EREA Aviation Safety Research Plan 2018

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Short abstract: Future Sky Safety is a Joint Research Programme (JRP) on Safety, initiated by EREA, the association of European Research Establishments in Aeronautics. The Programme contains two streams of activities: 1) coordination of the safety research programmes of the EREA institutes and 2) collaborative research projects on European safety priorities.

This deliverable is produced by the Project P1 Coordination of institutionally funded safety research. The annually updated EREA Aviation Safety Research Plan will be based on different inputs and contain the planning for the coordination of the institutionally funded safety research of the participating Research Establishments for the fourth year of Future Sky Safety.

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Grant Agreement No.	640597
Document Identification	D1.9
Status	Approved
Version	2.0
Classification	Public

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Document Change Log

Version No.	Issue Date	Remarks
1.0	12-02-2018	First formal release (approved by FSS RECSC)
2.0	27-02-2018	Second formal release

Approval status

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FSS RECSC	EREA's FSS partners (participating in P1)	RE Coordination Steering Committee (on EREA's aviation safety research)	09-02-2018
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Acronyms

Acronym	Definition
ACARE	Aviation Research and Innovation in Europe
ACARE WG4	Advisory Council for Aviation Research and innovation in Europe Working Group 4 Safety & Security
ACT/FHS	Flying Helicopter Simulator
ADAWI	Assessment of Aircraft Ditching and Water Impact
A-NPA	Advance Notice of Proposed Amendment
ANSP	Air navigation service provider
APOC	Airport Operation Centre
ASRP	Aviation Safety Research Plan
CAA	British Civil Aviation Authorities
CEIIA	Centre for Excellence and Innovation
CEL	Coupled Eulerian-Lagrangian
CIRA	Italian Aerospace Research Centre
CSEM	Centre Suisse d'Electronique et de Microtechnique
DLR	German Aerospace Centre
EASA	European Aviation Safety Agency
EASP	European Aviation Safety Plan
EC	European Commission
EDA	European Defence Agency
EPAS	European Plan for Aviation Safety
EREA	European Research Establishments in Aeronautics
ERSG	European RPAS Steering Group
ESA	European Space Agency
FEP	Flight Envelope Protection
GARTEUR	Group for Aeronautical Research and Technology in EURope
GNC	Guidance, Navigation & Control
HOTAS	Haptic Obstacle and Terrain Avoidance System
INCAS	National Institute for Aerospace Research "Elie Carafoli"
INTA	Instituto Nacional de Técnica Aeroespacial
JRI	Joint Research Initiative

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Acronym	Definition
JRP	Joint Research Programme
L-bows	Land-based and onboard wake systems
LIDAR	Light detection and ranging
NARSIM	NLR ATC Research SIMulator
NLR	Netherlands Aerospace Centre
ONERA	Le Centre Français de Recherche Aérospatiale
R&I	Research and Innovation
R&TD	Research and Technology development
RECSC	Research Coordination Steering Committee
RE	Research Establishments
RPAS	Remotely Piloted Aircraft Systems
RTCA	Radio Technical Commission for Aeronautics
SAE	Serious Adverse Event
SHM	Structural Health Monitoring
SJU	SESAR Joint Undertaking
SLD	Super-cooled Large Droplets
SPH-FE	Smoothed Particle Hydrodynamics – Finite Elements
SRIA	Strategic Research and Innovation Agenda
SRIA	Strategic Research and Innovation Agenda
TRL	Technology Readiness Level
UAS	Unmanned Aircraft System
UTM	Unmanned Aircraft System Traffic Management
VFR	Visual Flight Rules
VZLU	Výzkumný a zkušební letecký ústav
WOLV	Weather optimised air traffic

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EXECUTIVE SUMMARY

Problem Area

Prior to Future Sky Safety, the safety research conducted by the European Aeronautical Research Establishments (RE) was not as coordinated among the establishments as it could be. This doesn't mean that the RE's were not conducting together a sizeable volume of research in this field. In fact, a survey – conducted as part of the effort for Future Sky Safety programme – on the safety research performed by REs revealed that the RE's already conduct together safety research worth thousands of Person Months' annually. However, based on this review, it seemed that the institutional programmes could be better connected and more structured around the European safety research priorities. Even if only partial coordination could be achieved, large benefits are expected by this connection. For this reason, Future Sky Safety dedicated a Project, denominated P1, on the Coordination of Institutionally Funded Safety Research, which aims at bringing the safety research of the EREA partner under coordination to maximize efficiency, develop a critical mass, and ensure excellent alignment with the relevant safety agendas in Europe.

To fulfil this goal, the coordination and cooperation between different research institutes on Safety Research should be improved. Therefore, yearly EREA Aviation Safety Research Plans (ASRPs) are needed. These ASRPs will foster awareness regarding ongoing and planned safety research and thereby significantly strengthen the coordination and cooperation among EREA Research Establishments (REs) and contribute to build a pan-European harmonized approach to safety.

Description of Work

The main objectives of the EREA Aviation Safety Research Plan (ASRP) are threefold:

- The first goal for the ASRP is to define an EREA Safety Research Roadmap and thus identify new institutionally funded safety research topics to be performed by the EREA partners (see sections 8 and 9).
- The second goal is the support to the Collaborative Research projects of the Future Sky Safety Program for identifying missing links in their safety research (see section 5).
- The third goal is to coordinate the EREA safety roadmap with other relevant European Safety Research Roadmaps and to ensure the filling of gaps, avoiding future duplications of efforts and resources and putting current initiatives on a common, more robust path (see section 6).

This report summarizes the FSS Project P1 activities in 2017 dedicated to coordination and cooperation of EREA Safety R&TD activities and identifies relevant safety research topics to focus EREA safety efforts in 2018 and 2019.

The ASRP is resulting from a strategic view of the "needs", an analysis of European Research Roadmaps, and a set of information collected within EREA REs. The latter information is collected via workshops,

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questionnaires and status reports and is provided by all the EREA participants and most of the internal stakeholders to the FSS Programme. These inputs are analysed for their potential value for the ASRP and are then summarized in the P1 context.

Results & Conclusions

This report presents the results of the ARSP process described in the previous section. Thus, the main findings of the analysis of all the workshops, questionnaires and reports are included.

Figure 1 shows the current view for coordination topics of EREA Safety R&TD activities for the upcoming years. In 2015 the project started with initial coordination activities for 2016. The projects in 2016 were mostly bilateral cooperation between EREA partners. As presented in Figure 1, the cooperation's for 2017 involved more partners. The growing interest in P1 will lead to a broader perspective on safety and more cooperation's on a variety of different topics in 2018 and 2019.

For the future, P1 will perform surveys and workshops to support the different research projects and review the coordination and cooperation topics.

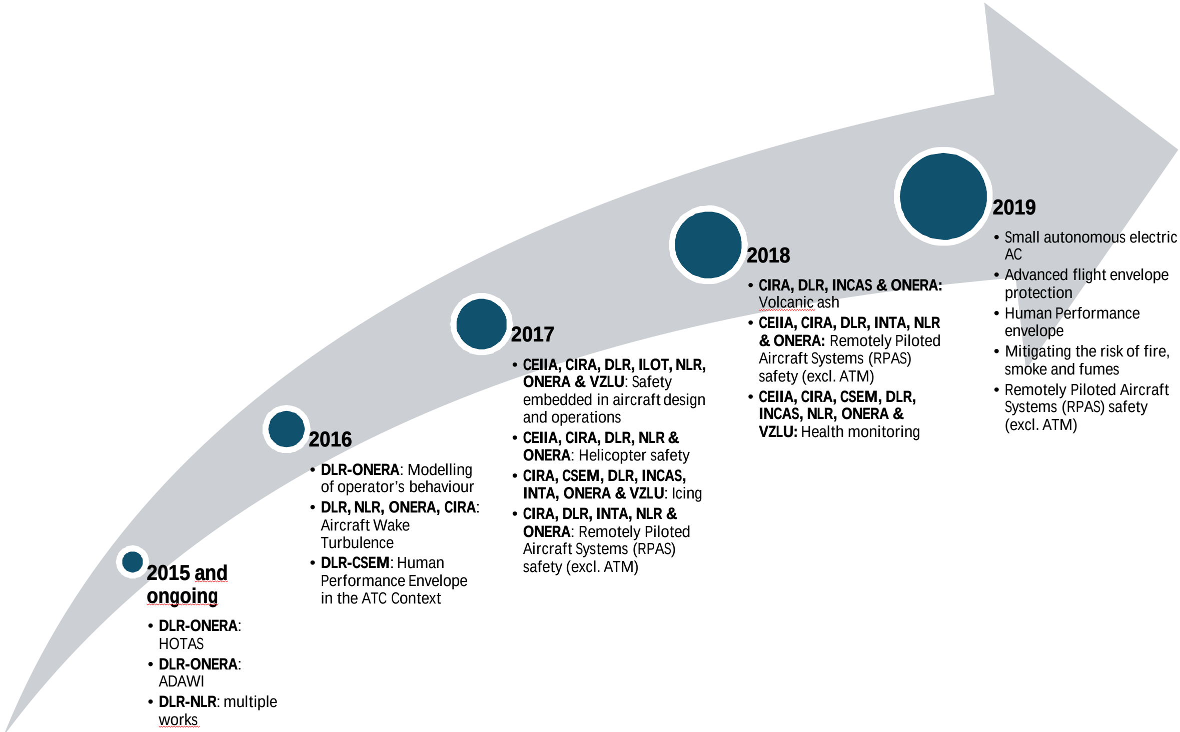

Figure 1: Coordination topics of EREA Safety R&TD activities

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Applicability

This report is applicable to the REs participating in Future Sky Safety Project P1 and is a guideline for them to proceed in the following year. In view of this, this 2018 version was reviewed by the representatives from all EREA partners involved in Future Sky Safety P1. Their feedback was processed into a version for the RE Coordination Steering Committee, asking it for approval (which was obtained early February 2018).

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1 INTRODUCTION

1.1. The Future Sky Safety Research Programme

Flight Path 2050 aims to achieve the highest levels of safety to ensure that passengers and freight as well as the air transport system and its infrastructure are protected. To support these goals, a Joint Research Initiative (JRI) for aviation (Future Sky) with a Joint Research Programme (JRP) on safety was started, including coordination of safety research conducted under the institutional programmes of the European research establishments. The JRP on safety (Future Sky Safety), established under coordination of the Association of European Research Establishments in Aeronautics (EREA), is built on the relevant European safety priorities as brought forward in Flightpath 2050 and the European Aviation Safety Plan.

The programme is structured around four main themes, each one consisting of a small set of projects. Theme 1 (New solutions for today's accidents) aims for breakthrough research with the purpose of enabling direct, specific, significant risk reduction for the two main accident categories. Theme 2 (Strengthening the capability to manage risk) conducts research on processes and technologies to enable the aviation system actors to achieve near-total control over the safety risk in the air transport system. Theme 3 (Building ultra-resilient systems and operators) conducts research on the improvement of organizations, systems and the human operator with the specific aim to improve safety performance under unanticipated circumstances. Theme 4 (Building ultra-resilient vehicles), aims at reducing the effect of external hazards on the aerial vehicle integrity, as well as improving the safety of the cabin environment. Complementing these thematic projects, an additional activity called "Coordination of institutionally funded safety research" specifically addresses the coordination of safety research among the participating EREA partners.

1.2. The P1 project context within Future Sky Safety

An important goal of the Future Sky Safety Programme is to enhance the coordination of safety research carried out by participating EREA establishments on institutional funding, in order to reach a critical mass and contribute with the highest efficiency to the relevant safety agendas in Europe, thus leveraging the invested EU funding. Institutional Research Establishments (RE) programmes are often the result of bilateral coordination between governments and national institutes. There are however multiple forces that shape these programmes like institute ambitions, governmental responsibilities and ambitions and European plans. The goal of the P1 research coordination is to add another driving force to shape the national programmes. For this purpose, the ambition of Project 1 is to elaborate an Aviation Safety Research Plan (ASRP) endorsed by EREA establishments that maps and coordinates their institutionally funded safety research.

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1.3. Motivation

1.3.1. Situation before Future Sky Safety

An estimated 1000 Person Months of effort is spent on safety related research annually in the participating Research Establishments (data gathered in the FSS proposal phase). So far, the safety research conducted by the REs was however not as coordinated as it could be.

Clearly, there is a very large potential to improve the situation. Even if partial coordination will be achieved, the benefits to be expected in terms of efficiency, critical mass and alignment with European safety priorities would be very large. For this reason, Future Sky Safety dedicated a Project, denominated P1, on the Coordination of Institutionally Funded Safety Research.

Thus, the coordination and cooperation between different research institutes on Safety Research has to be improved and the establishment of annual EREA Aviation Safety Research Plans (ASRPs) are an essential part of that. These ASRPs will foster awareness regarding ongoing and planned safety research and thereby significantly strengthen the coordination and cooperation among EREA Research Establishments (REs) and contribute to build a pan-European harmonized approach to safety research.

1.3.2. Future Sky Safety P1 Ambition

The goal of Future Sky Safety P1 is to develop an ASRP to better coordinate institutionally funded research. Consequently, the institutional funding could be used in a more efficient and effective way, thus creating the desired leverage effect. The annual coordination will result in an increased awareness and shared insight among the research institutes regarding the content, results and ambitions of the institutional RE programmes and the ongoing and planned safety research. Institutes are then potentially able to initiate new projects, discontinue ongoing activities, combine programmes between institutes, achieve coordination in the planning and conduct of new safety research projects and create cooperative research projects in which multiple REs work together. This will lead to a reduction of gaps; it will reduce unnecessary duplication and will leverage commonalities where possible (for example by combining tests or test results). Furthermore, activities complementary to the Technical Projects can be identified and support these projects by sharing results, and institutional RE programmes can be aligned with other European roadmaps (ACARE SRIA, EPAS).

1.3.3. Research Objectives

The objective of the ASRP is to describe the planned coordination of safety research for the upcoming year through:

- **Coordination/cooperation of institutionally funded safety research between the Research Establishments**
  - o “Join forces” on topics of common interest and achieve “critical mass” to launch new projects
  - o identification of overlapping research activities and free resources by avoiding duplication
  - o identification of new institutionally funded safety research topics (challenges for the identified time frames, see D1.1 (Ruttke et al., 2016a))

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  - definition of safety research topics to be performed in a coordinated/cooperative manner

- **Coordination/cooperation with the Future Sky Safety Projects funded by the European commission**
  - offering support (freeing of resources, joining forces and facilitating work complementing content in FSS projects) to cover potential gaps (scientific, technological, and man power)
  - identification or initiation of possible input to FSS P3 – P7

- **Coordination/cooperation with other European organisations and roadmaps**
  - alignment with other European roadmaps (SRIA, EPAS)
  - cooperating with key European organisations and actions dedicated to safety (EASA, Eurocontrol, ACARE WG4, OPTICS)
  - filling the existing gaps (topics uncovered, lacking resources, missing expertise…)

The ASRP objectives are of utmost importance for the stakeholders of the Future Sky Safety Programme (Table 1). All internal stakeholders (EREA partners) participated for the survey on institutionally funded safety research projects (D1.2 (Ruttke et al., 2016b)).

Table 1 Identified Stakeholder for P1

Stakeholder	External / Internal	Involvement	Why it matters to stakeholder?
European Commission	External	Supervision of all Future Sky Safety activities	The commission is interested to see the coverage of the safety research priorities in order to exploit their results, assess current needs and to efficiently drive future research initiatives.
Industry	External		Industry partners are interested to know what the Research Establishments are doing, to possibly drive research requirements and/or to allow a V&V aiming at increasing TRL.
Non-Participating RE	External		These RE's see an opportunity for cooperation within existing projects to acquire state of the art or to complement or to validate results. The project also uses their roadmaps (e.g. EPAS from EASA, Optics) to coordinate its own research.
Others	External	Not directly involved	General interest for existing research.

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Participating RE	Internal	EREA Partner	Intrinsic motivation to: • Join forces" on topics of common interest and achieve "critical mass" to launch new projects • Identify overlapping research activities and free resources by avoiding duplication • alignment with other European roadmaps
SMEs	External		SME's might be interested in new opportunities for their market, benefiting from research results which they would not be able to fund by themselves
Universities	External		Universities may want to align and coordinate their own research (at low TRL) in relation to the leading RE.

1.4. Approach

The adopted approach to develop the EREA ASRP 2018 identifies the following steps:

1. Analysis of ongoing or planned institutionally funded safety research activities at the participating Research Establishments (D1.2; (Ruttke et al., 2016b), and its annual updates through surveys)
2. Survey of the different institutional funding mechanisms (D1.1, (Ruttke et al., 2016a))
3. EREA Programme Manager Survey of the different institutional future safety projects (Friedrich, Carstengerdes, & Amato, 2017)
4. Analysis of the current status of the Future Sky Safety Technical Projects (P3-P7)
5. Analysis of the relevant European roadmaps (e.g. SRIA)
6. Deduction of Subjects for Cooperation
7. Conclusions

1.5. Structure of the document

The document is structured as follows:

- Chapter 1 "Introduction" describes the purpose and scope of the document and stakeholders that are involved.
- Chapter 2 "Goal and Scope of the ASRP" describes the objectives and the scope of the document.
- Chapter 3 "Continued Cooperation" describes ongoing EREA cooperation.
- Chapter 4 "Results from survey of institutionally funded programs: possibilities for collaboration" describes results of the annually updated survey initially reported in D1.2 (Ruttke et al., 2016b).

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As an extension, the results from a newly developed survey, called "Program Manager Survey" (Friedrich et al., 2017) are presented. These surveys serve as input for this ASRP.

- Chapter 5 "Priorities from Future Sky Safety Technical Projects" describes the input from Future Sky Safety Technical Projects (P3 to P7) to this ASRP
- Chapter 6 "Review from European roadmaps for safety research: priorities for research" describes the input from European Roadmaps (ACARE SRIA, EASA EPAS and RPAS related research).
- Chapter 7 "Criteria for selection of topics" describes selection criteria for future EREA cooperation.
- Chapter 8 "Planned Cooperation's for 2018" provides an overview of the current status of planned cooperation for 2018.
- Chapter 9 "Suggested Subjects of Cooperation for 2019" provides an overview of possible new cooperation for 2019.
- Chapter 10 "Conclusions" provide a summary and recommendations for the following years.

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2 GOAL AND SCOPE OF THE ASRP

The document describes the planned EREA Institutionally Funded Safety Research for the year 2018 resulting from the coordination effort performed in P1. The ASRP will be delivered as a new document on a yearly basis; this approach will ensure that relevant research topics are taken into account for the next planning period. The ASRPs for the years 2016 (Carstengerdes & Friedrich, 2016) and 2017 (Carstengerdes & Friedrich, 2017) are already available.

The first goal for the ASRP is the identification of new safety research topics and projects to be institutionally funded (compare also D1.2, D1.5 & D1.6) by the EREA partners. This activity has to be performed in a coordinated and cooperative manner among the interested EREA partners.

The second goal is the support to EC funded FSS Projects for identifying gaps or bottlenecks (EREA activities which could support the projects by scientific/technical results specifically in terms of: research cooperation, related data sources, approaches, software tools, capabilities/expertise, and so forth) in their safety research. This could mean links among the different Technical Projects or to external projects that are not directly related to Future Sky Safety but known to the project managers or other project participants. The ASRP serves here as a documentation of all support requested and delivered for the last year and the support actions requested for the upcoming year. Furthermore, the Technical projects are offered the opportunity to express wishes regarding safety research gaps which could be filled by EREA partners or coordinated efforts of EREA establishments.

The third goal is to take into account relevant European roadmaps on safety research (SRIA, EPAS) for harmonising the goals and fill the gaps.

These goals will support a better coordination of safety research carried out by participating EREA establishments on institutional funding.

The results of the efforts resulting from the P1 work from 2015 to March 2017 and the ASRP 2016 were analysed in dedicated reports (D1.7 (Novelli, 2017) and D1.8 (Amato, Lizza, Paparone, & Vozella, 2017)). Recommendations of these reports are taken into account in this third and final ASRP.

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3 CONTINUED COOPERATION

This chapter summarizes the cooperation that are already in place and ongoing within the Future Sky Safety Programme. This overview is to support and inspire additional cooperation. The following cooperations are currently ongoing:

- Haptic Obstacle and Terrain Avoidance System (HOTAS)
- Assessment of Aircraft Ditching and Water Impact (ADAWI)
- DLR-NLR cooperation on ATM
- Wind Turbine Wakes and Helicopter Operations
- Modelling of operator's behaviour
- Aircraft Wake Turbulence
- Human Performance Envelope in the ATC Context
- Cooperation for the elaboration of the RPAS safety roadmap
- Cooperation on Helicopter Safety

The following sections give a short summary of each cooperation, additional information can be found in D1.5 (Friedrich & Carstengerdes, 2016), D1.6 (Carstengerdes & Friedrich, 2017) and D1.7 (Novelli, 2017). Note that in addition to these activities discussions on super large droplet (SLD) icing initiated during the first FSS workshop were successfully pursued in another context, together with industry and other academic partners, and resulted in the submission of a collaborative project in the H2020 call for proposal.

3.1. Haptic Obstacle and Terrain Avoidance System (HOTAS)

The purpose of the DLR-ONERA cooperation on rotorcraft is to study FEP (Flight Envelope Protection) functions based on haptic side sticks. The aim is to develop a generic obstacle avoidance algorithm that can be applied on different helicopter models: ACT/FHS, Dauphin, real helicopters simulation models. The avoidance algorithms get the obstacle information, like distance and direction from given sensors. The focus is on developing emergency procedures, in case of the sudden occurrence of obstacles on the flight path of the helicopter incorporating haptic cues presented by active sidesticks.

3.2. Assessment of Aircraft Ditching and Water Impact (ADAWI)

The DLR/ONERA collaboration in the Common Research Project ADAWI aims to further develop and validate capabilities of numerical simulation tools to model aircraft ditching, i.e. the controlled emergency landing on water and water impact of aeronautical structures. CIRA has also high interests to participate in this cooperation.

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The project is primarily focused on the impact phase of ditching because structural loads during this phase are most critical and structural failure of the hull should be prevented to maintain sufficient flotation capability.

Within the EU-FP7-SMAES project (02/2011 – 10/2014), large progress has been made in alternative simulation methods and fluid modelling. DLR and ONERA studied in parallel two numerical methods, i.e. SPH-FE (Smoothed Particle Hydrodynamics – Finite Elements) and CEL (Coupled Eulerian-Lagrangian), which both proved high capabilities but could neither be fully validated nor compared to identify individual advantages and their ability to fulfil industrial needs. Moreover, an important experimental database has been generated which could not be fully exploited to date. The ADAWI project will complete the missing steps with respect to the validation of these simulation methods in order to allow for future application within an industrial context and ends in December 2017.

3.3. AT-One: cooperation on ATM

AT-One is the strategic alliance between DLR's Institute of Flight Guidance and NLR's Air Transport Division. Both institutes have a long track record of providing innovative and independent approaches to Air Traffic Management research. They work together on a different number of safety related projects, e.g. the EU funded project A-PiMod which deals with applied pilot models to increase the safety within the cockpit and the EU funded Coordination and Support Action (CSA) OPTICS.

Within the AT-One Area of Expertise "Safety & Security", safety knowledge is maintained about safety modelling, assessment and incident and accident investigation. The activities in the safety domain are broad. At the top level advanced safety models and methods are developed. On a more operational level, activities include safety analyses, assessments and incident and accident investigations. Furthermore, safety expertise is also used to design and build tools for safety assessments and safety decision support. The knowledge from this area of expertise is also used to support the activities in the other areas of expertise. An important asset is the extensive incident and accident database that is built and maintained.

3.4. Wind Turbine Wakes and Helicopter Operations

HC/AG23 is a GARTEUR Action group under the Garteur Group of Responsibles - Helicopters (GoR-HC), which purpose is to examine critical effects of wind turbine wake on the stability, handling qualities and safety of a helicopter and provide recommendations for legislation to the appropriate authorities and parties concerned. This will be done by performing a survey on the wind turbine wake characteristics and using this data for the identification of relevant flow phenomena for the study of its effects on rotary flight. The partners of this project are NLR (Chairman), DLR (Vice Chairman), CIRA, ONERA, TU München, TU Delft, Politecnico di Milan, University of Liverpool, and National Technical University of Athens.

3.5. Modelling of operator's behaviour

DLR and ONERA are planning a future cooperation on the topic Human Performance Modelling in Human-System Interaction as EREA Joint Forces. Therefore they decided to combine their interests in an activity to support the effort on both sides. The cooperation activity is open for other EREA partners to participate as well and they will be invited to join. Currently the team is working together in the context of SESAR and plans to submit a project in H2020.

As basic principles in Human-System Interaction are applicable to a wide variety of systems and not only relevant for Aviation, other institutes might be interested as well and will also be invited to join this cooperation. The aim of modelling human performance in human-system interaction is two-fold. In the short-term, the knowledge gained by modelling human performance will be used (1) to develop tools for pilot state monitoring, and (2) to derive design principles for human-system interaction. The long-term goal is to develop executable models which can predict human-performance in complex environments like those faced by pilots and air traffic controllers. These models can be applied to quickly evaluate new system and procedures during the design process to reduce the necessary amount of Human-in-the-Loop simulation and to speed up the development process.

3.6. Aircraft Wake Turbulence

The cooperation activity can be divided into the following topics. First is the research on wake turbulence separation optimisation. The second is the improvement of sensing and detection of (wake) turbulence phenomena.

The coordination activities began with the initiation of LIDAR applications between DLR-IPA-LIDAR and ONERA-DOTA-SLS. A Kick-Off Meeting (May 6th, 2015) was performed to officially start the activity and agree on the topics. The intention was to create a Memorandum of Understanding. In 2015 also the activity called LIDAERO, supported by DLR-ST-INT, „Projektförderung in der Internationalen Zusammenarbeit (PIZ)"was performed.

The coordination activities for 2016 included an ONERA-NLR-DLR general wake vortex workshop (8th of June 2016 at DLR Braunschweig), which had the goal to focus even more on the different approaches for research within the different research institutes:

- establish basis for cooperation
- prepare coordinated research activities

The activities also include actions to prepare project plans for coordinated research activities and to analyse the progress made in LIDAERO. The activities included the joint thesis supervision DLR-IPA-LIDAR and ONERA-DOTA-SLS on short-range direct-detection wind LIDAR developed within DLR-project L-bows. These activities were supported by another workshop on agreed main LIDAR topics and the coordinated project and fund raising (uni-/bi-/multilateral). However, no new activities were started in 2017 besides bilateral contacts.

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3.7. Human Performance Envelope in the ATC Context

This is a complementary activity to the technical project P6 (DLR, CSEM) of Future Sky Safety (FSS).

The "Human Performance Envelope" is already under investigation in the project of the same name in the Programme FUTURE SKY SAFETY. The project builds on a concept previously proposed in the Air Traffic Management (ATM) domain (Edwards, 2013). In FSS project P6 the limitations of human performance are studied in the cockpit with relation to the pilot's workload, situation awareness and stress and the interdependencies of these three Human Factors.

Now EREA partners CSEM and DLR bring the concept back to the Air Traffic Controllers' (ATCo) working position. The context of interest is now the Remote Tower Operation (RTO) environment. Physiological measurements of ATCos have been used to predict limitations of human performance well in advance in order to prevent so called human errors. The performed study focused on the question if physiological parameters like heart-rate variability as indicator for workload and eye point of regard measurement (pupilometry, Ahlstrom & Friedman-Berg, 2006) can predict performance outside the envelope. A first Master´s thesis was successfully finished in this cooperation and publications have been submitted.

A further study was performed to evaluate the pilots' fatigue. Therefore fatigue data were measured in the cockpit environment and a Master´s thesis was successfully finished.

Future studies are planned and foreseen after 2017. The collaboration might be extended together with additional EREA partners.

3.8. Cooperation for the elaboration of the RPAS safety roadmap

The goal pursued by the RPAS group (CIRA, DLR, INTA, NLR and ONERA, CEIIA and AFIT/ITWL) since the first workshop in February 2016 was to build a harmonized roadmap providing the vision on research needs for RPAS safety to 2030 and 2050.

For this, the group has discussed terminology and analysed market projections to determine where we are going and where we are today. The roadmap is aimed at guiding future research, as well as the selecting cooperative research projects. The group has completed the identification of research gaps corresponding to three different scenarios that could emerge for the future development of RPAS:

- Full integration of RPAS in air traffic - UTM concept,
- Combination of UTM and ATM concepts,
- ATM concept alone if RPAS market does not develop.

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The next steps are now to analyse gaps in more details and to categorise them in short-term and long-term gaps. For this, experts groups are created, which will review the work to date and refine the research gaps. Five groups are established to cover the following aspects:

- Operations,
- Technical aspects,
- Human factors,
- Systems (e.g. detect and avoid system),
- UAS Traffic Management.

Moreover, partners share information about the projects on RPAS they are working on, especially RPAS safety, in order to foster the definition of collaborative actions on the topic in 2018 (like a cooperation project).

3.9. Cooperation on Helicopter Safety

During the first Future Sky Safety Workshop, Helicopter safety and safety issues related to rotorcraft ship landing was identified as a topic on which CIRA, NLR, DLR and ONERA had common interest and could initiate collaboration. A detailed project plan and a cooperation agreement were established, which have been submitted for signature by CIRA, DLR, NLR and ONERA executives in March 2017. The start will be in Q2/2017. A two-year cooperation with an effort of 28.5 PM is foreseen to perform the proposed cooperation.

The proposed cooperation focuses on the prediction of aerodynamic disturbances during ship (platform) landing, their inclusion in flight mechanics models and GNC algorithms to assist the pilot during this sensitive maneuver. It will mostly consist of benchmarking activities allowing to compare different approaches on a common configuration.

A first benchmark will be performed on the prediction of ship's wake interaction with helicopters. A range of computation methodologies, including simplified methods and detailed CFD computation, will be compared and assessed against wind-tunnel on a simplified generic configuration.

The aerodynamic computations will be used to introduce various levels of prediction of the aerodynamic disturbances into the flight mechanics models, and, beyond the fidelity of aerodynamic models, will help to assess which level of modelling of the wake flow is required for the GNC. As for disturbance prediction, a benchmark will be performed to compare different approaches for including the aerodynamic disturbances in the flight mechanic models and assess GNC algorithm to assist the pilot for landing.

A final workshop will organised at the end of the cooperation for the presentation and discussion of the results.

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4 RESULTS FROM SURVEY OF INSTITUTIONALLY FUNDED PROGRAMS: POSSIBILITIES FOR COLLABORATION

This section supports the first goal for the ASRP to give an overview of the (explicit) safety research conducted within the EREA partner research establishments. Within D1.2 a questionnaire was used to collect necessary information for this section. The questionnaire focuses on (explicit) safety activities which are at least partially institutionally funded, as defined in D1.2[1]. Therefore the following subsections cover different parts of the questionnaire D1.2 with regard to its impact on the ASRP. The first part of the analysis is dedicated to the present state of safety activities in the year 2017. The second part shows the trend for 2018 in comparison to the fixed years 2015 to 2017. The third part analyses the budget and it looks also to the trend for 2018.

4.1. The updated D1.2 for 2017

The previous and initial version of the D1.2 collected a total of 78 activities with relation to safety. The questionnaire was updated between February and April 2016 and again between June and December 2017. The task of the participating EREA partners was to update the existing activities and at the same time add new ones. Activities that ended in 2016 or before were removed because they are no longer in the focus of this document. The latest update for the existing activities was mainly performed on the estimated budgets for 2017 and 2018 (in total 80 activities). For the following analyses, data for the year 2018 are used. This leads to a total of 63 activities. However, the number of activities in the following analyses may vary slightly because not all data fields have been filled completely by all project managers. Therefore, not all figures have the same amount of projects depicted.

4.1.1. Connection to continued cooperation

The following overview orders the described cooperation's in chapter 3 into the overall safety research activities by looking at the amount of research projects, their budgets and the person month invested by each EREA partner. This connection is important for interpreting the existing cooperation but also might allow some insight on the research interest that some cooperation have in general.

The SKYbrary classification will be used as a reference to define the keywords adapted to categorize the safety projects. SKYbrary is a wiki created by the European Organisation for the Safety of Air Navigation - EUROCONTROL, International Civil Aviation Organization, and the Flight Safety Foundation to create a comprehensive source of aviation safety information freely available online. It includes four top-categories:

- operational issues,

[1] Projects are classified as *explicit safety* research projects under the following conditions:
- (Within the abstract it is declared that) the project specifically addresses aviation safety;
- (Within the abstract it is declared that) the project addresses safety-related enablers or capabilities of the SRIA; or
- In public available information (e.g. reports, website, etc.) the project addresses specific safety matters.

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- human performance,
- enhancing safety
- safety regulations

These categories are subdivided into sub-categories (e.g. runway excursion or weather for the category "operational issues"), and for some topics a third level of classification (e.g. icing or volcanic ash for the sub-category "weather"). The SKYbrary website is maintained by Eurocontrol and is supported by many actors such as ICAO, the Flight Safety Foundation or EASA through the European Strategic Safety Initiative (ESSI).

Although SKYbrary is basically a framework to organise safety documentation, it is adopted as a reference in Future Sky, specifically it is already used in WP1.1 and WP1.2 of P1 (i.e. for D1.2, ASRPs, communication platform). SKYbrary is used to classify projects as it is a well-recognised framework. Using the same classification throughout the project will ensure consistency between the deliverables and facilitate the use of the information by scientists.

For practical reasons, some categories will be excluded as they are not relevant for FSS (for details see D1.2, Ruttke et al., 2016b).

The three following tables present the SKYbrary main categories "Enhancing Safety", "Operational Issues", "Human performance", "Safety regulations", and the two subcategories "Weather", and "Fire, smoke and fumes" in relation to the EREA research establishments. The tables only account for the projects that were mentioned by the EREA partners in D1.2 and its updates. Table 2 presents the amount of research activities per RE. Table 3 presents the summarized budgets per RE. Table 4 presents the summarized person months that are invested by each RE into the SKYbrary categories. It can be seen in this table that the sum of person months of the RE is even higher than the 1000 person months per year estimated at the beginning of Future Sky Safety. Around 2100 to 1500 person months are invested for safety research for 2017 and 2018. It has to be noted that the numbers for 2018 and 2019 could still increase because the planning phase is not finished yet. However, a decline in invested person months in (at least partially) institutionally funded explicit safety research is observable from 2015 to 2018 (see Figure 2).

Note that these tables are not available in the public version of this document and only available in the confidential version.

Note that if a project was assigned to more than one main category, the budget and person month were equally divided to each category. It has to be kept in mind that this is a simplification to avoid incorrect double counting of budget or person month.

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Table 2: Amount of research projects per partner and main SKYbrary category for 2018 (if one project was assigned to more than one main category, then it was equally divided by the number of categories and assigned to all stated categories); information not available in the public version of this document

RE	Enhancing Safety	Fire smoke and fumes	Human performance	Operational Issues	Safety regulations	Weather	Total
CEiiA							
CIRA							
CSEM							
DLR							
INCAS							
INTA							
NLR							
ONERA							
VZLU							
Total							

Table 3: Total budget (in €) per partner and main SKYbrary category for 2018; information not available in the public version of this document

RE	Enhancing Safety	Fire smoke and fumes	Human performance	Operational Issues	Safety regulations	Weather	Total
CEiiA							
CIRA							
CSEM							
DLR							
INCAS							
INTA							
NLR							
ONERA							
VZLU							
Total							

Table 4: Total person month per partner and main SKYbrary category for 2018; information not available in the public version of this document

RE	Enhancing Safety	Fire smoke and fumes	Human performance	Operational Issues	Safety regulations	Weather	Total
CEiiA							
CIRA							
CSEM							
DLR							
INCAS							
INTA							
NLR							
ONERA							
VZLU							
Total							

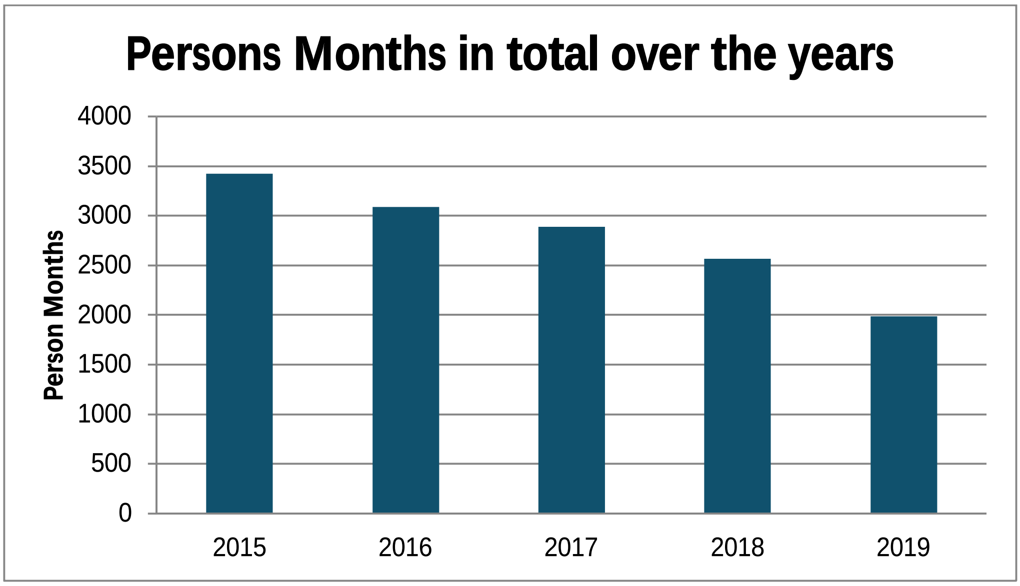

Figure 2: Summary of person months in safety projects per year; due to the ongoing planning phase for 2018 and 2019 these values may raise

It has to be noted that a decrease in the number of institutionally funded projects (as seen in Figure 2) does not necessarily mean a decrease of the activities on safety if these can be funded through contracts.

For the following chapters the RE are aggregated to put the focus on the research areas and their development within the EREA consortium.

4.1.2. Categories, funding, consortium, accessibility, cooperation

The following data analysis shows the results for main and subcategories that are used to describe the projects. The analysis also summarizes the funding mechanism, type of consortium, accessibility of results, and possible level of cooperation with EREA partners.

Figure 3 shows the histogram of the main categories for projects that are safety relevant in 2018. This allows a view on the most common topics in safety research. In detail, these are the four SKYBRARY classes “Operational issues”, “Human Performance”, “Enhancing Safety”, “Safety regulations” plus two subclasses of “Operational issues”, namely “Fire, Smoke and Fumes” and “Weather”. Each of these categories is supported by subcategories to provide a detailed view. The main focus on SKYbrary categories is on Operational Issues, Enhanced Safety and Human performance. The research on Fire, smoke and fumes seems to be very specifically focussed and not wide-spread.

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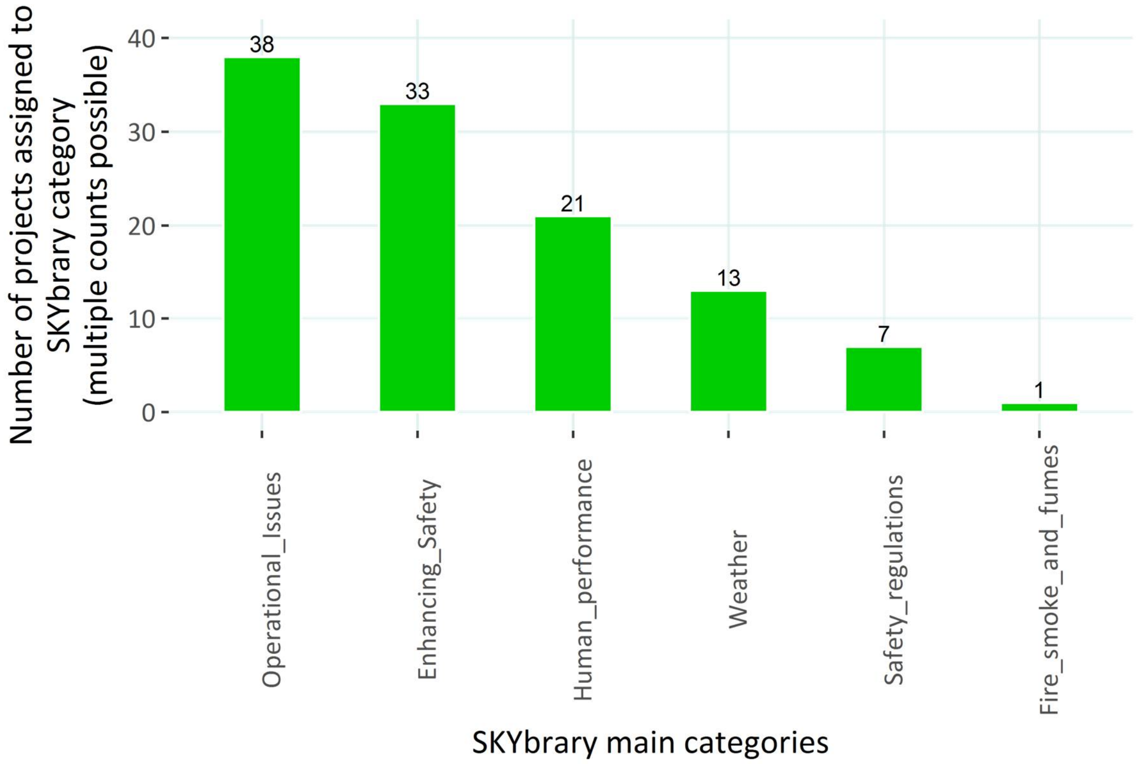

Figure 3: Summary of the main categories for all projects in the D1.2 survey for 2018 (multiple counts for each project possible).

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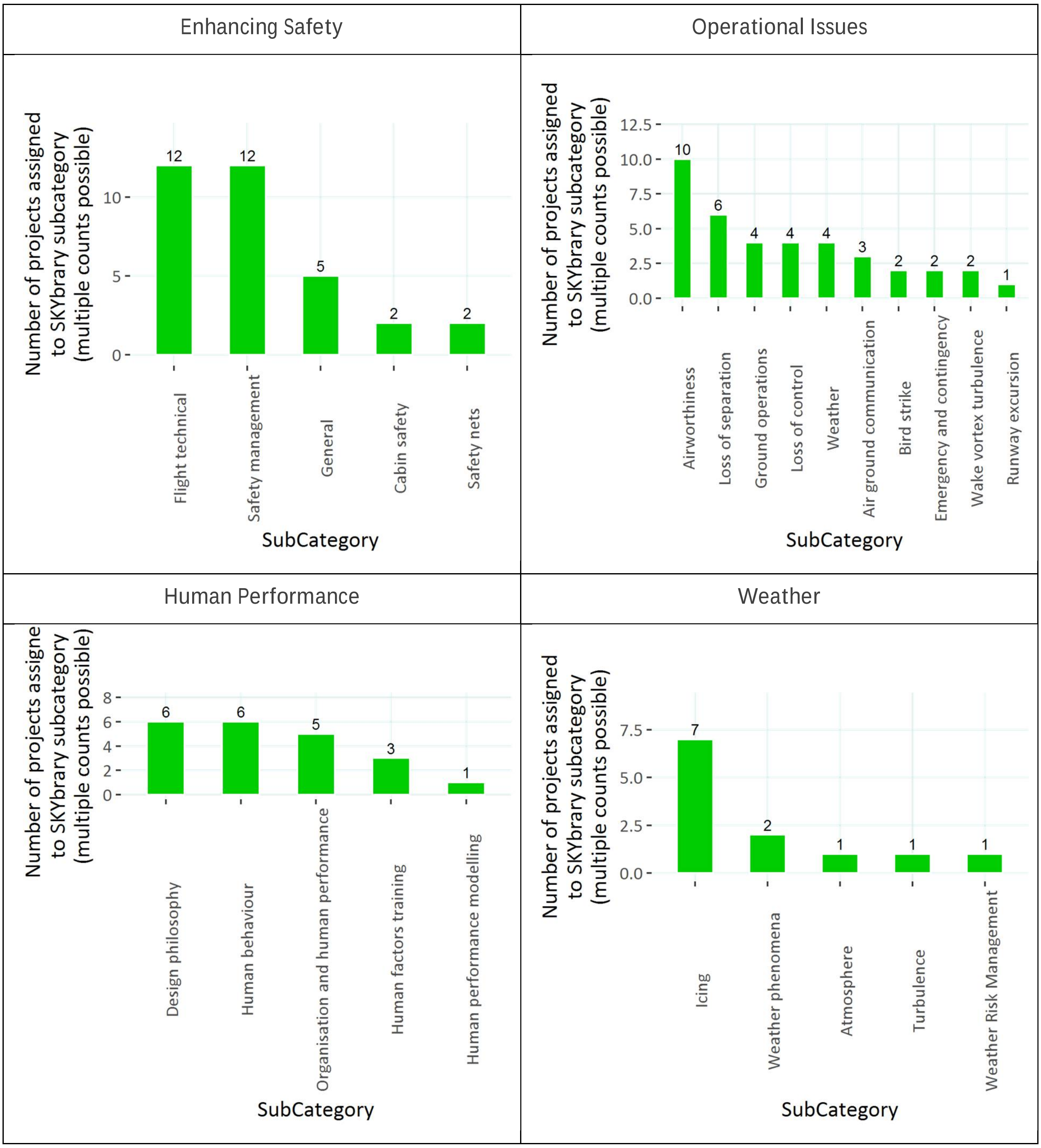
Figure 4 shows the results for each subcategory. The major subcategories independent from the main categories are Flight technical (12), Airworthiness (10), Safety Management (12) and Icing (8). As “Fire, Smoke and Fumes” and “Weather” are already subcategories, the shown contents are actually the sub-subcategories (e.g. “Combustion-related Smoke”).



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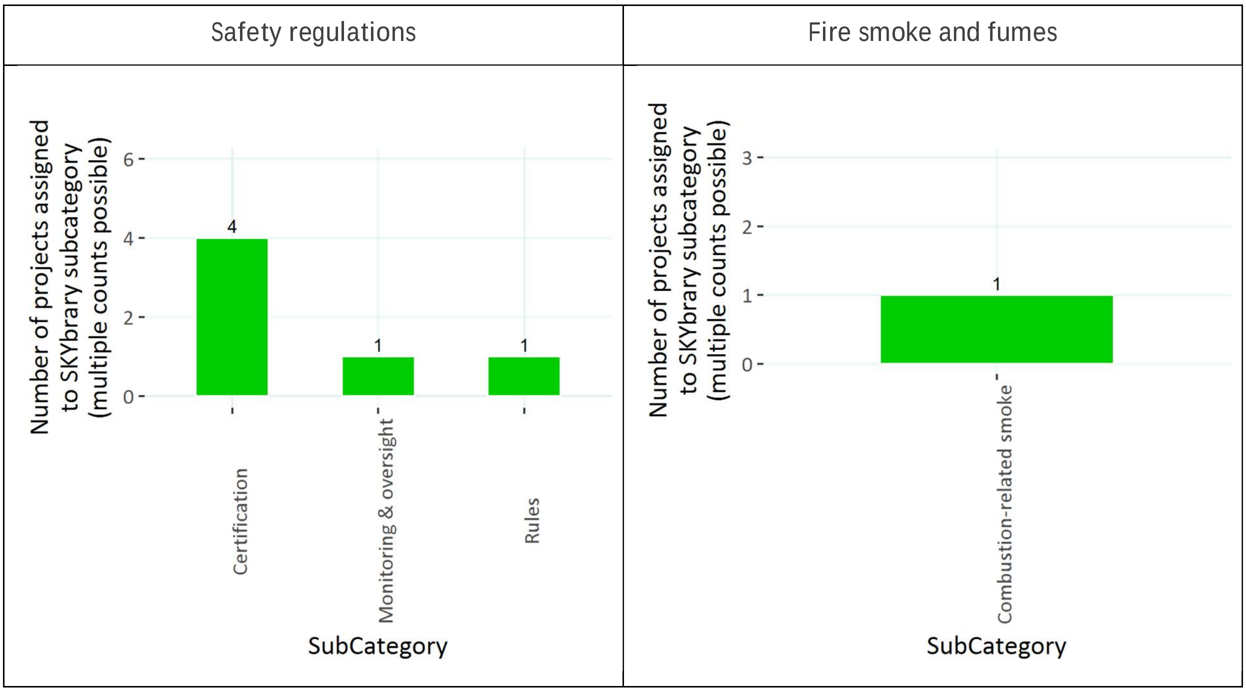

Figure 4: Summary of the sub categories separated by main categories for all projects in the D1.2 survey for 2018.

The funding mechanism is presented in Figure 5. The results show that around 80% of the projects are either funded only institutionally or are EU co-funded. Majority of projects (41.6%) is conducted on institutional funding only.

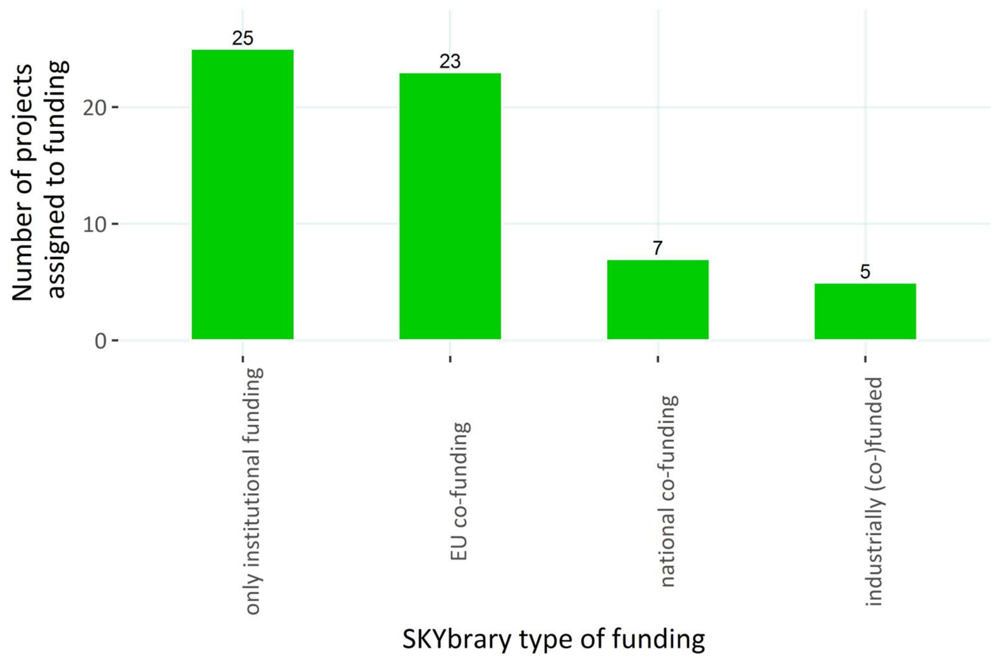

Figure 5: Summary of the type of funding mechanism for all projects in the D1.2 survey for 2018.

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The next analysis is related to the types of consortia that are used for safety projects. Figure 6 shows the number of projects per consortium type. There is a balance between stand-alone research activities (i.e. research by one RE only) and research projects within a national or international research consortium.

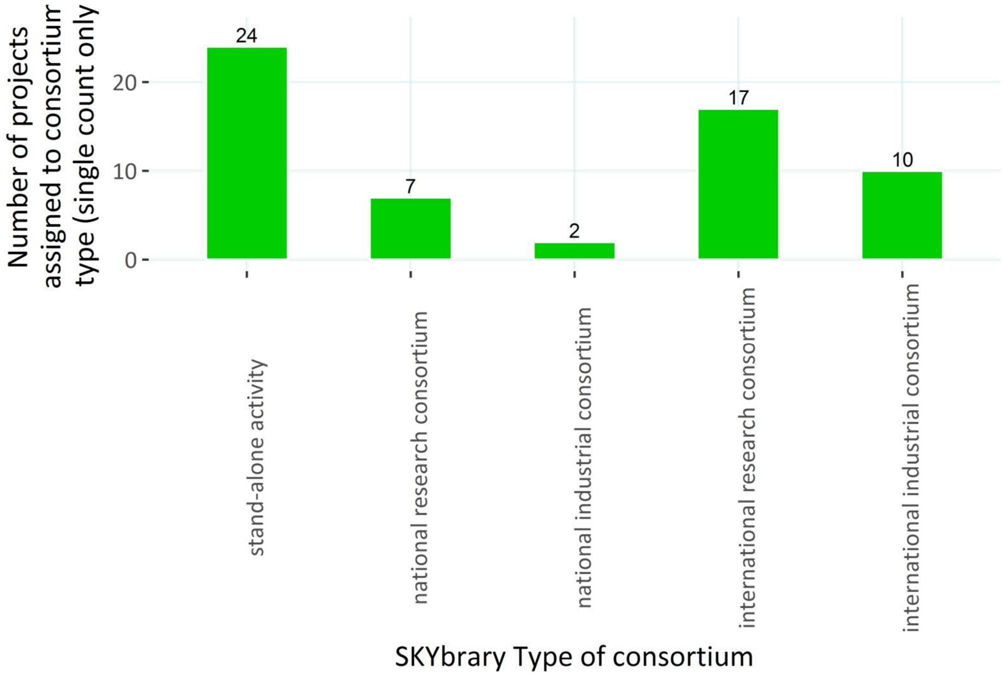

Figure 6: Summary of the type of consortium for all projects in the D1.2 survey for 2018.

Figure 7 shows the accessibility of the projects and therefore the possibly to share the results with other partners. The large majority of projects (83%) are partly confidential or fully confidential.

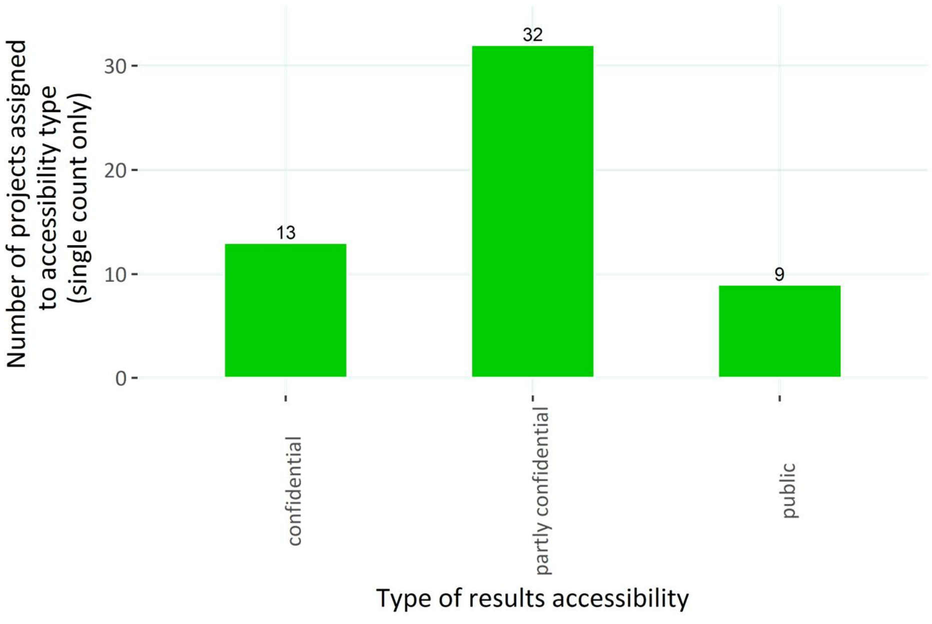

Figure 7: Summary of the type of result accessibility for all projects in the D1.2 survey for 2018.

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Figure 8 shows the possible levels of cooperation with EREA partners, which is expressed by the partners (the possible potential their activities could have in cooperation) in relation to their activities. 21 activities were classified as no exchange with EREA partners. This leads to the positive result that for more than 60% of activities, some form of cooperation should be possible. The possible level of cooperation is defined in 3 levels. The lowest level "share information with EREA" was selected if there is no action resulting from the information exchange. The medium level is "coordination" were activities of the REs, although carried out separately, are harmonised so that overlap is avoided. Instead, synergies or complementarity are created between the REs but no exchange of results. The highest level is "cooperation" were at least two EREA partner work together on a common project, with exchange of results and possibly some interdependency between the tasks carried out by each EREA partner.

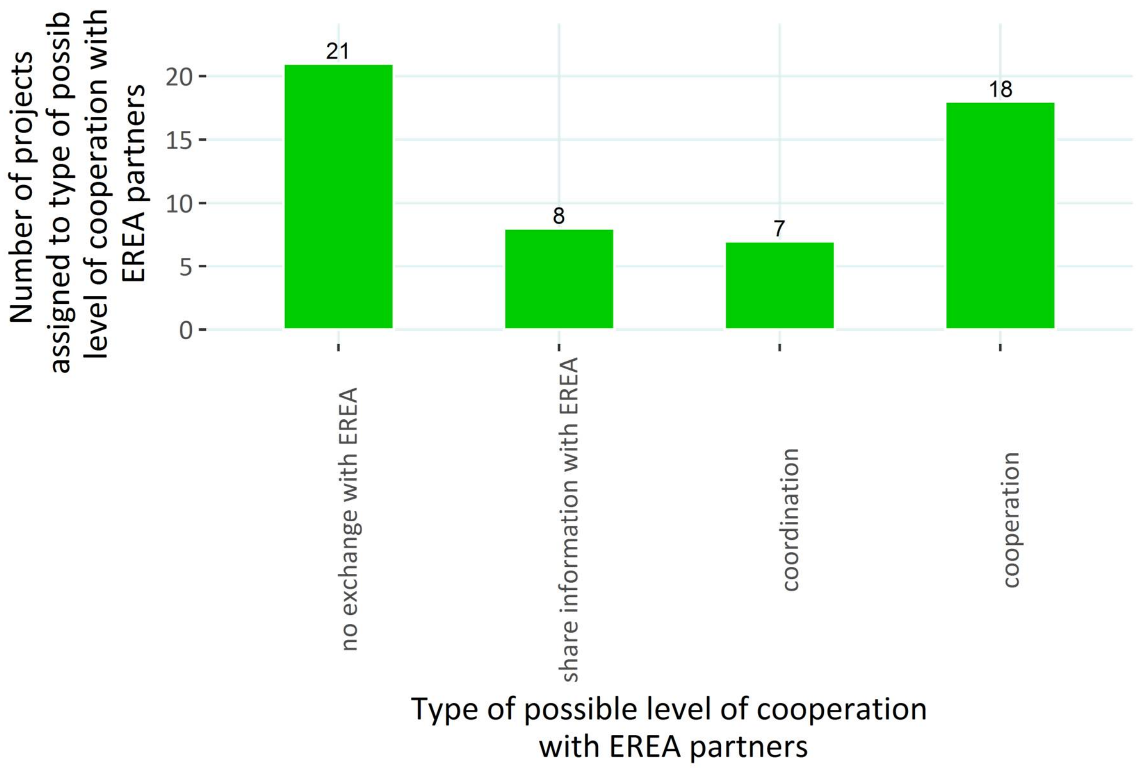

Figure 8: Summary of the type of possible level of cooperation with EREA partners for all projects in the D1.2 survey for 2018.

4.1.3. Trend analysis

The trend analysis is restricted to the years 2015, 2016, 2017, 2018 and 2019. The data for 2015, 2016, and 2017 are solid in terms of explanatory power, because the planning for 2017 activities was finished by the time the analysis was done for D1.2. The data for 2018 and 2019 was not completed, because some activities were still in development or not yet granted when the questioning for D1.2 was performed (June-December 2017). Also, 17 safety activities are planned to end in 2017 and therefore have no influence on the trend analysis for 2018. Nevertheless, the data from D1.2 provides an indicator for 2019.

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The figures in this section cover almost the same areas as the figures in 4.1.2, except for the SKYbrary subcategories. For the following analysis the total number of 50 activities in 2015, 55 activities in 2016, 38 activities in 2017, 56 activities for 2018 and 42 activities for 2019 were taken into account. For this analysis the percentages per year and categories were calculated to make the years comparable to each other and make a possible trend visible.

Figure 9 shows the percentage of every main category for the years from 2015 to 2019. As described above, it has to be kept in mind that “Fire, Smoke and Fumes” and “Weather” are two subclasses of “Operational issues”. The distribution of activities over the categories seems quite stable over the years. In terms of percentage values the category “Operational Issues” seems to gain importance whereas the category “Enhancing Safety” is facing a decline in activities over the last years.

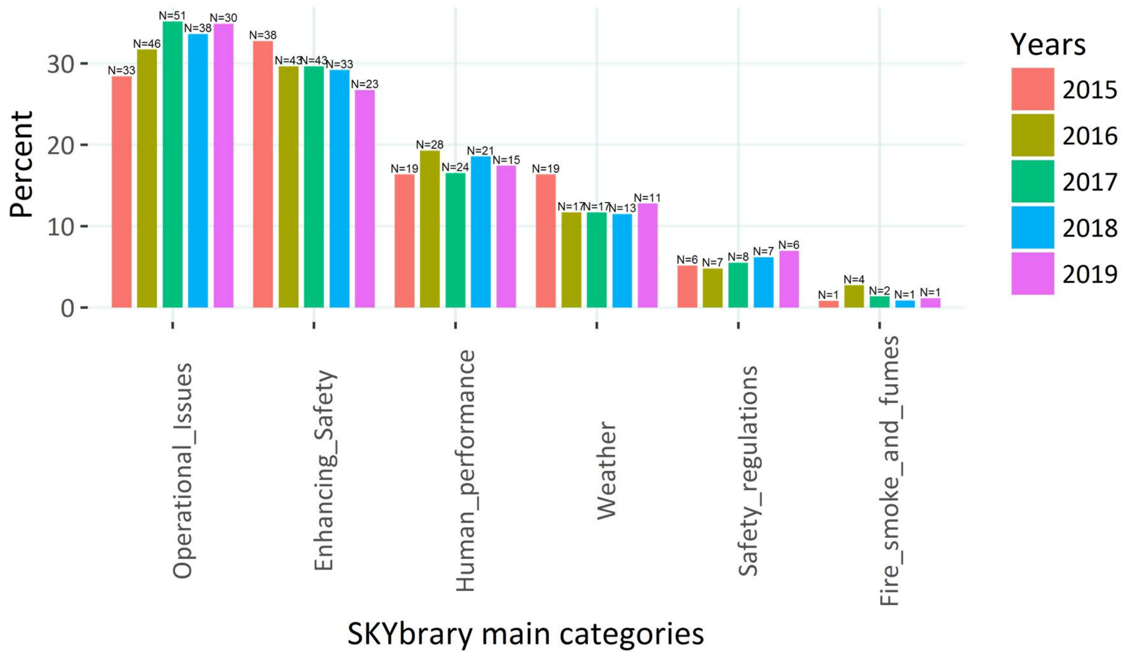

Figure 9: Trend analysis for main categories for all projects in the D1.2 survey

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Figure 10 shows the type of funding mechanism in percentage separated by years. No significant changes could be identified. The percentage of institutionally funded activities is quite stable over the years. The EU co funding of activities seems to increase over the years; however the absolute number of projects with EU co-funding is relatively stable from 2016 to 2019 (in fact facing a small decline in absolute numbers can be observed in the data).

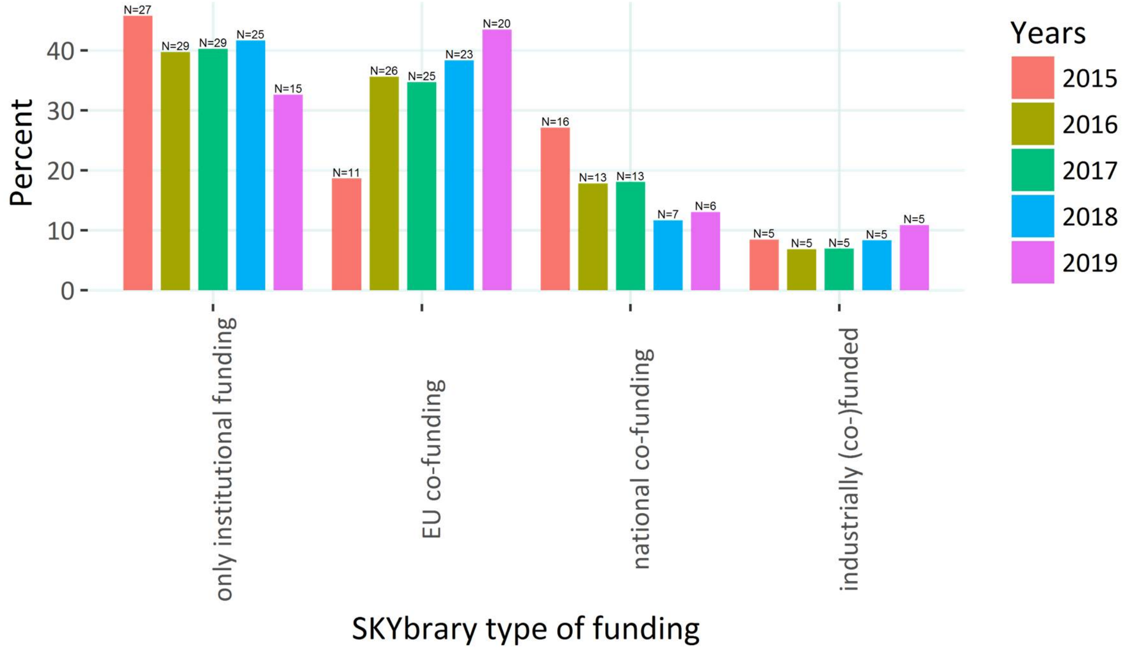

Figure 10: Trend analysis of the type of funding mechanism for all projects in the D1.2 survey.

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Figure 11 shows the type of consortium in percentage separated by years. No significant changes could be identified, but a trend for more international research consortia and a decline in stand-alone activities is indicated (which is exactly what Future Sky Safety P1 is aiming for). The absolute number of international industrial consortium activities is stable over the years.

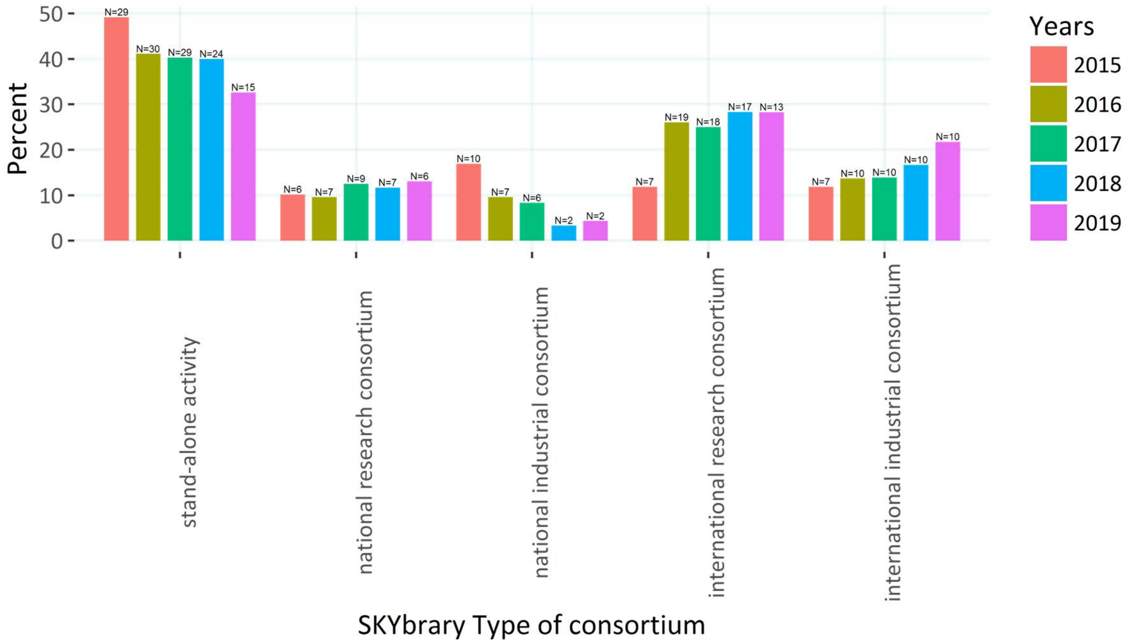

Figure 11: Trend analysis of the type of consortium for all projects in the D1.2 survey.

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Figure 12 shows the type of accessibility for the results in percentage separated by years. A decline in partly confidential activities is observable. Both activities with confidential and publicly accessible results are increasing. There is an observable trend that the emphasis amongst partners has shifted from passive sharing of information to active coordination efforts (if information is not confidential).

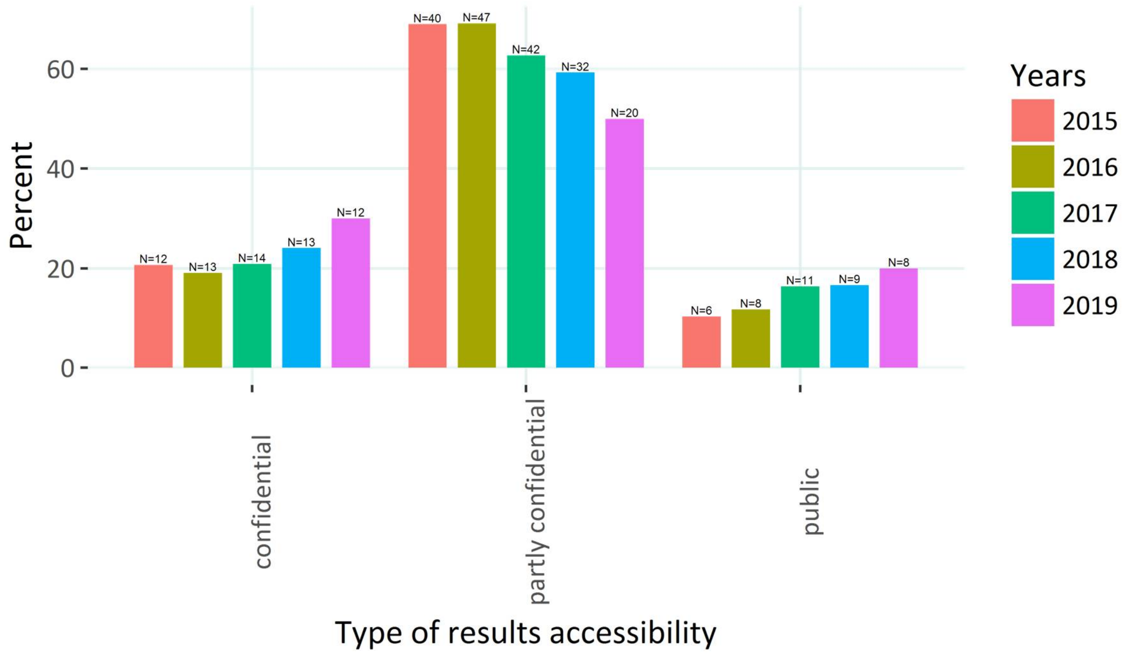

Figure 12: Trend analysis of the type of result accessibility for all projects in the D1.2 survey.

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Figure 13 shows the level of cooperation between the EREA partners in percentage separated by years. Two effects are observable: One the one hand the percentage of activities without exchange is increasing. However, this observation does not hold true if absolute numbers are taken into account. On the other hand, there is a slight indication that emphasis amongst EREA partners has shifted from passive sharing of information to active cooperation efforts. Although this can only be interpreted as a trend, this effect is reflecting the goals of Future Sky Safety P1.

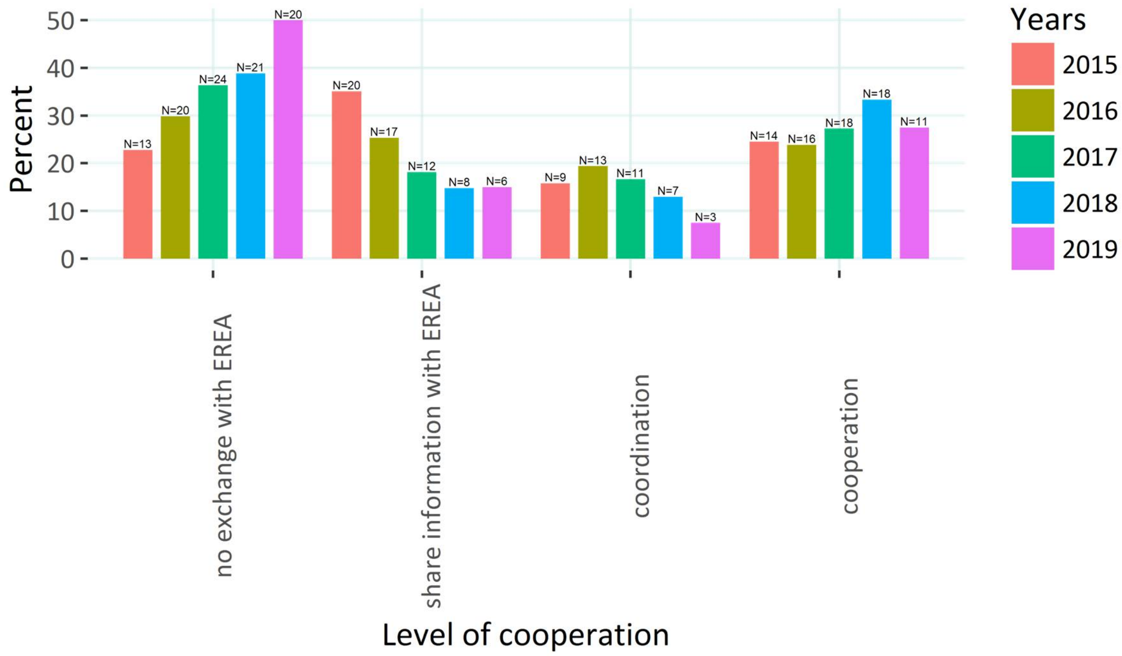

Figure 13: Trend analysis of the type of possible level of cooperation with EREA partners for all projects in the D1.2 survey.

4.1.4. Budget analysis

The budget analysis should provide an overview on the money and person months that were invested in safety activities. Because the activity periods varied between continuously (no fixed end date) and fixed time (e.g. projects with a duration of three years), the overall budget of each activity is not comparable, because the overall budget of continuous activities is not calculable. Therefore the budgets per year and month per year were analysed in this section. First we look at the year 2018 and then also include 2015, 2016; 2017 and 2019 to show a trend between these years.

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Figure 14 shows the budget as histogram over 57 activities collected for 2018. 34 activities have a budget that is less then € 800.000.

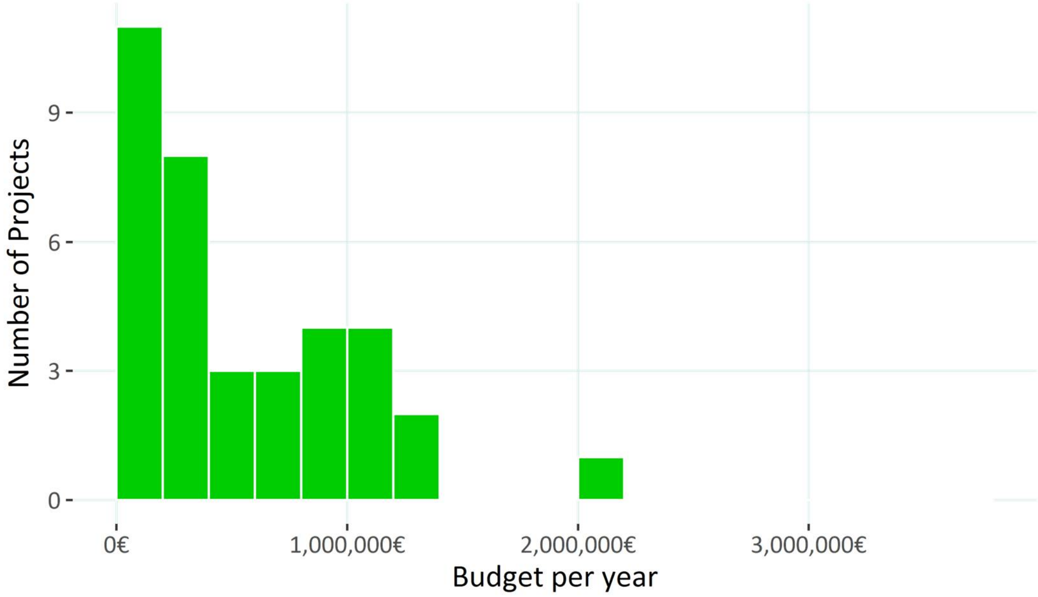

Figure 14: Budget histogram to approximate the amount of projects and the budgets available for 2018.

Figure 15 shows the person month as histogram over the same activities then Figure 14.

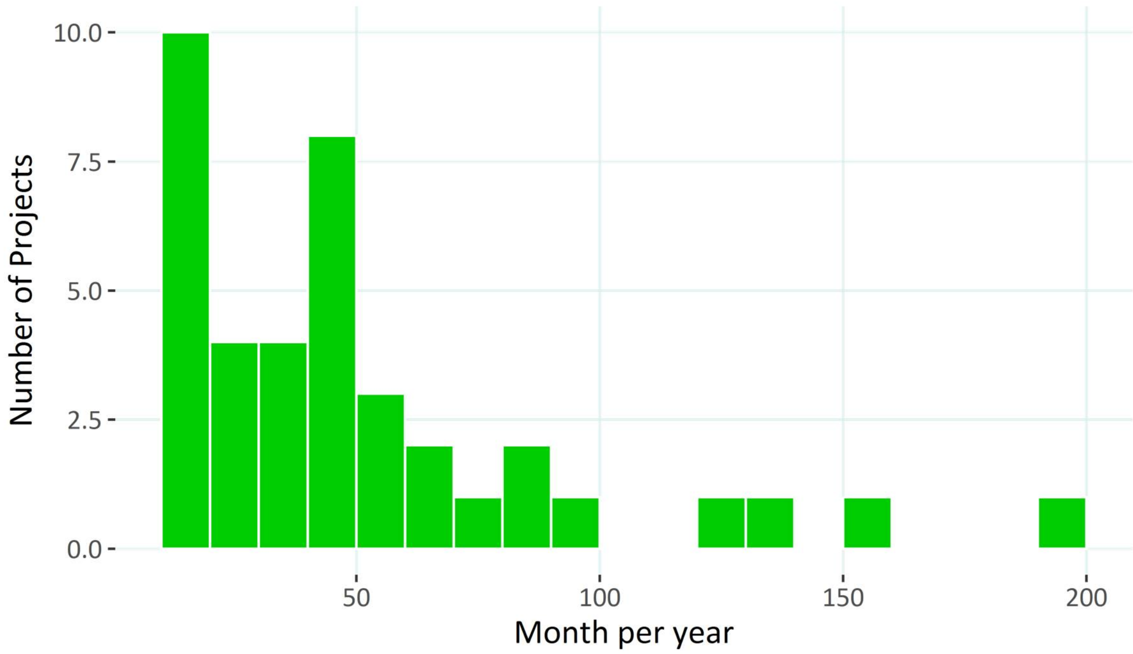

Figure 15: Person month to approximate the amount of projects and the person month available for 2018.

The trend analysis in Figure 16 has the same limitations as chapter 4.1.3. The total number of 50 activities in 2015, 55 activities in 2016, 38 activities in 2017, 56 activities for 2018 and 42 activities for 2019 were taken into account. As before, the results for 2019 can only be interpreted as approximation due to the time of the questioning. The red square in Figure 16 represents the mean value of each year. This shows that the mean value stays around € 580.000 per year (min: € 547.283 in 2017; max: € 623.534 in 2016).

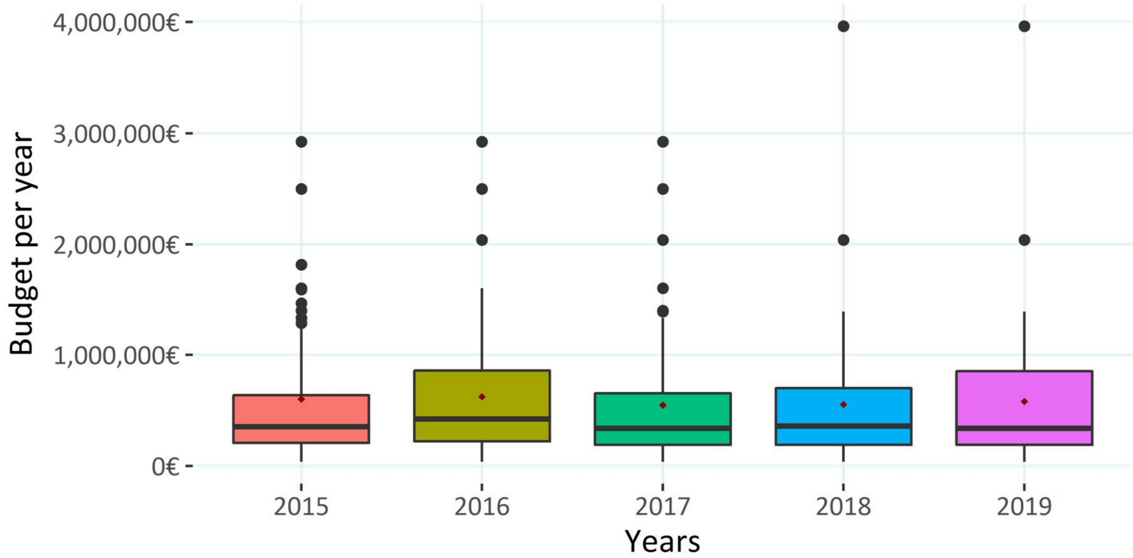

Figure 16: Trend analysis for the budget per year from 2015 to 2019.

4.2. Program Manager Survey

The Program Manager survey was conducted in the Q2/2017. The survey was completed by the programme managers from all FSS P1 partners (CEIIA, CIRA, CSEM, DLR, INCAS, INTA, NLR, ONERA, and VZLU).The survey contained questions concerning institutional funded research topics that might become of interest in the next couple of years. Three criteria have been considered: Importance for the research establishments, impact of the topic, and initiated or planned projects.

4.2.1. Importance of SKYbrary Categories for the Research Establishments

In order to gather information, the following question was asked: "Please rate the following SKYbrary subcategory concerning the expected interest in the following (3) years.". Figure 17 shows the 9 highest rated SKYbrary topics within the questionnaire. Even though their general interest is almost equally distributed, the standard deviation is relatively high. This indicates that some RE are very interested in the topic while others no interest at all.

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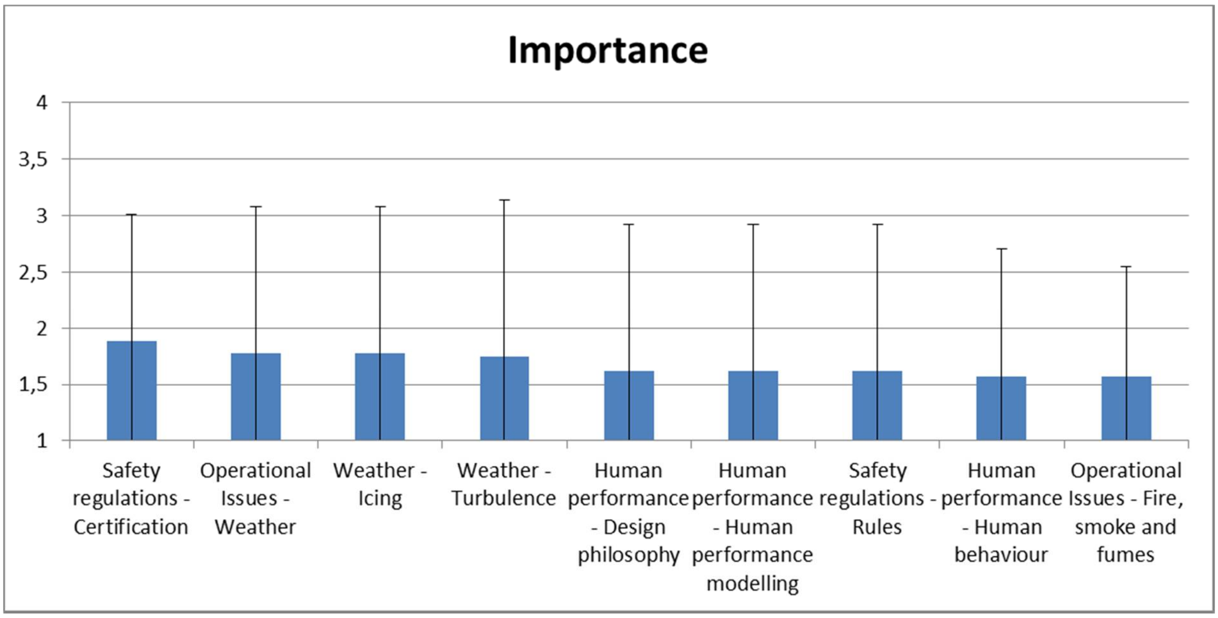

Figure 17: Rating of the importance of each SKYbrary category. (Scale from "Not at all interested"= 1 to "Extremely interested"=4)

4.2.2. Rank of the Categories

To gain insights in research priorities of each EREA partner, the programme managers were asked to rank the SKYbrary subcategories according to their priority. The exact question was: "Please select the 3 SKYbrary subcategory that have the greatest impact on your RE in the next 3 years.". Figure 18 shows the results by summarizing the ranking position (position 1 = 3 points; positions 2 = 2 points, and position 3 = 1 point) for each SKYbrary sub-category in respect to the amount of its selection.

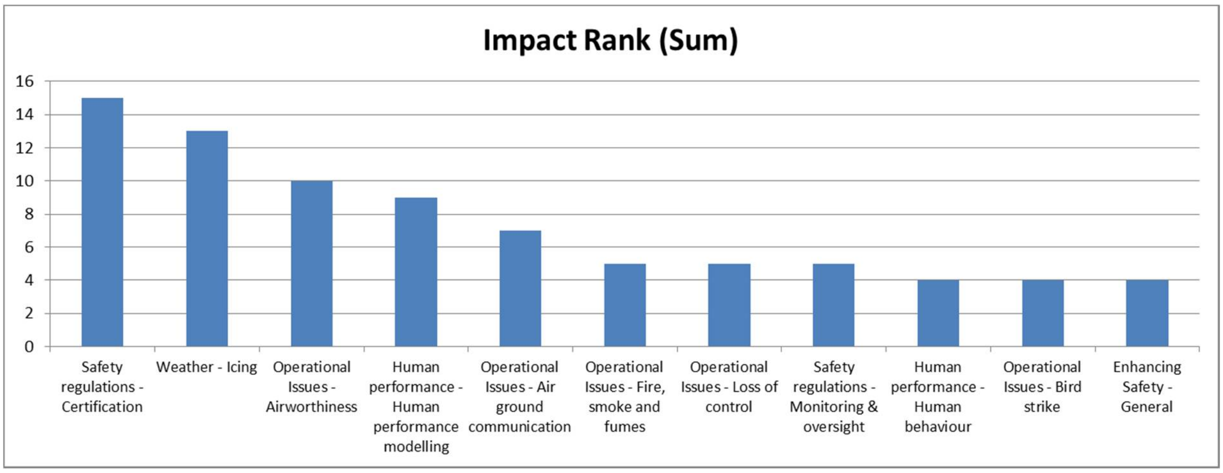

Figure 18: Ranking of the SKYbrary according to their importance for the EREA programme managers

As can be seen in Figure 18 the topics safety regulations – certification, weather – icing and operational issues – airworthiness had the highest priority among all EREA partners.

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4.2.3. Planned or initiated Projects

The third question to the programme managers was if safety research projects in the respective SKYbrary categories have already been planned or initiated in their research establishment.

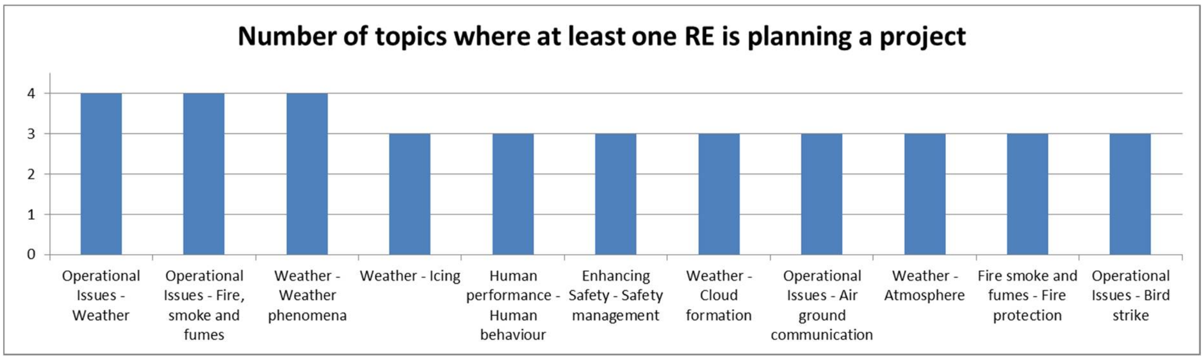

Figure 19: Number of EREA partners initiating or planning research projects in each SKYbrary category

Figure 19 shows that the EREA partners are quite active in planning safety projects in different safety-related domains. Especially topics related to operational issues and weather are often mentioned.

4.2.4. Conclusion

As a result of the aforementioned questions, topics scoring high in at least two criteria were derived. These topics are seen as a common denominator on which coordination and cooperation activities could be beneficial from a strategic point of view of the EREA partners:

- Weather – Icing
- Human performance – Human behaviour
- Operational Issues – Fire, smoke and fumes
- Safety regulations – Certification
- Operational Issues – Weather
- Human performance – Human performance modelling
- Operational Issues – Air ground communication
- Operational Issues – Bird strike
- Weather – Volcanic Ash

4.3. Summary

The analysis presented above is based on the results of the D1.2 and its annual updates. First the year 2018 was analysed in detail. Second a trend analysis of already planned and performed activities for 2015, 2016, 2017, 2018 and 2019 was performed. Third the budget was analyzed. Forth the Program Manager Survey was analyzed.

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The results for 2018 and 2019 show that EREA safety activities have a wide range and a lot of potential for cooperation. Summarizing the trend analysis, no major changes between the years were identified. This might depend on the continuity that some projects are influencing all selected years. However, the category "Operational Issues" seems to gain importance whereas the category "Enhancing Safety" is facing a decline in activities over the last years. Nevertheless, some trends (more coordination and cooperation; more international research consortia and less stand-alone activities) are supporting the interpretation that the coordination efforts of Future Sky Safety P1 are starting to have an impact on European Aeronautical Research Establishments. P1 is further trying to influence the trend by suggesting coordination and cooperation activities (see chapters 8 and 9). The results of the programme manager survey are an additional source of information, giving deeper insights into strategies of future safety research activities and priorities of each EREA partner. Common interest were identified which could serve as a starting point for coordination activities between EREA partners.

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5 PRIORITIES FROM FUTURE SKY SAFETY TECHNICAL PROJECTS

The Aviation Safety Research Plan is based on three main inputs: The annually updated list of ongoing or planned safety research activities that are institutionally funded by the participating Research Establishments (already described in chapter 4), the relevant European roadmaps (described in chapter 6) and the current status of the Future Sky Safety Technical Projects (this chapter).

In order to identify the priorities from FSS Technical Projects, all future sky project managers (P3 to P7) were ask to answer the following questions:

1. Do you have any ideas for coordination / cooperation activities or topics 2018 from your Project Management perspective? Could you give us your priority from FSS point of view?
2. Did you observe any missing links in safety research we should address in the future?
3. Do you know if RE in your project are working on the same safety topics and could intensify their collaboration with help of P1?
4. Do you know if there are REs in your project which would benefit from a closer cooperation on a certain safety topic, because the research complements each other?
5. Do you foresee long-term cooperation between RE beyond your FSS project duration to be beneficial?
6. Are there any cooperation regarding personnel exchange or PHDs? Do you have input for the ASRP on this topic?

Furthermore, it was explained to think about topics where EREA partners should work closer together to solve some of the challenges the project managers encountered in their project (P3 to P7). If there are any topics on which EREA partners should work more collaboratively in the future, than they should inform P1. Finally, the project managers where offered the opportunity to express one free wish regarding future safety research of EREA partners and were asked what this wish would be.

5.1. Results

The results section is structured according to the questions stated above. Feedback was received from the project managers of P3, P4, P7.

5.1.1. Ideas for coordination / cooperation activities or topics 2018

Besides some specific topics like “aircraft ground modelling and control” and “Icing”, “Lightning” and “Ditching” more general and strategic activities were suggested by the project managers. One advice was to cooperate on standardization topics (e.g. OBAQ, Fire, etc.). Furthermore, they suggested cooperating on topics planned for Future Sky Safety Phase 2, which have not been funded.

5.1.2. Missing links in safety research to be addressed in the future

For the time being, most of the project managers have not observed any missing links in safety research to be addressed in the future. One topic, which was suggested to be addressed, is "Wet runway braking performance of aircraft and certification guidelines".

5.1.3. RE working on the same safety topics and willing to intensify their collaboration

For the time being, no P1 assistance is needed to intensify collaboration between EREA partners, however it was highlighted by the respondents that ONERA and DLR are already working together on ditching, on composites HVI and on crashworthiness and that ONERA, DLR and CIRA are working on icing.

One obstacle, which might complicate intensified collaboration, was mentioned by one project manager. Despite observing overlaps in some activities, most REs tailor the activities to their own needs, making it different from each other and thereby difficult to combine. While this observation may be true, the work of FSS P1 is exactly to increased awareness and shared insight among the research institutes regarding the content and ambitions of the institutional RE programmes. Institutes are then potentially able to initiate new projects, combine programmes between institutes and to achieve coordination in the planning and conduct of new safety research projects

5.1.4. RE which would benefit from a closer cooperation on certain safety topics

The project managers indicated that composite crashworthiness would be a topic which could benefit from a closer cooperation between REs. However, specific REs have not been mentioned by the project managers.

5.1.5. Long-term cooperation between RE beyond FSS project duration

The project managers welcomed the idea of long-term cooperation, praising benefits like the efficient use of European (both from Europe and from the countries in Europe) public funds. During the duration of FSS projects, some project managers learned that partners had knowledge which the managers were not aware of in the beginning. Besides these general comments, specific, beneficial long-term cooperation beyond FSS project duration were suggested in terms of composite crashworthiness and aircraft ground modelling and control.

5.1.6. Cooperations with personnel exchange or PHDs

Personnel exchange is not foreseen at the moment for most technical projects of FSS. However, cooperation on PhDs would be a major and significant step forward and would be welcomed by all project managers. ONERA and DLR indicated to exchange personnel on the topic of ditching in 2017.

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5.1.7. A free wish regarding future safety research of EREA partners

According to one project manager, an interesting step would be to make available sets of safety data (occurrence reports, FDM-data etc.) that EREA can then use for research purposes.

5.2. Conclusions

For the time being, most of the project managers have not observed shortcomings where P1 could be of help regarding coordination or cooperation. However, it was suggested that formalizing the connections for instance with other EREA research teams involved in previous, running or future projects on related topics would be beneficial. Furthermore, collecting information (e.g. projects summaries) about possible future EU project proposals and distributing it specifically to the right partners was a suggestion. Derived from the comments of the project managers, further topics of interest and worthwhile to prioritize are aircraft ground modelling and control, icing, lightning, ditching, standardization topics, topics planned for Future Sky Safety Phase 2, wet runway braking performance of aircraft and certification guidelines, composites HVI and crashworthiness.

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6 REVIEW FROM EUROPEAN ROADMAPS FOR SAFETY RESEARCH: PRIORITIES FOR RESEARCH

For the 2017 update of the Future Sky Safety (FSS) Aviation Safety Research Plan (ASRP), a review of European Roadmaps for Safety Research is performed in accordance to the approach defined in this document. This exercise will obviously allow identifying research priorities.

At the RCT meeting #3 in Amsterdam several roadmaps were suggested (ACARE SRIA, EASA EPAS) and in addition the OPTICS Annual Assessment Report. Furthermore, also roadmaps and input documents related to Remotely Piloted Aircraft Systems are reviewed such as the ERSG Roadmap for the integration of civil RPAS into the European Aviation System.

6.1. Roadmaps

6.1.1. ACARE SRIA

The Advisory Council for Aviation Research and Innovation in Europe (ACARE) has provided Europe a vision for aviation called FlightPath 2050. ACARE developed the Strategic Research and Innovation Agenda (SRIA), a roadmap providing guidance on what is required to realize this vision, as well as when it is required, and how it can be delivered via Research and Innovation (R&I) activities. FlightPath 2050 recommends addressing five key challenges (ACARE, 2012b), one of which is considered relevant for the ASRP: Challenge 4 Ensuring safety and security.

The Flightpath 2050 goals for Challenge 4 are (ACARE, 2012a):

1. Overall, the European ATS has less than one accident per ten million commercial aircraft flights. For specific operations, such as search and rescue, the aim is to reduce the number of accidents by 80% compared to the year 2000 taking into account increasing traffic.
2. Weather and other hazards from the environment are precisely evaluated and risks are properly mitigated.
3. The European ATS operates seamlessly through interoperable and networked systems allowing manned and unmanned air vehicles to safely operate in the same airspace.
4. Efficient boarding and security measures allow seamless security for global travel, with minimum passenger and cargo impact. Passengers and cargo pass through security controls without intrusion and unnecessary intervention or disruption.
5. Air vehicles are resilient by design to current and predicted on-board and on-the-ground security threat evolution, internally and externally to the aircraft.
6. The ATS has a fully secured global high bandwidth data network, hardened and resilient by design to cyber-attacks.

To reach these goals, enablers (what is needed to achieve the goals) and capabilities (how the goal can be achieved) are defined (ACARE, 2012a):

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Cluster of Enablers	Enabler
Societal expectations	System wide safety management (safety) System wide security management (security) An intelligence-based approach (security)
Air vehicle operations and traffic management	Safety radar (safety) Security radar (security) Operational mission management systems and procedures (safety) System behavior monitoring and self-healing (safety)
Design, manufacturing and certification	Diagnostic analysis (safety) Efficient and effective standardization and certification (safety) Resilience (safety)
Human factors	Human-centred automation (safety) New crew/team concepts (safety) Passenger management (safety)

For all Enablers, Capabilities, R&I Needs and Achievements in 2020, 2035 and 2050 are described in detail in Volume 2 of the SRIA (ACARE, 2012c).

6.1.2. EASA EPAS (EASA, 2016)

The European Aviation Safety Agency (EASA), Member States (MS) and industry work closely together in the process of safety risk management (hazards identification, risks assessment and decision-making on the best course of action to mitigate those risks). At European level, this process is coordinated by EASA and documented in the European Plan for Aviation Safety (EASA, 2016). EPAS contains three categories of safety issues: systemic, operational and emerging. For each category some safety areas are identified, including an objective and actions for achieving the objective. These actions are divided in rulemaking tasks, safety promotion activities, focused oversight activities and researches/studies.

In the summary of the EPAS, several key safety actions are presented (EASA, 2016):

- (systemic) incorporate safety management principles in initial and continuing airworthiness;
- (systemic) work with Member States to implement the State Safety Programmes; and
- (systemic) work with competent authorities to ensure the availability of adequate personnel.
- (operational) for commercial air transport (CAT) by aeroplanes:
    - review and promote new pilot training provisions in order to address the prevention of and recovery from upset scenarios;

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   - identify measures to prevent loss of control during go-around or climb; and
   - introduce technology on board aircraft to mitigate the risk of runway excursions.
- (operational) for helicopter operations:
   - strengthen design requirements for helicopter gearbox lubrication;
   - improve off-shore helicopter safety in Europe; and
   - develop risk awareness and training material to further improve helicopter safety through safety promotion.
- (operational) for General Aviation (GA) operations:
   - work with competent authorities to address the risk of airspace infringement in GA; and
   - develop risk awareness and training material to further improve GA safety, including on the transportation of dangerous goods.
- (emerging) develop a road map to address cybersecurity threats in collaboration with the European Commission, Member States and industry;
- (emerging) create harmonised EU rules for remotely piloted aircraft systems (RPAS); and
- (emerging) evaluate whether the regulatory system adequately addresses safety risks arising from new and emerging business models.

Research tasks mentioned in EPAS are:

- (operational CAT ground safety) RES.001: Erroneous weight or centre of gravity

  Erroneous weight or centre of gravity have been identified as a potential safety issue leading to LOC-I accidents. The task is to perform a survey of approval processes for the use of the electronic flight bags (EFBs) with a focus on applications for performance calculations including weight and balance, and to identify best practices.
- (operational CAT fire, smoke, fumes) RES.002: Research study on toxicity

  Characterise the toxic effect of the chemical compounds from oil pyrolysis being released to the cabin or pilot compartment. The characterisation shall be performed for all compounds acting together and also taking into account the cabin/pilot compartment reduced pressure environment (typically limited to 8 000 ft equivalent altitude), and also the mode of exposure.
- (operational CAT) RES.003: Research study on cabin air quality

  Investigate the quality level of the air inside the cabin of large transport aeroplanes and its health implications (follow-up from initial studies launched by the Agency).
- (operational CAT) RES.004: Transport of lithium batteries by air

  Develop mitigating measures for the transport of lithium metal and lithium ion batteries on board an aircraft and determine the requirements/limitations to impose for such transport (e.g. quantity, packaging).

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- (operational CAT LOC-I) RES.005: Startle effect management

  Identify the main training requirements for mitigating the effect and impact on CAT pilots of surprise and startle during unexpected in-flight events (potentially leading to loss of control) and develop a series of associated training exercises and scenarios for execution using FSTDs.

6.1.3. OPTICS

OPTICS is a Coordination and Support Action of the European Commission, working in close co-operation with ACARE on the topic of safety. It provides a comprehensive evaluation of relevant safety research & innovation in aviation and air transport. The main objective of the project is assessing if Europe is performing the right safety research and if the research is delivering the expected benefits to society.

OPTICS uses the 10 SRIA Safety Enablers and Capabilities (see previous section) to be able to assess ongoing research and to identify where there are gaps. Moreover, OPTICS organizes expert workshops to identify top priorities in aviation safety research. Interesting and relevant intermediated results are provided in the OPTICS Handout (OPTICS, 2016). Some conclusions and recommendations are repeated here.

Gaps and bottlenecks in safety research

There are still clear gaps that overarch separate Enablers identified by the state-of-the-art assessment:

- All of the research that is assessed by OPTICS focuses on aviation. No research looks into aspects of multi-modal transport – a long term research direction that is included in the SRIA.
- Most research on equity of access to airspace focus on remotely piloted aircraft systems (RPAS). Other future aviation concept (e.g. personal aviation, commercial space flight) are taken into account far less.
- Research in the maintenance domain is under-addressed.
- There seems to be a gap between near-term research which is close to implementation (e.g. the projects performed under SESAR) and research projects that can be seen as 'thought experiments' that are unlikely to be implemented in the near or medium-near term.

Top priorities emerging from the first OPTICS workshop

1. Human Centred Automation. Automation is key for the success of FlightPath 2050, and if the Human Factors associated with how people will use this automation is not properly done, the intended performance benefits won't be seen.
2. Human Performance Envelope. A relatively new concept in Human Factors, it is nevertheless a place-holder for the detailed research on a range of Human Factors issues that are poignant in Aviation, including fatigue, workload and situation awareness. Better understanding of such factors' interactions, and better methods in these areas are still needed to achieve FlightPath 2050.
3. Human Factors in Design and Manufacturing. Integration is needed and progress must be made in the identification of a new systems engineering approach, considered as a crucial factor in improving safety across the industry.

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Top priorities emerging from the second OPTICS workshop

1. Develop a new CONOPS that accommodates the rapidity and scale of developments occurring with RPAS/UAS and their impending integration into airspace.
2. Develop real-time data analysis capability of human and system behaviour, and their interactions, in order to detect precursors to adverse events and initiate protective measures before safety margins are affected.
3. Demonstrate the safety benefits to aviation and air transportation through the application of resilience in complex socio-technical systems.
4. Increase the resilience of operation in adverse weather conditions by making possible shared understanding of weather hazards and cooperative building of weather awareness.
5. Derive a new and more agile Verification and Validation approach for RPAS/UAS, one that includes in-service validation.
6. Develop advanced models of shared situation awareness and collaborative and dynamic decision-making for fully-integrated RPAS/UAS systems.
7. Determine the success factors in automation and its development cycle that lead to human trust in automation.
8. Insights from data analysis should be fed back into design, but this is rarely done except in long time-frames. This has led to a gap between ‘systems-as-designed’ and ‘systems-as-used’. A new, fast-track system for feeding back operational data into design needs to be developed.
9. Develop affordable technologies to go beyond current flight limitations in adverse weather conditions.
10. Use the weather knowledge in the decision chain to optimise the interest of each aviation actor while ensuring safety and global fairness.

Four areas of improvement

1. Areas where research urgently need to advance (e.g. RPAS integration, identification of emergent vulnerabilities)
2. Areas where research is nearing industrialisation, and needs to be brought to operational readiness (e.g. some areas of Human Centred Automation)
3. Areas where consolidation is needed to bring all elements up to the same level of maturity (e.g. research on safety impact of all types of adverse weather conditions)
4. Areas where research needs to begin (e.g. advanced crew concepts; search and rescue; passenger management)

6.1.4. RPAS related research

RPAS Steering Group Roadmap

The European RPAS Steering Group (ERSG) is a group of stakeholders gathering the main organisations and experts interested in the integration of RPAS into the European aviation system. The Group established a roadmap for the safe integration of civil RPAS into the European aviation system, aiming at an initial RPAS integration by 2016. The Roadmap is expected to facilitate the decisions to be taken by the different organisations involved, provide transparency and efficiency in the planning of different initiatives and support the coordination of the related activities in Europe (ERSG, 2013). The Roadmap

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includes a Regulatory Approach, a Strategic Research Plan and a Study on the Societal Impact. Here, some issues of the Strategic Research Plan (ERSG, 2013) are repeated.

To meet operational requirements key technology gaps are identified:

- EC 1 Development of a methodology for the justification and validation of RPAS safety objective:
  - Gap EC 1.1 - Short-term validation: current ATM;
  - Gap EC 1.2 - Long-term validation methodology: future ATM environment, liaison with SESAR, integration into SES and SWIM.
- EC 2 Secure command & control / data links / bandwidth allocation:
  - Gap EC 2.1 - Secure C2 systems and links;
  - Gap EC 2.2 - Infrastructures associated with RLOS and BRLOS, including SATCOM;
  - Gap EC 2.3 - Radio bandwidth management.
- EC 3 Insertion of RPAS into the air traffic management system, detect & avoid (air and ground) and situational awareness (including for small RPAS), weather awareness:
  - Gap EC 3.1 - ATM interfaces in current context (Classes A-C);
  - Gap EC 3.2 - ATM interfaces in SESAR context;
  - Gap EC 3.3 - Airborne Based Detect and Avoid;
  - Gap EC 3.4 - Ground Based Detect & Avoid and other emerging technologies;
  - Gap EC 3.5 - Ground station HMI;
  - Gap EC 3.6 - Ground and Obstacle Avoidance;
  - Gap EC 3.7 - Weather detection and protection;
  - Gap EC 3.8 - Detectability solutions;
  - Gap EC 3.9 - Observer & pilot roles and responsibilities (E-VLOS);
  - Gap EC 3.10 - Other hazards including protection against wake vortices.
- EC 4 Security issues attached to the use of RPAS:
  - Gap EC 4.1 - RPAS system security threats and potential mitigations
  - Gap EC 4.2 - RPAS operations overview.
- EC 5 Safe automated monitoring, support to decision making and predictability of behaviour:
  - Gap EC 5.1 - Safe and standard recovery procedures for contingencies and emergencies;
  - Gap EC 5.2 - Safe automated health monitoring & Fault detection;
  - Gap EC 5.3 - On-board real-time smart processing.
- EC 6 Automated take-off and landing and surface operations:
  - Gap EC 6.1 - Automatic Take-off and landing, Auto-Taxiing and automated aerodrome Operations.

These technological gaps are bridged by various R&D efforts, grouped into 14 activities. These activities are described in the Strategic R&D Plan (ERSG, 2013) in detail. The 14 activities are:

- Activity #1: 2013 – Extended Visual Line Of Sight (EVLOS)/VLOS – RPAS activities awareness for security
- Activity #2: 2013-2015 – EVLOS/VLOS – Operations in urban areas
- Activity #3: 2013-2015 – EVLOS – Human Factors
- Activity #4: 2013-2014 – IFR/VFR – Visual detectability solutions
- Activity #5: 2013-2018 – IFR/VFR – D&A
- Activity #6: 2013-2018 – Beyond Visual Line of Sight (BVLOS) – D&A

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- Activity #7: 2013-2018 – IFR/VFR – Comms C2 data link
- Activity #8: 2014-2018 – BVLOS – Comms C2 data link
- Activity #9: 2013-2016 – IFR/VFR – Airspace Access and Airport Operations
- Activity #10: 2013-2016 – BVLOS – Airspace Access and Airport Operations
- Activity #11: 2014-2018 – IFR/VFR – Contingency
- Activity #12: 2014-2019 – IFR/VFR and BVLOS – Human Factors
- Activity #13: 2013-2018 – Security
- Activity #14: 2013-2016 – Demonstrations of best practices

EASA Technical Opinion on the introduction of a regulatory framework for the operation of unmanned aircraft

The Technical Opinion (EASA, 2015b) is the result of the consultation performed with Advance Notice of Proposed Amendment (A-NPA) 2015-10. It includes 27 concrete proposals for a regulatory framework and for low-risk operations of all unmanned aircraft irrespective of their maximum certified take-off mass. This regulatory framework is operation centric, proportionate, risk- and performance-based, and establishes three categories: 'Open' category (low risk), 'Specific' category (medium risk) and 'Certified' category (higher risk).

Section 4.4 of this Technical Opinion describes that EASA is contributing to the research activities of the European Defence Agency (EDA), the European Space Agency (ESA) and the SESAR Joint Undertaking (SJU). Beyond these activities, the Agency has identified the following ones:

- Proposal for acceptable levels of safety especially for the operation of small unmanned aircraft in urban areas, above crowds and for low-level operations beyond VLOS;
- Development of a tool for registration, identification and (geo)fencing of certain small unmanned aircraft operations;
- Identification of options for the environmental regulation of small unmanned aircraft;
- Definition of a concept for traffic management of all types of unmanned aircraft operations including low-level airspace design, traffic rule, security of landing zones, the role of the human, interception rules and techniques, and devices for electronic conspicuity and autonomous operations.
- Electric propulsion (not only an issue for unmanned aircraft, but still small unmanned aircraft are making extensive use of electric propulsion).

For other relevant documents is referred to (EASA, 2015c) and (EASA, 2015a).

6.2. Relation with other FSS projects

As presented on the Future Sky Safety website (EREA, 2016), institutionally funded projects and the coordination of the institutional programs, both among the research establishments and with Technical Projects are integral parts of a single roadmap, see the following Figure 20.

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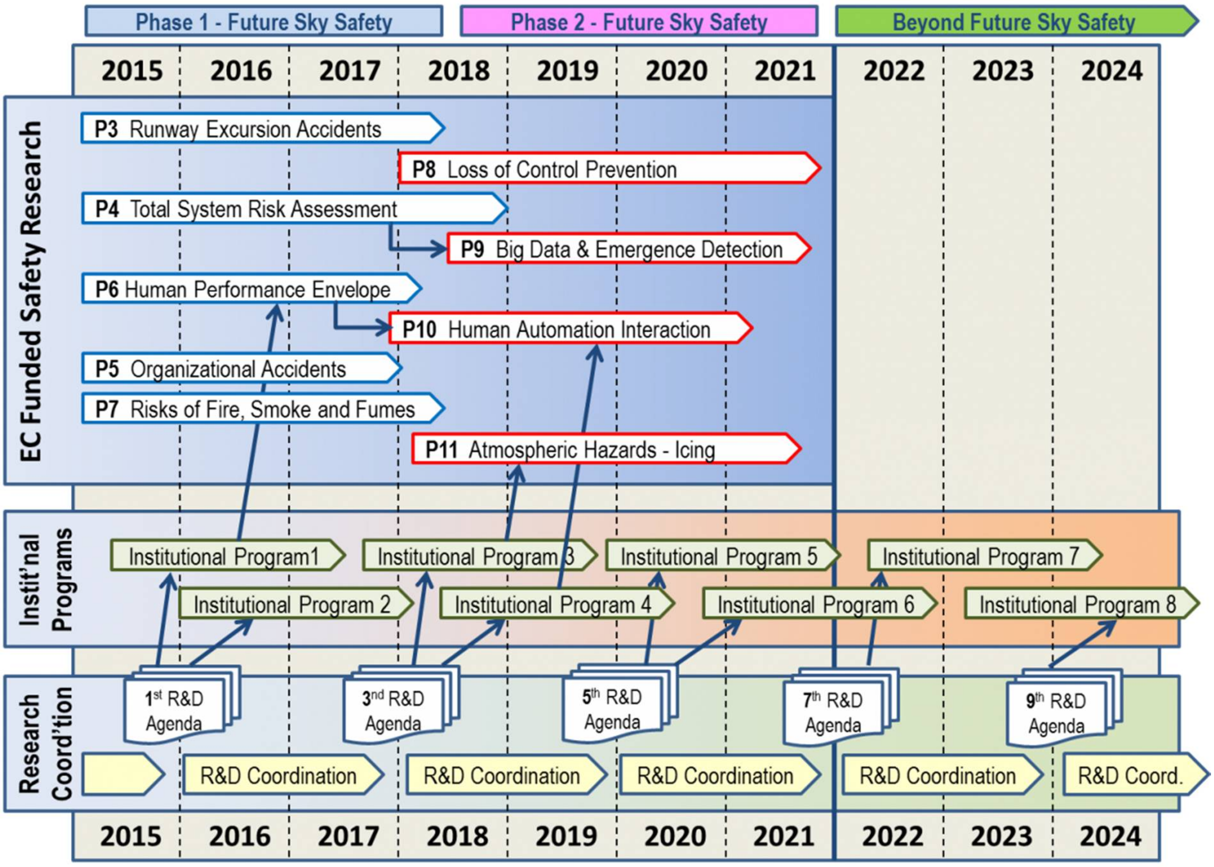

Figure 20: Institutional funded research (EREA, 2016).

It is recommended that the institutionally funded research should be aligned with the activities in the technical projects in FSS. They can be positioned to complement or support the work in the technical projects.

6.3. Mapping of Roadmaps

In the following table a high level mapping of the SKYbrary main and subcategories and the number of associated EREA safety projects on roadmap topics like the ACARE SRIA Enablers are presented (an additional mapping of OPTICS, EASA EPAS and SRG RPAS roadmap topics on the ACARE SRIA Enablers is presented in the Annex). The mapping in the table below should illustrate which safety research is supported by each roadmap on a meta-level. It is noted that due to the high level approach adopted here, details of the individual research topics (e.g. capabilities, subcategories) are lost and the suggested 1-1 mappings are sometimes a little bit forced. To provide a thorough mapping, the details of the roadmaps should be studied, which is beyond the scope of the mapping task.

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Table 5 shows that many SKYbrary categories are covered by EREA research projects and there is generally a good overlap between the roadmap topics and the safety projects. In fact, EREA research covers a broad variety of topics. Rows which are coloured yellow indicate a mismatch between roadmap topics and EREA safety research as gathered through D1.2. The topics in yellow rows therefore suggest areas of improvement and possible research subjects for EREA safety projects.

SKYbrary Main category	SKYbrary Subcategory	Number of EREA projects	ACARE SRIA Enabler	Optics[2]	EASA EPAS	SRG RPAS[3]	Potential topic due to Survey program manager (4.2)
Operational_Issues	Air ground communication	3					YES
	Airspace infringement						YES
	Bird strike	2					
	Controlled flight into terrain						
	Fire, smoke and fumes						YES

[2] Optics is not necessarily a roadmap but provides top priorities emerging from the workshops, and gaps in research. These are mentioned in the table.
[3] SRG RPAS only considers RPAS related research. In the table, the enablers are identified that address RPAS/UAS related topics.

SKYbrary Main category	SKYbrary Subcategory	Number of EREA projects	ACARE SRIA Enabler	Optics[2]	EASA EPAS	SRG RPAS[3]	Potential topic due to Survey program manager (4.2)
	Ground operations	4					
	Airworthiness	10					
	Level bust						
	Loss of control	4			Prevent LOC during go-around or climb Off-shore helicopter safety		
	Loss of separation	6					
	Runway excursion	1			Technology to mitigate the risk of runway excursions		

SKYbrary Main category	SKYbrary Subcategory	Number of EREA projects	ACARE SRIA Enabler	Optics[2]	EASA EPAS	SRG RPAS[3]	Potential topic due to Survey program manager (4.2)
	Runway incursion						
	Wake vortex turbulence	2					
	Weather	4	Safety radar	Weather knowledge in decision chain Flight limitations in adverse weather conditions			YES
	Emergency and contingency	2					
Human_performance	Human behaviour	6	Passenger management	Human trust in automation			YES
	Design philosophy	6	Human-centred automation	Human centred automation			

SKYbrary Main category	SKYbrary Subcategory	Number of EREA projects	ACARE SRIA Enabler	Optics[2]	EASA EPAS	SRG RPAS[3]	Potential topic due to Survey program manager (4.2)
				Human factors in design and manufacturing			
	Human performance modelling	1					YES
	Organisation and human performance	5		Human performance envelope			
	Human factors training	3	New crew/team concepts				
	Aeromedical						
Enhancing_Safety	Cabin safety	2			Cabin air quality		
	Flight technical	12			Safety promotion helicopters		

SKYbrary Main category	SKYbrary Subcategory	Number of EREA projects	ACARE SRIA Enabler	Optics[2]	EASA EPAS	SRG RPAS[3]	Potential topic due to Survey program manager (4.2)
					Helicopter design requirements		
	Safety management	**12**	System wide safety management Diagnostic analysis	Feedback of data analysis into design	SMS in airworthiness		
	Safety nets	**2**	System behavior monitoring and self-healing	Real-time data analysis capability			
	Safety culture				SMS of Member State (SSP)		
	Just culture						
	General	**5**	System wide security management	Multi-modal transport research			

SKYbrary Main category	SKYbrary Subcategory	Number of EREA projects	ACARE SRIA Enabler	Optics[2]	EASA EPAS	SRG RPAS[3]	Potential topic due to Survey program manager (4.2)
			Operational mission management systems and procedures Resilience: ATS robust by design. Coordinated forums, including with other transport modes.	Resilience in Socio-technical systems			
Safety_regulations	Rules	1		Integration of RPAS/UAS into airspace Equity of RPAS/UAS access to airspace ✓ ConOps development		Framework ensuring equity in access to airspace by all air vehicles. Safe access and integration of	

SKYbrary Main category	SKYbrary Subcategory	Number of EREA projects	ACARE SRIA Enabler	Optics[2]	EASA EPAS	SRG RPAS[3]	Potential topic due to Survey program manager (4.2)
				Models for dynamic decision making		RPAS/UAV within airspace and airports	
	Certification	4	Efficient and effective standardization and certification	Validation/verification approach for RPAS/UAS	Harmonized EU rules for RPAS	Certification requirements for RPAS/UAV	YES
	Personnel licensing						
	Monitoring & oversight	1			Oversight by competent authorities		
	Human error and legal process				Safety risks arising from business models		
Weather	Icing	7	Safety radar		Icing		YES
	Turbulence	1	Safety radar				

SKYbrary Main category	SKYbrary Subcategory	Number of EREA projects	ACARE SRIA Enabler	Optics[2]	EASA EPAS	SRG RPAS[3]	Potential topic due to Survey program manager (4.2)
	Volcanic Ash		Safety radar				YES
	Weather Risk Management	1	Safety radar	Weather related resilience			
	Weather phenomena	2	Safety radar				
	Cloud formation		Safety radar				
	Climatic phenomena		Safety radar				
	Atmosphere	1	Safety radar				
Fire_smoke_and_fumes	Operational fires						
	Post crash fires						
	Combustion-related smoke	1					
	Non-combustion related fumes						

SKYbrary Main category	SKYbrary Subcategory	Number of EREA projects	ACARE SRIA Enabler	Optics[2]	EASA EPAS	SRG RPAS[3]	Potential topic due to Survey program manager (4.2)
	Fire protection						

Table 5: Mapping of EREA research projects to European roadmaps (yellow rows are indicating a mismatch and therefore areas for improvement)

6.4. Summary

This chapter presents a brief overview of several European roadmaps stating goals and activities for aviation research. The objective is to use the Aviation Safety Research Plan of Future Sky Safety P1 as information, recommendation and guideline to enable coordination of institutional aviation safety research. This coordination is important to avoid overlap in European research and to intensify work on identified research gaps. Details of the various roadmaps are provided in the related references.

An important and good reference for the identification of research activities is the SRIA roadmap which focuses on achieving the FlightPath 2050 goals and enablers to reach these goals. The other roadmaps can be mapped on the SRIA roadmap. For a specific topic as RPAS it is suggested to account for the specific roadmap as provided by the RPAS steering group.

In Table 5 a mapping of EREA research projects to the above described European roadmaps was done, indicating mismatches and therefore areas for improvement.

Before new safety research is defined it is suggested to study the valuable work that is performed by the OPTICS Coordination and Support Action of the European Commission. OPTICS assesses gaps and bottlenecks in European research with respect to the FlightPath 2050 enablers and by identifying additional top research priorities. Especially the third release of the state-of-the-art in safety research of OPTICS (2016), which addresses the national projects provides relevant information for the FSS's coordination of institutionally funded safety research, provides relevant information for the FSS's coordination of institutionally funded safety research and is considered in this ASRP, in conjunction with our own analysis as summarized in the tables above.

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7 CRITERIA FOR SELECTION OF TOPICS

In the following table, seven criteria are listed which can be used to identify and select new topics for cooperation. These criteria should be kept in mind in the selection procedure.

ID	Criteria
CRI-ASRP-1001	The topic has to be important for more than one EREA partner.
CRI-ASRP-1002	Gaps identified in European roadmaps should be addressed
CRI-ASRP-1003	Closer alignment of EREA research with roadmaps
CRI-ASRP-1004	Leverage effect
CRI-ASRP-1005	Establishment of new cooperation
CRI-ASRP-1006	Easy to implement
CRI-ASRP-1007	Potential for long term cooperation
CRI-ASRP-1008	No overlaps
CRI-ASRP-1009	Complementarity (all research needs are addressed)

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8 PLANNED COOPERATIONS FOR 2018

The selection procedure for cooperation and coordination in the ASRP 2018 did follow the originally planned procedure. During the development of the ASRP 2016 and ASRP 2017, the involved EREA members agreed on which activities were considered mature enough to start cooperation projects in 2016 respectively 2017. These activities have already been described in chapter 3. Activities which were not mature enough yet to directly start in 2016 or 2017, but of high interest to the involved parties, were picked as topics for the Second Future Sky Safety P1 Coordination Workshop which was carried out on 1.-2. February 2017 in Palaiseau (France). During this workshop with 25 participants, discussions on possible cooperation between EREA research establishments were focused on three selected topics: health monitoring, RPAS (as continuation of 2016 activities) and volcanic ash. For each of these topics, dedicated sessions allowed participants to identify activities of common interest. The topics were discussed in-depth during the workshop to develop them further into cooperation topics for activities to start in 2018. To discuss these topics already in early 2017 was one of the lessons learned from the review of the original ASRP selection procedure and D1.1 (Ruttke et al., 2016a), as most research establishments need at least one year in advance to make their institutional funding available for cooperative research.

This chapter provides an overview of the activities that have been discussed and are planned for the year 2018, based on the outcomes of this FSS P1 Coordination Workshop. A detailed description of the workshop results can be found in the dedicated workshop report of FSS P1 WP1.2 (D1.7, Novelli, 2017) from which the next sub-chapters are also taken.

8.1. Health Monitoring

Ten experts from eight EREA establishments (CEIIA, CIRA, CSEM, DLR, INCAS, NLR, ONERA and VZLU) participated to the session on health monitoring.

The presentations of all the participants proved to be quite rich and evidenced how broad the health monitoring question can be. In particular, multiple dimensions emerged both regarding the objectives pursued by health monitoring and regarding the levels at which it may be implemented.

Broadly speaking, health monitoring covers all the technics aiming at monitoring and evaluating the actual state of systems or subsystems through a network of sensors, non-destructive diagnostics and/or behaviour analysis to detect deviation, default, performance degradations or failures. Different purposes can be pursued through such monitoring:

- Design optimization purpose by allowing to reduce conservatism in the design thanks to a continuous and optimized monitoring of the system;

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- Maintenance purposes, including anticipation of required maintenance operation at aircraft stop, maintenance planning or condition based maintenance (CBM) for which prognosis may be envisaged beyond diagnostics;
- Remaining useful life estimates;
- Real time actions, either to limit the evolution of the damages or to avoid the appearance of a critical situation (e.g. flight domain limitation), or to recover from a failure by system reconfiguration or fault tolerant control.

The different possible levels of implementation include:

- Structural components (Structural Health Monitoring, SHM);
- Vehicle's subsystems and subsystems' components such as actuators, ball-bearings, electronic systems, avionics, etc.;
- Aircraft as a whole.

The associated approaches may rely mostly on dedicated sensors implementation (e.g. grid of piezoelectric on a structural panel) or the use of existing captors, or be mixed with model-based analysis (e.g. identification techniques).

Health monitoring tends to be understood as on-board continuous or real time monitoring. Furthermore, health monitoring may be regarded as a complementary layer next to the conventional non-destructive diagnostics for ground checking and even manufacturing control or certification demonstration. For application such as prognosis or remaining useful lifetime assessment, load monitoring enters the scope of health monitoring in addition to default detection.

There are also general questions about the operational and system aspects of health monitoring deployment, among others:

- What does the deployment of SHM on an aircraft implies at system level? Is it feasible and acceptable (although preliminary experiences with military aircraft already exist)?
- What about certification constraints?
- How does CBM fit with exploitation constraints of aircraft fleets by airlines?

8.2. Volcanic Ash

Four experts from four EREA establishments (CIRA, DLR, INCAS and ONERA) participated to the session and presented their on-going research and fields of interests.

Beyond these activities, the discussions aimed at identifying the various research fields and needs involved in the volcanic ashes issue for aviation. They resulted in a list of seven topics.

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1) Measurements technics for volcanic ashes in the atmosphere.

   Past experience evidenced significant confusion generated by the various measurements performed during crisis situation because of the use of different technics which were not inter-calibrated. There is a need for a harmonised and well calibrated set of measures that could be used in situation of crisis. This requires inventorying available aircrafts and instruments for measuring volcanic ash and SO_2, and defining ways for a co-use/cross-use of available platforms with standard outputs.

2) Data acquisition in situation of crisis

   A need exists for a network of measurements that could be deployed in situation of crisis to characterise ashes dispersion over Europe. This could be for example the use of a grid of balloons (preferably also used for other applications) embarking a standardised sensor package that would need to be developed.

3) Integrated observation systems

   Space observation and ground based observations and measurements should be integrated with airborne ones in order to get a complete characterization of volcanic ash clouds.

4) Impact of volcanic ashes on thermal coating of engines' turbines

   To characterise the impacts of volcanic ashes on engines, there is a need to perform cross-tests between research establishments using natural volcanic ashes and artificial volcanic ashes. In such tests, the volcanic ashes should be heat-treated in order to simulate their evolution through the engine, particularly through the combustion chamber. The development of new compositions of thermal barrier coating, resistant to volcanic ash corrosion is the primary goal of these tests. High temperature erosion testing is also of interest.

5) Volcanic ashes' flow modelling in engines

   An important research axis for the understanding of the consequences of volcanic ashes on engines is the modelling of their flow and evolution through the engine. In particular, this should aim at modelling the physical state of ashes at impact location and the accretion on engine's parts taking into account erosion, as well as erosion material impact. In this field, modelling activities could build on the research carried out for icing.

6) ATM issues in situation of crisis

   Based on previous experiences, a challenge is to be able to not close the entire air space and to manage properly the re-opening.

7) Impacts on air quality

   The issue is related to cabin air quality when aircraft fly in volcanic ashes clouds and to the development of sensors inside the cabin.

The groups elaborated a preliminary table collecting the potential interest of the different partners for each of these topics. This table will be circulated more largely within the research establishments for

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consolidation. On this basis, the idea is to select one or two topics that could be selected to develop cooperation and to identify potential leaders. Meanwhile, more information will be collected regarding the project that is currently starting under H2020, in order to ensure the global consistency of EREA decisions with on-going activities.

8.3. Remotely Piloted Aircraft Systems (RPAS) safety (excl. ATM)

See chapter 3.8.

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9 SUGGESTED SUBJECTS OF COOPERATION FOR 2019

This overview should inspire all EREA partners to use the opportunities provided by P1. This chapter provides a detailed summary for the new, suggested subjects of cooperation with the focus on a description including objectives, current and next steps. Even if the goal is to foster cooperation projects, the reader should keep in mind that there are different forms of coordination and cooperation. Possible activities include: Projects, Coordination, PhDs, Personnel exchange, Workshops,… .

Input from each EREA RE was gathered either via e-mail, workshop participation, telephone conferences and the EREA Programme Manager Survey described in chapter 1.1. This input was the basis to to fill the following table in order to gain an overview over the interests of each RE. The results will be summarized and used to organize future workshops and coordinate the research in a mix of top-down approach derived through the review of European Roadmaps (see chapter 6.1) and the mapping of these roadmaps (see chapter 6.3) and the bottom-up approach coming from Future Sky Safety Technical Projects demands (see chapter 5) and the strategies, needs and ambitions from EREA Programme Managers (see chapter 1.1).

Topic	NLR	DLR	ONERA	CEIIA	CIRA	CSEM	INCAS	INTA	VZLU*
Small autonomous electric AC	**H**	**H**	**H**	**H**	**H**				-
Advanced flight envelope protection		**H**	**H**		**H**				-
Human Performance envelope		**H**	**H**		**H**				-
Mitigating the risk of fire, smoke and fumes:		**H**	**H**						-
RPAS	**H**	**H**	**H**	**H**	**H**		**H**	**H**	-

* **Note that VZLU recently announced that they cannot pursue new activities on safety**

Table 6: New Topics for cooperation and interested partners for cooperation activities (filled from EREA Research Establishments; H=high interest, M=medium interest, low=low interest); empty cells denotes missing information from EREA Research Establishments

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Based on the results of Table 6, the third and last coordination workshop of Future Sky Safety P1 was planned. The topics where most Research Establishments are interested in have been chosen. Accordingly, three sessions for the workshop are suggested:

- Safety and certification of small autonomous aircraft (CEIIA, CIRA, DLR, NLR and ONERA are interested)
- Flight envelope protection (CIRA, DLR and ONERA are interested)
- Human factors (CIRA, DLR and ONERA are interested)

In addition, it is suggested to make a follow-on session on RPAS, which was also part of the first and second coordination workshops.

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10 CONCLUSIONS

The main objectives of the EREA Aviation Safety Research Plans (ASRPs) are threefold:

- To define an EREA Safety Roadmap and thus identify new institutionally funded safety research topics within the EREA partners.
- To support to Collaborative Research Future Sky Safety Projects for identifying missing links in their safety research.
- To coordinate the EREA safety roadmap with other relevant European Safety Research Roadmaps and to fill the gaps, avoiding future duplications of efforts and resources and putting current initiatives on a common more robust path.

Figure 21, also given below, shows the coordination topics of EREA Safety R&TD activities for the past and upcoming years. In 2015 the project started with initial coordination activities for 2016. The projects in 2016 were mostly bilateral cooperation between EREA partners. As presented in Figure 21, the cooperation's for 2017 involved more partners. The growing interest in P1 will lead to a broader perspective on safety and more cooperation's on a variety of different topics in 2018 and 2019 (compare the recommendations in section 9). The topics where most Research Establishments are interested in and which are considered promising for cooperation activities for the upcoming years are:

- Safety and certification of small autonomous aircraft (CEIIA, CIRA, DLR, NLR and ONERA are interested)
- Flight envelope protection (CIRA, DLR and ONERA are interested)
- Human factors (CIRA, DLR and ONERA are interested)

In addition, it is suggested to make a follow-on session on RPAS, which was already part of the first and second coordination workshop.

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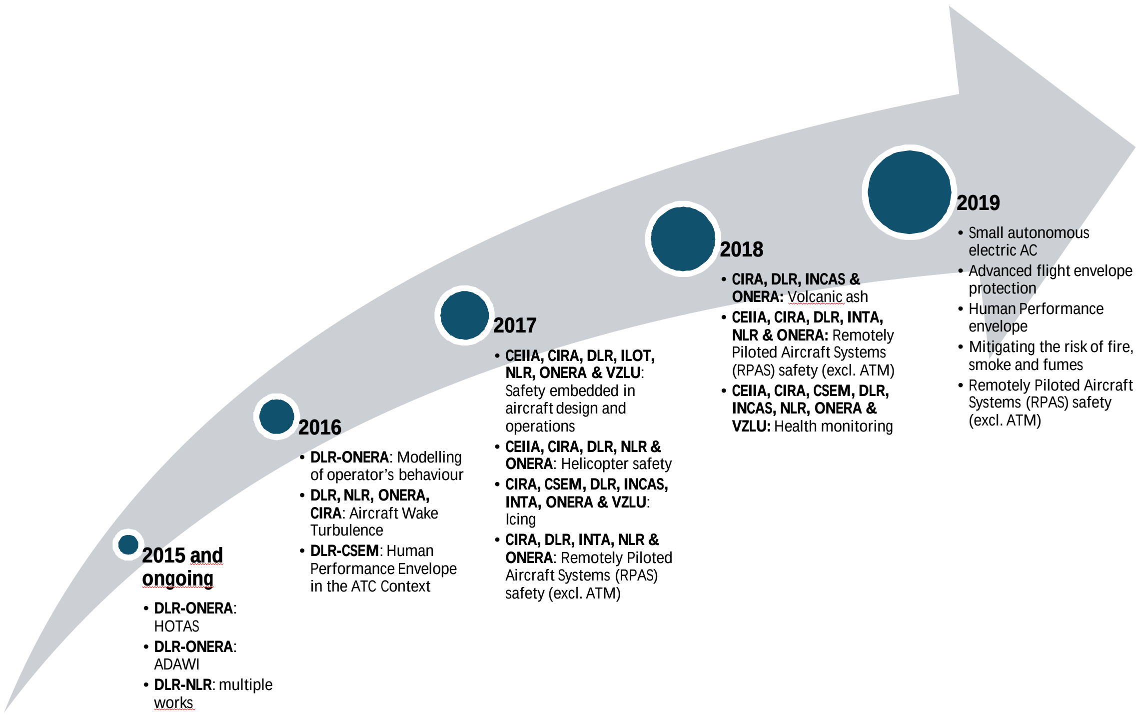

Figure 21: Coordination topics of EREA Safety R&TD activities

For information on the results regarding the P1 workshops and cooperation activities see D1.7 "Report on the implementation of the EREA Aviation Safety Research Plan 1" (Novelli, 2017). In this report both the workshops and further implementation actions (development of a generic collaboration agreement, specification, development and implementation of a communication platform to share publications and project information between the REs, and the analysis of past experience of personnel exchanges to derive recommendations in order to facilitate such exchange and build an exchange plan of scientists and PhD students among the REs) are described in detail. Furthermore, the first assessment of the leverage effect of P1 activities is available since 2017 (Amato et al., 2017).

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11 REFERENCES

ACARE. (2012a). *Realising Europe's vision for aviation. Strategic Research & Innovation Agenda Executive Summary*.

ACARE. (2012b). *Realising Europe's vision for aviation. Strategic Research & Innovation Agenda Executive Summary / Volume 1 / Volume 2*.

ACARE. (2012c). *Realising Europe's vision for aviation. Strategic Research & Innovation Agenda Volume 2*.

Ahlstrom, U., & Friedman-Berg, F. J. (2006). Using eye movement activity as a correlate of cognitive workload. *International Journal of Industrial Ergonomics, 36*, 623-636.

Amato, M., Lizza, A., Paparone, L., & Vozella, A. (2017). D1.8 Assessment of the leverage effect on the institutionally funded safety research.

Carstengerdes, N., & Friedrich, M. (2016). D1.5 EREA Aviation Safety Research Plan 2016.

Carstengerdes, N., & Friedrich, M. (2017). D1.6 EREA Aviation Safety Research Plan 2017.

EASA. (2015a). *Concept of Operations for Drones, A risk based approach to regulation of unmanned aircraft*.

EASA. (2015b). *Introduction of a regulatory framework for the operation of unmanned aircraft.*, Technical Opinion.

EASA. (2015c). *Proposal to create common rules for operating drones in Europe*.

EASA. (2016). *European Plan for Aviation Safety 2016-2020*.

Edwards, T. (2013). *Human performance in air traffic control.* (PhD), Dissertation, University of Nottingham.

EREA. (2016). Safety / Future Sky.

ERSG. (2013). *Roadmap for the integration of civil Remotely-Piloted Aircraft Systems in to the European Aviation System ANNEX 2 A Strategic R&D Plan for the integration of civil RPAS into the European Aviation System*.

Friedrich, M., Carstengerdes, N., & Amato, M. (2017). Survey Program Manager.

Novelli, P. (2017). D1.7 Implementation of the EREA Aviation Safety Research Plan.

OPTICS. (2016). *D2.3 - STATE-OF-THE-ART IN SAFETY RESEARCH PART 3*.

Ruttke, D., Krajenski, V., Mortágua, J. P., Amato, M., Madrigal, A. M., Bogos, S., . . . Kašpar, J. (2016a). *D1.1 Updated survey of the different institutional funding mechanisms*, Köln.

Ruttke, D., Krajenski, V., Mortágua, J. P., Amato, M., Madrigal, A. M., Bogos, S., . . . Kašpar, J. (2016b). *D1.2 Updated list ongoing/planned institutionally*, Köln.

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ANNEX

In the following table a high level mapping of roadmap topics on the ACARE SRIA Enablers is presented. This mapping should illustrate which safety research is supported by each roadmap on a meta-level. It is noted that due to this approach, details of the individual research topics are lost and the suggested 1-1 mappings are sometimes a little bit forced. To provide a thorough mapping, also to enable covering research issues that do not fit the Enablers of Challenge 4, the details of the roadmaps should be studied, which is beyond the scope of the mapping task.

ACARE SRIA **Enabler**	**Optics**[4]	**EASA EPAS**	**SRG RPAS**[5]
1. System wide safety management Connections with other transport modes All air vehicles	Multi-modal transport research Integration of RPAS/UAS into airspace	SMS in airworthiness SMS of Member State (SSP) Oversight by competent authorities Safety promotion helicopters	Framework ensuring equity in access to airspace by all air vehicles.
2. System wide security management Connections with other transport modes All air vehicles	Multi-modal transport research		

[4] Optics is not necessarily a roadmap but provides top priorities emerging from the workshops, and gaps in research. These are mentioned in the table.
[5] SRG RPAS only considers RPAS related research. In the table, the enablers are identified that address RPAS/UAS related topics.

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ACARE SRIA Enabler	Optics[4]	EASA EPAS	SRG RPAS[5]
3. An intelligence based approach Big data intelligence, proactive identification and prevention of security threats, background information analysis.		Develop roadmap to address cybersecurity threats	
4. Safety radar Identification and detection of safety hazards. Atmospheric and other external hazards, behavior analysis of passengers	Weather related resilience Weather knowledge in decision chain	Icing	
5. Security radar Identification of security threats, behaviour analysis of passengers.		Develop roadmap to address cybersecurity threats	
6. Operational mission management systems and procedures Optimisation of trajectories to ensure hazard and collision avoidance throughout all flight phases. Safe access and integration of all air vehicles, a.o. UAV	Equity of RPAS/UAS access to airspace ✓ ConOps development ✓ Models for dynamic decision making	Prevent LOC during go-around or climb Off-shore helicopter safety	Safe access and integration of RPAS/UAV within airspace and airports
7. System behavior monitoring and self-healing Automatic reconfiguration/re-routing in response to safety or security vulnerabilities.	Real-time data analysis capability	Technology to mitigate the risk of runway excursions	
8. Diagnostic analysis Data analysis of aviation accidents, incidents and occurrences.	Feedback of data analysis into design		

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ACARE SRIA Enabler	Optics[4]	EASA EPAS	SRG RPAS[5]
9. Efficient and effective standardization and certification Harmonized approaches, methods and tools.	Validation/verification approach for RPAS/UAS Flight limitations in adverse weather conditions	Helicopter design requirements Harmonized EU rules for RPAS Safety risks arising from business models	Certification requirements for RPAS/UAV
10. Resilience ATS robust by design. Coordinated forums, including with other transport modes.	Aspects of multi-modal transport Resilience in Socio-technical systems		
11. Human-centred automation Design of automation and information systems to support and optimize human roles across the ATS.	Human centred automation Human factors in design and manufacturing Human trust in automation		
12. New crew/team concepts Functional interactions of all operators and users of the ATS and their culture.	Human performance envelope	Cabin air quality	
13. Passenger management Better understanding of the characteristics, behaviours and cultures.			

Table 7: Mapping of OPTICS, EASA EPAS and SRG RPAS roadmap topics on the ACARE SRIA Enablers

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