European Commission

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RESULTS PACK

Lifting off for safer aviation in Europe

EDITORIAL

LIFTING OFF FOR SAFER AVIATION IN EUROPE

The massive increase in aviation traffic over the past 20 years means that safety measures remain of crucial importance. The European Union aims to have the safest region to fly in the world by 2050, reducing the number of accidents in commercial flights to less than one per ten million and reducing the accident rate in non-commercial flights by 80 % compared to the year 2000. Research and innovation are thus essential ingredients and this Results Pack highlights six EU-funded projects that are charting the flightpath forward for ultimately reaching this goal.

Flying is indeed one of the safest forms of transport, with Europe having an extremely good record in this regard. However, with ever-increasing traffic levels and the fact that Europe is home to approximately 150 airlines, our skies are becoming busier and fuller. Consequently, the European Commission is dedicated to ensuring that new technologies are developed and deployed to further reduce the likelihood of future accidents and casualties (see for example the Commission's 'Flightpath 2050 — Europe's Vision for Aviation' report and the EU's 2015 Aviation Strategy).

There are several key areas where EU-funded research and innovation efforts are focused. These include: addressing aspects of the design, manufacturing and operations of aircraft and infrastructures; mitigating the risks of the effects of extreme weather conditions and other hazards from the natural environment; and reducing the impact of human factors and human errors on active and passive safety. Intelligent and integrated transport systems, as well as connectivity applications, may also provide useful tools for enhanced aviation safety.

Moreover, maintaining a high level of safety in the skies is not just a European challenge, rather it is a truly global effort. International cooperation is thus essential to ensure network safety and the development of globally agreed rules and standards (also a keen topic of interest for EU research) that complements and provides an important framework for the exciting technological solutions being championed by European researchers and industry.

This CORDIS Results Pack is honing in on six EU-funded projects that are reaching for the skies to provide concrete and ground-breaking solutions for increasing aviation safety in Europe. These results will also contribute to further cementing the European aviation industry's world-leading role in terms of competitiveness and providing the best products and services. European air transport has a long history of innovation and worldwide cooperation, which will be vital for its future success, particularly in a twenty-first century world where we must do more, sooner, and with less available economic resources.

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New cockpit concept targets human-machine cooperation

A new cockpit concept has been developed by EU-funded researchers, designed to help pilots select the perfect level of automation for specific flying conditions.

Airplane crews never know exactly what to expect on a flight. Congested airspace or bad weather can increase workload — and stress — considerably, while a smooth eight-hour flight from Paris to New York generates far less workload. The goal of the EU-funded A-PIMOD (Applying Pilot Models for Safer Aircraft) project was to develop a system that can be adjusted by the crew to provide just the right level of automation for any given flight condition.

This system works by first providing a risk analysis of the outside world in terms of weather, traffic etc., and then determining a list of tasks that the crew will have to work on.

Sharing the workload

'This system works by first providing a risk analysis of the outside world in terms of weather, traffic etc., and then determining a list of tasks that the crew will have to work on,' explains A-PIMOD project coordinator Dr Andreas Hasselberg from the German Aerospace Center (DLR).

'The system also pays attention to the crew's situation and makes an assessment if they are overworked or stressed. From this information the system provides a recommendation for the level of automation which the crew can then adjust; if flying conditions are difficult, the system can help out by taking on some of the workload. If flying conditions are straightforward, automation can be reduced to ensure that crew are stimulated and alert. This is a safety issue.'

The project has also pioneered new ways of human-machine interaction in the cockpit through touch displays, voice and gesture recognition technologies, which could be of benefit in safety critical environments.

Achieving industry acceptance

A-PIMOD began with the development of individual technology prototypes that focused on specific cockpit roles. The project also introduced new touch display and voice and gesture recognition technology. These individual elements were trialled in simulations by a high-level advisory board made up of experts from avionics industry, airlines and experienced pilots.

'This group provided us with valuable input, which enabled us to adjust the technology and increase functionality,' said Hasselberg. 'Finally, we were able to build a high fidelity simulator that integrated all these individual parts, in full communication with each other.'

This advisory group was also crucial in helping to overcome scepticism towards the automation trend. 'We knew that gaining acceptance would be challenging,' said Hasselberg. 'There are a number of concerns. For example, if we have this system that collects data on the condition of the crew, then what happens to this? We had to make clear that the system is not about rating pilots or crew, but rather about assessing the situation in order to offer the ideal level of automation.'

The project was completed in August 2016. In order to move towards commercialising this new technology, Hasselberg is adamant that both researchers and industry must be transparent about the safety benefits and how the technology will be used. Otherwise, the technology might fail on the issue of social acceptance. 'We are still working on this system in a very general way,' he says. 'As a consortium we would like to continue to work together, but that of course depends on funding.'

One interesting new avenue is the possibility of applying the technology not in the cockpit but in the control tower. 'We are moving towards acceptance that machines and humans can work together,' he says. 'It is about cooperation and sharing the workload in order to increase efficiency. Ultimately, we want to keep the performance of systems of humans and machines at the highest level possible.

We had to make clear that the system is not about rating pilots or crew, but rather about assessing the situation in order to offer the ideal level of automation.

Project	**A-PIMOD: Applying Pilot Models for Safer Aircraft**
Coordinated by	DEUTSCHES ZENTRUM FUR LUFT - UND RAUMFAHRT EV, Germany
Funded under	FP7-TRANSPORT
Project website	http://www.apimod.eu/

New sensory approaches to addressing high altitude ice

Three levels of sensory technology designed to detect hazardous icy flying conditions at high altitude have been developed by EU-funded researchers. These tools will help the aeronautics industry to certify and to meet stringent regulatory standards.

'Certain atmospheric conditions can cause aircraft icing, which can pose a potential threat to parts of an airplane especially the engine,' explains HAIC (High Altitude Ice Crystals) project coordinator Florent Huet from Airbus Operations. This phenomenon was first discovered in the 1990s, and since then both authorities and industry have sought to find effective ways to detect — and thus avoid or adapt the protection to — high altitude crystals.

Multi-level detection

'We developed three levels of detection in this project,' says Huet. 'First of all, satellite detection enables operators to observe large parts of the Earth and helps them to chart appropriate routes and avoid areas with potential crystal in it.'

This system was validated during the project and was also used on test flights to identify suitable ice crystals areas for analysis. The technology is now operational. 'This is first generation technology that can of course be further refined, but the first step has been taken,' says Huet.

Second level technology involves radar for use in the aircraft itself. An antenna capable of detecting 80 miles in front of the craft warns pilots of approaching ice crystals areas, which can then be avoided.

'There has been big interest from industry because this technology is easy to implement,' says Huet. 'We already have the hardware; it is the software that has been improved, which means that we can retrofit existing aircraft.' The Airbus team is currently in discussion with authorities on the best way of validating and certifying these tools.

Finally, a third-level prevention involves on-board detectors for when pilots actually find themselves in high altitude crystal areas. 'The satellite technology is less precise but covers a big area, while the radar technology is for use when the aircraft is close to crystals,' explains Huet. 'These on-board detectors are even more precise.' The project successfully achieved proof of concept for these on-board detectors, though more trials are needed.

'Everything we did in this detectors project was about performance demonstration,' says Huet. 'Next steps will focus on industry demonstration; reducing the weight and cost until the technology is ready for commercialisation.'

Supporting cutting edge research

The HAIC project also successfully upgraded European icing wind tunnels in order to allow for a more accurate reproduction of mixed phase and glaciated icing conditions. Devices capable


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There has been big interest from industry because this technology is easy to implement.

of creating ice crystals with specific sizes have been installed, which will enable the aeronautical industry to perform equipment tests to the highest possible standards.

'One of these tunnels can now simulate the degree of pressure you would find at altitude, while another can generate the kind of crystals you would find at altitude, instead of just generating pieces of ice,' says Huet. 'These developments will help us to understand further how crystals affect engines.'

The project also worked on numerical simulations, to help researchers develop more accurate predictive models of how ice crystals interact with airplane parts. 'We'd like to know more about, for example, the impact of melted crystals on hot surfaces,' says Huet. 'We now have some models, but we really need 3D tools to really understand the potential impact of crystal ice on complex parts like engines.'

The HAIC project, which brought together experts from around the world, including 34 European partners plus five from Australia, Canada and the United States, was completed in January 2017.

Project	HAIC: High Altitude Ice Crystals
Coordinated by	AIRBUS OPERATIONS SAS, France
Funded under	FP7-TRANSPORT
Project website	http://www.haic.eu/

Wing de-icing technologies promise safer flying

European and Japanese researchers have developed and tested new de-icing technologies to protect aircraft wings. Achieved through the JEDI ACE project, the results have helped to strengthen aircraft safety and highlight new avenues for future research.

Ice build-up on aircraft structures represents a flight hazard and has played a key role in several deadly accidents. It degrades performance and controllability and significantly increases pilot work load and aircraft fuel consumption. While in-flight de-icing technologies — such as the use of hot engine air — have been around for decades, researchers believe that aircraft safety and reduced energy consumption could still be further strengthened.

'Some of these new technologies are close to commercialisation, which is now responsibility of the relevant partners,' says JEDI ACE project coordinator Nadine Rehfeld from the Fraunhofer Institute in Germany. 'Overall, though, this project really helped to highlight the need for further research and standardisation. For example, in the field of ice-phobic materials there is a great deal of interest in not only better understanding the icing process during flight, but also identifying relevant test regimes during different development phases. This is an ongoing activity, and will require international research and industry cooperation.'

Testing new technologies

The JEDI ACE project focused on developing the next generation of integrated 'Wing ice protection systems' (WIPS). These include the use of new 'Shape memory materials' (SMM) for aircraft de-icing applications, new anti-icing coatings and an ice sensor system for real time measurements of ice build-up on aircraft structures. Reliable testing methods for the performance of each developed component were also investigated.

SMM are smart materials that respond to particular stimuli such as heat, changing shape and then recovering their original form. This change in surface characteristics can help aircraft wings adapt to

In the field of ice-phobic materials there is a great deal of interest in not only better understanding the icing process during flight, but also identifying relevant test regimes during different development phases.

icy conditions. 'Future challenges for this approach are related to material availability as well as layer composition,' explains Rehfeld. 'Coating layers need to show excellent adherence.'

Different coating approaches were also developed, including super-hydrophobic coatings for areas behind the leading edge of wings. By comparing results of different ice adhesion tests, the team was able to provide a ranking of coatings and identify which ones have most potential to support heating devices.

'There are indications that test results correlate with different ice formation processes,' says Rehfeld. 'This requires further assessment in order to improve the reliability of test results and correlations with realistic icing scenarios.' Novel photonic sensors for real-time ice monitoring were also developed and a prototype embedded in an aerodynamic surface.

Benefits of international cooperation

By bringing together European and Japanese researchers (the project received funding from both the EU and the Japanese Ministry of Economy and Trade), JEDI ACE benefited from having a uniquely global perspective on the issue of aircraft safety. 'This project proved to be a great opportunity for all participating research partners to learn from each other and to bring in experiences from different continents,' says Rehfeld. 'This applies not only to icing test facilities and coating development strategies, but also to de-icing technologies and ice sensing devices.'

Next steps, says Rehfeld, will involve establishing the reliability of components, developing up-scaling processes for materials and defining new manufacturing and processing rules. She also envisages further collaboration in order to fully integrate all concepts at the aircraft level. 'This means interdisciplinary working groups consisting of coating suppliers, sensory specialists and aircraft manufacturers. Certification bodies also need to be included.'

Another exciting possibility for the future is transferring JEDI ACE results to other sectors such as wind energy, rail and automotive applications. 'The interest in materials we have developed has been very high,' says Rehfeld. 'We're busy looking at ways of how to implement these results across a range of products.'

Project	**JEDI ACE: Japanese-European De-Icing Aircraft Collaborative Exploration**
Coordinated by	FRAUNHOFER-GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V, Germany
Funded under	FP7-TRANSPORT
Project website	http://www.jediace.net/

Assessing the effectiveness of Europe's aviation safety research

Is Europe funding the type of safety research that will successfully bring it closer to achieving its Flightpath 2050 goals? This is the question that researchers from the EU-funded OPTICS project aimed to answer.

Flightpath 2050, Europe's vision for aviation, believes that passengers and freight should enjoy efficient, seamless and global travel services based on a resilient air transport system thoroughly integrated with other transport modes. Such an integrated system is needed to meet the growing demand for travel and to cope with unforeseeable events.

However, getting to this point requires multiple levels of research being conducted on a decades-long trajectory. If this research is to progressively carry EU aviation safety towards its 2050 objective, regular assessment of the research being funded is required — which is exactly what the OPTICS project set out to do.

'The OPTICS team has assessed more than 200 aviation safety research projects across Europe, ranging from studies on how to regain control of an aircraft to a range of measures for combating icing hazards on the ground and at altitude,' says Project Manager Barry Kirwan.

The OPTICS perspective is that it is best to have a mixture of smaller projects, where true innovation and ground-breaking research can take place, as well as large-scale industrial programmes that ensure good ideas are being taken up by industry.

Objective findings

Using a robust methodology, researchers conducted an objective assessment of aviation safety related FP7 and Horizon 2020 projects. Their focus was on evaluating the degree to which the project addressed key safety areas and issues, its level of maturity and the likelihood it would eventually be implemented into real aviation systems. 'Our first success was a confirmation that this type of assessment can actually be done in an objective, credible and repeatable way,' says Kirwan.

Next, researchers turned their attention to such large-scale projects as SESAR and the Clean Sky initiative to assess their progress on advancing state-of-the-art technology. 'Here we discovered that these large programmes, which involve many industrial partners, were better at transitioning safety research into real operations,' explains Kirwan.

According to Kirwan, this finding gives the European Commission food for thought on the best way to fund research to ensure a return on investment. 'The OPTICS perspective is that it is best to have a mixture of smaller projects, where true innovation and ground-breaking research can take place, as well as large-scale industrial programmes that ensure good ideas are being taken up by industry,' he adds. 'After all, there's no point in doing the right research if it never moves beyond the labs and research papers.'

Re-evaluating Europe's aviation safety research business model

Based on this research, the project provides a better understanding of Europe's aviation safety research business model. Prior to OPTICS, the common perception was that research takes place based on needs, gradually maturing until it is eventually picked up by industry and implemented. What OPTICS teaches us is that this is not actually the case. 'Some ideas do not appear to migrate to actual flight operations and supporting systems, even if they are demonstrably useful for safety and could save lives,' says Kirwan. 'In other words, although Europe is largely doing the right research, refinements in the way we go about this research and deciding what to use from its results need to be addressed.'

In the final months of the project, which ends in August 2017, researchers will focus on providing actions to address this gap. Furthermore, the project is preparing to expand its scope to include security as well as safety via a subsequent proposal already submitted.

Project	**OPTICS: Observation Platform for Technological and Institutional Consolidation of research in Safety**
Coordinated by	EUROCONTROL — EUROPEAN ORGANISATION FOR THE SAFETY OF AIR NAVIGATION, Belgium
Funded under	FP7-TRANSPORT
Project website	http://www.optics-project.eu/

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Designing the next generation of safe fuel systems

EU-funded researchers from the SAFUEL project have been developing, testing and validating a new, safer fuel system designed to meet the evolving challenges of air transportation.

Although air travel is today's safest form of transportation, safety can never be taken for granted. As the global air transport industry continues to evolve, constant effort is needed to ensure the highest levels of safety. For example, with aircraft using more and more composite materials and electronic systems, the risk of fire within the aircraft's fuel system increases. Likewise, as more aircraft fly polar routes, the risk of ice forming within the fuel system also increases. If not properly addressed, these new risks could pose a serious threat to the industry's level of safety.

The EU-funded SAFUEL project aims to address this threat by developing the next generation of safe fuel systems. Specifically, the project is developing, testing and validating a new, safer fuel system designed for use in more extreme temperatures. Key deliverables include a new fuel system design that meets the constraints of composite built and more electrically-connected aircraft, innovative technologies for gaging fuel circulation, and the necessary data to support authorities in issuing rules and regulations for safe flights in icing conditions.

Potential for commercialisation

Many of the innovative deliverables coming out of the project have significant potential for commercialisation. For example, although the SAFUEL Water-in-Fuel Sensor was originally designed to measure the quantity of dissolved water in the fuel, it can also be used for other applications. 'This sensor has been shown to have value in monitoring the quality of fuel at airports and, outside the aviation sector, in monitoring the quality of fuel in the automotive industry and fuel distribution networks,' says project coordinator Bruno Reynard. According to Reynard, commercial exploitation in the short- to medium-term is likely to come from these less demanding applications than on-board aircraft.

The project's research into the icing phenomena has also led to new, unexpected market opportunities. For example, the project's icing test bench is now available to the aeronautic industry and can be used for any other systems in non-accessible areas. 'The size of the potential market for using the test bench is difficult to estimate, but we believe it to be in the range of EUR 250 000 to EUR 500 000 in revenue for Hamburg University of Technology (TUHH), a project partner and where the bed is located,' adds Reynard.

This sensor has been shown to have value in monitoring the quality of fuel at airports and, outside the aviation sector, in monitoring the quality of fuel in the automotive industry and fuel distribution networks.

Collaboration is key

By improving water detection in fuel tanks, enhancing flammability protection, removing ignition sources, validating compatibility with modern avionics and verifying compliance with alternative fuel standards, SAFUEL is successfully building the next generation of fuel systems.

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According to Reynard, the key to this success is how the project has brought together more than 10 aviation related companies, research institutions and associations, including such industry leaders as Airbus and Zodiac Aerospace. 'This collaborative approach encourages companies to not only develop new technologies, but also develop new processes for developing this new technology,' says Reynard.

As an example, Reynard points to an instance when one partner ran into an innovation roadblock and another partner joined in to take a fresh look at the problem. 'This process lets us quickly move past difficulties, resulting in the successful development of numerous solutions, four of which have already been patented,' he adds.

Project	SAFUEL: The SAfer FUEL system
Coordinated by	ZODIAC AEROTECHNICS SAS, France
Funded under	FP7-TRANSPORT
Project website	http://www.safuel-fp7.eu/page/project.php

A step forward in ice simulation

Researchers with the EU-funded STORM project have created an extensive database on ice mechanical properties for aircraft engine designers. Not only will this reduce the lead time for testing engine designs, it will also result in safer air travel.

As icing conditions pose one of the greatest risks to aircraft engines — and to the safety of air travel — the certification process for even the most high-tech aircraft engines is demanding, to say the least. Before a new engine is used to power a jet from Point A to Point B, it must first satisfy a rigorous certification process. Part of this multi-layered process involves being certified for use in icing conditions, and, because the icing phenomena is so complex, certification tests are never simple.

The main challenge is that, when it comes to icing and its effect on aircraft engines, engineers have access to a very low level of prediction capability. As a result they must rely on a very fragmented knowledge based on past empirical evidence. With the development of the next generation of engines, there is a crucial need for a way to better predict these icing aspects early in the design process and, based on this information, develop state-of-the-art ice protection systems.

Thanks to new simulation methodologies developed by the EU-funded STORM project, it is now possible for engineers to more easily predict these icing aspects. Specifically, the simulation solution is capable of making accurate predictions as to ice release, ice accretion with runback aspects and ice trajectory. Based on this improved knowledge of engine component behaviour under icing conditions, the project has laid the foundation for the development of several innovative technologies for ice protection. 'The STORM research has contributed greatly to improving cost efficiency for future engines and in developing a higher level of competitiveness in the field of ice protection systems,' says project coordinator Morgan Balland.

Building a knowledge base

For each of the three main focus areas — ice release, ice accretion and ice trajectory — researchers gathered, analysed and consolidated all available information, thus creating a comprehensive knowledge centre which simulation tests, designs and technological development could be based on. For example, based on a thorough literature review, STORM researchers identified different ways of measuring ice adhesion. 'Here we were able to introduce a standardised approach for measuring ice release based on a selection of reference materials and test conditions,' explains Balland.

During the project's testing of ice block trajectory, researchers identified five ice shapes representative of typical shapes of accretion


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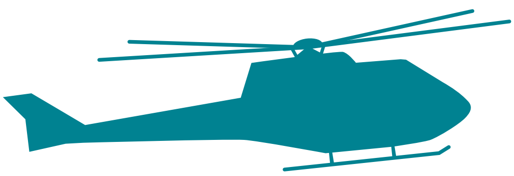
for engine and aircraft application. 'Having this knowledge at the start of the design process allows engineers to design aircraft engines capable of withstanding each of these ice shapes, as opposed to basing their designs on best guesses,' says Balland.

New technologies

This research also laid the foundation for the development of several new technologies aimed at mitigating icing risks. For example, as to coating technology, researchers developed a score card using different application requirements. 'In parallel to this, we also created a list of the most promising coatings based on previous research projects and partner recommendations,' adds Balland. For Active Ice Protection System technologies, the project identified three potential solutions and successfully carried out testing of their engine and nacelle components.



A big impact

Thanks to the project's research, aircraft engine designers now have access to an extensive database on ice mechanical properties — all compiled into a validated simulation and European standard procedure for ice release tests. This includes detailed models of ice release phenomenon and best practices, among other essential information.

'With this information in hand, we will see a reduction of the conceptual design phase for retrofitted engines and new engine architectures, along with a reduction in the lead time and costs for testing these designs,' concludes Balland. 'Most importantly, this will result in safer aircraft engines and safer air travel.'

Project	**STORM: Efficient ice protection Systems and simulation Techniques Of ice Release on propulsive systeMs**
Coordinated by	SNECMA SA, France
Funded under	FP7-TRANSPORT
Project website	http://www.fp7-storm.eu/

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Editorial coordination

Melinda KURZNE OPOCZKY

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About CORDIS Results Packs

CORDIS Results Packs are a thematic grouping of articles based on EU-funded projects and aim to disseminate information about new studies, contemporary scientific findings and technologies to the relevant target audience, in order to facilitate their exploitation across Europe and beyond. Eligible projects are those currently funded under the Seventh Framework Programme (FP7) and Horizon 2020.

From December 2015 to May 2017, 16 Results Packs have been published on the CORDIS website, focusing on topics as diverse as quantum technologies, energy, e-Government, resource efficiency, climate services, safer surface transport, cybersecurity, biomass, supercomputing and innovative ICT solutions for active and healthy ageing. In 2017 we have several exciting new Results Packs in the pipeline.

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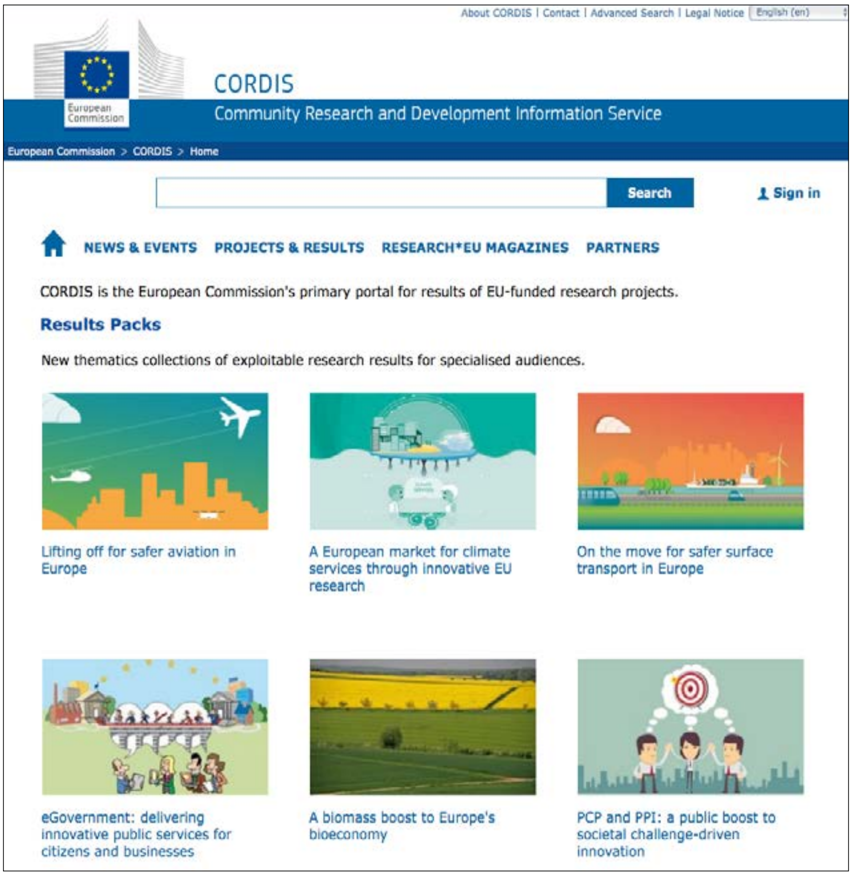

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