EREA Aviation Safety Research Plan 2017

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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 third year of Future Sky Safety.

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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 or 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

Acronym	Definition
JRI	Joint Research Initiative
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
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 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. This will 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.
- 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.

This report summarizes the FSS Project P1 activities in 2016 dedicated to coordination and cooperation of EREA Safety R&TD activities and identifies relevant safety research topics to focus EREA safety efforts in 2017.

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, 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 provided 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 will involve 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.

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

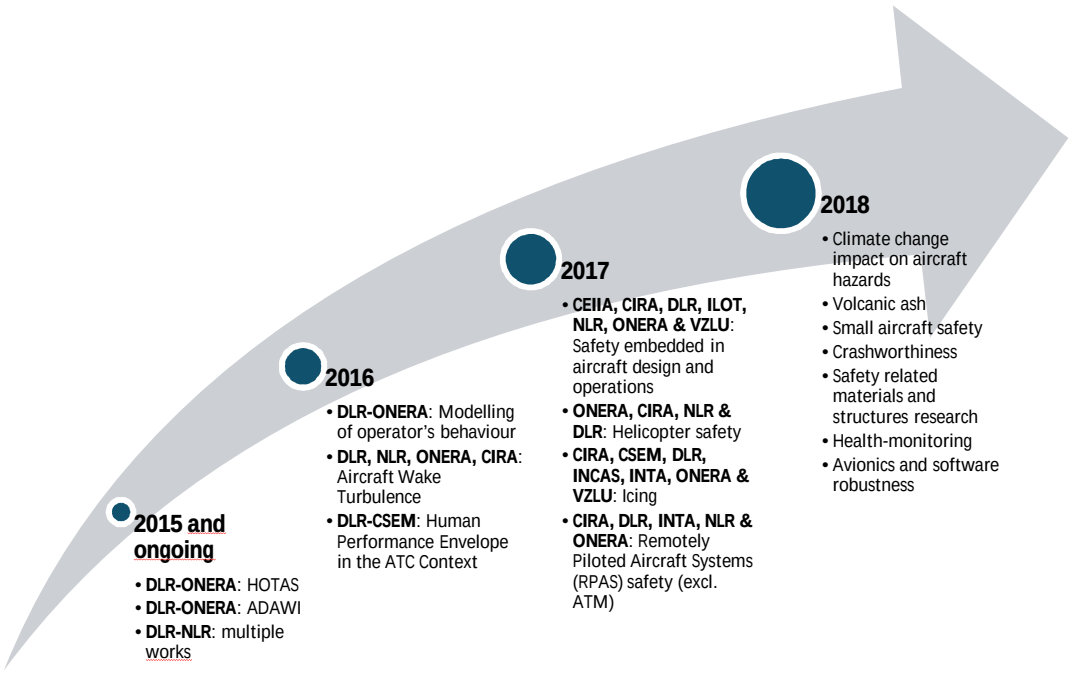

Figure 1: Coordination topics of EREA Safety R&TD activities

Applicability

This report is applicable to the REs participating in P1 and is a guideline for them to proceed in the following year. In view of this, this 2017 version was provided to the EREA Coordination Steering Committee (RECSC) of Future Sky Safety, which consists of one representative for each of the EREA partners in Project P1, asking the RECSC for adoption. Feedback is processed into following ASRPs.

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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.

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. The safety research conducted by the REs was however not coordinated so far.

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. Such plans will 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). The coordination of institutionally funded safety research is done in close cooperation with key European organisations and actions dedicated to safety (EASA, Eurocontrol, ACARE WG4, OPTICS)

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**
  - "Join forces" on topics of common interest and achieve "critical mass" to launch new projects
  - identification of overlapping research activities and free resources by avoiding duplication

- identification of new institutionally funded safety research topics (challenges for the identified time frames)
- 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, EASP [now 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).

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 to 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.
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 and/or use current overlapping of research activities on a validation path for technologies/approach • 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 2017 identifies the following steps:

1. Analysis of ongoing or planned institutionally funded safety research activities at the participating Research Establishments (D1.2; DLR, 2016b)
2. Survey of the different institutional funding mechanisms (D1.1, DLR, 2016a)
3. Analysis of the current status of the Future Sky Safety Technical Projects (T3-T7)
4. Analysis of the relevant European roadmaps (e.g. SRIA)

The general schedule for the elaboration of the ASRP is presented in Table 2.

Table 2 Schedule for the ASPR

Time	Activities
January - March	• analysis of surveys internally and together with key European organisations • analysis of relevant European roadmaps • preparation of draft ASRP • preparation of Program Directors Workshop
April - May	Endorsement of draft ASRP by Program Directors
June - September	Update of draft ASRP using suggestions from the Program Directors Workshop

Time	Activities
October – November	• discussion of the updated draft ASRP (internally and with European Safety Research Advisors) • preparation of final ASRP
December	Adoption of final ASRP by RE Coordination Steering Committee
January - February	Preparation of public ASRP
March	Adoption of public ASRP by RE Coordination Steering Committee

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 scope of the document and the level of maturity 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 D1.2 (DLR, 2016b) as an 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) and the results of the assessment performed in OPTICS to this ASRP.
- Chapter 7 “Criteria for selection of topics” describes selection criteria for future EREA cooperation.
- Chapter 8 “Planned Cooperation’s for 2017” provides an overview of the current status of planned cooperation for 2017.
- Chapter 9 “Suggested Subjects of Cooperation for 2018” provides an overview of possible new cooperation for 2018.
- Chapter 10 “Conclusions” provides a summary and brief implications for the following years.

2 GOAL AND SCOPE OF THE ASRP

The document describes the planned **EREA Institutionally Funded Safety Research** for the year 2017 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 first goal for the ASRP is the identification of new safety research topics and projects to be institutionally funded (D1.2) 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 (activities which could support the projects by scientific/technical results specifically in terms of: 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 delivered for the last year and the support actions requested for the upcoming year.

The third goal is to take into account relevant European roadmaps on safety (SRIA, EPAS) research 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.

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

The following sections give a short summary of each cooperation, additional information can be found in D1.5 (Friedrich & Carstengerdes, 2016).

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.

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.

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 kick-off meeting was on November 2014 in Braunschweig. 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 have initiated cooperation on the topic Human Performance Modelling in Human-System Interaction. The cooperation activity is open for other EREA partners to participate (Friedrich, M., & Carstengerdes, N. (2016)).

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 in 2015 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 include 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 starting in 2017 and to analyse the progress made in LIDAERO. This 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).

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 are used to predict limitations of human performance well in advance in order to prevent so called human errors. The study focusses 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 is finished in this cooperation and publications are being prepared.

Future studies are planned and foreseen after 2016 to evaluate the ATCos' fatigue. Possibly fatigue data are about to be measured in the cockpit environment as well. The collaboration might be extended together with Cranfield University.

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 2016. The second part shows the trend for 2017 in comparison to the fixed years 2015 and 2016. The third part analyses the budget and it looks also to the trend for 2017.

4.1. Results from the updated D1.2 for 2016

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. The task of the participating EREA partners was to update the existing activities and at the same time add new ones. The update for the existing activities was mainly performed on the estimated budgets for 2016 and 2017. The two new added activities were “Hot-Windows” by CSEM and “A-PiMod” by DLR. Activities that ended in 2015 were removed because they are no longer in the focus of this document. This leads to a total of 58 activities that were used for the following analysis.

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. For this overview, the safety activities are grouped in different categories, in accordance with safety categories used in Skybrary.

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. The three following tables present the SKYbrary main categories “Enhancing Safety”, “Operational Issues” , “Human performance”, “Weather”, “Safety regulations”, 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. Table 3 presents the amount of research activities per RE. Table 4 presents the summarized budgets per RE. Table 5

[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.

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 estimated at the beginning of Future Sky Safety.

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.

Table 3 Amount of research projects per partner and main SKYbrary category

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

Table 4 Budget (in €) per research projects per partner and main SKYbrary category

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

Table 5 Person month per research projects per partner and main SKYbrary category

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

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 2 shows the histogram of the main categories for projects that are safety relevant in 2016. 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 Enhanced Safety, Operational Issues, and Human performance. The research on Fire, smoke and fumes seems to be very specifically focussed and not wide-spread.

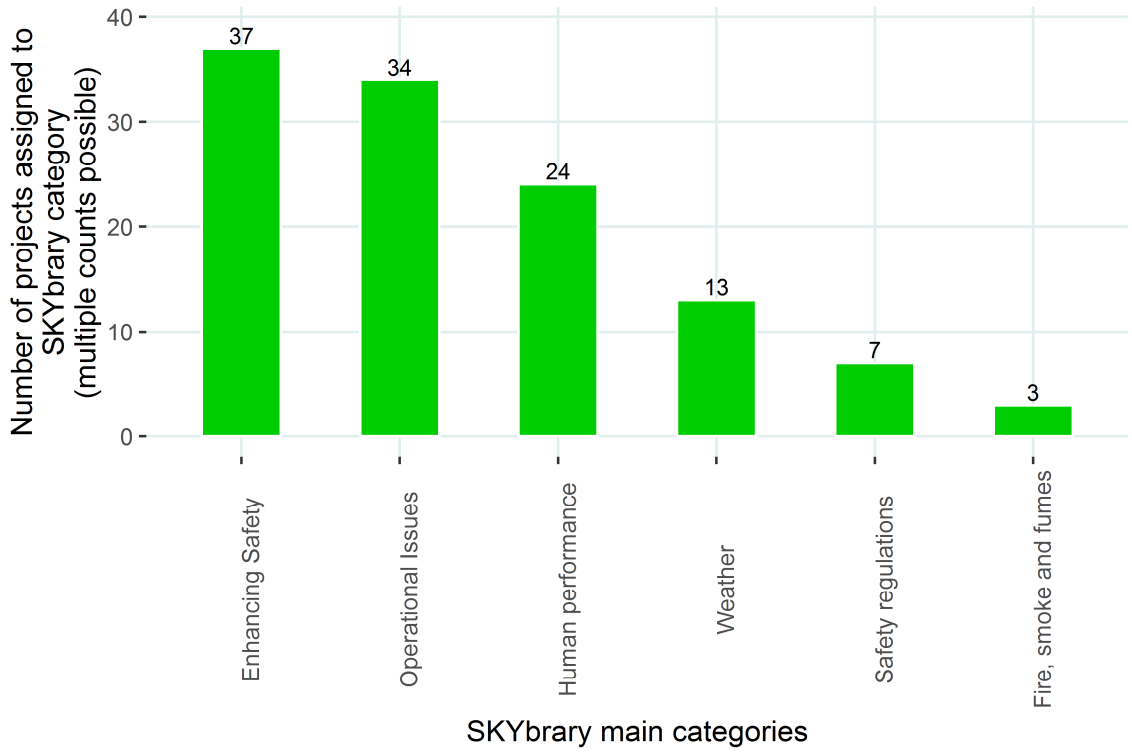
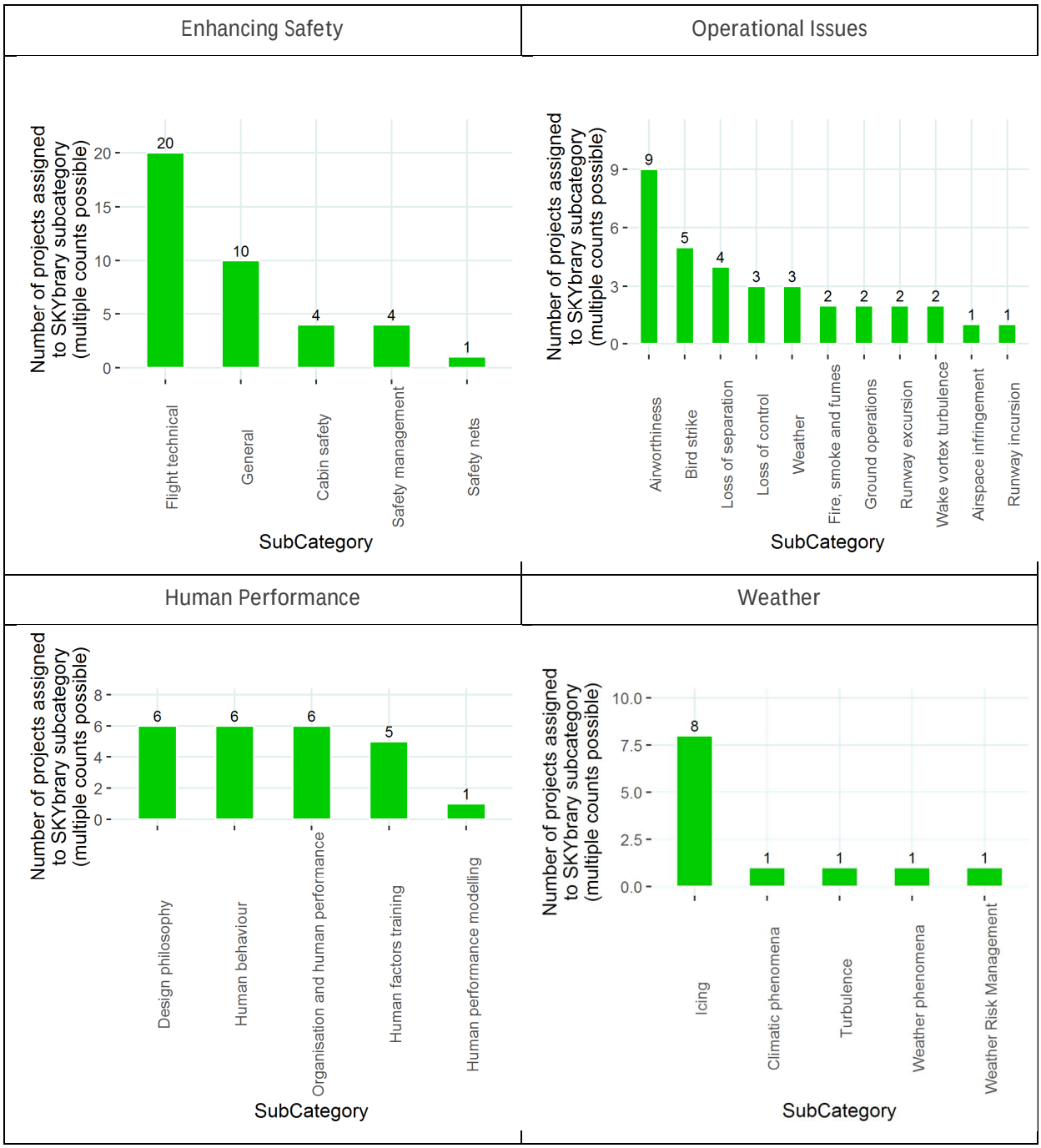


Figure 2: Summary of the main categories for all projects in the D1.2 survey.

Figure 3 shows the results for each subcategory. The major subcategories independent from the main categories are Flight technical (20), Airworthiness (9), and Icing (8). As “Fire, Smoke and Fumes” and “Weather” are already subcategories, the shown content are actually the sub-subcategories (e.g. ”Operational Fires”, “Post-Crash Fires”, “Combustion-related Smoke”, “Non Combustion-related Fumes” and “Fire Protection” for “Fire, Smoke and Fumes”).



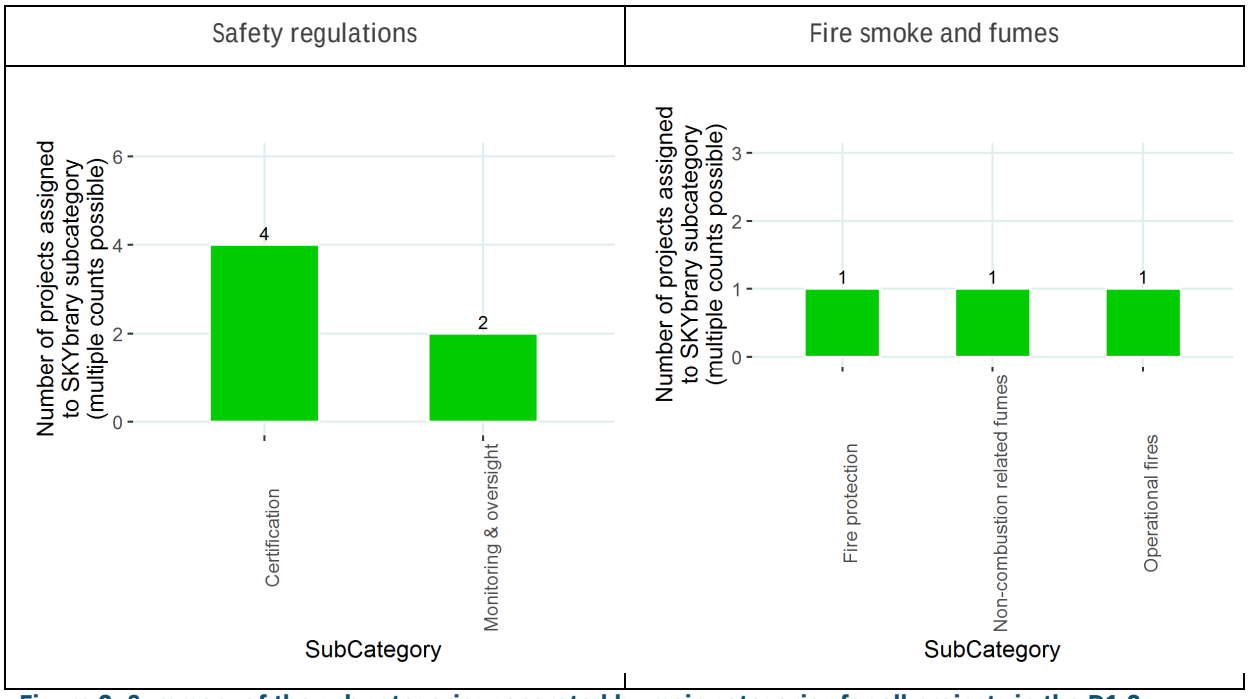


Figure 3: Summary of the sub categories separated by main categories for all projects in the D1.2 survey.

The funding mechanism is presented in Figure 4. The results show that around 75% of the projects are either funded only institutionally or are EU co-funded. Majority of projects (55%) is conducted on institutional funding only.

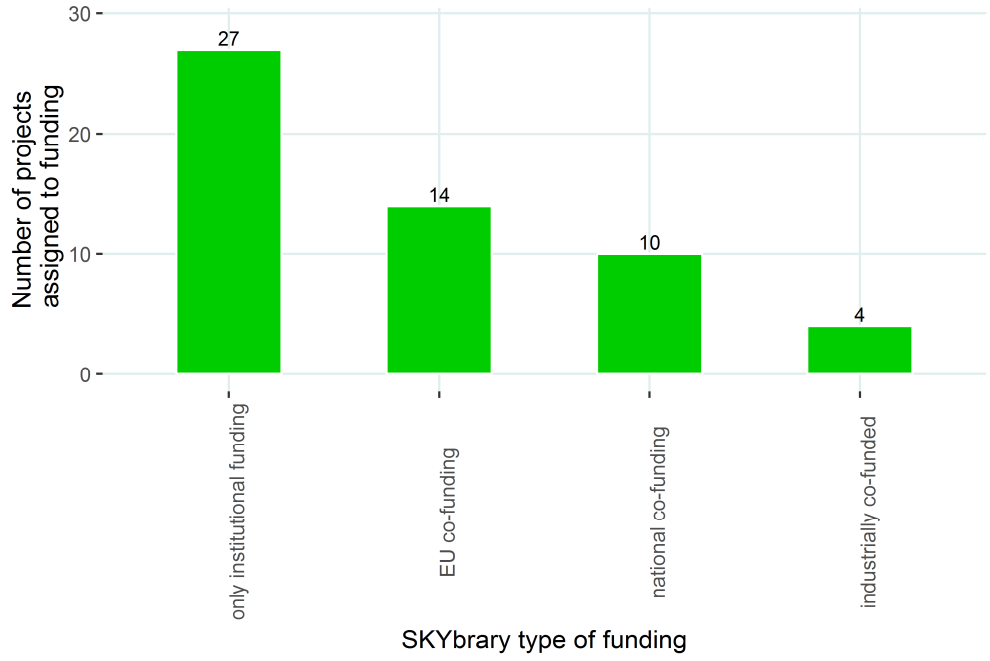


Figure 4: Summary of the type of funding mechanism for all projects in the D1.2 survey.

The next analysis is related to the types of consortiums that are used for safety projects. Figure 5 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 consortium.

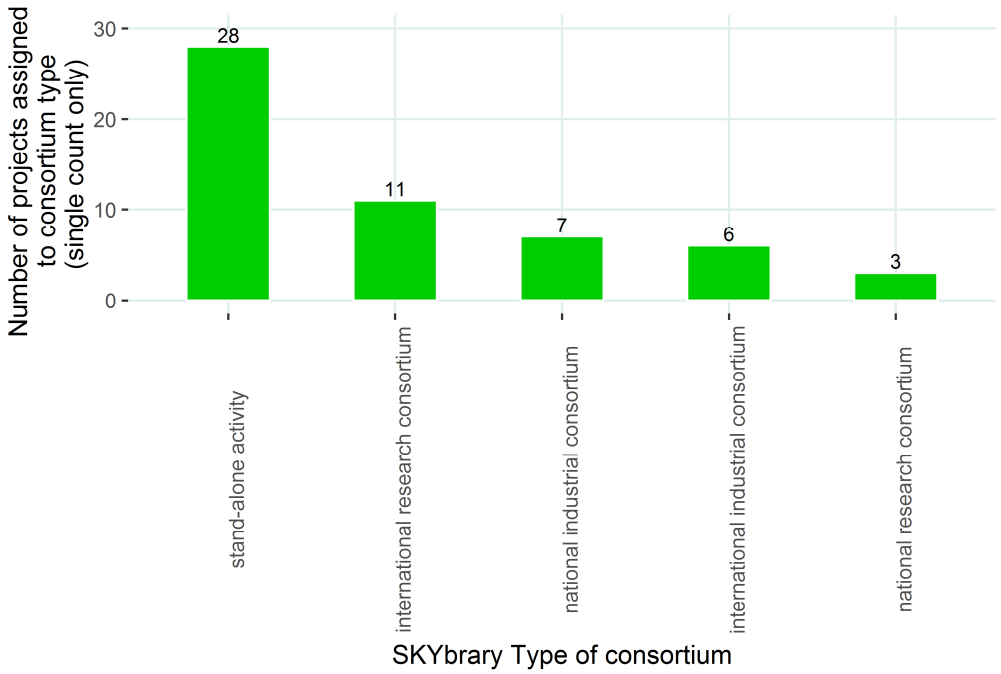


Figure 5: Summary of the type of consortium for all projects in the D1.2 survey.

Figure 6 shows the accessibility of the projects and therefore the possibly to share the results with other partners. The large majority of projects (76%) are at least partly confidential.

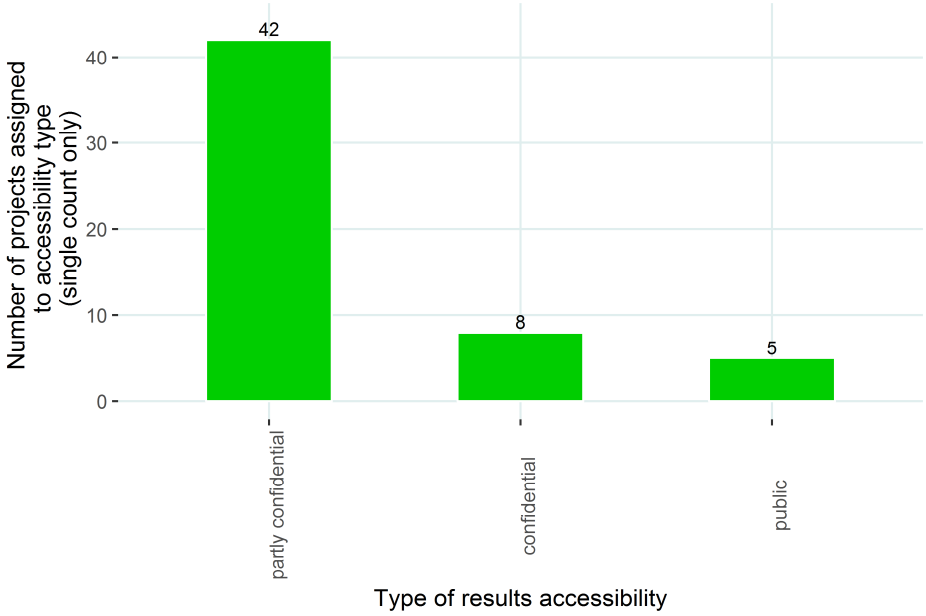


Figure 6: Summary of the type of result accessibility for all projects in the D1.2 survey.

Figure 7 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. Only 12 activities were classified as no exchange with EREA partners. This leads to the assumption that for 3 out of 4 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.

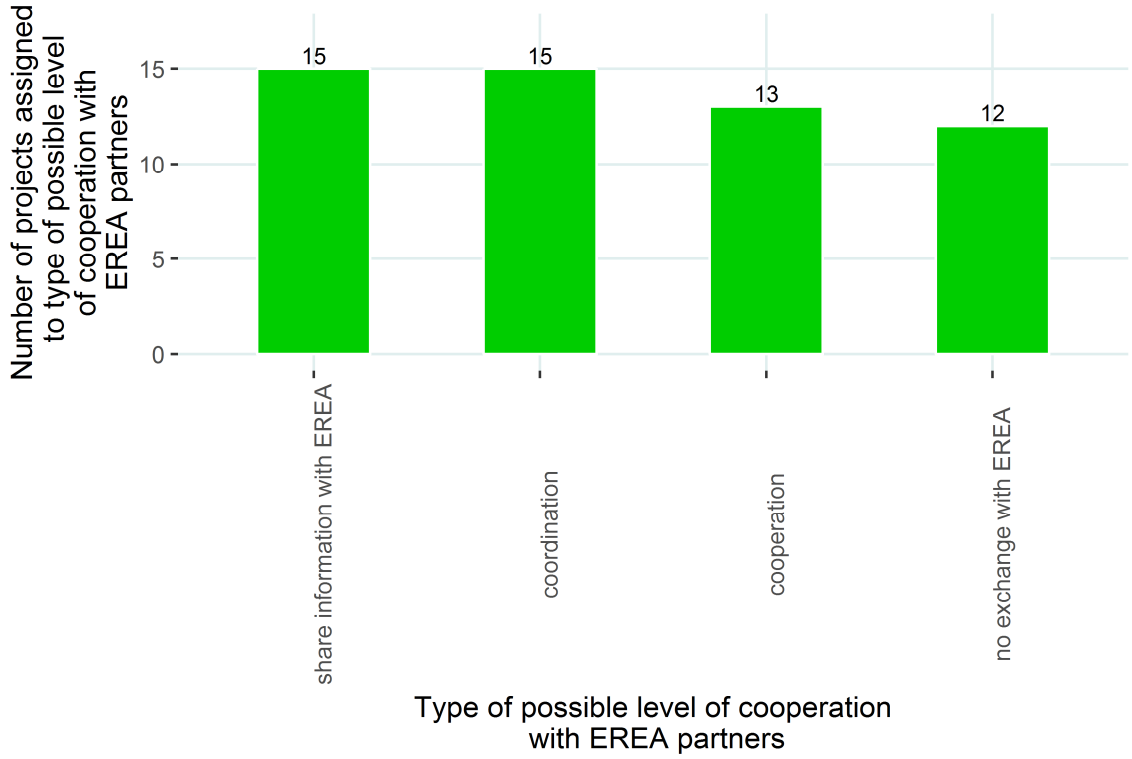


Figure 7: Summary of the type of possible level of cooperation with EREA partners for all projects in the D1.2 survey.

4.1.3. Trend analysis

The trend analysis is restricted to the years 2015, 2016 and 2017. The data for 2015 and 2016 are solid in terms of explanatory power, because the planning for 2016 activities was finished by the time the analysis was done for D1.2. The data for 2017 was not completed, because some activities were still in development or not yet granted when the questioning for D1.2 was performed (February-March 2016). Also, 18 safety activities are planned to end in 2016 and therefore have no influence on the trend analysis for 2017. Nevertheless, the data from D1.2 provides an indicator for 2017.

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 and 38 activities in 2017 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. For example (as shown in Figure 2) a total of 118 answers were given regarding the main categories of all activities. This accounts for the distribution in 2016 of 31% for "Enhancing Safety", 28% for "Operational Issues", 20% for "Human performance", and so on.

Figure 8 shows the percentage of every main category for the years 2015, 2016 and 2017. As described above, it has to be kept in mind that "Fire, Smoke and Fumes" and "Weather" are two subclasses of "Operational issues". The small differences in the three categories in the years 2015 and 2016 could thus be due to a different categorization. Concerning the apparent growth in the Human Performance category, the total number of projects is comparable through the years (2015: 19; 2016: 24; 2017: 21).

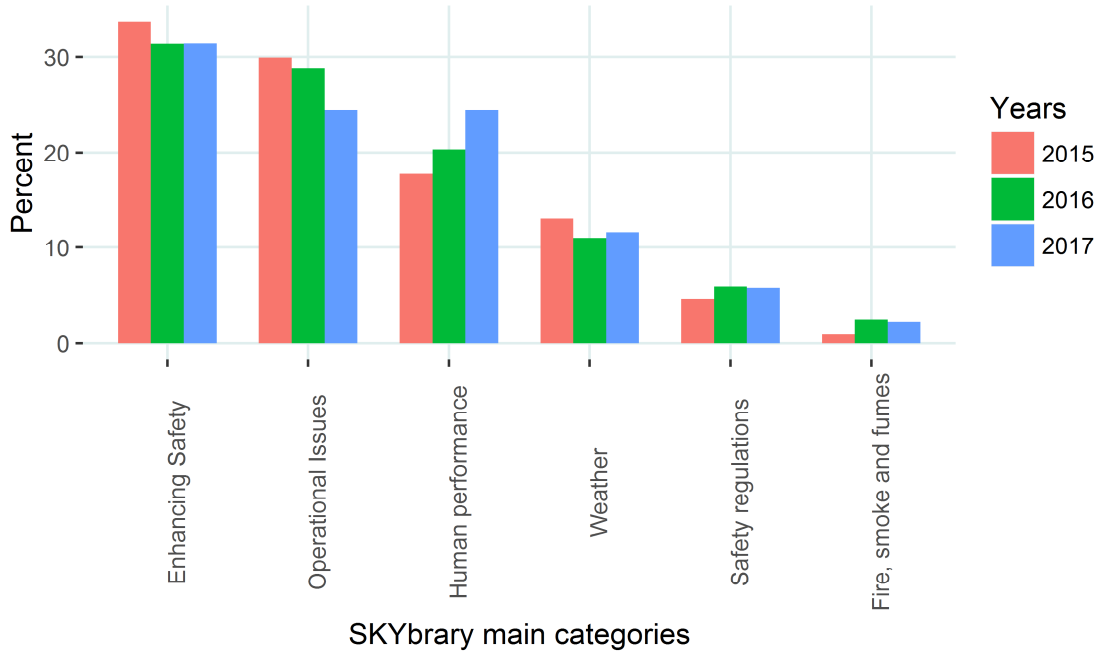


Figure 8: Trend analysis for main categories for all projects in the D1.2 survey

Figure 9 shows the type of funding mechanism in percentage separated by years. No significant changes could be identified.

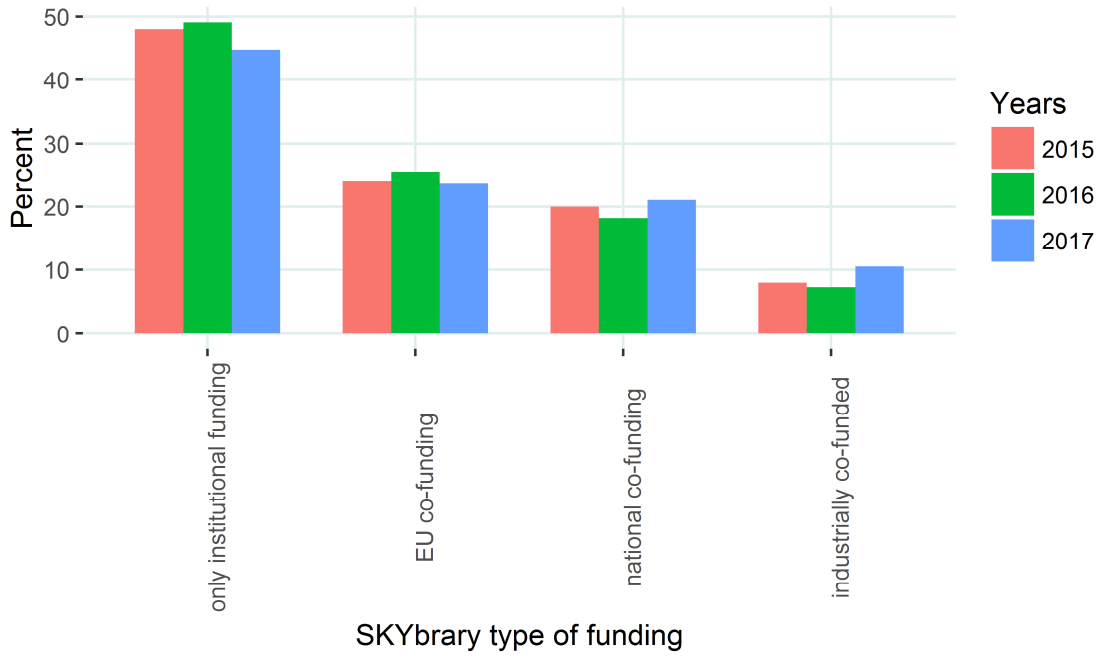


Figure 9: Trend analysis of the type of funding mechanism for all projects in the D1.2 survey.

Figure 10 shows the type of consortium in percentage separated by years. No significant changes could be identified, but a trend for more international research consortiums is indicated (which is exactly what Future Sky Safety P1 is aiming for).

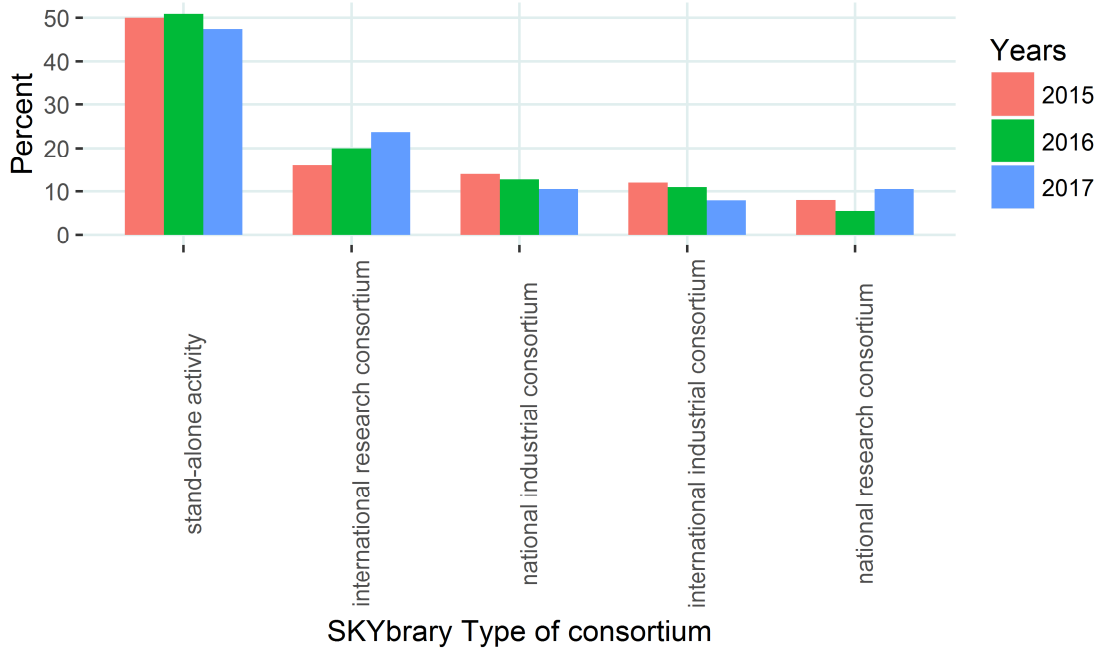


Figure 10: Trend analysis of the type of consortium for all projects in the D1.2 survey.

Figure 11 shows the type of accessibility for the results in percentage separated by years. No significant changes could be identified.

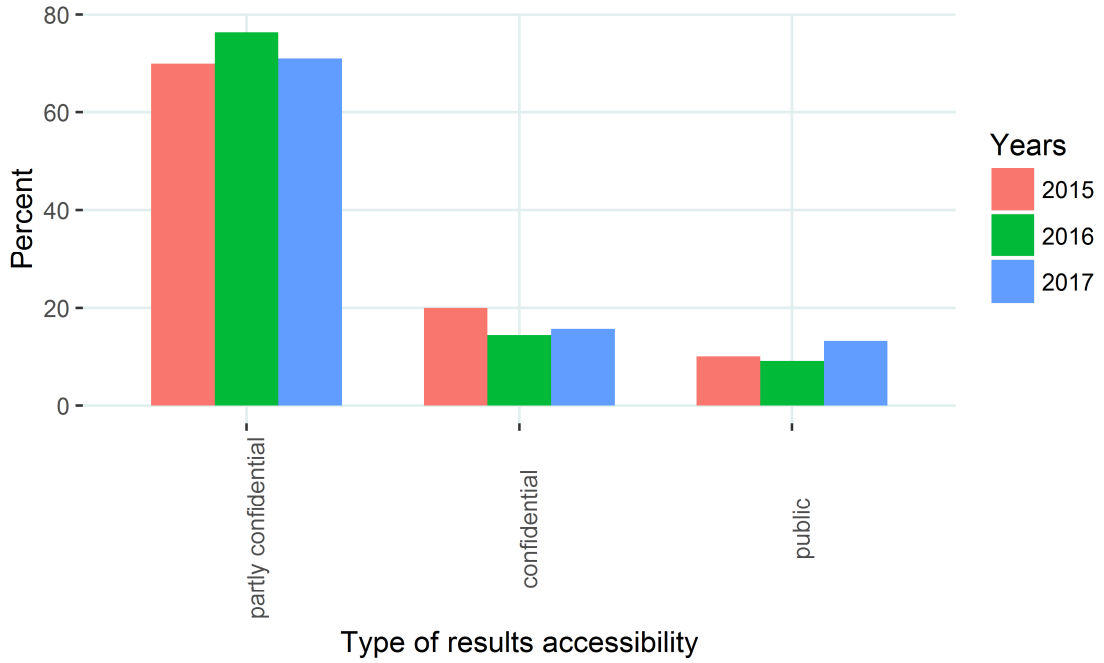


Figure 11: Trend analysis of the type of result accessibility for all projects in the D1.2 survey.

Figure 12 shows the level of cooperation between the EREA partners in percentage separated by years. The emphasis amongst EREA partners has shifted from passive sharing of information to active coordination efforts. Although this can only be interpreted as a trend, this effect is reflecting the goals of Future Sky Safety P1.

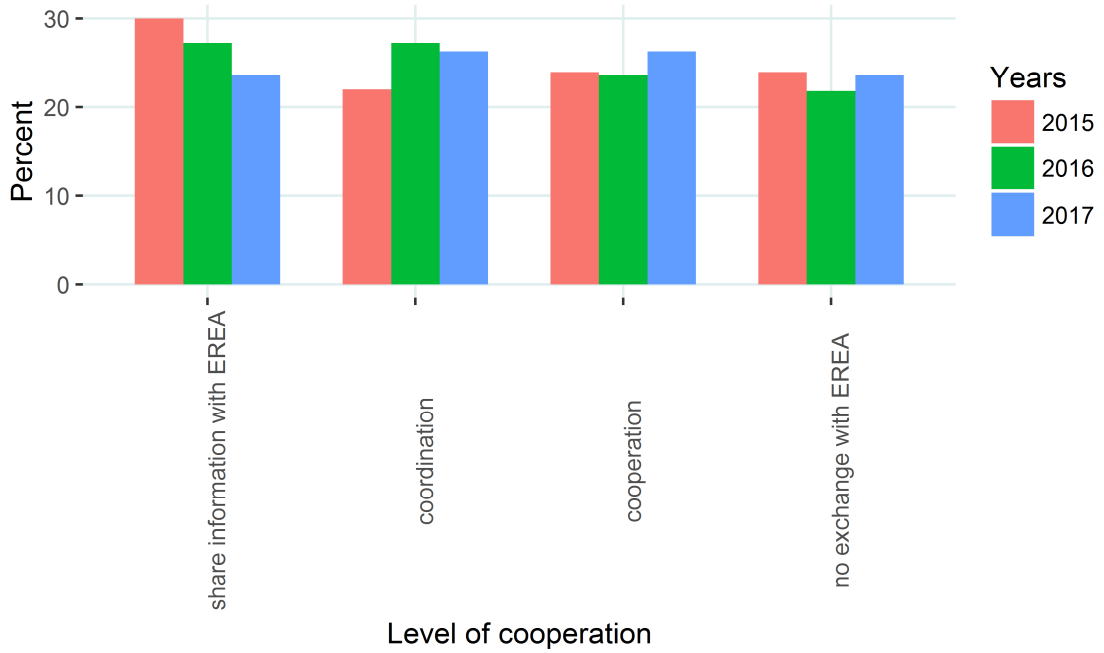


Figure 12: Trend analysis of the type of possible level of cooperation with EREA partners for all projects in the D1.2 survey.

4.2. 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. Therefore the budgets per year and month per year were analysed in this section. First we look at the year 2016 and then also include 2015 and 2017 to show a trend between these years.

Figure 13 shows the budget as histogram over 55 activities collected for 2016. 43 activities have a budget that is less then € 800.000.

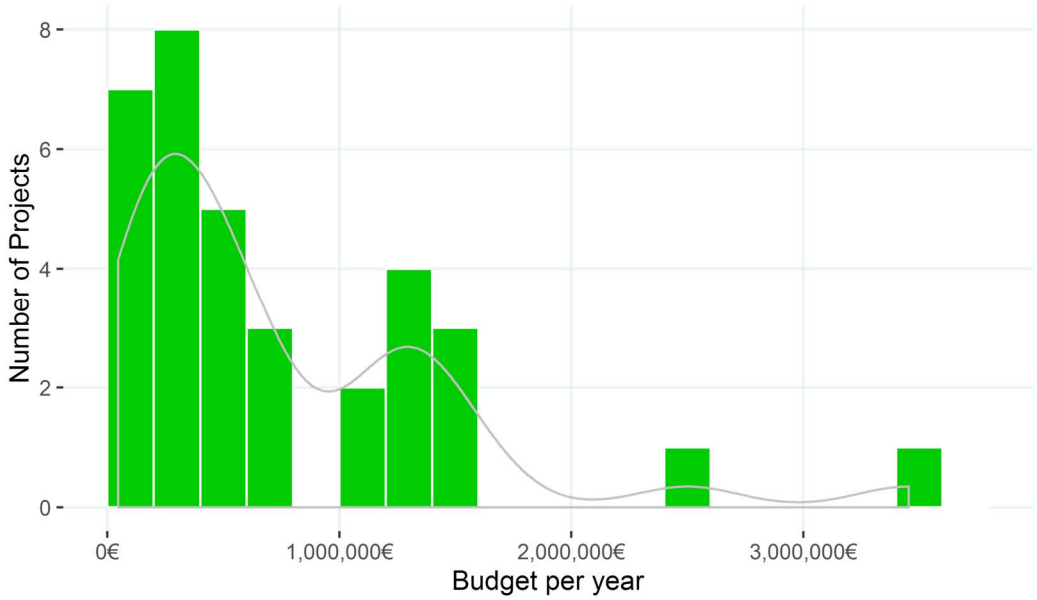


Figure 13: Budget histogram with density curve to approximate the amount of projects and the budgets available for 2016.

Figure 14 shows the person month as histogram over the same activities then Figure 13. Because person month and budget are connected the results are almost the same.

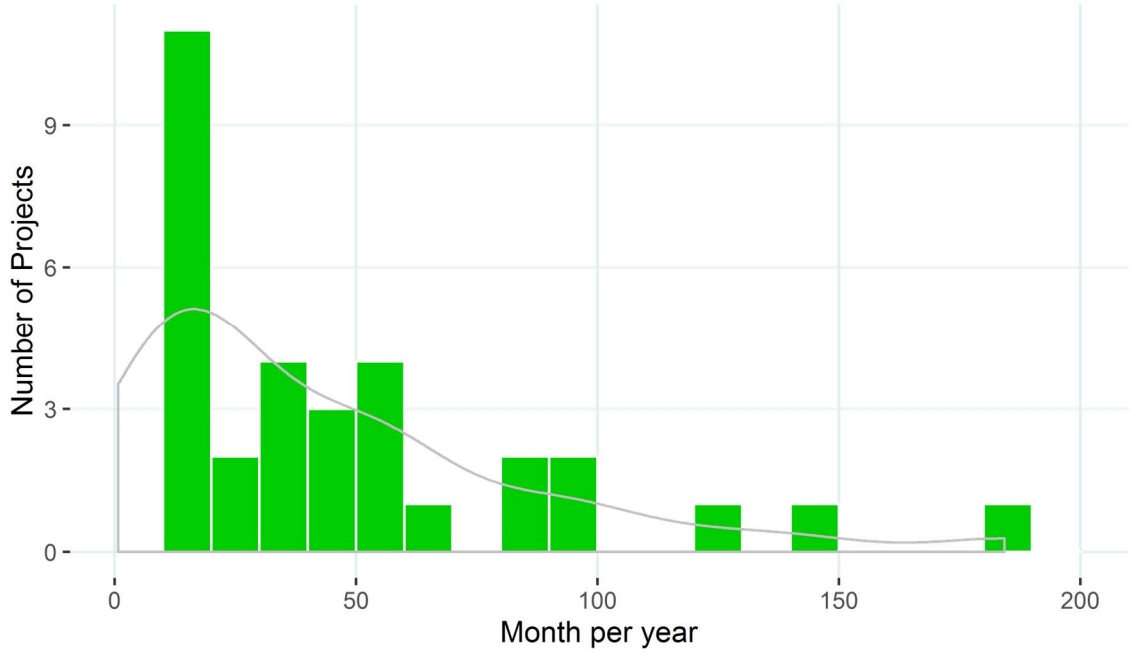


Figure 14: Person month with density curve to approximate the amount of projects and the person month available for 2016.

The trend analysis in Figure 15 has the same limitations as chapter 4.1.3. The total number of 50 activities in 2015, 55 activities in 2016 and 38 activities in 2017 were taken into account. As before, the results for 2017 can only be interpreted as approximation due to the time of the questioning. The orange square in Figure 15 represents the mean value of each year. This shows that even though the box is much smaller in 2016 and 2017 as in 2015 the mean value always stays around € 600.000 per year.

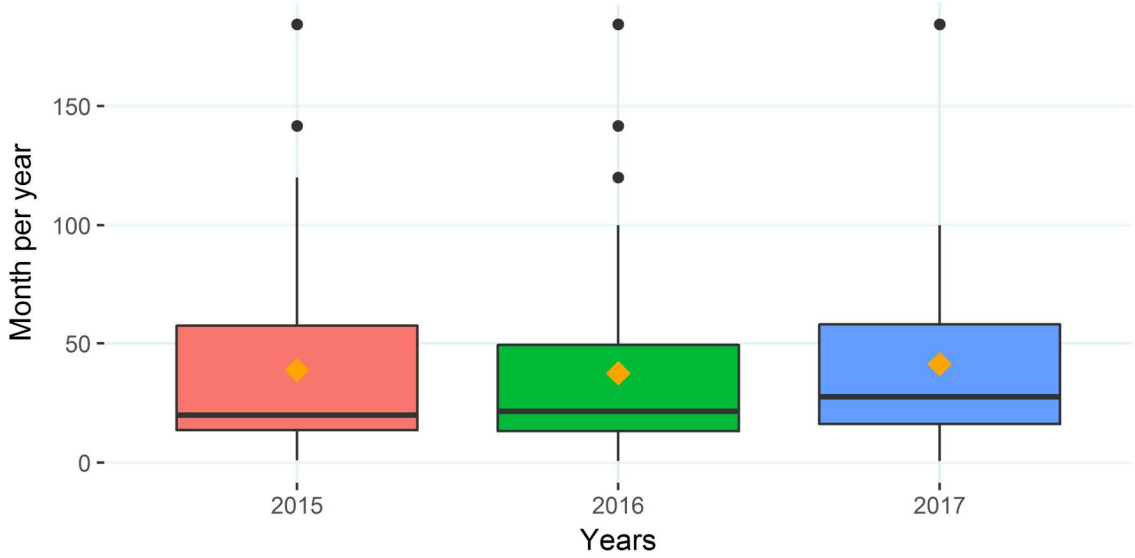


Figure 15: Trend analysis for the budget per year from 2015 to 2017.

4.3. Summary

The analysis presented above is based on the results of the D1.2. First the year 2016 was analysed in detail. Second a trend analysis of already planned activities for 2015, 2016 and 2017 was performed. Third the budget was analyzed.

The results for 2016 show that EREA safety activities have a wide range and 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 three selected years. Nevertheless, some trends (more coordination and cooperation; more international research consortiums) 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).

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).

5.1. Results

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 as a project manager have any shortcomings where P1 could support you?
    - This is especially for the coordination or cooperation that you see in connection with other projects within or outside FSS.

For the time being, most of the project managers have not observed any shortcomings where P1 could be of any 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 coming from one project manager of Future Sky Safety in order to better coordinate and cooperate.

2. Do you have any ideas for Activities, Projects or Discussion that might complement your work?

Three project managers indicated that they did not have any ideas for activities, projects or discussions at the moment that might complement their work. But they suggest that this could change over time as the project progresses.

However, the project managers of P6 and P7 were more concrete in their ideas.

P6 envisaged that in addition to the HPE study on Remote Tower Operations (conducted by DLR and CSEM) similar studies are foreseeable to explore the Human Performance Envelope further.

P7 stated that P7 is at the moment mainly focussed on constituting and sharing an experimental database to confront test results with state of the art models. The next interesting step would be to improve these models and modelling tools. Furthermore, depending on P7 final results about Onboard Air Quality, maybe further research items can be identified.

In addition to these questions, the following questions were prepared by P1:

- Did you observe any missing links in safety research we should address in 2017/18?
- Do you know if RE in your project are working on the same safety topics and could intensify their collaboration with help of P1?
- 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? If yes, P1 could assist for example with cooperation agreement templates and coordination activities like the FSS workshop in February.
- Do you foresee long-term cooperation between REs beyond your FSS project duration to be beneficial?
- What about cooperation regarding personnel exchange or PHDs? Do you have input for the ASRP on this topic?

The P6 manager indicated that they did not observe any missing links in safety research for 2017/18. But they recently learned that Deep Blue's NINA project is close to P6. Furthermore ONERA and CSEM have been identified as partners for cognitive modelling resp. physiological measurement but for the time being no P1 assistance is needed. The collaboration with CSEM was highlighted and should be continued according to P6. The application of physiological measurements in shape of CSEM's vest is reported to be quite promising and should therefore be tested in other facilities (radar simulation) or even field resp. flight tests. However, personnel exchange is not foreseen at the moment. Cooperation on PhDs would be a major and significant step forward and would be welcomed by P6 resp. DLRs Institute of Flight Guidance. The other project managers (P3, P4, P5, P7) are expected to provided their feedback and inputs for these topics in support of the next version(s) of the EREA Aviation Safety Research Plan(s).

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):

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;

    - 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).

- (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, 2015). 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.

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

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

- 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 16.

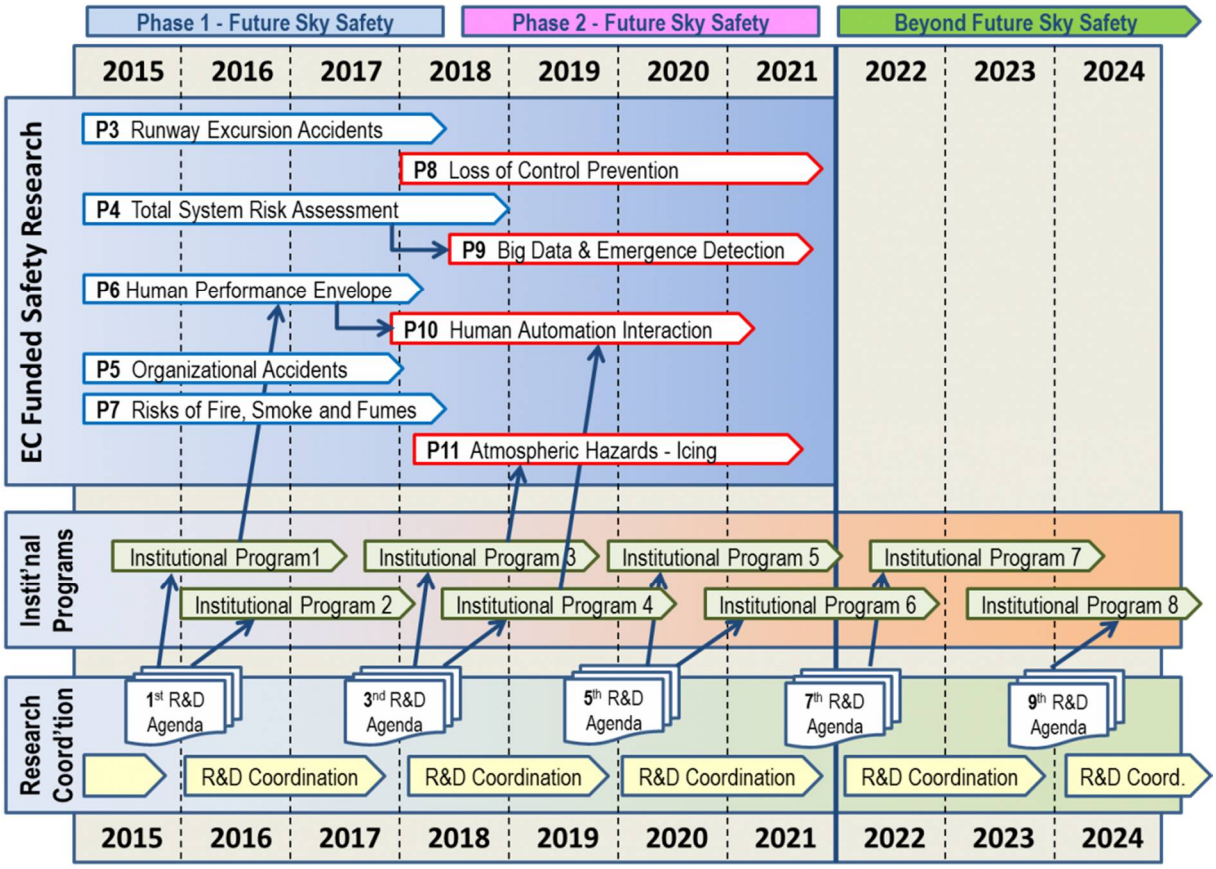


Figure 16: Institutional funded research.

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.

Table 6 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]
Operational_Issues	Air ground communication					
	Airspace infringement	**1**				
	Bird strike	**5**				
	Controlled flight into terrain					
	Fire, smoke and fumes	**2**				
	Ground operations	**2**				
	Airworthiness	**9**				
	Level bust					
	Loss of control	**3**			Prevent LOC during go-around or climb Off-shore helicopter safety	
	Loss of separation	**4**				

[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]
	Runway excursion	**2**			Technology to mitigate the risk of runway excursions	
	Runway incursion	**1**				
	Wake vortex turbulence	**2**				
	Weather	**3**	Safety radar	Weather knowledge in decision chain Flight limitations in adverse weather conditions		
	Emergency and contingency					
Human_performance	Human behaviour	**6**	Passenger management	Human trust in automation		
	Design philosophy	**6**	Human-centred automation	Human centred automation Human factors in design and manufacturing		
	Human performance modelling	**1**				

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SKYbrary Main category	SKYbrary Subcategory	Number of EREA projects	ACARE SRIA Enabler	Optics[2]	EASA EPAS	SRG RPAS[3]
	Organisation and human performance	**6**		Human performance envelope		
	Human factors training	**5**	New crew/team concepts			
	Aeromedical					
Enhancing_Safety	Cabin safety	**4**			Cabin air quality	
	Flight technical	**20**			Safety promotion helicopters Helicopter design requirements	
	Safety management	**4**	System wide safety management Diagnostic analysis	Feedback of data analysis into design	SMS in airworthiness	
	Safety nets	**1**	System behavior monitoring and self-healing	Real-time data analysis capability		
	Safety culture				SMS of Member State (SSP)	
	Just culture					
	General	**10**	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]
			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			Integration of RPAS/UAS into airspace Equity of RPAS/UAS access to airspace ✓ ConOps developme nt Models for dynamic decision making		Framework ensuring equity in access to airspace by all air vehicles. Safe access and integration of RPAS/UAV within airspace and airports
	Certification	**4**	Efficient and effective standardization and certification	Validation/verif ication approach for	Harmonized EU rules for RPAS	Certification requiremen ts for

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SKYbrary Main category	SKYbrary Subcategory	Number of EREA projects	ACARE SRIA Enabler	Optics[2]	EASA EPAS	SRG RPAS[3]
				RPAS/UAS		RPAS/UAV
	Personnel licensing					
	Monitoring & oversight	**2**			Oversight by competent authorities	
	Human error and legal process				Safety risks arising from business models	
Weather	Icing	**8**	Safety radar		Icing	
	Turbulence	**1**	Safety radar			
	Volcanic Ash		Safety radar			
	Weather Risk Management	**1**	Safety radar	Weather related resilience		
	Weather phenomena	**1**	Safety radar			
	Cloud formation		Safety radar			
	Climatic phenomena	**1**	Safety radar			
	Atmosphere		Safety radar			
Fire_smoke_and_fumes	Operational fires	**1**				
	Post crash fires					
	Combustion-related smoke					
	Non-combustion	**1**				

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SKYbrary Main category	SKYbrary Subcategory	Number of EREA projects	ACARE SRIA Enabler	Optics[2]	EASA EPAS	SRG RPAS[3]
	related fumes					
	Fire protection	**1**				

Table 6: 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 provide the Aviation Safety Research Plan of Future Sky Safety P1 input to enable coordination of institutional aviation safety research. This coordination is important to avoid overlap in European research and to identify 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. It can be concluded that newly identified research is well defined if it fits the SRIA roadmap especially if it considers generic safety research. For a specific topic as RPAS it is suggested to account for the specific roadmap as provided by the RPAS steering group.

In Table 6 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. For 2016, a third release of the state-of-the-art in safety research is planned in which also the national projects are addressed. Therefore, this new release is expected to provide relevant information for the FSS's coordination of institutionally funded safety research and will be considered in the next ASRP, in conjunction with our own analysis as summarized in the tables above.

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)

8 PLANNED COOPERATIONS FOR 2017

The selection procedure for cooperation and coordination in the ASRP 2017 did follow the originally planned procedure. During the development of the ASRP 2016, the involved EREA members agreed on which activities were considered mature enough to start cooperation projects in 2016. These activities have already been described in chapter 3. Activities which were not mature enough yet to directly start in 2016, but of high interest to the involved parties, were picked as topics for the Future Sky Safety P1 Coordination Workshop which was carried out on 18th February 2016 in Brussels. During this workshop, discussions on possible cooperation between EREA research establishments were focused on four selected topics: Safety Embedded in Aircraft Design (SEAD), RPAS safety, helicopter safety and icing. 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 2017. To discuss these topics already in early 2016 was one of the lessons learned from the review of the original ASRP selection procedure and D1.1 (DLR, 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 are planned for the year 2017, 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).

8.1. Safety embedded in aircraft design and operations

Table 7: Summary for Safety embedded in aircraft design and operations

Rapporteur	CEIIA
Workshop participants	CIRA, DLR, ILOT, NLR, ONERA and VZLU
Identified subjects for cooperation	1. Structural health monitoring (on which almost all the partners are working) 2. System design, including MDO/design framework and system engineering approach
	• Develop an integrated framework for the design of future aircraft concepts, which would include safety requirements in the design process. • Note: health monitoring will be addressed separately as a topic in itself
Action for 2016/2017	• As a first step for the development of the cooperation, the partners will elaborate a White Paper in 2016

8.2. Helicopter safety

Table 8: Summary for Helicopter safety

Rapporteur	ONERA
Workshop participants	CIRA, NLR and DLR
Identified subjects for cooperation	• Ship (and platform) landing was identified as a topic of common interest for the participants and selected for setting a cooperation.
Proposed cooperation	A two-year project is envisioned with the following activities: • Benchmark of different simplified aerodynamic approaches • Benchmark of the inclusion of the aerodynamic disturbance • Study of GNC algorithms
Action for 2016/2017	• The project will be submitted for approval to EREA establishments • Detailed work plan will be established in 2016 as well as the cooperation agreement Cooperation could start in early 2017

8.3. Icing

Table 9: Summary for Icing

Rapporteur	CIRA
Workshop participants	CSEM, DLR, INCAS, INTA, ONERA and VZLU
Identified subjects for cooperation	Five main topics were proposed: • Super-cooled Large Droplets (SLD), by CIRA, INCAS, INTA and ONERA • Hydrophobic coating by CSEM and CIRA • Film modelling by ONERA • Instrumentation and testing by DLR • Impact of ice debris by VZLU
Proposed cooperation	• Super-cooled Large Droplets was selected for building a cooperation
Action for 2016/2017	• A work plan will be elaborated on SLD in 2016 and submitted for approval

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

Table 10: Summary for Remotely Piloted Aircraft Systems (RPAS) safety

Rapporteur	NLR
Workshop participants	CIRA, DLR, INTA and ONERA (observer CEIIA and AFIT/ITWL)
Identified subjects for cooperation	Elaborating a global view of the needs for research on RPAS safety was identified as the first priority for a cooperation
Proposed cooperation	A first cooperation for 2016/17 will consist of elaborating the RPAS safety roadmap through a series of workshops.
Future plans	A first two day workshop was scheduled for the end of May 2016.
Identified subjects for cooperation	• Elaborating a global view of the needs for research on RPAS safety was identified as the first priority for a cooperation
Proposed cooperation	A first cooperation for 2016/17 will consist of elaborating the RPAS safety roadmap through a series of workshops.

9 SUGGESTED SUBJECTS OF COOPERATION FOR 2018

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 or workshop participation and used 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.

Topic	NLR	DLR	ONERA	CEIIA	CIRA	CSEM	INCAS	INTA	VZLU
Climate change impact on aircraft hazards		M	M		**H**	L			L
Volcanic ash	**H**	**H**	M/**H**		L	**H**	**H**	**H**	L
Small aircraft safety		L	L	**H**	**H**	M			**H**
Crashworthiness		L	**H**		**H**	L			L
Safety related materials and structures research		L	L		M	**H**			**H**
Health-monitoring	**H**	**H**	M	**H**	**H**	**H**	**H**	**H**	M
Avionics and software robustness		L	M		**H**	L			L
RPAS	**H**	**H**	**H**	**H**		M		**H**	M

Table 11: 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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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 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 17, also given below, shows the 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 17, the cooperation's planned for 2017 will involve 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 (compare the recommendations in section 9) in 2018.

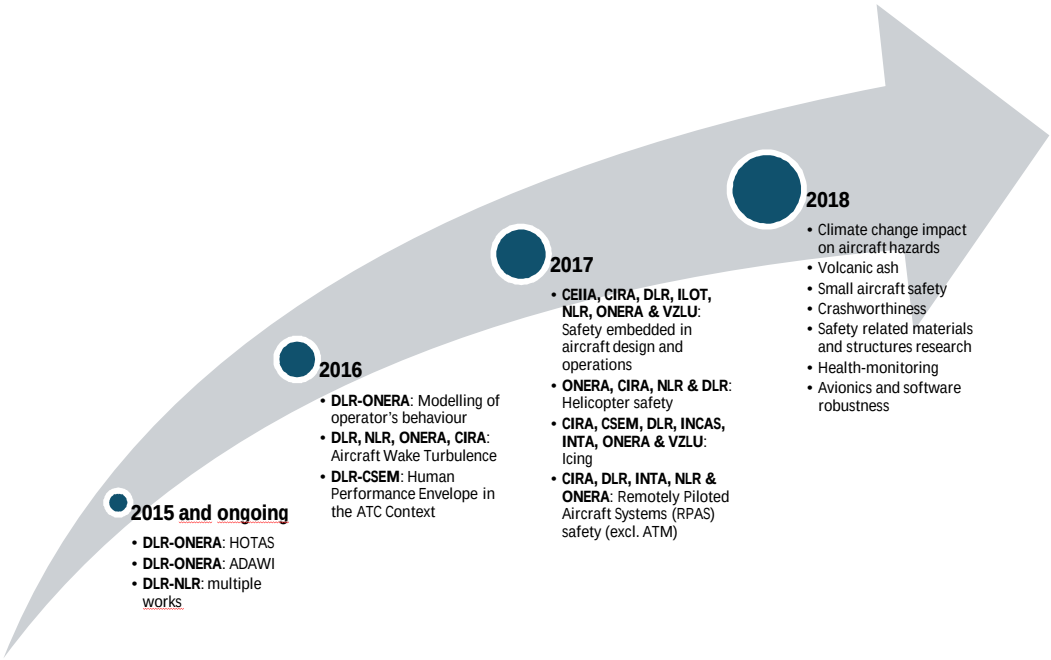

Figure 17: Coordination topics of EREA Safety R&TD activities

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" (available in 2017). In this report both the workshops and further implementation actions (development of a generic collaboration agreement,

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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 will be available in 2017 in D1.8.

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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.

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		

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