optics

OBSERVATION PLATFORM
FOR TECHNOLOGICAL AND INSTITUTIONAL CONSOLIDATION OF RESEARCH IN SAFETY

IS EUROPEAN AVIATION SAFETY RESEARCH DELIVERING?

In this handout:

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OPTICS

NAVIGATING TOWARDS THE SAFETY GOALS OF FLIGHTPATH 2050

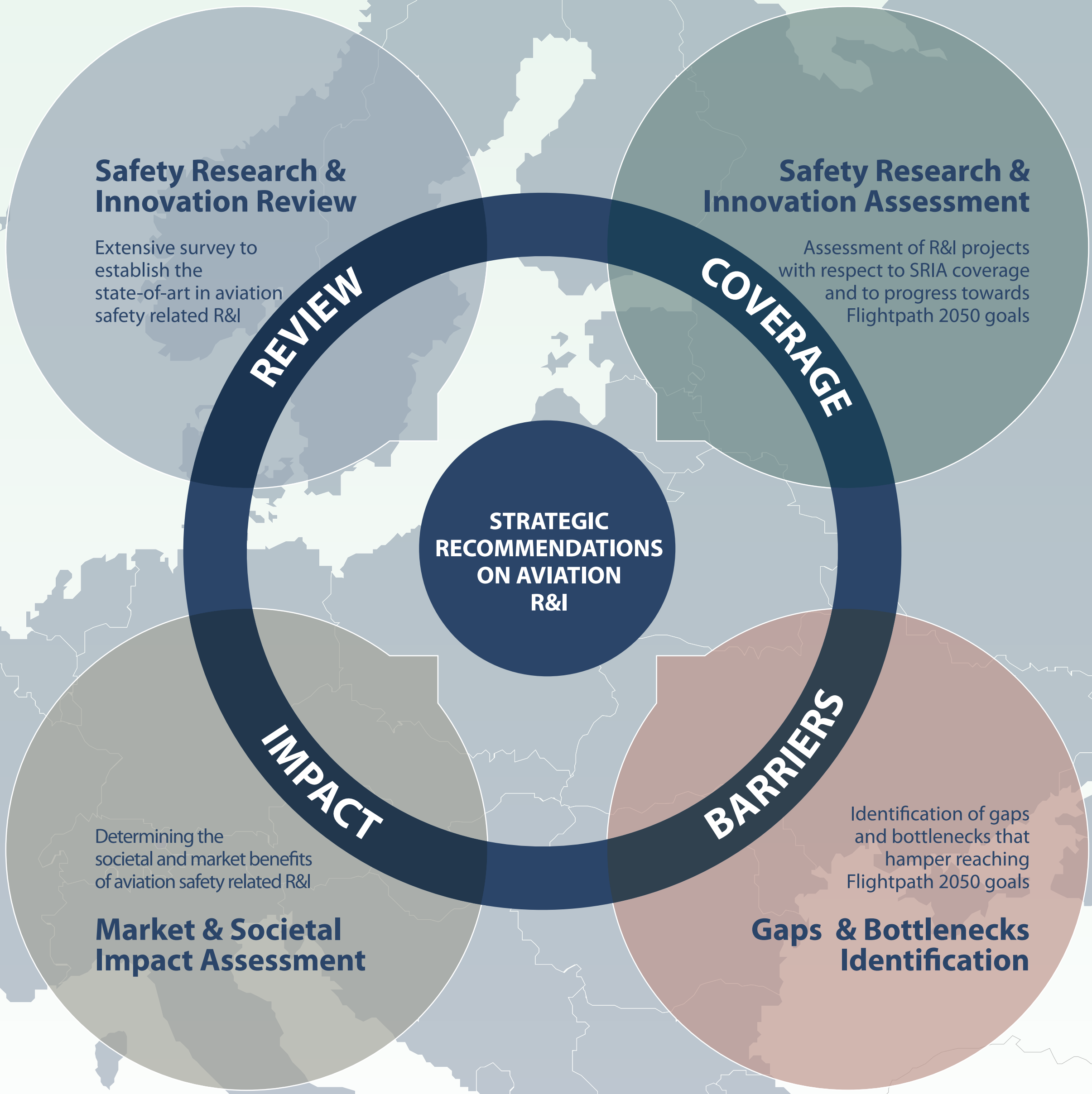
The Advisory Council for Aviation Research and Innovation in Europe (ACARE) has provided Europe with a vision for aviation. To identify a pathway towards this vision, called Flightpath 2050, ACARE developed the Strategic Research and Innovation Agenda (SRIA), a roadmap providing guidance on what is required, as well as when it is required, and how it can be delivered via Research and Innovation (R&I) activities. The SRIA goals are challenging: ensuring that Europe maintains its competitive edge in the global market through sustainable investment in R&I activities, and assuring that aviation achieves the highest levels of safety and security throughout the whole air transport system. A number of projects have been funded to see if we are on the right track towards Flightpath 2050. One such project is OPTICS.

ARE WE DOING THE RIGHT SAFETY RESEARCH?

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 OUTCOMES

- Extensive review of aviation safety R&I in and outside Europe; delivering an annual state-of-the-art review of R&I activities.
- Assessment of selected projects and their impact towards achieving the FlightPath 2050 goals.
- Evaluation of the overall societal and market impact of safety R&I activities in aviation safety.
- Conclusions and recommendations on key gaps within safety R&I activities needed to achieve the identified safety goals, and on the most promising research avenues for consideration by aviation stakeholders and policy deciders.



EACH YEAR OPTICS ASSESSES PROJECTS FROM DIFFERENT RESEARCH PROGRAMS, SO THAT BY 2017 THERE IS A GLOBAL VIEW OF THE STATE OF AVIATION SAFETY RESEARCH.

2014

- State-of-the-art in safety research, ***First release***: FP7 projects
- Project repository - ***First release***
- Methodological framework
- Workshop #1: ***Human Factors***

2015

- State-of-the-art in safety research, ***Second release***: SESAR, SESAR WP-E, Future Sky Safety, Clean Sky projects
- Project repository - ***Second release***
- ***Report*** on preliminary market and societal impact assessment
- Workshop #2: ***Hazard Management***

2016

- State-of-the-art in safety research, ***Third release***: national projects
- Project repository - ***Third release***
- Workshop #3: ***Do Politics and Safety mix well?***

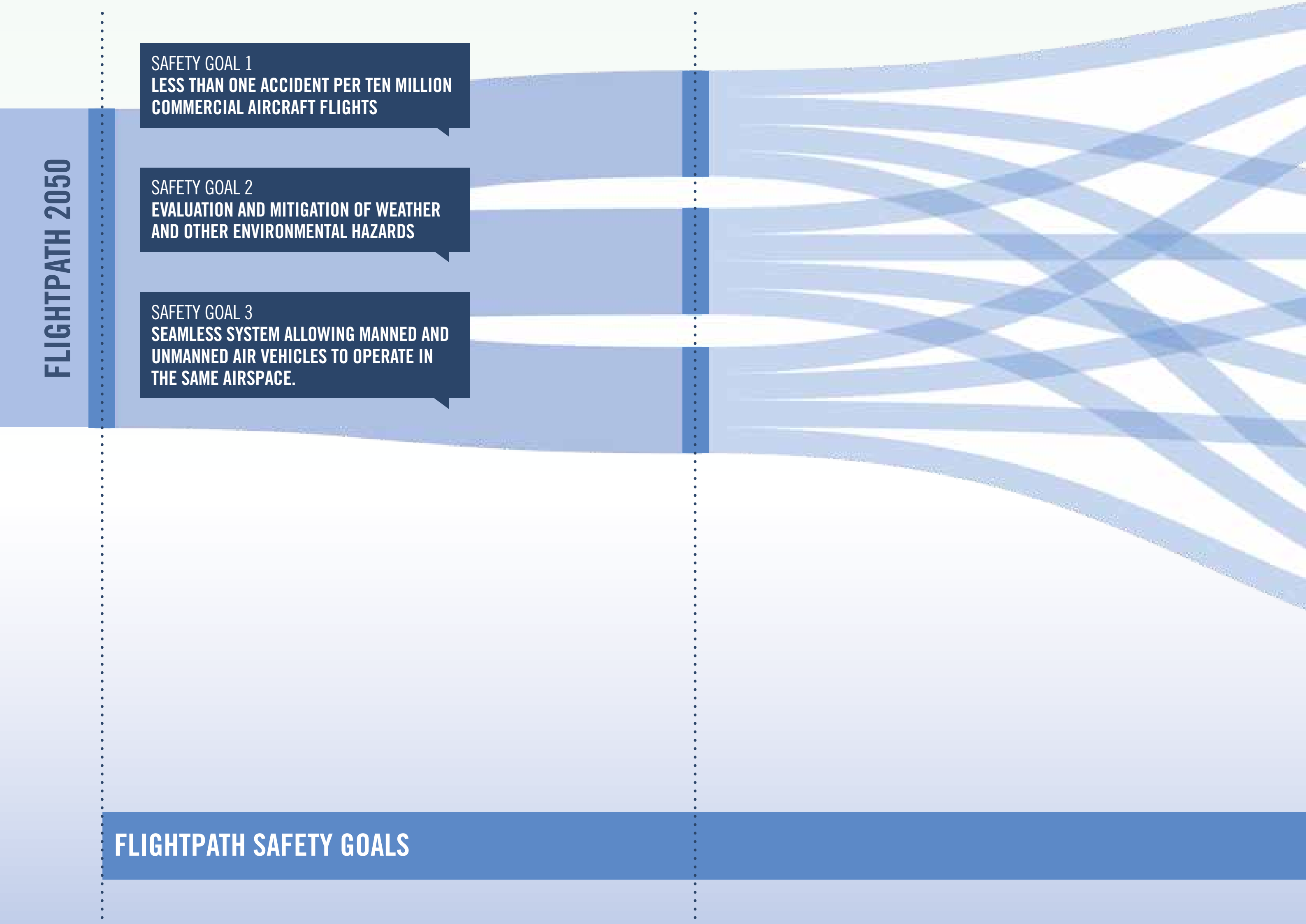
2017

- State-of-the-art in safety research, ***Consolidated report***: non European projects
- Project repository – ***Final release***
- ***Consolidated report*** on market and societal impact assessment
- Workshop #4: ***Resilience by design***

HOW OPTICS **WORKS**

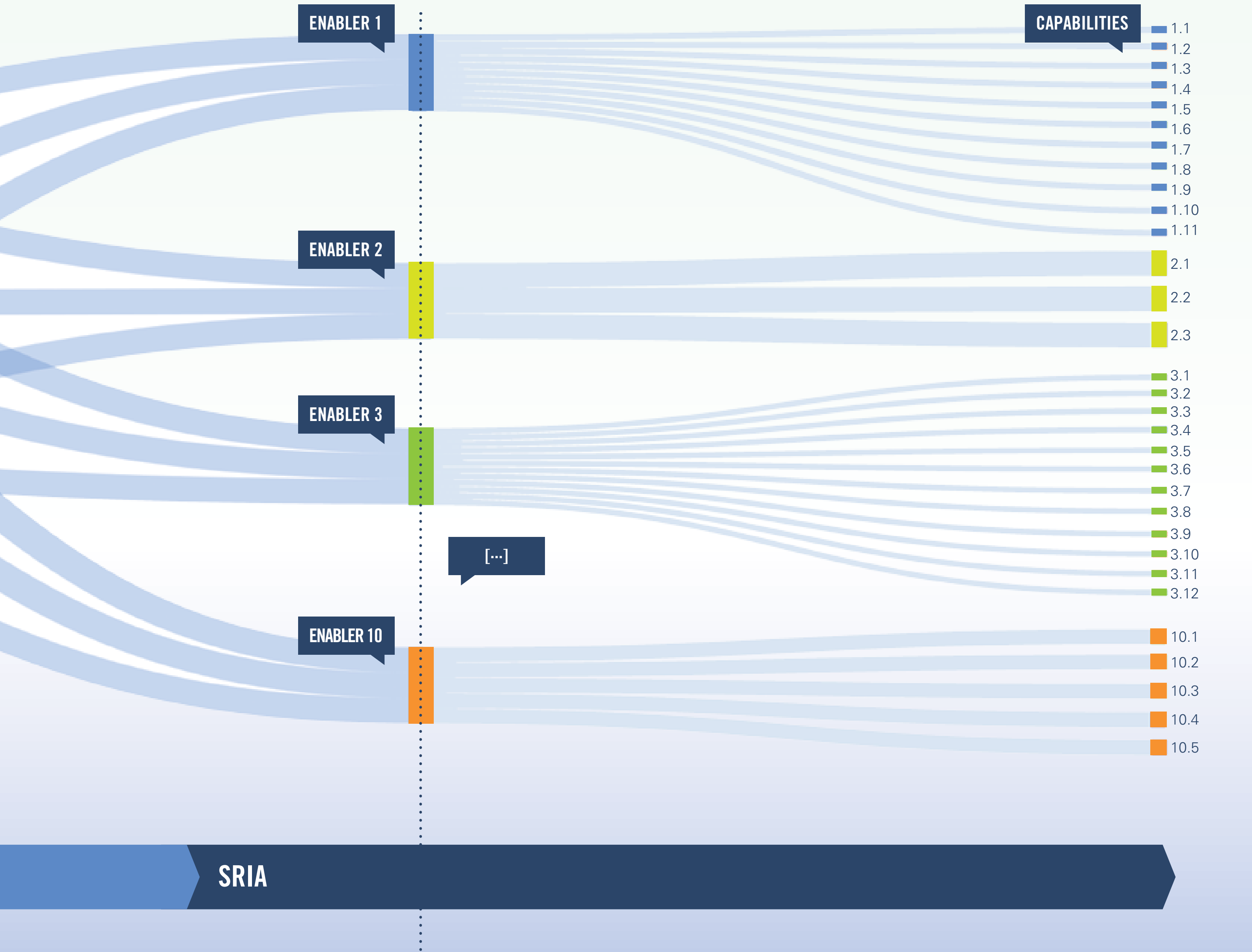
The Flightpath 2050 Safety Goals will be achieved by realising four overall clusters of R&I activities:

1. **Societal expectations concerning aviation safety**
   reassuring the public and regulators it is safe to fly via proper safety governance.
2. **Air vehicle operations and traffic management**
   operating all aspects of the air transport system safely.
3. **Design, manufacturing and certification**
   delivering intrinsically safe aviation systems.
4. **Human Factors**
   ensuring that all human elements –including passengers– work together safely.



This is the vision: if we can design, build and certify safer aircraft and air traffic management systems, if we can operate them in safer ways, and if we can optimise the human element on the ground and in the air, we will achieve the goal of one accident in ten million flights, even with drones integrated into civil airspace and with difficult weather patterns. The question is whether the research we are funding and executing is helping us achieve this vision.

But this vision is too high level to evaluate if safety research is progressing in the right direction. Therefore the four clusters are broken down into ten more concrete **Safety Enablers**. These Enablers are the key properties of the future system that will deliver the safety goals of 2050, such as a system-wide safety management system (SMS), resilient system designs, and properly balanced human centred automation. If we achieve these Enablers, we deliver the vision and we will be able to meet the safety goals. Because the Enablers are still high level, covering broad areas of safety research and engineering, and safety-related disciplines, each Enabler is further broken down into a number of 'bite-size' **Capabilities**, which are more manageable as research objectives. It is then possible to compare ongoing R&I activities to the Capabilities and see where there is research serving them, where it brings the expected benefits to society, and where there are gaps, and hence answer the questions that OPTICS the poses: **Are we doing the right research? Are we doing the research right?**

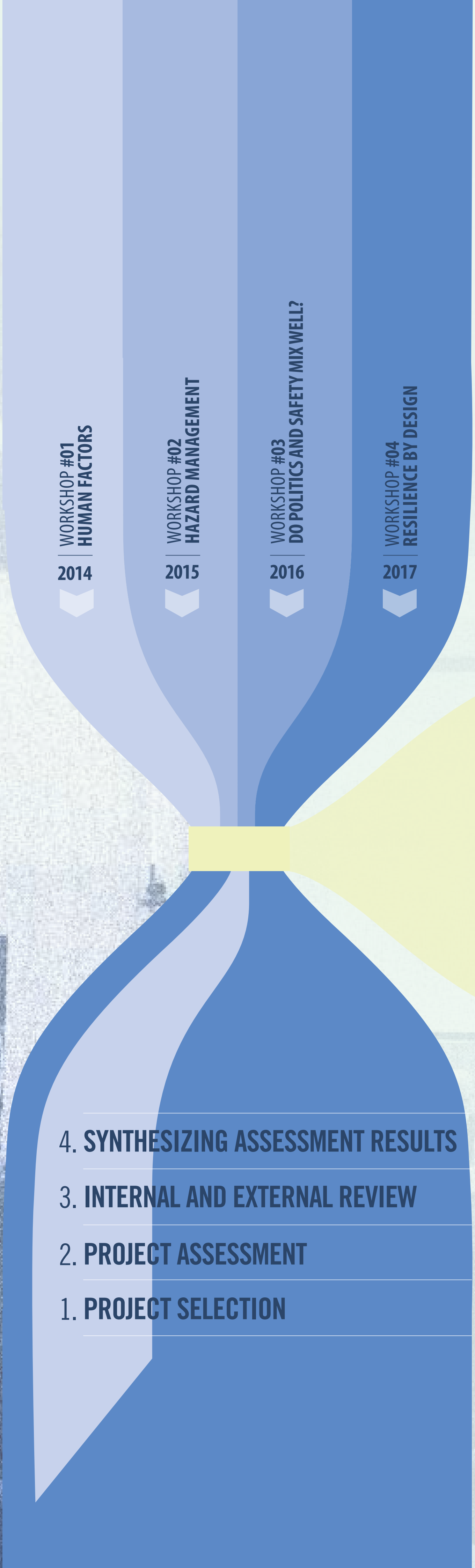


LOOKING **BOTH WAYS**

OPTICS is therefore like a magnifying lens, seeing all the way from the Safety Goals through the clusters to the Enablers and finally down to the level of Capabilities, which is the level where most safety research projects operate. But looking through a lens is not enough, it is sometimes necessary to step back and see the broader picture. For this reason OPTICS adopts a twofold approach to evaluate safety R&I activities in aviation and air transport, in order to assess if the right research is being conducted and if research is delivering the expected benefits to society.

The bottom-up project-based assessment focuses on how safety R&I projects and programmes cover the SRIA Capabilities – and hence the Enablers, clusters and goals – and allows the identification of research strengths and gaps, as well as bottlenecks or constraints affecting research progress. But there is always the chance that the SRIA is missing a relevant research avenue. The bottom-up assessment is therefore complemented by top-down workshops in which aviation experts with an overview of safety R&I identify issues and opportunities. The experts can look at the SRIA, or completely ignore it, and simply tell us where they think the research priorities lie. Most of the assessment effort in OPTICS is bottom-up, since assessing projects takes time, whereas a three day top-down workshop can yield a prioritised list of top ten research issues in a particular area relatively quickly. Typically, the workshops are carried out at Cluster level based on specific research topics, incorporating a focus on Enablers within that cluster.

These results from bottom-up and top-down processes are then reviewed and compiled to provide strategic recommendations to the EC and/or ACARE via an annual 'State-of-the-Art' report, including suggested corrective actions and priorities.



TOP-DOWN APPROACH

FROM EXPERTS TO PRIORITIES & GAPS

This approach is structured around workshops with aviation safety experts, used to identify major R&I priorities, issues, and opportunities for new research.

Each workshop has a specific topic, selected amongst critical elements for aviation safety and mapped onto the SRIA Volume 2.

ASSESSMENT RESULTS

- Safety R&I gaps and bottlenecks
- Recommended priorities in safety R&I
- Ideas for new projects
- Updated SRIA
- Strategic recommendations to EC and ACARE, including suggested corrective actions

BOTTOM-UP APPROACH

FROM PROJECTS TO SRIA

Structured assessment of how R&I projects contribute (individually and on aggregate) to elements of the SRIA Volume 2.

Metrics for the assessment:

- Contribution to SRIA
- Maturity of the results
- Ease of adoption of the innovation (economic, legal/regulatory and organisational)

ARE WE DOING THE **RIGHT RESEARCH?**

The best way to gain an overview of whether we are moving in a good direction towards the 2050 safety goals is at the Enabler level – the Clusters are too hazy, and the Capabilities are too numerous. The state of each Enabler is defined by five relevant criteria:

Coverage the key criterion that indicates the degree to which research is occurring in this Enabler. OPTICS found that two Enablers are doing well, seven reach a reasonable level of coverage by research, while one Enabler is completely unaddressed. This picture is encouraging, especially considering the SRIA 2030/2050 targets, but research on Passenger Management is largely missing.

Maturity is next, and tells us how close – on average – to industrialisation the research is – whether it is still at the concept stage, or at the prototype stage, or is conducting live trials and is close to realising its operational potential. Through this indicator, OPTICS tries to understand how many projects actually make it into operational deployment.

Ease of Adoption relates firstly to the **economics of the research** – will it be too costly to ever implement? Whilst OPTICS has found some projects that fall into this category, most do not. This means that the researchers are not overly 'dreaming' when it comes to safety research.

Ease of Adoption also concerns the **legal aspects of the research**, usually relating to certification requirements should the research mature to readiness. In some cases, the good ideas found in some projects are unlikely to ever make it into practice because the discussions with the regulators did not occur early enough. This is an issue which EASA is concerned about, and the topic was discussed several times during the OPTICS workshops.

The third **Ease of Adoption** aspect relates to industry's appetite for what the research is aiming to deliver, and is often called the **organisational 'pull'.** Great research will not make it into practice if industry does not know about it or remains unconvinced or is looking at other options. This is a concern to OPTICS, and the 3rd OPTICS workshop was dedicated to understanding how to obtain better industry engagement with the research delivery process.

OPTICS carried on its assessment process incrementally. In the first year, the assessment focused on safety-related FP7 projects. In the second year, the state-of-the-art was integrated with projects from different research programmes: SESAR, SESAR WPE, Clean Sky (C-SKY), Future Sky Safety (FSS), as well as FP7 projects with an implicit, rather than direct, safety goal. The third year was dedicated to the national research projects in Europe, funded by national or regional funds.

2014: FP7 Projects → **2015:** SESAR, SESAR WP-E, Clean Sky, FSS Projects → **2016:** National Projects

After three years, with more than 200 projects assessed, OPTICS was able to provide a reasonably complete overview of the status of the European aviation safety research, and how well we are performing against the SRIA goals. In its final year, OPTICS is performing a comparison with other international programmes, aiming to answer the following questions: Are they looking at the same things we are? Are they tackling any of the issues in a different way, maybe with better ideas? Are they focusing on things we are not? Are they skipping some things we are focusing on?

Detailed results for each of the ten Safety Enablers are given in the following pages, including the identification of gaps and bottlenecks.

ENABLER 1
SYSTEM-WIDE SAFETY MANAGEMENT SYSTEMS

Managing safety is a strength of aviation. Most sectors across aviation use a Safety Management System or equivalent, i.e. formal ways of managing safety through analysis of safety and operational data. This helps learning from the past to protect the future, as well as using safety cases to determine if new systems or system changes are safe enough, and if not, to determine what needs to be done.

Although most of the capabilities of this enablers are addressed, even with a good level of coverage, the actual adoption of a system-wide SMS that hits the total aviation system is still far from happening. Few projects consider the aviation system as a whole, and cross-boundary hazards, and risk issues dependent on the interactions between stakeholders, are often unaddressed.

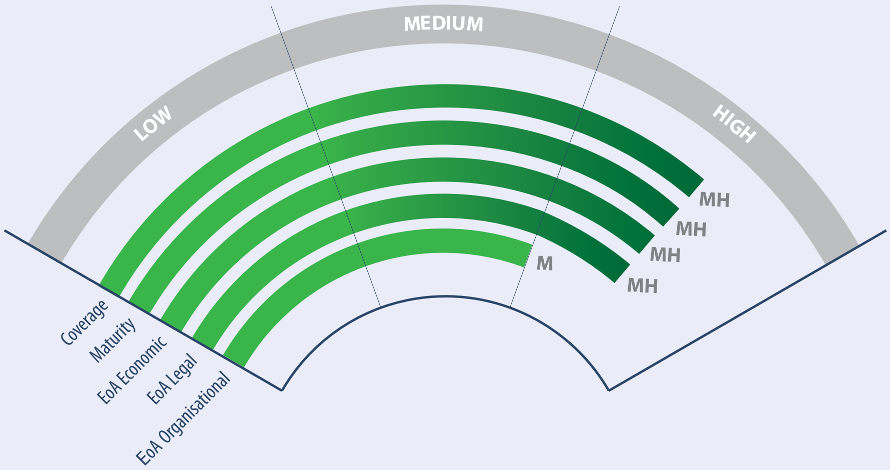
The lack of data sharing across organisations and sectors of industry is a bottleneck. Even when it comes to the research field, constraints are encountered due to confidentiality of data, legal issues, union considerations, etc. As emerged during the 2nd OPTICS Workshop, the only way to reach an overall SMS is to persuade the industry to get on with sharing operational data (not only incident data), and use new data science approaches to 'see around the corner'.

Aspects that are well addressed by European research concern the implementation of an operational risk management system and the development of tools, metrics and methodologies to assess and pro-actively manage current and emergent risks. Although complete coverage is not yet achieved, there seem to be no major obstacles in order to implement this innovation using existing data.

The Enabler full coverage can be reached by tackling the trans-modal aspects, for example through a multi-modal approach to safety or implementing effective and efficient trans-modal safety regulations and procedures. The former is probably a 2035 issue, and thus is not seen as urgent, while for the latter there is work ongoing for example via the approach of performance-based regulation (although there are not yet specific research projects on this area). A future potential game-changer, as remotely piloted aircraft systems is today, could be the arrival of personal vehicles, which would pose novel safety issues (e.g. non-professional pilots). Research exploring future operational concepts involving personal vehicles should start soon.

RESEARCH ROADMAP: WHAT'S NEXT?

- Enable the use of Safety Performance Indicators covering the total aviation system by addressing bottlenecks related to data ownership, data use and data protection, and regulatory acceptance.
- Transfer findings on tools, metrics and methodologies for the assessment and pro-active management of current and emergent risks to key aviation players, including regulators, in order to allow the adoption of proactive risk-based performance management systems across the entire aviation system.
- Start looking at the long term challenges, such as the development of integrated safety competence and safety management policies across multiple transport modes, as well as the seamless introduction of personal air vehicles.



ADDRESSED CAPABILITIES

1.1 *Medium coverage*
Understanding safety factors on transport system

1.2 *Med-high coverage*
System-wide operational risk management system

1.4 *Low-med coverage*
Safety Management Systems integrated with Business Managements

1.5 *Medium coverage*
Effective and efficient safety regulations and procedures

1.6 *Medium coverage*
Safety framework that ensures equity in access to airspace by all air vehicles

1.7 *High coverage*
Positive corporate safety culture within organisations

1.9 *Med-high coverage*
Tools, metrics and methodologies for risk assessment and management

1.10 *Medium coverage*
Pro-active identification of external hazards

1.11 *High coverage*
Measurement of system safety performance

UNADDRESSED CAPABILITIES

1.3 Transport (multi-modal) safety governance

1.8 Common safety risk management policy across all sectors of transport

COVERAGE COMPOSITION

ENABLER 2
SAFETY RADAR

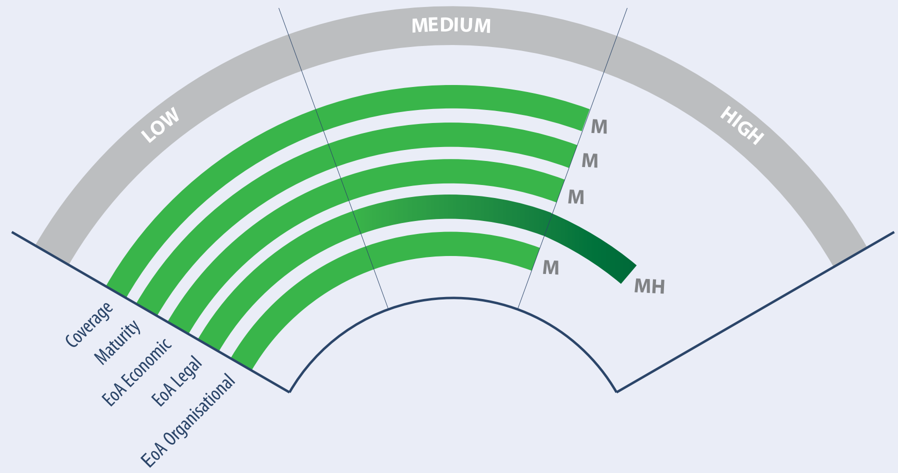
Although all three Capabilities under this Enabler are covered by projects, the actual research does not yet provide means for a real-time safety radar function. This area could benefit from data acquisition across the aviation system, while up to now only certain segments seem to be properly taken into account. A significant improvement in the coverage was provided by the analysis of national projects, which extended the scope of research and addressed additional stakeholders of the aviation system.

These projects address a variety of environmental and external hazards, including extreme weather events, lightning, and wake-turbulence. However, there is still something to do when it comes to the "pro-active identification" of these hazards. Also, more focused research needs to occur to bring the technology readiness level (TRL) closer to an operational system, or at least a prototype. Such a system could be developed in ATM, for example, initially in certain locations but ultimately for the entire European network, with the goal being to have a relatively short look-ahead window of between 15 and 30 minutes for hazard avoidance purposes.

When it comes to behavioural analysis, a large set of aviation stakeholders is addressed, even though additional research for pilots and flight crew seems to be needed to achieve the SRIA targets. Similarly, the analysis of customer behaviour should be extended to situations other than emergency evacuation under fire conditions.

RESEARCH ROADMAP: WHAT'S NEXT?

- There is still a lack of investigation on the dependencies between certain passengers' behaviours and safety critical situations arising consequently.
- Issues in data sharing represent a bottleneck to achieve the real-time Safety radar target.
- A better access to data will benefit all three capabilities under this enabler.



ADDRESSED CAPABILITIES

2.1 *Medium coverage*	**2.2** *Med-high coverage*	**2.3** *Medium coverage*
Behaviour analysis for safety hazards identification	Behaviour analysis of airspace and airport use	Pro-active identification of the external hazards

COVERAGE COMPOSITION

ENABLER 3

OPERATIONAL MISSION MANAGEMENT SYSTEMS AND PROCEDURES

This is a key Enabler since it concerns safe flight operations. This is the 'sharp end' of safety, so it is not surprising that this area is relatively well-served by research. A notable amount of research is being performed on on-board sensors to ensure hazard avoidance in-flight and on the ground, and on new safety concepts to allow airspace and runway optimisation and maximise the use of these resources.

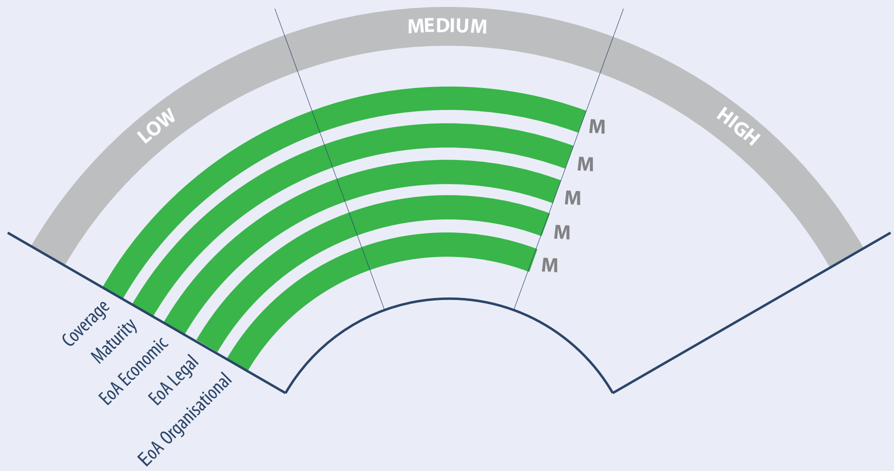
Projects from all the funding schemes can be found under this enabler, and research on the identification, warning and avoidance of meteorological and other external hazards (e.g. traffic proximity, wild life, FOD), is quite advanced. Thus, a project aimed at bringing together the outcomes of the previous works should be encouraged, considering the limited economic and legal constraints for the introduction of such products. This would go a long way to achieving the 2050 goal of being able to fly in more difficult weather circumstances. Of course, it should be investigated to what extent the models and technologies developed enable the provision of meteorological information on a strategic, pre-tactical and tactical basis.

Hazard avoidance on the ground remains quite an unexplored area, as well as commercial space operations and integrated search and rescue capabilities. Research on the tracking and monitoring of all flights is lacking as well (although there is a global tracking initiative in place at the moment, under the auspices of ICAO, following the loss of MH370).

Finally, the integration of RPAS and drones into civil airspace needs urgent research, since at the present there seems to be no stable concept of operations on the table, although the introduction of drones is already happening. This is seen as a game-changer we were not prepared for by research, since most research focused on large-scale RPAS of the military variety, rather than the smaller 'domestic' drones or use of drones by global players such as Amazon and Google. Research in this field should go together with the development of a new CONOPS that accommodates the rapidity and scale of developments occurring with RPAS/UAS and their impending integration into airspace. This new CONOPS must address issues ranging from legal (who is liable in case of an accident?) to regulatory (how must the operators and manufacturers account for safety and protection of the consumer?) to human performance (how can pilots and controllers manage the step-change in traffic complexity that may occur with UAS/RPAS?).

RESEARCH ROADMAP: WHAT'S NEXT?

- Hazard avoidance on the ground is still quite unexplored, and little attention is given to hazard to civil aviation, such as bird detection.
- Aircraft operators are under-represented, so there is a need to balance mission planning from a pilot´s perspective and the impact on network operations. The impact of Human Factors on the successful/safe introduction of UAS in the civil airspace seems to be under-represented.



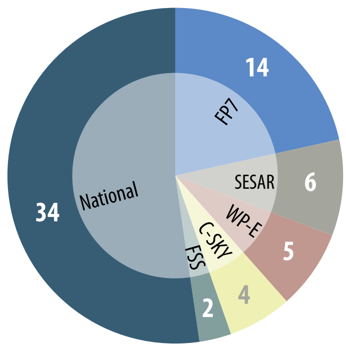
ADDRESSED CAPABILITIES

3.1	*Med-high coverage*	Mission planning models addressing environmental hazards
3.2	*Medium coverage*	Predictive & Real Time complexity assessment to support mission planning
3.3	*Medium coverage*	Hazard avoidance in-flight and on the ground
3.5	*Med-high coverage*	Safe integration of non-commercial flights, personal air vehicles and UAS
3.6	*Medium coverage*	Adaptive automation allowing human intervention
3.7	*Medium coverage*	Safety concepts allowing maximum use of resources
3.8	*Low coverage*	Seamless robust CNS coverage

UNADDRESSED CAPABILITIES

3.4 Safe merging of Commercial Space operations with traditional flight operations and airspace structures
3.9 Integrated search and rescue capabilities, rapid and appropriate intervention
3.10 Unique and positive identification, tracking and monitoring of all flight objects
3.11. Globally networked organisational structures to support safety and/or security crisis

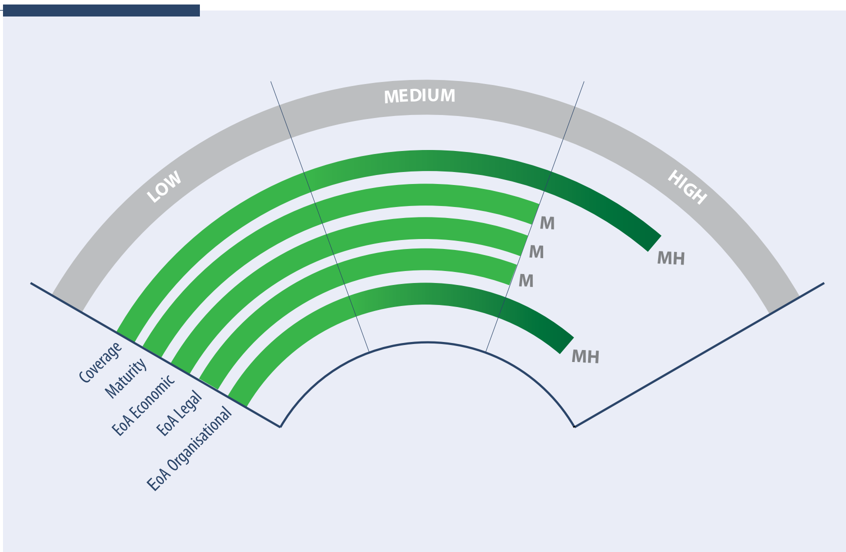
COVERAGE COMPOSITION



ENABLER 4

SYSTEM BEHAVIOUR MONITORING AND HEALTH MANAGEMENT

One of the 2050 safety goals concerns better search and rescue, something that was found only in one national project dedicated to the investigation of technologies enabling global surveillance and vehicle monitoring. A safe and efficient concept of operation is needed as well.



The lack of European projects on this topic confirmed ACARE's Working Group 4 (Safety and Security) opinion that passenger and crew survivability, tracking, and search and rescue is under-represented by research. It is as if, once there is an aircraft loss, it is presumed there are no survivors, which is not always the case. Therefore, additional research in these 'post-accident' areas is warranted.

Most of the effort under this enabler is devoted to improving health monitoring capabilities and maintenance processes. This research area is particularly well addressed by national research, which covers a wide range of systems and tools to improve health monitoring and system response to failures. Despite the amount of work, research on self-healing technology is still at a low level of maturity, and additional effort is required to see real progresses in the field and accomplish the 2050 goal of enabling automated self-correcting capabilities for all critical systems.

Another gap to be filled is represented by the need to guarantee reliability and security for health management systems, which are vulnerable to risks due to technological limits or malevolent attacks. Health management and self-healing for air vehicle operations in flight and traffic management is also a relatively empty area. There is a need to overcome current limits in fast and efficient implementation of aircraft system health management, and for the ability to face slowly or rapidly evolving critical situations during flight.

ADDRESSED CAPABILITIES

4.1 *Low-med coverage*

Continuous health management of airports and airspace

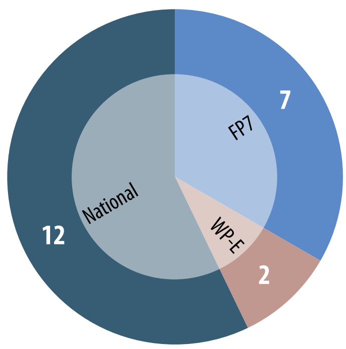
4.2 *Med-high coverage*

Global surveillance for tracking and location of air vehicles

4.3 *Med-high coverage*

Innovative Health Management systems and Maintenance

COVERAGE COMPOSITION

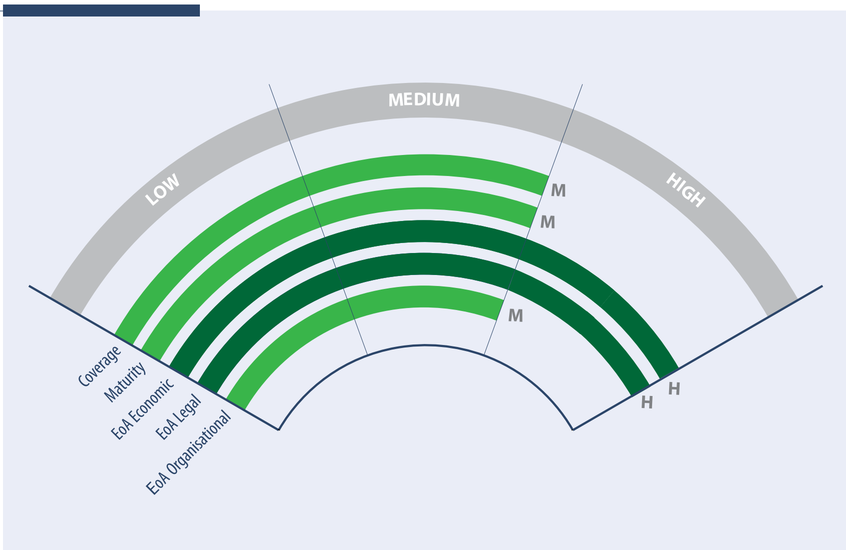


RESEARCH ROADMAP: WHAT'S NEXT?

- Need for additional research on the tracking and locating of air vehicles in case of serious accidents. Novel manufacturing techniques can be used to improve damage tolerance of materials and increase survivability in case of accidents.
- Research on continuous health monitoring of airports and airspace is still at low TRL, and the identified approaches for system performance monitoring are barely applicable to complex systems.

ENABLER 5
FORENSIC ANALYSIS

Incident and accident investigation is a cornerstone of safety in the entire aviation system, and recent initiatives have helped to ensure better reporting through Just Culture and Safety Culture initiatives, as well as regulations in the area. Nevertheless, this area tends to be stuck in looking backwards, and sharing of data remains an issue.



The point is not solely the lack of data, but the problems in obtaining reliable data. This is the enabler to achieve the short, medium and long-term targets of the SRIA and try to move from a reactive approach (counting events) to a proactive one (indicators for safety learning and improvement). As emerged during the 3rd OPTICS Workshop, the only sensible way forward is for better collaboration across aviation industry sectors, e.g. via Collaborative Analysis Groups involving all the key stakeholders and data owners.

None of the assessed research addresses new sensor technology to capture key safety data, and not all stakeholders across the Air Transport System are taken into account (including e.g. general aviation). Furthermore, improvement in leading indicators from safety data (e.g. safety culture and processes) is missing. Lastly, there is not yet research dedicated to the identification of emergent vulnerabilities, i.e. of looking forwards to predict the next event. More generally, it is being discussed whether the focus should be on forensic analysis alone, or considering all forms of safety 'intelligence', and harnessing new technologies such as Big Data to try to learn before the event, and not only afterwards.

ADDRESSED CAPABILITIES

5.1 *Medium coverage*

Systematic analysis of safety data

5.3 New sensor technology to capture key safety data

COVERAGE COMPOSITION

RESEARCH ROADMAP: WHAT'S NEXT?

- Increase the research effort on the identification of emergent vulnerabilities.
- Need for a fully integrated means of capturing safety data of all stakeholders across the ATS (including e.g. general aviation), and improvement of e.g., safety culture and safety risk management processes.

ENABLER 6

STANDARDISATION AND CERTIFICATION

Both safety Capabilities under this Enabler are addressed, at least partly. In particular, the development of a common certification framework and the identification of new technologies and methods for the certification and approval process seem to be the most investigated areas in aviation safety R&I, with 28 projects between European and national ones addressing this Capability.

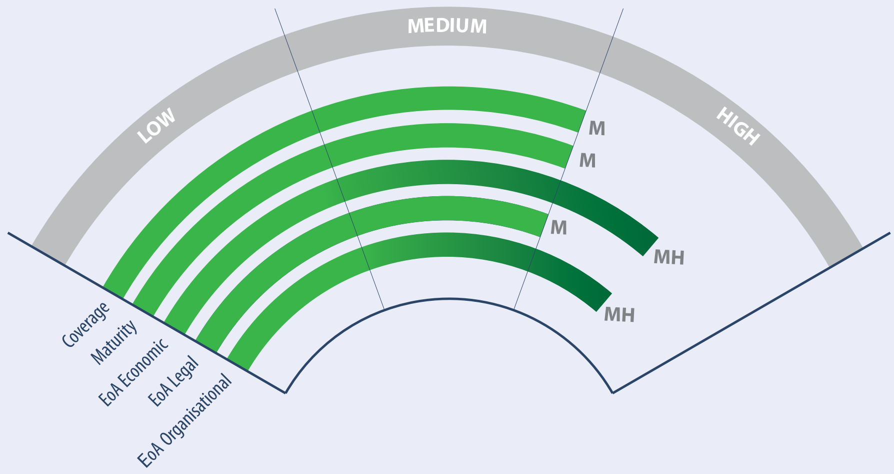
The proposed methodological framework (model-based) to tackle key technological challenges for aircraft design and airworthiness certification (e.g. modularity, complex system of systems, etc.) is not yet fully matured. But early linkage to industry standards (e.g. ARP 4761, ARP4754) allows a stepped approach.

However, several segments of the total aviation system are not yet addressed (e.g. light aircraft). There is a lack of use of large operational data sets to feed risk models, and the impact of organisational changes is not yet properly addressed. An issue specific to research is that sometimes projects do not consider certification aspects until too late, leading to research ideas that cannot be implemented.

Enabler 6 is one of the enablers characterised by high complementarity with other enablers. So, research under its capabilities is seen as a contributory factor to other capabilities, more as an ease of adoption facilitator than a research area by itself. High maturity research in this capability is therefore likely to happen only if coupled with high maturity in the accompanying capability.

RESEARCH ROADMAP: WHAT'S NEXT?

- Several segments of the total aviation system are still not considered (e.g. general aviation).
- Lack of work on system inter-dependencies and Human Factors.
- Use of large operational data sets to feed risk models is still missing, and the impact of organisational changes is not yet properly addressed.



ADDRESSED CAPABILITIES

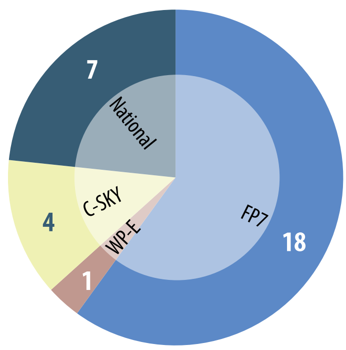
6.1 *Medium coverage*

Common framework for Certification / Approvals

6.4 *Medium coverage*

Air transport system standardisation, certification and approvals processes

COVERAGE COMPOSITION



ENABLER 7

RESILIENCE BY DESIGN

Resilience is neither a well-understood nor well-agreed concept, and yet it covers a broad range of areas and domains. This led to the need for the OPTICS team to expand the Resilience Capabilities into sub-capabilities, in order to be able to attach projects to this area. To complete the view on this topic, another OPTICS Workshop was dedicated solely to New Resilient Designs for Aviation. In the SRIA update, ACARE's Working Group 4 has already determined that this Enabler needs better explanation and rationalisation.

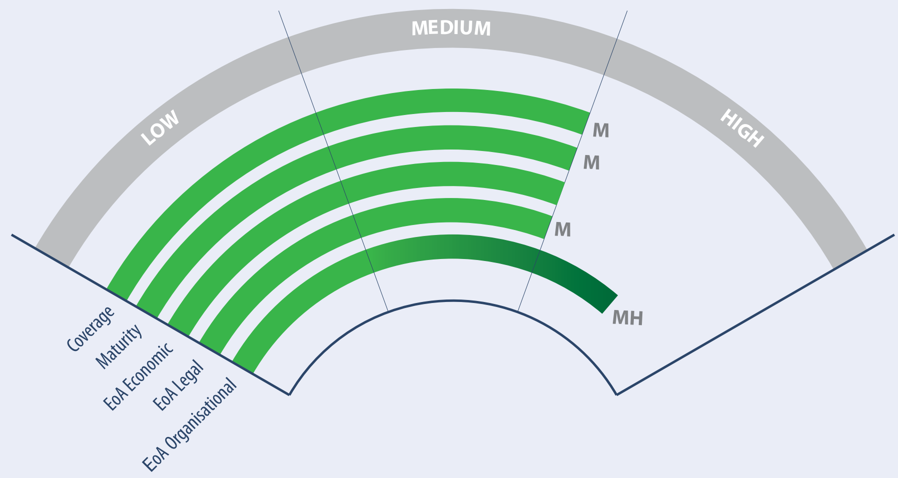
Despite this lack of clarity over the concept, there has been a lot of research in this area. Above all, ongoing research focuses on design to mitigate environmental hazards, new technologies and improved system designs, and on new materials and manufacturing techniques to improve survivability. Many of the projects aim to advance engineering and analysis capability, including Human Factors in design, all of which are cornerstones of Resilience by design. Possibly what is needed is a CSA-type project to better organise the research and the concept and help its connection with industry to ensure better transition into operation. Nevertheless, there is an urgent need to consider the new emerging threats on board, such as personal devices (mobile phones and/or tablets), and to evaluate their impact on the aircraft.

A research gap linked to human Resilience concerns the availability of suitably qualified and adaptable workforce as the aviation industry continues to evolve. This area of Resilience has strong links with Human Factors Enablers and in particular both Human-Centred Automation and New Crew and Team Concepts. SESAR's approach for ensuring that the results of safety analyses are fed back into the design process could be extended to other parts of the air transport system.

Research on crashworthiness is also lacking, though this is clearly a resilience area. This may require some new low-TRL research to come up with new ideas. Use of new materials and structures with adaptability properties can support the systems to reduce consequences of failure and increase passenger survivability chances. Improvement of standards to discipline the design for survivability is strongly recommended, as well as learning from other domains where survivability is a key issue.

RESEARCH ROADMAP: WHAT'S NEXT?

- Adopt a multi-disciplinary approach to research on crashworthiness and survivability, involving different disciplines and expertise. Where possible, look at solutions from other domains (e.g. nuclear and automotive).
- Extend the work on environmental hazards to risks other than ice and wake vortex. Future direction can be the development of integrated predictive sensors for environmental threats.
- More has to be done to form a suitably qualified and adaptable workforce as the aviation industry continues to evolve.



ADDRESSED CAPABILITIES

7.1 *Medium coverage*
Integration of safety / security analysis results into design process

7.2 *Medium coverage*
Systematic methods for ensuring in-service experience

7.3 *Med-high coverage*
Characterisation and mitigation of environmental hazards

7.5 *Medium coverage*
Improved resilience through new technologies or system designs

7.6 *Med-high coverage*
Improved survivability through new materials, manufacturing techniques & design

7.9 *Medium coverage*
Methodology and toolset for advanced Systems Engineering

7.10 *Med-high coverage*
Human factors and psycho-social issues in design and manufacturing

7.11 *Medium coverage*
Human factors and psycho-social issues in design and manufacturing

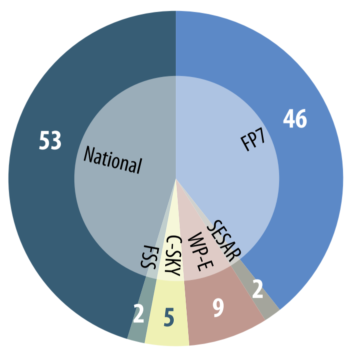
7.12 *Low-med coverage*
Reliability engineering of critical software

UNADDRESSED CAPABILITIES

7.7 Multi-modal forums for ATS design, involving the various interested parties

7.8 Availability of a suitably qualified and adaptable workforce and a framework which ensures the continued support to legacy and emerging technologies

COVERAGE COMPOSITION



ENABLER 8
HUMAN-CENTRED AUTOMATION

Human Centred Automation appears to be an area where there is 'low hanging fruit', i.e. the research is ready to be brought closer to industrialisation. However, there is a significant blockage, in that Human Factors does not typically enjoy a good position in organisational hierarchies, and there is a tendency to see Human Factors as the final step in design and development, by which time it is too late to 'get it right'. What is needed therefore is a way to raise the profile of Human Factors and see it better embedded into design organisations in particular, or else we will continue to see poor automation usage since it does not 'fit' the pilot/controller/airport driver, etc.

This may be achieved by benchmarking organisations according to their Human Factors Capabilities, which could be a high TRL research project aimed at harvesting the good research for industry while it is still fresh. Maturity of this area is also evidenced by recent guidance from UK CAA on how to get Human Centred Automation right, though it remains at a high level. Legal aspects of automation are still a bottleneck, as well as the impact of automation of human roles despite the amount of work on the optimal allocation of functions between human and machine, both in normal and degraded operations.

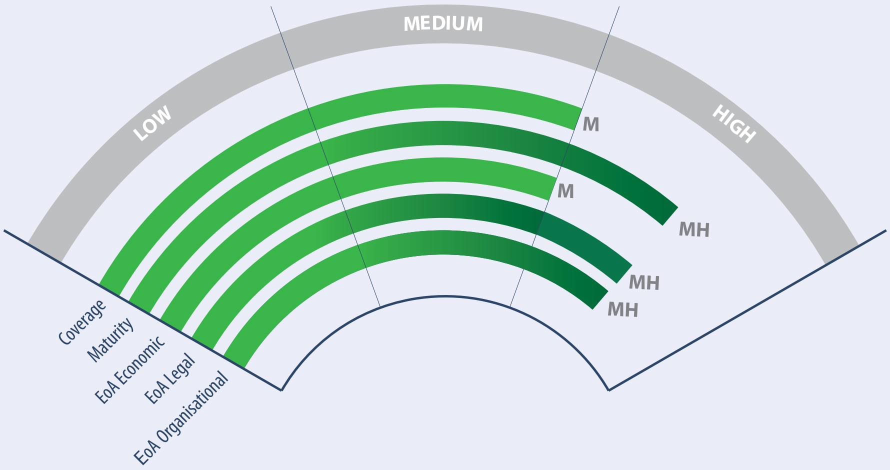
As pointed out at the 1st OPTICS Workshop, although automation has been around for a long time in Aviation there are still many unknowns about how to get it right, and caution was expressed from a regulatory perspective, when addressing automation adapted to an individual's performance.

There is still a lack of consolidation of past results, with a fragmented community heading in different directions. There isn't a good view on what's achieved, and it's possible to find projects doing similar research at different levels of maturity.

Preventive maintenance and system upgrades of automated systems are still unaddressed. Research on technologies to support turnaround processes could benefit from the integration of existing solutions with airport and aircraft.

RESEARCH ROADMAP: WHAT'S NEXT?

- A consolidated state-of-the-art overview on Human Centred Automation would be beneficial, as it appears to be an enabler ready for supporting the exploitation of research results so they can be migrated into live operations, and also avoiding further research duplication.
- The scope of Human Factors research needs to be extended to preventive maintenance. Automation support for maintenance operators should be investigated as well.



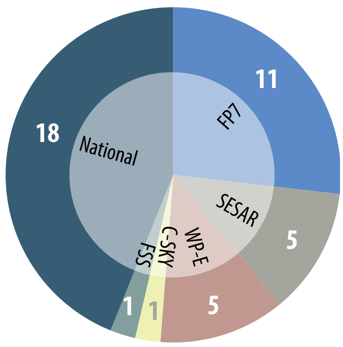
ADDRESSED CAPABILITIES

8.1 *Med-high coverage*	**8.2** *Medium coverage*	**8.4** *Low coverage*
Automation support	Human collaboration across seamless operational concepts	Technologies to support turnaround process

UNADDRESSED CAPABILITIES

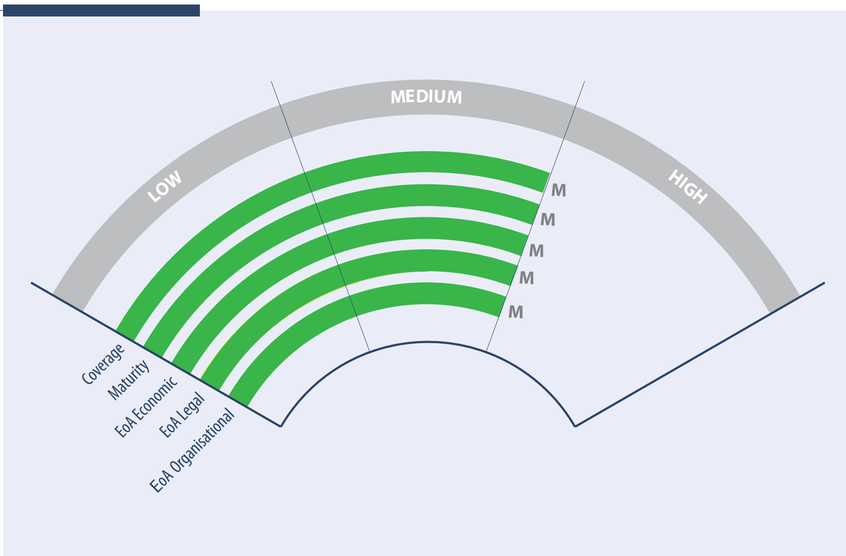
8.3 Automated processes and adapted human support systems for Preventive Maintenance.

COVERAGE COMPOSITION



ENABLER 9
NEW CREW AND TEAM CONCEPTS

Crew Resource Management has been a mainstay of aviation for decades, and a singular Human Factors success story. However, the future will almost certainly hold new challenges and new crew concepts, and questions such as how air and ground staff will interact with each other and with RPAS, for example, or future pilotless aircraft or even personal vehicles, remain relatively unaddressed. There needs to be research to evaluate the potential impact of such future concepts on human performance and safety of the entire air transport system.



Most of the projects lying in this area focus on solutions or concepts to support pilots or Air Traffic Controllers, while other aviation operators such as remote pilots, engineers, ground handlers or maintenance operators, are not covered by research. As for the previous enabler, in this area the lack of consolidation of past research, with a fragmented community, is a bottleneck for research progresses.

Although some projects proposed interesting and mature solutions, their adoption seems still far from becoming a reality. Issues can be anticipated in the acceptance by operators of the solutions, e.g., operators' opposition against being monitored, and opposition against different team concepts (e.g. single pilot operations). Similarly to high automation level acceptance, there is a need to tackle legal and organisational issues proactively, and at the system level (as a strategic issue, not project by project).

Additionally, none of the assessed research addresses the psycho-social needs of crew/team/organisation following a disaster, and passenger/personnel culture. The research assessed does not cover crews other than pilots and controllers – such as maintenance operators. In the future, more and more jobs will become inter-connected, so team concepts need to extend to the cooperation across professional roles further than controllers and pilots.

ADDRESSED CAPABILITIES

9.1 — *Low-med coverage*	9.2 — *Medium coverage*	9.3 — *Medium coverage*
New collaborative team concepts across the whole ATS system	Optimisation of human performance envelope	Monitoring of crew/team capacity

UNADDRESSED CAPABILITIES

9.4 Critical Incident Stress Management for crew/team/organisation following major disruption or disaster.

9.5 Analysis and understanding of the dimensions of passenger and personnel culture to foster system effectiveness in relation to safety and security goals.

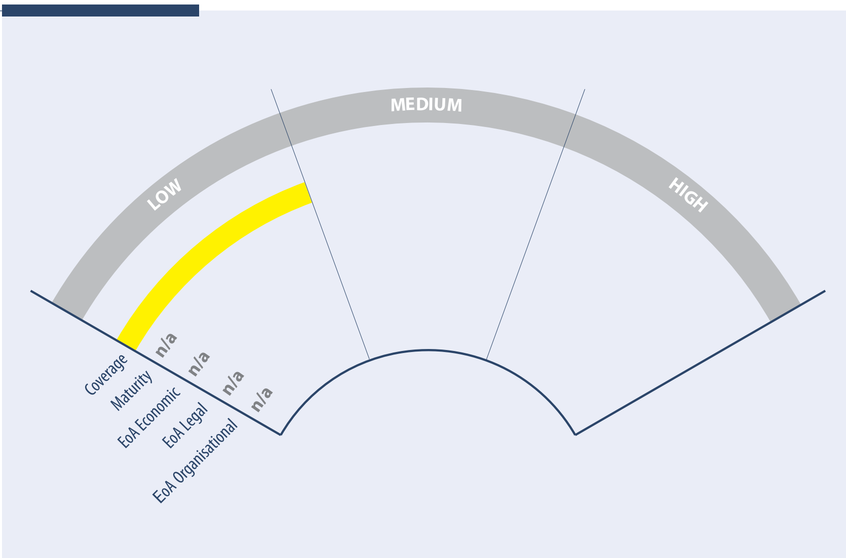
COVERAGE COMPOSITION

RESEARCH ROADMAP: WHAT'S NEXT?

- Team concepts need to outreach further than controllers and pilots, integrating maintenance operators and RPAS pilots and other aviation workers.
- Collaboration between teams from different organisations and cultures still need to be explored. Potential applications and transfer of project results to job design or training should be integrated in the research, to improve the ease of adoption.

ENABLER 10
PASSENGER MANAGEMENT

Clearly from the diagram, this appears at present to be a 'research desert'. All three safety relevant Capabilities – management of human behaviours during emergencies, post-traumatic stress and psycho-social needs after distress, and passenger culture – are unaddressed by European and national projects. Research needs to be initiated related to this Enabler, at least to reach the short term goals of developing an operational framework for emergency management, training multidisciplinary teams for crisis management and post crisis trauma, and investigate the dimensions of cultural diversity in order to understand their impact and relation with safety procedures.



UNADDRESSED CAPABILITIES

10.1 Improved prediction of terrorist threats or sabotage through the understanding of the socio-cultural aspects of threat.

10.2 Management of human behaviours during emergencies.

10.3 Ability to safely control disruptive behaviour.

10.4 Services address post-traumatic stress and psycho-social needs of passengers and public following major disruption or disaster.

10.5 Diverse dimensions of passenger culture are understood so that system change can positively respond to cultural diversity, influence cultural evolution and behaviours with an aim to enhance system effectiveness in relation to security goals.

ARE WE DOING THE **RESEARCH RIGHT?**

Beside the right direction of research, OPTICS is interested to understand whether safety research contributes to the socio-economic well-being of EU citizens. Do the direct and indirect benefits justify the investments made in such research, and do they allow the European market to maintain global leadership in aviation?

Following the Enabler-Capability information breakdown, OPTICS developed a framework for Socio-Economic Impact Assessment (SEIA) which, using projects and initiatives as "units of analysis", intends to assess the broad societal impact of research and provide answers to five questions:

- Does European safety research contribute to the well-being of society?
- Is European safety research giving Europe a competitive edge in the global market?
- Is European aviation safety research actually addressing European top safety risks?
- Are we well-equipped to do world-leading safety research?
- What is the societal 'return on investment' from aviation safety research?

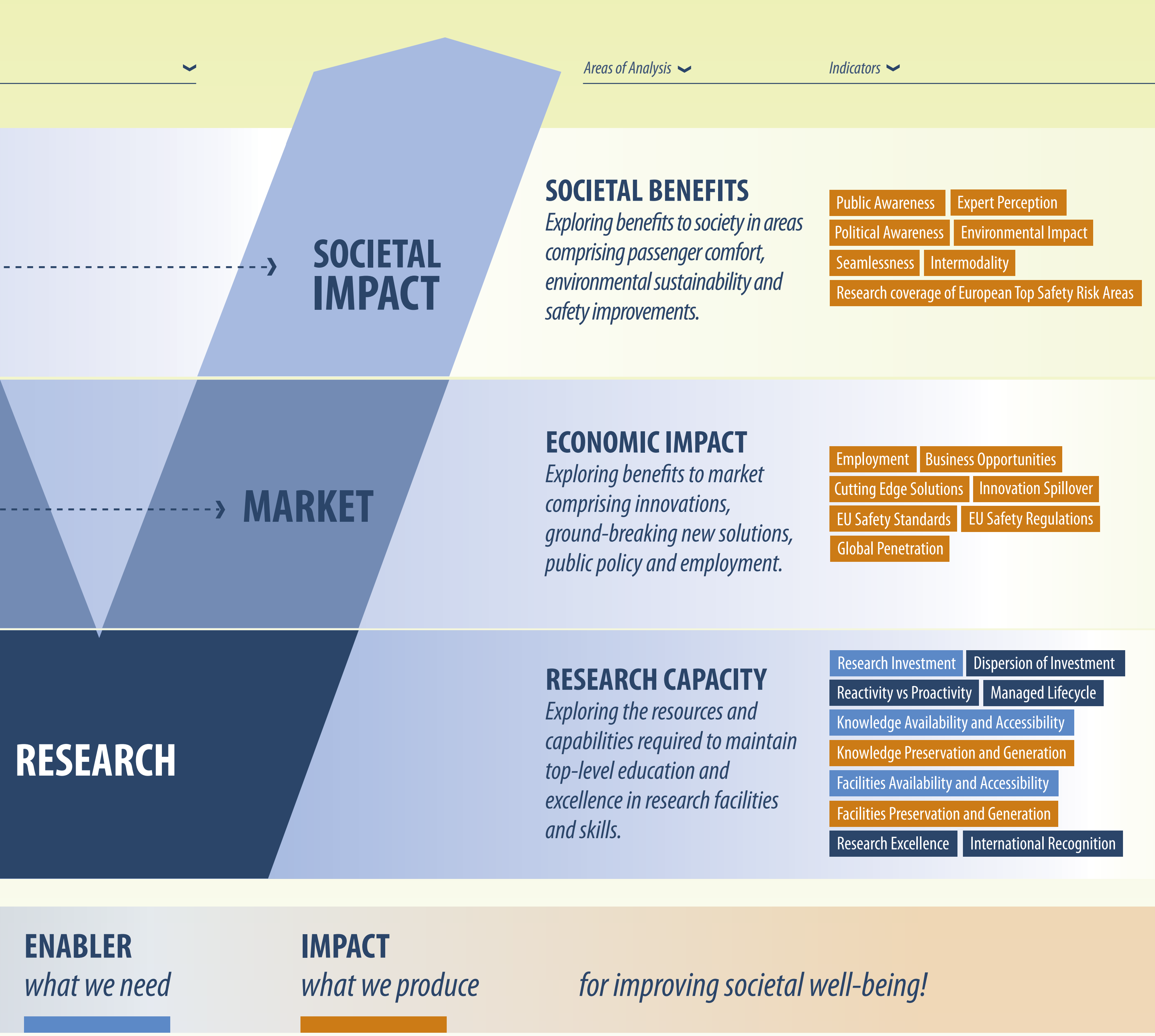
Three main areas of societal well-being in Europe are key within this Framework:

Societal Benefits. This area explores the impact of science on society as well as its actual contribution to safety improvements. It aims to address two questions: *Does European safety research contribute to well-being of society?* and *Is European aviation safety research actually addressing European top safety risks?*

Economic Impact: This area explores the economic impact of applied research. It aims to address the question *Is European safety research giving Europe a competitive edge in the global market?*

Research capacity: This area explores the resources and capabilities required to maintain top level education and excellence in research facilities and skills. It aims to address the question *Are we well-equipped to do world-leading safety research?*

Each area includes a set of indicators used as a basis for information collection and evaluation. The majority of the indicators are labelled as ***impact indicators*** measuring the effects generated by the aviation safety research conducted in Europe. A second set – labelled as ***enabler indicators*** – aims to assess the means needed to carry out safety research. The third and final set – labelled as ***foundation indicators*** – analyse high level contextual aspects upon which the aviation safety research is built.



The SEIA Framework was applied to a representative sub-set of ongoing research. The selected sample covers the large range of SRIA Enablers and gathers projects with different levels of maturity and sources of funding. The application of the Framework used data collected via internet and through surveys and interviews to project coordinators and generated valuable results. This handout presents a selection of those results, in the following areas:

- Societal Benefits, through the investigation of research coverage of European Top Risk Areas;
- Economic Impact, through the analysis of European Safety Standards and Regulations;
- Research Capacity, with the analysis of investments.

The application gives an initial understanding about the societal and economic benefits deriving from research, as well as recommendations for future full-scale applications of the Framework.

Sub-set of analysis
all projects for which financial data is available

62 FP7 Projects
10 Clean Sky Projects
15 SESAR WPE Projects
13 SESAR2020 Projects
6 H2020 Projects
5 Future Sky Safety Projects

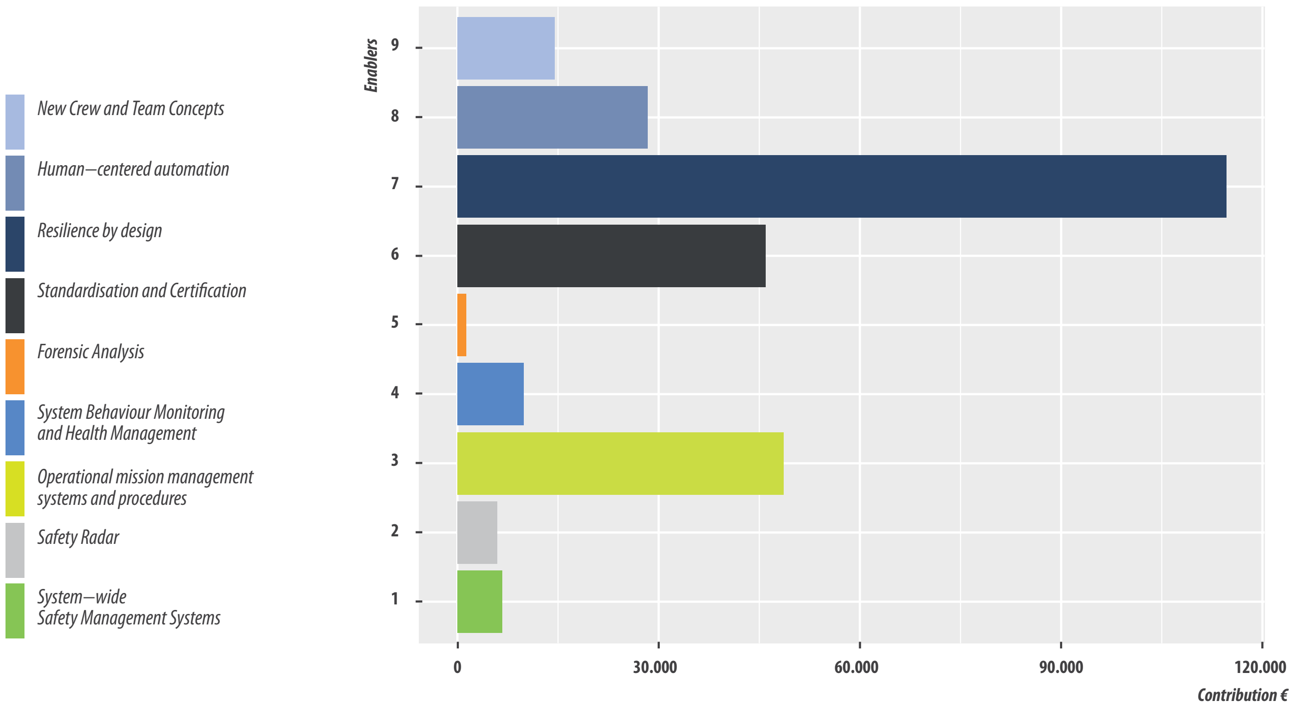
IS THERE A BUSINESS MODEL OF AVIATION SAFETY RESEARCH IN EUROPE?

The analysis of resources distribution across Europe, complemented with the broad overview on the state-of-the-art of European research, helps in understanding how European money is spent in aviation safety research.

The Research Investment indicator shows the distribution of funding among the SRIA's safety-related enablers and capabilities. The analysis comprises the majority of the projects assessed for the state-of-the-art and is based on the financial data available on the web or accessible through internal sources.

The indicator shows that the greater part of the European Contributions among the SRIA enablers goes to Enabler 7 *Resilience by design*, followed by the Enabler 3 *Operational mission Management systems and procedures* and Enabler 6 *Standardisation and Certification*. Zooming in to the analysis at capability level, Capability 7.5 *Improved resilience through new technologies or system designs*, would be by far the one with the largest funding. However, this Capability has a wide scope, and when it is narrowed-down at sub-capability level it loses the first place compared to Capability 6.1 *Common framework for Certification'* and Capability 8.1 *Automation supports human in both normal and degraded operations.* While the high investment in the Enabler 7 is motivated by the large set of research topics falling under the enabler, the large amount of funding in Enabler 6 is probably due to the perceived urgency for a common certification framework.

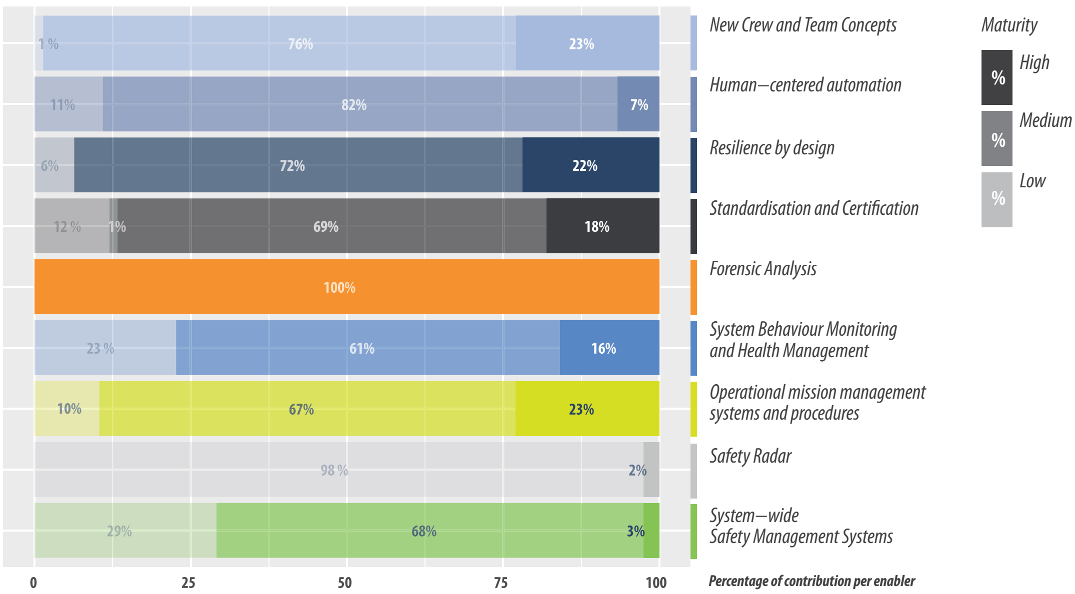
DISTRIBUTION OF CONTRIBUTIONS BY TYPE OF ENABLER



Although it is still a major area of investment, a progressive decrease in funds allotted to Enabler 7 *Resilience by design* is observed from 2008 up today, as well as on Enabler 6 *Standardisation and Certification*. An increasing trend is observed in the funds for research activities on Enablers 8 *Human-centred automation* and 9 *New Crew and Team Concepts*.

When looking at the three metrics of the Safety Research Assessment (Coverage, Maturity, Ease of Adoption), the analysis of funding shows that the majority of investments went to projects addressing a significant (Medium) or a small part (Low) of the scope of SRIA capabilities. This may be related to the level of definition of the capabilities in the SRIA, as it's almost impossible that a single project is able to cover the full scope of one capability. Satisfying results emerge when looking at the maturity indicator, as a strong concentration of funds went on projects that delivered a medium maturity outcome. However, the delivery of high maturity project outcomes is marginal and this brings to light a potential bottleneck, inhibiting the effective transition into operations of research outcomes. Furthermore, the legal and economic ease of adoption seem to be the most critical barrier towards industry uptake, hindering all the projects delivering new products, tools or systems that imply certification costs.

DISTRIBUTION OF CONTRIBUTIONS BY TYPE OF ENABLER AND MATURITY LEVEL



DEEP DIVE ANALYSIS OF INVESTMENTS

Enabler 3 **Operational Mission Management Systems and Procedures**

A healthy and clear trend of progress from medium maturity to high maturity emerges from the analysis of investments in this area. The strategy of prioritising projects with wide scope within the enabler but giving room for different approaches to tackle specific needs seems to work well for the nature of the enabler.

Enabler 6 **Standardisation and Certification**

This enabler is seen as a contributory factor to other enablers, more as an ease of adoption facilitator than a research area by itself. High maturity research in this enabler is likely to happen only if coupled with high maturity in the accompanying enabler.

Enabler 8 **Human-Centred Automation**

Although the topic is very popular, the lack of research with high maturity brings to light that the actual industrial results seem to be limited, or not progressing in the right direction. There is a need to re-think the role of automation research – including the underlying business model. Two ways forward are proposed. The first is for research to focus on low maturity projects with an exploratory nature, for example studying disruptive automation. The second is for a project (similar to a CSA) to 'harvest' the results of automation research so far (including from other transport modes), creating a coherent body of knowledge, and then interfacing with industry to see how such automation principles, concepts and practices can be exploited and transitioned into existing and future operational systems.

Sub-set of analysis
all projects with at least medium coverage and maturity

36 FP7 Projects
4 Clean Sky Projects
3 SESAR WP-E Projects
11 SESAR Projects
1 Future Sky Safety Project

IS AVIATION SAFETY RESEARCH ACTUALLY ADDRESSING EUROPEAN TOP SAFETY RISKS?

EUROPEAN TOP SAFETY RISK AREAS *

1. **Aircraft Upset in Flight (Loss of Control)**
2. **Aircraft System Failure**
3. **Ground Collisions and Ground Handling**
4. **Terrain Conflict**
5. **Runway Incursions**
6. **Abnormal Runway Contact and Excursions**
7. **Airborne Conflict**
8. **Fire**

**EASA Annual Safety Review 2016*

Statistics over the past decade show that European operators maintain a significantly lower rate of fatal accidents than the rest of the world, remaining well below 0.5 accidents per million departures since 2006 (EASA Annual Safety Review 2016). It is reasonable to think that aviation safety research has played a role in the continuous improvement of safe operations within the air transport industry. But this contribution remains obscure, with little explicit evidence showing direct causal relationships. By exploring the societal impact of investments in safety research, we aim to shed some light on links between research and safety improvement.

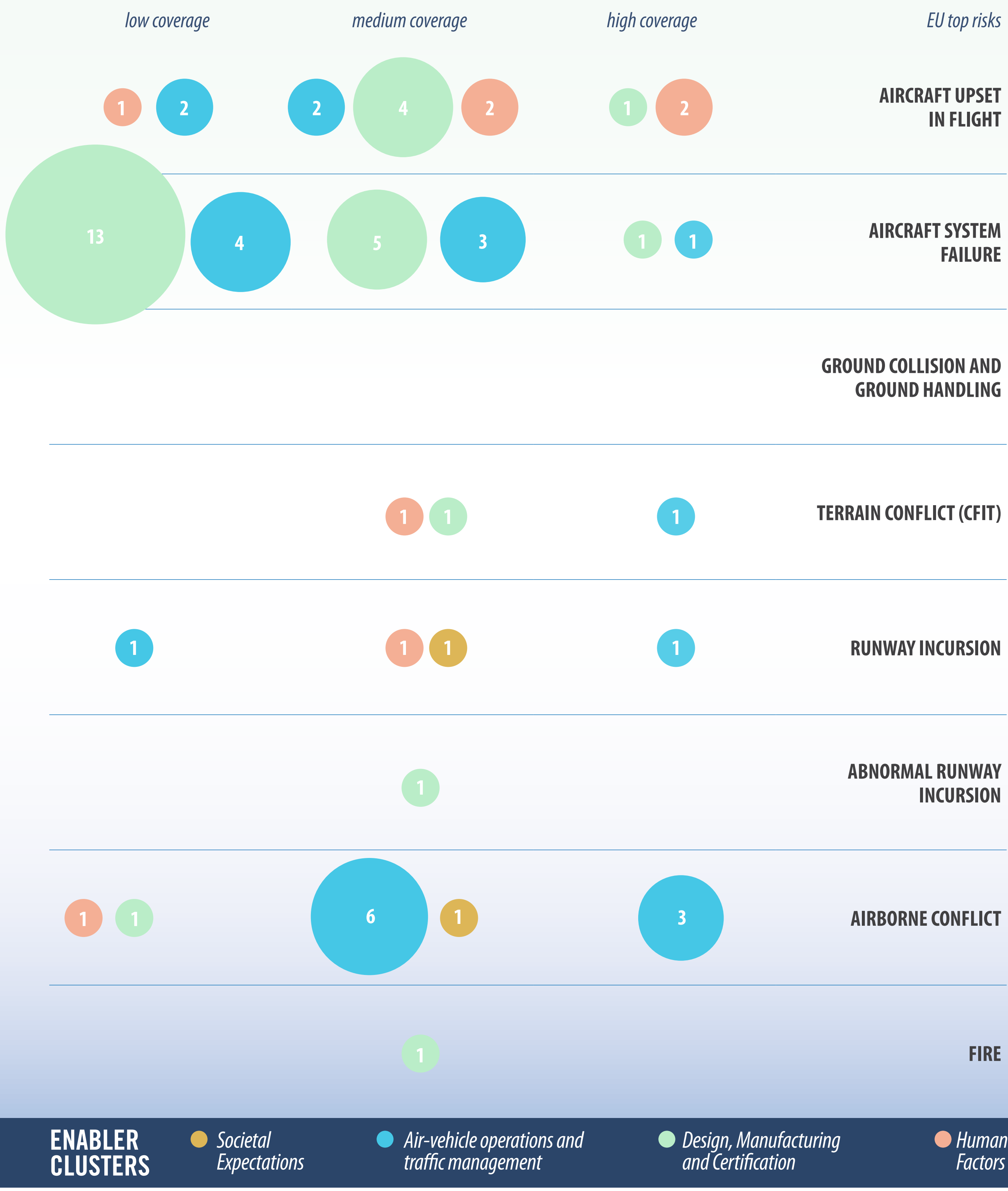
OPTICS assessed the contribution of a set of projects to the European Top Safety Risk Areas defined by EASA. As we are referring to current known safety deficiencies, projects with low TRL were excluded from the assessment. In the same way, projects with low contribution to capability were disregarded.

The research mapping shows that research coverage of European Top Risks is uneven. The two major risk areas – *Aircraft system failure* and *Airborne conflict* – are observed to be the most addressed by the European research activities, followed by the most fatal one *Loss of control / Aircraft Upset*. However, the level of coverage tends to be mostly low and medium, and only a few projects are associated with high contribution to these three risk areas. At the same time, a sort of a research desert is observed in *Ground collision and ground handling*, while a little research is found in *Abnormal runway contact and excursion* and *Fire*.

The most relevant contribution to current risks seems to come from the more operational enablers (i.e. Enabler 3 *Operational mission management systems and procedures* and Enabler 7 *Resilience by design*), which target more than one risk area.

The "organisational" enablers - Enabler 1 *System-wide Safety Management Systems,* Enablers 2 *Safety Radar* and Enabler 5 *Forensic Analysis* – are less directly connected to the Top Risk Areas. Thus, despite the relevance of research happening under these topics, the evaluation of the deriving safety benefits or safety impact is more difficult to realise.

DISTRIBUTION OF CONTRIBUTIONS BY TYPE OF ENABLER AND MATURITY LEVEL



Cluster 1
Societal Expectation includes Enabler 1

Cluster 2
Air-vehicle operations and traffic management' groups Enablers 2, 3, and 4

Cluster 3
Design, Manufacturing and Certification' includes Enablers 5, 6, and 7

Cluster 4
Human Factors groups Enablers 8 and 9

Sub-set of analysis

all project for which survey results are available

12 FP7 Projects
1 Clean Sky Project
3 SESAR WP-E Projects
1 SESAR Project
3 Future Sky Safety Projects
1 H2020 Project

IS INDUSTRY UPTAKE OF SAFETY RESEARCH LINKED TO STANDARDISATION AND REGULATION?

The future of air transport relies on increased investment in the safety technologies of tomorrow, as the market demands shorter cycles for the integration of new technologies and international competitors enter the market with an aggressive approach on prices. In this regard, one of the expected benefits of European aviation safety research investment is the potential influence on the standardisation and regulatory process.

As part of the application of the SEIA Framework, OPTICS investigated if European research contributes somehow to the development or improvement of existing or new Industry Safety Standards. On average, two standards per project were found, including technical as well as procedural standards, standards of global and of local applicability, and of various levels of development. When asked, all of the project coordinators indicated they believed that the contributions ensure the legal ease of adoption of the project results.

To get insight into the impact of projects on EU Safety Regulations, the project coordinators were asked whether they expected the results of their project to contribute to the development, revision and/or improvement of any Safety Regulations. A positive answer was given by 40% of coordinators, with an expected contribution to EU regulations, to global regulations, or to both. In follow-on interviews, about two-thirds of the project coordinators indicated to believe that the contributions ensure the legal ease of adoption of the project results; one third of coordinators replied that they had seen no evidence to that effect.

There is still room for improvement when it comes to the cooperation with research in the area of regulation and certification. It is important to better comprehend the whole landscape of safety activities but also to improve the regulation development process. Projects do not always consider the mandatory changes in regulation their results may evoke, because they focus on the development part and not so much on the implementation of their outcomes. There is a need for even more cooperation between the research community and the regulator, from the early stages of development onwards.

To conclude, safety research results are adopted more easily if they are linked to the improvement of EU safety standards and safety regulations. However, this requires the reduction of legal barriers through evolution of the legal regulatory framework, more cooperation between the research community and the regulator from an early start onwards, and coordination between research community and policy makers, during the project as well as after project completion.

ISSUES AND PRIORITIES EMERGING FROM EXPERT WORKSHOPS

Parallel to the project assessments, OPTICS held in 2014 its **1st Expert Workshop** *Human Factors in Aviation Safety*, attended by 77 experts from 17 countries. The Workshop determined the major Human Factors R&I priorities and gaps in the SRIA. The 'Top 3' priorities in the context of Aviation Safety emerging from the experts' debate were:

TOP PRIORITIES

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.

The experts highlighted complacency as one key danger for Aviation, since safety often appears to be so good, people think there is no need for research. Human Factors R&I must be seen instead as adding safety and productivity to the system, or else it risks staying on the side-lines, rather than being acknowledged as an essential player in assuring future system performance.

1ST WORKSHOP
STAKEHOLDERS SEGMENTATION

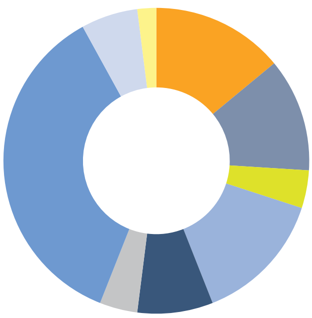
- **19%** Universities
- **9%** Aeronautics industries
- **2%** Airspace users
- **13%** ANSPs
- **4%** Consulting
- **4%** European Commission
- **27%** R&I Institutes
- **13%** Regulators
- **9%** Training Institutes

The **2nd Workshop** was dedicated to *Hazard Management and Operational Resilience*, attended by 50 experts in aviation safety. The Workshop succeeded in finding a top ten priority list for research directions for four focal areas in aviation and aviation research today: autonomous systems, use of data, self-healing and weather. The resulting top ten of priorities for research directions is given below. The first four represent the top priority in each of the four focal areas.

TOP PRIORITIES

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.

2ND WORKSHOP
STAKEHOLDERS SEGMENTATION



- **14%** Universities
- **12%** Aeronautics industries
- **4%** Airspace users
- **14%** ANSPs
- **8%** Consulting
- **4%** EUROCONTROL
- **36%** R&I institutes
- **6%** Regulators
- **2%** Professional Body

In 2016, the **3rd Workshop** was co-organised by OPTICS and EASA to talk about how to mix *Politics and Safety*. With 60 participants from all over Europe, representing a diverse range of aviation sectors and research communities, the event saw discussions around four key topics: how to monitor safety; how to 'see around the corner' to future safety events and game-changers; how to improve research uptake by industry; and how to ensure effective use of European aviation safety research facilities.

Overall, everyone taking part in the **3rd Workshop** saw that the only sensible way forward is for more collaboration across the industry, and the need to forge effective and efficient research-industry partnerships.

3RD WORKSHOP

STAKEHOLDERS SEGMENTATION

- 11% Universities
- 11% Aeronautics industries
- 2% Airports
- 4% Airspace users
- 10% ANSPs
- 21% Consulting
- 6% EUROCONTROL
- 2% Maintenance
- 4% Professional Associatians
- 6% R&I Institutes
- 23% Regulators
- 9% Training Institutes

TOP PRIORITIES

Improve Safety and Business Performance

1. Targets on leading indicators might be more beneficial for safety by inducing positive behaviour; it is easier to share information on leading indicators than incident reports.
2. 'Hard data' (accidents and incidents) needs to be tempered by expertise, knowledge and qualitative data (e.g. safety culture surveys) to determine our true risk levels and priorities.
3. Talk to people doing line operations – they are the closest to what is coming. But Just Culture is imperative.
4. Deeper analysis of combinations of known events can help identify the weak but important signals. Consider those events we currently deem 'non-credible' and then assess them.
5. Think outside the box and consider social changes – e.g. use of social media and smart devices in the workplace.

Implement the good safety research and make efficient use of the European Safety Research resources

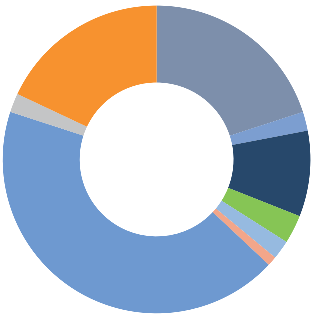
1. Look for better ways to involve the airlines in research, and make industry involvement 'admin-lite'
2. More mobility of researchers around the European research network, as well as between industry and academia, would lead to better collaborative relationships and a better-understood combined European research capability.
3. Better information about existing infrastructures is urgently needed, following the US example.
4. The biggest facility lacking in research is the airline. Easier access to airlines by researchers would be a significant step forward.
5. If researchers cannot engage with the operational parties, research will remain 'academic' and lower-TRL.

The **final OPTICS Workshop** *New Resilient Designs for Aviation* was dedicated to resilience and survivability, with a focus on novel aircraft concepts, improved materials and new aircraft sensors, crashworthiness and post-crash survivability, and all the other tools, products and services that ensure resilience of systems and operations, able to face current and emerging environmental (safety and even security) hazards. 45 attendees from all over Europe met in Capua, with Italian researchers and industry representatives dominating the participation.

TOP PRIORITIES

1. Barriers to hazards need to be developed in the design stage of the product. The adaptation and application of the "three layers of defence to hazard" approach from nuclear could lead to a step change in aviation resilience.
2. Need for advanced control systems in degraded pilot/engine/aircraft situations, possibly with HMI that does not overload the pilot with information ("return home capability").
3. Need for a global index summarising the "survivability" property of aircraft systems.
4. Design methods and tools for operations taking into account new threats, new concepts of operations, and new actors.
5. Improve damage tolerance of materials using novel manufacturing techniques and new multi-functional protective materials.
6. Invest in the development of predictive sensing of environmental threats (ice and ash).
7. Need for a performance framework for the assessment of resilience.
8. More investigation is needed in modelling aircraft material dynamic behaviour in case of accidents.
9. Regulators should work on specific standards for survivability.
10. Technology-transfer from nuclear and automotive domains to increase survivability rate in the aeronautic domain.

FINAL WORKSHOP
STAKEHOLDERS SEGMENTATION



- **18%** Universities
- **20%** Aeronautics industries
- **14%** ANSPs
- **9%** Consulting
- **3%** EUROCONTROL
- **2%** Maintenance
- **1%** Technology Cluster
- **43%** R&I institutes
- **2%** Regulators

OVERALL CONCLUSIONS
GAPS AND BOTTLENECKS IN SAFETY RESEARCH

A quick look at the overall status of safety R&I activities assessed by OPTICS reveals that there is a significant amount of relevant research ongoing or recently finished and that, on average, we are in line with ACARE's expectations. The different European and national funding programmes showed a good level of complementarity, involving the different actors of the Air Transport System and delivering a good coverage of the SRIA.

A certain amount of research overlap is visible from the assessment, but all in all this is not a negative fact. In some areas , such as in weather hazards research with a number of projects each tackling a single hazard, it results in a broader coverage. The same happens when exploring innovative concepts (for example personal vehicles) or addressing long term research goals. Research duplication can be considered a weakness in areas where several projects are at medium maturity and the transition to actual industrial results seems to be limited or not progressing in the right direction, as it seems to be the case for some Human-Centred Automation research.

Despite the number of safety projects in Europe, there are still unaddressed research areas. Passenger management is a research desert, and there are no projects looking into aspects of multi-modal transport – a long term research direction that is included in the SRIA. Investigation on search and rescue capabilities is also under-addressed, as well as research in the maintenance domain.

Research needs to be expanded to allow access to airspace to future aviation concepts other than RPAS, such as personal aviation and commercial space flight. The Human Factors area should include activities on training and selection for the pilot and controller and other aviation workers of the future, and a common Human Factors education system. Although collection of key safety data is a priority, more has to be done on new sensor technology to capture these data.

On average, the maturity of the research assessed by OPTICS is medium to high. However, the progressive advancement from low to high maturity (with eventual industrial take-up) does not appear to be the most applicable business model to aviation safety research. The various enablers seem to require different business models, differentiated by maturity levels too. The current business model of progressive maturity increase, with industry take-up after TRL 6 does not apply to all the safety research topics. It is effective for very specific and concrete problems (e.g. icing, or airborne separation), but less so for larger or non-technology driven research areas (e.g. System-wide SMS, Safety radar, Human Factors). 'Admin-lite' industry involvement in research might help to stimulate a greater involvement of the industry (manufacturers and end-users), with the aim of facilitating eventual industrial take-up.

Other bottlenecks to industrial take-up concern the costs of the certification processes for new technologies and systems. The organisational ease of adoption seems to be better addressed, however the reluctance from some stakeholders to make the transition to actual implementation appears to be significant in some areas, especially for extensive changes to the current operational concepts.

The Socio-Economic Impact Assessment shows that the majority of the projects assessed as contributing to the risk areas seemingly do so indirectly only, i.e. they do not specifically focus upon the issues directly relating to the identified risk. It is recommended that future revisions to the SRIA ensure that the "known risks" are sufficiently well covered to ensure manageable transitions towards Flightpath 2050 objectives and that future investment in research ensures that all main risk areas are explicitly addressed.

To sum up, there are four areas where European research needs 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 consolidated before transitioning into operations**
   (e.g. some areas of Human Centred Automation)

3. **Areas where harmonisation is needed to bring all elements up to the same level of maturity**
   (e.g. research on the safety impact of all types of adverse weather conditions)

4. **Areas where research needs to begin**
   (e.g. advanced crew concepts, passenger management)

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MORE DETAILS

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