OBSERVATION PLATFORM
FOR TECHNOLOGICAL AND INSTITUTIONAL CONSOLIDATION OF RESEARCH IN SAFETY

Are we doing THE RIGHT AVIATION SAFETY RESEARCH?

In this handout:

NAVIGATING TOWARDS FLIGHTPATH 2050 / HOW OPTICS WORKS / **THE RESEARCH METHODOLOGY** / PRELIMINARY RESULTS / **ENABLERS' STATUS** / RECOMMENDATIONS / **PRIORITIES FROM EXPERTS' WORKSHOPS** / OVERALL CONCLUSIONS

OPTICS

NAVIGATING TOWARDS THE SAFETY GOALS OF FLIGHTPATH 2050

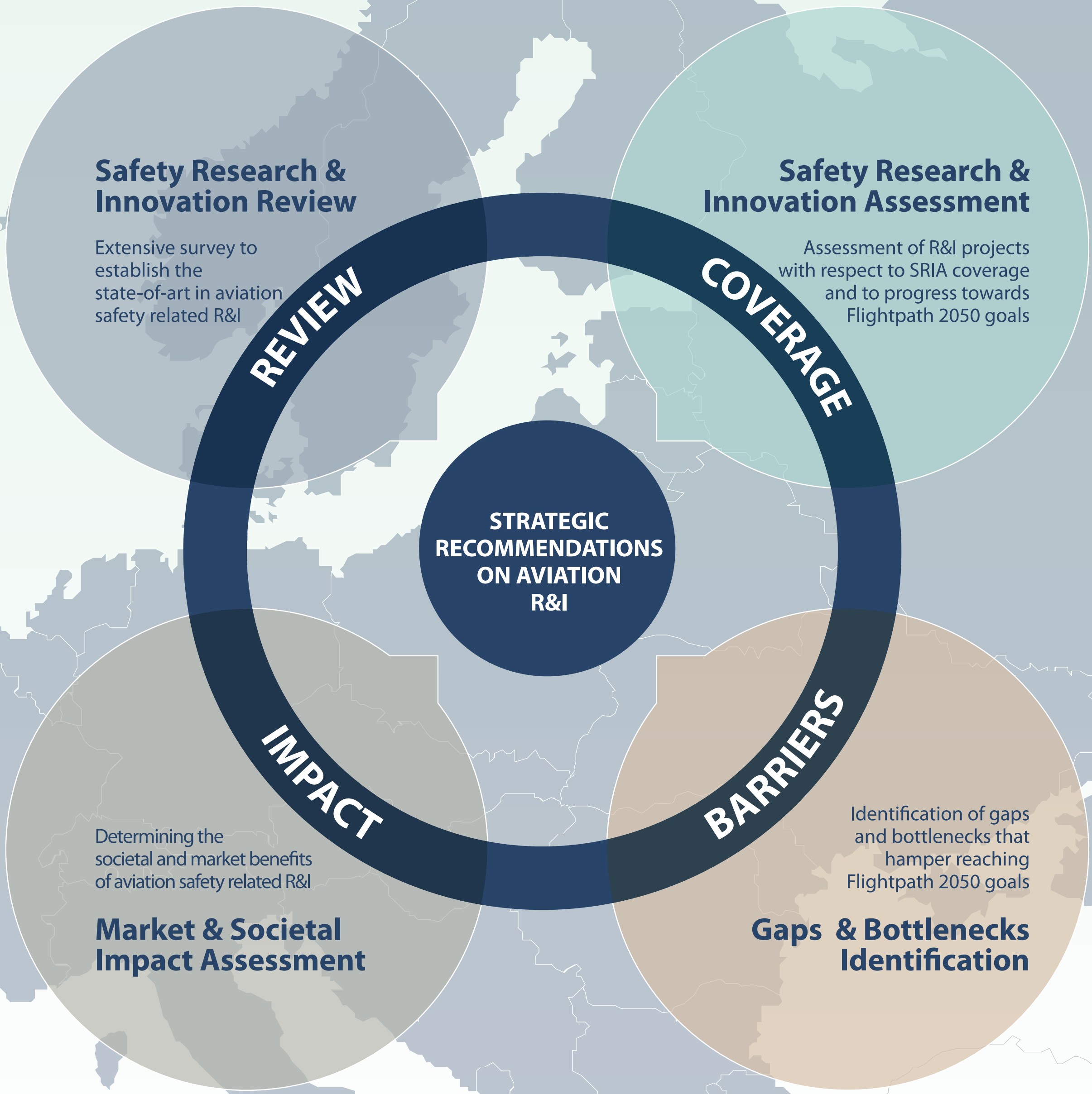
The Advisory Council for Aviation Research and Innovation in Europe (ACARE) has provided Europe a vision for aviation. To identify a pathway towards this vision, called FlightPath 2050, ACARE developed the Strategic Research and Innovation Agenda (SRIA), a roadmap providing guidance on what is required, 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.

KEY ACTIONS NECESSARY TO ACHIEVE OPTICS OBJECTIVES INCLUDE:

- Performing an extensive review of aviation safety R&I in and outside Europe; delivering an annual state-of-the-art review of R&I activities.
- Performing an assessment of selected projects and their impact towards achieving the FlightPath 2050 goals.
- Evaluating the overall societal and market impact of safety R&I activities in aviation safety.
- Delivering 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.



OPTICS RUNS FOR 48 MONTHS UNTIL THE END OF 2017

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: ***Operational Resilience***

2016

- State-of-the-art in safety research, ***Third release***: national projects
- Project repository - ***Third release***
- Workshop #3: ***Socio-Economical Impact***

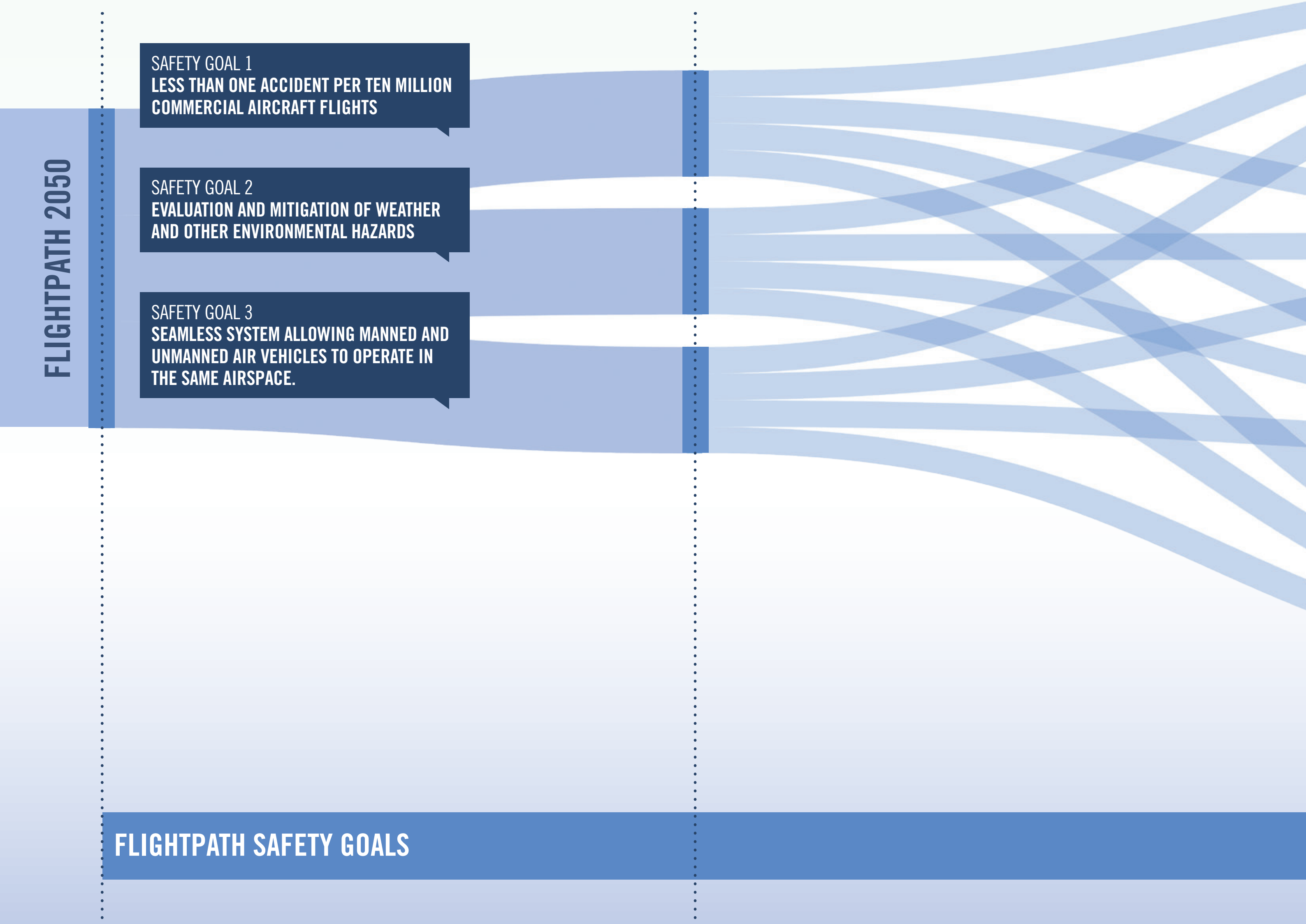
2017

- 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: ***Certification***

HOW OPTICS **WORKS**

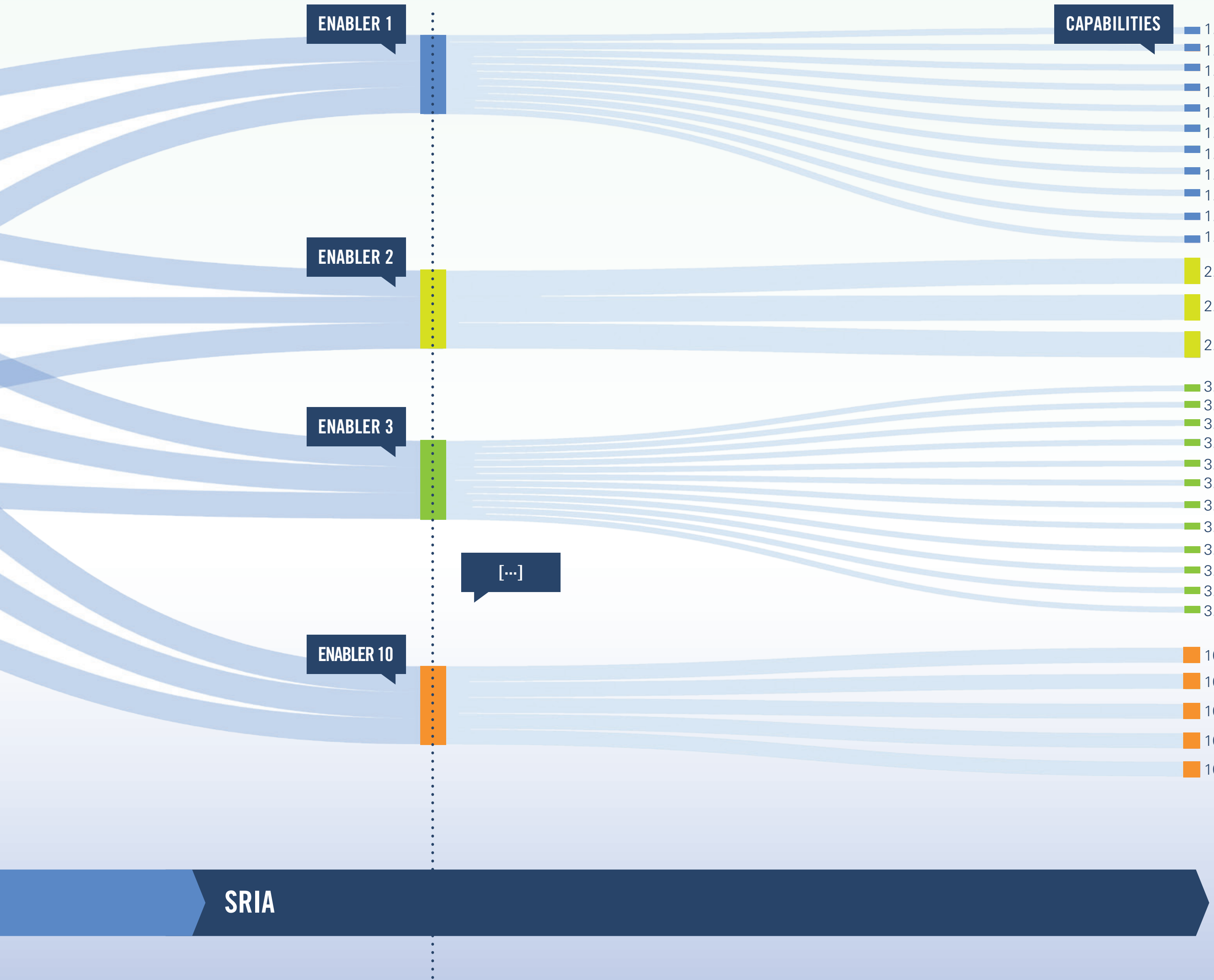
The FlightPath 2050 Safety Goals will be achieved by realising four overall clusters of R&I activities:

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.

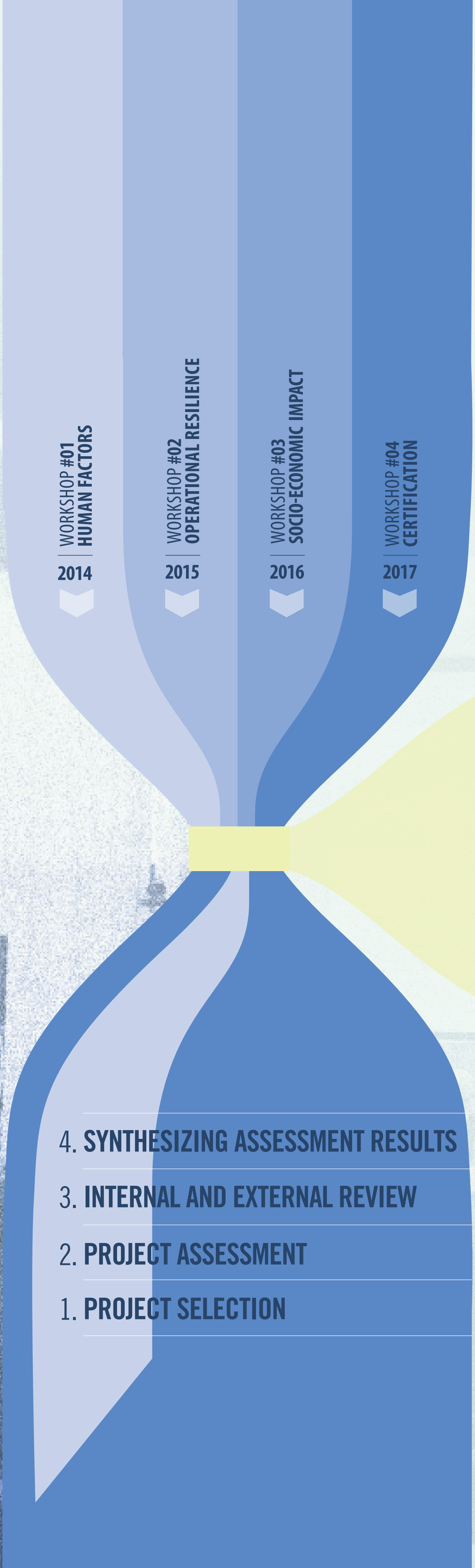
But this vision is too high level to evaluate if safety research is progressing in the right direction. Therefore the four clusters are broken down into ten more concrete **Safety Enablers**. These Enablers are the key properties of the future system that will deliver the safety goals of 2050, such as 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 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, and where there are gaps, and hence answer the OPTICS question: are we doing the right research?



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 of most safety research projects. 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 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)

PRELIMINARY RESULTS OF THE ASSESSMENT

IN 2014 - 2015

107 ASSESSED EU PROJECTS

FP7, SESAR, SESAR WPE, Clean Sky, Future Sky Safety

IN 2016 - 2017

NATIONAL & INTERNATIONAL PROJECTS WILL BE ASSESSED

National projects in 2016, International projects in 2017

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 is the key criterion. This is the degree to which research is occurring in this Enabler. OPTICS found that six Enablers are doing okay, while for four Enablers more research appears needed. Given that this is a roadmap for 2050, this overall picture is reasonable, especially considering that it does not yet include national and non-European projects.

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. This indicator looks relatively healthy, though a concern of the OPTICS team about how many projects actually make it into operationalisation or 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 projects have been found where there is a good idea, but because discussions with the regulators did not occur early enough, the ideas are unlikely to ever make it into practice. This is an issue which EASA is concerned about, and the fourth and last OPTICS workshop in 2017 will consider this as one of the critical aspects related to the Certification enabler.

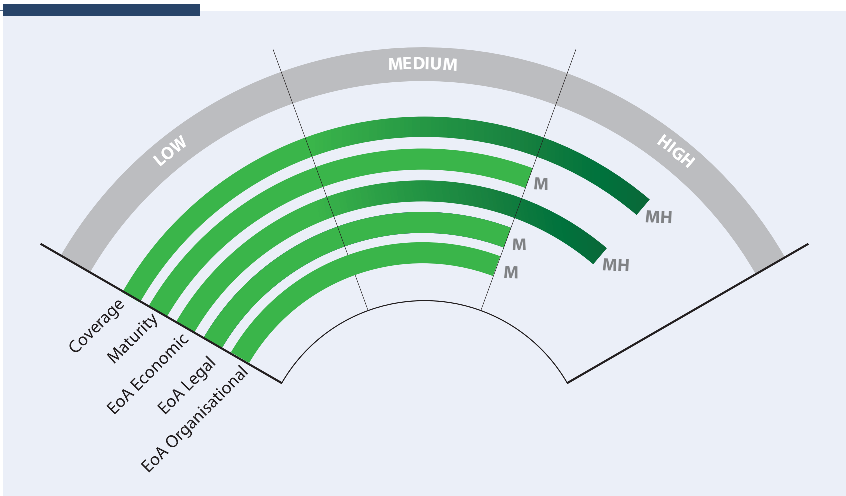
The third **Ease of Adoption** aspect relates to industry's appetite for what the research is aiming to deliver, and is often called the **organisational 'pull'.** Great research will not make it into practice if industry does not know about it or remains unconvinced or is looking at other options. This is a concern to OPTICS, and is also on the agenda for the 3rd OPTICS Workshop in 2016, as it is felt that there needs to be better industry engagement with the research delivery process.

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 an SMS or equivalent, i.e. formal ways of managing safety through analysis of safety and operational data, which helps us learn 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. However, the sharing of data across organisations and sectors of industry is not yet happening.



1.1 *Medium coverage*
Understanding safety factors on transport system

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

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

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

STRENGTHS

Most sectors across aviation use a Safety Management System.

GAPS

Start sharing safety data. Distil safety information from normal operational data, not only from occurrence data.

The 2nd OPTICS Expert Workshop's conclusion was quite clear on this matter: stop talking about sharing data, and get on with actually doing it. There is also a desire to look not only to incident data – few serious events happen, given that the industry is very safe – but also to more general operational performance data, possibly using new approaches such as Big Data (data science) to help us to see around the corner to future problem areas.

From the analysis of projects several gaps appear, mainly how to approach safety across different transport modes (rail, sea, and road) in a multi-modal manner, and how to implement effective and efficient 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 identified specific research projects on this area). A future potential game-changer, as remotely piloted aircraft systems (RPAS) is today, could be the arrival of personal vehicles, which would pose safety issues: research exploring future operational concepts involving personal vehicles should start soon. Two further gaps relate to the proactive identification of environmental hazards (the 'seeing around the corner' issue), and indicators of societal perception of safety, something that OPTICS itself has begun to address and will report on in 2017.

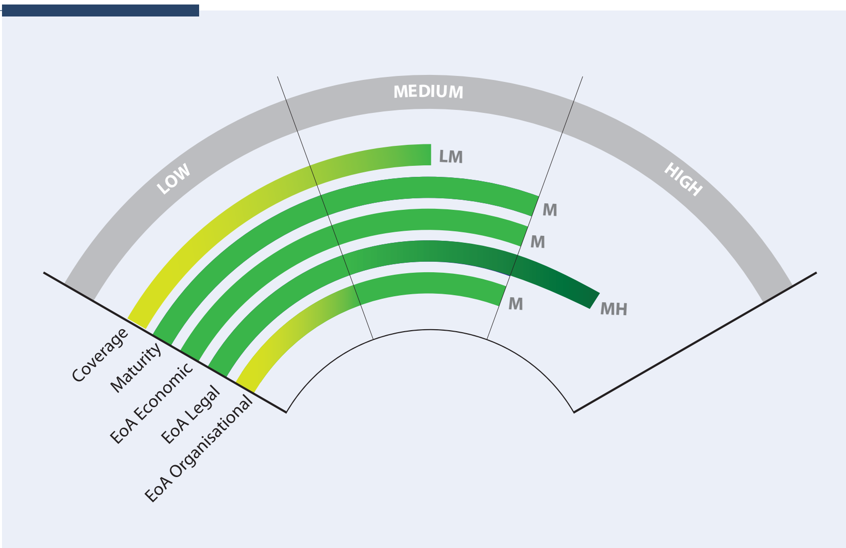
Aspects that are well addressed by current research concern the implementation of an operational risk management system across the whole air transport and the development of tools, metrics and methodologies to assess and pro-actively manage current and emergent risks (although complete coverage is not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

ENABLER 2

SAFETY RADAR

Despite all the three Capabilities under this Enabler are covered by projects, the actual research does not yet provide means for a real-time safety radar function. Coverage of this Enabler could benefit from data acquisition across the aviation system.

Future actions should consider working on pro-active identification of external hazards other than high-altitude icing, such as thunderstorms, turbulence and volcanic ash. As well as being able to address these other hazard types, 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 60 minutes for hazard avoidance purposes.



STRENGTHS

Research is performing behavioural analysis of airspace and airport use for safety improvement purposes.

GAPS

Need for data acquisition from all stakeholders in the Air Transport System.

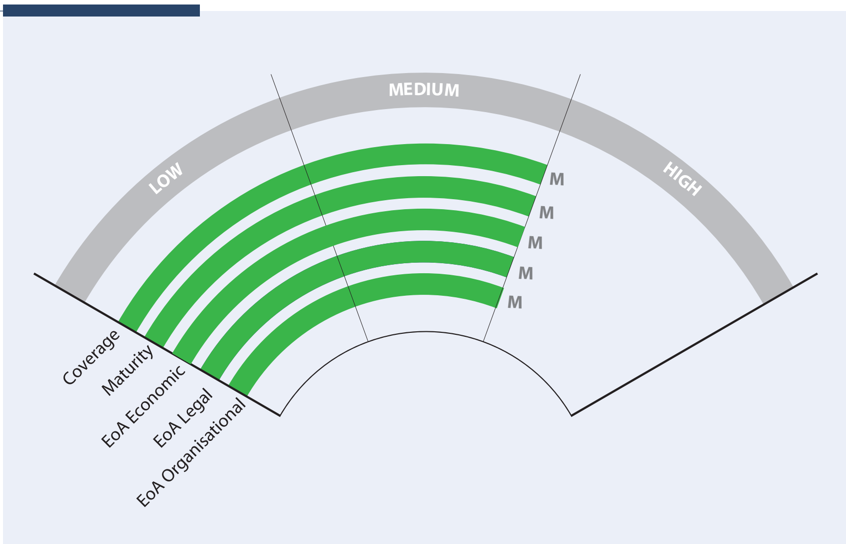
ADDRESSED CAPABILITIES

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

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. In particular, notable amount of research is being performing 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.



Nevertheless, there are gaps. Commercial Space operations and integrated search and rescue Capabilities are unaddressed in the research assessed so far. 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). Environmental hazard types other than wake vortex, wind shear, high altitude ice crystals, and clear air turbulence remain unaddressed (e.g. volcanic ash). What is missing is a project to try to bring together the research on environmental hazards, and encourage research into other as yet unaddressed weather hazards so that the complete set of weather hazards are mitigated. This would go a long way to achieving the 2050 goal of being able to fly in more difficult weather circumstances. The other main area needing urgent research is the integration of RPAS and drones into civil airspace, 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.

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 *Medium 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

STRENGTHS

The 'sharp end' of safety, it is well-served by research.

GAPS

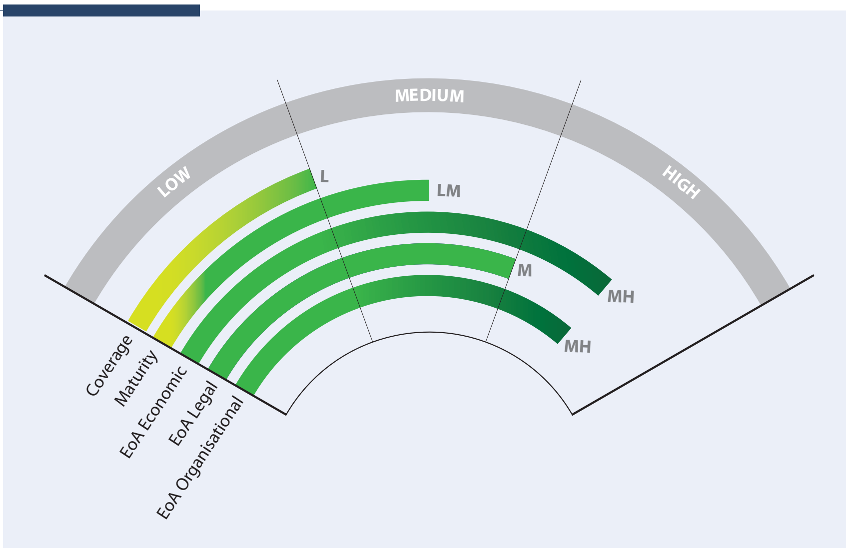
Bring together research on environmental hazards, including volcanic ashes and wind shear. Develop stable concept of operations for the integration of RPAS into civil airspace.

ENABLER 4

SYSTEM BEHAVIOUR MONITORING AND HEALTH MANAGEMENT

One of the 2050 safety goals concerns better search and rescue, something that is not represented in the research assessed so far. This need is reflected by ACARE's Working Group 4 (Safety and Security) which is also of the 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. Research in these 'post-accident' areas is therefore warranted.

Another gap relates to health management and self-healing for air vehicle operations in flight and traffic management. This area possibly needs low TRL research to launch new ideas into real-time inflight health management approaches and possibilities.



STRENGTHS

There is a significant effort devoted to improving health monitoring capabilities.

GAPS

Need for research on tracking and locating air vehicles in case of serious incidents.

ADDRESSED CAPABILITIES

4.1 *Low-medium coverage*

Continuous health management of airports and airspace

4.3 *Medium coverage*

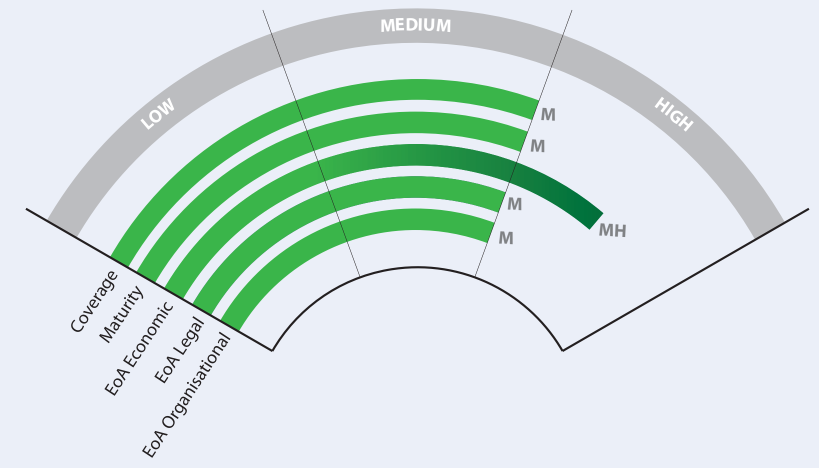
Innovative Health Management systems and Maintenance processes

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 as for Enabler 1. Furthermore, none of the assessed research addresses new sensor technology to capture key safety data.

Additional unaddressed topics are: fully integrated means of capturing safety data of all stakeholders across the air transport system, improvement of the associated safety culture and processes, and the use of these captured safety data by all stakeholders. Lastly, there is not yet research assessed that is 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.



STRENGTHS

Incident and accident investigation is a cornerstone of safety, further strengthened by Just Culture and Safety Culture initiatives.

ADDRESSED CAPABILITIES

5.1	*Medium coverage*
Systematic analysis of safety data	

GAPS

Increase the research effort on the identification of emergent vulnerabilities.

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 one of the most investigated areas in aviation safety R&I, with 21 projects addressing this Capability so far. 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. This and other certification issues will be discussed in the fourth and final OPTICS Workshop in 2017.

STRENGTHS

Certification is one of the most investigated areas in aviation safety research.

GAPS

Lack of work on system inter-dependencies and Human Factors, and several segments of the total aviation system are still not considered (e.g. general aviation).

ADDRESSED CAPABILITIES

6.1 *Medium coverage*	6.4 *Medium coverage*
Common framework for Certification / Approvals	Air transport system standardisation, certification and approvals processes

ENABLER 7

RESILIENCE BY DESIGN

In the 2nd OPTICS Expert Workshop it became clear that 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 fix projects to this area. In the ongoing SRIA update, ACARE's Working Group 4 has already determined that this Enabler needs better explanation and rationalisation. Notwithstanding this lack of clarity over the concept, there has been a lot of research in this area.

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.

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 Cluster and in particular both Automation and New Crew and Team Concepts. SESAR's approach for ensuring results of safety analyses are fed back into the design process could be extended to other parts of the air transport system. Research on current and emergent environmental hazards should be extended to include fog, wind shear and thunderstorms. Research on crashworthiness is also lacking, though this is clearly a resilience area, aimed at making aircraft more resilient to accidents such as controlled flight into terrain. This may require some new low-TRL research to come up with new ideas.

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	Medium coverage	Characterisation and mitigation of environmental hazards
7.5	Medium coverage	Improved resilience through new technologies or system designs
7.6	Medium 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
7.12	Low coverage	Reliability engineering of critical software

STRENGTHS

There are efforts to advance engineering and analysis capability, cornerstones of Resilience by design.

GAPS

Clarify the resilience concept, and improve the connection with industry in order to ensure better transition into operation.

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.

Preventive maintenance and system upgrades of automated systems are unaddressed in the research assessed so far. The research on technologies to support turnaround processes could benefit from the integration of existing solutions with airport and aircraft. Research on the optimal allocation of functions between human and machine, with automation supporting human in both normal and degraded operations, is well-covered and also shows a good balance of projects covering pilots and cockpit, and projects looking at controllers and ATM automation.

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

STRENGTHS

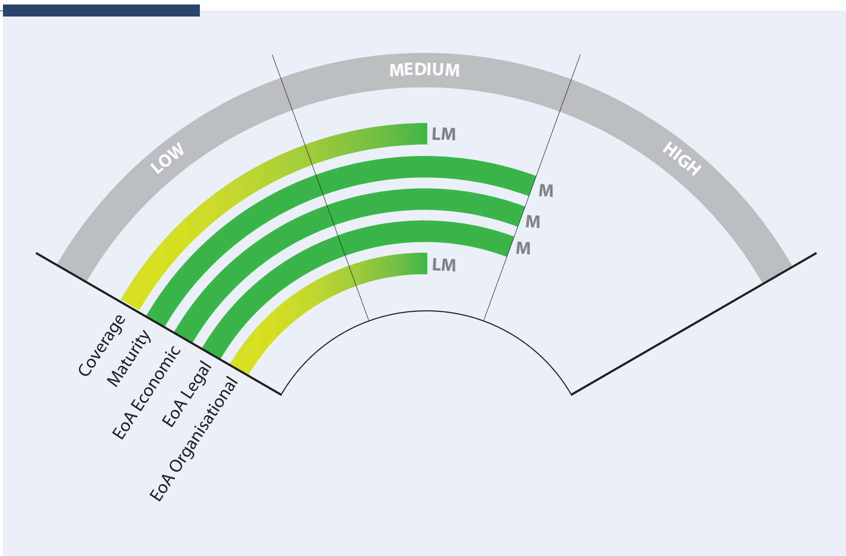
Research on Human-centred automation is maturing.

GAPS

Involve Human Factors experts from the first automation design phases. Extend the scope of research to preventive maintenance.

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.
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 outreach further than controllers and pilots.



STRENGTHS

Crew Resource Management is a singular Human Factors success story.

GAPS

Team concepts need to outreach further than controllers and pilots, integrating maintenance operators and RPAS pilots.

ADDRESSED CAPABILITIES

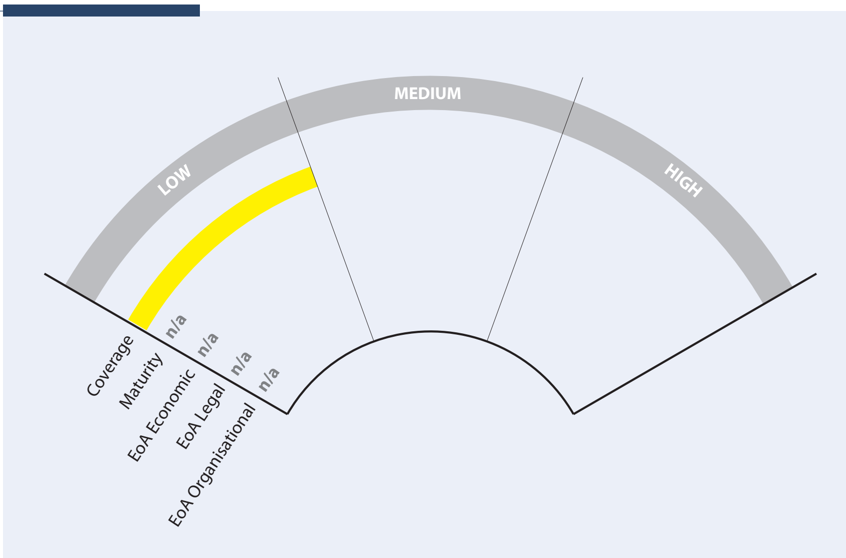
9.1 — *Low coverage*
New collaborative team concepts across the whole ATS system

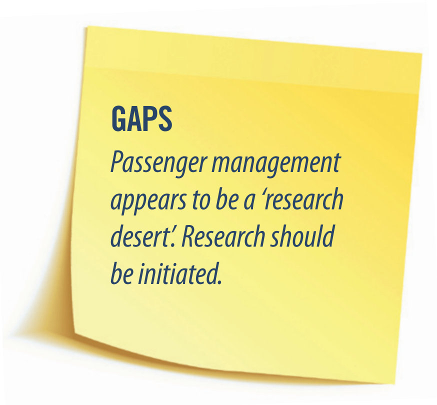
9.2 — *Medium coverage*
Optimisation of Human performance envelope

9.3 — *Medium coverage*
Monitoring of crew/team capacity

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 the assessed research. It may be that year 3 of OPTICS (2016) finds research in this area via the national programmes, but if not, research needs to be initiated related to this Enabler.





CONCLUSIONS AND **RECOMMENDATIONS**

GAPS AND BOTTLENECKS IN SAFETY RESEARCH

The addition of new projects in the state-of-the-art assessment in 2015 resulted in bridging gaps that were identified in 2014. Most Enablers –with the exception of Enabler 10 (Passenger Management)– have additional coverage from the three large programmes (SESAR, Clean Sky and Future Sky) assessed in 2015. It is interesting to note that the exploratory SESAR WPE research results in coverage of Capabilities not addressed by the other programmes. 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.

On average the maturity of the research assessed by OPTICS is moderate to high. This is biased by the research programmes considered thus-far; all have projects that include participation of industry. In the remaining years of OPTICS it is expected that more projects will be assessed that are predominantly performed by universities. This is likely to have an effect on the average maturity of assessed research.

From the ease of adoption assessments it becomes clear that there are commercial considerations (e.g. sensitivity of safety and operational data) that are hindering industry-wide collaboration on safety research. Certification is still a bottleneck in the ease of adoption of changes to the aviation system, even if safety improvement is the driving force. Organisational ease of adoption is challenging for radical changes (e.g. adaptive automation) and for changes that require coordination and agreement among different parties. Ease of adoption is improved where changes are incremental.

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

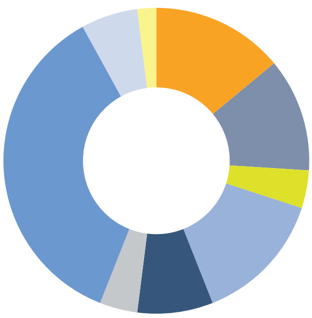
- **19%** Universities
- **9%** Aeronautics industries
- **2%** Airspace users
- **13%** ANSPs
- **4%** Consulting (4%)
- **4%** European Commission
- **27%** R&I institutes
- **13%** Regulators
- **9%** Training Institutes

OPTICS organised in 2015 its 2nd Expert Workshop From Hazard Management to Operational Resilience, attended by 50 experts in aviation safety. The Workshop succeeded in finding a top ten of priorities 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

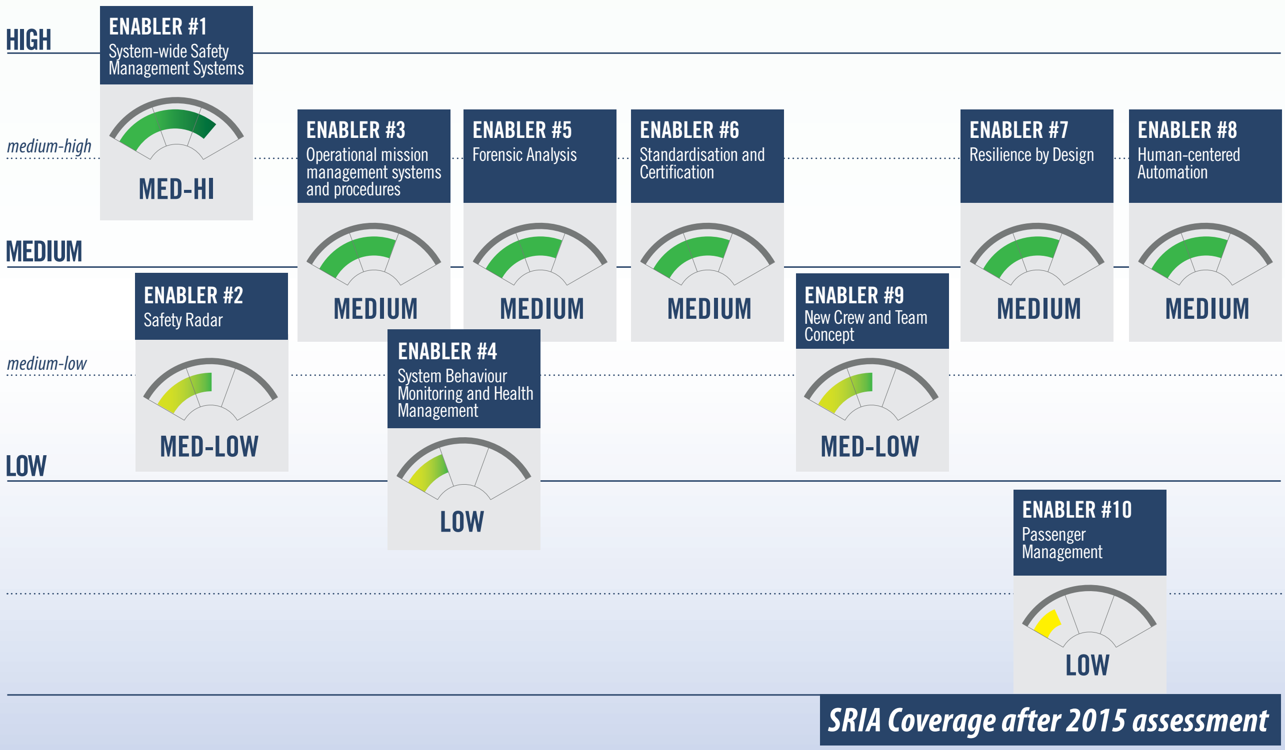


- **14%** Universities
- **12%** Aeronautics industries
- **4%** Airspace users
- **14%** ANSPs
- **8%** Consulting
- **4%** EUROCONTROL
- **36%** R&I institutes
- **6%** Regulators
- **2%** Professional Body

OVERALL CONCLUSIONS

A quick look at the overall status of safety R&I activities assessed by OPTICS reveals that the glass is more full than empty; there is a significant amount of relevant research ongoing or recently finished. There appear to be 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)



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MORE DETAILS

www.optics-project.eu

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