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ASCOS - Aviation Safety and Certification of new Operations and Systems

CUSTOMER: European Commission

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ASCOS - Aviation Safety and Certification of new Operations and Systems

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Abstract. Fundamental changes in the institutional arrangements for aviation regulation in Europe, the introduction of new technologies and operations as well as demands for higher levels of safety performance call for the adaptation of existing certification processes. The FP7 Transport ASCOS Project which ran from 1st of July 2012 to 30th of September 2015 had precisely the objective to develop new certification process adaptations and supporting safety driven design methods to ease the certification of safety enhancement systems and operations, thereby increasing safety. The present paper presents this ASCOS project, the way in which it was conducted and its main scientific and technological results.

Keywords: Aviation safety, certification, total system approach, continuous safety monitoring, risk picture, safety based design, safety risk management, safety data analysis, safety performance indicators, risk modelling

1. The objectives of the ASCOS Project

Many operators and users are eager to make use of new developments. However, many innovative technologies and operational concepts are not developed for reasons of implementation risk or too much time to reach implementation. To ease the introduction of safety enhancement systems and operations, an innovative approach towards certification needs to be developed and implemented. ASCOS aims to better account for the human element, already from the early stages of the certification process, and thus reducing consequences of human error and increasing safety.

The project follows a total system approach, dealing with all aviation system elements in an integrated way over the complete life-cycle. To investigate how dealing with all safety and certification aspects in an integrated manner may be made possible, ASCOS contains work packages on Certification processes (WP1), Continuous Safety Monitoring (WP2), Safety Risk Management (WP3), Certification case studies (WP4), Validation (WP5), and Dissemination and Exploitation (WP6). The main objectives of ASCOS, which are each addressed in one specific Technical Work Package, are:

a) To analyse the existing European certification and rulemaking process and propose potential adaptations to ease certification of safety enhancement systems and operations;
b) To develop a methodology and supporting tools for multi-stakeholder Continuous Safety Monitoring, using a baseline risk picture for all the parts of the total aviation system;
c) To develop 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;
d) To apply proposed certification process adaptations and the design systems and tools in case studies, so as to show how they can be used by operators and manufacturers;

e) To validate key results: a) new certification approach, b) method and tools for Continuous Safety Monitoring, and c) all the supporting safety based design systems and tools;
f) To inform air transport stakeholders on the proposed certification approach through promotion workshops, supported by exercises and an e-learning web-site environment.

Most of the objectives are achieved. ASCOS defines several different options for potential change of the certification processes and methods for approval. Supporting safety methods and tools are developed, made available, and used. New processes and lessons learned requirements for safety assurance in operation are developed. The ASCOS continuous safety monitoring tool is made available through the European Co-Ordination Centre for Aviation Incident Reporting Systems (ECCAIRS) Portal of the EC-JRC. A tool for risk assessment is developed. The developed certification approach is applied in case studies, and evaluated with potential users. A dissemination Forum, three User Group Workshops, and an ASCOS – EASA Workshop are organized. The only objective not fully achieved concerns the e-learning environment. The main recommendations resulting from the work performed in the ASCOS project are:

- Further research to explore and evaluate more (and other) promising options for certification process adaptations, will be needed;
- Assess the impact of certification process adaptations on aviation safety performance and the costs related to certification in more detail;
- Evaluate feasibility of the incorporation of ASCOS safety methods/tools in safety standards;
- Investigate the feasibility of using data from Flight Data Monitoring (FDM) or other operational data for continuous safety monitoring.

Moving towards performance based regulation, based upon agreed safety performance in combination with a risk based approach to standardization, is expected to improve the way that safety risks are controlled. It is recommended to further explore the potential use of ASCOS outputs in support of this.

2. Scientific and Technological Results

2.1. Proposed certification process adaptations and method for approval

The first phase analysed existing European certification and rulemaking processes and identify potential shortcomings and bottlenecks in view of regulatory changes and technological developments. Following this analysis, new and innovative approaches to certification have been defined and evaluated. Options include e.g. change between performance based and compliance based certification, proof of concept approach, enforce existing rules and improve existing processes, and cross-domain fertilisation. The work resulted in a consolidated new ASCOS method for approval of changes in the aviation system (Figure 1). This ASCOS Method integrates with the lifecycle of a change, from concept through into operational service, introducing activities which lead to building a safety argument supporting the application for approval. The proposed method considers the full impact of the change, and recognizes and manages the interaction between domains. The method is also flexible to embrace innovation while encompassing existing established certification processes and safety standards wherever appropriate.

Figure 1. Options for changing certification and approval processes.

2.2. Process and tool for continuous safety monitoring

The second phase developed a methodology and implemented supporting tools for multi-stakeholder continuous safety monitoring. First, a framework of Safety Performance Indicators (SPIs) for the aviation system was defined. Next, recognized accident scenarios have been used to describe the logical links between barrier failures and final outcome (the accident). A baseline risk picture for the operational issues identified in EASA's European Aviation Safety plan (EASP) was established with these SPIs. This was followed by the development of an improved process for safety performance monitoring. This is an integral part of safety assurance within safety management systems. Finally, tools to assist stakeholders in the aviation industry to implement continuous safety monitoring have been developed and implemented. The tools provide an overview (in the form of tables, charts, visual indicators, etc.) of the past evolution of given safety performance indicators (Figure 2).

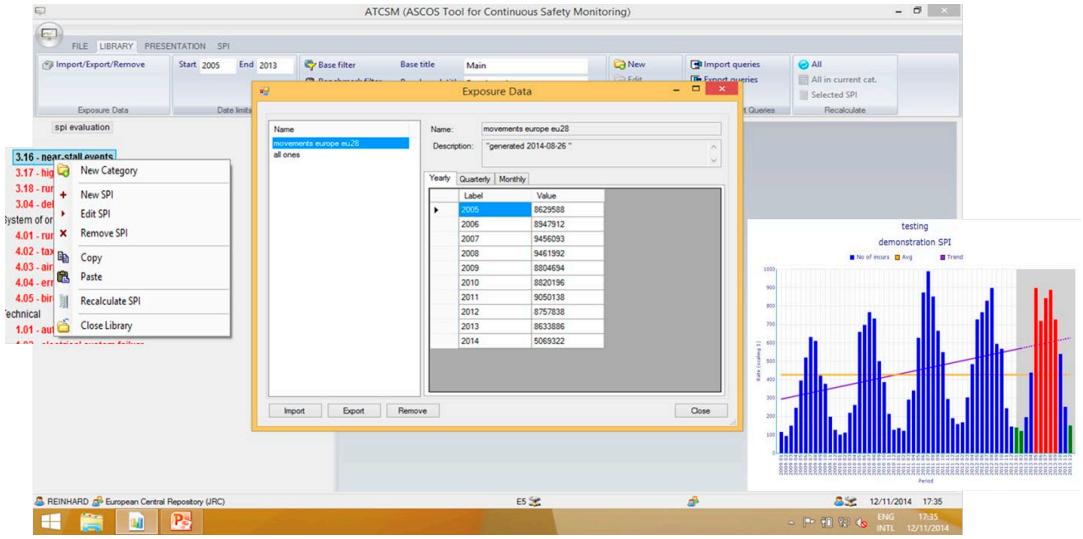

Figure 2. ASCOS Tool for Continuous Safety Monitoring (ATCSM).

These ASCOS tools are ECCAIRS compatible which means that they can be used by the many existing ECCAIRS users around the world. In fact, interactions with users of ECCAIRS have shown that the ASCOS tool has reached a sufficiently high Technology Readiness Level (TRL), to be directly used by the main stakeholders in aviation (including ICAO, EASA, CAAs).

2.3. Methods and tools for safety based design

The third phase established a safety assessment method and supporting tools. These are compatible with current safety standards and supported by risk modelling considering emerging and future risks. The risk model is based on previous accident model development work, primarily the work performed to create the Causal Model for Air Transport Safety (CATS), which represents the total aviation system. The representation and the evaluation of the emerging/future risks using CATS can be done if model elements are linked to precursors and if a dedicated capture process is defined for these precursors. The efforts of the Future Aviation Safety Team (FAST) in identification and publication of Areas of Change (AoC) and associated hazards across aerospace is proposed as a suitable precursor capture process. The application of this process allows calculating precursors' occurrence rates and then the emerging/future risks by using the ASCOS risk model. To improve the safety assurance in operation and the collection of safety precursors, a process for the implementation of automatic means to detect and capture safety precursor occurrences is proposed. Lessons learned requirements enable a feedback loop between safety events in operation and the development/design process for safety standards improvement (Figure 3).

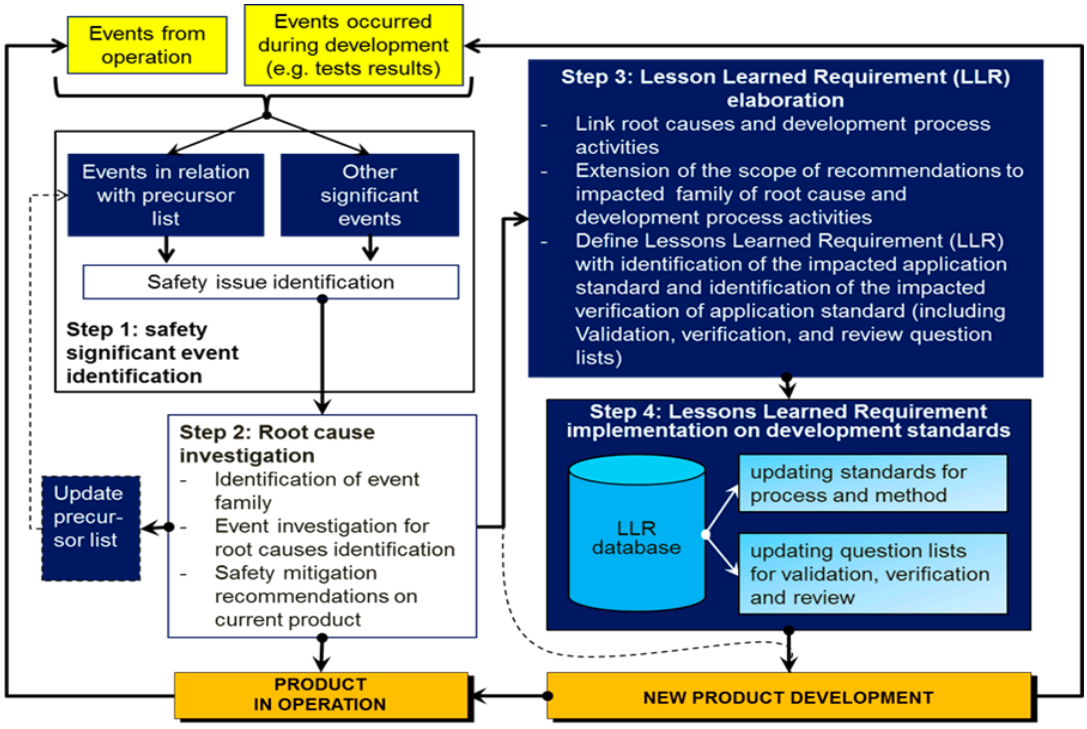

Figure 3. ASCOS Lessons Learned Requirements (LLR) process to improve standards.

2.4. *Certification case studies*

The fourth phase applied the newly proposed certification approach in four certification case studies, in order to evaluate the feasibility of the practical application, and to collect feedback of the experience with the application and benefits of the certification methodology in case studies. The topics are:

- Automated Failure Management System (AFMS) installed on Remotely Piloted Aircraft System (RPAS). This AFMS is a system that replaces the pilot in all decision making and surveillance tasks normally performed by a pilot on board in case of failure;
- The (initial) development of a hypothetical Automatic Aircraft Recovery System (AARS) intended to reduce the number of Loss of Control accidents by providing an on-board system that can recover the aircraft automatically from Loss of Control or Loss of Situational Awareness events;
- The certification of a de-icing/anti-icing service provider. This case study assumes a hypothetical situation in which the de-icing/anti-icing service provider is responsible and accountable for its safe operation in compliance with assumed novel regulations;
- The certification of an Integrated Surveillance System (ISS) consisting of cooperative surveillance and independent non-cooperative surveillance systems.

The case studies have then been evaluated from three angles. Firstly, the application of the certification approach and tools, the experienced benefits, lessons learned, conclusions and recommendations from the case studies have been analysed to formulate conclusions and recommendations regarding the ASCOS certification approach and supporting tools. Secondly, the four case studies have been reviewed against the performance framework that defines Key Performance Areas (KPAs) for the ASCOS approach to evaluate the 'fitness for purpose' of the certification approach. Thirdly, the case studies have been reviewed from a 'verification perspective' against a set of 'design' principles that was considered in the development of the certification approach. The aim was to evaluate the efficacy of the ASCOS approach and how it could be improved, rather than as a scoring mechanism for the quality of the case studies.

The ASCOS certification approach is applicable and beneficial in the light of a performance based approach to certification. The aviation industry is moving towards the introduction of performance based regulations, which can only be successful if the certification approaches are adapted to this new environment. The approach provides added value because it considers the Total Aviation System (TAS) from the start of design/certification activities and covers the entire lifecycle. The ASCOS approach is a suitable approach if there is a clearly defined change in the operation, e.g. in the ATM, airport or airline operation, in the context of performance based regulations. The application of the ASCOS certification approach in the current, mainly compliance-based certification framework introduces additional complexity as a result of the logical argument framework, and provides consequently – for compliance based certification – little to no benefits. Set-up of the ASCOS logical argument structure can provide the certification basis in a performance based regulatory framework, and may be worth the additional effort.

The ASCOS tool for continuous safety monitoring was not applied in the case studies because these focused on the definition, design and specification of proposed changes, while the tool is initially developed for monitoring, i.e. use after proposed change(s) are approved and transferred into operation.

The ASCOS tool for safety risk assessment can support safety assessment activities in the context of certification. The tool was applied by two case studies for a safety effect assessment and a safety target allocation. The tool supports a total system approach and a safety effect assessment of a change or subject of certification. It also helps to define relevant accident scenarios for the subject of certification. The tool can be applied during the hazard identification process as means to perform a cross-check whether all relevant types of accident scenarios and hazards have been covered. In the context of performance based regulations, the tool and risk model can support safety objective or safety requirement allocation to domains and stakeholders provided that the format of the safety performance target is in the form of an accident, incident or failure probability target. Three case studies also applied the Areas of Change (AoC) list from the Future Aviation Safety Team (FAST) as part of the certification approach stages. It is concluded that the FAST AoC list is helpful in defining the future environment as part of the description of the certification case in the context of the TAS. Furthermore, the FAST AoC list can be used as a source for hazard identification. However, it takes significant effort to assess all possible AoCs for the certification of a certain change. Another issue is that the FAST AoC list includes generally high-level, TAS related changes which may be difficult to "translate" to a specific, low-level change in a domain.

2.5. Validation of ASCOS methods, tools & processes

The fifth phase validates the scientific and technological advance that ASCOS is expected to bring:

- New affordable certification processes to make certification easier;
- Innovative safety based design systems and tools; and
- New methods and tools to support continuous safety monitoring.

First, the Validation Strategy was developed. It covered identification of the stakeholders and their expectations, the definition of the domain problem addressed by ASCOS, the identification of the proposed ASCOS solutions, with a determination of their maturity levels, the definition of the validation objectives, and the performance framework. Next, the Validation Plan was developed. In this plan, the different components of the validation strategy were translated into three concrete validation exercises. Thirdly, three Validation Exercises were performed with safety and certification experts external to ASCOS. This allowed gaining in-depth insights about the ASCOS products. Finally, the overall Validation Results and delivered corresponding set of recommendations for improvement of the initial proposed certification approach and the associated set of developed methods and tools are documented.

3. Conclusions and recommendations

3.1. Main conclusions

Moving towards performance based regulation, based upon agreed safety performance in combination with a risk based approach to standardization, is expected to improve the way that safety risks are controlled. ASCOS has defined several different options for potential change of the certification processes and methods for approval. Supporting safety methods and tools have been developed, made available, and are used. New processes and lessons learned requirements for safety assurance in operation have been developed. The ASCOS continuous safety monitoring tool has been made available through the ECCAIRS Portal of the EC-JRC. A tool for risk assessment has been developed. The developed certification approach has been applied in case studies, and evaluated with potential users. A dissemination Forum, three User Group Workshops, and an ASCOS – EASA Workshop have been organized. The only objective not fully achieved concerns the e-learning environment development.

The aviation industry is moving towards the introduction of performance based regulations, which can only be successful if the certification approaches are adapted to this new environment. The ASCOS approach is applicable and beneficial in the light of such performance based approach to certification. The approach provides added value because it considers the Total Aviation System from the start of design/certification activities and covers the entire lifecycle. The ASCOS approach is a suitable approach if there is a clearly defined change in the operation, in the context of performance based regulations.

3.2. Potential impact

Moving towards performance based regulation, based upon agreed safety performance in combination with a risk based approach to standardization, is expected to lead to improvements in the way that safety risks are controlled. Anticipating on future risks by using a "proactive approach" helps to make the certification process robust to new developments. Introducing ‘continuous safety monitoring’ ensures that new essential safety data is effectively used immediately after it has become available. ASCOS focuses on safety improvements in priority risk areas in the total aviation system. ASCOS applies its novel methods and supporting tools in four case studies, covering certification of an Autonomous System Failure Management System for Remotely Piloted Aircraft Systems (RPAS), an Automatic Aircraft Recovery System, a de-icing/anti-icing service provider, and an Integrated Surveillance System.

A novel approach to certification, which encompasses the whole life cycle, allows a more efficient introduction of new systems for safety improvements. However, adapting regulations and the applicable certification processes usually takes at least 5 years or more and ‘grandfather rules’ are still being applied in certification. In view of this and the aircraft lifetime, measurable results in the sense of ACARE safety goals may achieved from 2020 onwards. ASCOS takes into account at an early stage the safety aspects of novel technologies and the implications that they may have on the overall safety of the air transport system, while addressing the necessity to adapt and amend existing regulations for these systems.

3.3. Main dissemination activities

A wide variety of dissemination activities have been performed, towards the ASCOS User Group, towards the prospective users in general, as well as towards the general public. In total, three User Group Workshops, one Final Dissemination Forum, three validation workshops and five technical meetings with stakeholders were organised. EASA has provided significant inputs and feedback to ASCOS (in particular during the development phase). EASA has hosted an ASCOS – EASA Workshop on the 19th of April 2013, and has participated in the first User Group Workshop and Dissemination Forum.

Additionally, project results were presented at international workshops and meetings, and four technical publications have so far been realised. The ASCOS User Group started with members from EASA, FAA, SESAR, EUROCAE, EUROCONTROL, CAAs (Netherlands and Poland), Dassault, ESA, ESASI, ESSI, FAST, IATA, Rockwell Collins, SAE, SRC, TUV Nord. During the project also CAA Italy, KLM, LVNL joined. The User Group members provided an independent view of the work and of the project progress. In the development phase, User Group members interacted with the team and provided comments from a regulatory, safety, and certification perspective on intermediate results. In the final stage, in view of intermediate results, they commented on the best way to complete the work and move towards actual implementation and use of new methods, tools and processes.

3.4. Exploitation of results

ASCOS has produced a public exploitation plan, which describes for each of the ASCOS products and results its potential exploitation in the coming years. The ASCOS project results will be used to support operational stakeholders and national authorities, to embark on implementation activities (to directly use the ASCOS products), and research projects to further develop the recommendations from the main deliverables. The results will also be exploited further by incorporating them in research, products and training developments of partners as well as in their international collaboration projects. An exploitation plan was established to clarify how involved research institutes, industrial organizations, and university will use the results in their future research. Potential users of enhanced safety management techniques are candidates for using the ASCOS outputs, either directly in applying the methodologies and tools and/or through new standards. ASCOS proposes exploitation measures for each of the S&T results/foregrounds and for each of the involved partners. ASCOS contributes to the ACARE SRIA & Flightpath 2050 Safety goals, mainly through contributing to research for the following main safety enablers and capabilities:

- Safety Management System (SMS) to operate throughout whole chain of Air Transport, and
- Standardisation and Certification.

3.5. Recommendations

The main recommendations resulting from the work performed in the ASCOS project are:

- Further research to explore and evaluate more (and other) promising options for certification process adaptations, will be needed.

- Assess the impact of certification process adaptations on aviation safety performance and the costs related to certification in more detail;
- Evaluate feasibility of the incorporation of ASCOS safety methods/tools in safety standards;
- Investigate the feasibility of using data from Flight Data Monitoring (FDM) or other operational data for continuous safety monitoring.

Moving towards performance based regulation, based upon agreed safety performance in combination with a risk based approach to standardization, is expected to improve the way that safety risks are controlled. It is recommended to further explore the potential use of ASCOS outputs in support of this.

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