FUTURE SKY SAFETY

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FUTURE SKY SAFETY

on Final Approach

PROGRAMME OVERVIEW

PROGRAMME DURATION
Jan. 2015 - Jun 2019

The European Commission (EC) Flight Path 2050 vision aims to achieve the highest levels of safety to ensure that **passengers and freight**, as well as the **air transport system** and its **infrastructure are protected**. However, trends in safety performance over the last decade indicate that the ACARE Vision 2020 safety goal of an 80% reduction of the accident rate is not being achieved. A stronger focus on safety is required. **Future Sky Safety**, established under coordination of EREA, is built on **European safety priorities**, around four main themes with each theme consisting of a small set of Projects.

THEME 1
New solutions for today's accidents
Aims for breakthrough research with the purpose of enabling a direct, specific, significant risk reduction in the medium term.

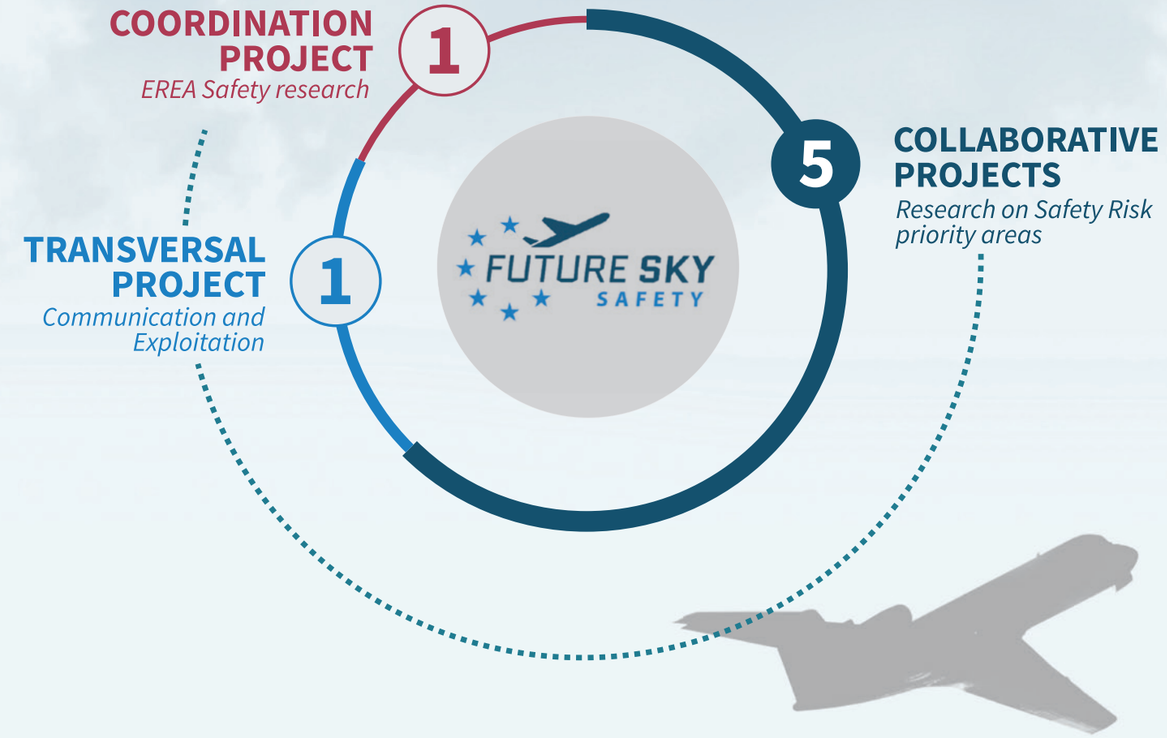
THEME 2
Strengthening the capability to manage risk
Conducts research on processes and technologies to enable the aviation system actors to achieve near-total control over the safety risk in the air transport system.

THEME 3
Building ultra-resilient systems and operators
Conducts research on the improvement of Systems and the Human Operator with the specific aim to improve safety performance under unanticipated circumstances.

THEME 4
Building ultra-resilient vehicles
Aims at reducing the effect of external hazards on the aerial vehicle integrity, as well as improving the safety of the cabin environment.

To really connect and drive institutionally funded Safety R&D (by EREA) to safety priorities as put forward in FlightPath 2050, the EC ACARE SRIA Safety challenges, and EASA's European Plan for Aviation Safety (EPAS) **EREA's Safety Research Coordination activities are planned**. Focus on key priorities that impact the safety level will significantly increase the leverage effect of the institutionally funded Safety Research and Innovation actions planned and performed by EREA Institutes.

JOINT RESEARCH PROGRAMME ESTABLISHED UNDER THE COORDINATION OF EREA AND CO-FUNDED BY THE EU INCLUDES:



PROGRAMME OBJECTIVES

The two main objectives of Future Sky Safety are:
- **Coordination of institutional safety research programmes**
- **Collaborative safety research**

The collaborative research within Future Sky Safety will address five safety priorities. Specific objectives are:

- Perform **breakthrough safety research**, in accordance with the EAPPRE priorities, to enable a significant reduction of runway excursion risk in the medium term.
- **Reduce** the likelihood of **organisational accidents** in aviation via development and implementation of a Safe Performance System (SPS).
- Develop a **prototype risk observatory** to assess and monitor safety risks throughout the Total Aviation System and allow frequent update of the assessment of risks.
- Define and apply the **Human Performance Envelope for cockpit operations and design**, and determine methods to recover crew's performance to the centre of the envelope, and consequently to augment this envelope, through HMI principles, procedures or training.
- Develop solutions to **mitigate the risk of fire, smoke and fumes** related accidents.

PROJECT #1

COORDINATION OF INSTITUTIONALLY FUNDED SAFETY RESEARCH

TYPE OF PROJECT
Coordination Project

PROJECT MANAGER
DLR

9
COUNTRIES AND INSTITUTIONS
involved

3
EREA AVIATION SAFETY RESEARCH PLANS
produced

9
RESEARCH TOPICS
brought under coordination

WHAT'S THE PROJECT FOCUS?

Prior to FSS, the safety **research conducted by the European Aeronautical Research Establishments** was not as coordinated among the establishments as it could be. The institutional programmes could be **better connected and more structured** around the European safety research priorities. P1 aimed at bringing the safety research of the EREA partners under coordination to **maximize efficiency, develop a critical mass, and ensure excellent alignment** with the relevant safety agendas in Europe.

WHAT DID THE PROJECT DO?

EREA **Aviation Safety Research Plans** (ASRPs) have been produced for the years 2016, 2017 and 2018 to fulfil the goals of strengthening the coordination and cooperation among EREA Research Establishments and of building a **pan-European harmonized approach to safety**. These ASRPs drive coordination of institutionally funded safety research by identifying new research topics and **missing links** and by filling **existing gaps**, taking into account a strategic view of the "needs" and an analysis of European Research Roadmaps. Thereby, future **duplication of effort and resources are reduced** and current initiatives are put on a common and more robust path. Accompanying coordination workshops to exchange about institutional research programmes and specific research topics were conducted. Furthermore, a communication platform for all EREA partners with a database of (up to now) more than 230 safety-related publications was set up. A **cooperation agreement** template simplifies starting cooperation and proposals for personnel exchange facilitate joint activities.
The leverage effect of the actions has been and will be assessed, and recommendations and corrective actions are provided.

WHAT DID THE PROJECT ACHIEVE?

The main goals of P1 are to **increase awareness** of content, results and ambitions of EREA safety research activities, to **coordinate** the institutionally funded safety research and to **create cooperative research projects** within EREA. Up to now **14 workshops/meetings** have been organised on specific topics for institutional projects coordination/cooperation. **Nine cooperation projects** of EREA partners are running or have already finished, with a sizeable amount of person months of institutional cooperative safety research invested on topics not included in the EC funded FSS projects. The results show that there is a **significant leverage effect**, which proves that coordination activities of P1 are effective and useful.

WHAT'S IN IT FOR AVIATION?

The **publicly available ASRP 2018** defines an EREA Safety Roadmap, which can be used in the following years to further coordinate institutionally funded safety research of EREA partners. New **coordination topics** are already identified and can be used to start coordination and cooperation activities. Personnel exchange activities and the communication platform can be used by EREA partners to get in contact, learn from each other, raise awareness about common topics and to inform about recent publications. These P1 activities will lead to a more efficient and effective use of resources.

WHAT'S NEXT?

Institutional research programmes are often the result of bilateral coordination between governments and national institutes. There are however multiple forces that shape these programmes like institute ambitions, governmental responsibilities and ambitions and European plans. The goal of EREA research coordination activities, as performed by P1, is to add another **driving force to shape the national programmes**. These activities should continue beyond FSS as they are efficient, effective and useful to significantly strengthen the coordination and cooperation of research activities among EREA Research Establishments.

2nd FSS coordination workshop at ONERA in Palaiseau

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PROJECT #3

SPECIFIC SOLUTIONS FOR RUNWAY EXCURSION ACCIDENTS

TYPE OF PROJECT
Collaborative project

PROJECT MANAGER
NLR

THEME
New Solutions for Today's Accidents

2
RUNWAY EXCURSIONS
worldwide, per week

IN MORE THAN 20 YEARS
their number has not decreased

9
MILLION DOLLARS
is the cost for the global industry

WHAT'S THE PROJECT FOCUS?

Runway excursions are the **most common type of accident** reported annually, in Europe and worldwide. They can easily damage aircrafts and buildings, and there have also been a number of fatal runway excursion accidents. Previous studies have identified **gaps in the research** on runway excursion risk: therefore, P3 focused on many of these gaps and issues to help reduce the number of runway excursions.

WHAT DID THE PROJECT DO?

The flight mechanics of ground operations on **slippery runways under crosswind conditions** were studied, as these conditions highly increase the likelihood of a veeroff. P3 identified some major **shortcomings of simulation models** currently used for pilot guidance in these operations, and explored areas of improvement by analysing computer simulations and full motion simulator experiments with pilots in the loop.

P3 carried out research on the **impact of fluid contaminants** of varying depth on aircraft **stopping performance**, in order to assess how modern aircraft tires and anti-skid systems impact such performance. Analysis of existing test data and dedicated flight tests showed that the current EASA guidance material for aircraft performance calculations, based on outdated flight tests, can be too optimistic; therefore, **improved models** for the braking of aircraft on flooded runways were created.

Advanced methods to **analyse** on-board recorded **flight data** for runway excursion risk factors were examined. Commercial software available limits the analysis capabilities of flight data for runway veer-off risk factors. Therefore, P3 identified the primary data sources useful to **develop several algorithms** to enhance such analysis; the new algorithms were successfully tested using flight data for a variety of commercial transport aircraft (from small regional jets to large jumbo jets). Use of machine learning was also explored.

WHAT DID THE PROJECT ACHIEVE?

New technologies to prevent excursions or their consequences were considered. These cover several areas of the aviation sector, including the aircraft systems, air traffic control tools, met offices, and airport infrastructures. P3 explored **new concepts** to prevent or mitigate runway excursions, and conducted **feasibility studies** for the most promising technologies, along with defining the R&D required to overcome obstacles to implementation.

Major shortcomings of existing aircraft ground models were identified, and areas for further **improvement of modelling** explored.

Based on the tests performed, together with other existing data, new improved models to predict the braking performance of flooded runways were developed. These **new models are more accurate** and less optimistic than the EASA model currently available.

New algorithms were developed that will help to **analyse flight data** for runway veeroff risk.

New technologies for reducing the runway excursion risk levels, varying from on-board systems to systems located at an airport, were identified.

WHAT'S IN IT FOR AVIATION?

The new models for braking friction performance of aircraft tyres on flooded runways can be used to certify civil transport aircraft instead of the less accurate EASA models. These models provide more realistic performance data to pilots, and therefore can reduce the runway excursion risk levels.

The new algorithms to analyse flight data give airlines the opportunity **to better analyse the risk of veeroff accidents** in their operation. These algorithms can be included in the existing flight data monitoring software by vendors or airlines.

New technologies to reduce the runway excursion risk, varying from on-board technologies to systems to be used at an airport, have been identified and can be further exploited at an operational level.

WHAT'S NEXT?

More test data for validating aircraft ground models on slippery runways and crosswind is needed, preferably using full scale aircraft test, although data collection from isolated elements, such as the tyres or airframe, is easier. Having a good runway microtexture for wet runways has shown to be relevant, but research on this topic is limited. New methods to identify the microtexture characteristics of runways and how this relates to braking performance of aircraft tyres should be explored and flight tests on runways with different microtexture levels should therefore be conducted.

Additional advanced algorithms to analyse flight data are needed, not only limited to runway veeroffs but also to other risk areas that can be monitored using flight and other data.

Water covered runway test

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PROJECT #4

TOTAL SYSTEM RISK ASSESSMENT

TYPE OF PROJECT
Collaborative project

PROJECT MANAGER
NLR

THEME
Strengthening the Capability to Manage Risk

5

PREVIOUS PROJECTS FED THIS WORK
CATS, AIM, ISAM, ASIAS, ASCOS

ANSPs *MANUFACTURERS* *OPERATORS*

3

DOMAINS P4 IS PROVIDING RISK ASSESSMENT FOR

WHAT'S THE PROJECT FOCUS?

Project P4 focused on the development of the so-called **Risk Observatory (RO)** and associated **Integrated Risk Assessment Framework**, facilitating integration of domain-specific (like aviation) risk assessment models, aiming to derive a holistic, total system approach to aviation safety. As such this particular RO is an enabling tool for Aviation Safety Management across various stakeholders.

WHAT DID THE PROJECT DO?

After setting up the business and technical requirements for the Risk Observatory, P4 created an **initial RO architecture** that fed the initial prototype design. The prototype consisted of a home page, an Occurrence and a Risk Dashboard, and a preliminary mechanism for "what-if" analysis Dashboard. The RO also coupled Flight Data Management (FDM) data to Safety Performance Indicators.
Then, the **first Risk Observatory prototype** was built. This prototype included risk modelling of backbone models on runway excursions and mid-air collisions, including derivation of influencing factors and contributing factors, and probabilities (based on expert judgement and supporting data). The two backbone models were verified and integrated into the RO, together with a number of FDM data cases selected by the project. A **Risk Observatory user manual** was developed and user feedback on the first RO was gathered from some stakeholders. The prototype software and associated (user-) interfaces are further being developed.
Finally, **a preliminary business model** was created using a business canvas model, stakeholders interview, and a reflection based on the Data4Safety and ASIAS's activities performed by EASA. The Risk Observatory is intended to be a complementary tool to those developments.

WHAT DID THE PROJECT ACHIEVE?

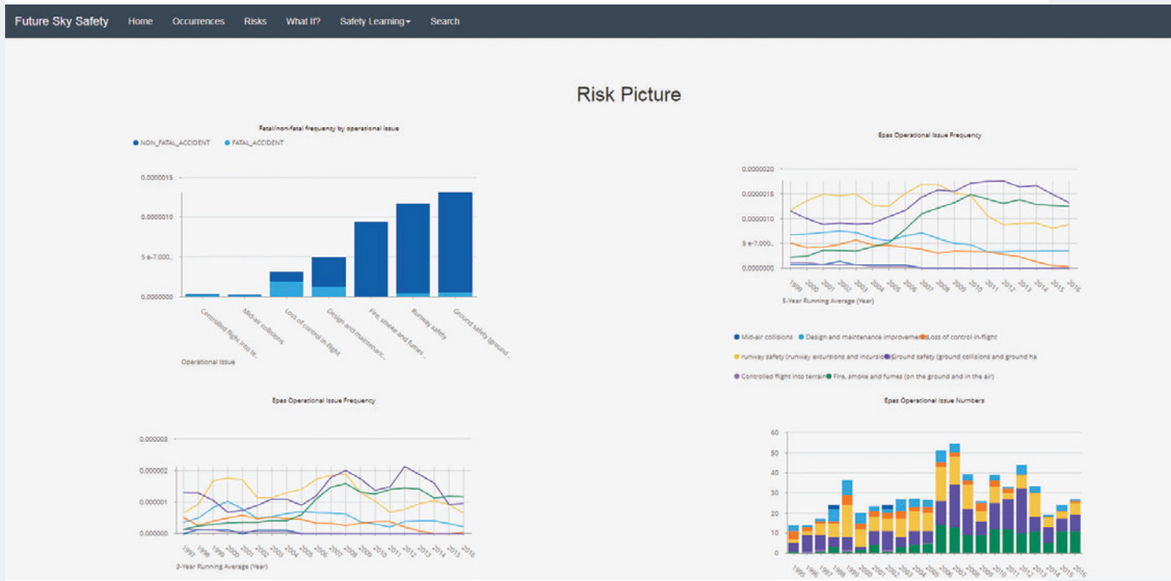
Via specifications, development and user-feedback, a new prototype was developed on a **Risk Observatory (RO)** and an **Integrated Risk Assessment Framework**. This RO will be part of an Aviation Safety Information Sharing and Learning Platform, containing specifically the Backbone Risk models for Runway Excursion and Mid Air Collision Risks, an Occurrence Dashboard, a Risk Dashboard, Flight Data Monitoring data coupling based on a first set of Safety Performance indicators (short, long and deep landings), and a user manual.
Work is ongoing to mature the RO and its associated Risk Assessment Framework, to expand it with more data-analysis intelligence and to set up a business model.

WHAT'S IN IT FOR AVIATION?

The RO prototype and Integrated Risk Assessment Framework are the primary project's exploitable items. Underlying back bone models for Runway Excursion and Mid Air Collision Risks are very suitable for exploitation as well. The Occurrence and Risk Dashboards, when fed with own, user-supplied data are open to expansions, and thereby allow exploitation as to create and derive new safety performance indicators needed by stakeholders.
Finally, work is underway to further enhance the RO to become an **Aviation Safety Information Sharing** and **Learning Platform** that will be a promising exploitation item, both on its own and as a building block for potential use by programs like Data4Safety.

WHAT'S NEXT?

To steer the future research aspects, the **Total System Risk** part of the RO **will be expanded** and enhanced allowing more advanced data trend analysis options, data-intelligence methods and techniques. Other back bone (risk) models should be added, (for example related to CFIT and Loss of Control in Flight, Runway Incursions, Runway veer-off, etc.). Inclusion and combination of more different types of **stakeholder data** (from OEM's, ANSP, Airports, etc.) should be facilitated, including data from other domains.



Detail of the Risk Observatory prototype

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PROJECT #5

RESOLVING THE ORGANIZATIONAL ACCIDENT

TYPE OF PROJECT
Collaborative project

PROJECT MANAGER
EUROCONTROL

THEME
Building Ultra-resilient Systems and Operators

16
TOP MANAGERS *interviewed*

1
SAFETY STACK *initiative*

5
SAFETY TOOLS *produced*

15
AVIATION ORGANIZATIONS *involved*

WHAT'S THE PROJECT FOCUS?

Most aviation accidents have an **organisational risk component,** whether due to a safety culture problem, poor (in hindsight) decision-making at senior levels, a failure to appreciate the importance of 'weak signals' in time, or failure to coordinate effectively during major crisis events. These **"soft aspects"** are hard to address, yet are important for safety. P5 set out to develop tools to help aviation companies **strengthen** their ***management*** of **organisational risks**.

WHAT DID THE PROJECT DO AND ACHIEVE?

P5 started top down, by interviewing 16 senior executives from a variety of European aviation organisations, finding out how they understood and dealt with safety from the top, leading to a **White Paper on "Safety Wisdom".** This led to two further action lines: development of a **safety dashboard for top executives**, and **guidance for middle managers** (called Safety Blueprint) on how to address safety during day-to-day running of the business. The second step focused on those at the **operational sharp end** (pilots, cabin crew, controllers, ground staff), who often notice new issues and potential risks (so-called weak signals), and developed an approach to help them channel such safety insights quickly and effectively to those who need to know, thus **maximising safety mindfulness** where it matters most.
The third step concerned safety culture, where surveys have been used effectively for more than a decade in European air traffic. P5 aimed to migrate the approach to other parts of the aviation system, and carried out **tailored surveys** in two major airlines, six companies at a UK airport, and an airframe manufacturer. This approach worked, and in the case of the airport led to a new innovation in safety culture now known as the **Luton Safety Stack**, in which **15 aviation organisations** are working together to **improve safety and safety culture**, sharing data and putting safety before economic competition. The fourth step focused on how organisations react in major crises such as volcanic ash, and based on insights and methods from the military experience, worked with the European Aviation Crisis Coordination Cell (EACCC) and several other companies to develop novel ways to **increase the resilience of organisations** and inter-organisational collaboration during major national and pan-European crises. The last step involved considering how these various tools and insights could be integrated into **contemporary Safety Management Systems** (SMSs), so that they become a fully-supported component of the way aviation companies stay safe.

WHAT'S IN IT FOR AVIATION?

The resulting guidance and tools from P5 are being hosted on a website (www.safeorg.eu). The tools are as follows:

Executive Safety Intelligence
safety wisdom, safety blueprint, safety dashboard.

Safety Mindfulness
guidance on how to collect and share rapid intel on safety hazards.

Safety Culture
guidance on how surveys work and the Luton Stack process.

Agile Response
guidance on how to improve organisational resilience and agility during crisis events.

SMS
how to integrate such approaches into an existing Safety Management System.

WHAT'S NEXT?

Since P5 is concerned with real organisations managing a complex risk profile, the main ideas for future research concern **further trialling** of the methods in aviation organisations, e.g. migrating the Luton Stack concept to another airport, **further validation** of the mindfulness approach to see how weak signals can really improve safety performance, **further interviewing** of middle managers and use of dashboards at Executive level, and more use of the **agility guidance** in crisis simulations. At a certain point in the future, it would then be useful to carry out an independent evaluation of the safety benefits of the P5 approaches, and the degree of their industrial uptake.

The Luton Stack

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PROJECT #6

HUMAN PERFORMANCE ENVELOPE

TYPE OF PROJECT
Collaborative project

PROJECT MANAGER
DLR

THEME
Building Ultra-resilient Systems and Operators

MULTIPLE FACTORS IMPACT
on human performance

THE HUMAN PERFORMANCE ENVELOPE CONSIDERS A RANGE OF FACTORS
alone or in combination

WHAT'S THE PROJECT FOCUS?

P6 builds on a concept previously proposed in the Air Traffic Management domain. It aims at defining and applying the **Human Performance Envelope for cockpit operations** and at identifying methods to measure the different factors of the Human Performance Envelope and to recover the crew's performance to the centre of the envelope through **improved Human Machine Interface design.**

WHAT DID THE PROJECT DO?

The project started with **defining the Human Performance Envelope for cockpit operation** and selecting the factors of the Human Performance Envelope to be investigated in simulator experiments. Scenarios to be simulated were developed and validated in a workshop with airline pilots and Human Factors experts. At the same time, the project identified potential **sensors to measure the different factors** of the Human Performance Envelope. Those sensors were tested and evaluated in simulator experiments conducted in an A320 full flight simulator with professional pilots. The scenarios of the experiments pushed the pilots to the boundary of the envelope, revealing potential problems for pilots facing complex situations. The results of the simulator experiments steered the development of **new Human Machine Interfaces** (HMIs) to provide the required support to the pilots to safely handle complex situations. These new HMIs were validated in further simulator experiments with professional pilots, conducted in the Thales Avionics 2020 cockpit simulator using the same scenario and sensors of the first simulation.
Finally, the results of both experiments were compared to determine the effectiveness of the new Human Machine Interfaces.

WHAT DID THE PROJECT ACHIEVE?

The results of the first simulator experiments conducted in an A320 full flight simulator showed that the **physiological sensors** are able to measure the different factors of the Human Performance Envelope, especially workload and stress.
The results of the second simulator experiments conducted in the Thales Avionics 2020 cockpit simulator showed that the newly developed **Human Machine Interfaces** significantly improve the situation awareness and decision making of pilots when confronted with a complex situation.

Experiments conducted in an A320 simulator

WHAT'S IN IT FOR AVIATION?

The sensors tested and evaluated in the first simulator experiments can be used to measure some factors of the Human Performance Envelope, which **enables the identification of the pilots'performance.** In case the performance is degraded and outside the boundary of the envelope, **recovery measures** like adaptive automation or Human Machine Interfaces can be triggered to provide necessary support to the pilots to maintain the desired level of safety. This is what the new Human Machine Interfaces developed and validated in the second simulator experiments do. The concept of the New Human Machine Interfaces highlights the required support pilots need when handling complex situations.

WHAT'S NEXT?

Future research should identify and develop **additional sensors** to measure the different factors of the Human Performance Envelope. The focus should be on **non-intrusive sensors** that can be used in real operation. More sensors would increase the robustness of the measurement of the factors and thus would **increase the overall reliability of the Human Performance Envelope** concept applied to trigger situation dependant and individual support to operators in any transport domain when required.

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PROJECT #7

MITIGATING THE RISK OF FIRE, SMOKE & FUMES

TYPE OF PROJECT
Collaborative project

PROJECT MANAGER
ONERA

THEME
Building ultra-resilient vehicles

17'

TO LAND AND EVACUATE THE AIRCRAFT *in case of fire*

SMOKE IMPAIRS VISIBILITY *of aircraft controls*

FUMES INFLUENCE *human comfort, health and safety*

HEAT DAMAGES THE AIRCRAFT *systems and structure*

WHAT'S THE PROJECT FOCUS?

P7 set out to improve aircraft resilience towards risks of fire. It aimed to analyse the thermo-mechanical degradation of fibre reinforced polymer materials, so to numerically design new primary structures and thus avoid costly certification tests; to find new composite material solutions with better fire, smokes and fumes properties to replace phenolic resin based solutions in cabin environment; and to study on-board air quality to deal with concerns by the aircraft industry and safety or health authorities about the use of new materials.

WHAT DID THE PROJECT DO?

P7 manufactured a large number of **T700/M21**, a primary structure CFRP material, test specimens. Existing and newly developed **testing protocols** have been used (e.g. for charred materials, compression loadings, tyre debris impacts…) to **build up a large database**. Then, some state-of-the art thermal, mechanical, and multiphysical models in the industry and research labs have been challenged by comparison with the test results.

New material solutions have been surveyed and selected for **further study:** Hybrid Non-Woven, Fibre Metal Laminates, and Geopolymers. P7 manufactured specimens to **perform various tests:** smoke density, toxicity, heat release, flame propagation and penetration tests, but also mechanical tests at various temperatures and new compression under fire tests (CuFex). Again, state-of-the art models in the industry and research labs have been compared with the test results.

The **state of the art about cabin air quality** has been reviewed (definition, management, monitoring, contributing factors). P7 suggested a number of strategies for **sporadic and continuous air quality monitoring** in aircrafts. A general reflection about the best approach (embracing safety, health and comfort) to deal with Cabin Air Quality has led to a **cost-effective industrial framework proposal.**

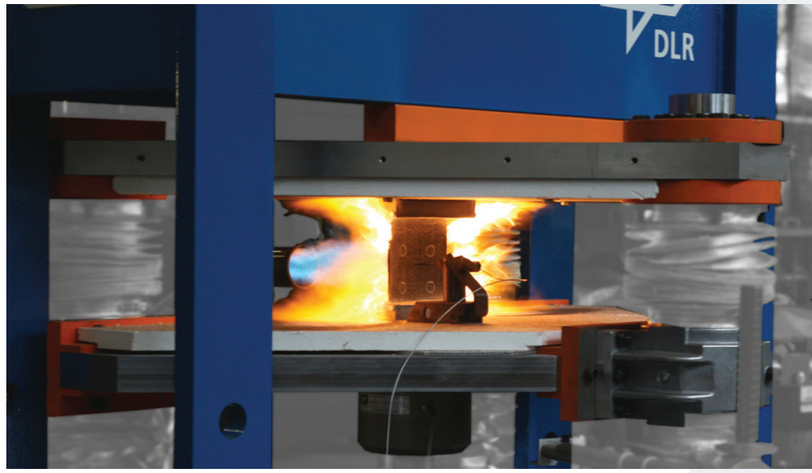
WHAT DID THE PROJECT ACHIEVE?

The main results P7 obtained include:

Almost complete **experimental database for the T700/M21 CFRP material**, including standard and unusual thermal, thermo-chemical and thermo-mechanical tests on virgin and charred specimens.

Demonstrated **improvement of the fire behaviour** of structural parts by using the layered architecture of Fibre-Metal-Laminates and high fire resistant potential for geopolymer based material solutions (resin or sandwich cores).

Development of an experimental methodology, based on affordable COTS sensors, to investigate cabin air quality and of an Industrial cabin air quality Framework based on **Continuous Air quality Sensing (IFCAS).**



Fire test performing

WHAT'S IN IT FOR AVIATION?

The **T700/M21 database** could improve material models, increasing the prediction capabilities of a large set of numerical models and tools against validation cases, to better design A/C primary structures in the future. **Carbon Fibre-Metal-Laminate** could be exploited to design more fire resistant primary structures parts. Industrialisation of manufacturing process for **geopolymer based material solutions** could be worth being further studied. The development of the **IFCAS framework for On Board Air Quality** could start, progressively integrating the latest sensing technologies, thus improving the flight experience for passengers and crew and increasing the cost effectiveness.

WHAT'S NEXT?

As follow up, we suggest that a programme is dedicated to develop a full simulation workchain for the **assessment of a T700/M21 primary structure** (e.g. curved CFRP stiffened panels) compression strength under fire exposure. **Geopolymer based new material solutions** for A/C cabin and cargo environment can be further developed and matured. Finally, business cases for the **generalisation of use of air quality COTS sensors** should be studied and governance of IFCAS framework assigned, potentially together with the EASA "Data for Safety" programme.

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