-icing service provider becomes certified itself, and becomes responsible and accountable for providing a safe service. The air operator is then no longer responsible for this. A change in regulations would be required for this. The overall goal of the change is to enhance safety. It is principally a change in responsibilities, which may be accompanied by an adaptation of the human roles, responsibilities and procedures. For example, in stage 5 it may be decided to expand the responsibilities of the de-icing/anti-icing service provider to include the decision to apply de-icing or anti-icing. The actual de-icing/ anti-icing activities and involved equipment can in principle remain unchanged.

3.3.5 Scenario 1.4: Certification of a an integrated ground surveillance system

This case demonstrates the application of ASCOS proposed approach to the approval of a change involving an Integrated Surveillance System (ISS) over Frankfurt PAM area (slightly greater than the TMA). This system is intended to be in charge of all the ATC Surveillance functions as the primary means of surveillance. Its aim is also to progressively replace (by attrition) all current PSR and SSR of the area. In the case of SSR, a possible conclusion of the system deployment maybe that after the attrition period coverage with SSR shall still be kept as a secondary mean of surveillance.

3.4 Roles and responsibilities

3.4.1 Moderator

The role of the facilitator is that of facilitating and conducting the group discussions with UG members' participants to collect feedback on the topics of interest. The facilitator will help the participants to understand the common goal of each discussion section and the purpose of the questionnaire; will hand out the questionnaire; will start the group discussion; will clarify the points raised by group participants; and will make space for more quite group members. At the end of each section the facilitator, with the support of the note taker, will prepare a list of the most important points emerged through the day. These will be presented at the end of the day to the UG members for the purpose of corroboration.

3.4.2 Expert Note Taker

This role will assist the facilitator in each discussion group. S/he will capture a detailed account of participants input. At the end of each section the note taker will help the moderator in the preparation of the material for the debriefing. The complexity of the discussed topic requires a note taker knowledgeable about ASCOS, with the WP4 cases and also with the certification process of aeronautical products. For this reason it is proposed to choose an ASCOS participant from the WP4.

3.4.3 Expert of the ASCOS Logical Argument Approach

The presence of an expert of the ASCOS proposed certification approach is required (i) for running a summary presentation of the approach at the start of the day, and (ii) for intervening in the developing discussions whenever there is a need for clarification regarding the approach. The former purpose is justified by the need to focus participants at the start of the workshop on the object of the evaluation, i.e. the concept of the proposed certification approach. This presentation does not need to be long because it will serve mainly as a reminder, as the participants will have had an extensive exposure to the approach during the day preceding the validation workshop. The latter purpose is justified by the need to help participants to clarify aspects of the approach that are not immediately clear to them, and that still need to be clarified to do justice to the concept and to collect more truthful questionnaire ratings. The expert of the ASCOS logical argument framework is expected to be the ASCOS partner who developed the approach.

3.4.4 Over the Shoulders Observers

These are "over the-shoulders" or "behind-the-glass" observers in each of the subgroups. It is, however, not the intention that other ASCOS participants will be active in the subgroup discussion. Main goal of the subgroup discussions is to obtain feedback from the User Group members. Discussions should not end in detailed technical discussions where ASCOS participants might feel the need to 'defend' their results. In order to prevent this from happening, it is considered to have the User Group members, ASCOS moderator and ASCOS note taker all taking place at a table, and to position the other ASCOS participants in a "second spectator ring" around the table.

3.4.5 Participants

This group includes certification experts, recruited from the ASCOS User Group, who will represent both the applicant and the certifier perspective. In order to stimulate fruitful discussions, prior to the event these experts (i) will be provided with the certification material prepared by the WP4 applicants; and (ii) will be asked to review this material as if they had to certify it. More details about this are provided in the next section.

3.5 Performance Indicators

Table 2 shows the Key Performance Indicators (KPIs) for the validation of the ASCOS WP1 results: the ASCOS "Logical Argument Approach to Aviation Certification" or "proposed certification approach". It has to be noted that the KPIs in this table are not the actual items to be asked directly to respondents during the validation exercises. These KPIs have been translated on a questionnaire that is available under section 0.

Table 2: Definition of KPIs for ASCOS proposed certification approach.

KPA	KPI	Metric
1. Soundness of the Certification Safety Assurance Documentation	1.1 Degree to which the proposed certification approach is able to consider TAS hazards in the certification safety assurance documentation. This includes the capability of proposed certification approach to improve the consideration of cross domain hazards (hazards from other domains than the primary domain of interest), to improve the consideration of the associated evidence and design assumptions.*	Respondent subjective rating.
	1.2 Degree to which the proposed certification approach is able to improve the consideration of human factors related hazards in the safety assurance documentation. This includes the capability of the proposed certification approach to address human factors issues in a consistent manner, to establish safety requirements to mitigate human factors related hazards, to improve the consideration of the associated evidence and design assumptions.	Respondent subjective rating.
	1.3 Degree to which the proposed certification approach is able to improve the consideration of hazards from all phases of the lifecycle (including transition into operation) in the safety assurance documentation.	Respondent subjective rating.
	1.4 Degree to which the proposed certification approach enables the continuous consideration and improvement of the feedback mechanism to stakeholders about the context, conditions, in-service performance and assumptions made in the design, safety assessments or the safety assurance documentation (including feedback from domains other than the primary domain of application).**	Respondent subjective rating.
2. Efficiency of the Certification Process	2.1 Time needed by the applicant for completing the certification process with the proposed certification approach.	Respondent subjective rating.
	2.2 Time needed by the certifying authority to follow and review proposed certification approach, and to review the result from this approach applied by the applicant.	Respondent subjective rating.
	2.3 Time needed for the training of personnel to familiarise with the proposed certification approach.	Respondent subjective rating.
	2.4 Time needed to develop the certification safety assurance documentation by the applicant.	Respondent subjective rating.
	2.5 Time to complete the review of the certification safety assurance documentation by the certifying authority.	Respondent subjective rating.
3. Cross domain integration	3.1 Degree to which the proposed certification approach promotes and supports coordination, cooperation and exchange of information between stakeholders and across domains during the certification process.	Respondent subjective rating.
	3.2 Degree to which the proposed certification approach provides	Respondent

	clarity of roles and responsibilities of the stakeholders involved in the certification process from the start of the process (or through stage 1-11 in the proposed approach).	subjective rating.
	3.3 Degree to which the proposed certification approach is able to support the involvement of stakeholders from other domains than primary certification domain.	Respondent subjective rating.
	3.4. Degree to which the proposed certification approach is able to integrate the local approaches in use in each domain, regardless of whether they are compliance or performance based.	Respondent subjective rating.
4. Harmonisation	4.1 The extent to which the proposed certification approach promotes harmonisation and can be a standard reference approach in use across different domains and stakeholders.	Respondent subjective rating.
	4.2 The level of compatibility and consistency of the certification approach with existing certification practices, organisation and culture in aviation industry.	Respondent subjective rating.
5. Accommodation of Innovation	5.1 The potential of the proposed certification approach to ease the certification and continuous safety performance monitoring of innovative products and services.	Respondent subjective rating.
6. Operability of ASCOS processes and tools	6.1 Usability of the proposed certification approach in the certification process.	Respondent subjective rating.
	6.2 Usefulness, from an end user perspective, of the proposed certification approach in the certification process.	Respondent subjective rating.
	6.3 Acceptability, from an end user perspective, of the proposed certification approach in the certification process.	Respondent subjective rating.
7. Flexibility	7.1 The applicability of the proposed certification approach to a range of products and services varying in “size” and “complexity”.	Respondent subjective rating.
	7.2 Applicability of the proposed certification approach to the products and services of different domains, of different stakeholders and to the TAS.	Respondent subjective rating.
	7.3 Applicability of the proposed certification approach to both novel and derivative products and services.	Respondent subjective rating.

Notes:

*Related to 1.1: The degree to which the documentation accounts also for the hazards of the TAS domains impacted by the concerned change (other than those hazards from the primary domain of certification). TAS level hazards are important to consider as today each domain carries out its assessment in isolation from other approaches, without a consideration of the TAS.

**Related to 1.4: Often individual elements may have a good individual safety argument, but these are dependent on assumptions the safety case makes about the environment in which the element is used, i.e. about the rest of the TAS (see D1.2 [13]). The more complete the description of the context in which the safety argument is made, the more reliable the argument is considered to be.

3.6 Preparatory Activities

3.6.1 Before-the-event training

Before the event, in order to ensure the successful validation exercises, the User Group members need to be briefed on:

- The content of Deliverable 1.3 in order to understand the proposed ASCOS method;
- At least one of the Case Studies, such that they can take part in the validation exercises and discussions with one of the case studies in mind.

The content of Deliverable 1.3 will be briefly described in a one-pager which will be part of the pre-meeting document package to be sent to the participants. Each User Group member will receive information on the full set of Scenarios prepared by the WP4 in the pre-meeting document package. However, each individual member will be asked to specialize in only one of the scenarios, depending on their specific competences and interests. Also, the proposed ASCOS method will be explained in depth on the day prior the focus group, and will be briefly summarized in the morning of the event.

The decision to ask the user group members to specialize on only one of the scenarios is based on the need to limit the amount of time the User Group members need to prepare for the meeting. Each user member will be in fact requested not simply to read the application and certification material, but to study it and imagine how the approach would impact on the role of the applicant and the certifier in a real-life certification context. As a consequence of this, each subject will need to spend some time on the scenario to gain a level of understanding necessary for the validation exercise.

The pre-meeting document package is expected to contain a summary by WP4 of the 'ASCOS application and certification documentation covering: the first three steps of the ASCOS approach for the relevant Scenario. An alternative option is to schedule some time during the first day of the User Group meeting and give user group members the opportunity to read the material and prepare themselves for the validation exercises during that scheduled time. It might even be worthwhile to do both: send the material in the pre-meeting document package AND schedule time during the first day of the User Group Meeting. This is because a thorough preparation by User Group members is essential for successful validation exercises.

3.6.2 Recruiting of UG members

In order to ensure the success of the validation exercises it is important to maximize the participation of experts with direct professional experience in the certification process, either as a certifier or as an applicant, or both. This is necessary to ensure that questionnaire ratings about ASCOS validity, and the rationale for these ratings, are made/expressed based on a sound knowledge of the current certification practices in use nowadays across various domains and contexts.

3.6.3 Materials

Table below lists the materials that have to be in place to ensure the success of the event, together with their filename and responsible partners. These materials have been collected by the 3rd September 2014 for internal ASCOS approval. They will be available in their final version by the 3rd October 2014.

Table 3. Materials for Exercise 1

#	Material	Filename	Responsible Partner
1	Agenda of the day 1	ASCOS UG3 meeting – Agenda V2.0.doc	NLR-CTFLY
2	Introduction and instruction for participants	General Overview of Scenario Objectives.ppt	NLR
3	Summary and overview of the ASCOS approach to be validated	-	EBE
4	RPAS Certification Material (WP4.1)	Use case WP4.1 description	WP4.1Leader
5	AARS Certification Material WP4.2	Use case WP 4.2 description	WP4.2 Leader
6	Ground De-icing Service Certification Material WP4.3	Use case WP4.3 description	WP4.3 Leader
7	ISS Certification Material WP 4.4	Use case WP4.4 description	WP4.4 Leader
8	Agenda of day 2	ASCOS UG3 meeting – Agenda V2.0.doc	DBL-CTFLY
9	Introduction and instruction for participants	ASCOS_UG3_Day2_Introduction	DBL
10	Questionnaire	ASCOS_UG3_Day 2_Questionnaire	DBL

3.7 Risk and Mitigation

The following table reports risks and mitigation measures for exercise 1.

Table 4. Risks and mitigation measures for Exercise 1

ID	Risk	Mitigation
1	WP4 Partners do not produce the required material in time for the Validation Workshop	- Ensure appropriate coordination with WP4 leader and WP4 sub work package leaders
2	Number of attendee is insufficient for the event	- Allow sufficient time for recruiting. Recruiting for this exercise started in June 2014 so to ensure a minimal sufficient level of participation (i.e. about ten experts). To date (5/sept 2014) expected attendance ranges between 10 and 20 expert).
3	Focus group discussions lacking focus on the concept of ASCOS product to be evaluated	- Allow sufficient time at the start of day 1 and day to present the ASCOS approach; - Require experts to review a summary of the proposed approach prior the event; - During the group discussion, remind participants of the approach to be evaluated and the KPAs/KPIs under discussion.
4	Dominant or passive attitude of some participants affecting the quality of the discussion	- The moderator to maintain a comfortable discussion in which everyone can express his/her own opinion freely

4 Exercise 2: Validation of ASCOS Continuous Safety Monitoring Tool (WP2)

4.1 Objective

Exercise 2 will evaluate the outcome of ASCOS WP2, namely the ASCOS software tool for continuous safety monitoring. The specific objective is to evaluate the fitness for purpose of the concept. This means evaluating whether and to which extent the capabilities of this software tool meet the expectations of safety experts active in a certification context. This objective translates into understanding how and for which safety monitoring purpose the software tool can be useful in a real life certification context.

4.1.1 Scope

The validation of the ASCOS tool for continuous safety monitoring does not consider the usability aspects of the tool. These have been already evaluated under work package WP2.4 [3] . Also, the evaluation does not address the verification of the reliability of the ATCSM output, i.e. the computed trends of Safety Performance Indicators. These trends are in fact computed based on exposure data that depends on sources external to the software tool. In particular the availability of this data depends on the existence of appropriate political and organizational arrangements at national and international level that are not in the scope of ASCOS. Also, the evaluation will not assess quality of the occurrence data stored in the ECCAIRS system, i.e. the data base that is interrogated by the ATCSM. For these reasons, the reliability of the output will be considered as a given during the evaluation. This choice is coherent with the validation objective of exercise 2, which is more focused on exploring how SPIs trends can be used for safety analysis in the context of certification.

4.2 Exercise description

Exercise 2 will consist of a one day validation workshop with selected safety and certification experts from the ASCOS user members group. The workshops is organized around the following phases:

Phase 1: Familiarization

- In a presentation and demonstration format the participants will be briefed on the ASCOS tool for continuous safety monitoring. A set of predefined scenarios will be presented to participants in order to exemplify the use the methodology and tool. This demonstration is intended to help the participants to gain an understanding of the types of safety analyses that are supported by the methodology and tool. For the purpose of demonstrating functionalities, the exact output of the tool in the Scenarios (SPIs trends) is less relevant. Due to the current maturity level of the tool, the familiarization session will consists of a demonstration session only, with no interactions between the tool and the participants. This conservative choice has been made for achieving the dual purpose of maximizing the time spent for useful group discussions about the value of the proposed concept in the area of safety monitoring and certification, while (ii) avoiding discussions related to the structure and quality of the reported occurrence data and to the interface management aspects of the tool. Experts not familiar with ECCAIRS may overly focus (i) on the effort requested to adapt their way of

expressing issues to the ECCAIRS taxonomy and (ii) on the low level technicalities of the interface instead of commenting on the broader concept under evaluation.

Phase 2: Feedback Gathering

- Focus Group. During this session the participants will be taken through a guided group discussion aimed at collecting feedback on the continuous safety monitoring tool. Feedback will be sought in relation to relevant KPAs and KPIs specifically defined for this exercise. Such items have been developed as part of the D5.1 and are available under section 5.3.
- Questionnaire. A questionnaire will be used to collect semi structured feedback, in particular to obtain subjective ratings for the different KPAs/KPIs.

4.3 Scenarios

4.3.1 Identification of Scenarios

The validation scenarios for Exercise 2 have been designed consistently with the following criteria so to make them relevant to ASCOS:

- Coverage of different EASP Operational Issues, i.e. Runway excursion, Mid-air collision, Controlled Flight Into Terrain, Loss of control in flight, Ground collisions;
- Coverage of different category of ASCOS defined Safety Performance Indicators, i.e. Technology, Human, Organization, System of Organization;
- Consideration of different Total Aviation System domains, i.e. Aircraft, Air Traffic Management, Airport Operations, etc.

Based on these criteria several possible scenarios have been considered in preparation for this evaluation. However, the final choice has been constrained by the difficulty to retrieve the data set needed by each scenario. In particular, the retrieval of occurrence data was constrained by the availability of suitable publicly available occurrence data in ECCAIRS format. In addition, exposure data had to be retrieved by public sources such as EUROCONTROL annual performance reports, and hence its availability and suitability depended on these sources.

4.3.2 Scenario 2.1: Runway Incursions

This scenario exemplifies the use of the tool on the side of a safety analyst working for a European Air Navigation Service Provider, which is planning to implement the Runway Incursion and Collision Avoidance System (RIMCAS) at one of its major international Airports. The safety expert is tasked to investigate the effect of introducing RIMCAS in some of the major European Airports in the last years. As part of the exercise, the analyst decides to take as reference the period between January 2011 and December 2013 and to compare the number of Severe Runway Incursions occurrences in 6 European Airports: Geneva, Frankfurt, Milan

Malpensa, Brussels National Airport, Paris Charles De Gaulle, and Schiphol. The first three have been equipped with RIMCAS starting from 2011, while the last three are not yet equipped with it. Although the number of flight movements is different in the various airports, for the purpose of the demonstration it is decided that the analyst will make this first comparison to spot if any remarkable difference can be identified.

4.3.3 Scenario 2.2: Monitoring occurrences related to auto-flight systems

This scenario exemplified the use of the system by a safety officer working for the Civil Aviation Authority of a European country. S/he wishes to assess the reliability of auto-flight systems in the context of a study concerning Loss-of-Control in Flight incidents. S/he decides to investigate the number of auto-flight system failure occurrences involving commercial aviation aircraft flying over Europe in the last 5 years and to compare it with the previous 5 years.

4.3.4 Scenario 2.3: Monitoring crew reaction to EGPWS

This case exemplified the use of the tool by a safety analyst who wishes to monitor the effect of introducing E-GPWS in the nineties and the effectiveness of the existing E-GPWS training practices. For this purpose s/he analyses all the Controlled Flight into Terrain accidents and incidents involving a response to an E-GPWS alert occurred in the last five years in Europe.

4.4 Roles and responsibilities

4.4.1 Moderator

The role of the moderator is that of facilitating and conducting the group discussions with participants in the workshop to collect feedback on the topics of interest. The moderator will help the participants to understand the common goal of each discussion section and the purpose of the questionnaire, will hand out the questionnaire, will start the group discussion, will clarify the points raised by group participants, and will make space for more reticent group members. At the end of each session the moderator, with the support of the expert note taker, will prepare a list of the most important points that have come out of the workshop. These points will be presented at the end of the day to the UG members for the purpose of verification.

4.4.2 Expert Note Taker

This role will assist the facilitator in each discussion group. S/he will capture a detailed account of participants input. At the end of each section the note taker will help the facilitator in the preparation of the material for the debriefing. The complexity of the discussed topic requires a note taker knowledgeable with ASCOS and the Tool for Continuous Safety Monitoring.

4.4.3 ATCSM Expert

The presence of the developer of the ASCOS tool for continuous safety monitoring is required during the workshop. Because of his in depth knowledge of the tool, this person will demonstrate to participants how the tool works, and will help participants to clarify aspects of the software that are not immediately clear to them.

4.4.4 Participants

This group includes safety and certification experts, recruited from the ASCOS User Group, who will represent both the applicant and the certifier perspective. An effort will be made to focus on expert knowledgeable with either the ECCAIRS or occurrence reporting systems, or both.

4.5 Performance Indicators

Table 5 shows the Key Performance Indicators (KPIs) for the validation of the ASCOS WP2 results: the ASCOS Safety Performance Monitoring Process and Tools including the Safety Performance Indicator (SPI) Framework.

Important notes:

- In the context of the WP2 results, the KPA 1 should be interpreted as the extent to which the ASCOS Safety Performance Monitoring Process and Tools, including the Safety Performance Indicator (SPI) Framework, contribute to the soundness of the certification safety assurance documentation and continued safety performance monitoring (or continued airworthiness).
- The KPIs in this table are not the actual items to be asked directly to respondents during the validation exercises. Rather, these KPIs will be translated into a validation questionnaire, which will be designed in WP5.2.

Table 5: Definition of KPIs for ASCOS Safety Performance Monitoring Process and Tools.

KPA	KPI	Metric
1. Soundness of the Certification Safety Assurance Documentation	1.1 Degree to which the Safety Performance Monitoring Process and Tools contribute to the soundness of the Certification Safety Assurance Documentation.	Respondent subjective rating.
	1.2 Completeness of the SPI framework in relation to the TAS, different domains and stakeholders.	Respondent subjective rating.
	1.3 Degree to which the Safety Monitoring Process and Tools provide and improve feedback to suppliers and service providers on in-service performance and on assumptions regarding the operating environment made in design and certification safety assessments.	Respondent subjective rating.
2. Efficiency of the Certification Process	2.1 Impact on efficiency of stage 8, 9, 10 of the proposed certification approach by the Safety Performance Monitoring Process and Tools as part of the 'a posteriori risk assessment'.	Respondent subjective rating.
	2.2 Time needed to collect data to quantify the relevant SPIs in the context of a certification process and continued safety monitoring.	Respondent subjective rating.
	2.3 Degree of effort for the applicant required to maintain the database and tools and to semi-continuous update the SPIs of the (total) aviation system.	Respondent subjective rating.
	2.4 Time needed by the applicant to train its personnel on the Safety Performance Monitoring Process and Tools.	Respondent subjective rating.
3. Cross domain integration	3.1 Degree to which the Safety Monitoring Process and Tools promote and support coordination, cooperation and exchange of information between stakeholders and across domains during the certification process.	Respondent subjective rating.
	3.2 Degree to which the Safety Monitoring Process and Tools enable	Respondent

	the monitoring of the safety performance of systems of organisations.	subjective rating.
4. Harmonisation	4.1 The extent to which the Safety Monitoring Process and Tools promote harmonisation and can be a standard process and common framework for safety performance monitoring across different domains and stakeholders.	Respondent subjective rating.
	4.2 The level of compatibility and consistency of the Safety Monitoring Process and Tools with existing practices, organisation and culture in aviation industry.	Respondent subjective rating.
5. Accommodation of Innovation	5.1 The potential of the Safety Monitoring Process and Tools to ease the certification and continuous safety performance monitoring of innovative products and services.	Respondent subjective rating.
6. Operability of ASCOS processes and tools	6.1 Usability of the Safety Monitoring Process and Tools in a certification process.	Respondent subjective rating.
	6.2 Usefulness, from an end user perspective, of the Safety Monitoring Process and Tools in a certification process.	Respondent subjective rating.
	6.3 Acceptability, from an end user perspective, of the Safety Monitoring Process and Tools in a certification process.	Respondent subjective rating.
7. Flexibility	7.1 Applicability of the Safety Monitoring Process and Tools to a range of products and services varying in “size” and “complexity”.	Respondent subjective rating.
	7.2 Applicability of Safety Monitoring Process and Tools to the products and services of different domains, of different stakeholders and to the TAS.	Respondent subjective rating.
	7.3 Applicability of the Safety Monitoring Process and Tools to both novel as well as derivative products and services.	Respondent subjective rating.

4.6 Preparatory Activities

4.6.1 Before-the-event training

Before the workshop participants will receive via e-mail a short two page summary about ASCOS Exercise 2. This document will be useful to let user members to get an overall flavour about the ASCOS products to be evaluated and the structure of the related evaluation activities. This briefing material will be brief as anything demanding—i.e. a complete pre-workshop training package—would risk to be ignored mostly by the invited experts.

4.6.2 Recruiting of the UG members

In order to ensure the success of the validation exercises it is important to maximize the participation of experts with (direct) professional experience in safety analysis and the certification process, either as a certifier or as an applicant or both. This is necessary to ensure that questionnaire ratings about ASCOS products validity, and the rationale for these ratings, are made/expressed based on a sound knowledge of the certification practices in use nowadays across various domains and contexts. It is expected to involve in the exercise some of the experts that have attended Exercise 1: these experts will be familiar with the ASCOS proposed validation approach, and consequently, are more likely to provide informative views about how the tool for continuous safety monitoring can fit into this context.

4.6.3 Materials

Table below lists the materials that have to be in place prior the execution of Exercise 2 to ensure the success of the event.

Table 6. Materials for Exercise 2

#	Material	Type of material	Responsible Partner
1	Overview of WP2 products (length, 1 to 2 pages) (pre-meeting material)	.doc	DBL
2	Agenda of the Day	.doc	DBL
3	Introduction and instruction for participants	.ppt	DBL
4	Presentation of the WP2 products under evaluation and link with ASCOS certification process	.ppt	JRC
8	Questionnaire	.doc	DBL

4.7 Risk and Mitigation

The following table report risks and mitigation measures for Exercise 2.

Table 7. Risks and mitigation measures for Exercise 2

ID	Risk	Mitigation
1	Number of attendees is insufficient for the event	- Allow sufficient time for recruiting; - Announce the date of Exercise 2 at the start of Exercise 1, so to recruit potential interested UG members;
2	Participating experts getting over critical about the use of the interface of the tool	- Let the expert of the system to run the demonstrations, so that the participating experts do not use the tool directly.
3	Focus group discussions lacking focus on the concept of ASCOS product to be evaluated	- Allow sufficient time at the start of the day to present the ATCMS; - During the group discussion, remind participants of the approach to be evaluated and the KPAs/KPIs under discussion.
4	Dominant or passive attitude of some participants affecting the quality of the discussion	- The moderator to maintain a comfortable discussion in which everyone can express his/her own opinion freely.

5 Exercise 3: Validation of the safety risk assessment model and methodology and the supporting software tool (WP3)

5.1 Objectives

The objective of the exercise 3 is to validate the ASCOS risk assessment risk model and supporting software tool developed in WP3. The exercise 3 will collect the data, information and feedback on the fitness for purpose and benefits of these ASCOS outcomes by means of an interactive demonstration and evaluation with the ASCOS User Group. The specific objectives of the Exercise 3 include:

1. Evaluating whether the ASCOS safety risk assessment model is fit for purpose. The focus is on evaluating how and to which extent the risk model meets the expectations of certification stakeholders (defined in D5.1). This objective translates on understanding how and for which purpose the model can be useful in a real life certification context, for either a certifier and an applicant, or both.
2. Evaluating whether the supporting software tool is fit for purpose. The focus is on evaluating whether and to which extent the capabilities of this software tool meet the expectations of certification stakeholders. This objective translates on understanding first how and for which purpose the software tool can be useful in a real life certification context for either a certifier, and applicant, or both. Second, it emphasizes the understanding of the low level usability aspects, which pertain the ease with which the user can access, manipulate, and retrieve information.

5.1.1 Scope

The scope of the exercise 3 will be limited to the ASCOS WP3 developed risk assessment methodology (D3.1), the risk model (D3.2) and the supporting software tool to manage the model (3.3). The respective potential of these products is investigated with specific reference to the context of certification.

Verification of the risk model and the software tool fall outside the scope of the exercise, which focusses on the added value and fitness for purpose instead. In particular:

- **Verification of the model.** The validation of the model will focus on general aspects related to the usefulness and use of the model; but it does not provide a review of the low level details of each Fault Trees and Event Sequence Diagrams. However, prior the exercise, it is expected a minimum level of verification to ensure that that the parts of the risk model and the quantifications to be discussed during the exercise have been correctly implemented from paper into the software code. (It is acknowledged that during the exercise users may be interested on knowing how reliable or accurate the risk model's output is. It is simply assumed that the risk model output is correct for the validation purpose. In that sense the accuracy of the end result is less important that the usability or benefit of the methodology/model/tool.)

- **Verification of the software**. Similar considerations apply the verification of the software. The exercise does not consider whether the software code complies with the initial specifications. There

will be no consideration of aspects such as whether the source code was developed correctly, whether the algorithms function as intended, etc. These activities would fall under the scope of verification. Nonetheless, a minimum level of verification of the software functionalities that will be used during the exercise is expected. This is needed to have a test prototype in place that is sufficiently reliable to let the user explore and work with the tool with limited support.

5.2 Exercise description

Exercise 3 will consist of a one day validation workshop with selected certification experts from the ASCOS user group. The workshops are organized around the following phases:

Phase 1: Familiarization and user software trial

- Demo Session: Risk Assessment Methodology (concept) and its functionalities: In a presentation and demonstration format the participants will be briefed on the risk assessment methodology, risk model and functionalities. A set of predefined scenarios will be presented to participants in order to exemplify the use the methodology in a real life certification context. This demonstration is intended to help the participants to gain an understanding of the types of risk analyses that are supported by the methodology and model, and how the methodology can be used in the context of the ASCOS proposed certification approach (D1.3). For the purpose of demonstrating functionalities, the exact output of the risk model in the scenarios (probability of occurrence of certain events for instance) is less relevant.
- Interactive Session: Using the supporting software tool: Participants will be given an opportunity to use the software tool in order to perform a few basic risk assessment tasks in the context of two predefined scenarios. This session will allow the user to gain a first-hand understanding of the software tool, of its capabilities for risk analysis in a certification context, and of its usability aspects, i.e. ease of use.

Phase 2: Feedback Gathering

- Focus Group. During this session the participants will be taken through a guided group discussion aimed at collecting feedback on the proposed risk assessment methodology and the supporting software tool. Feedback will be sought in relation to relevant KPAs and KPIs specifically defined for this exercise. Such items have been developed as part of the D5.1 and are available under section 5.3.
- Questionnaire. A questionnaire will be used to collect semi structured feedback, in particular to obtain subjective ratings for the different KPAs/KPIs.

5.3 Validation Scenarios

5.3.1 Identification of scenarios

For identifying and selecting a set of scenarios that can be used in exercise 3 to meet the validation objectives we have defined a set of criteria. To avoid confusion it is useful remembering that the scenario presented here are not the same as the accident scenarios available in the model.

Criteria for selecting scenarios are:

- Be relevant to the context of certification.
- Coverage of different stakeholders: certifying authority and applicant (manufacturer, airport, aircraft operator).
- Coverage of different certification "products": an aeronautical product (system, equipment), operation.
- Coverage of different level of size and complexity.
- Coverage of new/innovative novel and existing/derivative products and services.
- Consideration of different Total Aviation System domains: Aircraft, Air Traffic Management, Airport Operations.
- Consideration for future (FAST Areas of Change).

A precondition is that the ASCOS risk model will not be modified, both qualitatively and quantitatively, to implement scenarios due to time and resources constraints. Only simple / small modifications will be made for the exercise 3 scenarios.

5.3.2 Scenario 3.1: Demo on the application of the risk assessment methodology, the risk model and their functionalities with reference to a Runway Excursion at Take-Off Scenario

This validation scenario serves the purpose of presenting and illustrating to the participants the risk assessment methodology and model. In particular, this scenario should show/explain the approach to build the risk model, explain what an ESD and FT is, what accident scenarios are included in the risk model, how quantification was done (e.g. data sources, data processing etc.), what sort of risk analyses can be run etc. Furthermore the process for emerging and future risk assessment shall be explained, including the FAST approach (Areas of Change). Also this scenario should show how the approach works in the contexts of certification, in particular the steps 4 and 5 in the proposed certification approach (refer to D1.3). The use of the risk model and the risk assessment methodology will be exemplified in the context of a runway excursion at take-off scenario, which has been described under section 3.4 of deliverable D3.2, issue 1.3.

5.3.3 Scenario 3.2: Tutorial with the software tool

This validation scenario introduces the supporting software tool to manage the risk model. It should provide participants with a basic understanding of the software interface and its functionalities or capabilities, i.e. how to add/modify ESD, FT, and barriers and how to compute overall risk figure. Also this case will make use of the

runway excursion at take-off scenario to illustrate the working details of the system. During this case participating experts will be invited to play with the software and to conduct a few basic tasks: they will be asked to develop simple ESD and FT based on paper ESD and FT that will be provided during the workshop. Other tasks that may be required include sharing the analysis, export the scenario, and add an Area of Change.

In order to speed up familiarization with the software tool, prior the meeting participants will be provided with user manual and a link to access the software tool.

5.3.4 Scenario 3.3: Introduction of Remote Virtual Tower (RVT) operations

Objective:

To validate (demonstrate and evaluate) the application of the ASCOS risk assessment methodology and tool for future risk assessment.

Approach:

- Demonstrate on a conceptual level by a presentation the application and performance of the ASCOS risk assessment methodology for future risk assessment. This case can also be used to demonstrate the fact that the methodology applies to the TAS, and supports a TAS-wide risk assessment. In addition, this case can illustrate how it can be used to demonstrate satisfying a safety requirement.
- Demonstrate with the software tool how a precursor / hazard can be linked to an existing model element, how a new hazard can be introduced in the risk model, how that model element will change as a result of the precursor, and what effects this will have TAS wide, i.e. on the set of EASp OI probabilities.
- Collect UG feedback by interview, questionnaire, and/or group discussion.

Detailed description

Change

Introduction of remote virtual tower operations (RVT).

User Task

The following user questions may come up during the risk assessment of this introduction:

- What is the future risk related to the introduction of RVT operational concepts?
- What is the related FAST AoC and hazards for this change?
- Which scenarios (ESD) or risk model elements (FT events) are associated with the change?
- What would be the impact on the EASp Operational Issues probabilities of this change?
- What is the future risk compared to the current risk?

Modelling approach

a) Define the change: The change is identified in the FAST list of AoC and the associated hazards are already defined by FAST. AoC_064 Remote Virtual Tower (RVT) operational concepts is applicable.

b) Define potential hazards: According to FAST the hazards are:
   - Reduced sensory information upon which clearance decisions are based.
   - Inadequate awareness of other conditions on or around the airport that may affect flight operations (such as nearby weather formations).
   - NextGen/SESAR hazard condition: As departing aircraft taxi to runway, ground controller overly relies on observing automation to monitor conformance. Associated human performance hazard: Ground Controller fails to issue corrective instruction to resolve conflict because of lack of alert from surface automation. Ground controller is overly reliant on remote conformance alert.

c) Select a hazard: Ground Controller fails to issue corrective instruction to resolve conflict because of lack of alert from surface automation. Ground controller is overly reliant on remote conformance alert.

d) Find relevant ESDs: In the risk model [D3.2], ESD 32 “Runway incursion” and ESD 36 “Conflict on taxiway or apron” are applicable as they contain elements that will be influenced by the hazard.

e) Relate the AoC hazard to the risk model elements. Possibly the current risk model may need to be expanded to include the effect of the FAST hazard on the scenarios. For example the current FT may need to be developed in more detail, e.g. expand the FT element ASC36b114 FT. Another approach is that the effect of the FAST hazard on the current risk model elements is modelled through a “modification factor” that modifies the existing probability of occurrence of certain model element (FT events) to present the effect of the hazard on the accident scenarios.

f) The hazard is linked to risk model elements, pivotal events and/or base events, for example:
   - ASC32b1 (ATC does not resolve conflict).
   - ASC36b1 FT (ATC does not resolve conflict).
   - ASC36b114 (ATCO does not resolve conflict in time).

g) For the demonstration we will assume a probability for FAST hazard and/or assume a certain effect of the FAST hazard on the probability of occurrence of the existing risk model element.

h) Current risk level calculation: The software tool is used to determine the current risk level, meaning the probability of occurrence, of events (for example) ASC32b1, ASC36b1and the end states of ESDs ASC32 and ASC36.

i) Future risk level calculation: The software tool is used to recalculate the probabilities of occurrence after the applicable FT elements are modified by the modification factor or with the relevant FT expansion to include the FAST hazard as a separate model element. The result can be present as absolute probabilities or relative change in probability (percentage change).

j) This case can also show that the RVT operations meet a certain safety objective or requirement. The target safety level should be assumed in the scenario for demonstration purpose only.

5.3.5 Scenario 3.4: Introduction of Upset Prevention and Recovery Training (UPRT)

Objective:

To validate (demonstrate and evaluate) the application of the ASCOS risk assessment methodology and tool for emerging risk assessment.

Approach:

- Demonstrate on a conceptual level by a presentation the application and performance of the ASCOS risk assessment methodology for emerging risk assessment. This case can also be used to demonstrate the fact that the methodology applies to the TAS, and supports a TAS-wide risk assessment.
- Demonstrate with the software tool how a hazard or an existing model element can be modified as a result of a safety improvement, how that model element will change, and what effects this will have TAS wide, i.e. on the set of EASp OI probabilities.
- Collect UG feedback by questionnaire, and/or group discussion.

Detailed description

Change

The European Aviation Safety plan (EASp) [10] action item AER4.16: Develop regulations which ensure that initial and recurrent pilot training and checking is adequate to provide a pilot with the knowledge, skills and attitude to be competent in preventing and, if necessary, recovering from a loss of control in flight situation.

User questions

The following user questions may come up during the risk assessment of this introduction:

- What is the emerging risk related to the introduction of UPRT training?
- Which scenarios (ESD) or (FT) model elements are associated with the change?
- What would be the impact on the EASp Operational Issues probabilities?
- What is the emerging risk compared to the current risk?

Modelling approach

a) Define the change: We assume that training program for upset prevention and recovery (UPRT) will be introduced worldwide in airlines.
b) Find relevant ESDs: In the risk model [D3.2], find all applicable ESD that contain elements that will be influenced by the change. Especially the ESDs with the pivotal event “Flight crew does not maintain control” will be affected by this change.
c) Relate the change to specific ESD events and FT base events. For example, FT event ASC12b11 (unsuccessful attitude monitoring) or FT event ASC12b12 (unsuccessful recovery from extreme attitude) is likely affected by the change.

d) Assume for the sake of the example a certain effectiveness or impact of the change on flight crew. In the end a modification factor is applied to the model events that are relevant, i.e. that have a relation with aircraft control or recovery of control by the flight crew.

e) Current risk level calculation: The software tool is used to determine the current risk level, meaning the probability of occurrence, of events (for example) “flight crew fails to maintain control” and end state “collision with ground”.

f) Future risk level calculation: The software tool is used to recalculate the probabilities of occurrence after the applicable FT elements are modified by the modification factor. The result can be present as absolute probabilities or relative change in probability (percentage change).

5.3.6 Scenario 3.5: One of the WP4 cases (optional)

The objective of this scenario is to illustrate the application of the ASCOS risk assessment methodology and risk model in the ASCOS certification approach using one of the WP4 cases. In particular, this scenario will make use of a WP4 case in which the risk assessment, the risk model and the supporting software tools were used. This presentation shall focus on the process and the methodology at a conceptual level, and not on whether the WP4 scenario was correctly executed, whether the WP4 case results are realistic, whether the quality of the WP4 case report is sufficient etc. The participants have to evaluate the methodology and the tool, not the quality and content of the WP4 case. The feasibility of this case is subject to the availability of a relevant WP4 case in which the risk assessment methodology, the risk model, and the software tool have been actually used and documented.

5.4 Roles and responsibilities

5.4.1 Moderator

The role of the moderator is that of facilitating and conducting the group discussions with participants in the workshop to collect feedback on the topics of interest. The moderator will help the participants to understand the common goal of each discussion section and the purpose of the questionnaire, will hand out the questionnaire, will start the group discussion, will clarify the points raised by group participants, and will make space for more reticent group members. At the end of each session the moderator, with the support of the recorder, will prepare a list of the most important points that have come out of the workshop. These points will be presented at the end of the day to the UG members for the purpose of verification.

5.4.2 Expert Note Taker

This role will assist the facilitator in each discussion group. S/he will capture a detailed account of participants input. At the end of each section the note taker will help the facilitator in the preparation of the material for the debriefing. The complexity of the discussed topic requires a note taker knowledgeable with ASCOS, with the risk assessment methodology, the risk model, and the associated supporting tool.

5.4.3 Risk assessment tool expert

A person involved in the development of the supporting software tool is expected to be available during the Exercise. In the first part of the day, this person will provide an overview of the capabilities of the software. During the user trials this person will be available on demand for IT support, for showing the software capabilities, for helping participants with the use of the software, and for addressing issues with the tool that may be unclear to participants.

5.4.4 Participants

This group includes certification experts, recruited from the ASCOS User Group, who will represent both the applicant and the certifier perspective. An effort will be made to involve experts familiar with safety risk assessment and the proposed ASCOS certification approach.

5.5 Performance Indicators

Table 8 shows the Key Performance Indicators (KPIs) for the validation of the ASCOS WP3 results: the ASCOS Safety Risk Assessment Methodology, Risk Model and Tool.

Important notes:

- In the context of the WP3 results, the KPA 1 should be interpreted as the extent to which the ASCOS Safety Risk Assessment Methodology, Risk Model and Tool contribute to the soundness of the certification safety assurance documentation and continued safety performance monitoring (or continued airworthiness).
- The KPIs in this table are not the actual items to be asked directly to respondents during the validation exercises. Rather, these KPIs will be translated into a validation questionnaire, which will be designed in WP5.2.

Table 8: Definition of KPIs for ASCOS Safety Risk Assessment Methodology, Risk Model and Tool.

KPA	KPI	Metric
1. Soundness of the Certification Safety Assurance Documentation	1.1 Degree to which the Safety Risk Assessment Methodology, Risk Model and Tool contribute to the soundness of the Certification Safety Assurance Documentation	Respondent subjective rating.
	1.2 Ability to identify, assess, and provide risk estimates based on the consideration of TAS level failures (i.e. failures from other TAS domains than solely from the primary domain of certification) and consideration of emerging and future risks (future risk picture).	Respondent subjective rating.
	1.3 Accuracy and reliability of output of the Risk Model and Tool.	Respondent subjective rating.
	1.4 Completeness of the Risk Model and Tool (accident scenarios in the model) in reference to international definitions and standards, taxonomies, accident categorisations etc.	Respondent subjective rating.
2. Efficiency of the Certification Process	2.1 Impact on efficiency of stage 4, 5, 6 of the proposed certification approach by the Safety Risk Assessment Methodology, Risk Model and Tool as part of the 'a priori risk assessment'.	Respondent subjective rating.

	2.1 Degree of effort needed by the applicant to develop a future risk picture, inclusive of emerging and future risks, during the certification process.	Respondent subjective rating.
	2.3 Degree of effort needed by the applicant to operate and maintain the Safety Risk Assessment Methodology, Risk Model and Tool.	Respondent subjective rating.
	2.4 Time needed by the applicant to train its personnel on the Safety Risk Assessment Methodology, Risk Model and Tool.	Respondent subjective rating.
3. Cross domain integration	3.1 Degree to which the Safety Risk Assessment Methodology, Risk Model and Tool promote and support coordination, cooperation and exchange of information between stakeholders and across domains during the certification process.	Respondent subjective rating
	3.2 Degree to which interfaces between disciplines, between domains and the entire system life-cycle are part of the Safety Risk Assessment Methodology, Risk Model and Tool to support cross domain integration.	Respondent subjective rating
4. Harmonisation	4.1 The extent to which the Safety Risk Assessment Methodology, Risk Model and Tool promote harmonisation and can become a standard reference model used in the certification process.	Respondent subjective rating.
	4.2 The level of compatibility and consistency of the Safety Risk Assessment Methodology, Risk Model and Tool with existing practices, organisation and culture in aviation industry. Including compatibility and consistency with other risk models and tools used in different (certification) domains.	Respondent subjective rating.
5. Accommodation of Innovation	5.1 The potential of the Safety Risk Assessment Methodology, Risk Model and Tool to ease the certification and continuous safety performance monitoring of innovative products and services.	Respondent subjective rating.
6. Operability of ASCOS processes and tools	6.1 Usability of the Safety Risk Assessment Methodology, Risk Model and Tool in the certification process.	Respondent subjective rating.
	6.2 Usefulness, from an end user perspective, of the Safety Risk Assessment Methodology, Risk Model and Tool in a certification process.	Respondent subjective rating.
	6.3 Acceptability, from an end user perspective, of the Safety Risk Assessment Methodology, Risk Model and Tool in a certification process.	Respondent subjective rating.
7. Flexibility	7.1 Applicability of the Safety Risk Assessment Methodology, Risk Model and Tool to a range of products and services varying in “size” and “complexity”.	Respondent subjective rating.
	7.2 Applicability of the Safety Risk Assessment Methodology, Risk Model and Tool to the products and services of different domains, of different stakeholders and to the TAS.	Respondent subjective rating.
	7.3 Applicability of Safety Risk Assessment Methodology, Risk Model and Tool to both novel and derivative products and services.	Respondent subjective rating.

5.6 Preparatory Activities

5.6.1 Before-the-event training

Before the workshop participants will receive via e-mail a short two page summary about ASCOS Exercise 3. This document will be useful to let user members to get an overall flavour about the ASCOS products to be evaluated and the structure of the related evaluation activities. This briefing material will be brief as anything demanding—i.e. a complete pre-workshop training package—would risk to be ignored mostly by the invited experts. Also, this summary doc could contain an invitation to access and try the software tool URL.

5.6.2 Recruiting of the UG members

In order to ensure the success of the validation exercises it is important to maximize the participation of experts with direct professional experience in the certification process, either as a certifier or as an applicant or both. This is necessary to ensure that questionnaire ratings about ASCOS validity, and the rationale for these ratings, are made/expressed based on a sound knowledge of the certification practices in use nowadays across various domains and contexts. It is expected to involve in the exercise some of the experts that have attended Exercise 1: these experts will be familiar with the ASCOS proposed validation approach, and consequently, are more likely to provide informative views about how the safety risk assessment model and tool can fit into this context.

5.6.3 Materials

Table below lists the materials that have to be in place prior the execution of Exercise 3 to ensure the success of the event.

Table 9. Materials for Exercise 3

#	Material	Type of material	Responsible Partner
1	Overview of the concept of the risk model and supporting tool (length, 1 to 2 pages) (pre-meeting material)	.doc	DBL
2	User Manual (pre-meeting material)	.doc	TUD
3	Agenda of the Day (pre-meeting material)	.doc	DBL
4	Objective of the day, Introduction and instruction for participants	.ppt	DBL
5	Presentation of the WP3 risk model, and link to the ASCOS certification approach (Scenario 3.1)	.ppt	DBL-NLR
6	Presentation of the software tool. It explains scope, maturity level, high level functionalities (e.g. changes that can be done to the risk model by means of the	.ppt	TUD

	software tool) (Scenario 3.2)		
7	Preparation of user instructions (e.g. narrative and task to perform during the trial) for Scenario 3.3	.doc	DBL-NLR
8	Preparation of user instructions (e.g. narrative and task to perform during the trial) for Scenario 3.4	.doc	DBL-NLR
9	Use case from WP4 (*optional*) for scenario 3.5	.doc	DBL-WP4
10	Questionnaire	.doc	DBL

5.6.4 Software

Table below lists the software changes that have to be in place prior the execution of Exercise 3 to ensure the success of the event.

#	Software change	Responsible partner
1	Adapt ESDs ad FTs with the tool as required by scenarios 3.3, 3.4	NLR TUD
2	Verification that the software has a level of stability sufficient to let the user to use the tool	TUD

5.7 Risk and Mitigation

The following table report risks and mitigation measures for Exercise 3.

Table 10. Risks and mitigation measures for Exercise 3

ID	Risk	Mitigation
1	Number of attendees is insufficient for the event	- Allow sufficient time for recruiting; - Announce the date of Exercise 3 at the start of Exercise 1, so to recruit potential interested UG members;
2	Focus group discussions lacking focus on the concept of ASCOS product to be evaluated	- Allow sufficient time at the start of the day to present the ASCOS approach, the risk assessment methodology, risk model and tool; - Require experts to review a summary of the proposed approach, risk

		assessment methodology and risk model prior the event; - During the group discussion, remind participants of the products to be evaluated and the KPAs/KPIs under discussion. Ensure they understand the objective and scope of validation
3	Dominant or passive attitude of some participants affecting the quality of the discussion	- The moderator is to maintain a comfortable discussion in which everyone can express his/her own opinion freely.

6 Conclusions

This deliverable has provided an overview of the plan for the validation of ASCOS outcomes; it has identified three validation exercises that are consistent with this plan; and it has described the aspects necessary to run each exercise. These include exercise objectives, exercise description, scenarios, preparatory activities, performance framework, and risk and mitigation strategies. From a methodological perspective, all of the three exercises share the same basic format of the validation workshop. This consists of a familiarization session followed by a group discussion session with certification experts to be recruited from the ASCOS User Group. Overall, the material developed in this deliverable provides the foundation for the next phase of the work, "WP5.3 Validation Exercises Execution" [7], which will execute the validation exercises defined here to obtain data about the validity of ASCOS products.

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Appendix A Definitions

Applicant. In a certification context, the organization that formally asks for a certificate to the certifier or certification authority.

Benefit Mechanism. It consists of a cause-effect description of the improvement proposed by a project. It shows how the change proposed by a project leads the intended benefit. It can be presented in both textual and diagrammatic form [27].

Certification. The process and set of activities aiming at the satisfaction of an authority that a "deliverable" (e.g. aircraft, aviation product, service, or organisation) complies with a set of regulations in order to ensure its proper operation and to ensure continued performance of these items during their operational life.

Certification Safety Argument. A documented body of evidence that provides a convincing and valid argument that a system is acceptably safe for a given application in a given environment [31]. A safety case is composed by a set of explicit claims about the system, a body of supporting evidence, by a set of inference rules that link the claims to the evidence, an explicit set of fundamental assumptions and judgments in which the argument is valid. While this definition applies to safety arguments in general, we refer here to certification safety argument as the safety argument to be used in a certification context.

Certification Safety Assurance Documentation. The documentation produced by the applicant to demonstrate to the certifying authority that the change in question is acceptably safe. This documentation contains the evidence, the data, and the assumption that support the overall claim that the change is acceptably safe. After being produced by the applicant(s), this documentation is then reviewed by the certifiery body which will have to approve or reject such documentation. In countries like the UK the Certification Safety Assurance Documentation corresponds to the certification safety argument. However, while this latter is perhaps the most sophisticated methodology to demonstrate the acceptable safety of a given change, safety arguments are not adopted uniformly across all states and stakeholders, and some states might use other approaches.

Certifier. In a certification context, the authority that provides certification.

Change. In this context, the replacement or the introduction of a new procedure, service, operation, hardware or software system.

Cross acceptance. A situation where equipment in service accepted by a particular authority is accepted for use by a different authority.

Emerging risk. This is defined as an existing hazard with a change in risk level, i.e. a change in severity level, a change in the likelihood, or both.

Future risk. This is defined as a risk associated with the future introduction of a novelty (e.g. new design, new procedure, and new organization).

Key Performance Area (KPA). "Key performance areas are broad categories that describe different areas of performance of an ATM system." [22]. "Key Performance areas are a way of categorising performance subjects related to high-level ambitions and expectations. ICAO has defined 11 KPAs: Safety, security, environmental impact, cost effectiveness, capacity, flight efficiency, flexibility, predictability, access and equity, participation and collaboration, interoperability." [28].

Key Performance Indicator (KPI). Key performance indicators "measure performance in key performance areas and are identified once key performance areas are known. A key performance indicator is a measure of some aspect of a concept or concept element, for example 'the total number of runway incursions per year', the 'mean arrival delay per week at airport X'." [22]. "Current/past performance, expected future performance (estimated as part of forecasting and performance modelling), as well as actual progress in achieving performance objectives is quantitatively expressed by means of indicators (sometimes called Key Performance Indicators, or KPIs). To be relevant, indicators need to correctly express the intention of the associated performance objective. Since indicators support objectives, they should not be defined without having a specific performance objective in mind. KPIs are not often directly measured. They are calculated from supporting metrics according to clearly defined formulas, e.g. cost-per-flight-indicator = Sum (cost) / Sum(flights). Performance measurement is therefore done through the collection of data for the supporting metrics." [28].

Metrics. "Supporting metrics are used to calculate the values of performance indicators. For example cost-per-flight indicator = Sum(cost) / Sum(flights). Performance measurement is done through the collection of data for the supporting metrics (e.g. this leads to a requirements for cost data collection)" [28].

Modularization. It is the process of breaking up complex or large arguments into manageable modules.

Performance Framework. A performance framework is "used to document and establish the framework for performance assessment. It typically consists of Key Performance Areas (KPAs), key performance indicators (KPIs), performance targets, metrics and measurement-related assumptions which are used to validate a concept. The performance framework may be enhanced to support the understanding of how benefit is produced and delivered and for the examination of performance trade off" [22]. A performance framework needs "to be in place at the very early stage to ensure that it is taken into account in the planning of the validation programme and exercises" [22].

Performance Target (PT). "Performance targets are closely associated with [key] performance indicators: they represent the values of performance indicators that need to be reached or exceeded to consider a performance objective as being fully achieved." [28].

Validation Scenario. "A validation scenario is a specific scenario developed for the purposes of undertaking validation activities and to gather evidence relevant to the validation objectives. It is used to analyse the performance and interactions described or expected in the operational concept scenarios." (EOCVM)

Validation. The process by which the fitness-for-purpose of a new system or operational concept being developed is established". The objective of the validation of the ASCOS results is to demonstrate that they are suitable for their intended purpose or use and brings the expected benefits for the user

Verification. Verification is the set of activities aimed at testing or demonstrating that the product (e.g. a tool) meets the technical specifications. The verification aims to assess the technical quality and performance of the products.

Appendix B Exercise 1: Comparing the current vs the alternative plan

Table 11. Comparison between the current plan for Exercise 1 (i.e. Use of WP4 Case Studies) and the alternative plan (i.e. Retrospective application of ASCOS in the context of an existing case study). The T and M signal whether the identified pro or con is a technical or managerial one.

	Pro (+)	Cons (-)
Current Plan for Exercise 1	1. Maintains consistency with ASCOS stakeholder expectations: The plan validates ASCOS approach with cases: - owning to different aviation domains *(T)* - developing innovative solutions *(T)* 2. Makes use of existing WP4 effort and certification competences *(M)* 3. **Actual possibility to perform 4 certification steps**: 1) documentation acquisition, 2) application of the process, 3) review by certifiers 4), collection of feedback on the process *(M)* 3. **Makes use of existing arrangements to access UG members** - **UG members difficult to access** - **The plan uses the 2nd day of the UG Meeting 3** for validation purposes and preserves 2 smaller familiarization workshops for the validation of ASCOS tools *(M)*	1. **Lacks direct comparison** between the new and old approach in the same case (no clear baseline available) *(T)* 2. **Does not take on board a relevant proposal** by a relevant user group member *(M)*
Alternative Plan for Exercise 2	1. Shows a direct **comparison** between the new and old approach as instantiated in the same case ***(M)*** 2. **Takes on board the proposal made** by a relevant user group member ***(M)***	1. Lacks the required certification **competences in WP5** ***(M)*** 2. It can produce **unacceptable delays** due to the time needed for : - accessing **certification documentation** about a past case, **due to confidentiality issues** ***(M).*** - Involving a partner with **certification expertise** willing to allocate resources and man power to the implementation of ASCOS approach ***(M).*** - Involving other partners representatives of the other TAS domains relevant for the specific case 3. Misses important ASCOS expectations: - ASCOS approach would **not be validated with innovative systems** *(T)* - **Only one validation domain** is considered instead(as a baseline/reference) - This is not representative of the variety of certification practices found across different domains and contexts. *(T)*

Appendix C Exercise 1: Agenda

Agenda V4.1

ASCOS User Group Meeting 3

9 & 10 October 2014

Amsterdam, The Netherlands

Agenda Friday 10 October

Goal of the meeting: The second day of the User Group Meeting is organized in the form of a workshop in which the participants are asked to take part in a number of validation sessions. These aim at testing and collecting feedback on the new certification approach proposed by ASCOS based on the Key Performance Areas that were identified.

8.30– 9.00	**1. Introduction into the validation activities for the new certification approach – Luca Save** *Form: short presentation by WP5 leader* *Goal: To clarify the goals of the second day of the User Group Meeting and to explain the difference with the discussions on the first day of the User Group Meeting*
9.00 – 10.00	**2. Validation Session 1 – Efficiency and Soundness of ASCOS certification approach** *Form: The validation exercise will start with a plenary presentation about the key performance area 'Soundness and Efficiency', this is followed by completing a questionnaire and discussions in subgroups.* *Goal: to collect feedback from the user group members on the soundness and efficiency of the ASCOS certification approach.*
10.00 – 10.15	**Break**

10.15 – 11.00	**3. Continuation Validation Session 1 – Soundness and Efficiency of ASCOS certification approach**
11.00 – 12.30	**4. Validation Session 2 – Cross domain integration and harmonization of ASCOS certification approach** *Form: The validation exercise will start with a plenary presentation about the key performance area 'Cross domain integration and harmonization', this is followed by completing a questionnaire and discussions in subgroups.* *Goal: to collect feedback from the user group members on the cross domain integration and harmonization of the ASCOS certification approach.*
12.30 – 13.00	**5. Validation Session 3 – Accommodation of Innovation, Operability and Flexibility of ASCOS certification approach** *Form: The validation exercise will start with a plenary presentation about the key performance area 'Accommodation of Innovation, Operability and Flexibility', this is followed by completing a questionnaire and discussions in subgroups.* *Goal: to collect feedback from the user group members on the Accommodation of Innovation, Operability and Flexibility of the ASCOS certification approach.*
13.00 -14.00	**Lunch**
14.00 – 15.00	**6. Continuation Validation Session 3 – Accommodation of Innovation, Operability and Flexibility of ASCOS certification approach**
15.00 – 15.30	**7. Debriefing – Luca Save & Simone Rozzi** Form: plenary presentation Goal: to inform all participants about the results of the day and the resulting next steps to be taken by the ASCOS team
15.30	**End of meeting – Gerard Temme**

Appendix D Exercise 1: Questionnaire

BIOGRAPHICAL DATA

NAME:	*IDENTIFICATION CODE*
ORGANIZATION:	
CURRENT POSITION IN THE ORGANIZATION:	
YEARS OF EXPERIENCE IN CERTIFICATION:	
INVOLVED IN CERTIFICATION ACTIVITIES IN THE ROLE OF: CERTIFIER APPLICANT BOTH CERTIFIER AND APPLICANT NONE OF THE ABOVE	
EXAMPLES OF PRODUCTS OR SERVICES OR YOU HAVE CERTIFIED: - - -	

1-EFFICIENCY OF THE CERTIFICATION PROCESS (5)

TIME

1.1: Compared to current certification practices, the ASCOS certification approach will reduce the overall time needed to complete a certification process from the initial application to the final approval by the authority.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

EFFORT

1.2: Compared to current certification practices, the ASCOS certification approach will reduce the effort (time and resources) needed by the certifying authority to follow the overall certification process and to review the final documentation produced by the applicant.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

1.3: Compared to current certification practices, the ASCOS certification approach will reduce the effort (time and resources) needed by the applicant to complete the overall certification process, including the production of the required final documentation.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

TRAINING

1.4: Compared to current certification practices, the ASCOS certification approach will reduce the effort required to the certifying authorities to train their personnel to fulfil the certifier role.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

1.5: Compared to current certification practices, the ASCOS certification approach will reduce the effort needed by the applicants to train their personnel to carry out certification activities.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

2 SOUNDNESS OF THE CERTIFICATION SAFETY ASSURANCE DOCUMENTATION (3)

2.1: Compared to current certification practices, the ASCOS certification approach will improve the consideration of cross-domain hazards in the safety assurance documentation.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

2.2: Compared to current certification practices, the ASCOS certification approach will improve the consideration of human factors related hazards in the safety assurance documentation.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

2.3: Compared to current certification practices, the ASCOS certification approach will promote the consideration of hazards through all the lifecycle phases (including 'transition into operations') when developing the safety assurance documentation.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

3 CROSS DOMAIN INTEGRATION (3)

3.1 The ASCOS certification approach will promote and support the cooperation and exchange of information among stakeholders from different aviation domains during the development of a certification process.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

3.2 The ASCOS certification approach will help to clarify the roles and responsibilities of different stakeholders across different aviation domains starting from the early stages of a certification process.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

3.3 The ASCOS certification approach will facilitate the integration among local certification approaches in use in each domain, regardless of whether they are performance or compliance based.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

4 HARMONISATION (2)

4.1: The ASCOS certification approach is sufficiently compatible with existing certification practices across Europe (such as different domains, geographical areas and industries) to prevent disruption or waste of existing experience and competences.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

4.2: The ASCOS certification approach has the potential to become a standard reference approach in use across different domains and stakeholders.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

5 ACCOMMODATION OF INNOVATION (1)

5.1: Compared to current certification practices, the ASCOS certification approach will simplify the certification of innovative product and services.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

6 ACCEPTABILITY (2)

6.1: The introduction of the ASCOS certification approach has the potential to be accepted by the existing certifying authorities

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

6.2: The introduction of the ASCOS certification approach has the potential to be accepted by the applicant organizations.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

7 FLEXIBILITY (2)

7.1: The ASCOS certification approach is sufficiently flexible to be applicable to a wide range of products and services of different size and complexity.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

7.2: The ASCOS certification approach is fit for certifying both novel and derivative products and services.

1. strongly disagree
2. disagree
3. neutral
4. agree
5. strongly agree
6. not sure/not applicable

Appendix E Exercise 1: Literature review on certification costs

Background

One of the objectives of ASCOS is to propose a new certification process that improves efficiency of the certification process in terms of cost and time, see the ASCOS Description of Work. In ASCOS Deliverable D1.2 [D1.2] the factor "cost benefit" was used as one of the two primary evaluation criteria for the evaluation of several new approaches to certification processes. The other primary factor was "safety benefits". [D1.2] explains that the factor "cost benefits" relates to the direct costs of the certification process, which includes all involved processes and activities, both at the side of the applicant and the certifying authority. A distinction is made between certification costs, purely related to the certification activities, and development costs. Both types of costs are often related or hard to separate, but in order to relate the cost of certification to the certification approach and activities undertaken during this approach, it was decided to only include pure certification related costs.

Scope of the efficiency or cost benefits

It is remarked that the ASCOS project addresses certain aspects of the certification process. In other words the entire certification program or process will entail much more activities, and thus costs, than the aspects covered by ASCOS. The assessment of the contribution of the ASCOS deliverables to the efficiency of the certification process is therefore limited to only those elements of the certification process that are addressed by ASCOS. During the validation exercises feedback will be collected on the fitness for purpose, efficiency and costs benefits of specific ASCOS deliverables, namely the proposed certification approach [D1.3], the process and tool for continuous safety monitoring [D2.3, D2.4] and the risk assessment methodology, risk model and supporting software tool [D3.1, D3.2, D3.3].

Efficiency relates to time and effort/cost. Hence, literature about the efficiency improvement of certification processes was reviewed to identify factors driving efficiency. Cost refers to the sum of money and includes many items such as man-hour costs, travel costs, cost of simulator tests, test flights, etc. Effort represents the amount of work (man-hours) required to produce a certain deliverable as part of the certification process. The effort can be expressed in costs as well. Since the amount is influenced by tariffs and taxes across countries and regions, it is less meaningful for the validation. It is considered more practical to assess the effect of the ASCOS deliverables on the effort (man-hours, workload) than on the actual amount of Euro's.

Objective of the literature survey

In WP5.2 a limited literature survey was conducted to search for data on costs of current certification programs. It was anticipated this information is useful in the validation exercises as a potential baseline for the performance assessment of ASCOS certification adaptations.

Challenges in assessing the ASCOS contribution to cost reduction

One way to approach the assessment of the cost benefits of the ASCOS approach and deliverables is to apply the current and proposed certification approach to the same test case and compare afterwards the cost and effort of both approaches. This approach requires significant resources and time, which is not available in the ASCOS project. The end result, comparing the cost or effort of both approaches in one test case, will be influenced by the expertise and experience of personnel working on the cases, their familiarity with the subject case, the complexity of the case, etc. The relative comparison would be of limited value to estimate the potential contribution of ASCOS to a cost reduction.

Another approach is to compare cost and effort of actual certification programs with the estimated cost and effort of the application of the ASCOS approach in the use cases of WP4 and WP5. Such a cost comparison between real certification programs and "fictive" ASCOS test cases is considered impractical in the current project. Firstly, it will be difficult to determine a proper baseline for comparison. If we would have cost data, we should take into account its context, e.g. certification domains, means of compliance, diversity and complexity in products etc. Finding a set of "typical" certification costs for a variety of programs is considered impractical. Even if we find some information on the cost of certification programs, it is questionable if they are relevant for the cases developed in ASCOS. Most likely they will not match. Secondly, it remains uncertain to what extent the estimated cost/effort in an ASCOS test case would be a representative figure for the actual cost/effort in real certification programs. It may depend on the expertise and experience of the team members working with the ASCOS approach on the case, but also the specific case (the domain, the complexity of the product to be certified etc.) and applied stages are influencing the outcome. Since not all stages of the ASCOS approach are applied in the WP4 use cases, any cost estimate based on the WP4 case would be an underestimation. In addition, cost saving thanks to the ASCOS approach earned later on during development, production, in operation, continued operational safety would be overlooked.

Main results of the literature survey

The final list of the documents retrieved by the survey is included at the end of this section. The survey has identified some references that provide numerical indications of costs of various types of certification programs [e.g. Boeing, Nickum, Thomas, AeroStrategy]. However, in using these indications it is important to note they are case specific: professional experience suggests that safety assessments may require a few days up to many months of work, depending on the scope, complexity of the case, regulatory requirements, means of compliance etc.; therefore, it is impossible to provide a cost estimate generally applicable beside the specific case in which it has been estimated—its value is too case specific. These cost data are less useful for the validation of ASCOS deliverables due to the challenges explained above. In the context of ASCOS the focus in the literature survey was therefore shifted towards the identification of cost factors, i.e. factors influencing the cost or the amount of work (effort) in certification programs.

Improvement of efficiency of FAA's certification process

In the United States the Federal Aviation Administration (FAA) Modernisation and Reform Act (2012) requires the reforms to the aviation system and to the FAA to improve the efficiency, to reduce costs, and amongst other to modernise the certification process. Several reports from FAA, the Advisory Rulemaking Committee (ARC) and US Government Accountability Office (GAO) address the improvement of the certification and approval processes, in particular increasing the efficiency of the FAA's certification process, and the progress FAA is making with respect to the Reform Act.

From [GAO-11-14], [Guzetti], [ARC] it appears that the FAA is taking several actions to increase the efficiency and effectivity of its certification processes:

- The FAA is working on guidance and improved flexibility to prioritise and schedule certification applications.
- Effective use of Organization Designation Authorization (ODA) programme is "key to managing FAA's resources and meeting the industry's certification needs" [Guzetti]. FAA estabilished ODA in 2005 to standardize its oversight of organizational designees, i.e. the organziations that are approved to perform certain functions on behalf of FAA. Currently, FAA is taking action to improve the efficiency of the ODA certification processes and improve the utilisation of the ODA authority. Better communication between the FAA and ODA and more flexibility on the side of the ODA should improve efficiency.
- Sharing information on the interpretation of regulations and guidance. Improvement of communication, interpretation of regulations and guidance for complying with regulations, would positively impact cost and reduce delays.
- Delegation of certification activities to organisations and individuals would ensure efficient use of resources so that FAA is able to focus on certification of new and complex designs or design changes.
- A more effective Continued Operational Safety (COS) process would free resources for certification.
- FAA's inconsistent interpretation of regulations and certification standards increase effort because of rework and delays to certification programs, although this happens infrequently in practice. Variation in interpretation and approval decisions is more likely the result of performance based regulations that allows multiple ways to show compliance. Standardised procedures may help reduce such variation [GAO-2013-10-13].
- [ARC] mentions three principles which improve efficient certification: early applicant/authority discussions, a project specific certification plan, and continuous project management review.

Factors influencing the efficiency of the certification process

The following factors influence the efficiency of the certification process:

- New technology: New technology increases the effort in certification, especially if regulations or certification specification do not exist and CRIs have to be established.

- Complexity: Complex projects increase the effort, such as use of new material on an aircraft, introduction of RPAS in civil airspace.
- Cross domains: Covering inter-domain relations will increase effort and costs in the ASCOS approach, as it considers the Total Aviation System in the proposed certification approach. In the longer term this approach bring efficiency as it could avoid costly rework or timely solve problems in the design and development stages.
- Team experience: The experience of the team with the regulations, specifications, means of compliance, methods applied etc. influences the effort. According to [Lange] especially with performance based regulations the team needs to build experience in resolving non-compliance issues and developing methods to demonstrate compliance since the regulation is not descriptive and does not provide examples. Cost reduction may be achieved through developing team experience, to hire experienced engineers or to subcontract the work.
- Dealing with multiple agencies: According to [Lange] dealing with different certifying authorities may increase costs because differences may apply and affect certification, even though FAA and EASA strive for harmonisation. [Lange] mentions that more harmonisation, a standardised approach, and good guidance material with examples of application will help building up experience and reduce the learning curve for the applicant.
- Toolset/methods: Using new tools requires initial training and building up experience, so the first programs may require more effort (less efficient) until the team has developed sufficient experience [Lange]. Qualified tools reduce the effort for software development activities and verification tasks for certification according to a Rockwell Collins study [Thomas]. Clear and accepted methods for complying with regulations/requirements support efficient certification.
- Standardisation: Standardised procedures for demonstrating compliance may help reduce the variation in certification approaches, especially in case of performance based regulations. This would have a positive impact on the efficiency.
- Early stakeholder involvement: Early applicant and authority discussions is mentioned as one of the areas that may bring more efficiency to the certification process. For instance, [Thomas] reports that it helps when applicants hold regular discussions with appropriate certification authorities designated personnel, not only at the start of the project to define expectations on both sides, but also during the development process when evidence of compliance with the requirements is produced gradually. [Thomas] mentions that in the end the certification of the product, the demonstration of compliance with the regulatory requirements is the outcome of the joint effort.

Lessons learnt from the Boeing 787 certification review

Boeing and FAA jointly formed a team to assess the Boeing 787–8 design, certification, and manufacturing systems. The Critical System Review Team (CSRT) independently validated the work conducted during the Boeing 787–8 certification process [Kaszycki & Ptacin]. In their final report three observations appear relevant in the context of the ASCOS project as they relate to the TAS and cross-domain integration, communication and interaction. In turn, they also relate to the efficiency of the entire process because lack of integration,

communication, interaction will have repercussion on effort, cost and time. In the validation exercises the question for the participants is whether the ASCOS deliverables will bring added value in those three areas (refer to [Kaszycki & Ptacin]):

- Requirements flow down: The CSRT identified inconsistencies in design requirements flow down and design verification. For example, in some cases complete and accurate design requirements did not flow down from Boeing to its primary supplier and then to further involved subcontractors. Boeing had established design requirements, but these requirements were inadequately verified and/or validated, resulting in inconsistency in parts manufacturing, part failures, and operational disruptions such as turn backs and diversions. In the validation the contribution of ASCOS in supporting flow-down of safety requirements TAS-wide, across domains and stakeholders should be assessed.
- Responsibility: The CSRT identified communication and verification issues along the supply chain. In some cases, these issues occurred because Boeing or its major suppliers with integration responsibilities did not clearly establish which supplier / subcontractor providing components for an integrated system was responsible for a specific detailed design requirement. In the validation it should be assessed if ASCOS can improve in the establishment of a clear responsibility of allocation and satisfying safety requirements across domains/stakeholders.
- Design review process/industry design standards: In some cases, requirements ambiguity led suppliers to incorrectly assume they successfully met all the requirements. However, the actual requirements had not been satisfied. The suppliers made these determinations independently, without consulting Boeing or the higher-tier supplier. In the validation it should be assessed if the proposed ASCOS approach can help to avoid or mitigate such a miscommunication and misinterpretation of fulfilling safety requirements across domains/stakeholders.

Efficiency improvement in relation to the safety assessment methodology

The ASCOS outcomes of WP3.2.3 [4] and WP3.3 [5] should be validated to determine their contribution to the efficiency of the certification process and in particular to their impact on the efficiency of the safety assessment part of the certification process. Areas for efficiency improvement of a safety assessment methodology were identified by NLR in a previous study [Scholte 2011]. This study provides four aspects that should be considered in the validation in order to determine how well the ASCOS deliverables contribute to each aspect.

- Applying a method that allows tailoring the safety assessment to the level of safety significance of the change could reduce effort. For changes that have little safety impact, it would be desirable to have a method that provides the user with a flexibility to apply a qualitative, relative safety assessment and/or that supports the applicant in developing arguments and evidence in a simple manner, e.g. using argument templates, documentation templates.
- Balancing the assessment of technical, operational (human factors and procedures) and organisational hazards is required. A methodology that supports flexibility in shifting the focus on specific hazard areas, that ensures that different domains are sufficiently covered and that allows addressing human

performance and organisational hazards would be helpful for an efficient assessment. Although the inclusion of hazards from other domains in the assessment may initially increase the workload, in the end a proper balance could save effort by avoiding in-depth modelling and analysis of areas that are not safety critical.

- Scoping the assessment is important for efficiency reasons, namely to ensure that the resources are spent on those hazards or issues that are most relevant for safety. A methodology that supports this scoping exercise and ensures that the effort is spent on the safety critical issues is favourable. In addition, being able to take into account in the safety assessment those interfaces between domains and interactions between hazards that have most impact on safety would improve the quality of the assessment. Although it may increase the effort initially, it is expected that in the end the effect on efficiency is positive as resources are spent on the safety significant issues.
- A methodology that supports readability, transparency, traceability of arguments and evidence and transferring safety requirements across domains may increase initially the effort. In the longer term it may reduce effort to correct issues with rework as a result of interface problems.

Conclusion of literature survey

In general the cost of certification programs is unclear. It is considered not feasible to establish a clear understanding of all cost factors, cost structure, cost benefit mechanisms in certification programs within the current ASCOS project. Basically, one should consider costs in all domains: product certification, operational certification, maintenance certification, ATC certification, etc. which makes it extra challenging to collect data with the limited resources we have for this task.

We have not found sufficient objective data on current or historic certification programs that indicate the level of cost or amount of effort (e.g. man-hours) associated with certification programs. In fact, the Aviation Rulemaking Committee (ARC) in the United States explains that this sort of information is proprietary and could not be used in the activities of this committee (see [ARC]). Likewise, in a Boeing comment on proposed rulemaking the company states that the certification cost estimates are proprietary information and cannot be released [Boeing]. Some authorities, like EASA and CAA UK publish the fees and charges that an applicant has to pay for different services in the certification programs. In case of EASA the level of fees payable by applicants for certificates and approvals issued, maintained or amended by the Agency, and of charges for publications, handling of appeals, training and any other service provided by the Agency are determined by Commission Regulation (EU) No 319/2014 [EASA website]. However, these data are not sufficient to estimate the total cost or effort of the authority involvement in a certification process.

Taking into account these findings, it was decided in WP5.2 that during the validation exercises the ASCOS User Group members will be asked to subjectively and qualitatively assess the impact of ASCOS deliverables on the efficiency of the certification process. The lack of objective data on the cost or effort in certification programs justifies this approach.

Recommendations

It is recommended to the European Commission to launch a project to collect more information and data within the industry and certifying authorities about the efficiency (effort, cost, throughput time) of certification programs. This may help the industry to better estimate the cost of certification programs and to manage their cost, learn lessons from other industries and seek areas for improving the efficiency of the certification process. At the same time, this support further refinement and improvement of certification processes applied by EASA and other authorities.

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