Dissemination material from second Future Sky Safety Internal Workshop

Vera Ferraiuolo (DBL)

Short abstract: Future Sky Safety is a Joint Research Programme (JRP) on Safety, initiated by EREA, the association of European Research Establishments in Aeronautics. The Programme contains two streams of activities: 1) coordination of the safety research programmes of the EREA institutes and 2) collaborative research projects on European safety priorities.

This deliverable is produced by the Project 2 "Dissemination Exploitation and Communication". The main objective is to present the main outcomes of the second Future Sky Safety Internal Workshop, together with the material produced to improve the internal dissemination of information.

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Acronyms

Acronym	Definition
ACARE	Advisory Council for Aviation Research in Europe
ANSP	Air Navigation Service Provider
ATM	Air Traffic Management
CAQ	Cabin Air Quality
EASA	European Aviation Safety Agency
EC	European Commission
ECAM	Electronic Centralized Aircraft Monitor
ECS	Environmental Control Systems
EFB	Electronic Flight Bag
EREA	European Research Establishments in Aeronautics
EU	European Union
FSS	Future Sky Safety
HMI	Human Machine Interface
HPE	Human Performance Envelope
INEA	Innovation and Networks Executive Agency
OM-B	Operations Manual part B
PFD	Primary Flight Display
R&D	Research and Development
R&TD	Research and Technology Development
RO	Risk Observatory
SESAR	Single European Sky ATM Research
SMS	Safety Management System
SPS	Safe Performance System
SRIA	Strategic Research and Innovation Agenda
WP	Work Package

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EXECUTIVE SUMMARY

Problem Area

Dissemination and exploitation of knowledge is a key ingredient for any successful research Programme. Dissemination is made through a set of specific, coordinated actions. Several dissemination and communication actions are undertaken for raising wider public participation and awareness, to engage with actors beyond the research community (also non-specialised people) and with public as a whole. In addition to these Programme external dissemination activities, it is important to also timely disseminate results internally within the Programme and with the European Commission and EU-related services. Besides the distribution of reports, deliverables and scientific publications, Future Sky Safety organizes two internal workshops on the complete Programme evolution and results for the whole consortium and EC (European Commission).

Description of Work

The objective of this document is to present the main outcomes of the second Future Sky Safety Internal Workshop, together with the material produced to improve the internal dissemination of information.

The second Internal Workshop consisted of two days, organized at the premises of the German Aerospace Center (DLR) in Köln, Germany on the 6-7th of December, 2017.

This report illustrates the dissemination actions and materials produced to promote the workshop and facilitate the transmission of information.

Results & Conclusions

The 2nd Future Sky Safety Internal Workshop was held on the 6-7th of December, 2017 in Köln, Germany at the German Aerospace Center (DLR) premises. About 40 people from the Consortium and representatives of EASA (European Aviation Safety Agency) took part in the event. It focused on the presentation of the achievements and progress of the five technical projects (P3, P4, P5, P6, P7) in the Programme. Presentations were well received by the participants, and fostered a fruitful internal discussion on research needs and future steps.

All FSS (Future Sky Safety) projects were properly represented at the event. Each presentation generated interesting and fruitful discussions, with several interventions from the participants to discuss both the technical aspects of the projects and the more theoretical/high level ones. Participants particularly appreciated the presentation of the main outcomes of each project, which matched the workshop objectives to share the main achievements to improve the internal coordination and overall awareness. A guided tour of the poster exhibition complemented the presentations given, and was very well received by participants as well.

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Overall, the workshop fully reached its objectives, in terms of awareness of the full consortium about projects goals and activities and of awareness of programme technical progress up to date.

Applicability

This document supports the dissemination of FSS results, both internally within the Programme and with the European Commission and EU-related services. In particular, it provides insight into FSS research on:

- P3 Solutions for runway excursions
- P4 Total system risk assessment
- P5 Resolving the organizational accident
- P6 Human performance envelope
- P7 Mitigating the risk of fire, smoke and fumes

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1 INTRODUCTION

1.1. The Programme

FUTURE SKY SAFETY is an EU-funded transport research programme in the field of European aviation safety, with an estimated initial budget of about € 30 million, which brings together 33 European partners to develop new tools and new approaches to aviation safety, initially over a four-year period starting in January 2015. The two main objectives of Future Sky Safety Programme are:

- **Coordination of institutional safety research programmes**, funded by the EREA (European Research Establishments in Aeronautics) institutes;
- **Collaborative safety research** on safety risk priority areas (co-funded by the EC).

The Programme research focuses on four main topics:

- Building ultra-resilient vehicles and improving the cabin safety;
- Reducing risk of accidents;
- Improving processes and technologies to achieve near-total control over the safety risks;
- Improving safety performance under unexpected circumstances.

EU is funding specific **Collaborative Safety Research** projects:

- Perform breakthrough safety research to enable a significant reduction of runway excursion risk in the medium term.
- 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.
- Reduce the likelihood of organisational accidents in aviation via development and implementation of a Safe Performance System (SPS).
- 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 (Human-Machine Interface) principles, procedures or training.
- Develop solutions to mitigate the risk of fire, smoke and fumes related (fatal) accidents.

Coordination/cooperation of institutional safety research programmes connects and drives the complementary in-house Safety R&D (Research and Development) in the European aeronautical research establishments. This achieves significant leverage of the invested EU funding through a more efficient and effective use of resources.

The Programme will also help to coordinate the research and innovation agendas of several countries and institutions, as well as to create synergies with other EU initiatives in the field (e.g. SESAR – Single European Sky ATM Research, Clean Sky 2). Future Sky Safety is set up with an expected seven years duration, divided into two phases.

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Future Sky Safety contributes to the EC Work Programme Topic MG.1.4-2014 Coordinated research and innovation actions targeting the highest levels of safety for European aviation in Call/Area Mobility for Growth – Aviation of Horizon 2020 Societal Challenge Smart, Green and Integrated Transport. Future Sky Safety addresses Safety challenges of the ACARE (Advisory Council for Aviation Research in Europe) Strategic Research and Innovation Agenda (SRIA).

1.2. Project context

Dissemination, exploitation and communication of knowledge are a key ingredient for any successful research project. Future Sky Safety Project P2 is specifically dedicated to Dissemination, Exploitation and Communication; its goals are to:

- Develop a dissemination plan and communication strategies;
- Disseminate safety research findings to relevant target audience;
- Develop a plan for exploitation of results;
- Develop a knowledge and data management policy and approach;
- Assess dissemination activities.

Project P2 ensures that all aspects of dissemination are efficiently and effectively managed over the entire duration of the project, aiming at communicating in a consistent and distinctive way, while engaging and involving different categories of audiences. In this context, an appropriate strategy for the dissemination assessment, with specific quantifiable targets needs to be developed and implemented.

1.3. Research objectives

The objective of this document is to present the main outcomes of the second Future Sky Safety Internal Workshop, together with the material produced to improve the internal dissemination of information. This Workshop was held on the 6-7th of December, 2017 in Köln, Germany at the German Aerospace Center (DLR) premises.

The document is intended for the Workshop participants as minutes of the event, and for the partners who were not able to attend to provide the relevant information about the workshop content.

The document also reports the dissemination actions undertaken to promote the event, and the dissemination material produced for the workshop participants.

1.4. Approach

Minutes of the event, presentations and dissemination material are all included in this report. The report also illustrates the main recommendations drawn from the event, which can be applied to improve the effectiveness and resonance of the last FSS Public Workshop.

1.5. Structure of the document

Section 2 presents an overview of the event held in Köln on the 6-7th of December 2017: the 2nd FSS Internal Workshop. Section 2.1 reports the promotional activities related to the workshop. Section 2.2

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provides the structure of the workshop, illustrating its agenda. Section 2.3 provides minutes for each technical presentation given. Section 2.4 illustrates the dissemination material supporting communication during the workshop.

Section 3 reports the main conclusions and lessons learnt, together with recommendations for future FSS Workshops.

Appendices include the list of participants to the Internal Workshop (Appendix A), presentations given during the Internal Workshop (Appendix B), the Internal Workshop Posters (Appendix C) and photographs from the workshop (Appendix D).

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2 SECOND FUTURE SKY SAFETY INTERNAL WORKSHOP

The Second Future Sky Safety Internal Workshop was held on the 6-7th of December 2017 in Köln, Germany, kindly hosted by the German Aerospace Center (DLR). The workshop was directed to the FSS Consortium with the overall goals of providing all Consortium members technical and scientific progress of the five collaborative projects initiated within Future Sky Safety (P3, P4, P5, P6, P7).

Pictures from the workshop can be found in Appendix D.

2.1. Promotion of the workshop

The event was promoted via email and through the project website, with a dedicated page[1].

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[1] https://www.futuresky-safety.eu/2nd-future-sky-safety-internal-workshop/

A save-the-date and later a final invitation (including agenda) were produced. Both of them were sent periodically via e-mail to more than 200 contacts. As a result, 55 people registered to the event.

Save the date

FUTURE SKY SAFETY
2nd Consortium Workshop

6-7 December 2017

Future Sky Safety is pleased to announce its 2nd Consortium Workshop to be held in Cologne, at DLR Headquarters, on the 6-7 of December, 2017.

The Consortium Workshop will be the opportunity to provide all Consortium members with progress on the five collaborative projects initiated within Future Sky Safety. Updates will include:

- An overview of the project;
- A presentation of the overall technical progress and results to date;
- A vision on the possibilities for exploitation.

The Workshop will also be a chance to network and to discuss the latest research developments on key topics such as:

- Reduction of Runway excursion;
- Total aviation system risk prevention and mitigation;
- Reduction of the likelihood of organisational accidents;
- Improvement of pilot performance and reduction of human errors;
- Mitigation of risk of fire, smoke and fumes in modern cabins.

The workshop is reserved to Future Sky Safety Consortium members.

Registration is required; registration form and workshop agenda will be available soon at: https://www.futuresky-safety.eu/2nd-future-sky-safety-internal-workshop

where

DLR | Cologne

Linder Höhe
51147 Cologne

www.futuresky-safety.eu

Figure 1: Initial save-the-date for the 2nd Future Sky Safety Internal Workshop

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Invitation

FUTURE SKY SAFETY
2nd Consortium Workshop

6-7 December 2017

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The Consortium Workshop will be the opportunity to provide all Consortium members with progress on the five collaborative projects initiated within Future Sky Safety. Updates will include:

- An overview of the project;
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- A vision on the possibilities for exploitation.

The Workshop will also be a chance to network and to discuss the latest research developments on key topics such as:

- Reduction of Runway excursions;
- Total aviation system risk prevention and mitigation;
- Reduction of the likelihood of organisational accidents;
- Improvement of pilot performance and reduction of human errors;
- Mitigation of risk of fire, smoke and fumes in modern cabins.

The workshop is reserved to Future Sky Safety Consortium members.
Registration is required: registration form and workshop agenda are available at:
https://www.futuresky-safety.eu/2nd-future-sky-safety-internal-workshop
All Consortium members invited

where
DLR | Cologne
Linder Höhe
51147 Cologne

www.futuresky-safety.eu

DAY 1

P3: Solutions for Runway Excursion

P4: Total system risk assessment

Poster Session

DAY 2

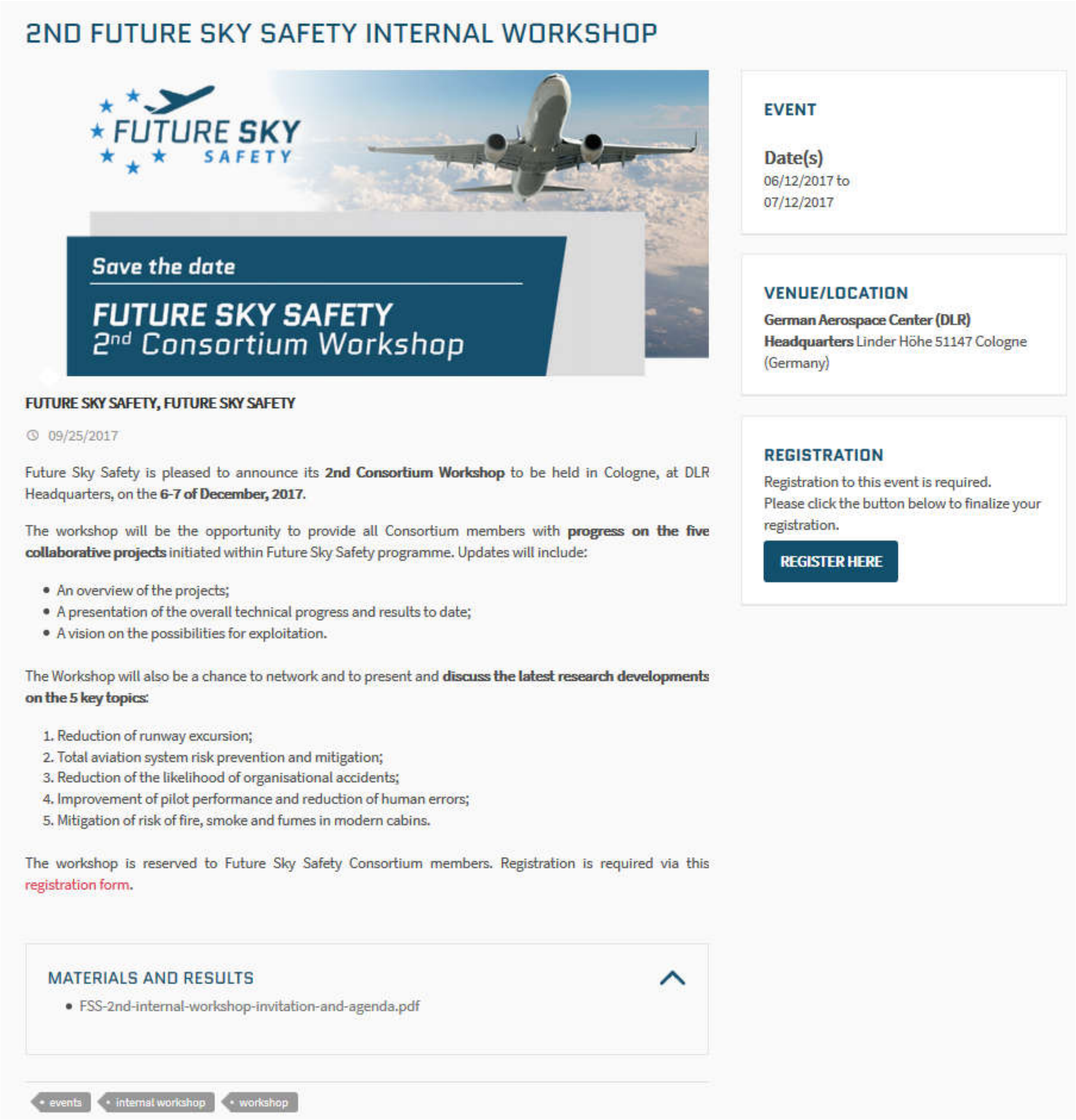
P5: Resolving the organisational accident

P6: Human performance envelope

P7: Mitigating risks of fire, smoke and fumes

Figure 2: Final invitation to the 2nd Future Sky Safety Internal Workshop

A dedicated page on the project website provided participants with all the relevant information regarding the workshop, such as date and location, registration link and an overview of the scope and objectives of the event.



2ND FUTURE SKY SAFETY INTERNAL WORKSHOP

FUTURE SKY SAFETY, FUTURE SKY SAFETY

09/25/2017

Future Sky Safety is pleased to announce its **2nd Consortium Workshop** to be held in Cologne, at DLR Headquarters, on the **6-7 of December, 2017.**

The workshop will be the opportunity to provide all Consortium members with **progress on the five collaborative projects** initiated within Future Sky Safety programme. Updates will include:

- An overview of the projects;
- A presentation of the overall technical progress and results to date;
- A vision on the possibilities for exploitation.

The Workshop will also be a chance to network and to present and **discuss the latest research developments on the 5 key topics:**

1. Reduction of runway excursion;
2. Total aviation system risk prevention and mitigation;
3. Reduction of the likelihood of organisational accidents;
4. Improvement of pilot performance and reduction of human errors;
5. Mitigation of risk of fire, smoke and fumes in modern cabins.

The workshop is reserved to Future Sky Safety Consortium members. Registration is required via this registration form.

MATERIALS AND RESULTS

- FSS-2nd-internal-workshop-invitation-and-agenda.pdf

events internal workshop workshop

EVENT

Date(s)
06/12/2017 to
07/12/2017

VENUE/LOCATION

German Aerospace Center (DLR) Headquarters Linder Höhe 51147 Cologne (Germany)

REGISTRATION

Registration to this event is required.
Please click the button below to finalize your registration.

REGISTER HERE

Figure 3: Dedicated webpage for the 2nd Future Sky Safety Internal Workshop

2.2. Structure of the workshop

The focus of the 2nd Internal Workshop was to present, share and discuss the main results achieved by the EC funded technical projects (P3, P4, P5, P6 and P7). For this reason, room for discussion was left at the end of each presentation batch, with 10 minutes dedicated to the questions and answers between the Project Managers and the workshop audience. The technical presentation given by Project leaders during

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the Workshop are reported in Appendix B; and are also shared with the Consortium via EMDESK[2], together with all the other technical presentations provided at the workshop.

As it can be seen in Table 1, the technical sessions were to be preceded by invited speakers providing the institutional framework:

- EC perspective on Future Sky Safety and European research given by EC-INEA (Innovation and Networks Executive Agency);
- EREA and Future Sky Joint Research Initiative given by a member of the EREA Board;
- Overview of the entire Future Sky Safety programme given by Programme Coordinator Michel Piers.

Table 1: Agenda of the 2nd Internal Workshop

Future Sky Safety 2nd Internal Workshop		
DAY 1		
10:00	***Welcome***	
10:15	***Introductory Remarks***	***EC-INEA***
10:30	***Future Sky***	***EREA BOARD***
11:00	***Future Sky Safety Programme***	***NLR*** Michel Piers
P3: Solutions for Runway Excursion		
11:30	***Short Overview of the Project /Overall Technical Progress and Results / Exploitation***	***NLR*** Peter van der Geest
12:00	***New technologies for reducing runway excursions***	***Thales Group*** Frédéric Barbaresco
12:30	***Crosswind and Tailwind Reconstruction using Flight Data***	***NLR*** Peter van der Geest
13:00	***Discussion***	
13:10	**Lunch**	

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[2] Folder: Workshops Dissemination – Internal Workshop 2 (T37)

P4: Total system risk assessment		
14:30	***Short Overview of the Project /Overall Technical Progress and Results / Exploitation***	***NLR*** Joram Verstraeten
15:00	***Risk modelling***	***Airbus*** Sylvain Metge
15:30	***Risk Observatory software development***	***CEiiA*** Fábio João Oliveira
16:00	***Discussion***	
16:10	**Coffee Break**	
Poster session		
16:30	***Introduction of available posters***	***NLR*** Michel Piers
17:15	***Partnering Event - Visit of the poster Area***	
18:00	**End of First Day**	
DAY 2		
09:00	***Welcome***	***NLR***
P5: Resolving the organizational accident		
09:10	***Are we any closer to resolving the organizational accident? Short Overview of the Project /Overall Technical Progress and Results / Exploitation***	***Eurocontrol*** Barry Kirwan
09:40	***Safety Mindfulness – a practical application for an airline***	***TCD*** Nick McDonald
10:10	***Towards an airport-wide safety dashboard***	***Deep Blue*** Carlo Valbonesi
10:40	***Discussion***	
10:50	**Coffee Break**	

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P6: Human performance envelope		
11:00	***Overview of the Project Human Performance Envelope***	***EUROCONTROL*** Barry Kirwan
11:30	***Can we exploit technology to measure the Human Performance Envelope?***	***Cranfield University*** Jim Nixon
12:00	***Simulator research and development of new cockpit interfaces***	***Lufthansa*** Carsten Schmidt-Moll
12:30	***Discussion***	
12:40	**Lunch**	
P7: Mitigating risks of fire, smoke and fumes		
13:50	***Short Overview of the Project /Overall Technical Progress and Results / Exploitation***	***ONERA*** Eric Deletombe
14:20	***Characterization of the thermo-mechanical behaviour of CFRP (T700/M21) under high temperature conditions***	***ONERA*** J. Berthe, C. Huchette
14:50	***Cabin Air Quality- overview of issues and future directions***	***Embraer*** Ricardo Reis
15:20	***Discussion***	
15:30	***Wrap-up***	***NLR*** Michel Piers
16:00	**End of Second Day**	

- EC-INEA could not participate to the event due to other institutional commitments.
- Volker Krajenski (DLR) as host of the meeting provided an introduction on DLR, on the DLR site in Cologne and main performed activities.
- Marcello Amato (CIRA), as a member of the EREA Board, presented EREA and the Future Sky Joint Research Programme. The first part of the presentation covered the EREA organisation and its activities, objectives and peculiarities, such as its specific approach from invention to innovation. The second part, dedicated to Future Sky, illustrated how the Programme is looking even further, building on four 4 pillars (safety, noise, energy, and air transport integration) and pushing two types of activities: the coordination of institutional activities, and the proposal of collaborative projects at European level.

- Programme Coordinator Michel Piers gave an overview of Future Sky Safety and provided updates concerning the two objectives of the Programme: R&TD (Research and Technology Development) activities and the coordination of institutional programmes. Overall, the technical projects are doing quite well, progressing as expected apart from small delays.
    - P3 is progressing as expected.
    - P4 will need to issue and demonstrate its Risk Observatory software.
    - P5 has been very active on Safety culture and appeared in the media on this topic. The project is close to making an actual, immediate impact on aviation; a good impact is already perceived at a political level.
    - P6 is going well, and experiments and modelling are progressing.
    - P7 is progressing nicely on its research on new materials, on the characterization of the fire behaviour of primary structure composite materials and on solutions to mitigate smoke and fumes in cabin environment.

  Michel Piers highlighted that 2018 is crucial to FSS with respect to exploitation and dissemination, as the Programme needs to demonstrate its impact and clear connections to applications. Four exploitation actions are planned already: application of the prototype risk observatory for P4; development of the next generation dashboard in P5; development of a bio-vest to be worn by the research subjects within P6; and development of a prototype composite part with fibre-metal laminates and polymers for P7.

  As for the collaborative projects (P1-P2), Piers underlined that the biggest result is the approval of FSS2, the second phase of the Programme. In addition, the coordination activities amongst EREA institutes are progressing in terms of exchange of personal and research, which will be put in place in 2018. Finally, there is a fruitful circulation of inputs between the EREA board and Future Sky Safety.

2.3. Presentations

2.3.1. P3 Specific solutions for runway excursion accidents

Peter van der Geest (NLR) provided the first two technical presentations, illustrating P3's progress.

First, van der Geest gave an **overview of the project**, presenting its general objectives:

- improving methods for analysing aircraft ground control on slippery runways under crosswind;
- quantifying the impact of water/slush covered runways on braking performance for modern tires and anti-skid systems;
- developing new methods to identify veer-off risk using operational flight data;
- exploring new concepts for prevention of excursions and reduction of consequences of runway excursions.

Then, he illustrated the activities performed in the four research areas the project covers: aircraft ground control on slippery runways under crosswind; braking performance on flooded runways; identification of

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veer-off risk using operational flight data; and new concepts to prevent and reduce consequences of excursions.

Finally, he shortly presented the expected products for P3: new data and tools for certification of transport aircraft on flooded runways; new technologies to reduce runway excursion risk; and new tools to be used in flight data monitoring.

In his second presentation, on the **Reconstruction of cross and tail wind components from flight data**, **van der Geest** presented the work performed as part of the development of new methods to identify veer-off risk using operational flight data.

Crosswind is a factor in 24% of veer-off occurrences. Based on this, P3 moved from two research questions: can we use flight data to estimate surface wind components during the critical phase of the landing? And what accuracy can we achieve? If the answers to these two questions prove satisfactory, can we monitor cross wind exposure from flight operational data to monitor critical events and trends?

Van der Geest illustrated the requirements needed to accurately determine the surface wind components (cross- and tail-wind components), and why we cannot use existing parameters to obtain an accurate representation of the instantaneous wind during the landing phase.

After explaining the research performed by P3, van der Geest concluded that:

- For determination of instantaneous cross- and tailwind during the landing phase, neither METAR-data, nor FMS-wind are well suited;
- ADIRS-wind is near instantaneous, but without sideslip correction and low sample rate (cross/tailwind accuracy = ~3 kt resp. 4 kt);
- Instantaneous wind can be reconstructed from flight data parameters, compensating for bias-errors and sideslip with fair accuracy (~2 kt);
- Reconstructed cross- and tail-wind can be used to monitor actual encountered wind conditions in relation to applicable limits or guidelines.

Frédéric Barbaresco (Thales) provided the last presentation for P3, illustrating the **new technologies the project is developing to reduce runway excursions**. Barbaresco introduced the main factors impacting the braking distance (to full stop). As there are many of them, P3 is working on a combination of concepts (both airborne and ground) aiming at reducing runway excursions by having a more complete view of the runway condition and by providing a forecast of runway conditions. Pre-requisites to this imply collecting huge quantities of data from various systems, creating a database with complementary information and then combining the two concepts in order to use weather prediction to predict runway conditions.

After illustrating past concepts used to prevent runway excursions, Barbaresco showed how P3 is going further, and the ground solutions it developed:

- Ground Runway Excursion Alert & Warning System based on Big Data Analytics & AI;

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- Predictive BD and ROT concept;
- Big Data Techniques;
- The water depth prediction model.

However, Barbaresco also highlighted that crew training, airborne equipment and airport systems have already reduced occurrence of runway excursions, but as the "zero risk" does not exist, we now have to focus on reducing consequences as the way forward to improve safety. The future lies in safety nets protecting stakeholders regardless of outside conditions. Recent models predict where accidents can happen in a much more precise manner; therefore, mitigation measures should be placed in a strategic manner to prevent consequences when likelihood is increased. A challenge remains open with respect to the cost borne by the airport for the benefit of the airline.

To conclude, Barbaresco presented an overview of airborne solutions, like the Landing Assessment, a system that provides to the pilot all information for approach phase preparation; and two concepts to reduce risks of runway excursion.

The first one, CORSAIR, provides on-board and aircraft based computation of Braking Action, providing a reliable, timely, objective runway condition evaluation means consistent with aircraft landing performance. A feasibility study has demonstrated the viability of this technology over 6 years of development.

The second one is a concept to prevent runway veer-offs during operations under crosswind: the crosswind landing controller. It is conceived as an on-board system for crosswind operations using steerable main landing gear to touch-down in crabbed motion and providing pilot assistance system to automatically perform de-crab after touchdown on ground, keeping the aircraft on runway centreline, and allowing manual steering inputs by pilot. So far, Future Sky Safety performed the following work: adaptation of A320 simulation model (main gear steerability); development of assistance system; implementation in motion-based full-flight-simulator; and simulator study with pilots.

Key points related to the cross-wind landing controller:

- It appears that better classification in landing operations is linked to more joined recordings of flight mode (manual, auto-land…) and tracks with associated detailed conditions in vicinity of the airport.
- There is still to explore and control a large set of scenarios: A/C type, A/C weight, air temperature, pressure, speed at threshold, touchdown place, slope and friction along the track, head and cross wind, targeted exit, exit speed, settings (slat/flap, auto-brake, thrust reverser).
- Due to the weak occurrence of abnormal cases, many simulated landings are required to produce accurately these cases for each triplet [A/C, runway, set of (extreme) conditions].

2.3.2. P4 Total system risk assessment

Joram Verstraeten (NLR) provided a short overview of the project, its technical progress and results on the **development of the Risk Observatory** and the possibilities for future exploitation.

P4 works to develop a prototype Risk Observatory (RO) as an enabling tool for safety management, and a risk assessment framework integrating risk assessment models specifically developed to represent a certain domain. The RO will acquire, fuse and structure safety data (which can include data from normal operations) and translate it to actionable safety information. The risk observatory targets analysts and managers in different domains, such as operators, ANSPs (Air Navigation Service Providers), manufacturers, airports and authorities.

During the first year of the project, P4 performed a series of consultations and desktop research useful do draft first requirements for the Risk Observatory; then, requirements were translated into an early prototype to be discussed with end users. The software prototype is the first important achievement of the project.

In the second year, the project worked to shift from domain specific risk models to an integrated risk assessment framework. Risk models calculate risk by estimating a probability of an occurrence with a certain severity. An estimate of risk is valuable safety information, but these models are often specific for one domain, e.g. ATM (Air Traffic Management) or manufacturer. The Risk Observatory, instead, aims at being of interest to a diverse group of users from both authorities and service providers.

In year three and four, P4 is working on perfecting its first “look and feel” prototype to achieve a fully functioning prototype, with proper functional design and software architecture. In the end, this will lead to an actual software that will include a graphical user interface and background systems to manage data. Also, the core of the risk observatory, i.e. the risk assessment framework that integrates risk assessment models specifically developed to represent a certain domain, should be available.

Sylvain Metge (AIRBUS) provided the second presentation on the risk dashboard and on the **development and integration of the Aircraft Safety Model into the risk observatory**.

The purposes of the risk dashboard are:

- To get an overall risk picture by plugging and running models from several domains instead of considering individual models;
- To estimate the impact of a risk mitigation action;
- To perform sensitivity risk measurement to the risk contributors.

In order to do so, the risk dashboard should manage interacting safety models using data from various sources. Therefore, the Risk Observatory needs to be structured in a way that allows to “plug” different types of models from several contributors of the different domains (e.g. aircraft/system manufacturers, aircraft operators, ANSPs). P4 uses the “Backbone Model” to integrate safety results from all the different domain specific models.

Metge then illustrated the Aircraft Safety model, which will produce two types of results: qualitative results, given by the shortest combinations of technical failures & flight crew errors leading to a dangerous situation; and quantitative results.

Finally, Metge concluded with the lessons learnt:

- The Backbone Model does allow the integration of domain specific models; it also integrates ground system contributors, operator errors, airborne systems, and considers the influencing factors;
- The same approach was used for the Mid Air Collision Risk;
- Probably, there is the possibility to apply the Backbone Model approach to any type of risks (controlled flight into terrain, runway incursion…).

Some challenges are still open:

- Integration and collection of data; managing in a consistent way different units of quantification; managing consistency amongst various domains
- Integration of collected data into the models
- Take into account the impact of common cause failures across various domains
- Manage in a consistent way the classification scheme over the various domains
- Manage in a consistent way several units of measurement used for quantification (per flight hour, per controlled flight hour, per operational hour…)

To close P4's sessions, **Fábio João Oliveira** (CEIIA) presented the **Risk Observatory software development and implementation**. The objective of this effort was to develop a prototype of the Risk Observatory that embeds the integrated risk framework and populates it with data for safety monitoring in order to obtain risk pictures for the total aviation system. Behind this, there was a high-level development process.

It started with establishing the users' requirements for the Risk Observatory (RO), collected in various ways, e.g. with questionnaires and interviews.

Then, the process to design an early prototype began in order to decide what the RO should look like. The early "look and feel" prototype came out of this process, addressing the needs and wishes of end-users and the requirements identified in WP4.1. P4 tested acceptability of the prototype with stakeholders, using specifically developed example use cases.

After that, P4 derived a preliminary system architecture by the questions the stakeholders posed. The RO is an analytical tool that analyses data, and P4 took as examples software on the market to include data integration tools, data visualization tools, and so on. Some features were kept in mind when deriving the system architecture, as the need to ensure functional and interface descriptions; to allow each organization to customize the product; to integrate and harmonize different data from different domains and stakeholders into a standardized data model, and so on.

The next step was functional design, needed to tell designers what to develop and how. All the previous work was further developed and especially the system architecture; the functional design also defined the workflows, the user and system interface, the data inputs and outputs and the procedures for operating the observatory. The functional design will also define the connection between the risk assessment framework and aviation data, serving as a basis for the actual software development.

The final stage will be software development for a Risk Observatory able to collect, protect and integrate external raw data to ensure data aggregation and system interoperability, making raw data accessible and standardized; and to develop tools for data quality assurance and data integration.

In the end, the software will respond based on what the user wants to achieve, processing the data in a different way. A large part of the software is already deployed and implemented; now, P4 has to prove this as a concept.

2.3.3. P5 Resolving the organisational accident

Barry Kirwan (Eurocontrol) introduced P5, a project seeking to **resolve the organisational accident**, which is very likely to be a component of the next aviation accident.

To achieve its ambitious objective, P5 had to address many challenges:

- How do you ensure safety leadership from the top?
- How do you ensure organisational focus is on the right issues?
- How do you maintain safety focus through the middle?
- How do you ensure rapid sharing of safety intelligence at the sharp end?
- How do you ensure the right safety and just culture?
- How do you work together with other organisations in a major crisis?
- How do you include all of this in your Safety Management System?

P5's research tries to answer these questions.

In the area of Safety Intelligence, P5 performed a study to explore how 16 aviation industry senior executives use safety intelligence to make safe business decisions. This led to the publication of the white paper "Keeping the aviation industry safe. Safety Intelligence and Safety Wisdom", a study that exposes some of the "wisdom" employed in identifying business decisions that protect safety, with the hope of supporting safety wisdom across the industry. P5 needed to get through the top managers as this is the only way to ensure that findings go into practice; however, as Kirwan underlined, as middle managers are managers of managers they may be an unexplored resource for safety. Currently, we do not know how they manage safety or what they think about it; therefore, in order to explore this, P5 contacted 28 middle managers in 2016 and another 20 in 2017, involving them in semi-structured interviews for thematic analysis. Although P5 could not give them each other's information, they were willing to come together and exchange directly their experiences. This exchange led to a model that served as guidance to all middle managers.

Under the research area of Safety Mindfulness, P5 has worked with an airline and an ANSP to design an App enabling ATCOs to post, update, and retrieve safety-related information useful to help them perform their daily tasks and activities safely. The App responds to the question, who are you going to call if you saw something unsafe? How can you tell someone that something unsafe has just happened?

Concerning the Safety Culture research area, P5 conducted a survey in collaboration with the European Cockpit Association; more than 7000 pilots from 32 airlines replied. The results of the survey received wide press coverage, even if the average article misunderstood the findings as "pilots fly when tired". As the survey concluded, instead, on average Safety Culture is quite good. There is, however, a worry on fatigue amongst pilots as they are concerned fatigue is affecting their performance; in addition, perceived organization support is not so good: more than half the pilots surveyed feel their companies do not take the fatigue issue seriously. Finally, the survey shows that on average Cargo and Low Cost airlines, and those pilots on unsecure contracts, generally had poorer safety culture and performed worse.

In order to deepen its research, P5 needed to get together Air Traffic Controllers, airlines, airports and aircraft engineers, all focusing on a single airport: 15 organisations are now in the “Luton airport safety stack”, a joint effort for safety improvement undertaken by organisations based in Luton airport, meeting every few months to work around just culture and safety culture. The Luton stack already obtained results regarding working procedures.

The Agile Response Capability research task found that there is a need to exercise for managing crises, with the main objectives of building a know-how on how to manage these situations and running simulations to test reactions. The ultimate scope is to have different organisations involved in airport management working together effectively in a crisis. In order to do so, we need to move from individual competence to organizational resilience and to create appropriately challenging exercise situations useful to increasing efficient and effective learning opportunities. In the end, experience gained through exercising and learning from actual crisis events will lead to a better preparedness and crisis management, managing and mitigating adverse events that could impair safety.

Kirwan concluded his presentation by illustrating the work P5 is doing on advanced Safety Management Systems (SMS) with the scope of setting standards of excellence for SMS.

Nick McDonald (Trinity College Dublin) presented the **Mindful Governance in aviation**, illustrating the results of P5’s three-year research activity on the **safety mindfulness concept**.

Organisational Mindfulness is a key concept in resolving the organisational accident. It focuses on the role of people at the operational sharp end: in fact, operators are a unique source of critical information about normal operations, and key recipients of intelligence about operations. This idea is at the heart of the original conception of safety mindfulness of Weick and Sutcliffe that, however, is not operationalized as a practical and effective approach. Aviation, being a ultra-safe industry, does not offer so many incidents to learn from; therefore, it is important to pay close attention to what is happening in everyday operations and to learn from them. In addition, we have to consider that organisations find it difficult to implement recommendations from their safety investigations and risk assessments. A scientifically sound evidence base for both of these features is lacking.

The Safety Mindfulness concept is now a very clear and credible concept: what is not clear is how to implement it. The Operational Mindfulness Model shows that mindfulness is more than just a state of mind, but rather consists of gathering information and have them flow in order to raise awareness and take appropriate action.

The Mindful Governance Model is not only about thinking of organisational principles and designing a system that works, but even more on supporting people in what they have to do. Therefore, P5 developed software applications to operationalize and evaluate the new mindfulness concept in two full-scale operational case studies. These software applications are of two types: reporting any issue from normal operations and generating narratives for circulation and comment, and implementing improvement in an accountable manner.

The Case Studies involve the MUAC ATC Centre (Netherlands) and Alitalia Ground Operations (Italy).

Research with the MUAC ATC Centre demonstrated the need for the gathering and circulation of potential risk-related narratives amongst air traffic operational staff in order to heighten safety mindfulness in this ultra-safe sector, ensuring effective feedback loops of relevant information into the operation. The case study has been designed, the software prototype developed and the trial implementation phase is planned to commence following the final preparation meetings that took place in October 2017. Full implementation trials are provisionally planned for the first quarter of 2018.

Alitalia is using a big data approach: “big data” risk pattern analysis of audit reports identified poor pre-turnaround briefing as a precursor of other operational failures, which in turn were associated with actual safety incidents. This has initiated a case study centred on improving turnaround briefings and mindful performance. It will deploy two applications designed to create a mindful improvement initiative:

- An Implementation Manager that supports a collective improvement effort and effective handover across implementation phases;
- Operational reporting to ensure continual information flow and feedback as the initiative continues.

Currently, there is a strong commitment from both MUAC and Alitalia to test, validate and implement the software during 2018. Implementations trial will have to:

- Demonstrate proof of concept, i.e. the overall validity of the concept, to ensure that the concept actually works in practice in a normal operation and validate the functionality and usability of the software applications;
- Include the integration of the application into the host’s IT and operational environment;
- Provide training, usability assessment, final adjustment and debugging;
- Validate and evaluate the software.

For sure, P5 has to provide evidence of this via a full trial of its scientific and industrial impact. An evaluation metric (the mindfulness survey) has been developed to assess the penetration of the concept of Safety Mindfulness in the day-to-day experience of those involved in or affected by the case studies.

Exploitation potential is wide: it may be applied not only to all sectors of aviation, but also to all industries that carry a significant operational risk, including health and social care, emergency services, financial services and other transport modes. The applicability of these ideas across these domains has been demonstrated through teaching and research at master’s level with risk, safety and change professionals across these industries, though no formal market analysis has yet been done in advance of the initial concept demonstration in the current case studies. Full trial implementation is key to provide powerful evidence of the exploitation potential of FSS Safety Mindfulness model and outputs both in aviation and wider afield.

Carlo Valbonesi (Deep Blue) closed the session illustrating the work done on the **Safety Dashboard**. The dashboard is a tool that safety managers can use to present results to their directors.

First, Valbonesi introduced the concept of Safety Intelligence. Eurocontrol defined safety intelligence as “the ability of people in management positions of an organisation to make good decisions about safety”. Three components make up Safety Intelligence: social competence (keeping safety central in the interactions with other people), safety knowledge (having access to information that makes sense about the safety performance of an organisation) and problem solving (understanding the problem and generating ideas to solve it). These components are all necessary for Safety Intelligence to be solid.

P5 wants to understand how to support Safety Intelligence in a way that helps those at the top to make good decisions on safety. Therefore, it came out with the idea of using dashboards, i.e. “cognitive tools that improve your "span of control” over many business data, helping people visually identify trends, patterns and anomalies, reason about what they see, help guide them toward effective decisions”. In other words, a dashboard is used to “tame” a lot of information for the user, in a way that it can be more easily used to make decisions. A Safety Dashboard supports all the three components of safety intelligence: mainly safety knowledge, as the Safety Dashboard provides information needed to understand what is going on in terms of safety. However, it supports problem solving as well, providing thresholds and trends needed to see whether a critical point is being approached. It also supports social competence, as dashboards are used to start conversations around safety.

Valbonesi presented the work done so far with ANSPs as a first step. P5 performed a survey with a Safety Dashboard User group composed of safety directors and managers, through in-person interviews and a workshop in Rome. The goal was to understand how safety managers design dashboards that their executives use. P5 found that most users have static dashboards that are the result of putting together information coming from the most different sources: just one had a quite advanced system for querying databases and coming up with charts and graphs. From here, P5 designed the “ideal dashboard” for executives. In order to do so, attendants, divided in groups, listed the indicators felt as more needed; the recurring ones were selected for the design of a prototype dashboard. This work was useful to start from the user needs to answer the question: as a safety manager, what is the most important information I want to discuss with the board when sitting at the quarterly meeting?

A first version of the Safety Dashboard was presented at the FSS Public Workshop in March 2017 in Brussels. Meanwhile, interactions with the user group continued in order to validate the prototype. All this work found endorsement from the Eurocontrol Safety team. Two meetings with the user group are planned for January and March 2018 to further refine and validate the safety dashboard. The goal is to have at least 4 ANSPs that start using the prototype Safety Dashboard at Executive Board level, in order to then feedback the lessons learnt to other ANSPs. A presentation of how the safety dashboard works in its current, second release followed.

Finally, Valbonesi presented the current strand of work aiming at serving the needs of a stack (i.e. a joint undertaking of several organisations working at the same aim). P5 is currently developing an airport stack dashboard for the Luton stack, which found the prototype dashboard interesting. The project collected needs for building the airport dashboard; two prototypes of the dashboard have been issued and discussed with the Luton operators already.

Overall, P5's achievements so far include:

- The interest the Safety Dashboard received from Eurocontrol, where the Dashboard was not imposed but raised genuine interest;
- The interest it raised in the Luton Stack and the agreement found with the Luton stack on sharing their safety data;
- The visual prototypes developed as a starting point for discussion.

There is still some uncertainty on some fundamental points and some future challenges to address. P5 has to answer questions regarding:

- Who are going to be the main users;
- What data can be shared and what cannot, and which are the boundaries for sharing safety data;
- What will be the frequency of updates;
- How to reconcile the user-centred approach to the dashboard with implementation constraints, e.g. technological and budget constraints;
- The fine-tuning of the collaboration process with the stack.

Overall, P5 needs to streamline the mass of information, and to come up with common requirements accepted by all the organisations.

2.3.4. P6 Human Performance Envelope

Barry Kirwan (Eurocontrol) introduced P6 and the **Human Performance Envelope**. The project had a series of objectives to achieve:

- Defining the Human Performance Envelope (HPE)
- Conducting preliminary experiments (includes selecting and assessing sensors)
- Conducting first flight simulator experiments (including validating the HPE and the sensors, and identifying performance decrement limits)
- Developing new HMI to recover performance
- Conducting second simulator experiments (including validating new HMI)

The HPE was defined during a workshop in April 2015: agreement was found to focus on Workload, Stress and Situation Awareness as the main factors of the HPE in the simulator experiments. The metaphor of the HPE comes from the flight envelope: just as if you push an aircraft outside the envelope it does not fly/crashes, if you push humans over their boundaries, they fail.

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Therefore, P6 conducted exploratory simulations to look for the edges of the human performance. For ATCOs, this means for example they are not able anymore to process what they are seeing on their screen; however, it is not a single factor but a combination of factors that is going to crash your plane. Preliminary experiments took place at ONERA and Cranfield University in October 2015 to develop the simulator scenarios, fine-tuning them with project members, pilots and Human Factors experts, and to select and assess the sensors for measuring the different factors.

First Simulator Experiments in A320 DLR flight simulator AVES involved 10 Lufthansa crews and employed nine scenarios with varying workload, stress and situation awareness. The challenge was trying to find objective measures of the internal status of the pilot. P6 used some subjective measures as well as eye tracking; performance data were collected along with physiological data. In addition, P6 conducted debriefings and a cognitive walk-through of critical situations (to analyse the mental representation of the pilots before, during and after a critical situation).

Determination of Recovery Measures led to identifying performance decrement limits and necessary HMI improvements. New HMI presents information about the limitations of the aircraft, the operational consequences of the limitations and the available options. New HMI were integrated in Thales Avionics 2020 Cockpit Simulator.

A second set of simulator experiments with the advanced cockpit took place at Thales in October 2017 and involved 20 pilots from Lufthansa (first officers flying A320). The simulations used the same aircraft model as in first simulator experiments (A320), the same scenario (approach intro Bremen with technical failure in complex situation), the same captain and measurements. Although complete results will be available only in March 2018, it was clear that pilots really liked the new HMI, but would like better if it were implemented tomorrow.

Jim Nixon (Cranfield University) presented next, aiming to answer the question **can we exploit technology to measure the human performance envelope?**

Nixon described the aircraft performance envelope and the changes in interface design. Aircraft today are much more sophisticated than in the past but, although the aircraft knows more than it lets on, it does not know about the state of the crew.

Therefore, P6 tried to find a way to measure the state of the crew, keeping in mind that such a system needs to be continuous, unobtrusive, reliable and acceptable to the crew and the operation. For example, it cannot be a helmet on the scalp as it is not acceptable for the crew. Luckily, technology provides a hand and many miniaturised devices (wearable technology, not looking like a medical device) exist that are able to measure electrical signals from the heart, ECG and EEG; eye tracking glasses and depth-sensing cameras are also spreading. Of course, this technology will have to be validated to establish how reliable these measures are, and parameters will have to be set to say when the performance is degraded; but we will probably end with having too much data and not knowing how to interrogate it. It is crucial, then, to try to understand what we could infer from these measures.

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Next, Lufthansa pilot **Carsten Schmidt-Moll** presented the simulator research and **development of new cockpit interfaces**. His presentation tried to answer the question **do pilots get the information they need when they need it**?

Recently, due to a change in the aviation industry there has been an increase of workload for pilots: larger aircraft fly into smaller airports; there is pressure for reliability of the schedule (independent of weather and time of day); and airlines operate with less extra fuel. As industry is changing, surely a new interface is needed. But, what interface?

Schmidt-Moll presented a scenario with a normal flight and then an abnormal procedure. In the normal approach, the pilot flies supported by the ATC. In the abnormal procedure, the pilot flies supported by the Electronic Centralized Aircraft Monitor (ECAM), operational manuals come into play (and additional documentation is provided on the EFB (Electronic Flight Bag), a tablet or notebook used by the pilot, crucial for flight safety), new landing performance calculation is needed as well as a new approach briefing. This leads to the pilot monitoring the flight.

In an easy scenario of management of the abnormal procedure, there would be no interruptions, no other ATC conversation, no distraction by the cabin crew, no turbulence, no distracting noises, extra fuel for 60 min and no decision making by the Captain (Pilot Flying). In a not-so-easy scenario, all of the above is not granted and, in addition, time is running out. Surely, a new interface could come in hand.

Schmidt-Moll focused on New Cockpit Interface, saying that improvements are needed.

In particular, the format (position in the cockpit and type of information provided) of the low fuel warning makes it go easily undetected by pilots, while instead this warning is crucial for the aircraft safety. Instead, fuel should be into the Primary Flight Display (PFD), which is now not the case; in addition, the remaining flight time should be provided in minutes, not in kg, as this requires calculation for the pilot, wasting time and increasing workload.

Then, Schmidt-Moll argued that although manufacturers do not recommend skipping a procedure, and although operational manuals say that “in any case, the basic procedures must be followed”, they do not support pilots in easily apply those procedures.

Again, Schmidt-Moll highlighted that new HMI are required for out-of-the-box scenarios, but a different approach is needed, as right now pilots do not get the important and relevant information.

The Electronic Flight Bag, crucial for flight safety, should be further exploited as:

- It is a library of over 30 different operational manuals and over 70 computer based training programs;
- Includes company news, duty roster, safety bulletin;
- Includes a performance calculation tool, a complete briefing tool (weather, NOTAMS, etc.) and different additional tools (dictionary, converter, etc.);
- Provides electronic communication (email, all reports) and route manual with maps and charts;
- Has a flight and fuel efficiency program.

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On the other hand, it requires frequent updates than can be an issue for pilots.

To conclude, according to Schmidt-Moll simulator research did show that Cockpit interfaces must still improve in different areas:

- Information must not be spread across different documents (e.g. ECAM, OM-B);
- Warnings and cautions must correspond to the severity of the risk;
- Relevant information must be in a usable format (e.g. remaining fuel in minutes);
- Relevant external data must be made available for decision making (e.g. weather conditions);
- Physiological data does not help pilots as it does NOT refer to actual risks;
- Pilots' electronic flight bag must also be considered relevant for flight safety.

2.3.5. P7 Mitigating the risk of fire, smoke & fumes

Eric Deletombe (ONERA) introduced P7, providing an **overview of the project**. The rationale behind it is that 50% of fatalities in case of aviation accidents are fire caused/related, and about 300 fatalities a year could be avoided if fire fatalities were suppressed.

In recent years, risks of fire are increasing with the adoption of new hybrid/electric aircraft because their design has more electric parts and uses more organic composites than before. In addition, there is limited knowledge on the fire and heat behaviour of composites materials: few test results are available with regards of mechanical properties of material above 200° and of toxic smoke and fumes, as tests are quite expensive and industrial tests are often confidential.

P7 aims at increasing safety by:

- Improving knowledge concerning OMC materials and structures behaviours vs. fire;
- Assessing mechanical properties of heating/burning/degraded materials;
- Evaluating the fire consequences (including toxicity and smoke), and proposing solutions to mitigate them;
- Sharing database for future modelling purposes;
- Establishing/giving design recommendations.

A specific task, "WP7.1 Understanding and characterising the fire behaviour of primary structure composite materials (epoxy resins, standard CFRP)", aims to increase knowledge of fire behaviour and performance of CFRP primary structure materials by producing a comprehensive experimental database on a reference material (T700GC/M21). Then, P7 aims to share results within the European research community and confront experimental results to state-of-the-art models and simulation tools. Deletombe reported the finding of WP7.1 about the physico-chemical and mechanical properties of T700/M21 after fire exposure, showing an important decrease of the mechanical properties and no more rate effect. As for the residual fire or mechanical properties of T700/M21 panels, reporting of results from post impact fire testing is still in progress.

"WP7.2 Improving material solutions to mitigate fire, smoke and fumes in cabin environment (plus toxicity)" aims at enhancing passengers' safety by developing and assessing new solutions at material and structural levels that mitigate risks of fire, smoke and fumes in the cabin. This has to be done in a way that meets current industrial safety requirements, and using standard experimental methods and state-of-the art simulation tools. Leonardo provided the requirements and specifications for tests and specimens, defined based on industrial state-of-the-art and applicability, and ensuring compliance to certification rules. P7 defined material characteristics to measure during the test, and almost all the tests have been performed.

Currently, P7 is gathering material characteristic data and flame penetration test results, evaluating material models and simulation tools (flame penetration), with respect to standard and new cabin material solutions, and evaluating the industrial applicability of materials defined in the project, in order to define/reformulate new standard aeronautical fire tests.

P7 tested different materials, including geopolymer materials, studied by the Czech Aerospace Research Centre (VZLU) through different tests (FS&F tests, mechanical tests) which also take into account comments from the previous workshop. DLR is exploring material characterisation of unidirectional CFRP and quasi-isotropic FML. Compression tests are currently in progress, and required the construction of a test stand for testing the compression properties under simultaneous fire exposure (CuFEx). Tests are under progress for FML, GPL and CFRP. Combination of natural fibres (flax) and recycled carbon fibres with Geopolymer Matrix (GPL) are being tested as suggested in the previous workshop, and are currently under progress.

WP7.3 studies the “effects of new materials, technology and fuel systems on the on board air quality” with a focus on safety, exploiting opportunities offered by latest technical developments. Recently, several questions concerning the impact of new materials on the on-board air quality, consequences of the use of new material in conditions of elevated temperatures and the issue of cabin fumes (health concerns) emerged. WP7.3 performed a literature study identifying a working definition of “Cabin Air Quality” (CAQ) and exploring environmental control systems (ECS) to manage cabin air, potential contaminants and sources, methods of monitoring air quality, current standards and performing a comparison with other enclosed environments (e.g. International Space Station or submarines).

New concepts of sensors were candidate to studying and/or monitoring Cabin Air Quality based on different criteria and building on real-time commercial sensors that are becoming less expensive in time. New sensors are smaller and cover a wider range of contaminants, but repeatability of results is still a challenge and a correct sampling strategy is required. P7’s third presentation further explores this topic.

P7 developed a Test Bench Concept (a possible WP7.3 product) and an Air quality test procedure for composite materials to investigate the feasibility of monitoring system with low cost sensors. This is the topic of P7’s second presentation.

Deletombe closed the first presentation with an overview of the dissemination actions performed by P7, including presentations in 5 international conferences, the organisation of a mini-symposium and the participation in one OPTICS project dissemination event, which reached more than 1000 people. The project will submit several papers in 2018. Exploitation measures include building a prototype demonstrator to show the technologies developed and tested in WP7.2. It will be made of two curved panels attached to each other by connectors, representing the inner (interior) and outer (fuselage) shell of an airplane.

Eric Deletombe also presented the work performed by ONERA on the **characterisation of the thermo-mechanical behaviour of CFRP under high temperature conditions,** on behalf of Julien Berthe and Cedric Huchette.

Burn-through resistance of aircraft structures. P7 performed burn-through tests to assess the fire behaviour of composite materials. Unlike some metallic structures, composite structures generally do not experience burn-through until after 4 or 5 minutes of fire exposure; however, better understanding of complex physical phenomena is needed to get better safety margin management and anticipate next fundamental issues.

Composite ply properties. Influence of the temperature increase showed that in carbon/epoxy composite material temperature dependency is due to the epoxy resin and may affect in-plane loadings (both compressive properties and shear properties).

The objective of WP7.1 is to understand and characterise the fire behaviour of primary structure composite materials, thus enhancing knowledge concerning the fire behaviour and performance of CFRP primary structure material. The aim is to produce a comprehensive experimental database on a reference composite material (T700GC/M21), sharing the results within the European research community and confronting experimental results to state-of-the-art models and simulation tools. The proposed approach used both classical (standard) and new test protocols.

Classical Test Protocols (DMA, TGA, DSC) were performed to study:

- The influence of the temperature on the composite material's thermo-mechanical and thermo-chemical response.
- The influence of high temperatures on the quasi-static tensile properties of composites in all directions.
- The high velocity impact response of composite panels.

Then, P7 designed, developed and put in place **New Test Protocols** to investigate:

- Pyrolysis of composite materials using a laser based heating system.
- Influence of the temperature on composite compressive properties in the fibre direction. High temperature compressive tests on unidirectional ply were performed: P7 developed a specific compressive testing set-up for high temperature compressive tests on unidirectional ply, to ensure correct loading conditions.
- Influence of temperature and strain rate on tensile properties in the shear direction. High temperature tensile shear tests were performed: P7 developed a specific testing set-up for high temperature tensile shear tests.

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- Influence of temperature on the tensile properties of composite materials in the fibre direction. INJECT (INternal Joule heating for thErmo meChanical characterisation) was used to study high heating ramp, using digital cameras (visible or infrared).
- Influence of the high temperature (by Joule effect) on toughness properties, for fracture toughness analysis under high temperature conditions.
- Flame-wall Interaction Research Experiment (FIRE), to study fire/flame effects on panels.

Deletombe then illustrated the **test results of thermal & thermo-chemical properties of composite materials**, which served to produce a comprehensive experimental database on the reference material (T700GC/M21). The protocol to prepare charred sample materials and the methodology of investigation implied conducting independent experiments to isolate a single (set of) parameter(s), as numerous input parameters are required for physico-chemical and thermo-mechanical models (here for T700/M21).

Deletombe illustrated the results of the **thermo-chemical kinetics and energetics** analysis, which employs:

    - Differential Scanning Calorimetry (DSC);
    - Thermo Gravimetric Analysis (TGA) at different heating rates (BLADE);
    - Global kinetics model developed using Arrhenius reaction rate equations.

Deletombe then explained the **test results on the mechanical properties of virgin materials**, with specific regard to:

- The influence of the temperature on the tensile properties in the fibre direction.
- The influence of the temperature on the tensile properties in the transverse direction. High temperature on static tensile test and transverse loading showed a high influence of the viscous behaviour for transverse loading.
- The influence of the temperature on the composite material tensile mechanical properties in all directions.
- The influence of the temperature increase on the compressive properties in all the directions: high temperature compressive tests on unidirectional plies show huge variation of the mechanical properties with the temperature increase.
- The influence of the temperature and the strain rate on the tensile properties in the shear direction: high temperature tensile shear tests show influence of strain rate and temperature on the shear behaviour.

Finally, Deletombe illustrated the **test results on the mechanical properties of charred materials & panels**, exploring:

- The residual mechanical properties of the T700/M21 carbon/epoxy composite material after degradation were studied; an experimental protocol was required to prepare charred sample materials.
- The definition of an experimental protocol to prepare charred sample materials was based on the hypothesis that slow isothermal decomposition in a furnace is needed for homogeneous decomposition.

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- A multi-physics characterisation approach was required to study the residual mechanical properties after degradation. P7 performed all the tests and analyses, which showed an important decrease of the mechanical properties and no more rate effect.
- A general methodology was established for the analysis of combined mechanical and fire loading during the life cycle of the composite structure. The methodology comprised three steps: first, the tyre debris impact on a composite panel; then, a post-impact damage analysis is performed; then, the fire test follows.
    - The above analysis also required an experimental setup for the tyre (an aircraft tyre from Michelin France) debris impact on a composite panel. The impact was loaded with a gas gun. Deletombe showed the test video.
    - Post-impact damage analysis was performed with a pulsed thermography. Results show that at V=150 m/s there is almost no damage; at V=170 m/s some damage is located in the surface ply; at V=186 m/s damage and delamination across the thickness occur.
- Fire tests were conducted on the impacted panels (T700/M21 panels, provided by CEiiA) to study their residual fire resistant properties:
        - Flame/composite interaction photographs on the exposed side
        - Thermal response on the back surface by quantitative IR thermography
        - Back surface deformation measured by Digital Image Correlation to detect delamination onset and growth
        - Mass loss measured during fire exposure
    - All impact tests were performed, but the analysis is still in progress.

To conclude his second presentation, Deletombe outlined the status of P7 as follows:

- WP7.1 “Understanding and characterising the fire behaviour of primary structure composite materials” has currently reached its objectives of producing a comprehensive experimental database of a reference composite material (T700GC/M21).
- A significant number of methodologies and results are now available for thermo-mechanical characterisation of composite material from the virgin state to the degraded one.
- WP7.1 deliverables provided data on T700/M21.
- Model analysis is currently in progress.

Ricardo Reis (Embraer) provided an **overview of issues and future directions on Cabin Air Quality**. Air cabin is a complex matter and even its definition was not clear at the beginning. As established by P7, an acceptable working definition is “the holistic (physical, chemical, biological, radiological) characteristics of cabin air”. As such, it concerns health, safety and comfort, and comes to a cost for companies.

Different factors influence Cabin Air Quality and the perception of related issues: world and industry trends affect it, as do problems related to smoke and fumes in the cabin and the possible impact of new materials. In addition, it relates to passengers’ comfort and to the increased awareness on air quality due to the increasing availability of sensing monitoring and reporting devices.

As for the safety and health concerns on fumes and odours, P7 reviewed results from an EASA Study (2017) and from the REACH project (ending in 2019). Preliminary results of the EASA study show that CAQ is better than in other indoor environments, and there are no causal links between fumes events and health. A new large scale study by DG MOVE/EASA was launched in 2017, focusing on abnormal events.

About passengers' comfort, the subject relates to the necessity of improving filtration and odour removal, and pressure and humidity level. Reis highlights that in recent years there is a change of perceptions about odours: the "new car smell" is not appreciated anymore and defence against outside pollution is a feature of new Tesla and Volvo cars.

On-board continuous monitoring will require an interface with the aircraft and physical interfaces for sensors and operation, and a data repository. The repository could pose a problem regarding governance and business model. The question whether this should be on airlines or institutions is open.

It is also important to involve passengers in future scenarios, as on-board monitoring is an increasing reality.

Studies on new materials and substances, used in the aircraft structure, for thermal and acoustic isolation, in furnishing and so on, are required as well, as many new types are coming in use, including composite materials, nano-materials, meta-materials and flexible electronics components. Therefore, modelling and testing for aging and release, as performed by WP7.3, are crucial.

To conclude, Reis highlights that:

- There are different lead initiatives to clear doubts on on-board contaminants;
- Research shows good CAQ so far, but doubts linger;
- World trends point to increased pressure on the aviation system;
- New technology for filtering and sensoring are more and more available;
- Introduction of new materials seems robust, but could be improved.
- Potential new challenges lie in the introduction of nanotechnologies.

2.3.6. Wrap up

FSS Programme Manager Michel Piers (NLR) offered a wrap up of the workshop, closing the event.

In addition to summing up the main achievements of each technical project, Piers highlighted how the workshop succeeded in providing the audience with a thorough overview of what the programme is doing globally. Piers underlined that all the projects are making good progress and stressed the importance of the next FSS Public Event to spread the results achieve to a wide audience.

2.4. Dissemination material

One of the main objectives of the 2nd Internal Workshop was improving consortium awareness of projects' progress and potential for future exploitation.

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Therefore, at the registration desk each participant received a copy of the Future Sky Safety handout produced for the 1st Public Workshop, so to have a quick overview of all the projects within FSS.

In addition, in order to raise participants' awareness on the status of the technical projects, a poster session was open to projects willing to contribute. In the afternoon of the first day of the workshop, FSS Programme Manager Michel Piers guided a poster tour in collaboration with the authors, so that each poster received a fair amount of attention.

Posters displayed during the workshop can be found in Appendix C.

3 CONCLUSIONS AND RECOMMENDATIONS

3.1. Conclusions

Overall, the 2nd Future Sky Safety Internal Workshop was successful and fully achieved its objective of providing the audience with a thorough overview of what the programme is doing globally and what are the next steps.

Nearly 40 people attended the event, including representatives of each project (see Figure 4) and three representatives of EASA.

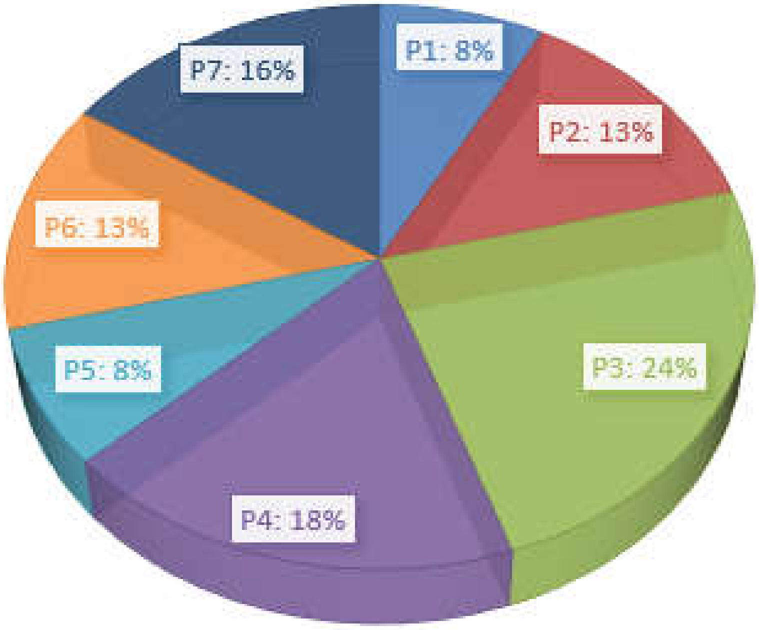

Figure 4: Representation of Future Sky Safety projects at the 2nd Internal Workshop

Each presentation raised interesting questions, with several interventions from the participants to discuss the technical aspects of the projects presented. Also the poster session was very well received, with the full audience attending the guided tour.

3.2. Recommendations

After the workshop, some recommendations can be made for the future FSS Public event.

Each presentation raised the interest of the audience, leading to many questions and discussions. It is recommended that a large amount of Q&A time slot is planned for the next Workshop.

With respect to P2 activities, recommendations are related to the production of dissemination material tailored to the event, as they were well received during all the events organised by Future Sky Safety. In addition, participants suggested that communication of the next Public event should be given fairly in

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advance, in order to allow for the invitation to circulate properly, and for the participants to save the date in their agendas.

Appendix A LIST OF PARTICIPANTS TO THE 2ND INTERNAL WORKSHOP

N.	Surname	Name	Organisation
1	Al-Tayawe	Abubaker	Cranfield University
2	Amato	Marcello	CIRA
3	Apostu	Emilia-Alexandrina	EASA
4	Barbaresco	Frederic	THALES AIR SYSTEMS
5	Bogos	Stefan	INCAS
6	Charles	Rebecca	Cranfield University
7	Chatzialekou	OURANIA	EASA
8	Chira	Alina-Ioana	INCAS
9	Deletombe	Eric	ONERA
10	Emelianov	Denis	TsAGI
11	Ferraiuolo	Vera	Deep Blue
12	Friedrich	Maik	DLR
13	Greene	Graham	CAA
14	Grimm	Ferdinand	Technical University of Munich
15	Hamelijnck	Regine	EASA
16	Kirwan	Barry	EUROCONTROL
17	Kos	Johan	NLR
18	Krajenski	Volker	German Aerospace Center (DLR)
19	Lamiscarre	Bruno	ONERA
20	Marchante Rodriguez	Veronica	Cranfield University
21	Martaus	Frantisek	VZLU
22	McDonald	Nick	Trinity College Dublin
23	Metge	Sylvain	AIRBUS
24	Moitas	Mónica	CEiiA
25	Nixon	Jim	Cranfield University
26	Oliveira	Fábio	CEiiA
27	Piers	Michel	NLR - Netherlands Aerospace Centre
28	Quintiaes	Marta	Embraer Portugal, S.A.
29	Reis	Ricardo	Embraer Portugal, S.A.
30	Ribeiro	Bernardo	CEIIA
31	Schmidt-Moll	Carsten	Lufthansa
32	Strelkov	Vladimir	TsAGI
33	Toader	Adrian	INCAS
34	Valbonesi	Carlo	Deep Blue
35	van der Geest	Peter	NLR - Netherlands Aerospace Centre
36	Verstraeten	Joram	NLR - Netherlands Aerospace Centre
37	Vozella	Angela	CIRA
38	Wang	Chong	Technical University of Munich

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Appendix B 2nd Internal Workshop Presentations

Appendix B.1 "P3: Prevention of runway excursions" – Peter van der Geest, NLR

European Commission

FUTURE SKY SAFETY

P3:Prevention of Runway Excursions

FUTURE SKY SAFETY – 2nd Consortium Workshop , 2017

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Presentation overview

- ☐ Project objectives
- ☐ Project results
- ☐ Expected products

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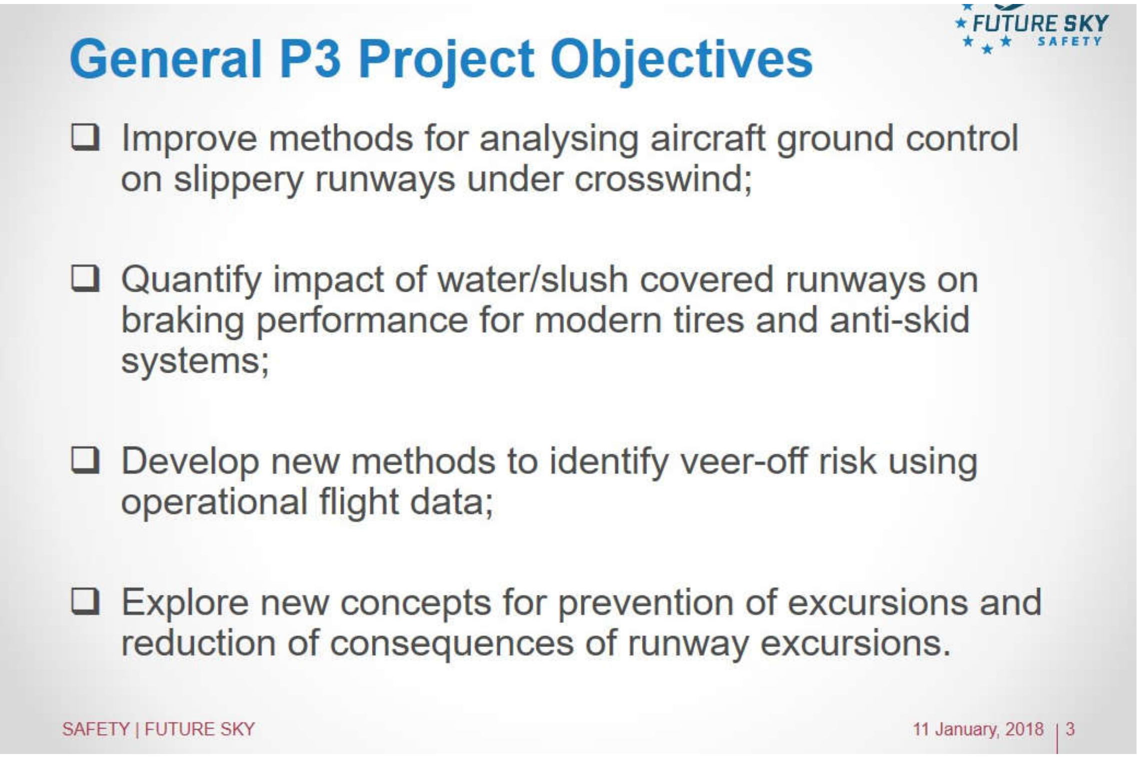

General P3 Project Objectives

- ☐ Improve methods for analysing aircraft ground control on slippery runways under crosswind;
- ☐ Quantify impact of water/slush covered runways on braking performance for modern tires and anti-skid systems;
- ☐ Develop new methods to identify veer-off risk using operational flight data;
- ☐ Explore new concepts for prevention of excursions and reduction of consequences of runway excursions.

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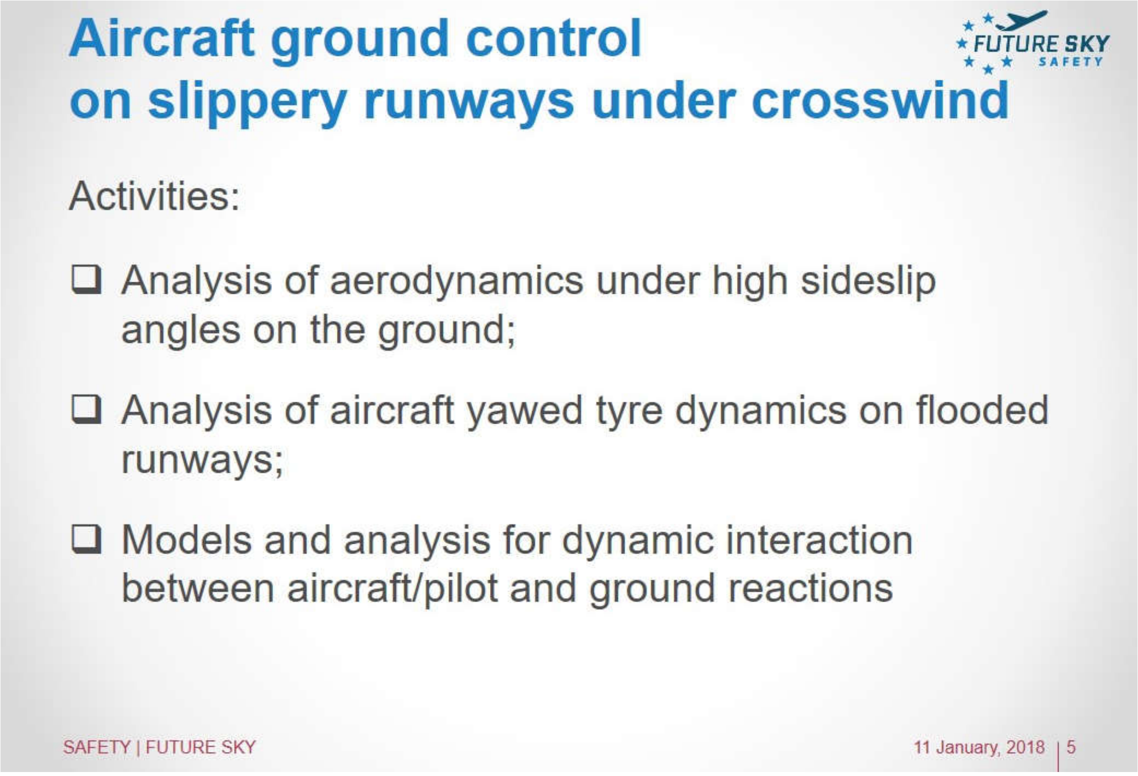
P3 hopes to contribute in avoiding these events....



Aircraft ground control on slippery runways under crosswind

Activities:

- ☐ Analysis of aerodynamics under high sideslip angles on the ground;
- ☐ Analysis of aircraft yawed tyre dynamics on flooded runways;
- ☐ Models and analysis for dynamic interaction between aircraft/pilot and ground reactions

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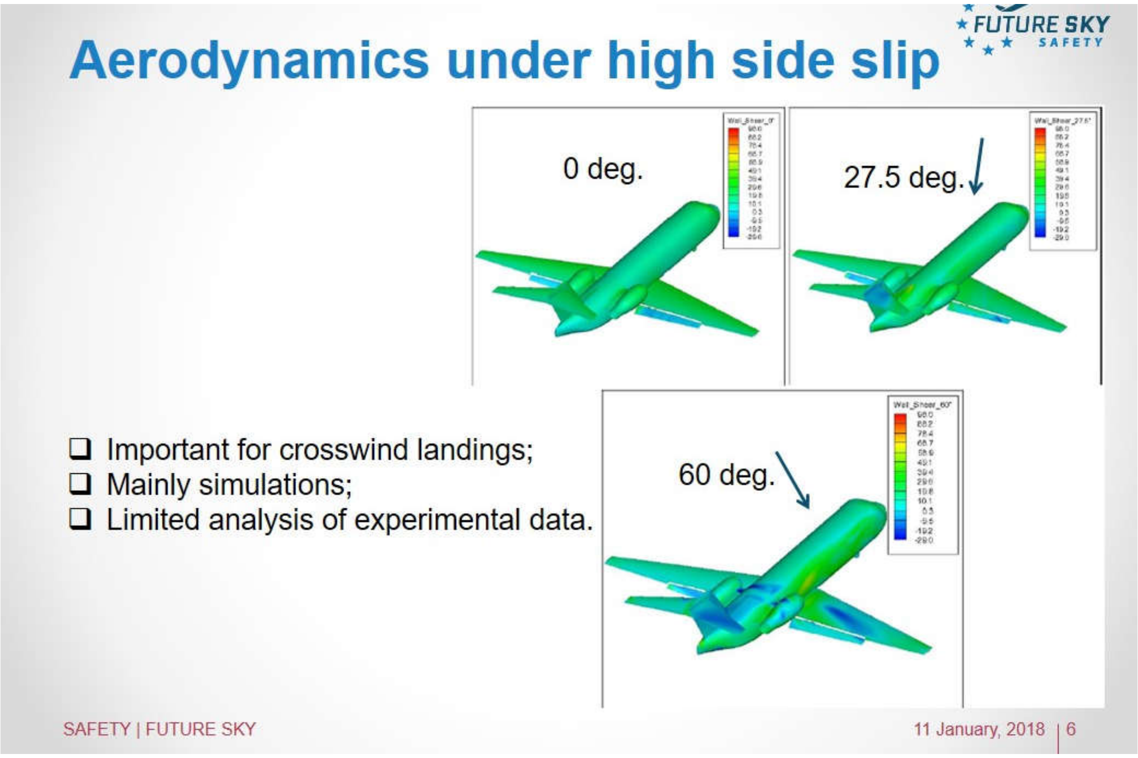

Aerodynamics under high side slip

- ❑ Important for crosswind landings;
- ❑ Mainly simulations;
- ❑ Limited analysis of experimental data.

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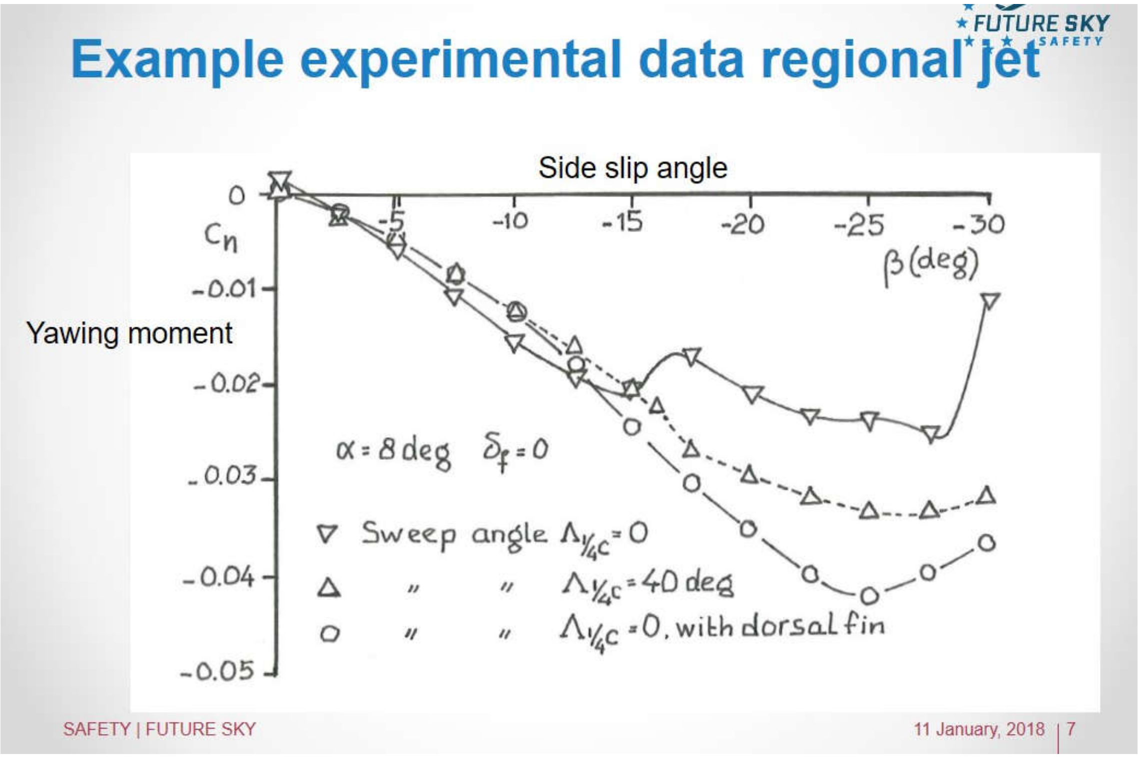

Example experimental data regional jet

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Aircraft yawed tyre dynamics on flooded runways

Aircraft test tyre

Tests on flooded surface

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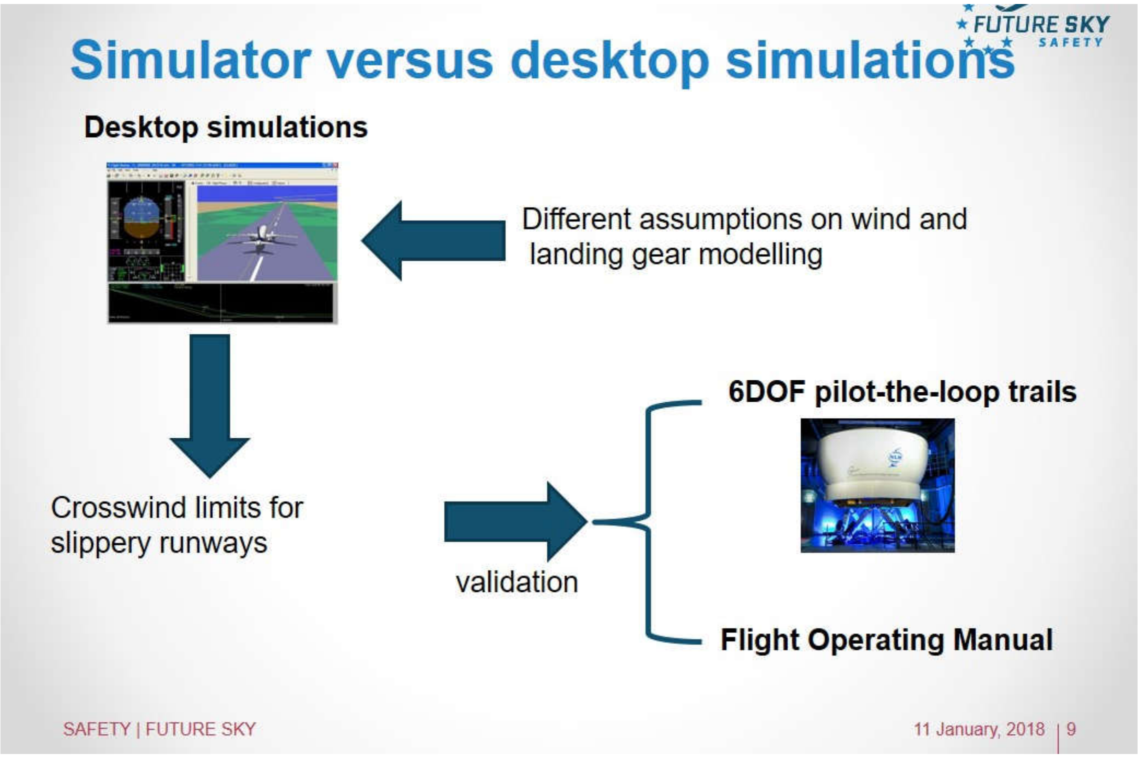

Simulator versus desktop simulations

Desktop simulations

Different assumptions on wind and landing gear modelling

Crosswind limits for slippery runways

validation

6DOF pilot-the-loop trails

Flight Operating Manual

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Braking on flooded runways

Activities:

- ☐ Analysis of available test data;
- ☐ Additional aircraft flight tests on flooded runways;
- ☐ Use data for model development / improvement of existing models for braking friction.

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Flight testing on flooded runways

Water pond used for testing

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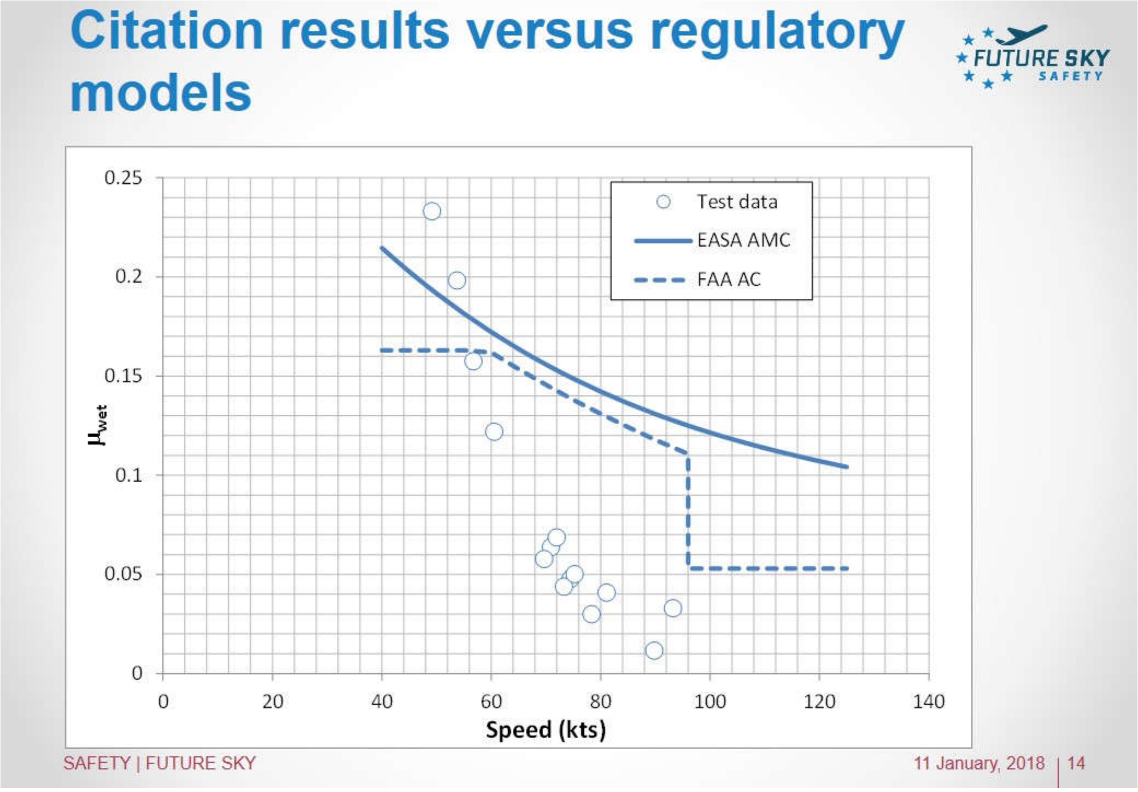
Test aircraft used

Cessna Citation

Airbus A400M



Citation results versus regulatory models

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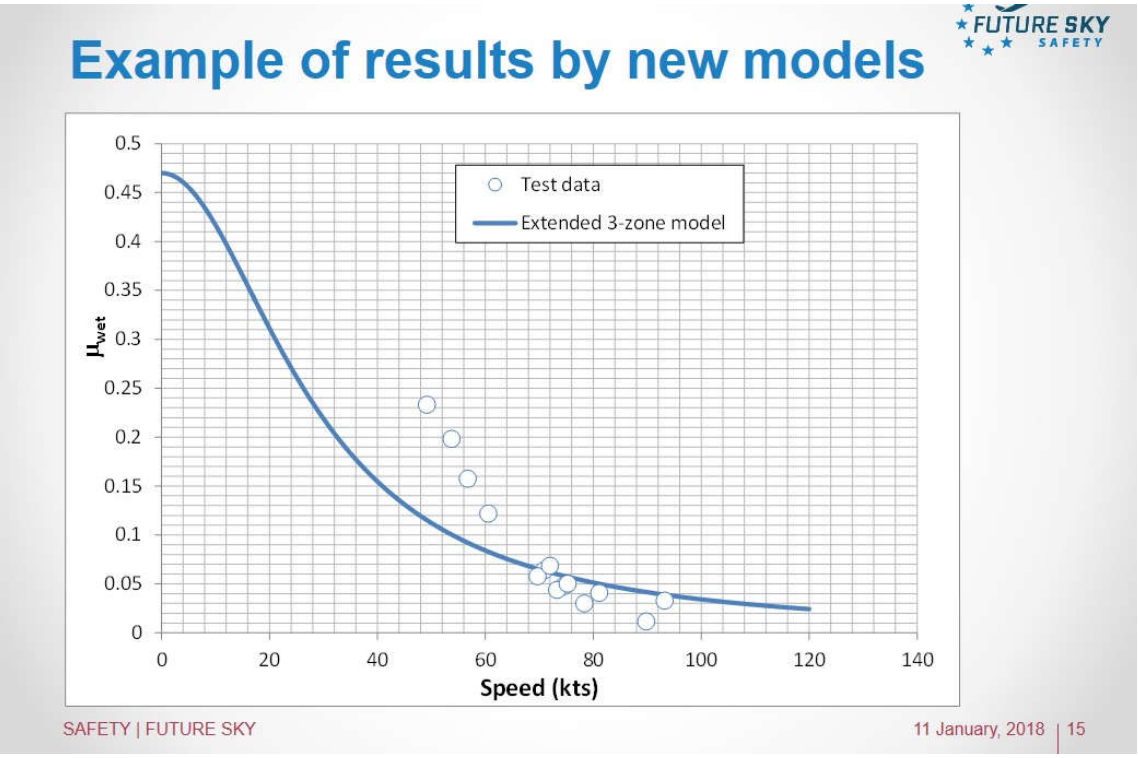

Example of results by new models

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veer-off risk using operational flight data

Activities:

☐ Identification causal factors in runway veer-offs;

☐ Identification of available and useable data;

☐ Development of new algorithms for flight data analysis.

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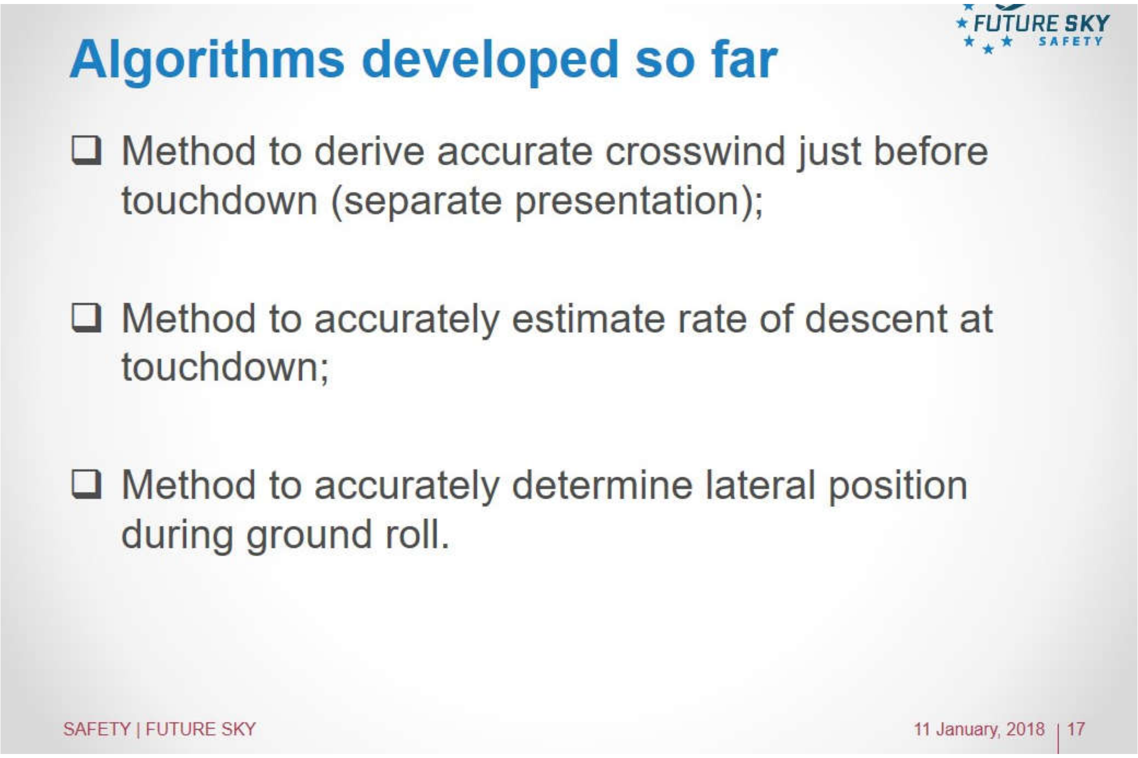

Algorithms developed so far

☐ Method to derive accurate crosswind just before touchdown (separate presentation);

☐ Method to accurately estimate rate of descent at touchdown;

☐ Method to accurately determine lateral position during ground roll.

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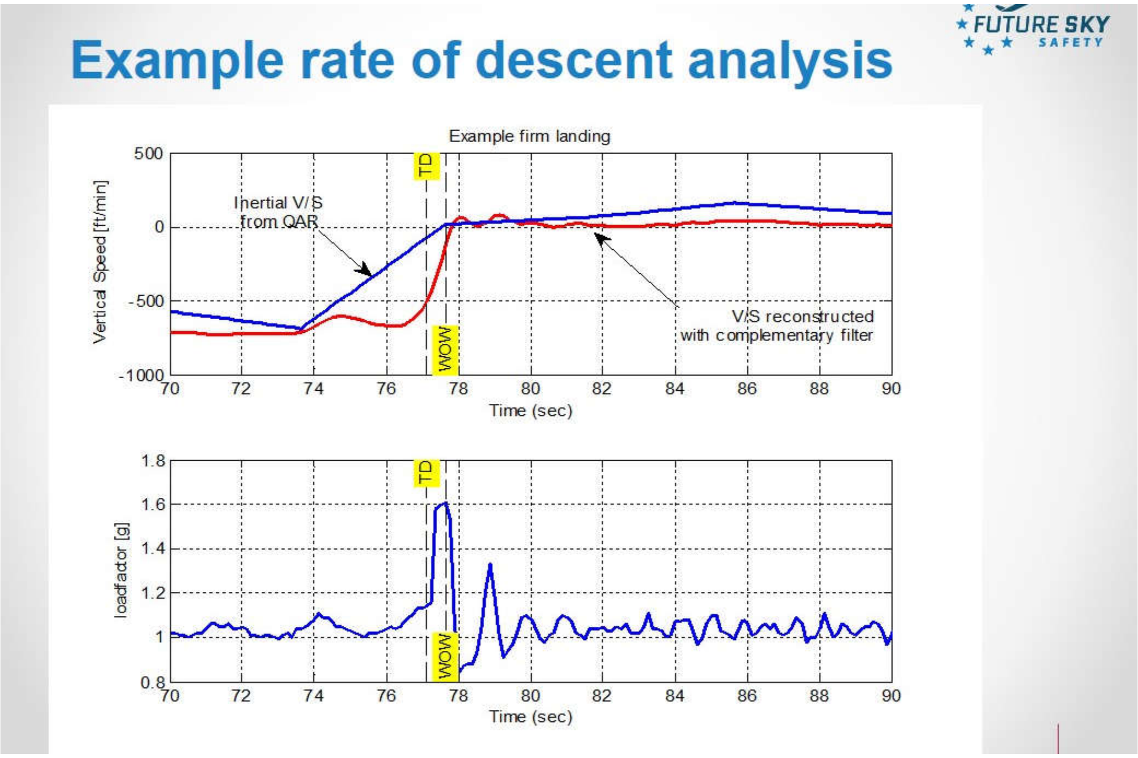
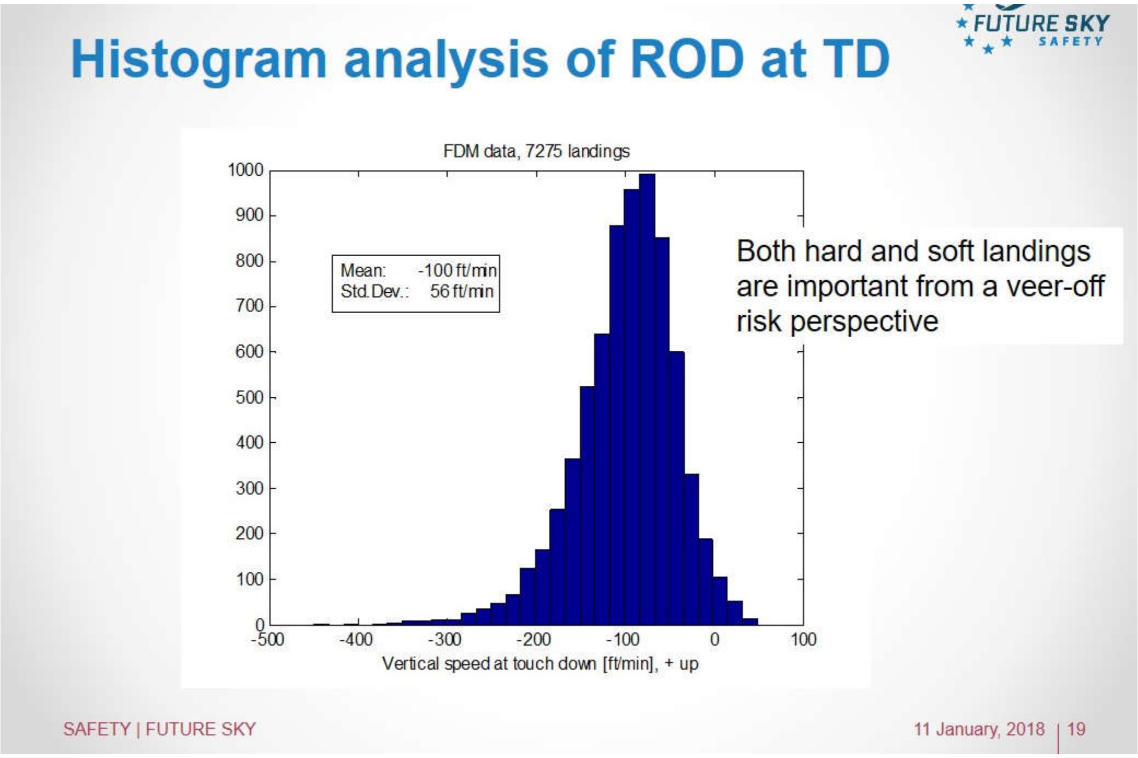
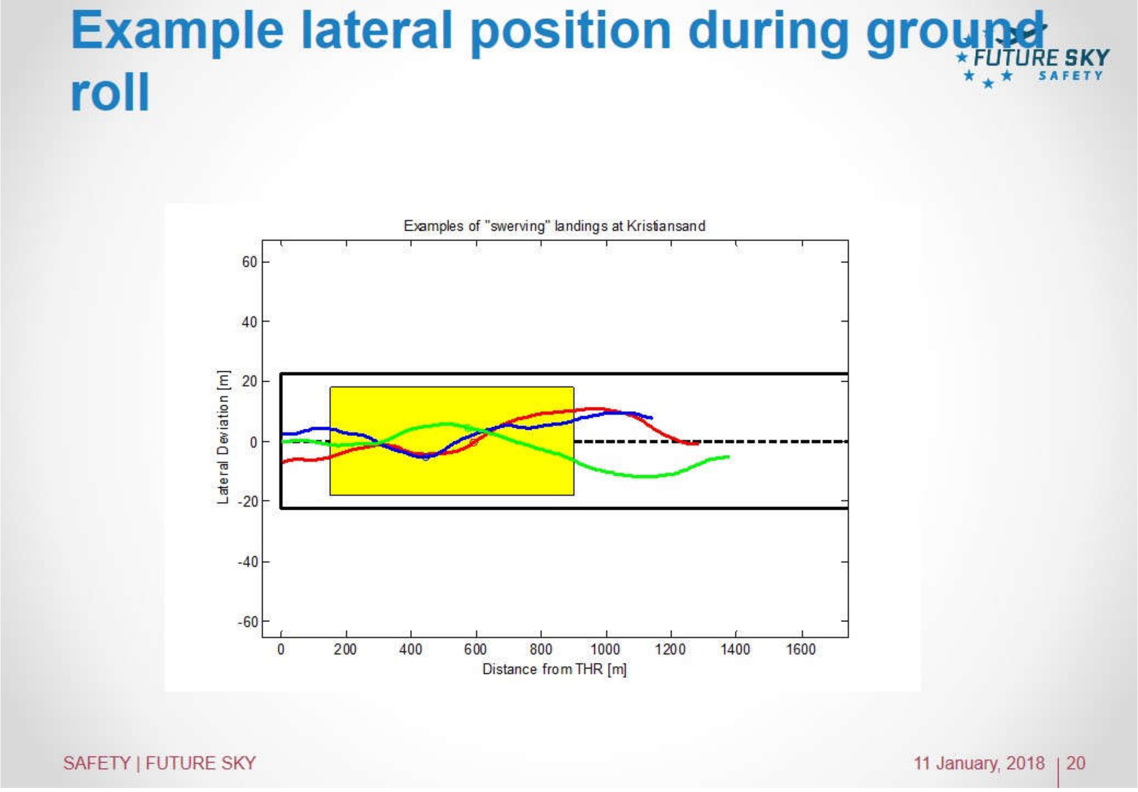


Example rate of descent analysis

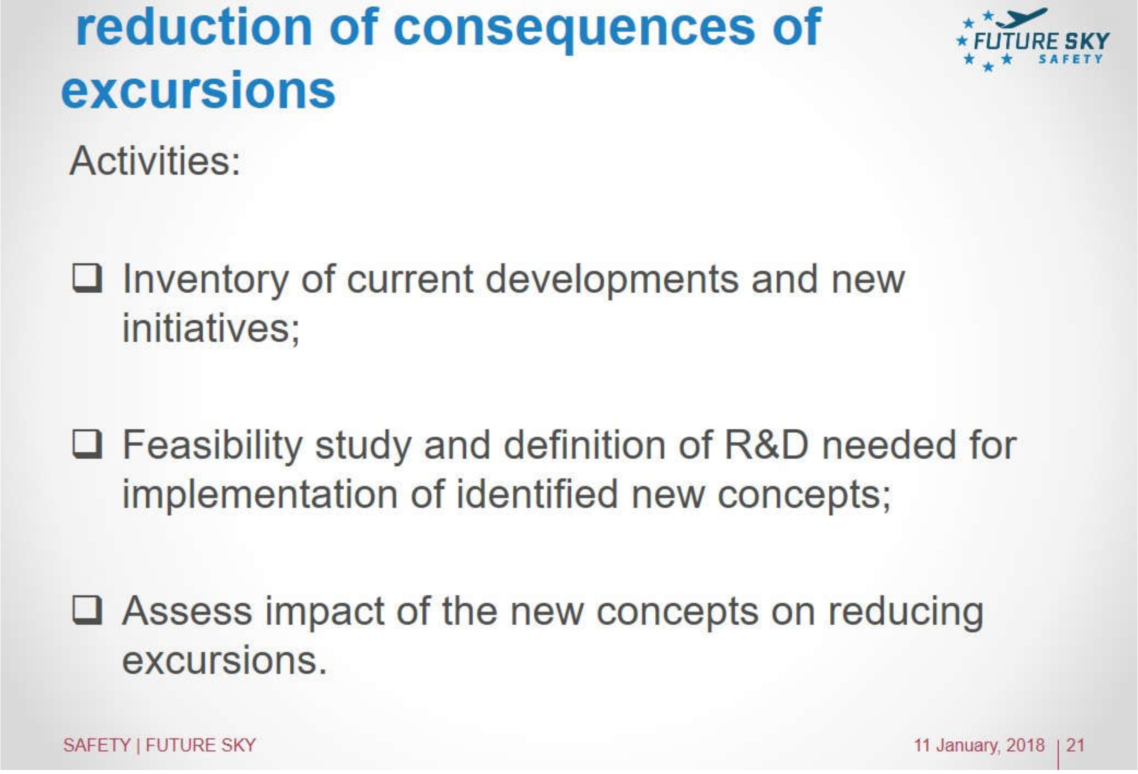


Histogram analysis of ROD at TD

Both hard and soft landings are important from a veer-off risk perspective



Example lateral position during ground roll

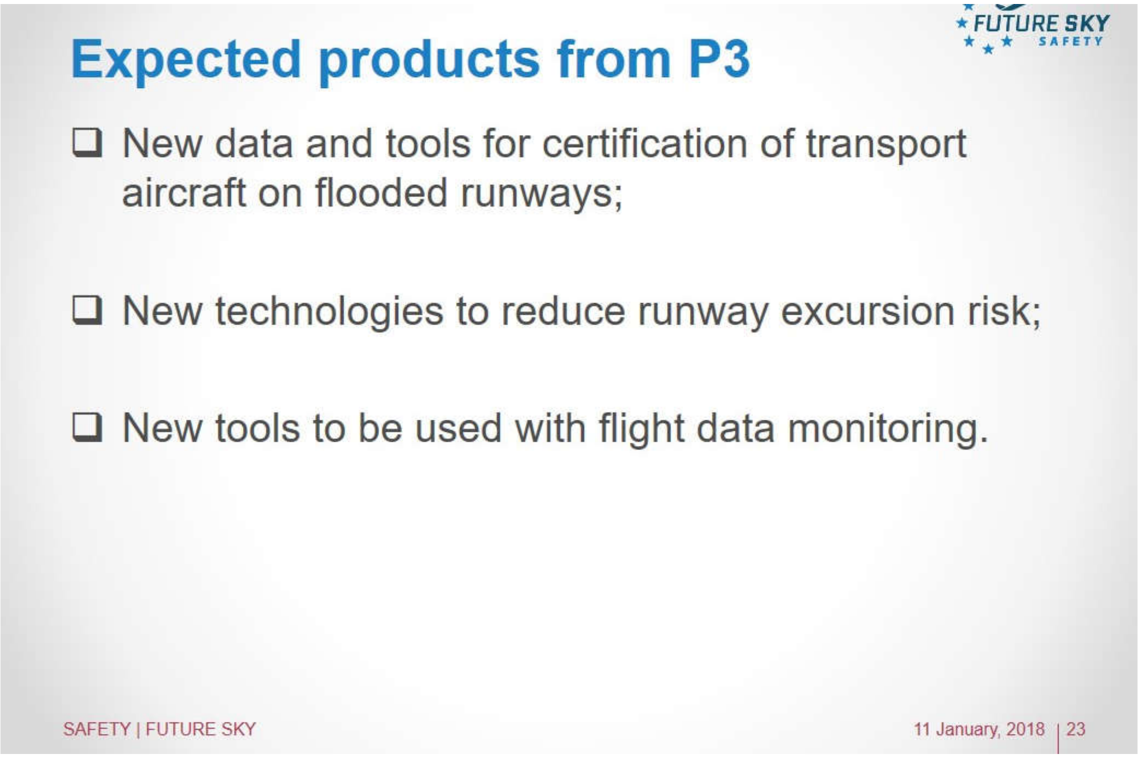


reduction of consequences of excursions

Activities:

- ❑ Inventory of current developments and new initiatives;
- ❑ Feasibility study and definition of R&D needed for implementation of identified new concepts;
- ❑ Assess impact of the new concepts on reducing excursions.

Further details on work accomplished on new technologies to be discussed in next presentation by Frédéric Barbaresco



Expected products from P3

- ☐ New data and tools for certification of transport aircraft on flooded runways;
- ☐ New technologies to reduce runway excursion risk;
- ☐ New tools to be used with flight data monitoring.

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Consortium

Stichting Nationaal Lucht- en Ruimtevaartlaboratorium
Deutsches Zentrum für Luft- und Raumfahrt
Office national d'études et de recherches aérospatiales
Centro para a Excelência e Inovação na Indústria Automóvel
Centro Italiano Ricerche Aerospaziali
Centre Suisse d'Electronique et Microtechnique SA
Institutul National de Cercetari Aerospatiale "Elie Carafoli"
Instituto Nacional de Técnica Aeroespacial
Výzkumný a zkušební letecký ústav, a.s.
Totalförsvarets FOrskningsInstitut
European Organisation for the Safety of Air Navigation

Civil Aviation Authority UK
Airbus SAS
Airbus Operations SAS
Airbus Defence and Space
Thales Avionics SAS
Thales Air Systems SA
Deep Blue SRL
Technische Universität München
Deutsche Lufthansa Aktiengesellschaft
Service Technique de l'Aviation Civile
Embraer Portugal Estruturas em Compositos SA

Russian Central Aerohydrodynamic Institute TsAGI
Ente Nazionale di Assistenza al Volo Spa
Boeing Research and Technology Europe SLU
London School of Economics and Political Science
Alenia Aermacchi
Cranfield University
Trinity College Dublin
Zodiac Aerosafety Systems
Institut Polytechnique de Bordeaux
Koninklijke Luchtvaart Maatschappij
Sistemi Innovativi per il Controllo del Traffico Aereo

http://www.futuresky.eu/projects/safety

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Appendix B.2 “P3: Reconstruction of cross- and tailwind components from flight data” – Peter van der Geest, NLR

Reconstruction of cross- and tailwind components from flight data

FUTURE SKY SAFETY – 2nd Consortium Workshop , 2017

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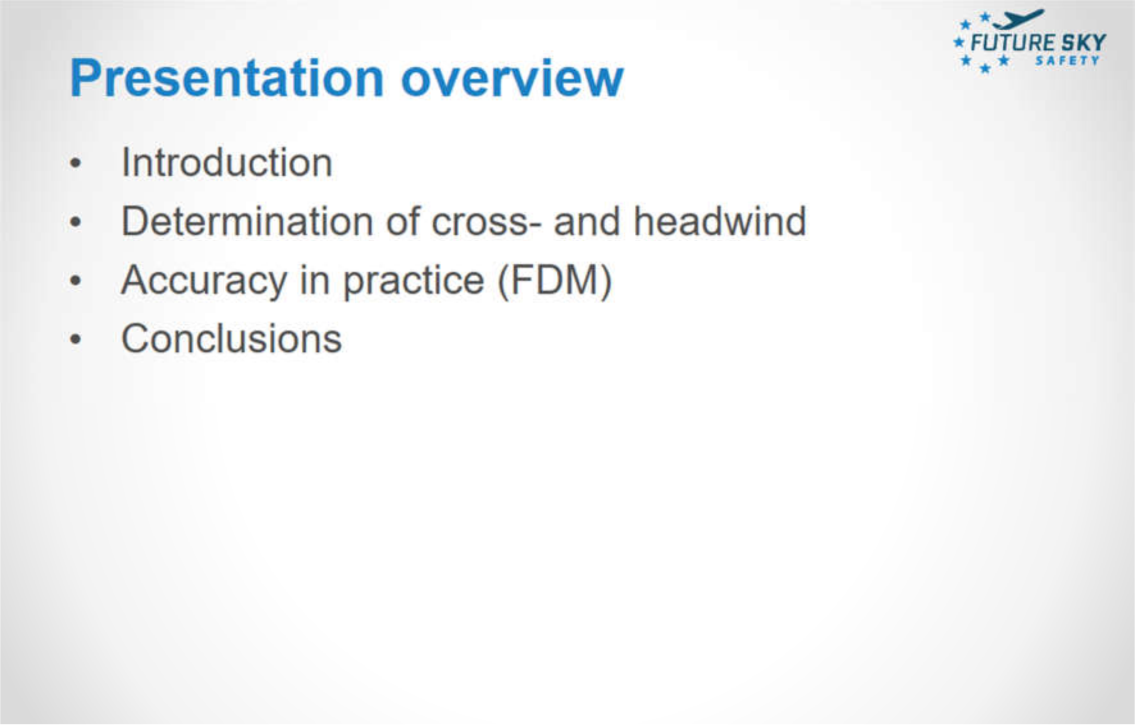

Presentation overview

- Introduction
- Determination of cross- and headwind
- Accuracy in practice (FDM)
- Conclusions

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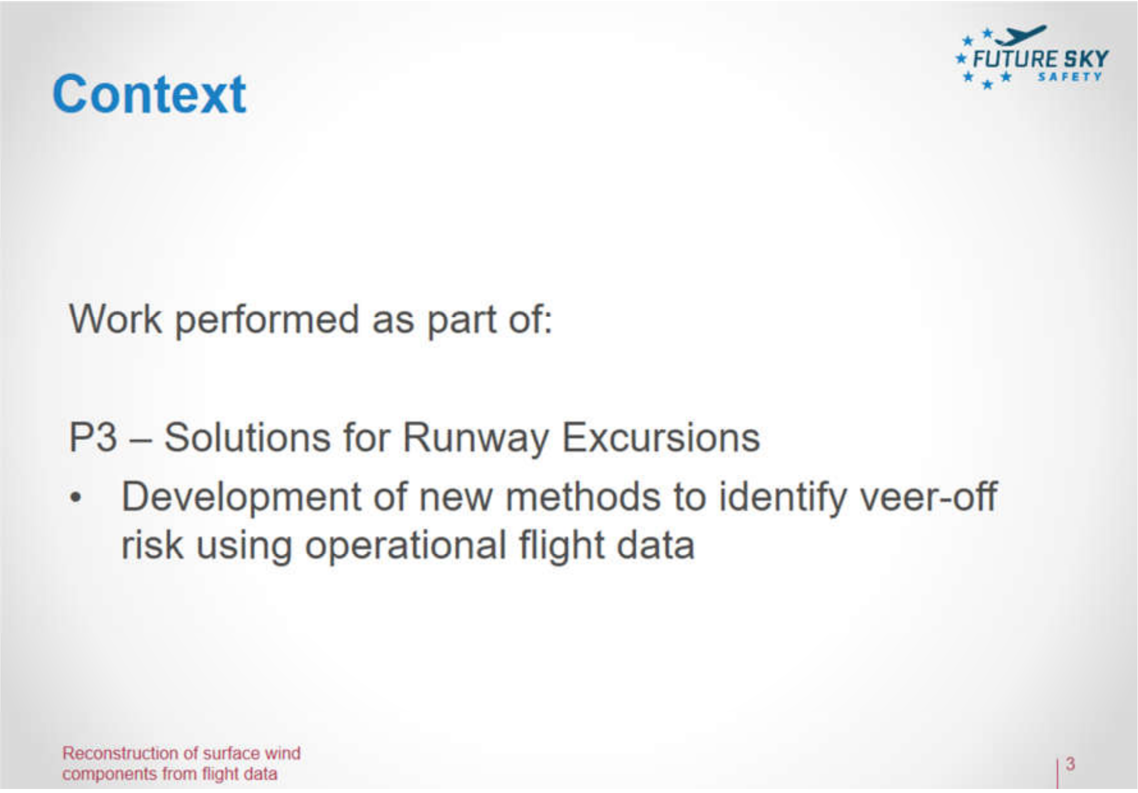


Context

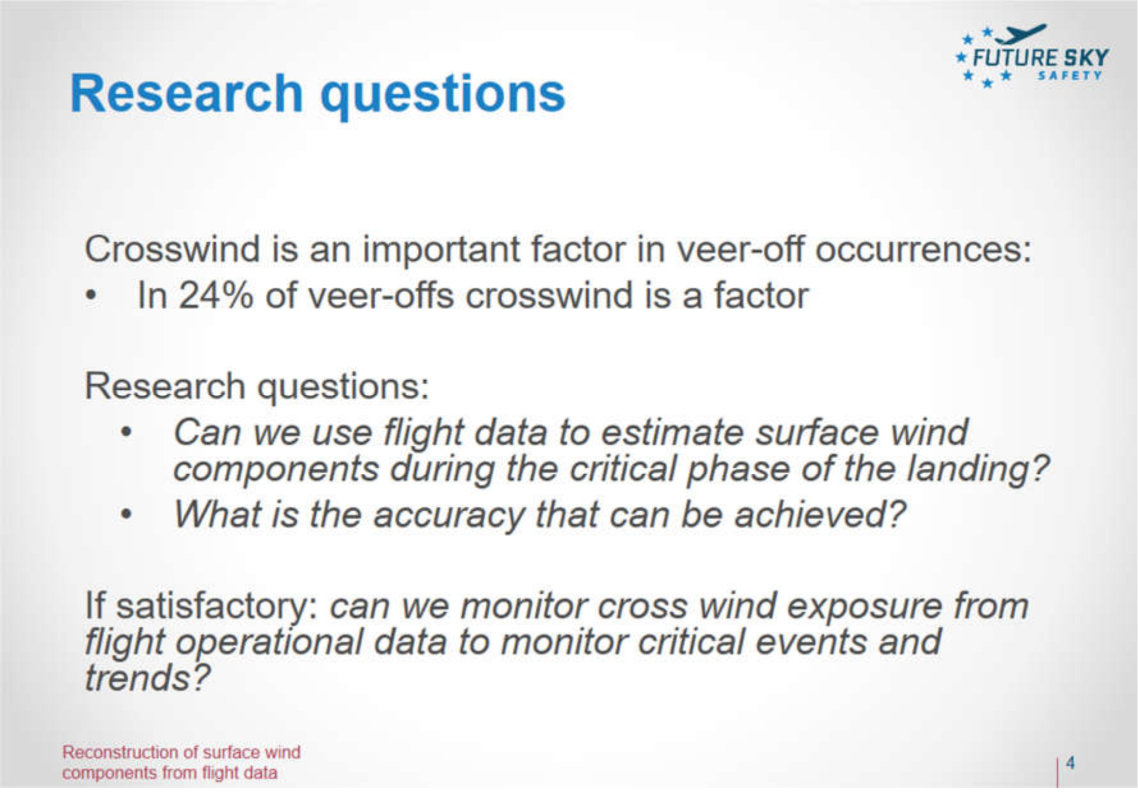
Work performed as part of:

P3 – Solutions for Runway Excursions

- Development of new methods to identify veer-off risk using operational flight data

Reconstruction of surface wind components from flight data

3



Research questions

Crosswind is an important factor in veer-off occurrences:

- In 24% of veer-offs crosswind is a factor

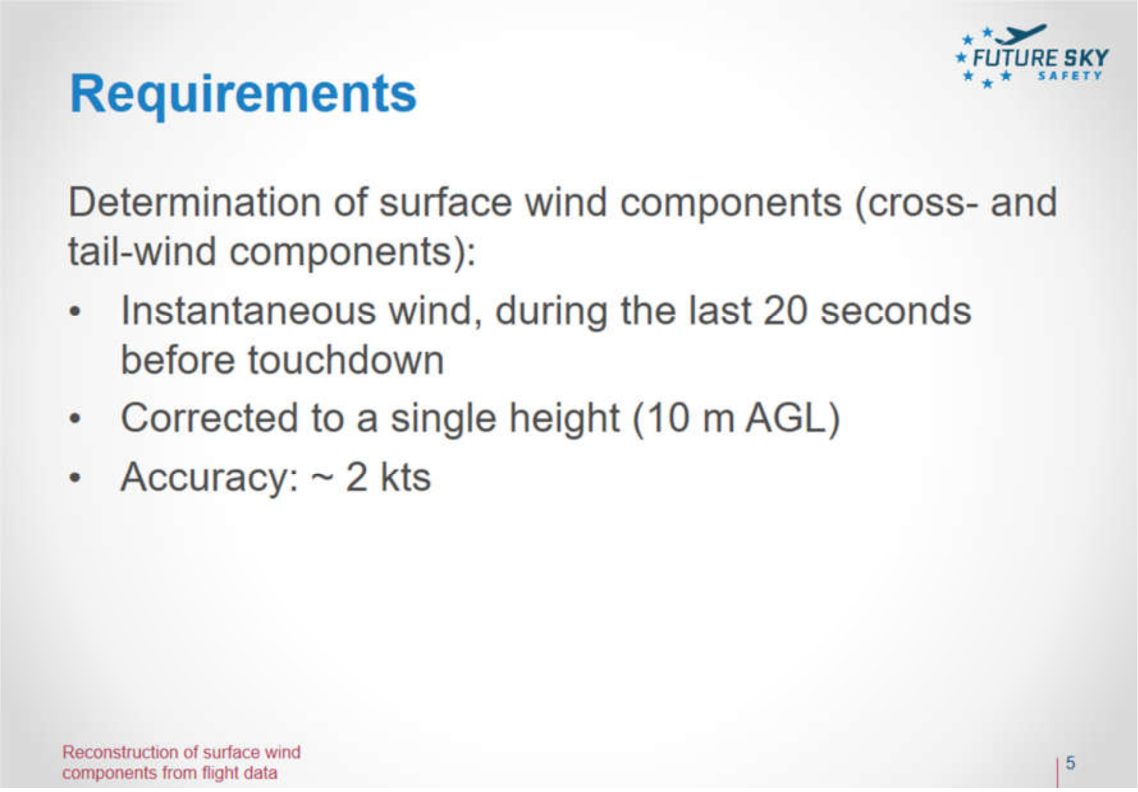
Research questions:

- *Can we use flight data to estimate surface wind components during the critical phase of the landing?*
- *What is the accuracy that can be achieved?*

If satisfactory: *can we monitor cross wind exposure from flight operational data to monitor critical events and trends?*

Reconstruction of surface wind components from flight data

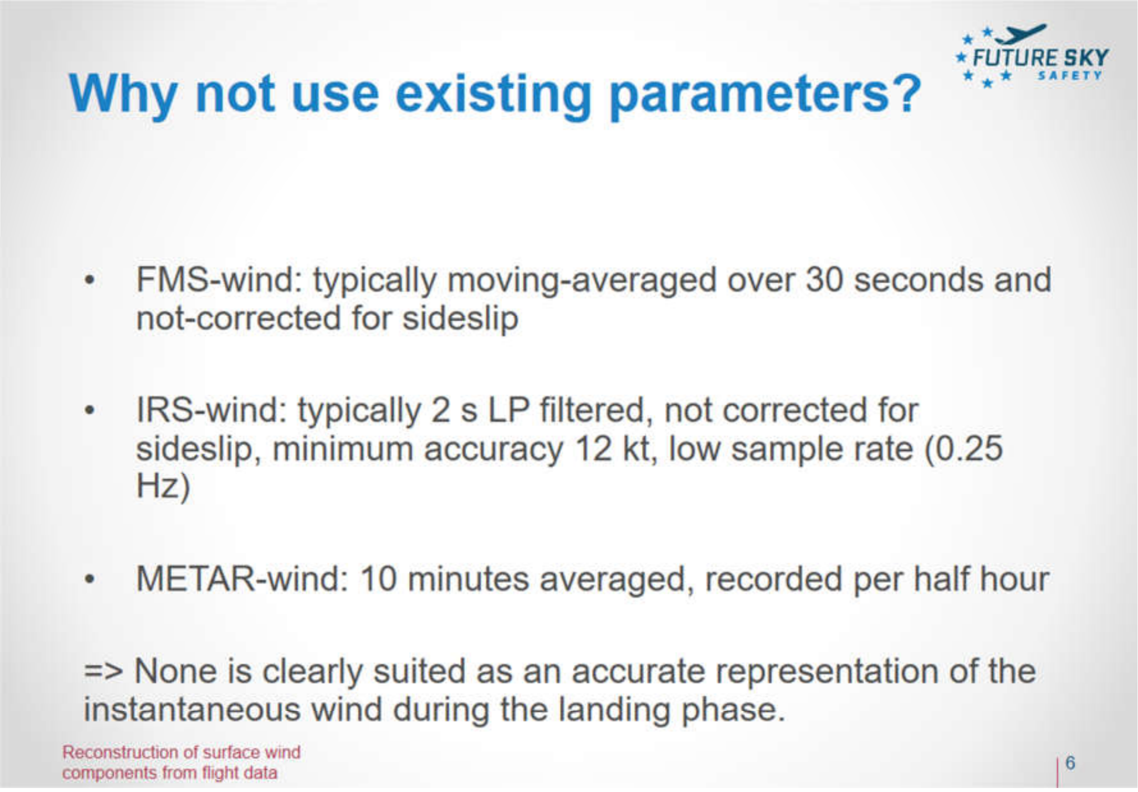
4



Requirements

Determination of surface wind components (cross- and tail-wind components):

- Instantaneous wind, during the last 20 seconds before touchdown
- Corrected to a single height (10 m AGL)
- Accuracy: ~ 2 kts



Why not use existing parameters?

- FMS-wind: typically moving-averaged over 30 seconds and not-corrected for sideslip
- IRS-wind: typically 2 s LP filtered, not corrected for sideslip, minimum accuracy 12 kt, low sample rate (0.25 Hz)
- METAR-wind: 10 minutes averaged, recorded per half hour

=> None is clearly suited as an accurate representation of the instantaneous wind during the landing phase.

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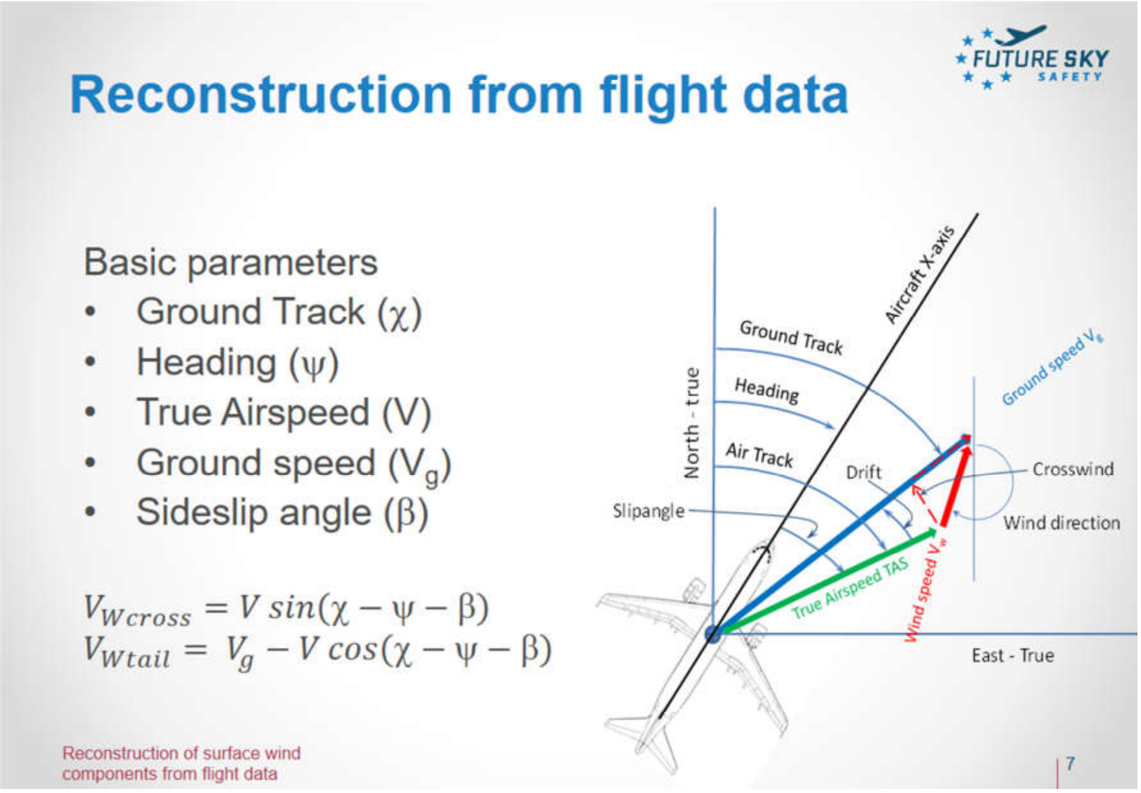


Reconstruction from flight data

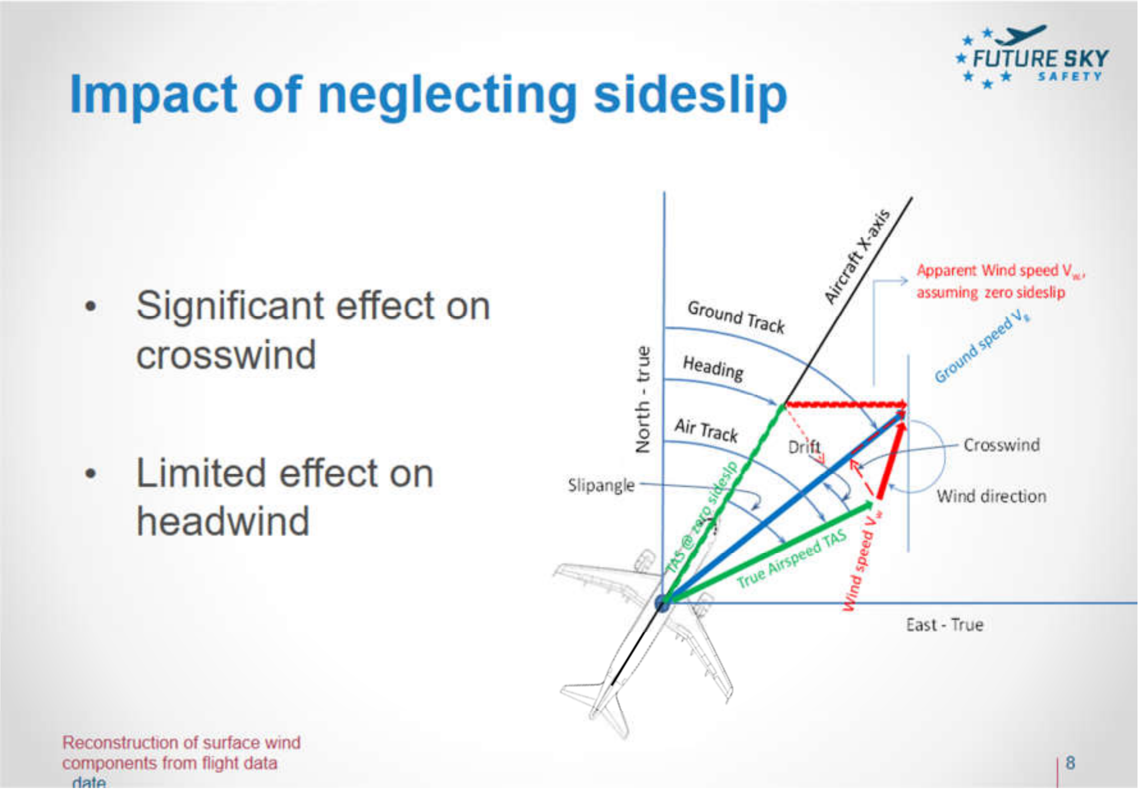
Basic parameters

- Ground Track (χ)
- Heading (ψ)
- True Airspeed (V)
- Ground speed (V_g)
- Sideslip angle (β)

$$V_{W_{cross}} = V\,sin(\chi - \psi - \beta)$$
$$V_{W_{tail}} = V_g - V\,cos(\chi - \psi - \beta)$$

Reconstruction of surface wind components from flight data

7



Impact of neglecting sideslip

- Significant effect on crosswind
- Limited effect on headwind

Reconstruction of surface wind components from flight data
date

8

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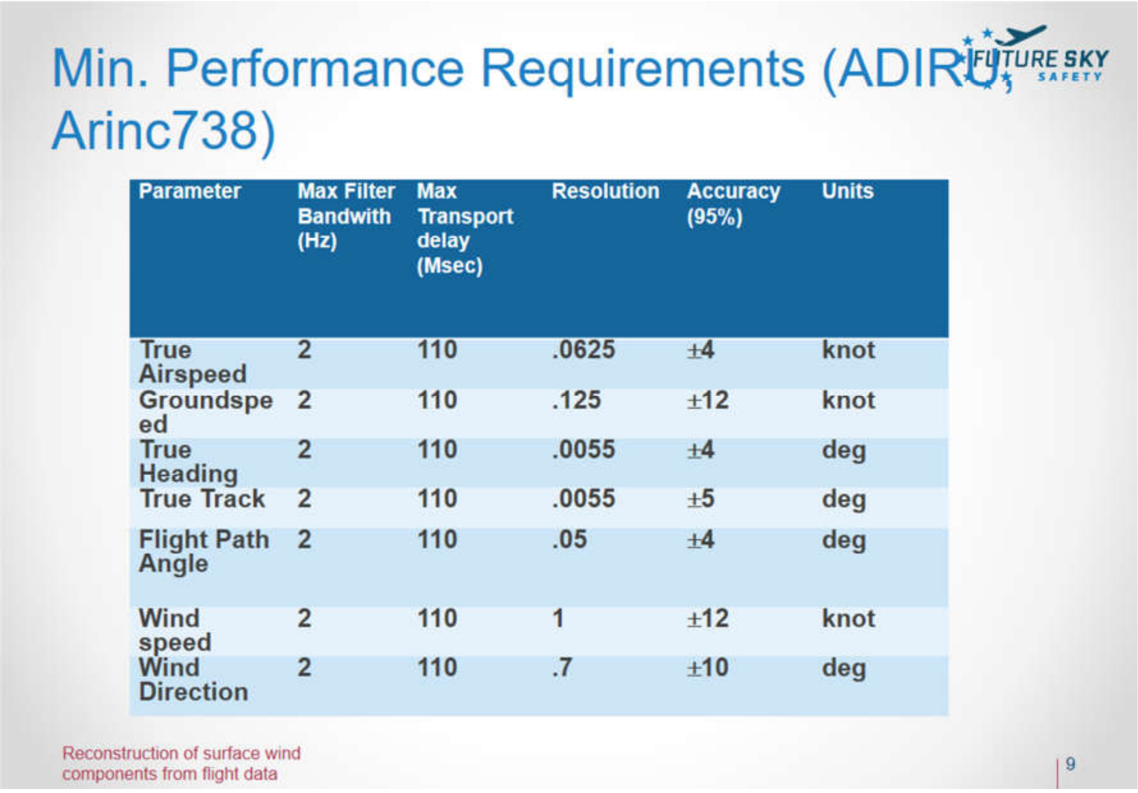
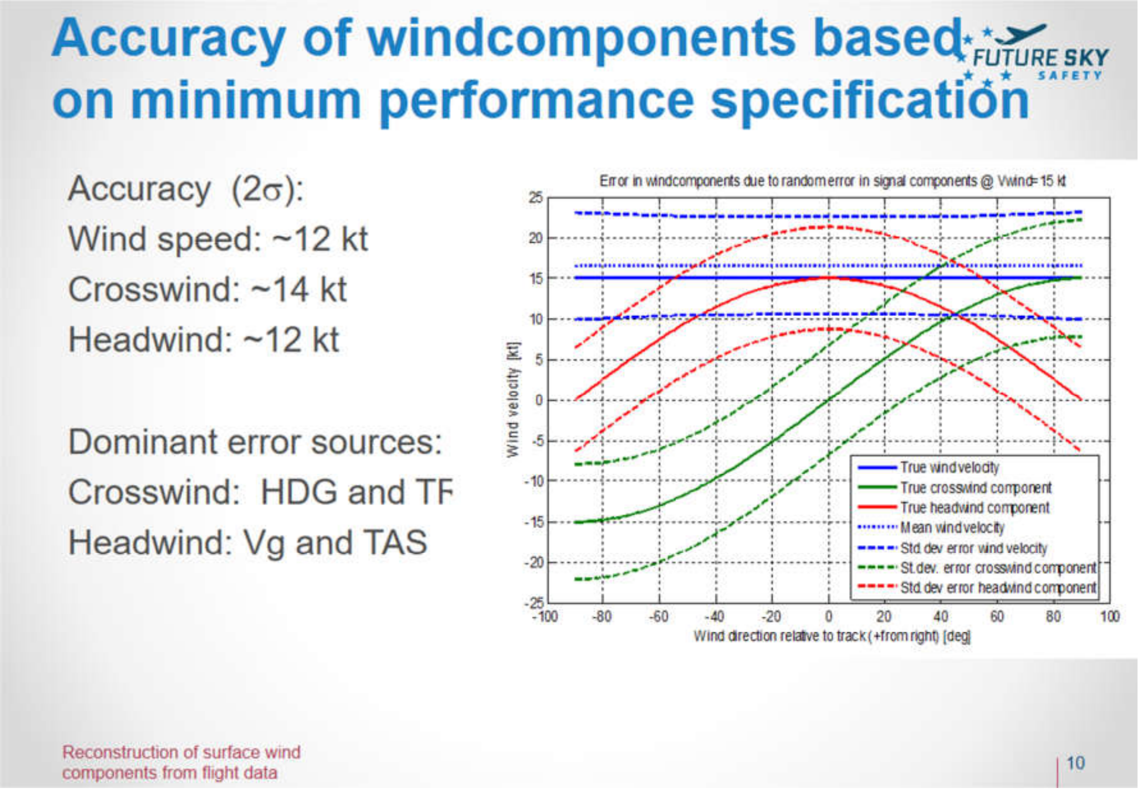


Min. Performance Requirements (ADIRU, Arinc738)

Parameter	Max Filter Bandwith (Hz)	Max Transport delay (Msec)	Resolution	Accuracy (95%)	Units
True Airspeed	2	110	.0625	±4	knot
Groundspeed	2	110	.125	±12	knot
True Heading	2	110	.0055	±4	deg
True Track	2	110	.0055	±5	deg
Flight Path Angle	2	110	.05	±4	deg
Wind speed	2	110	1	±12	knot
Wind Direction	2	110	.7	±10	deg

Reconstruction of surface wind components from flight data

9



Accuracy of windcomponents based on minimum performance specification

Accuracy (2σ):
Wind speed: ~12 kt
Crosswind: ~14 kt
Headwind: ~12 kt

Dominant error sources:
Crosswind: HDG and TF
Headwind: Vg and TAS

Reconstruction of surface wind components from flight data

10

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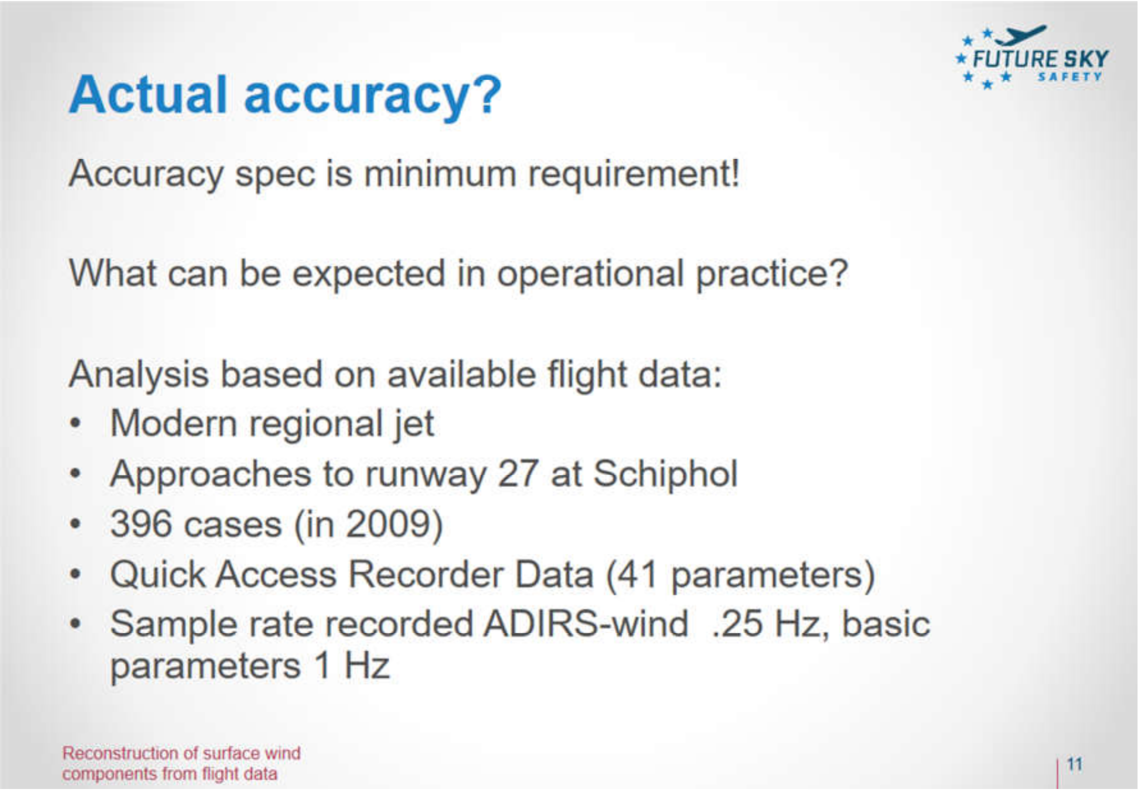


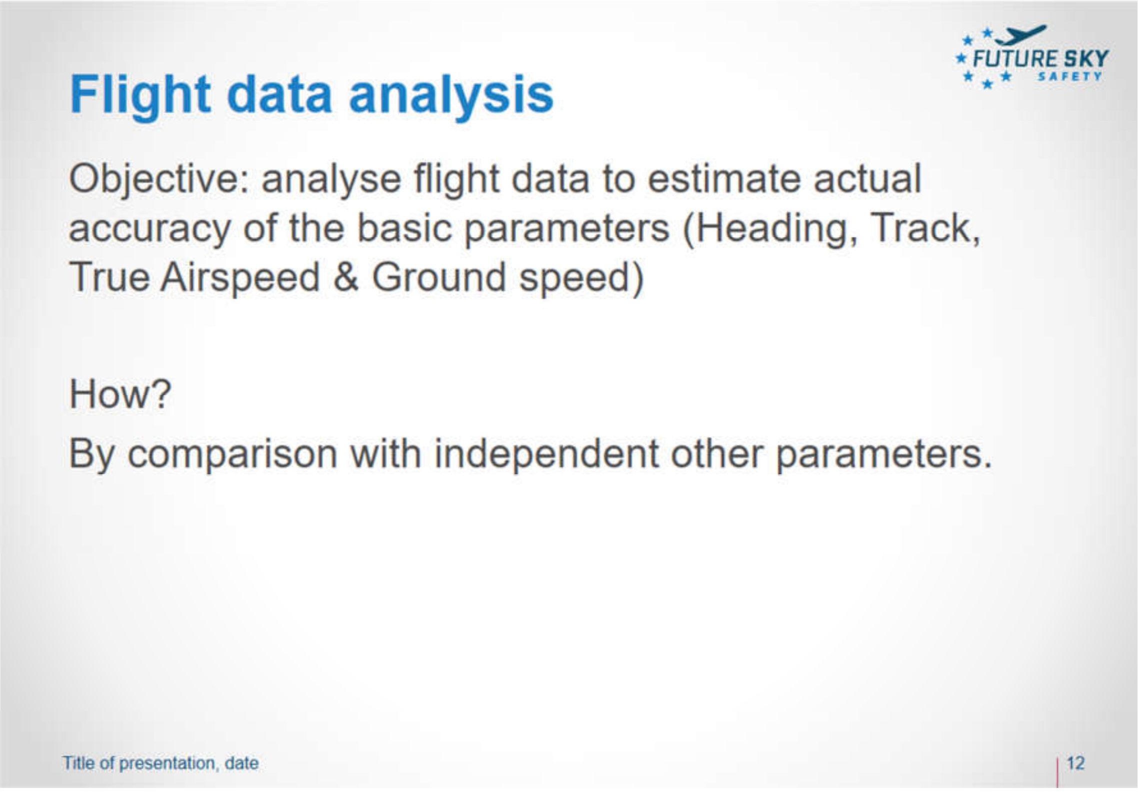
Actual accuracy?

Accuracy spec is minimum requirement!

What can be expected in operational practice?

Analysis based on available flight data:

- Modern regional jet
- Approaches to runway 27 at Schiphol
- 396 cases (in 2009)
- Quick Access Recorder Data (41 parameters)
- Sample rate recorded ADIRS-wind .25 Hz, basic parameters 1 Hz



Flight data analysis

Objective: analyse flight data to estimate actual accuracy of the basic parameters (Heading, Track, True Airspeed & Ground speed)

How?

By comparison with independent other parameters.

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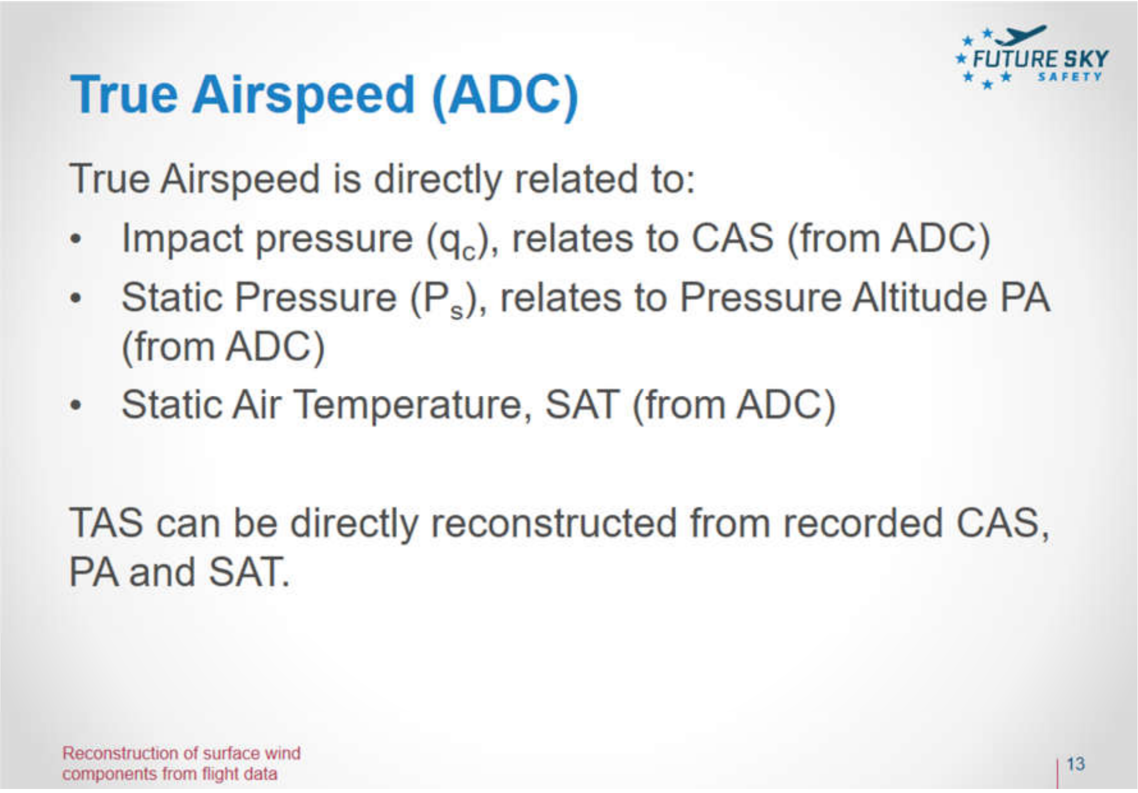


True Airspeed (ADC)

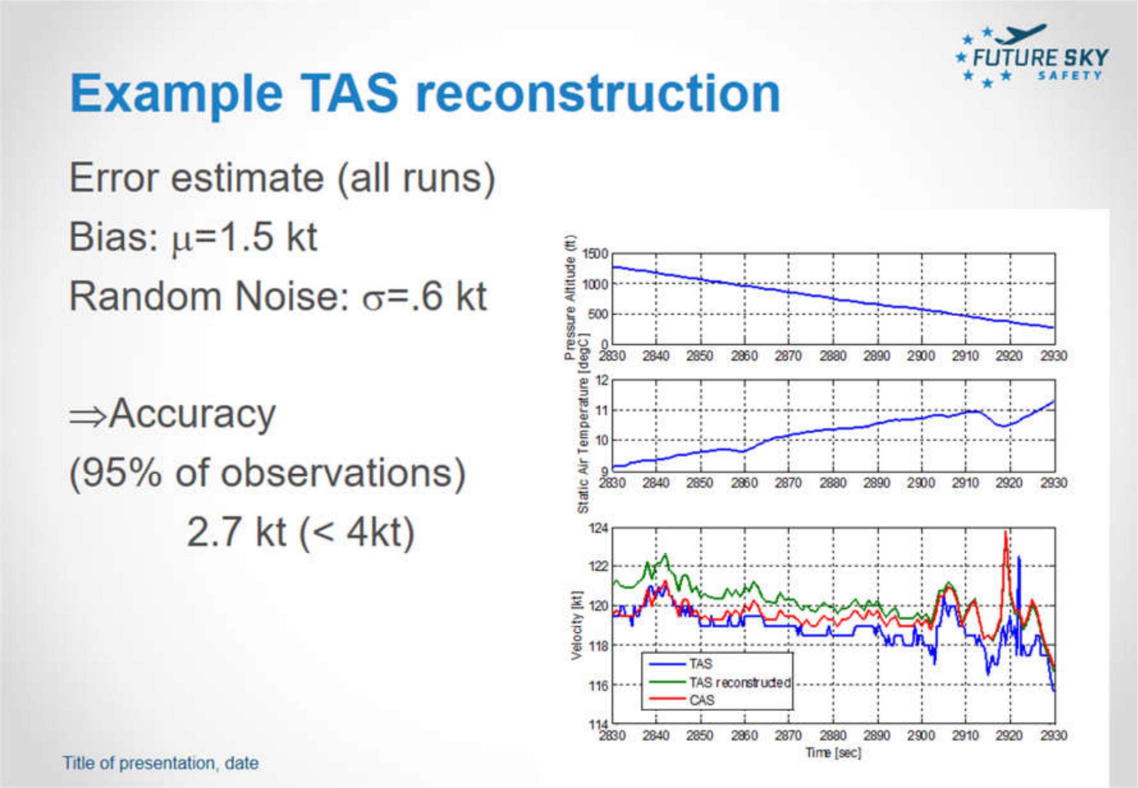
True Airspeed is directly related to:

- Impact pressure (q_c), relates to CAS (from ADC)
- Static Pressure (P_s), relates to Pressure Altitude PA (from ADC)
- Static Air Temperature, SAT (from ADC)

TAS can be directly reconstructed from recorded CAS, PA and SAT.

Reconstruction of surface wind components from flight data

13



Example TAS reconstruction

Error estimate (all runs)

Bias: μ=1.5 kt

Random Noise: σ=.6 kt

$\Rightarrow$Accuracy

(95% of observations)

2.7 kt (< 4kt)

Title of presentation, date

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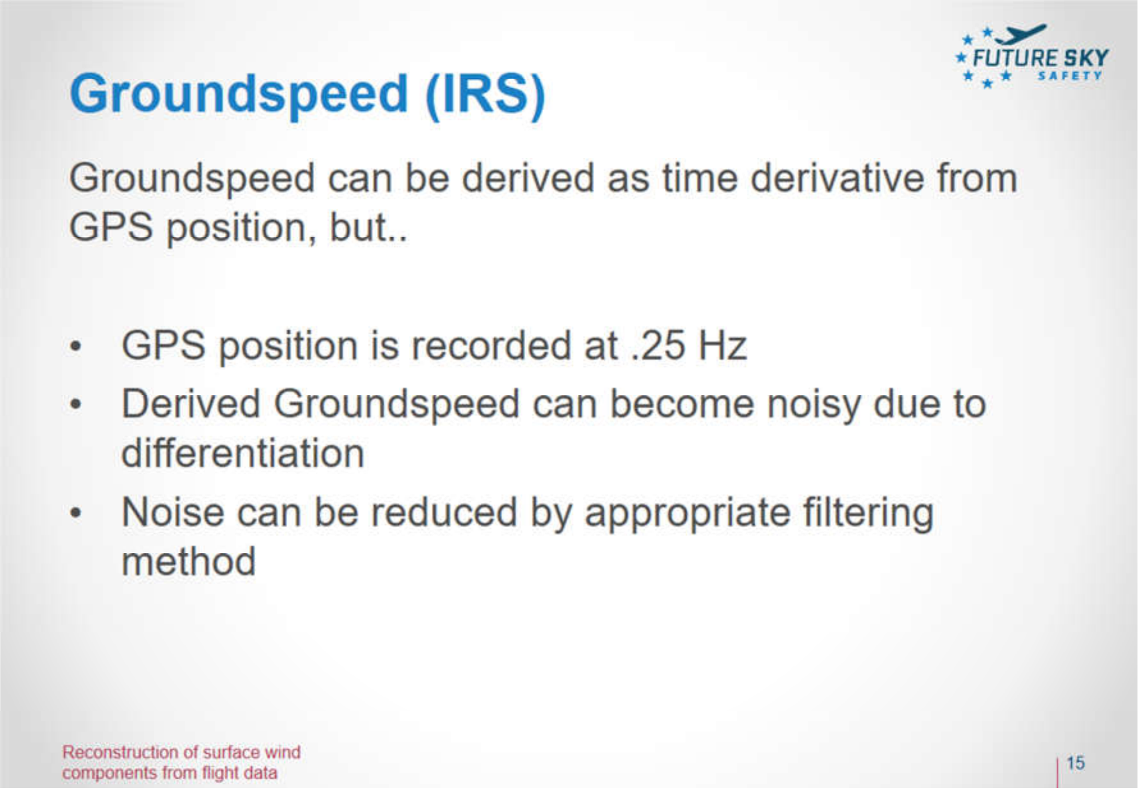


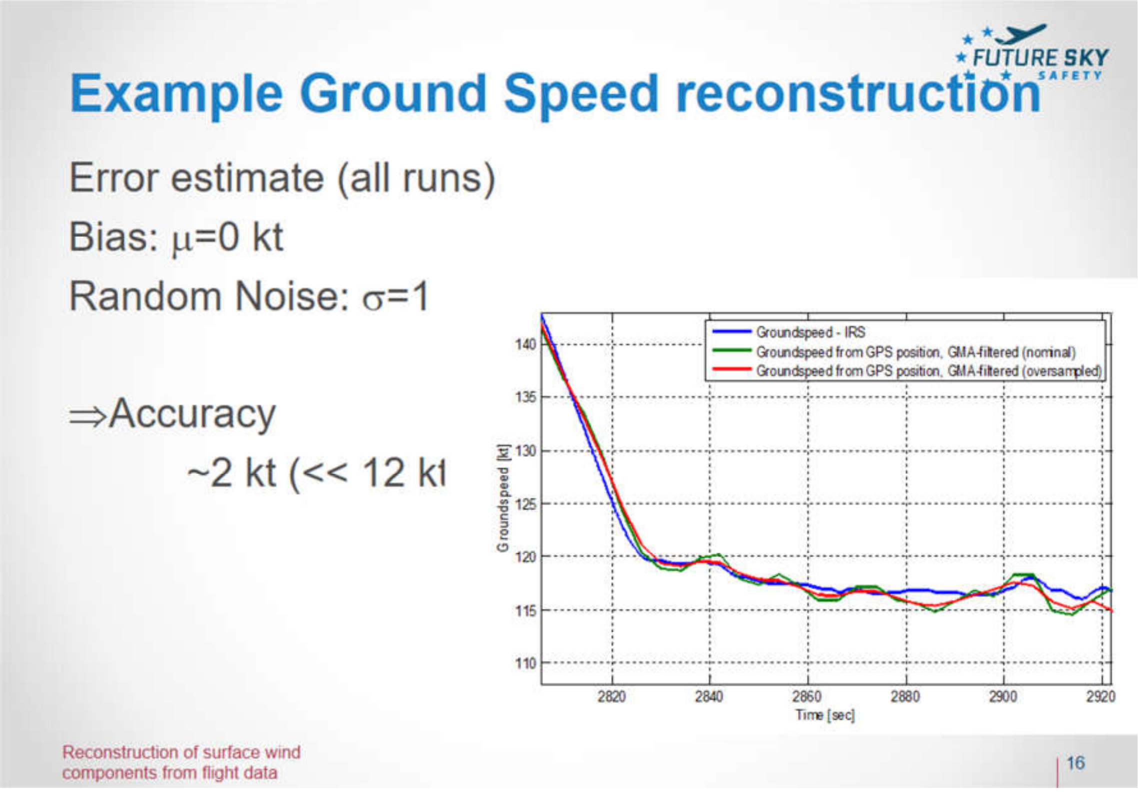
Groundspeed (IRS)

Groundspeed can be derived as time derivative from GPS position, but..

- GPS position is recorded at .25 Hz
- Derived Groundspeed can become noisy due to differentiation
- Noise can be reduced by appropriate filtering method

Reconstruction of surface wind components from flight data

15



Example Ground Speed reconstruction

Error estimate (all runs)

Bias: μ=0 kt

Random Noise: σ=1

⇒Accuracy

~2 kt (<< 12 kt

Reconstruction of surface wind components from flight data

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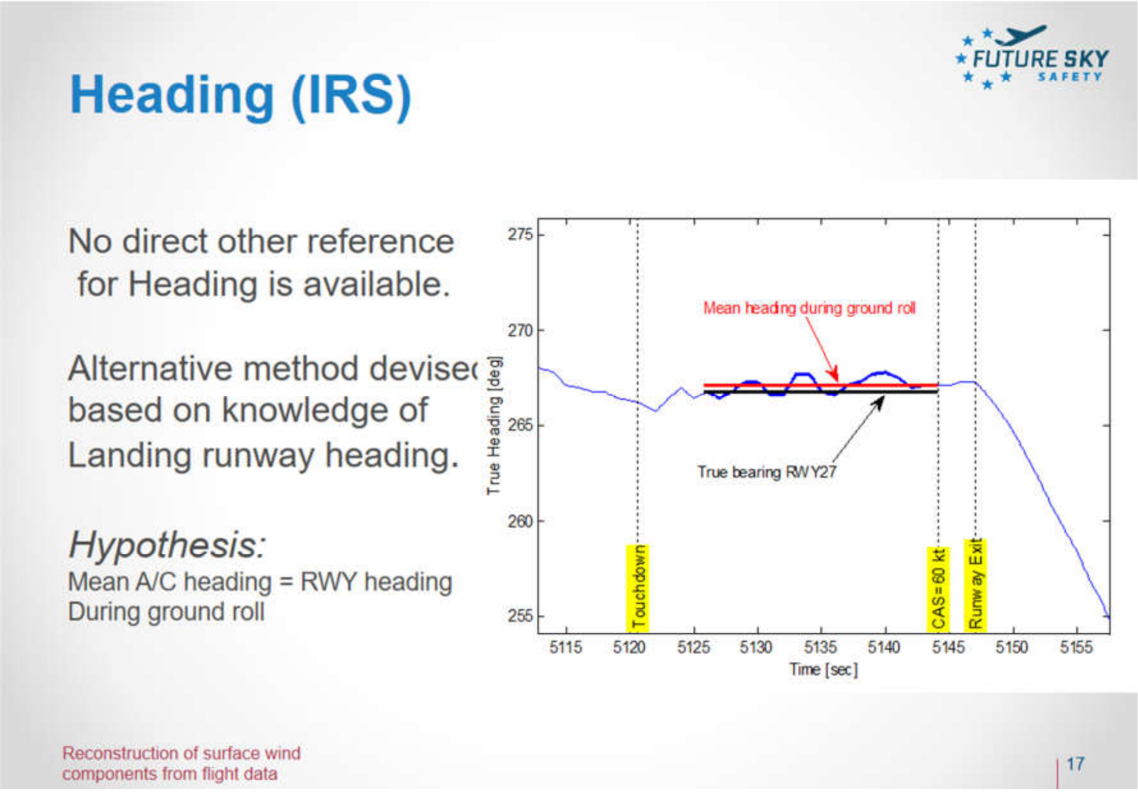


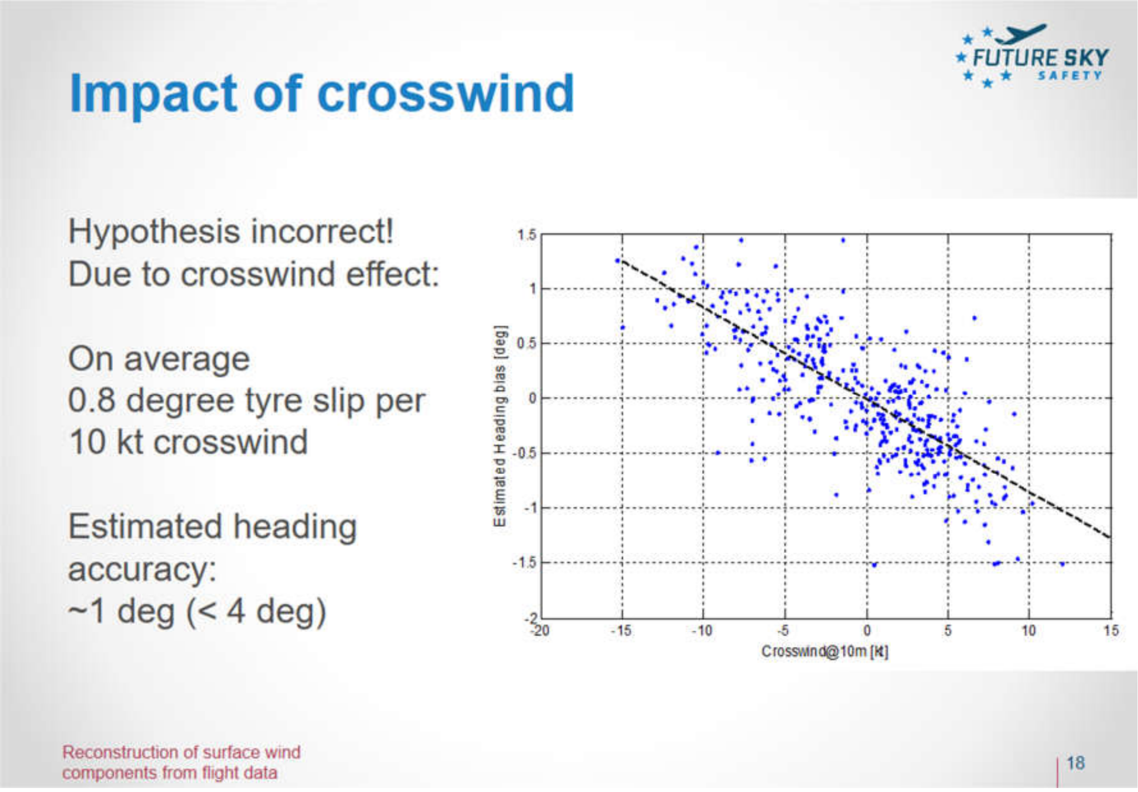
Heading (IRS)

No direct other reference for Heading is available.

Alternative method devise based on knowledge of Landing runway heading.

Hypothesis:

Mean A/C heading = RWY heading
During ground roll



Impact of crosswind

Hypothesis incorrect!
Due to crosswind effect:

On average
0.8 degree tyre slip per
10 kt crosswind

Estimated heading accuracy:
~1 deg (< 4 deg)

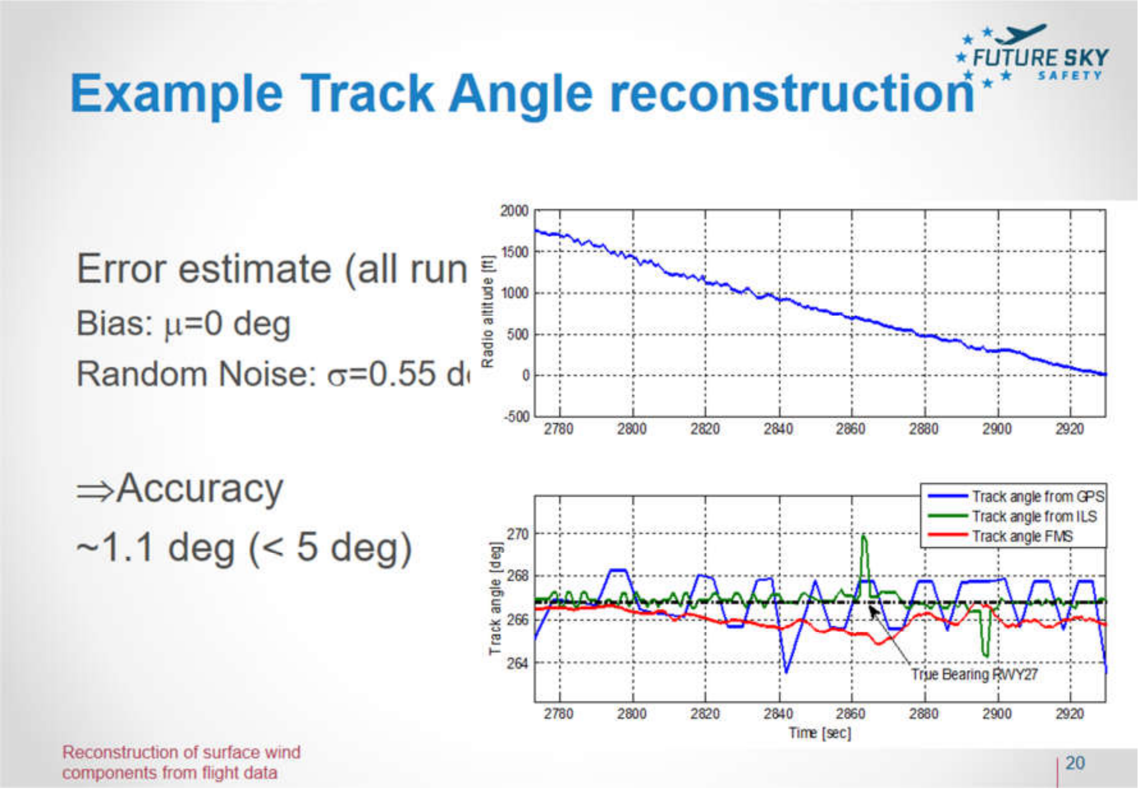
Track Angle (FMS)

Track Angle can be derived from:

1. Subsequent GPS coordinates
2. ILS Localizer deviation

Ad 1) Low sample rate (.25 Hz) and low resolution (~2 deg), noisy

Ad 2) Possibly affected by ILS characteristics (e.g. beam bends)



Example Track Angle reconstruction

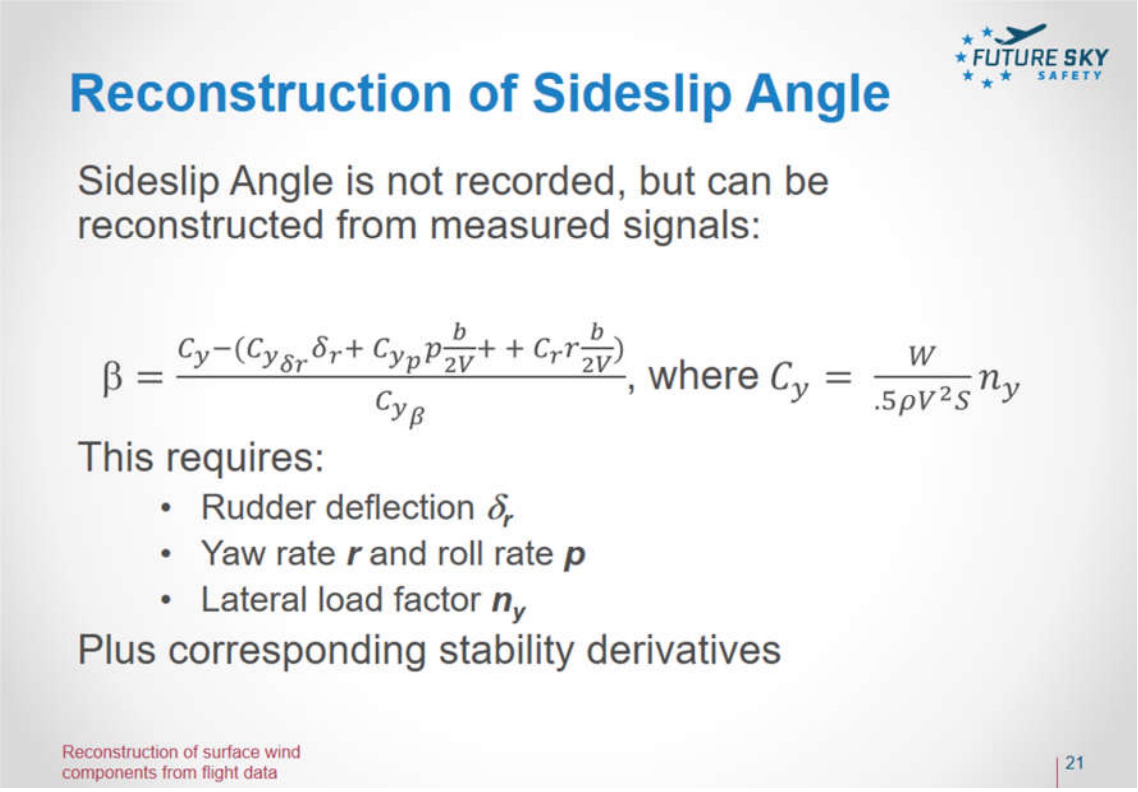
Error estimate (all run

Bias: μ=0 deg

Random Noise: σ=0.55 d

⇒Accuracy

~1.1 deg (< 5 deg)



Reconstruction of Sideslip Angle

Sideslip Angle is not recorded, but can be reconstructed from measured signals:

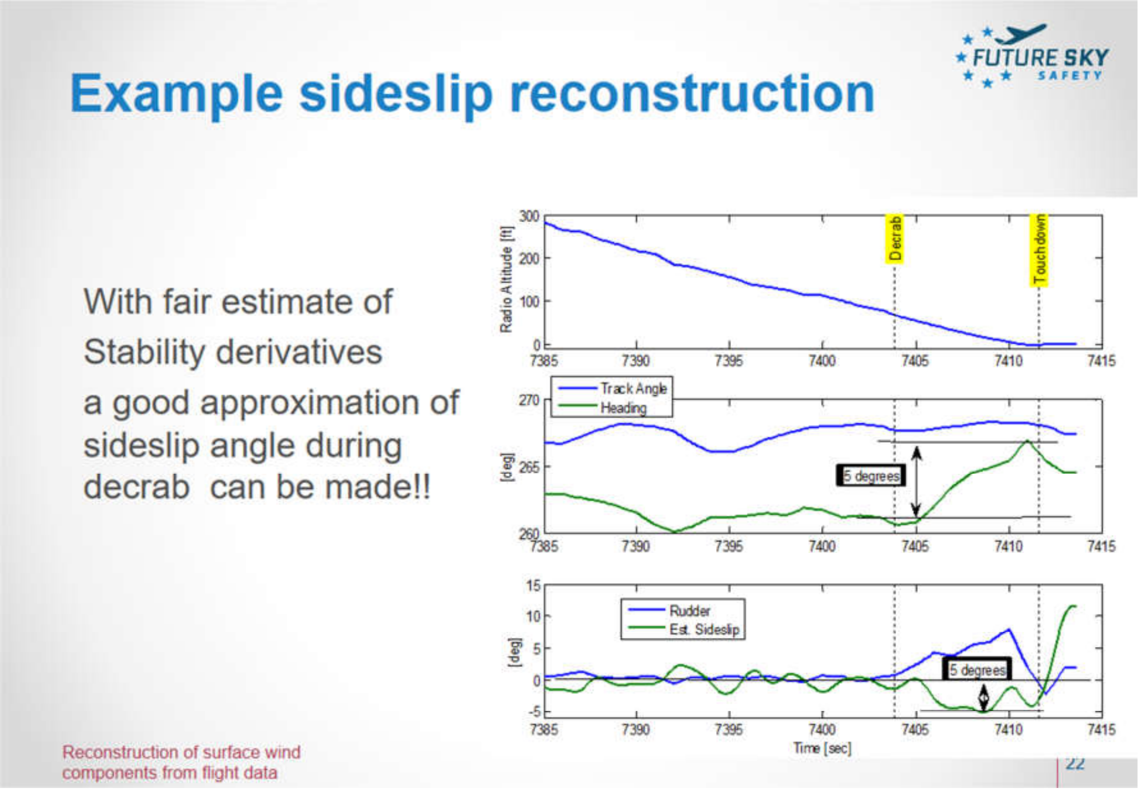
$$\beta = \frac{C_y - (C_{y_{\delta r}} \delta_r + C_{y_p} p \frac{b}{2V} + + C_r r \frac{b}{2V})}{C_{y_\beta}}, \text{ where } C_y = \frac{W}{.5 \rho V^2 S} n_y$$

This requires:

- Rudder deflection δ_r
- Yaw rate ***r*** and roll rate ***p***
- Lateral load factor $\boldsymbol{n_y}$

Plus corresponding stability derivatives

Reconstruction of surface wind components from flight data

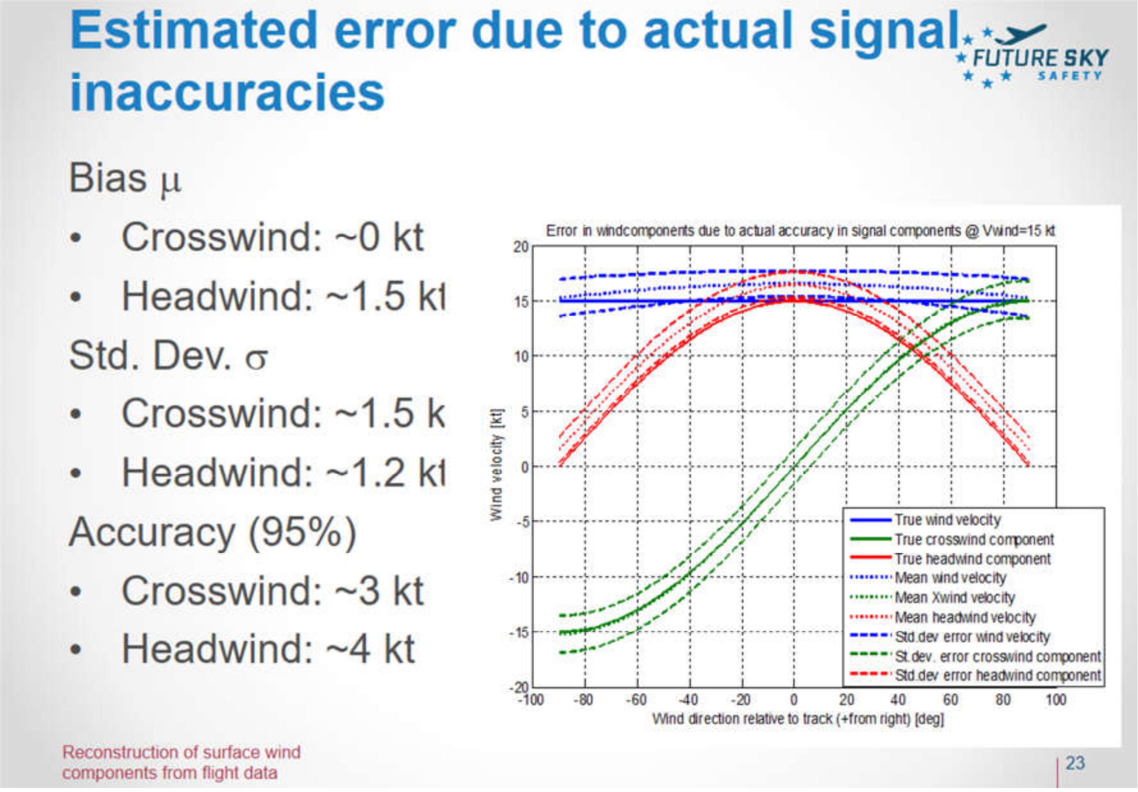


Example sideslip reconstruction

With fair estimate of Stability derivatives

a good approximation of sideslip angle during decrab can be made!!

Reconstruction of surface wind components from flight data



Estimated error due to actual signal inaccuracies

Bias μ

- Crosswind: ~0 kt
- Headwind: ~1.5 kt

Std. Dev. σ

- Crosswind: ~1.5 k
- Headwind: ~1.2 kt

Accuracy (95%)

- Crosswind: ~3 kt
- Headwind: ~4 kt

Reconstruction of surface wind components from flight data

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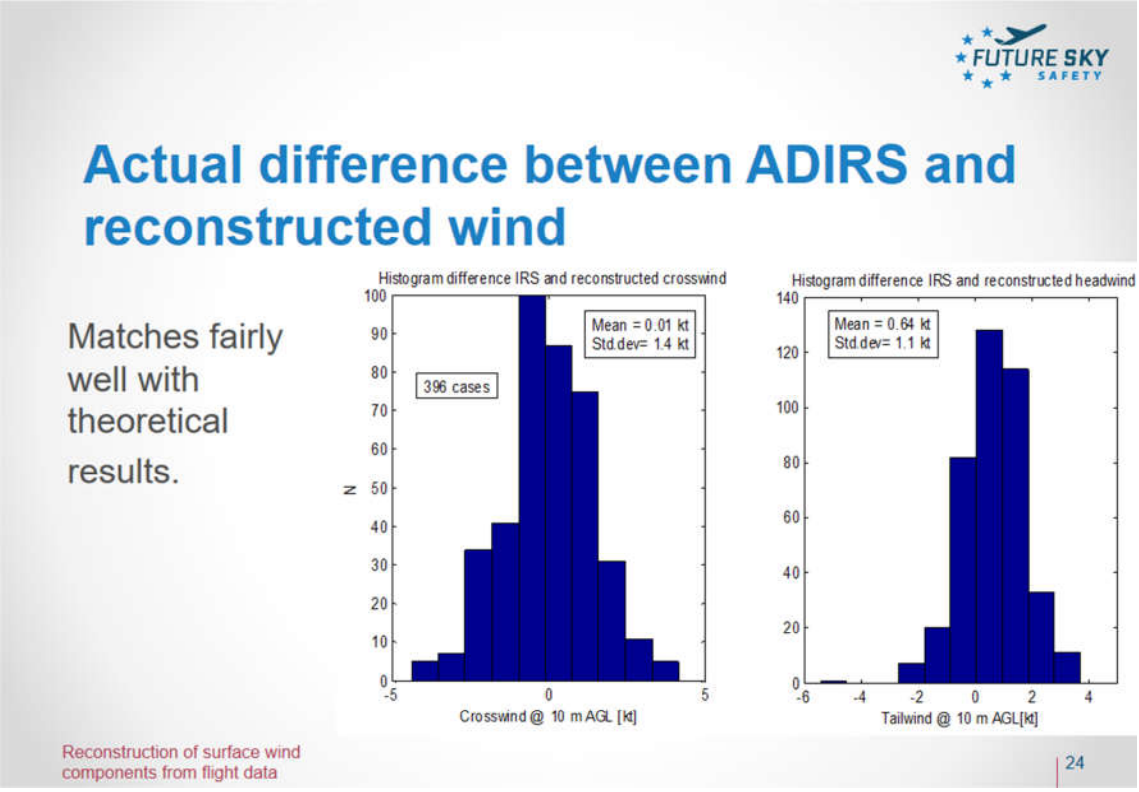

Actual difference between ADIRS and reconstructed wind

Matches fairly well with theoretical results.

Reconstruction of surface wind components from flight data

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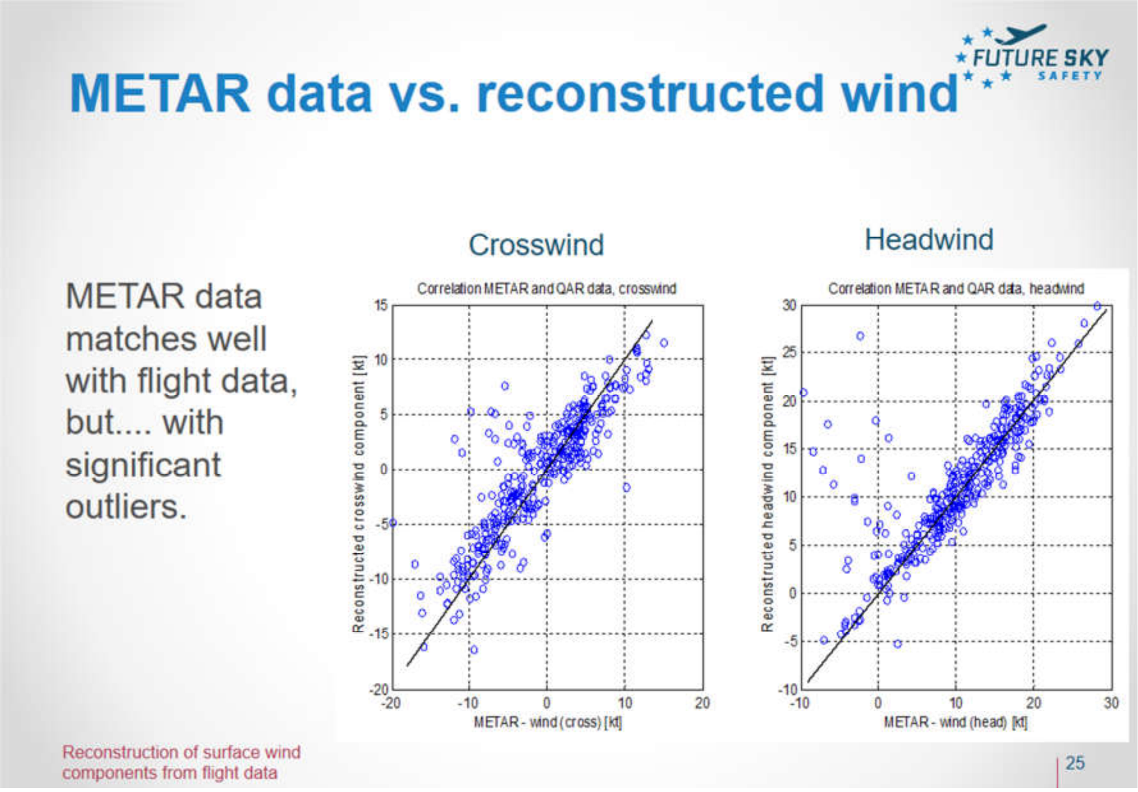
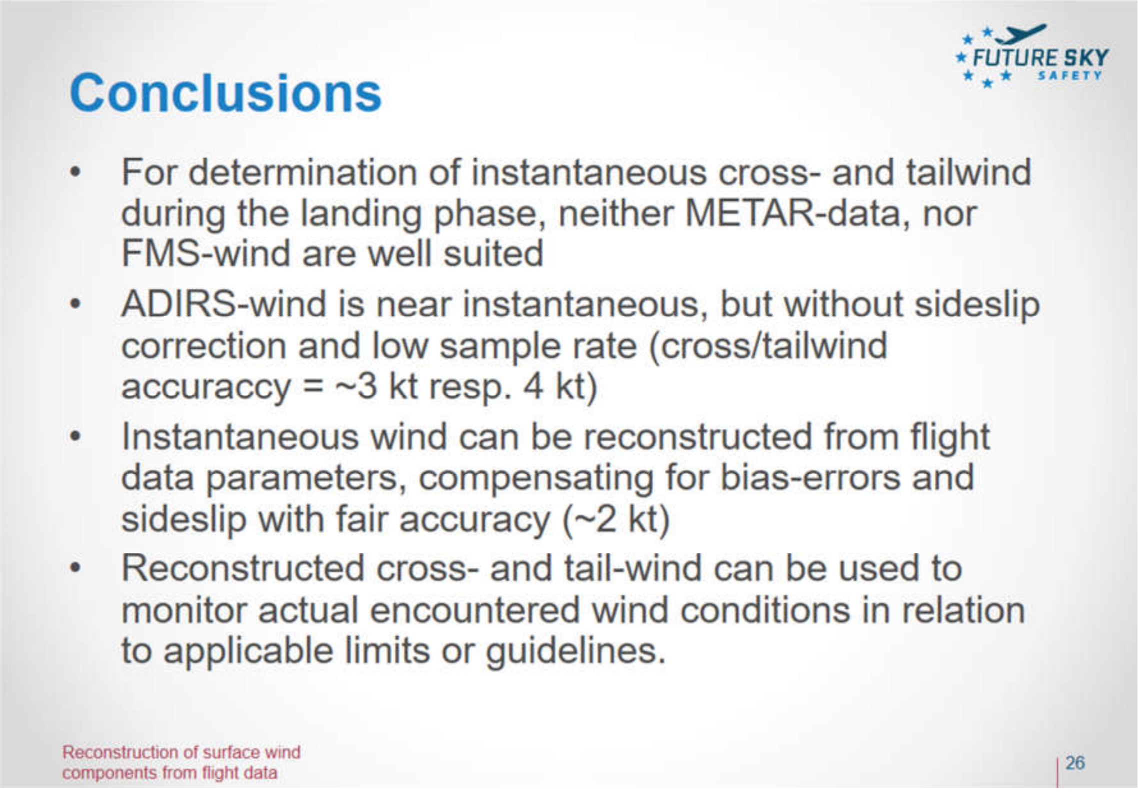


METAR data vs. reconstructed wind

METAR data matches well with flight data, but.... with significant outliers.

Reconstruction of surface wind components from flight data



Conclusions

- For determination of instantaneous cross- and tailwind during the landing phase, neither METAR-data, nor FMS-wind are well suited
- ADIRS-wind is near instantaneous, but without sideslip correction and low sample rate (cross/tailwind accaccy = ~3 kt resp. 4 kt)
- Instantaneous wind can be reconstructed from flight data parameters, compensating for bias-errors and sideslip with fair accuracy (~2 kt)
- Reconstructed cross- and tail-wind can be used to monitor actual encountered wind conditions in relation to applicable limits or guidelines.

Reconstruction of surface wind components from flight data

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Appendix B.3 "P3: New technologies for reducing the risk of runway excursions" – Frédéric Barbaresco, Thales Group

New technologies for reducing the risk of runway excursions

FP8 Future Sky Safety Project / WP3.4
F. Barbaresco

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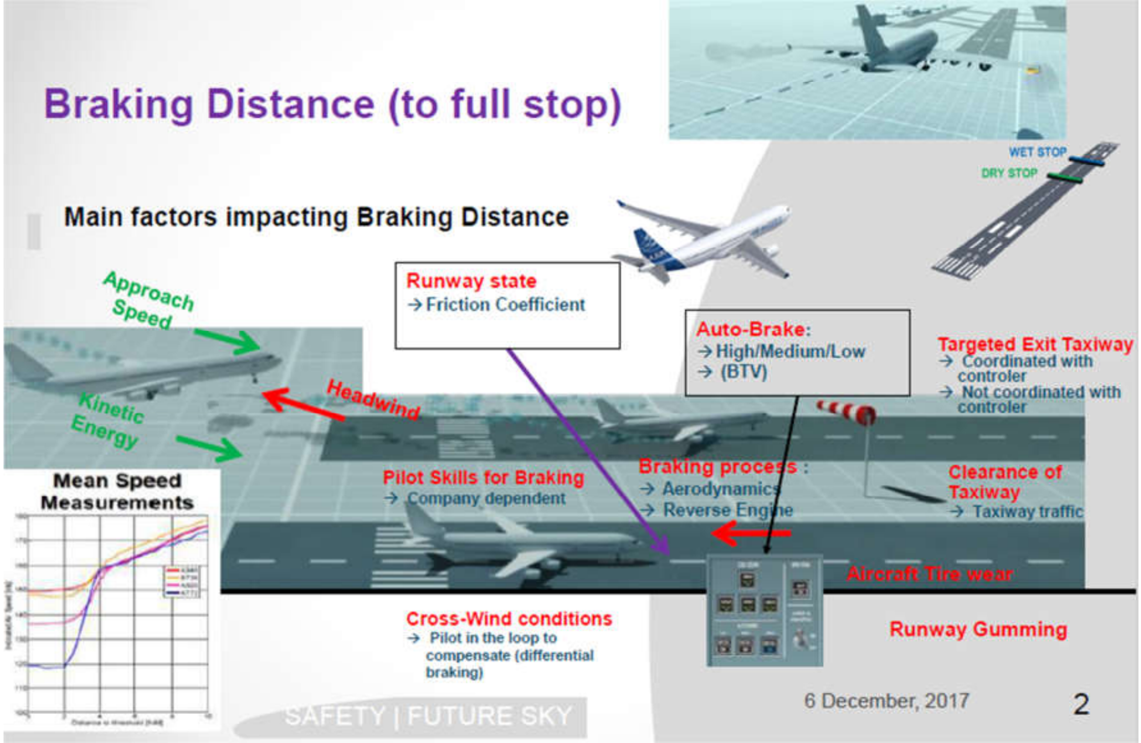

Braking Distance (to full stop)

Main factors impacting Braking Distance

Runway state
→ Friction Coefficient

Auto-Brake:
→ High/Medium/Low
→ (BTV)

Targeted Exit Taxiway
→ Coordinated with controler
→ Not coordinated with controler

Pilot Skills for Braking
→ Company dependent

Braking process :
→ Aerodynamics
→ Reverse Engine

Clearance of Taxiway
→ Taxiway traffic

Aircraft Tire wear

Cross-Wind conditions
→ Pilot in the loop to compensate (differential braking)

Runway Gumming

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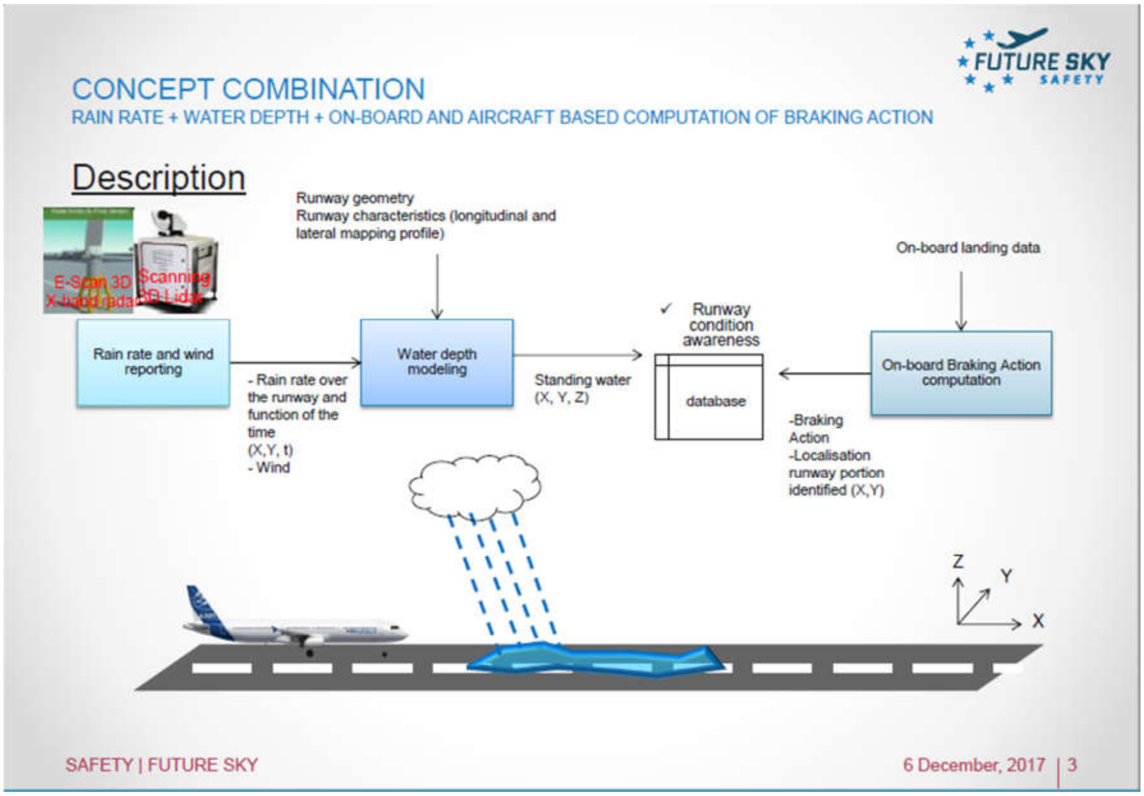
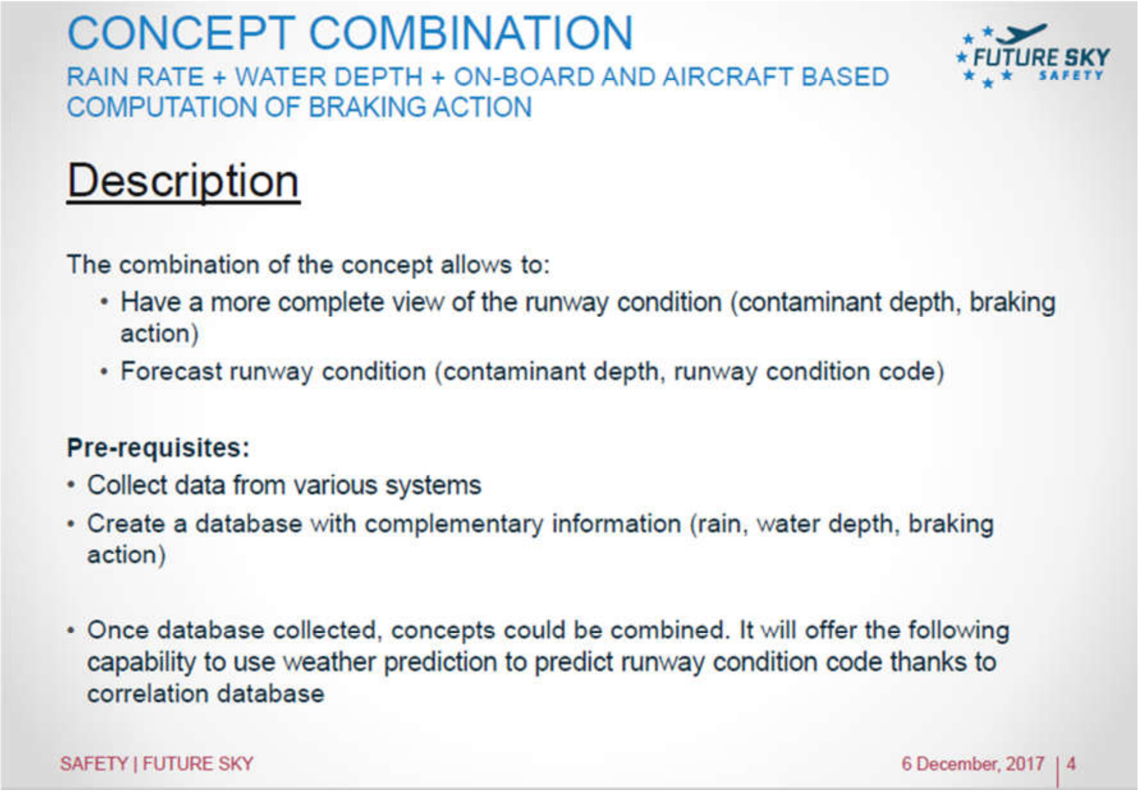


CONCEPT COMBINATION

RAIN RATE + WATER DEPTH + ON-BOARD AND AIRCRAFT BASED COMPUTATION OF BRAKING ACTION

Description



CONCEPT COMBINATION

RAIN RATE + WATER DEPTH + ON-BOARD AND AIRCRAFT BASED COMPUTATION OF BRAKING ACTION

Description

The combination of the concept allows to:

- Have a more complete view of the runway condition (contaminant depth, braking action)
- Forecast runway condition (contaminant depth, runway condition code)

Pre-requisites:

- Collect data from various systems
- Create a database with complementary information (rain, water depth, braking action)

- Once database collected, concepts could be combined. It will offer the following capability to use weather prediction to predict runway condition code thanks to correlation database

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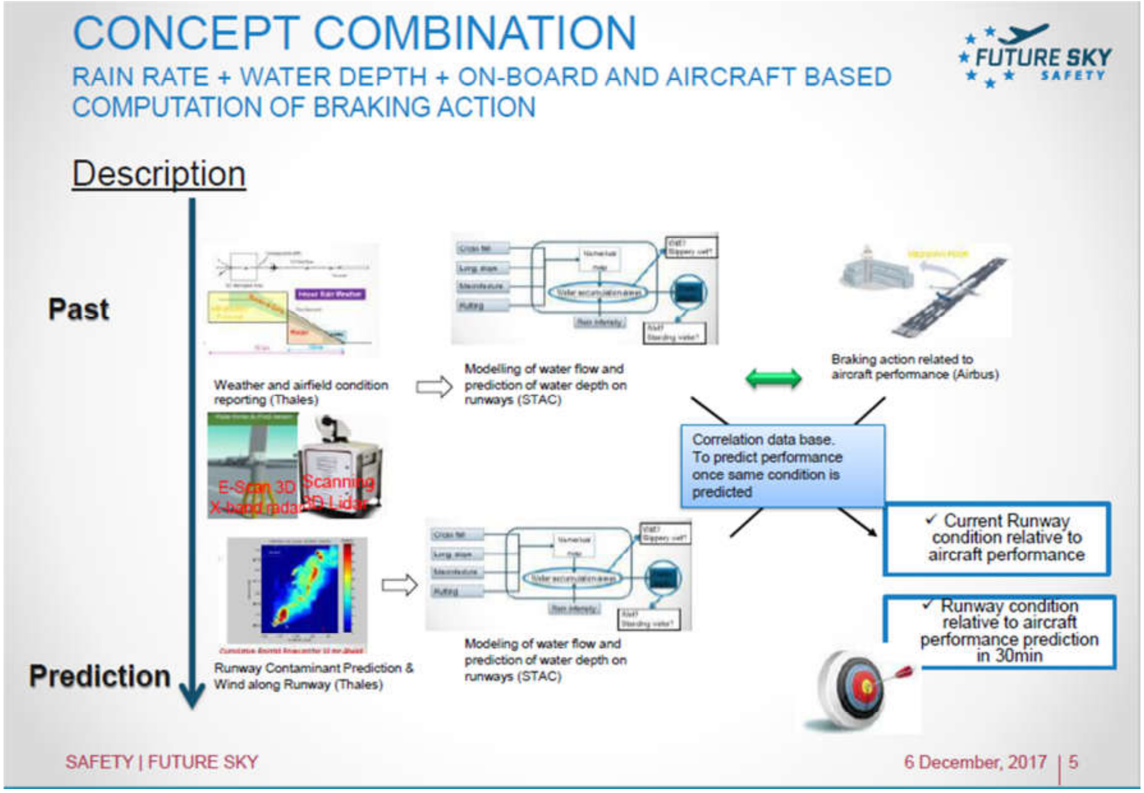

CONCEPT COMBINATION

RAIN RATE + WATER DEPTH + ON-BOARD AND AIRCRAFT BASED COMPUTATION OF BRAKING ACTION

Description

Past

Weather and airfield condition reporting (Thales)

Modelling of water flow and prediction of water depth on runways (STAC)

Braking action related to aircraft performance (Airbus)

Correlation data base. To predict performance once same condition is predicted

- ✓ Current Runway condition relative to aircraft performance
- ✓ Runway condition relative to aircraft performance prediction in 30min

Prediction

Runway Contaminant Prediction & Wind along Runway (Thales)

Modeling of water flow and prediction of water depth on runways (STAC)

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GROUND SOLUTIONS

(Thales Air systems)

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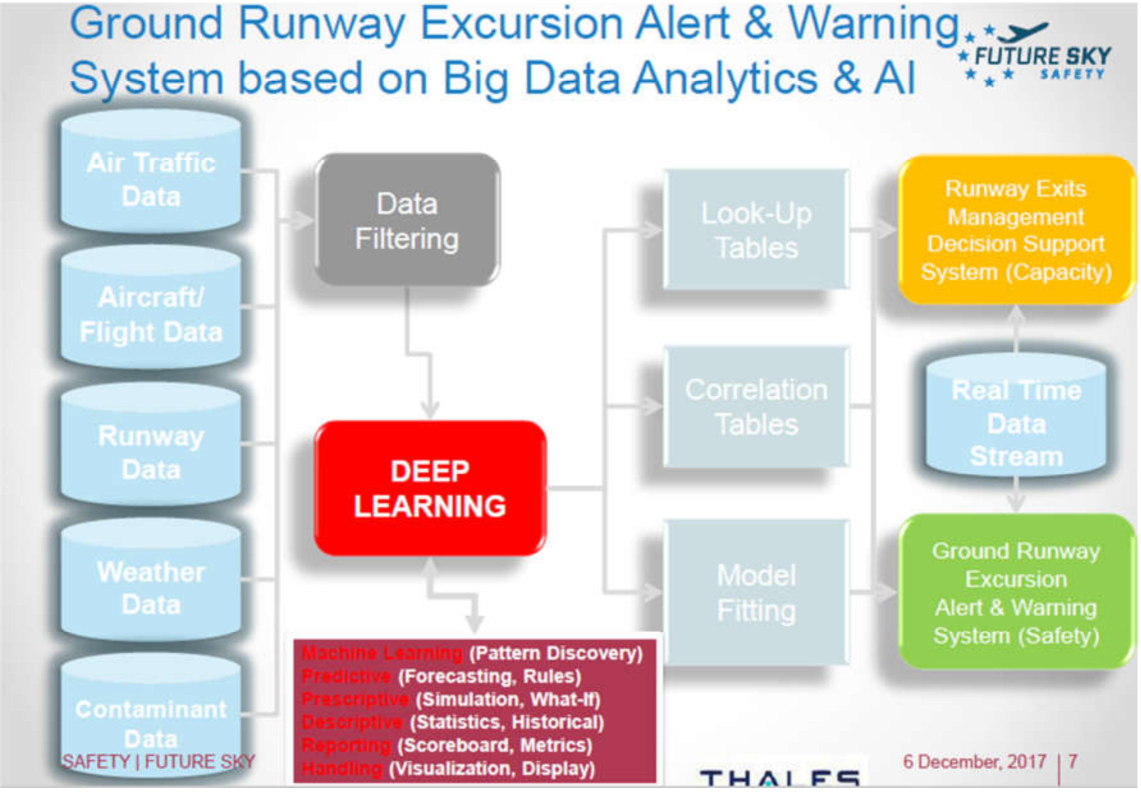

Ground Runway Excursion Alert & Warning System based on Big Data Analytics & AI

Air Traffic Data

Aircraft/ Flight Data

Runway Data

Weather Data

Contaminant Data

Data Filtering

DEEP LEARNING

Machine Learning (Pattern Discovery)
Predictive (Forecasting, Rules)
Prescriptive (Simulation, What-If)
Descriptive (Statistics, Historical)
Reporting (Scoreboard, Metrics)
Handling (Visualization, Display)

Look-Up Tables

Correlation Tables

Model Fitting

Runway Exits Management Decision Support System (Capacity)

Real Time Data Stream

Ground Runway Excursion Alert & Warning System (Safety)

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THALES

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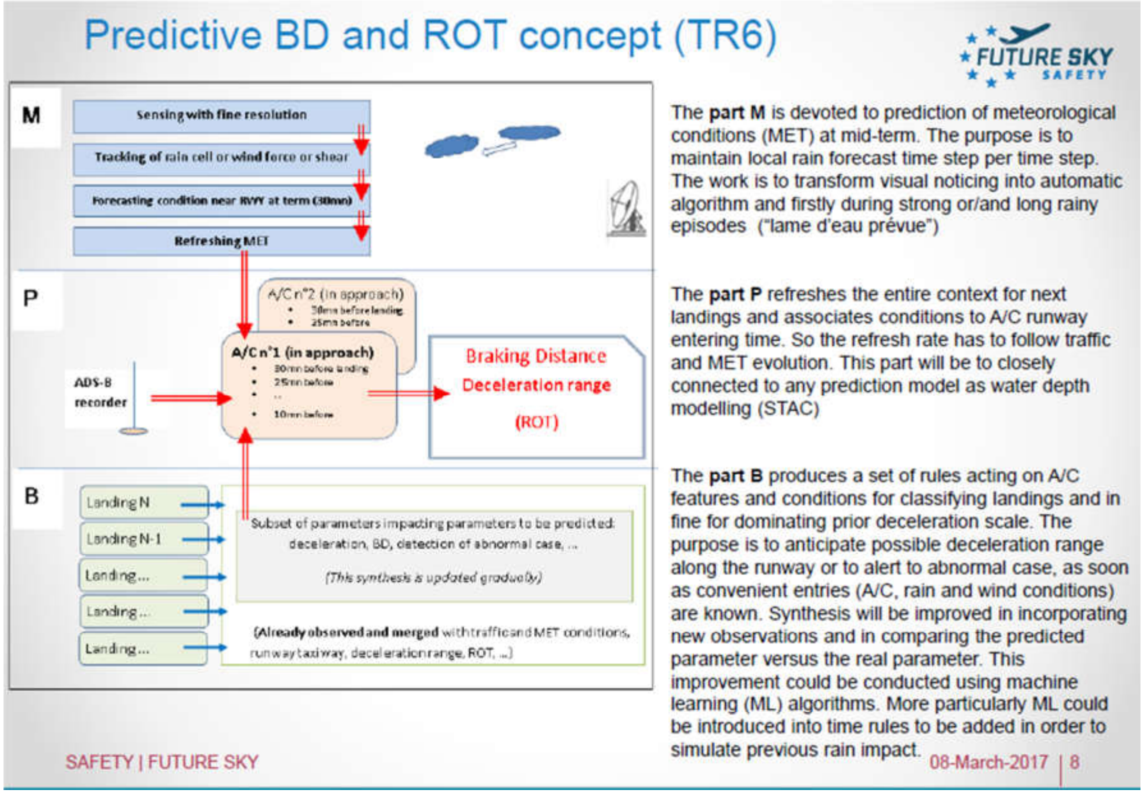

Predictive BD and ROT concept (TR6)

The **part M** is devoted to prediction of meteorological conditions (MET) at mid-term. The purpose is to maintain local rain forecast time step per time step. The work is to transform visual noticing into automatic algorithm and firstly during strong or/and long rainy episodes ("lame d'eau prévue")

The **part P** refreshes the entire context for next landings and associates conditions to A/C runway entering time. So the refresh rate has to follow traffic and MET evolution. This part will be to closely connected to any prediction model as water depth modelling (STAC)

The **part B** produces a set of rules acting on A/C features and conditions for classifying landings and in fine for dominating prior deceleration scale. The purpose is to anticipate possible deceleration range along the runway or to alert to abnormal case, as soon as convenient entries (A/C, rain and wind conditions) are known. Synthesis will be improved in incorporating new observations and in comparing the predicted parameter versus the real parameter. This improvement could be conducted using machine learning (ML) algorithms. More particularly ML could be introduced into time rules to be added in order to simulate previous rain impact.

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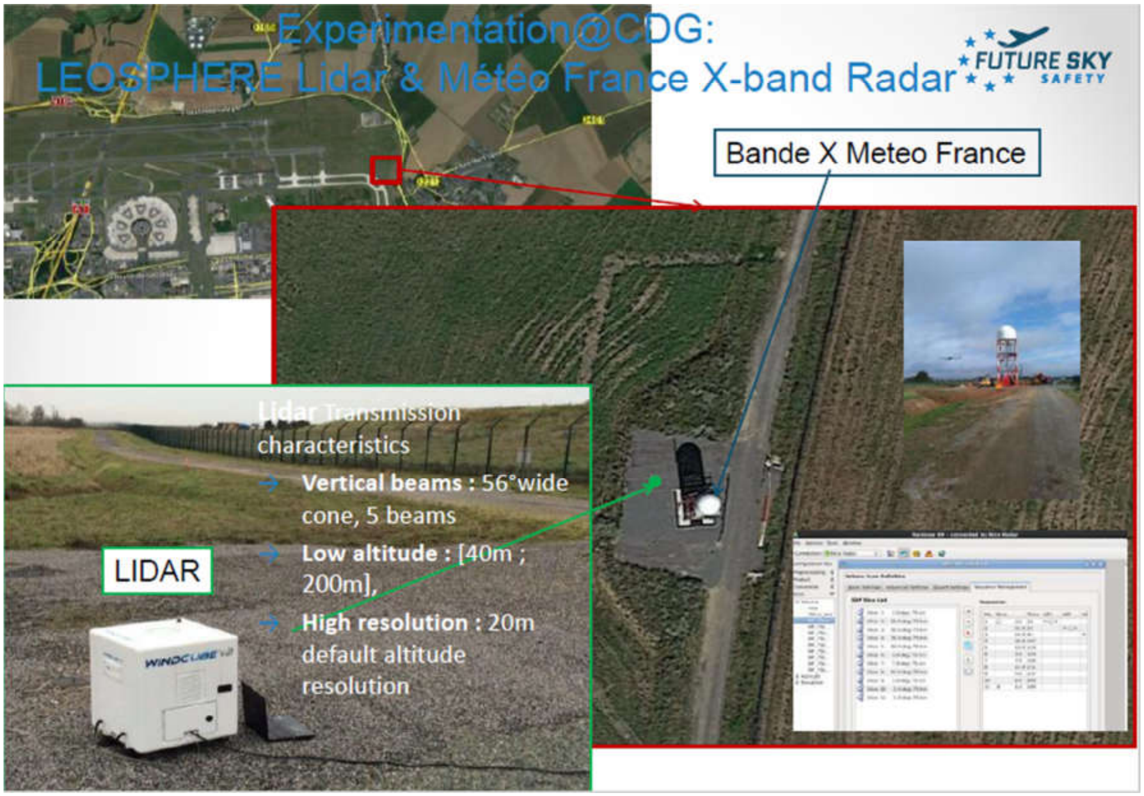
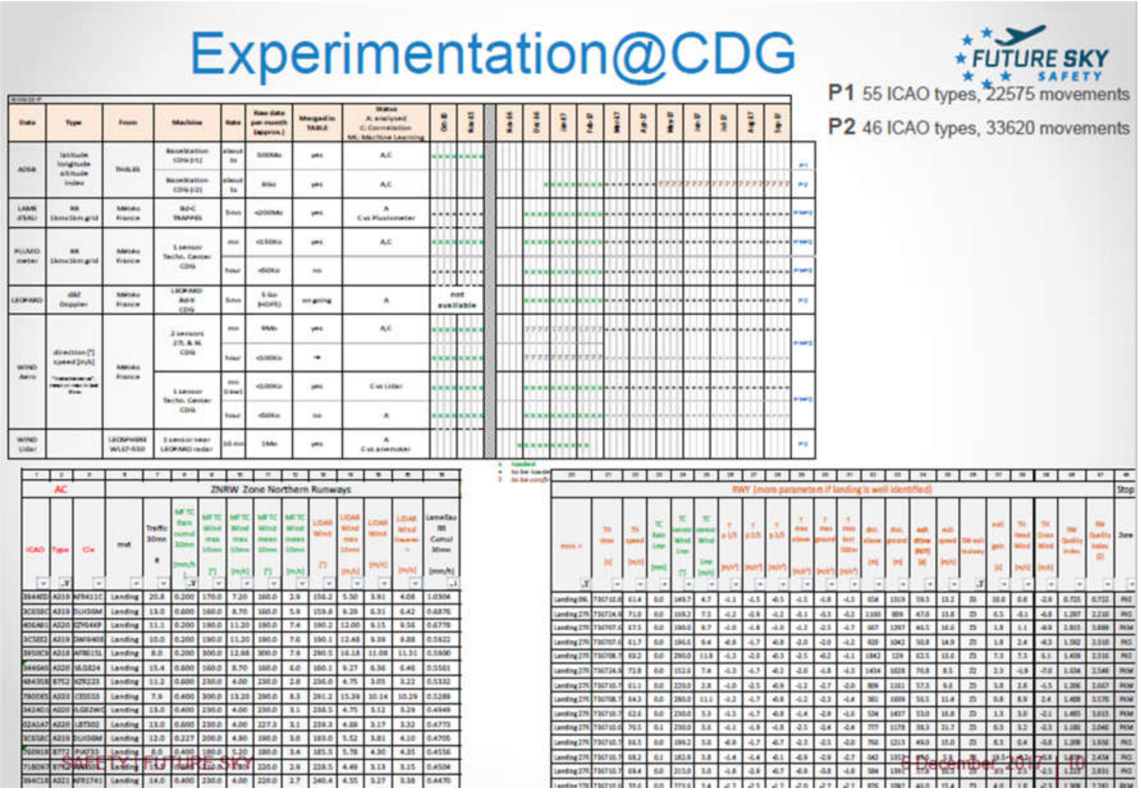


Experimentation@CDG:
LEOSPHERE Lidar & Météo France X-band Radar

Lidar Transmission characteristics

- **Vertical beams :** 56°wide cone, 5 beams
- **Low altitude :** [40m ; 200m],
- **High resolution :** 20m default altitude resolution



Experimentation@CDG

P1 55 ICAO types, 22575 movements

P2 46 ICAO types, 33620 movements

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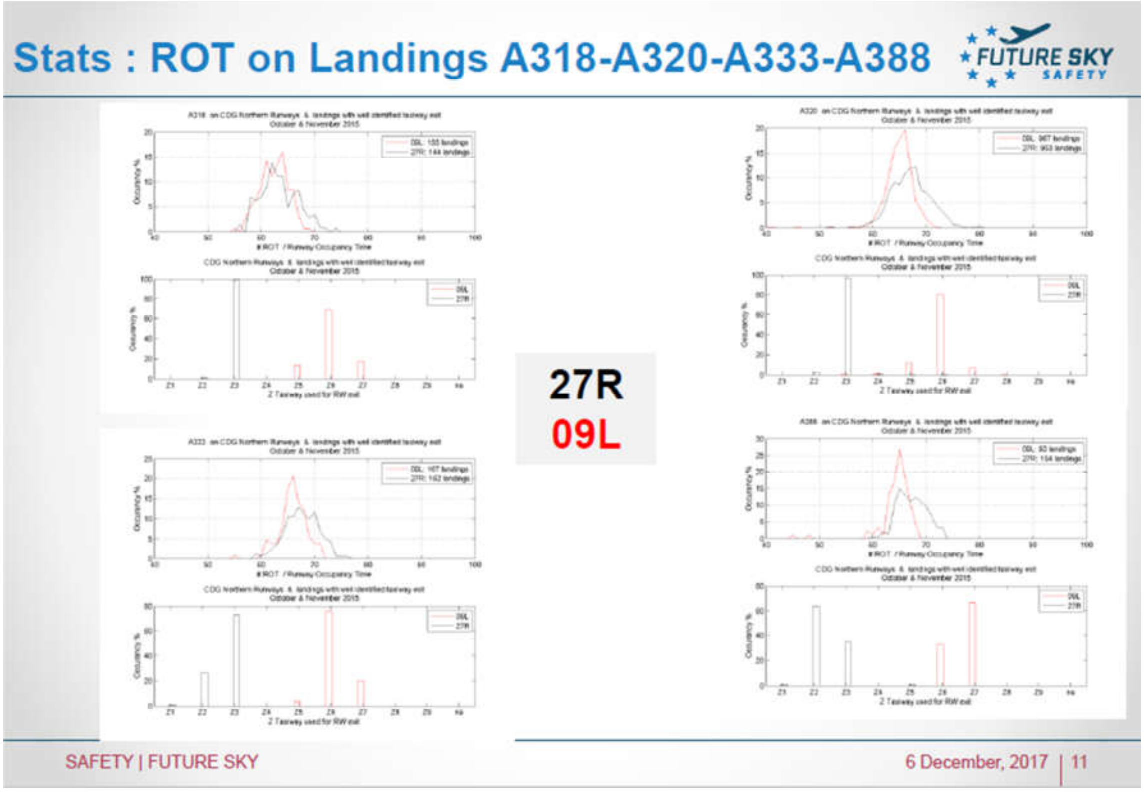

Stats : ROT on Landings A318-A320-A333-A388

27R
09L

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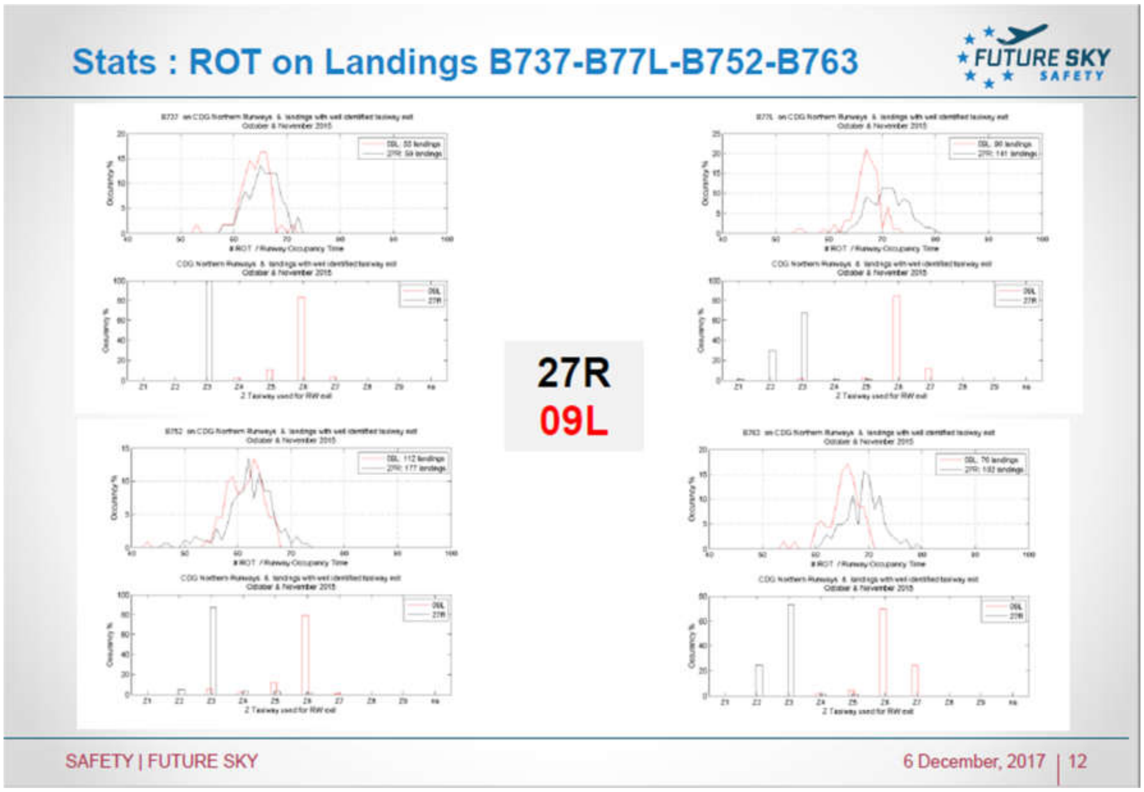

Stats : ROT on Landings B737-B77L-B752-B763

27R
09L

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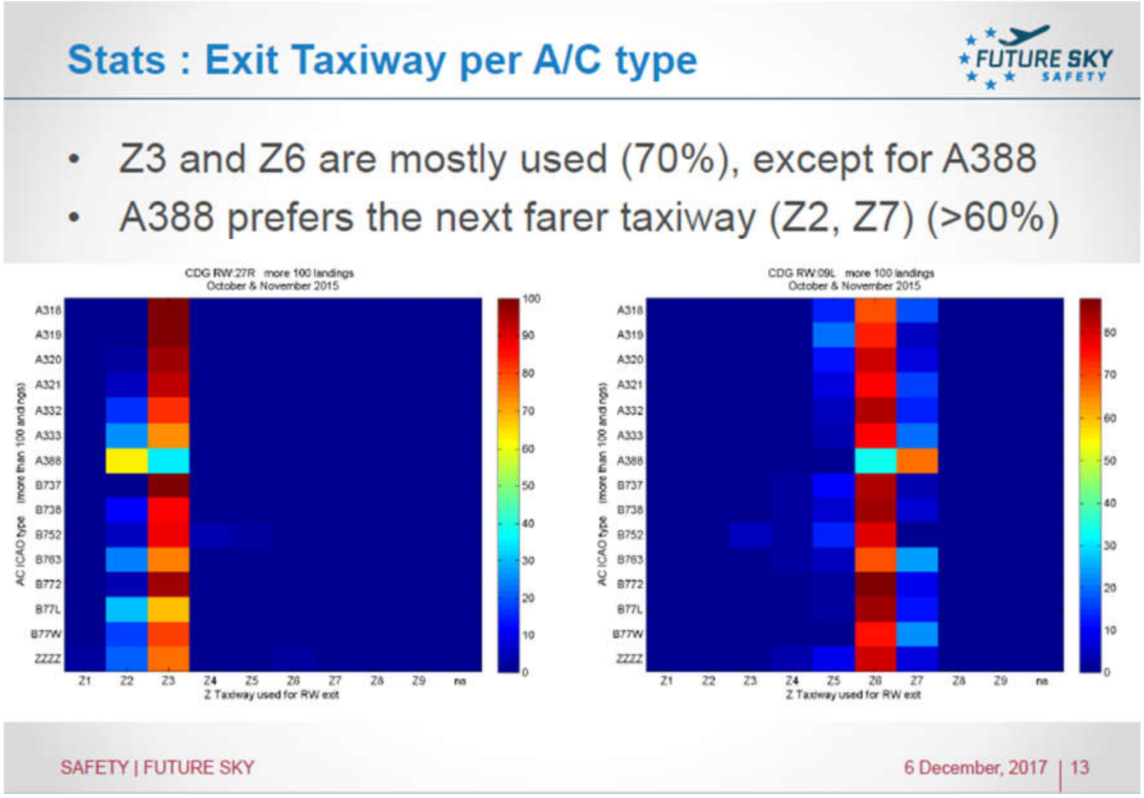

Stats : Exit Taxiway per A/C type

- Z3 and Z6 are mostly used (70%), except for A388
- A388 prefers the next farer taxiway (Z2, Z7) (>60%)

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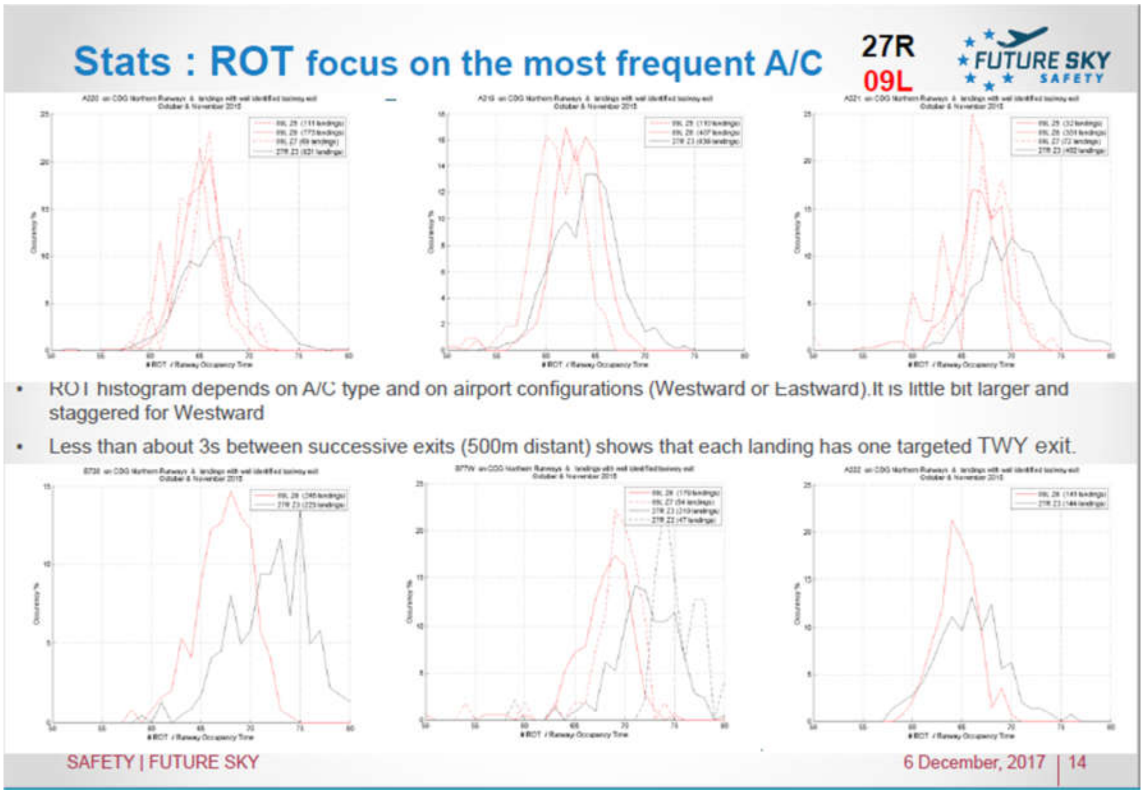

Stats : ROT focus on the most frequent A/C

27R
09L

- ROT histogram depends on A/C type and on airport configurations (Westward or Eastward).It is little bit larger and staggered for Westward
- Less than about 3s between successive exits (500m distant) shows that each landing has one targeted TWY exit.

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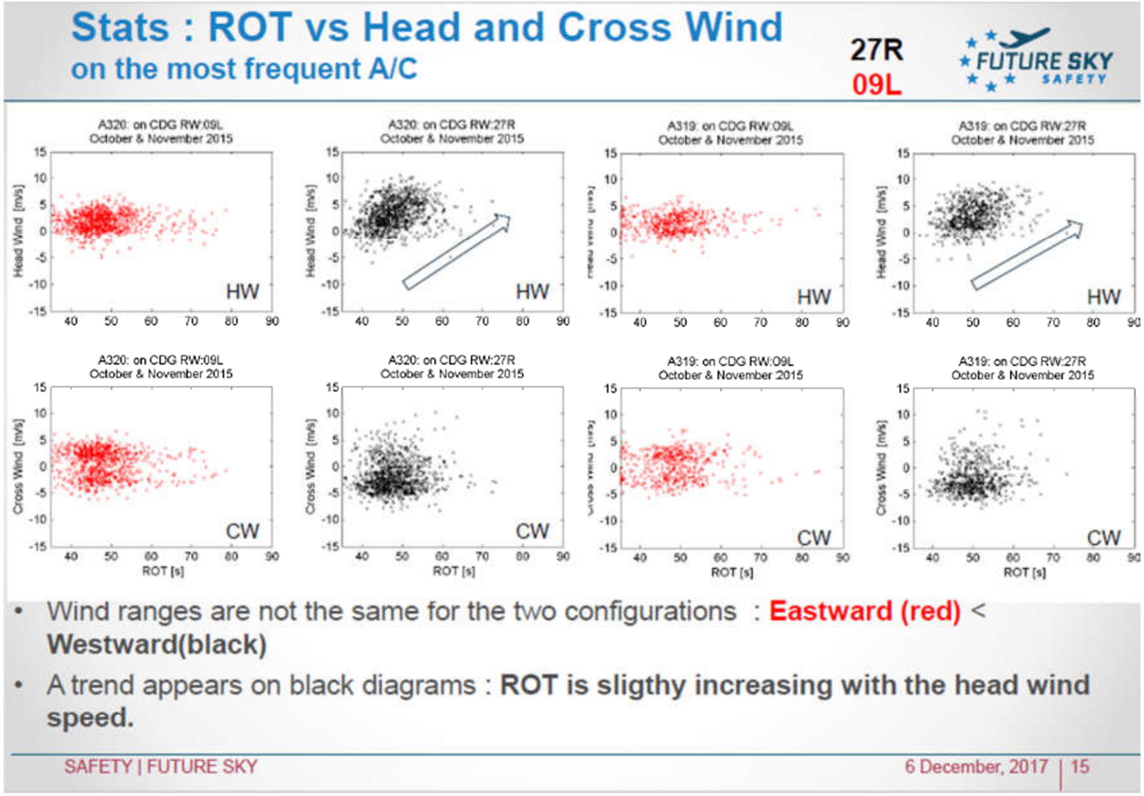

Stats : ROT vs Head and Cross Wind

on the most frequent A/C

- Wind ranges are not the same for the two configurations : **Eastward (red)** < **Westward(black)**
- A trend appears on black diagrams : **ROT is sligthy increasing with the head wind speed.**

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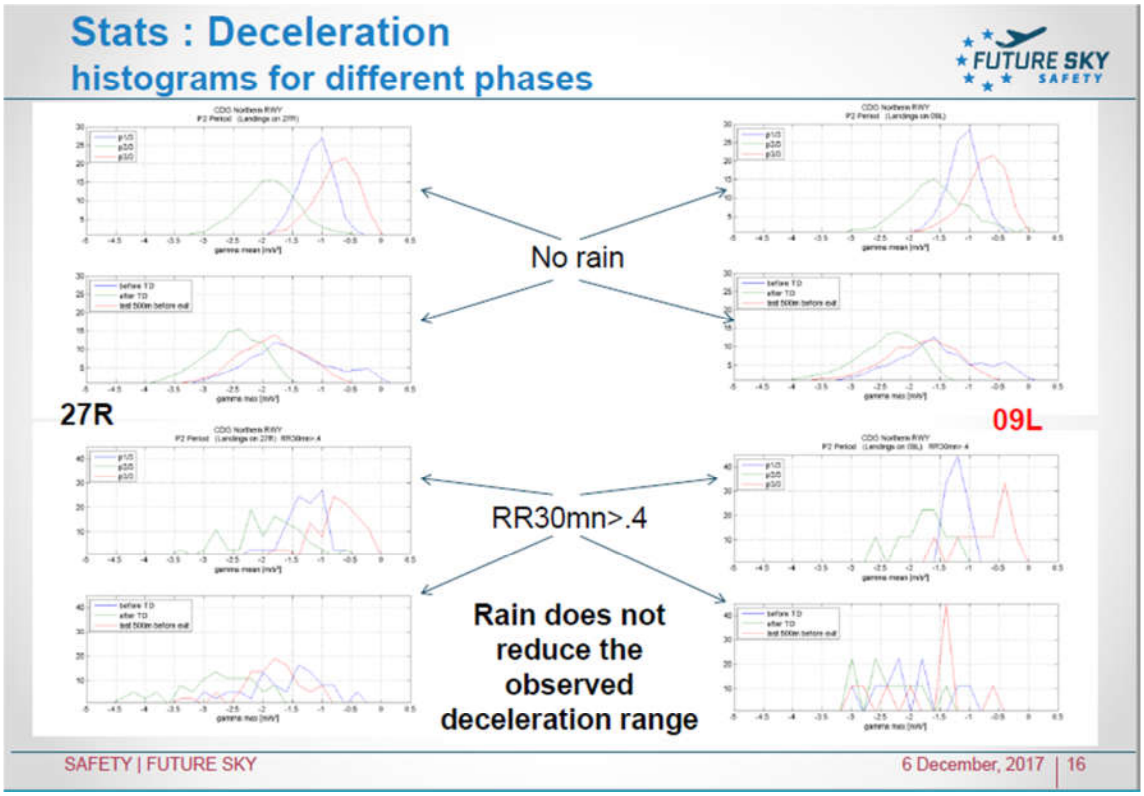

Stats : Deceleration

histograms for different phases

Rain does not reduce the observed deceleration range

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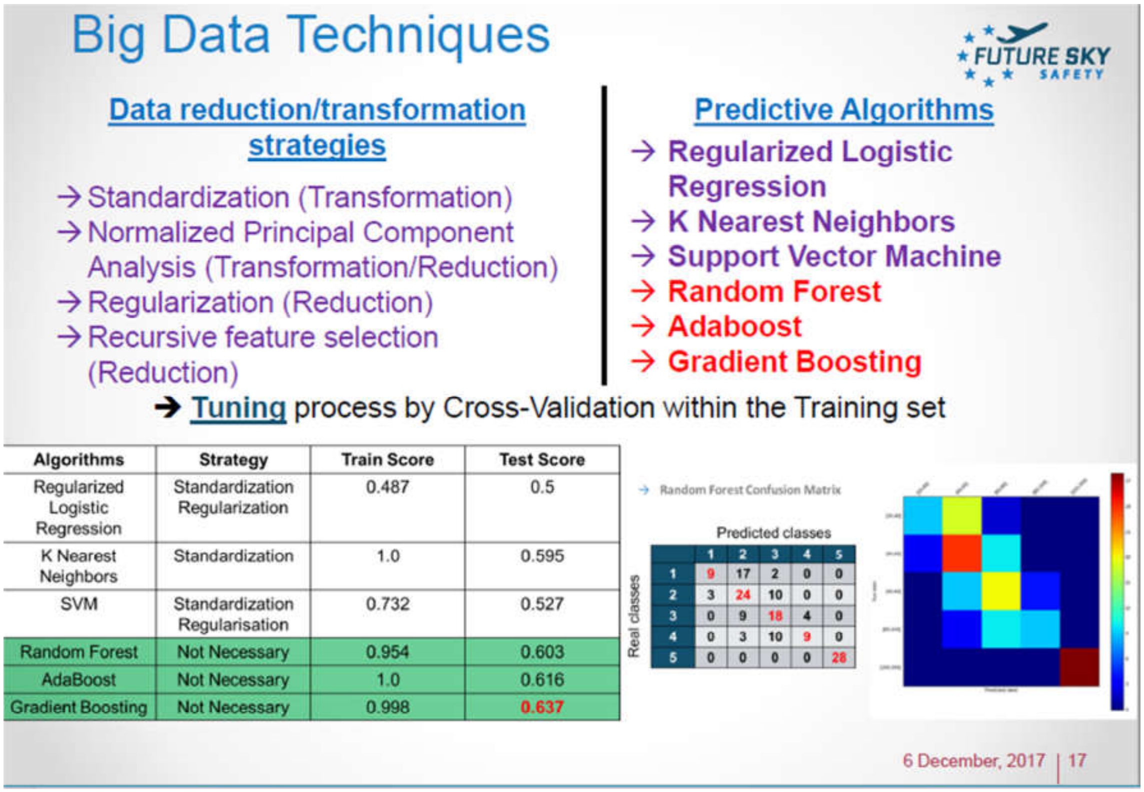


Big Data Techniques

Data reduction/transformation strategies

- → Standardization (Transformation)
- → Normalized Principal Component Analysis (Transformation/Reduction)
- → Regularization (Reduction)
- → Recursive feature selection (Reduction)

Predictive Algorithms

- → Regularized Logistic Regression
- → K Nearest Neighbors
- → Support Vector Machine
- → Random Forest
- → Adaboost
- → Gradient Boosting

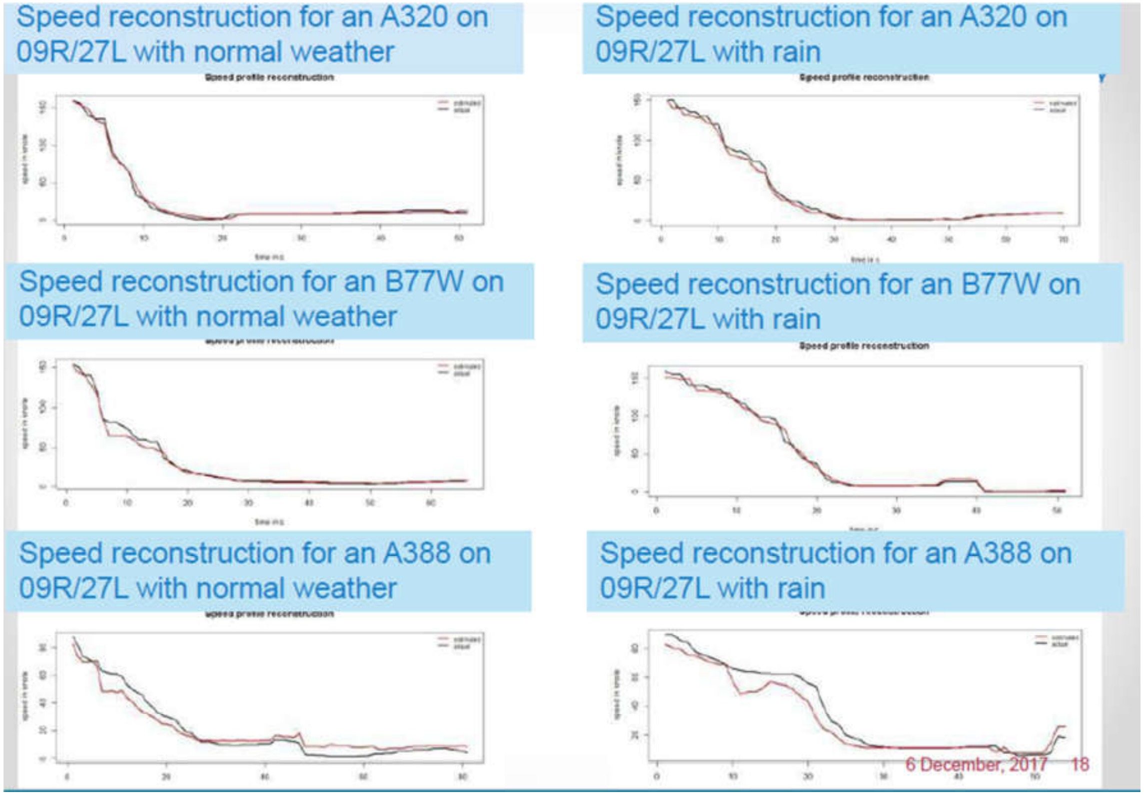
➔ Tuning process by Cross-Validation within the Training set

Algorithms	Strategy	Train Score	Test Score
Regularized Logistic Regression	Standardization Regularization	0.487	0.5
K Nearest Neighbors	Standardization	1.0	0.595
SVM	Standardization Regularisation	0.732	0.527
Random Forest	Not Necessary	0.954	0.603
AdaBoost	Not Necessary	1.0	0.616
Gradient Boosting	Not Necessary	0.998	0.637

→ Random Forest Confusion Matrix

Predicted classes

Real classes	1	2	3	4	5
1	9	17	2	0	0
2	3	24	10	0	0
3	0	9	18	4	0
4	0	3	10	9	0
5	0	0	0	0	28



Speed reconstruction for an A320 on 09R/27L with normal weather

Speed reconstruction for an A320 on 09R/27L with rain

Speed reconstruction for an B77W on 09R/27L with normal weather

Speed reconstruction for an B77W on 09R/27L with rain

Speed reconstruction for an A388 on 09R/27L with normal weather

Speed reconstruction for an A388 on 09R/27L with rain

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GROUND SOLUTIONS
(DGAC/STAC)

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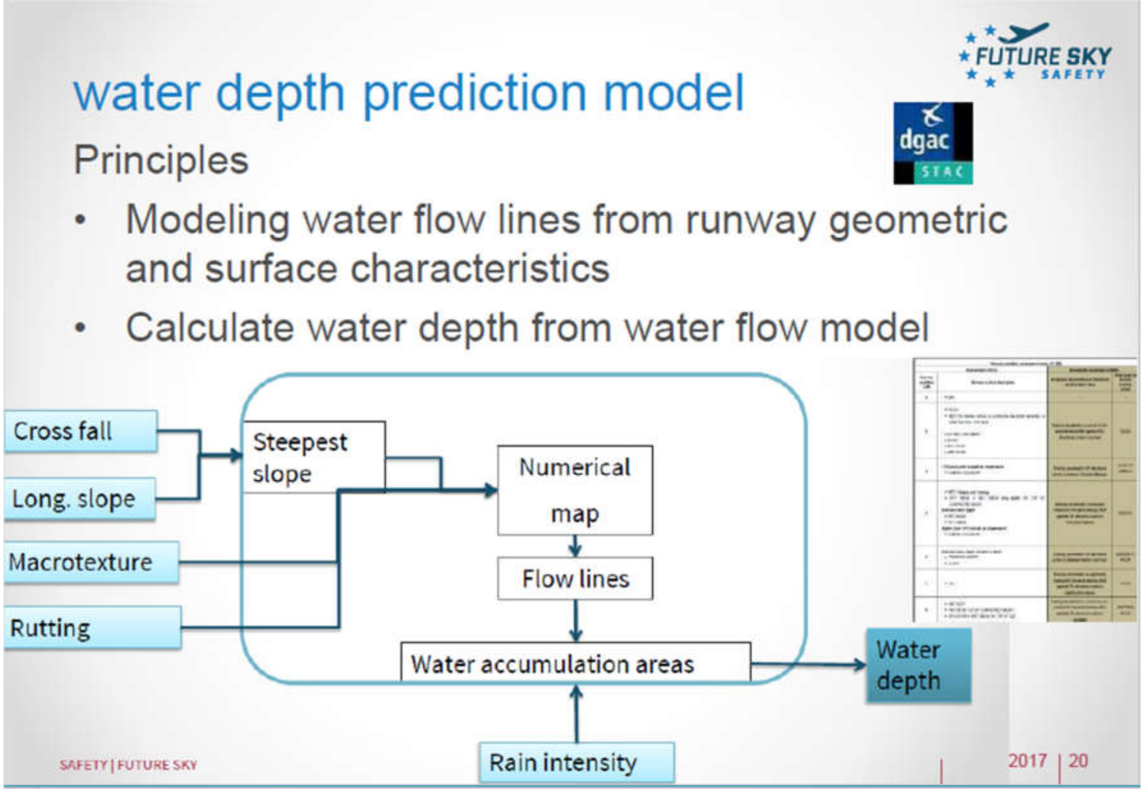

water depth prediction model

Principles

- Modeling water flow lines from runway geometric and surface characteristics
- Calculate water depth from water flow model

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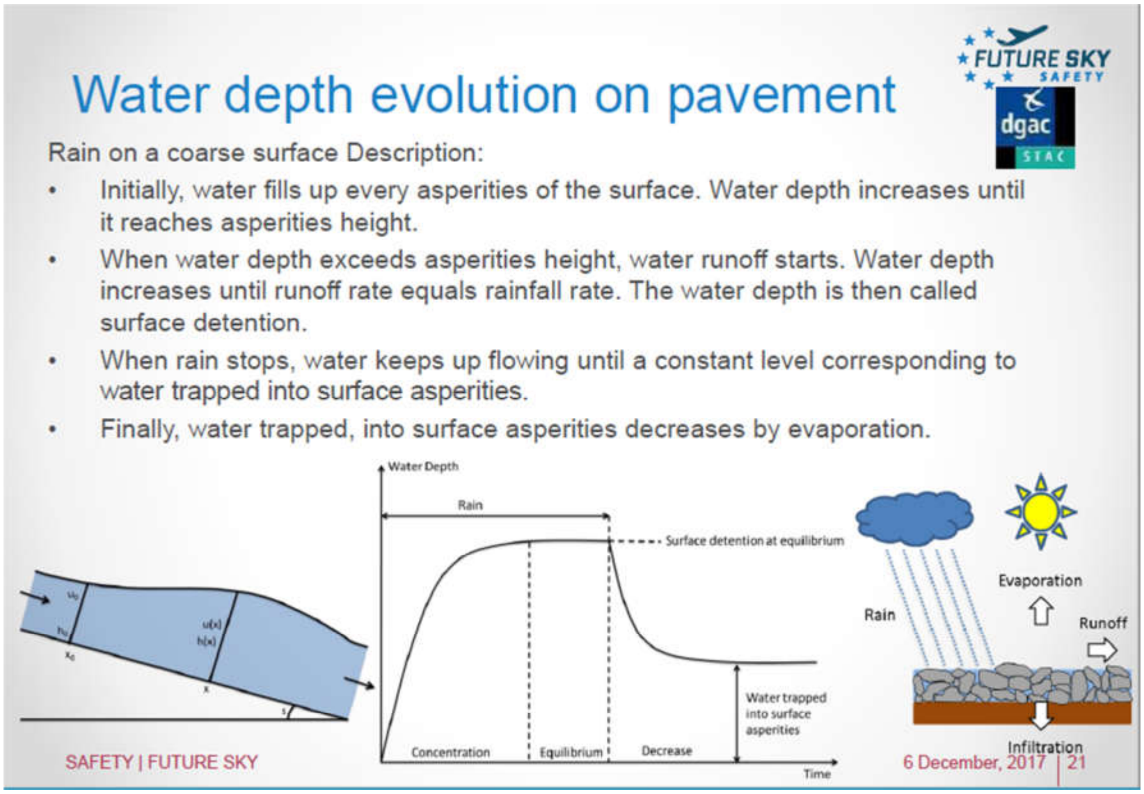

Water depth evolution on pavement

Rain on a coarse surface Description:

- Initially, water fills up every asperities of the surface. Water depth increases until it reaches asperities height.
- When water depth exceeds asperities height, water runoff starts. Water depth increases until runoff rate equals rainfall rate. The water depth is then called surface detention.
- When rain stops, water keeps up flowing until a constant level corresponding to water trapped into surface asperities.
- Finally, water trapped, into surface asperities decreases by evaporation.

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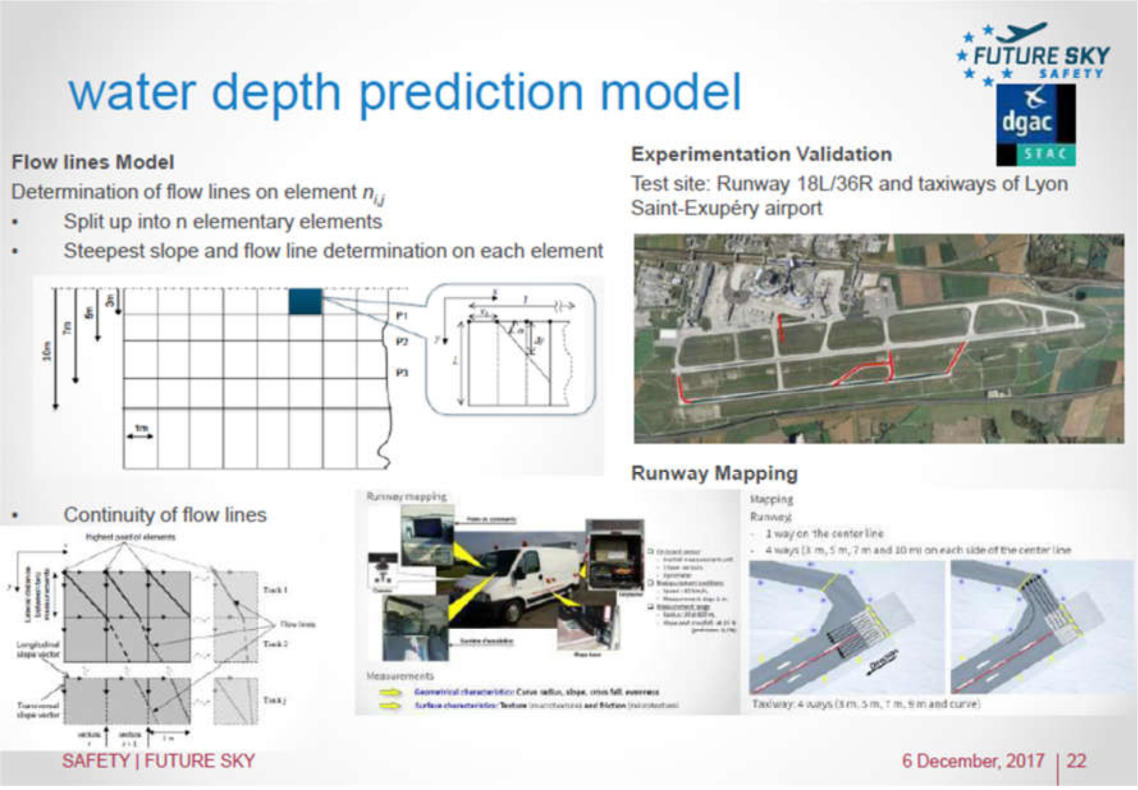

water depth prediction model

Flow lines Model

Determination of flow lines on element $n_{i,j}$

- Split up into n elementary elements
- Steepest slope and flow line determination on each element

- Continuity of flow lines

Experimentation Validation

Test site: Runway 18L/36R and taxiways of Lyon Saint-Exupéry airport

Runway Mapping

Runway mapping

Measurements

Geometrical characteristics: Curve radius, slope, cross fall, evenness

Surface characteristics: Texture (macrotexture) and friction (microtexture)

Mapping

Runway:

- 1 way on the center line
- 4 ways (3 m, 5 m, 7 m and 10 m) on each side of the center line

Taxiway: 4 ways (3 m, 5 m, 7 m, 9 m and curve)

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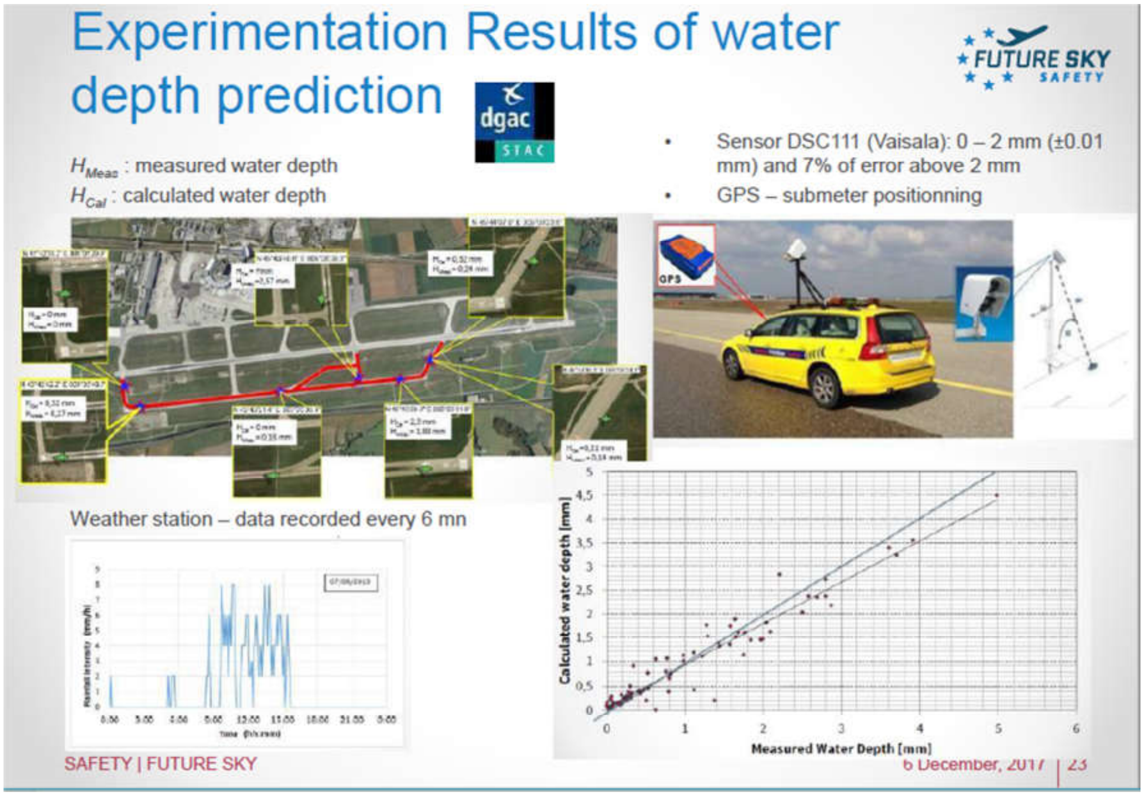

Experimentation Results of water depth prediction

H_{Meas} : measured water depth
H_{Cal} : calculated water depth

- Sensor DSC111 (Vaisala): 0 – 2 mm (±0.01 mm) and 7% of error above 2 mm
- GPS – submeter positionning

Weather station – data recorded every 6 mn

GROUND SOLUTIONS
(ZODIAC)

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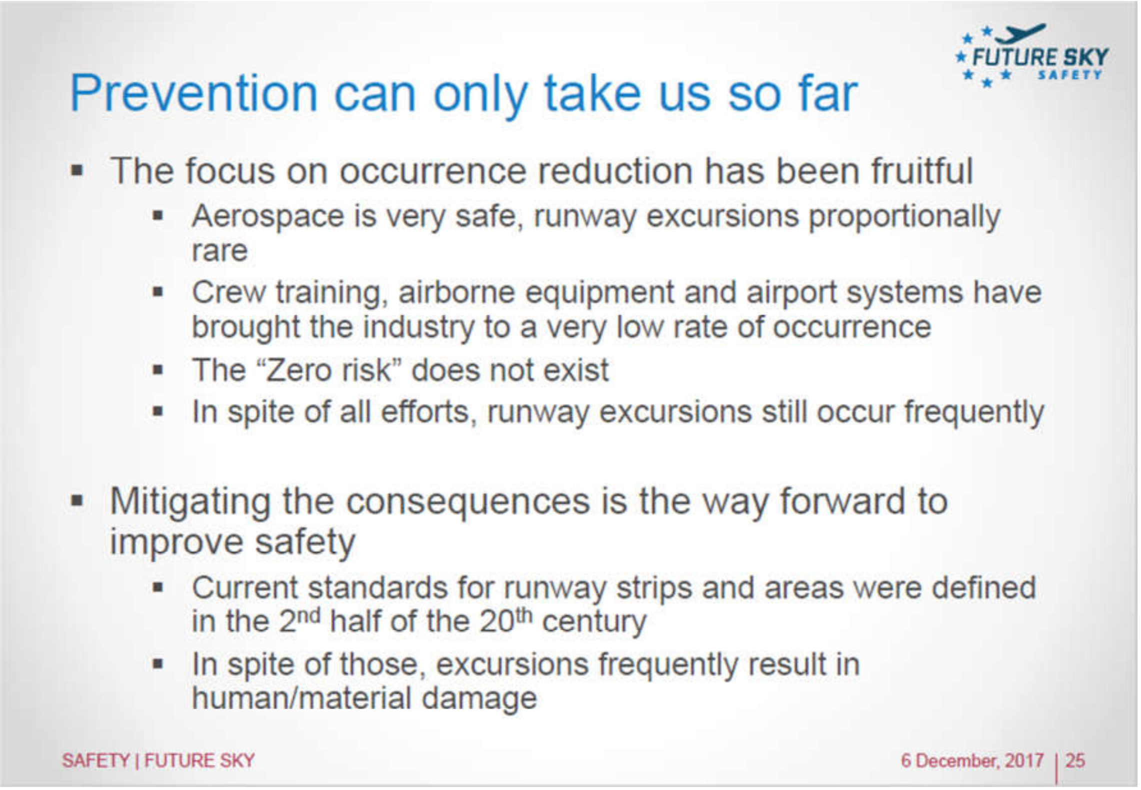
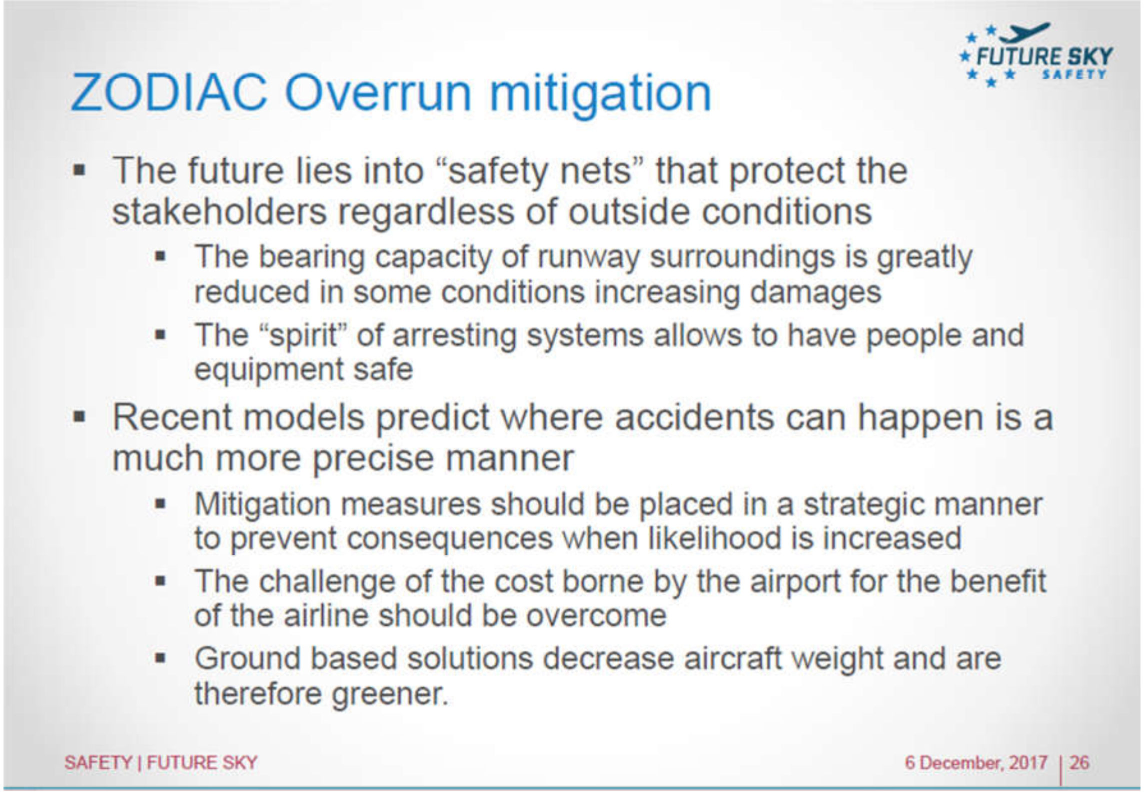


Prevention can only take us so far

- The focus on occurrence reduction has been fruitful
    - Aerospace is very safe, runway excursions proportionally rare
    - Crew training, airborne equipment and airport systems have brought the industry to a very low rate of occurrence
    - The “Zero risk” does not exist
    - In spite of all efforts, runway excursions still occur frequently
- Mitigating the consequences is the way forward to improve safety
    - Current standards for runway strips and areas were defined in the 2nd half of the 20th century
    - In spite of those, excursions frequently result in human/material damage



ZODIAC Overrun mitigation

- The future lies into “safety nets” that protect the stakeholders regardless of outside conditions
    - The bearing capacity of runway surroundings is greatly reduced in some conditions increasing damages
    - The “spirit” of arresting systems allows to have people and equipment safe
- Recent models predict where accidents can happen is a much more precise manner
    - Mitigation measures should be placed in a strategic manner to prevent consequences when likelihood is increased
    - The challenge of the cost borne by the airport for the benefit of the airline should be overcome
    - Ground based solutions decrease aircraft weight and are therefore greener.

European Commission

AIRBORNE SOLUTIONS

(Thales Avionics)

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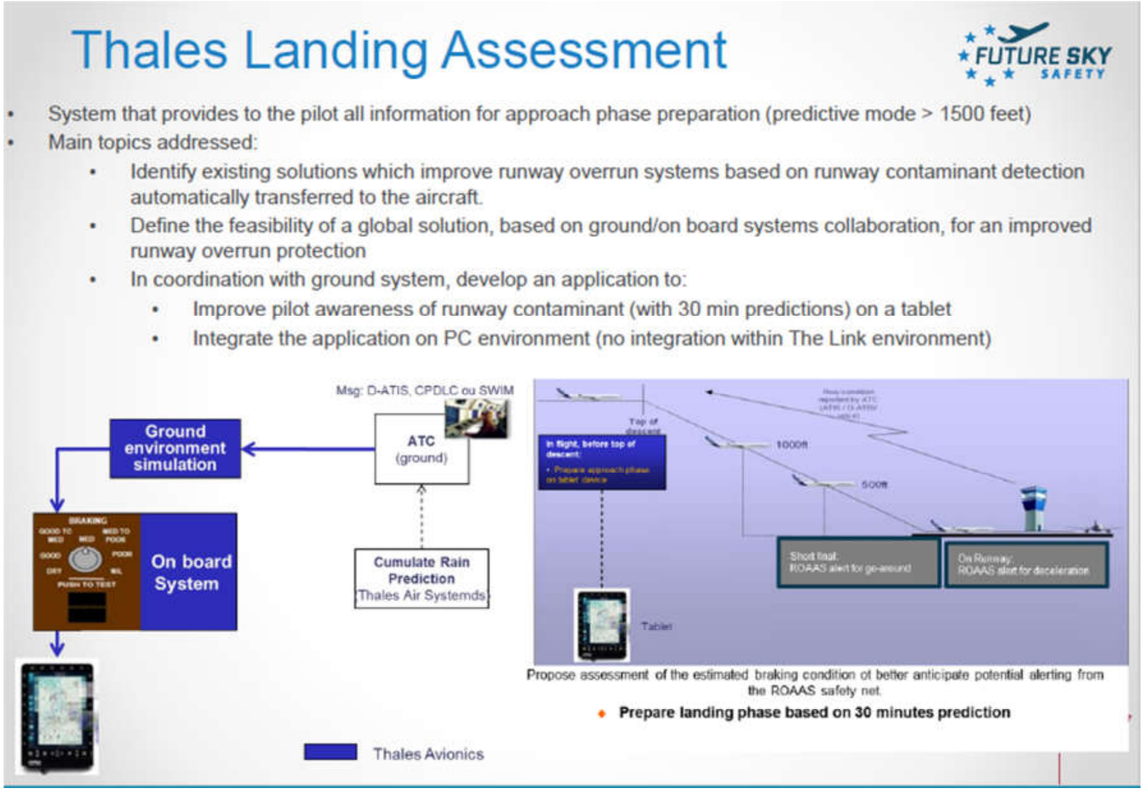

Thales Landing Assessment

- System that provides to the pilot all information for approach phase preparation (predictive mode > 1500 feet)
- Main topics addressed:
  - Identify existing solutions which improve runway overrun systems based on runway contaminant detection automatically transferred to the aircraft.
  - Define the feasibility of a global solution, based on ground/on board systems collaboration, for an improved runway overrun protection
  - In coordination with ground system, develop an application to:
    - Improve pilot awareness of runway contaminant (with 30 min predictions) on a tablet
    - Integrate the application on PC environment (no integration within The Link environment)

Propose assessment of the estimated braking condition ot better anticipate potential alerting from the ROAAS safety net.

- **Prepare landing phase based on 30 minutes prediction**

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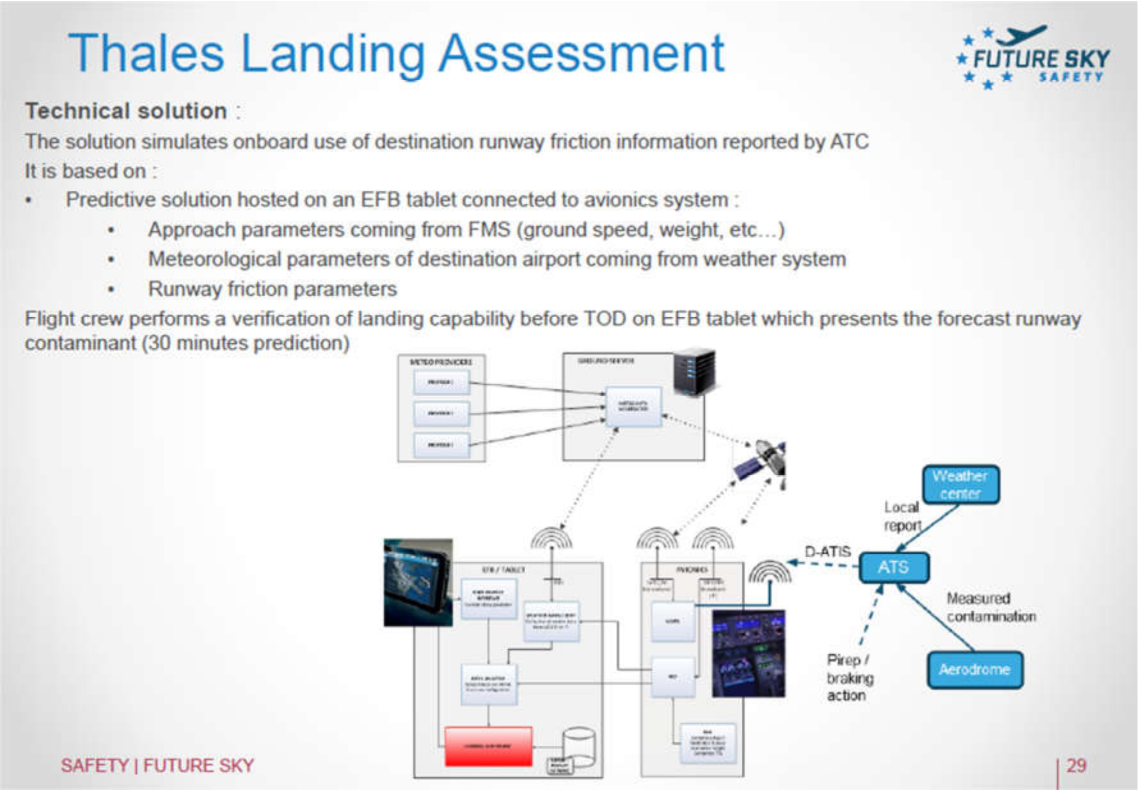

Thales Landing Assessment

Technical solution :

The solution simulates onboard use of destination runway friction information reported by ATC

It is based on :

- Predictive solution hosted on an EFB tablet connected to avionics system :
  - Approach parameters coming from FMS (ground speed, weight, etc…)
  - Meteorological parameters of destination airport coming from weather system
  - Runway friction parameters

Flight crew performs a verification of landing capability before TOD on EFB tablet which presents the forecast runway contaminant (30 minutes prediction)

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AIRBORNE SOLUTIONS

(Airbus)

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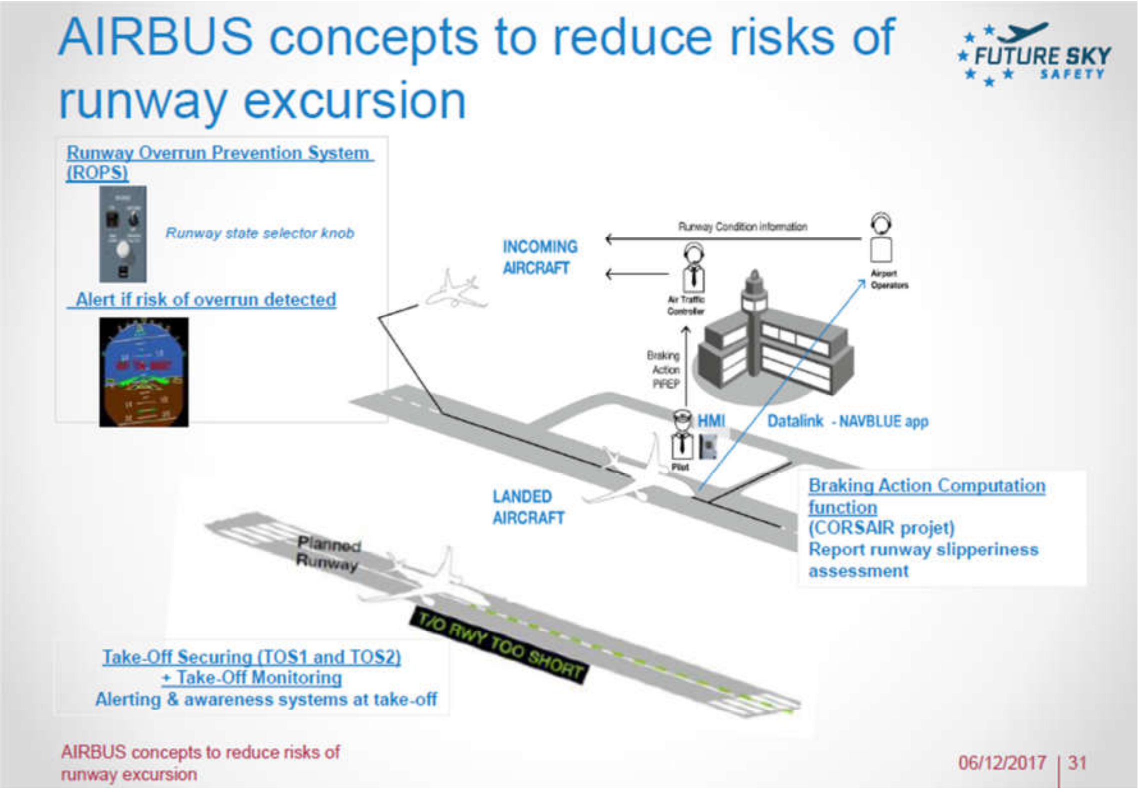


AIRBUS concepts to reduce risks of runway excursion

Runway Overrun Prevention System (ROPS)

Runway state selector knob

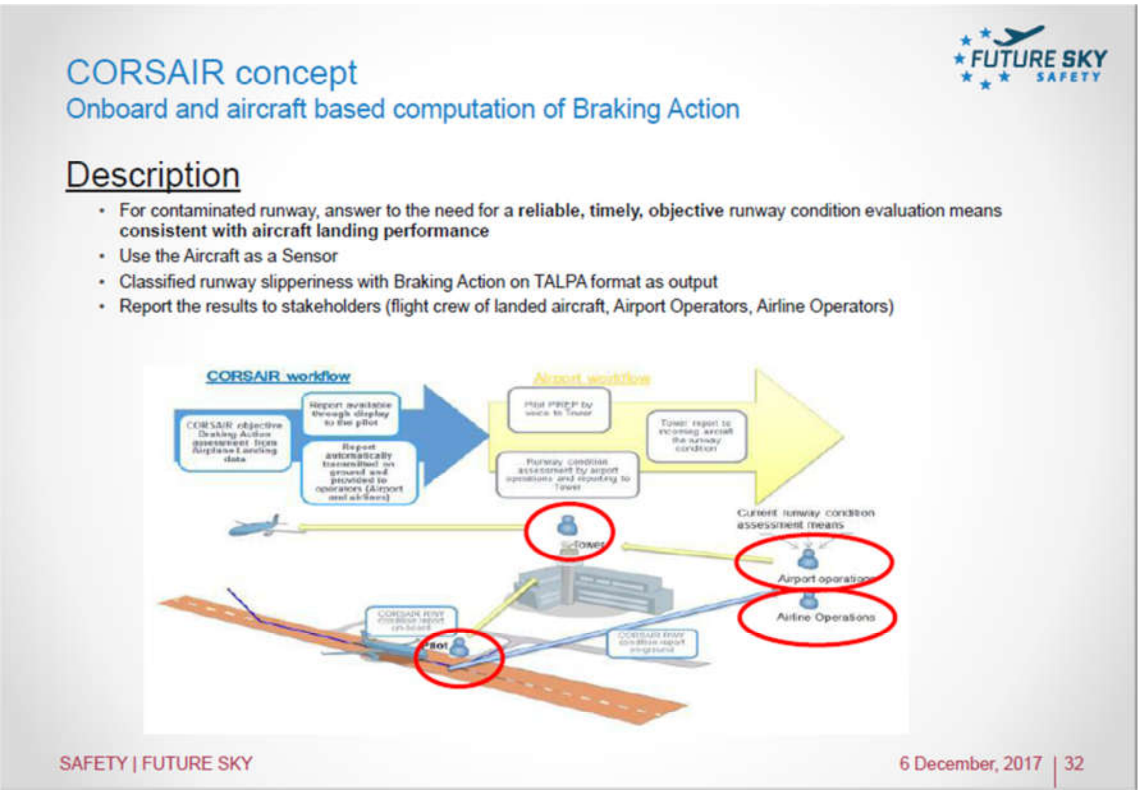
Alert if risk of overrun detected

Braking Action Computation function
(CORSAIR projet)
Report runway slipperiness assessment

Take-Off Securing (TOS1 and TOS2)
+ Take-Off Monitoring
Alerting & awareness systems at take-off

AIRBUS concepts to reduce risks of runway excursion

06/12/2017 | 31



CORSAIR concept

Onboard and aircraft based computation of Braking Action

Description

- For contaminated runway, answer to the need for a **reliable, timely, objective** runway condition evaluation means **consistent with aircraft landing performance**
- Use the Aircraft as a Sensor
- Classified runway slipperiness with Braking Action on TALPA format as output
- Report the results to stakeholders (flight crew of landed aircraft, Airport Operators, Airline Operators)

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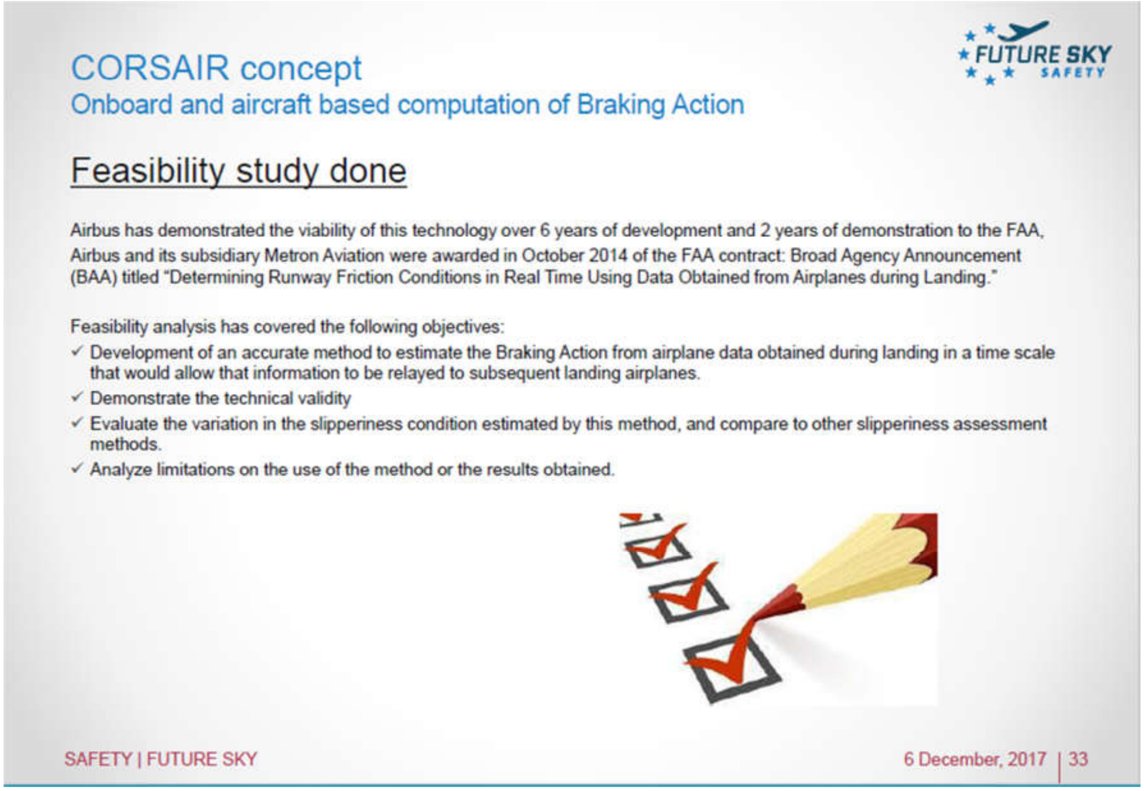

CORSAIR concept

Onboard and aircraft based computation of Braking Action

Feasibility study done

Airbus has demonstrated the viability of this technology over 6 years of development and 2 years of demonstration to the FAA. Airbus and its subsidiary Metron Aviation were awarded in October 2014 of the FAA contract: Broad Agency Announcement (BAA) titled "Determining Runway Friction Conditions in Real Time Using Data Obtained from Airplanes during Landing."

Feasibility analysis has covered the following objectives:

- ✓ Development of an accurate method to estimate the Braking Action from airplane data obtained during landing in a time scale that would allow that information to be relayed to subsequent landing airplanes.
- ✓ Demonstrate the technical validity
- ✓ Evaluate the variation in the slipperiness condition estimated by this method, and compare to other slipperiness assessment methods.
- ✓ Analyze limitations on the use of the method or the results obtained.

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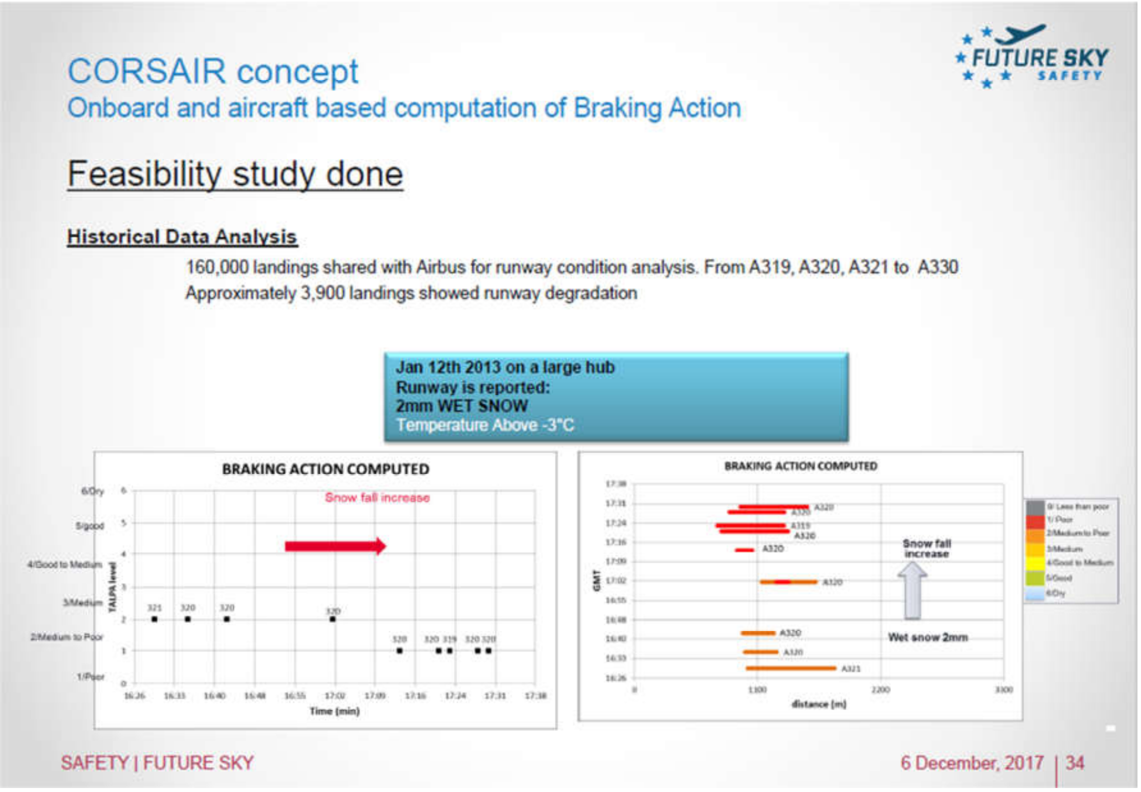

CORSAIR concept

Onboard and aircraft based computation of Braking Action

Feasibility study done

Historical Data Analysis

160,000 landings shared with Airbus for runway condition analysis. From A319, A320, A321 to A330
Approximately 3,900 landings showed runway degradation

Jan 12th 2013 on a large hub
Runway is reported:
2mm WET SNOW
Temperature Above -3°C

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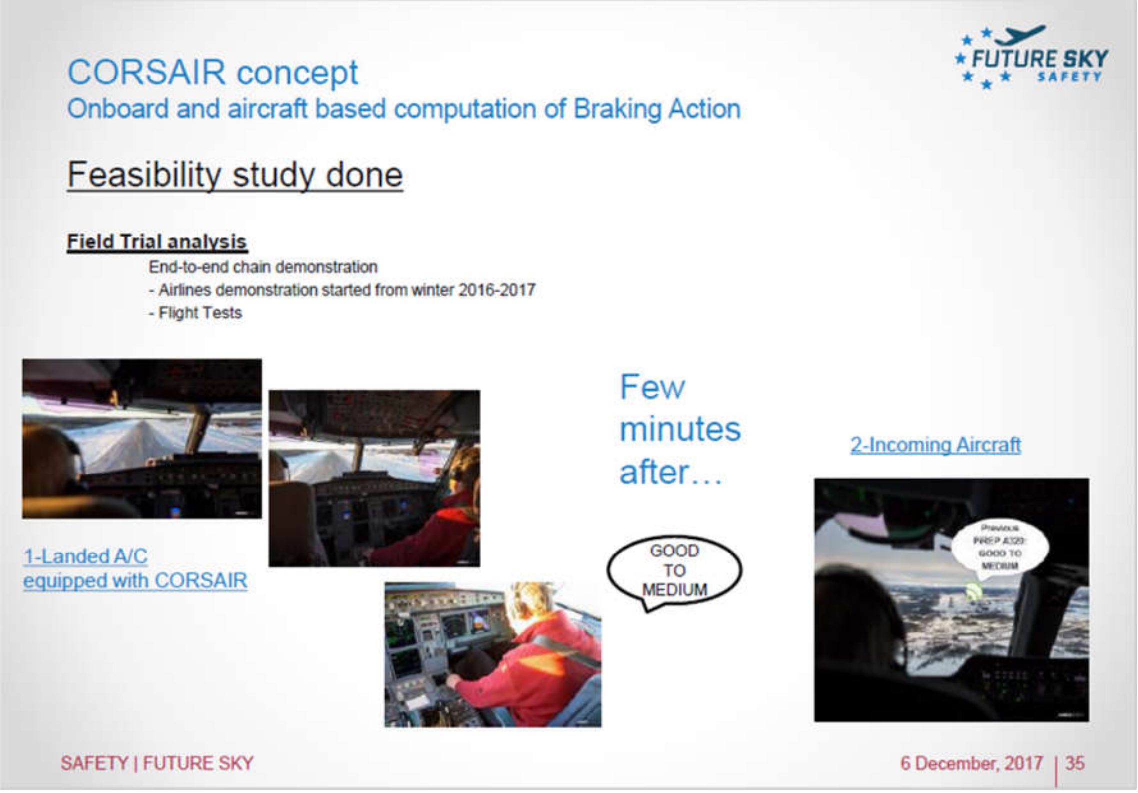

CORSAIR concept

Onboard and aircraft based computation of Braking Action

Feasibility study done

Field Trial analysis

End-to-end chain demonstration
- Airlines demonstration started from winter 2016-2017
- Flight Tests

1-Landed A/C equipped with CORSAIR

Few minutes after…

2-Incoming Aircraft

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AIRBORNE SOLUTIONS (DLR)

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DLR concept for future prevention of runway veer-offs during operations under crosswind

Idea

- On-board system for crosswind operations (currently landings)
- Using steerable main landing gear to touch-down in crabbed motion (such as B-52)
- Pilot assistance system to
    - Automatically perform de-crab after touchdown on ground
    - Keep aircraft on runway centreline
    - Allow manual steering inputs by pilot

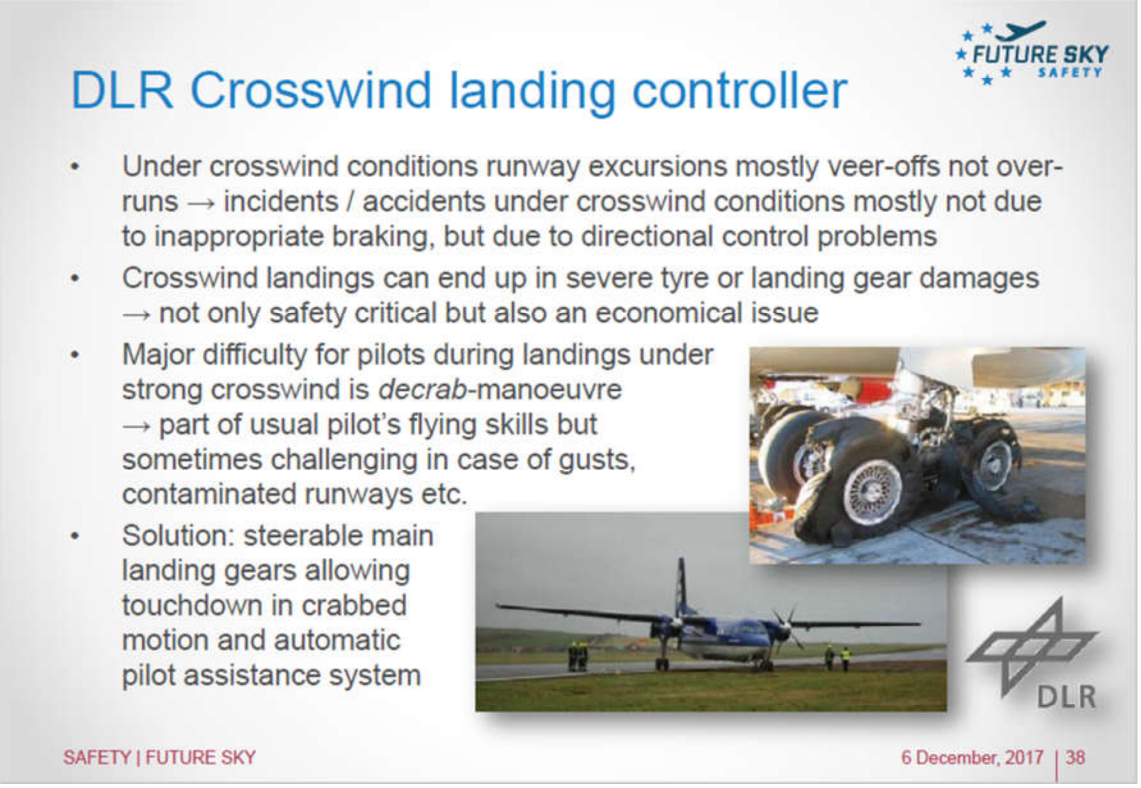
Application Area

- Future aircraft with tight geometric or controllability limitations, e.g.
    - Aircraft with high aspect ratio wings
    - Blended wing bodies / flying wings
    - Other unconventional aircraft configurations

Performed work within Future Sky Safety

- Adaptation of A320 simulation model (main gear steerability)
- Development of assistance system
- Implementation in motion-based full-flight-simulator
- Simulator study with pilots

DLR.de • Slide 37



DLR Crosswind landing controller

- Under crosswind conditions runway excursions mostly veer-offs not over-runs → incidents / accidents under crosswind conditions mostly not due to inappropriate braking, but due to directional control problems
- Crosswind landings can end up in severe tyre or landing gear damages → not only safety critical but also an economical issue
- Major difficulty for pilots during landings under strong crosswind is *decrab*-manoeuvre → part of usual pilot's flying skills but sometimes challenging in case of gusts, contaminated runways etc.
- Solution: steerable main landing gears allowing touchdown in crabbed motion and automatic pilot assistance system

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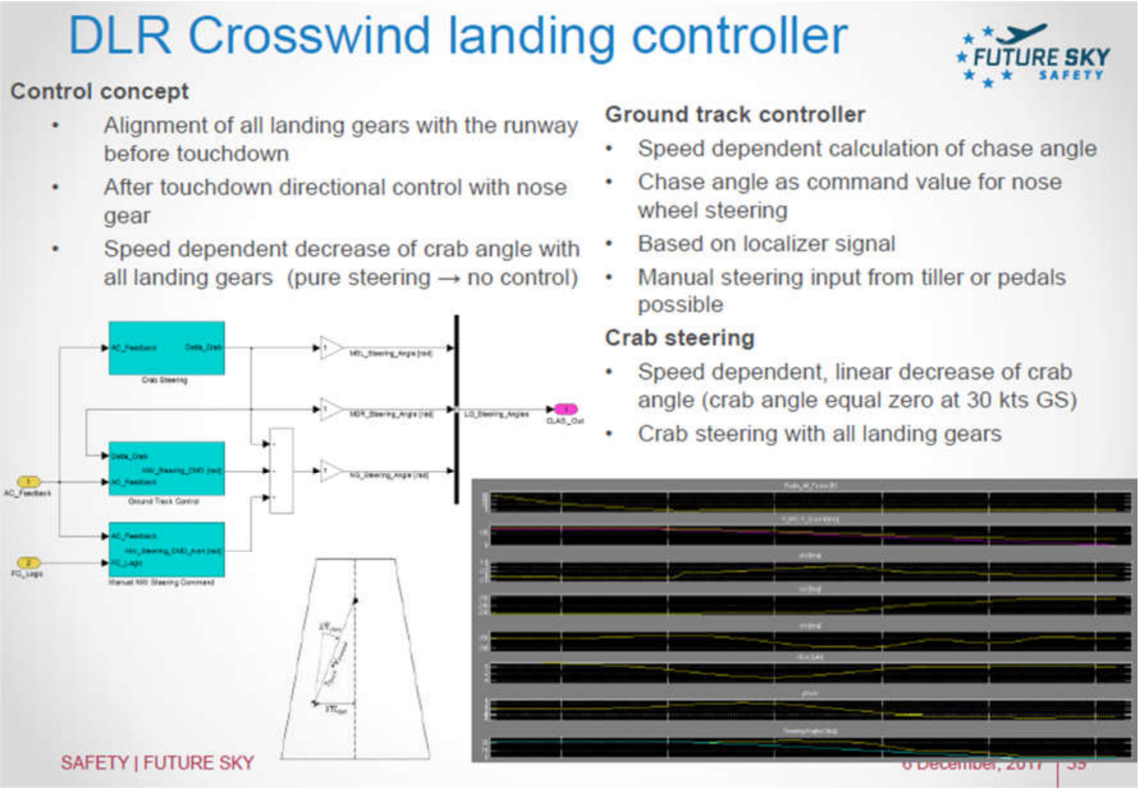

DLR Crosswind landing controller

Control concept

- Alignment of all landing gears with the runway before touchdown
- After touchdown directional control with nose gear
- Speed dependent decrease of crab angle with all landing gears (pure steering → no control)

Ground track controller

- Speed dependent calculation of chase angle
- Chase angle as command value for nose wheel steering
- Based on localizer signal
- Manual steering input from tiller or pedals possible

Crab steering

- Speed dependent, linear decrease of crab angle (crab angle equal zero at 30 kts GS)
- Crab steering with all landing gears

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Report

Feasibility and definition of R&TD needs for implementation of new concepts

Authors

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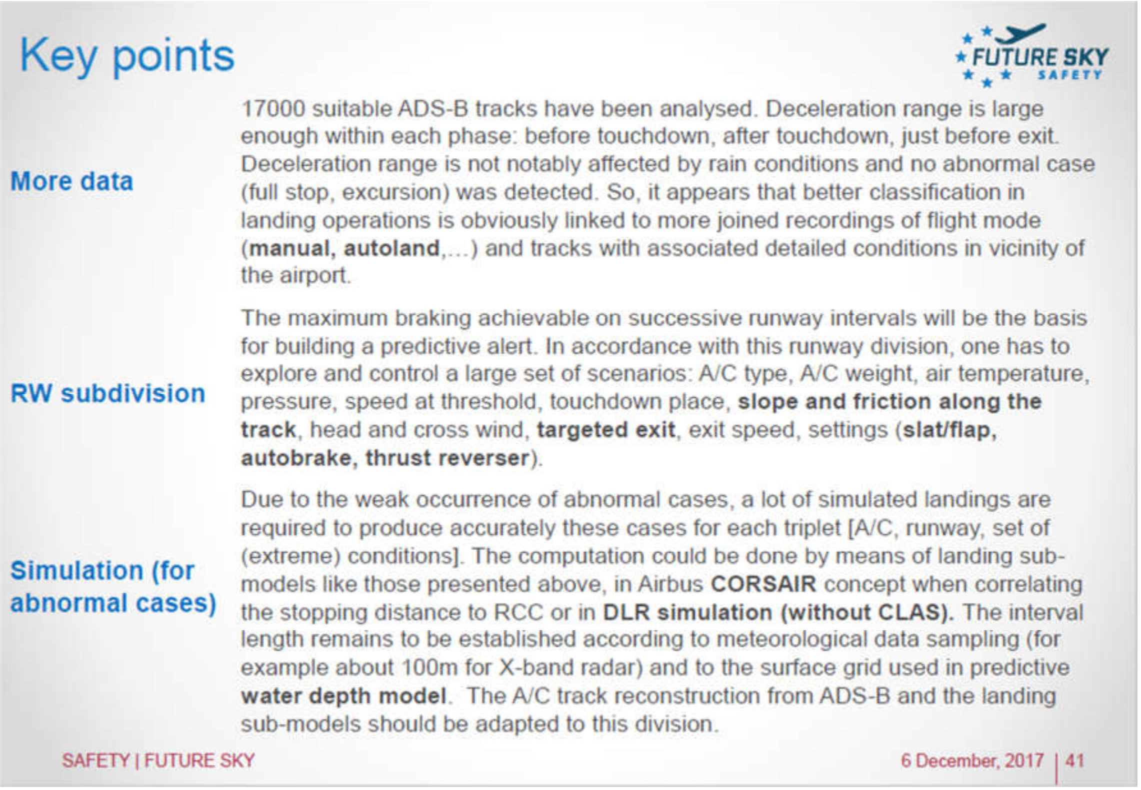

Key points

More data

17000 suitable ADS-B tracks have been analysed. Deceleration range is large enough within each phase: before touchdown, after touchdown, just before exit. Deceleration range is not notably affected by rain conditions and no abnormal case (full stop, excursion) was detected. So, it appears that better classification in landing operations is obviously linked to more joined recordings of flight mode (**manual, autoland**,…) and tracks with associated detailed conditions in vicinity of the airport.

RW subdivision

The maximum braking achievable on successive runway intervals will be the basis for building a predictive alert. In accordance with this runway division, one has to explore and control a large set of scenarios: A/C type, A/C weight, air temperature, pressure, speed at threshold, touchdown place, **slope and friction along the track**, head and cross wind, **targeted exit**, exit speed, settings (**slat/flap, autobrake, thrust reverser**).

Simulation (for abnormal cases)

Due to the weak occurrence of abnormal cases, a lot of simulated landings are required to produce accurately these cases for each triplet [A/C, runway, set of (extreme) conditions]. The computation could be done by means of landing sub-models like those presented above, in Airbus **CORSAIR** concept when correlating the stopping distance to RCC or in **DLR simulation (without CLAS).** The interval length remains to be established according to meteorological data sampling (for example about 100m for X-band radar) and to the surface grid used in predictive **water depth model**. The A/C track reconstruction from ADS-B and the landing sub-models should be adapted to this division.

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Appendix B.4 "P4: The Risk Observatory" – Joram Verstraeten, NLR

The Risk Observatory - P4

Future Sky Safety - 2nd Consortium Workshop

Joram Verstraeten
NLR - the Netherlands
verstraeten@nlr.nl

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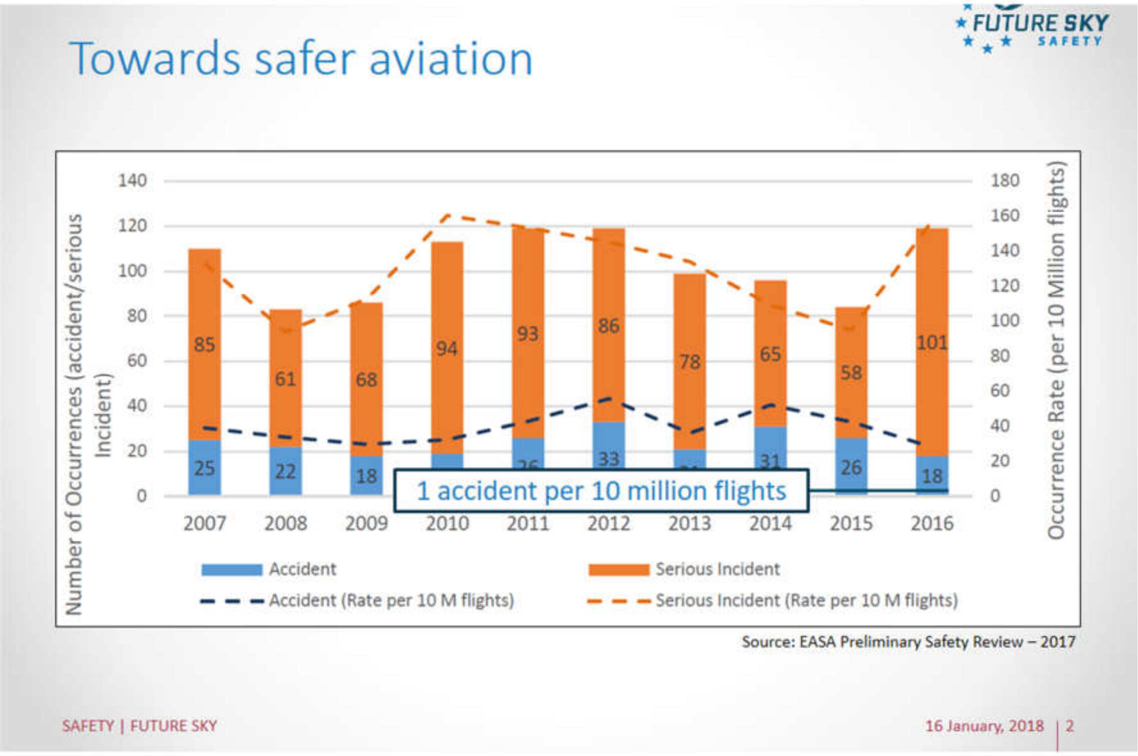
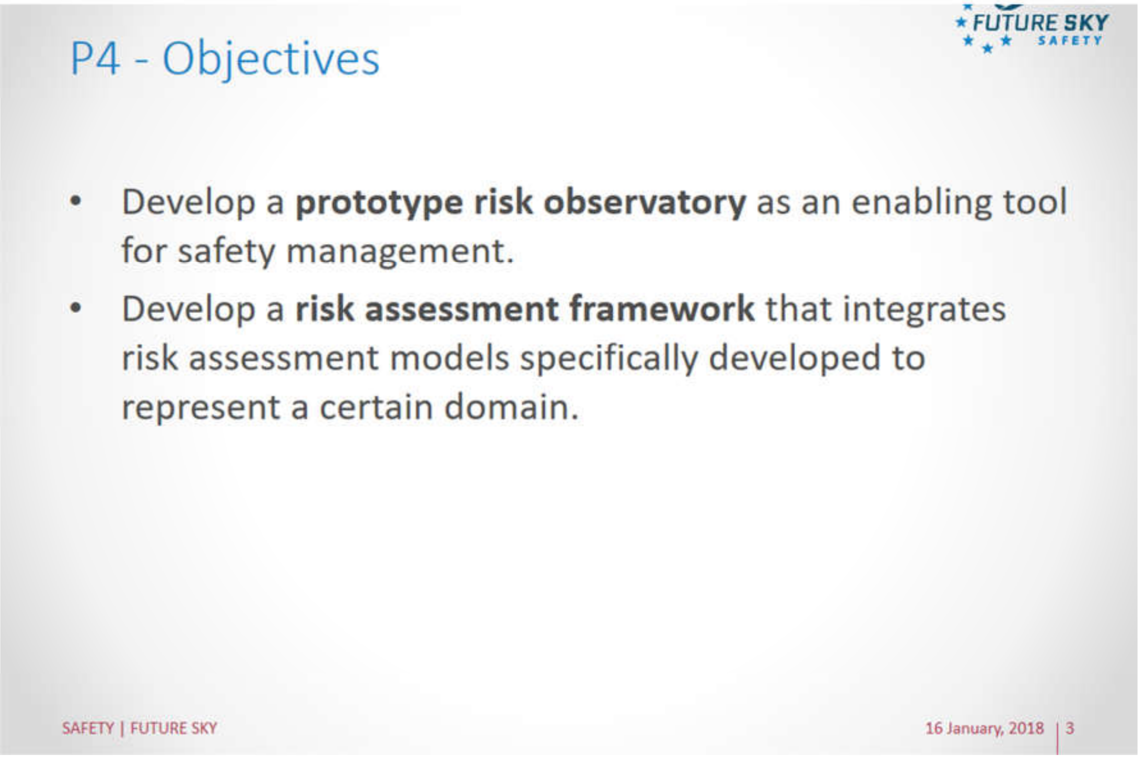


Towards safer aviation

1 accident per 10 million flights

Source: EASA Preliminary Safety Review – 2017



P4 - Objectives

- Develop a **prototype risk observatory** as an enabling tool for safety management.
- Develop a **risk assessment framework** that integrates risk assessment models specifically developed to represent a certain domain.

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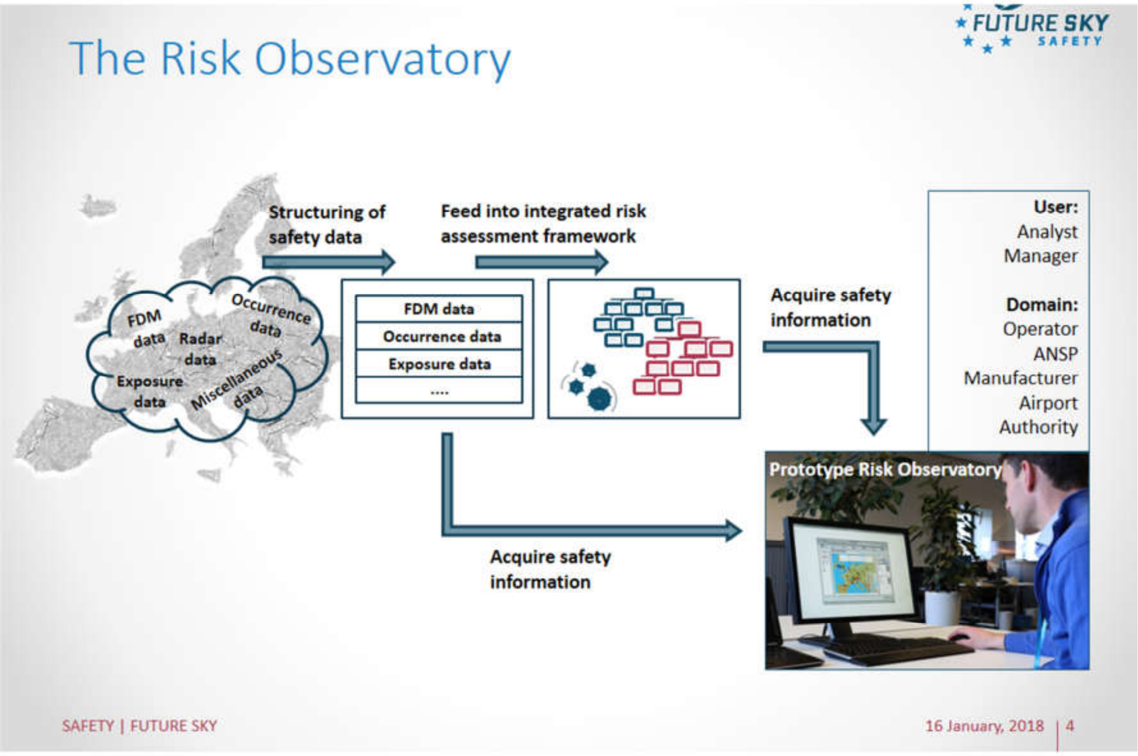

The Risk Observatory

Structuring of safety data

Feed into integrated risk assessment framework

Acquire safety information

Acquire safety information

User:
Analyst
Manager

Domain:
Operator
ANSP
Manufacturer
Airport
Authority

P4 - Year one

1. Consultation and desktop research
2. Drafted requirements
3. Translated early proto

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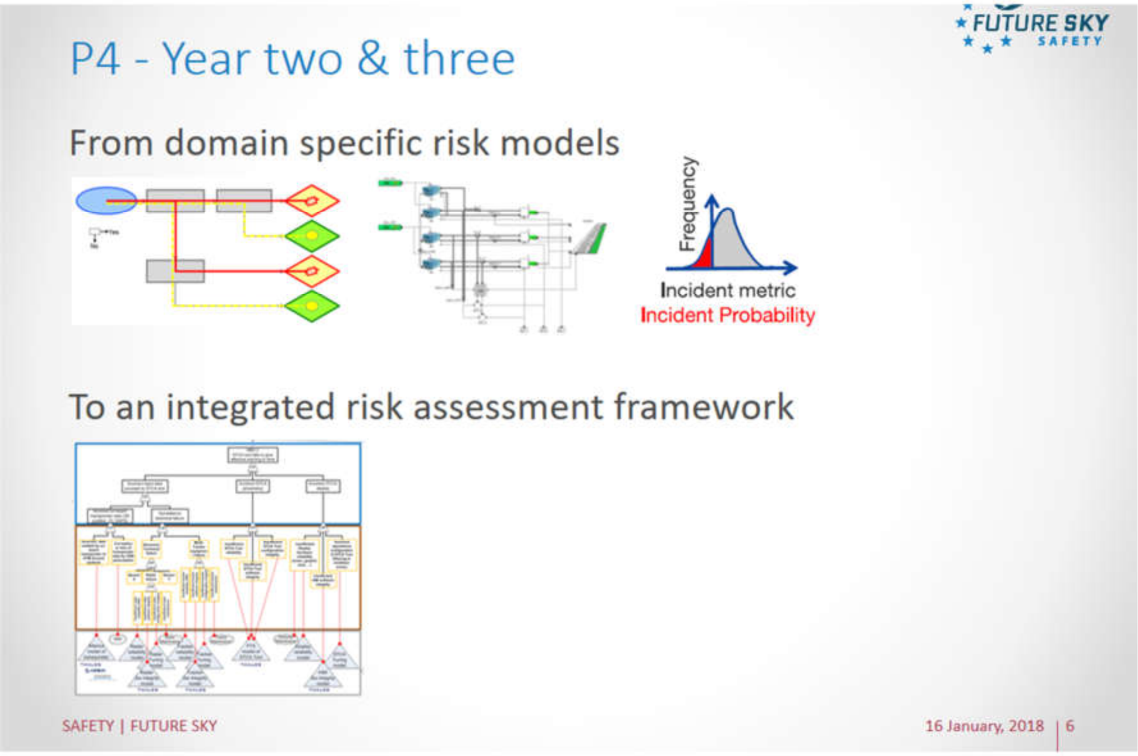

P4 - Year two & three

From domain specific risk models

To an integrated risk assessment framework

P4 - Year three & four

Look-and-feel prototype

Full functioning prototype

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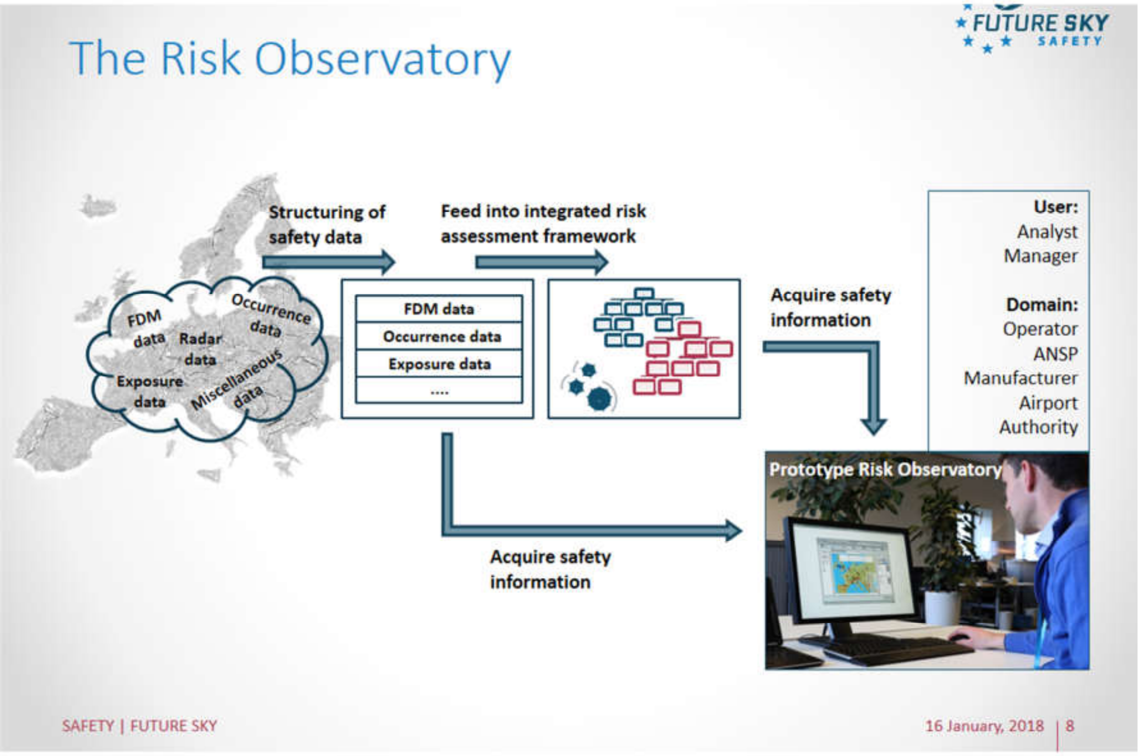
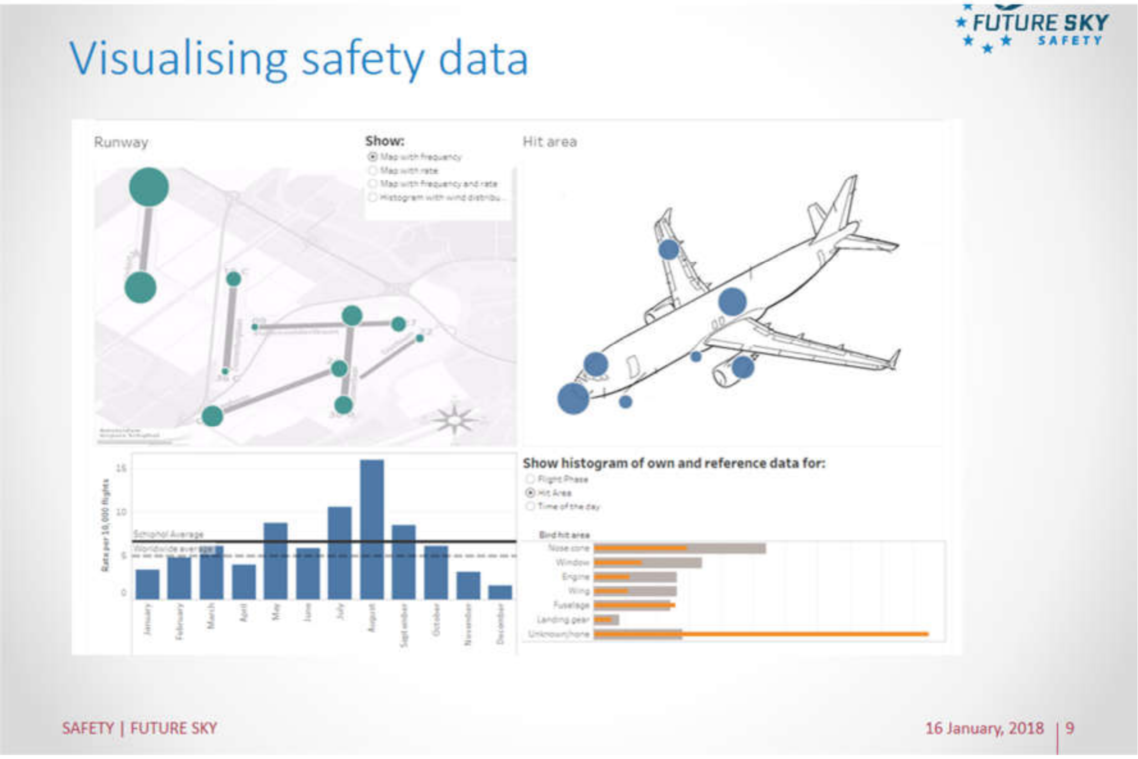


The Risk Observatory

User:
Analyst
Manager

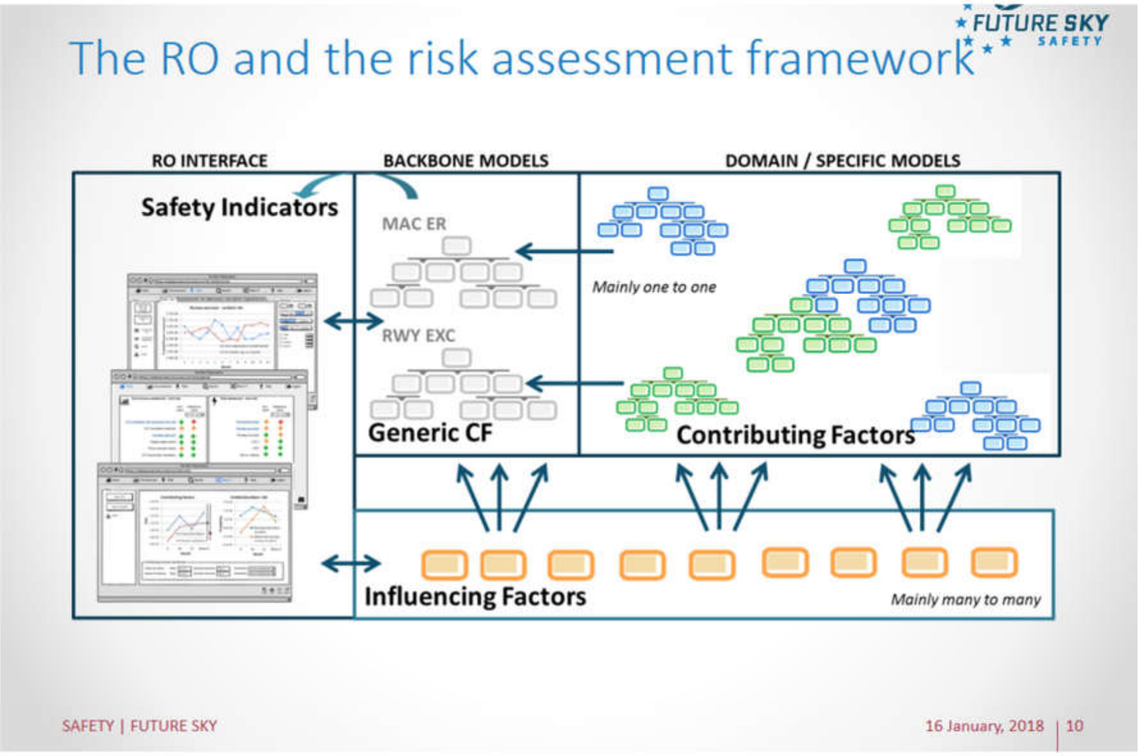
Domain:
Operator
ANSP
Manufacturer
Airport
Authority



Visualising safety data

Show:
● Map with frequency
○ Map with rate
○ Map with frequency and rate
○ Histogram with wind distribu...

Show histogram of own and reference data for:
○ Flight Phase
● Hit Area
○ Time of the day



The RO and the risk assessment framework

RO INTERFACE

BACKBONE MODELS

DOMAIN / SPECIFIC MODELS

Safety Indicators

MAC ER

RWY EXC

Generic CF

Mainly one to one

Contributing Factors

Influencing Factors

Mainly many to many

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How a RO helps to achieve the safety goal

- Raise the bar
- Best use of resources
- Learn from your peers
- Tackle big concerns together

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Appendix B.5 “P4: Aircraft safety model. Development and integration into a risk observatory” – Sylvain Metge, AIRBUS

European Commission

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AIRCRAFT SAFETY MODEL

DEVELOPMENT AND INTEGRATION INTO A RISK OBSERVATORY

FUTURE SKY SAFETY
2nd Consortium Workshop - DLR
6-7 December 2017

Sylvain Metge, AIRBUS
Pierre Bieber, ONERA
With the contribution of WP4.2.5 partners

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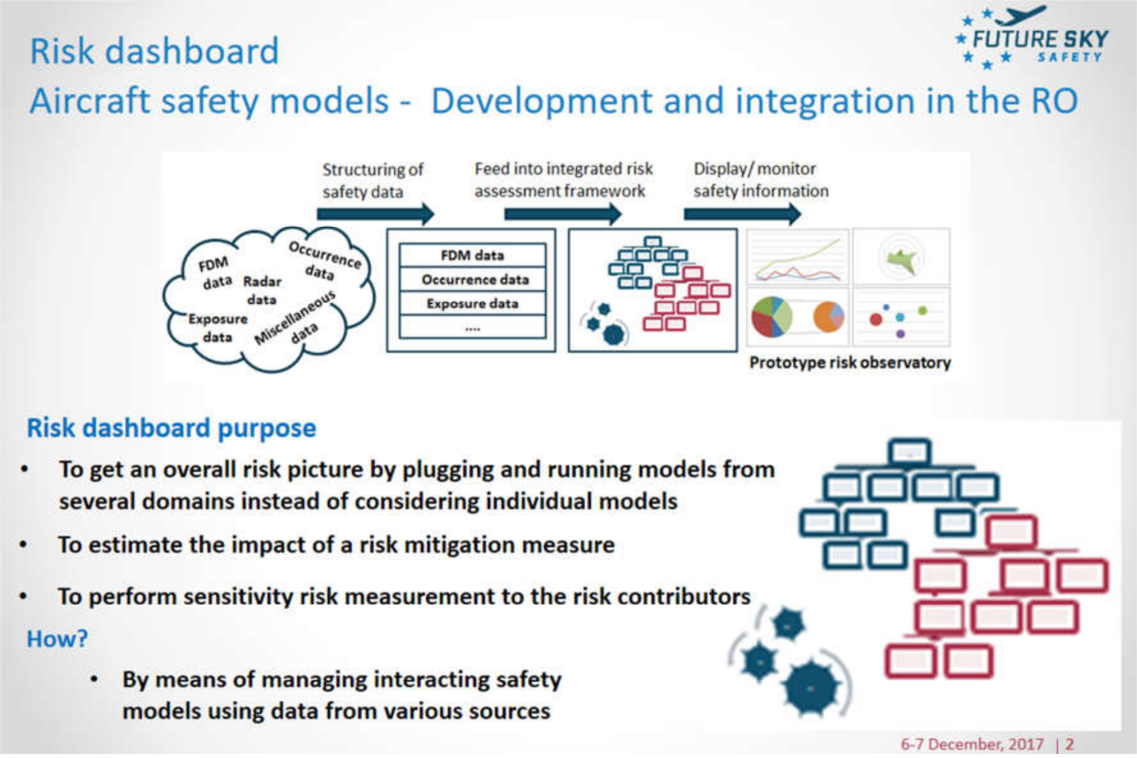
6-7 December, 2017



Risk dashboard
Aircraft safety models - Development and integration in the RO

Risk dashboard purpose

- To get an overall risk picture by plugging and running models from several domains instead of considering individual models
- To estimate the impact of a risk mitigation measure
- To perform sensitivity risk measurement to the risk contributors

How?

- By means of managing interacting safety models using data from various sources

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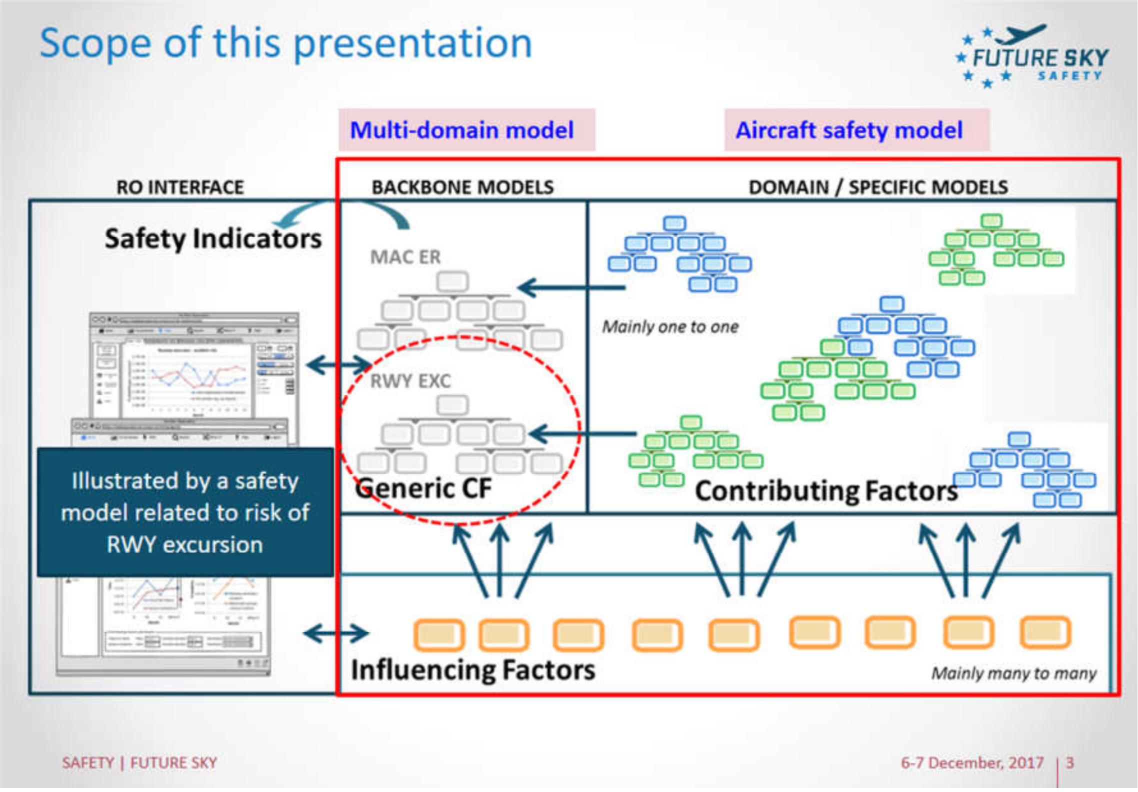

Scope of this presentation

Multi-domain model

Aircraft safety model

RO INTERFACE

BACKBONE MODELS

DOMAIN / SPECIFIC MODELS

Safety Indicators

MAC ER

Mainly one to one

RWY EXC

Generic CF

Contributing Factors

Illustrated by a safety model related to risk of RWY excursion

Influencing Factors

Mainly many to many

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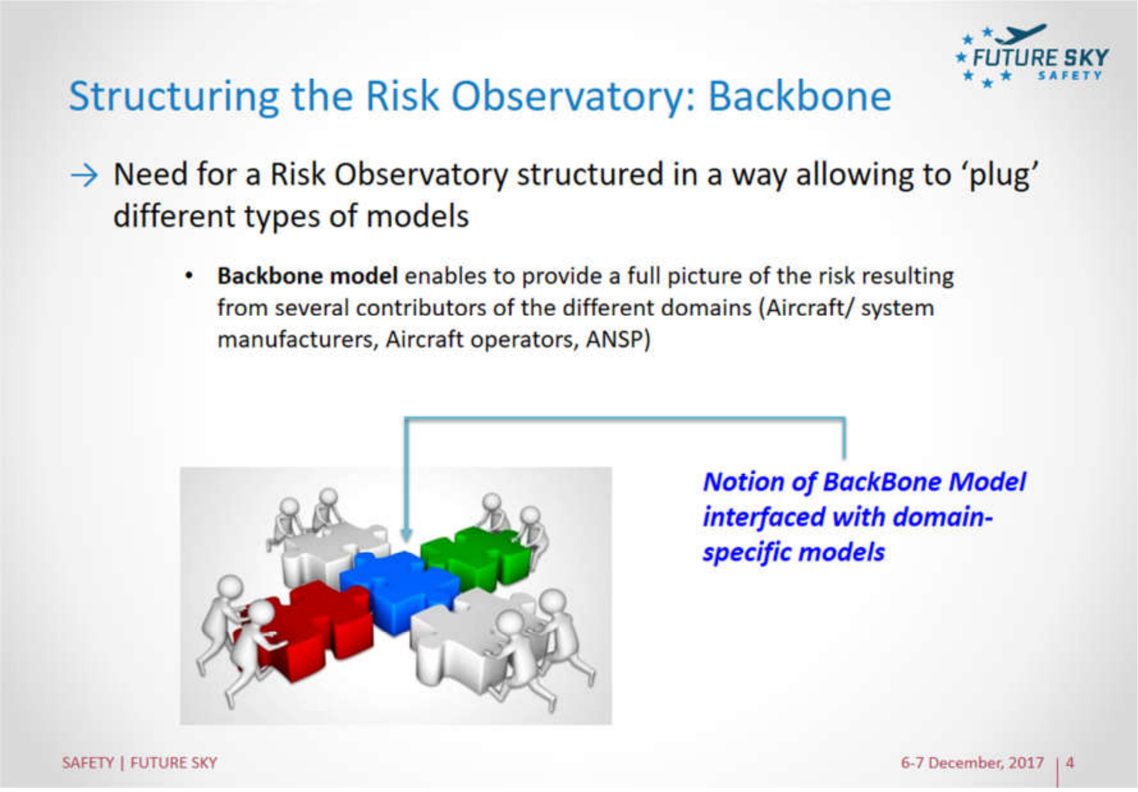

Structuring the Risk Observatory: Backbone

→ Need for a Risk Observatory structured in a way allowing to 'plug' different types of models

- **Backbone model** enables to provide a full picture of the risk resulting from several contributors of the different domains (Aircraft/ system manufacturers, Aircraft operators, ANSP)

Notion of BackBone Model interfaced with domain-specific models

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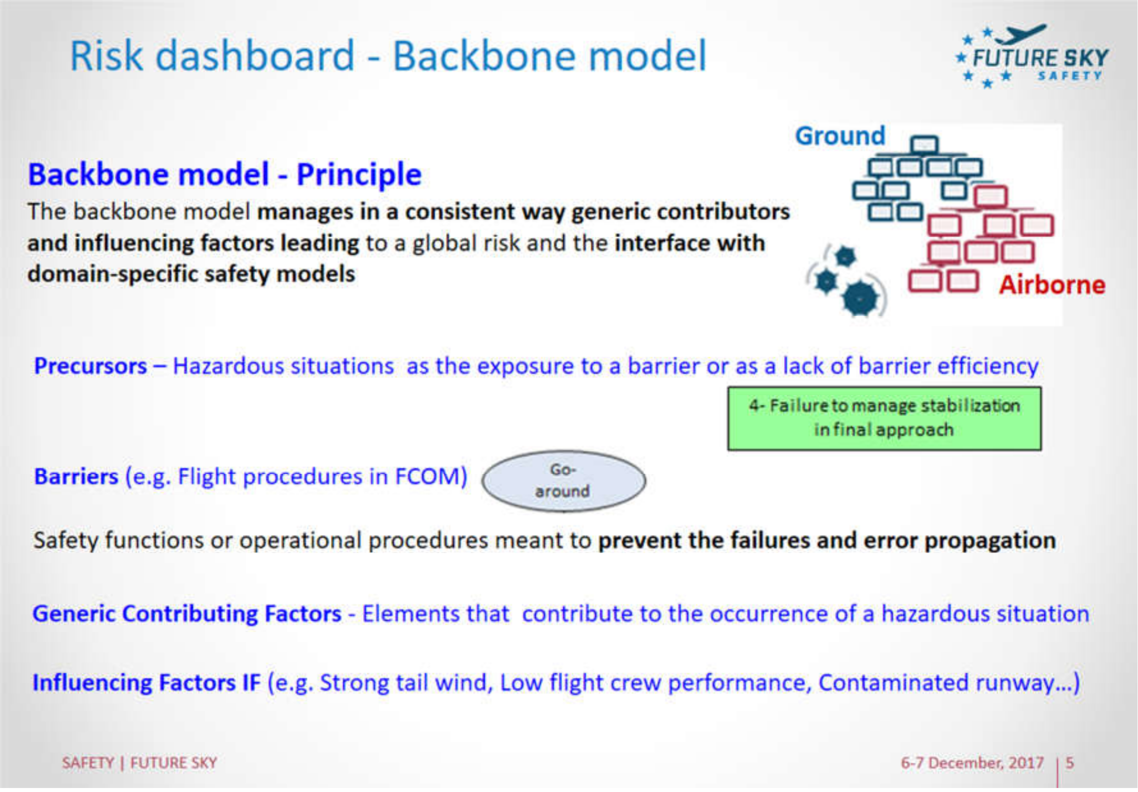


Risk dashboard - Backbone model

Backbone model - Principle

The backbone model **manages in a consistent way generic contributors and influencing factors leading** to a global risk and the **interface with domain-specific safety models**

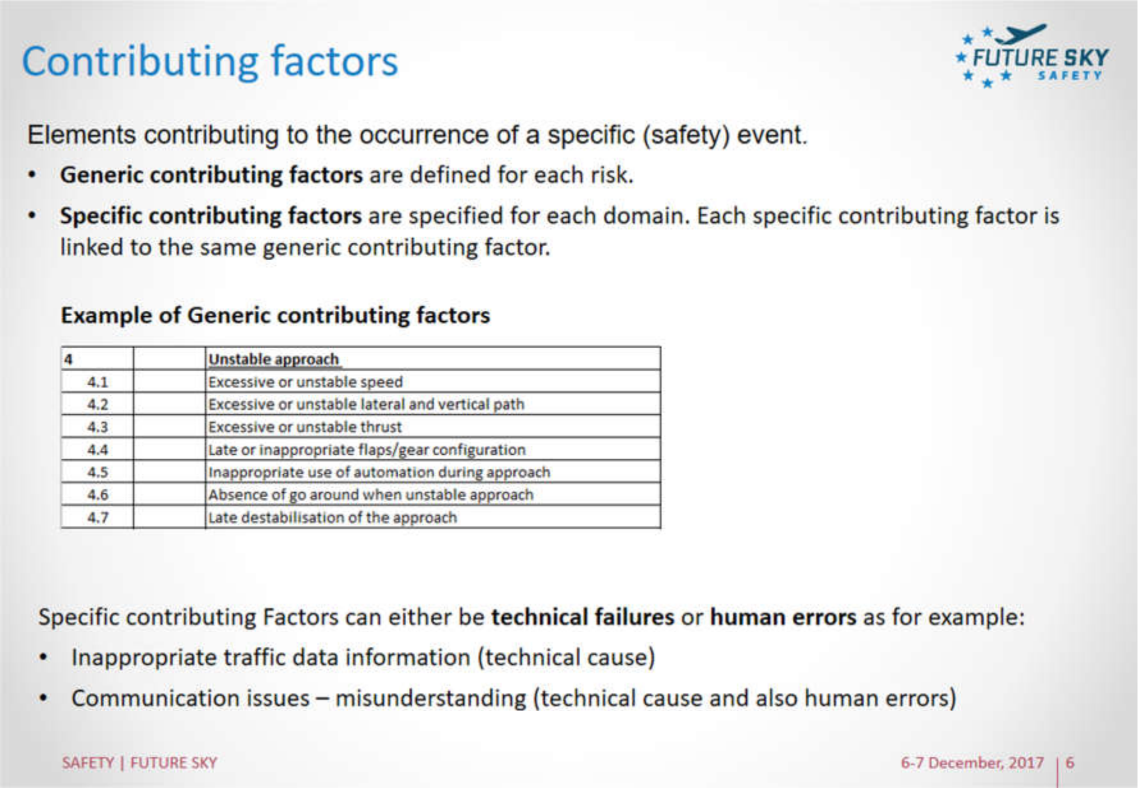
Precursors – Hazardous situations as the exposure to a barrier or as a lack of barrier efficiency

Barriers (e.g. Flight procedures in FCOM)

Safety functions or operational procedures meant to **prevent the failures and error propagation**

Generic Contributing Factors - Elements that contribute to the occurrence of a hazardous situation

Influencing Factors IF (e.g. Strong tail wind, Low flight crew performance, Contaminated runway...)



Contributing factors

Elements contributing to the occurrence of a specific (safety) event.

- **Generic contributing factors** are defined for each risk.
- **Specific contributing factors** are specified for each domain. Each specific contributing factor is linked to the same generic contributing factor.

Example of Generic contributing factors

4		Unstable approach
4.1		Excessive or unstable speed
4.2		Excessive or unstable lateral and vertical path
4.3		Excessive or unstable thrust
4.4		Late or inappropriate flaps/gear configuration
4.5		Inappropriate use of automation during approach
4.6		Absence of go around when unstable approach
4.7		Late destabilisation of the approach

Specific contributing Factors can either be **technical failures** or **human errors** as for example:

- Inappropriate traffic data information (technical cause)
- Communication issues – misunderstanding (technical cause and also human errors)

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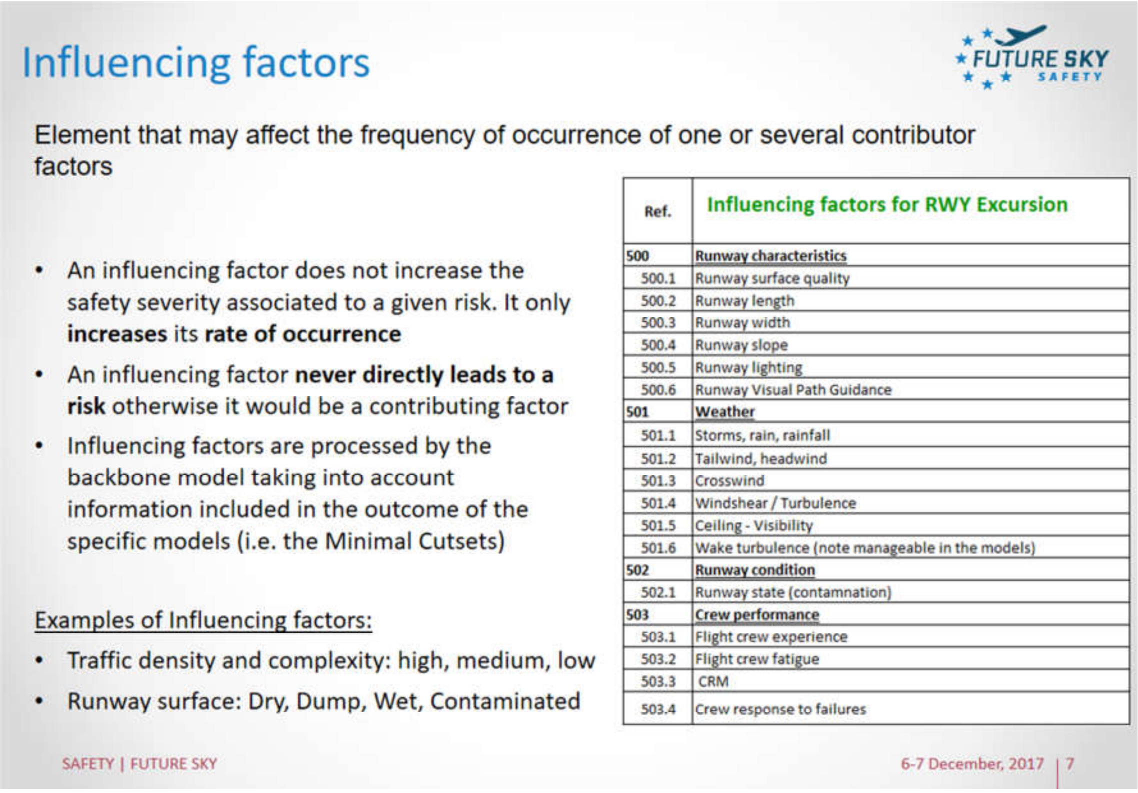

Influencing factors

Element that may affect the frequency of occurrence of one or several contributor factors

- An influencing factor does not increase the safety severity associated to a given risk. It only **increases** its **rate of occurrence**
- An influencing factor **never directly leads to a risk** otherwise it would be a contributing factor
- Influencing factors are processed by the backbone model taking into account information included in the outcome of the specific models (i.e. the Minimal Cutsets)

Examples of Influencing factors:

- Traffic density and complexity: high, medium, low
- Runway surface: Dry, Dump, Wet, Contaminated

Ref.	Influencing factors for RWY Excursion
500	**Runway characteristics**
500.1	Runway surface quality
500.2	Runway length
500.3	Runway width
500.4	Runway slope
500.5	Runway lighting
500.6	Runway Visual Path Guidance
501	**Weather**
501.1	Storms, rain, rainfall
501.2	Tailwind, headwind
501.3	Crosswind
501.4	Windshear / Turbulence
501.5	Ceiling - Visibility
501.6	Wake turbulence (note manageable in the models)
502	**Runway condition**
502.1	Runway state (contamnation)
503	**Crew performance**
503.1	Flight crew experience
503.2	Flight crew fatigue
503.3	CRM
503.4	Crew response to failures

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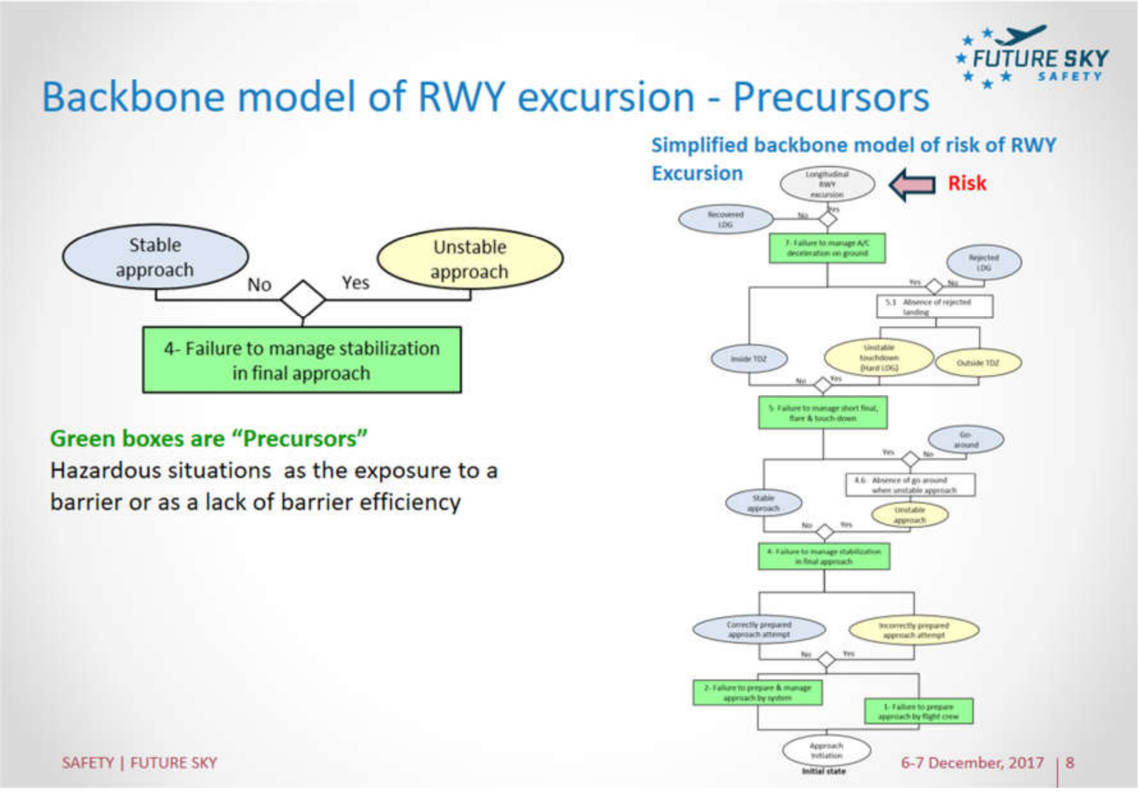

Backbone model of RWY excursion - Precursors

Simplified backbone model of risk of RWY Excursion

Stable approach

Unstable approach

No

Yes

4- Failure to manage stabilization in final approach

Green boxes are "Precursors"

Hazardous situations as the exposure to a barrier or as a lack of barrier efficiency

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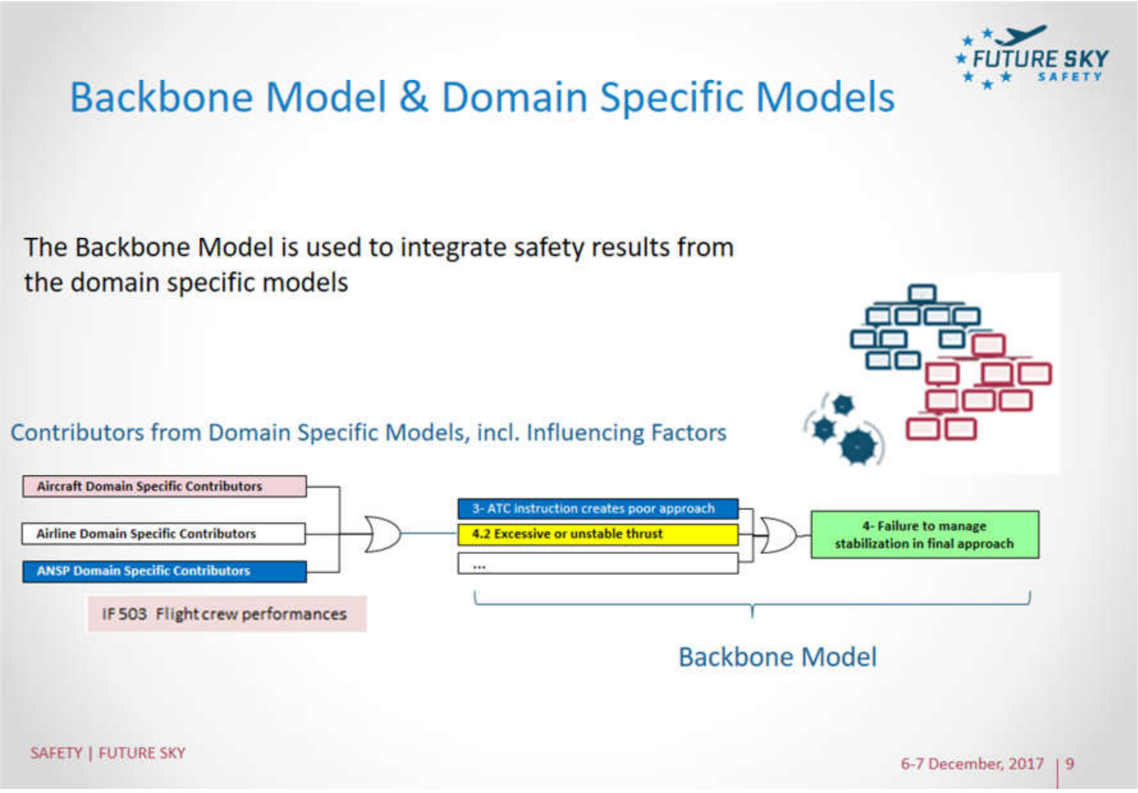


Backbone Model & Domain Specific Models

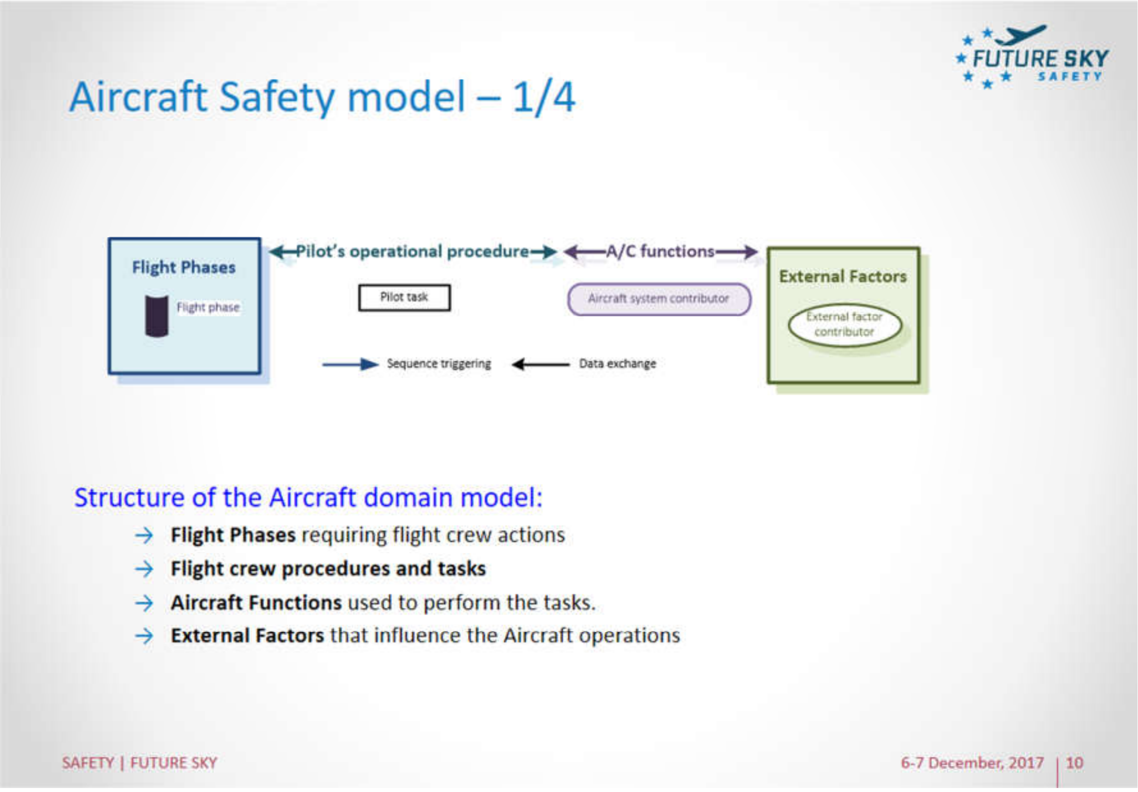
The Backbone Model is used to integrate safety results from the domain specific models

Contributors from Domain Specific Models, incl. Influencing Factors

Aircraft Domain Specific Contributors
Airline Domain Specific Contributors
ANSP Domain Specific Contributors
IF 503 Flight crew performances

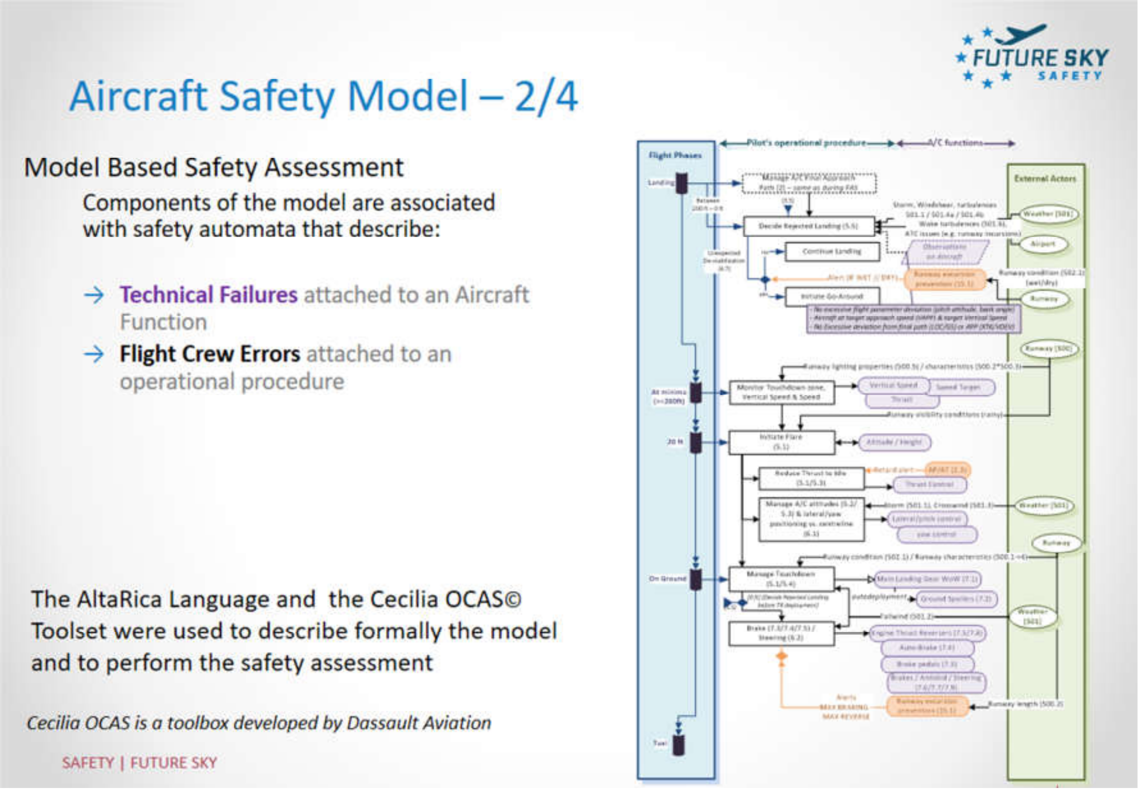
3- ATC instruction creates poor approach
4.2 Excessive or unstable thrust
...
4- Failure to manage stabilization in final approach

Backbone Model



Aircraft Safety model – 1/4

Structure of the Aircraft domain model:
- → **Flight Phases** requiring flight crew actions
- → **Flight crew procedures and tasks**
- → **Aircraft Functions** used to perform the tasks.
- → **External Factors** that influence the Aircraft operations



Aircraft Safety Model – 2/4

Model Based Safety Assessment

Components of the model are associated with safety automata that describe:

- → **Technical Failures** attached to an Aircraft Function
- → **Flight Crew Errors** attached to an operational procedure

The AltaRica Language and the Cecilia OCAS© Toolset were used to describe formally the model and to perform the safety assessment

Cecilia OCAS is a toolbox developed by Dassault Aviation

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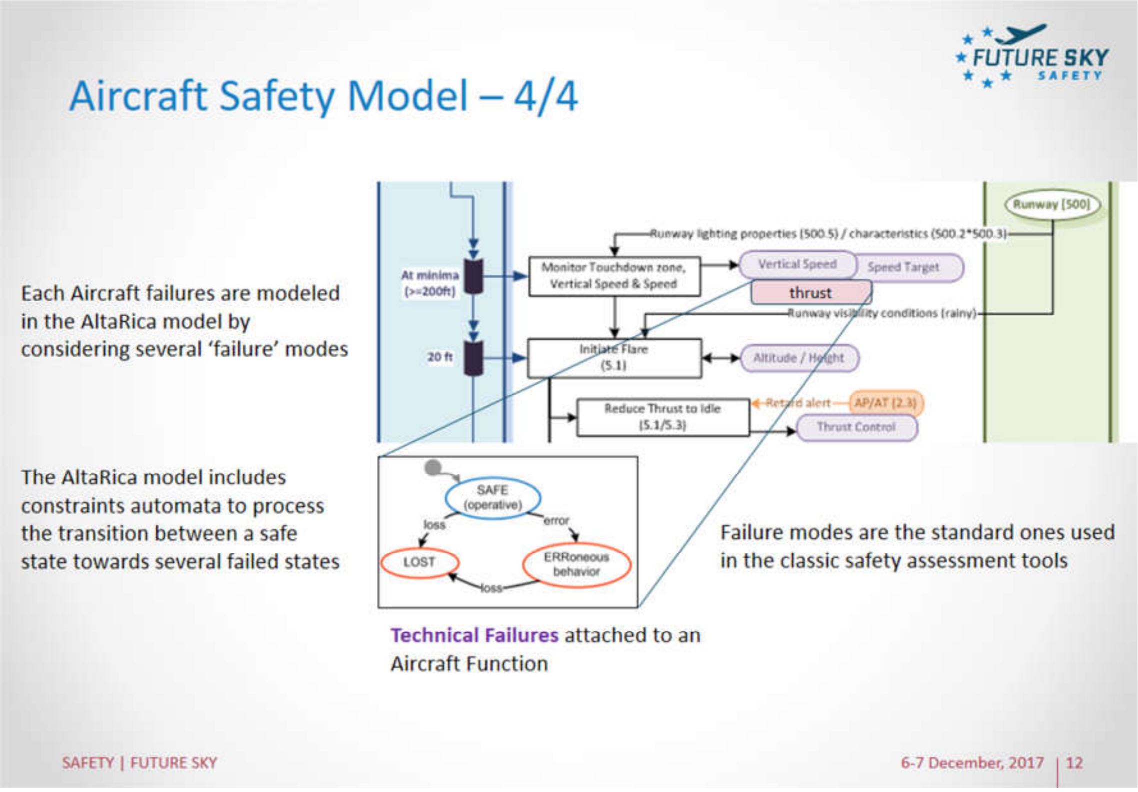

Aircraft Safety Model – 4/4

Each Aircraft failures are modeled in the AltaRica model by considering several 'failure' modes

The AltaRica model includes constraints automata to process the transition between a safe state towards several failed states

Failure modes are the standard ones used in the classic safety assessment tools

Technical Failures attached to an Aircraft Function

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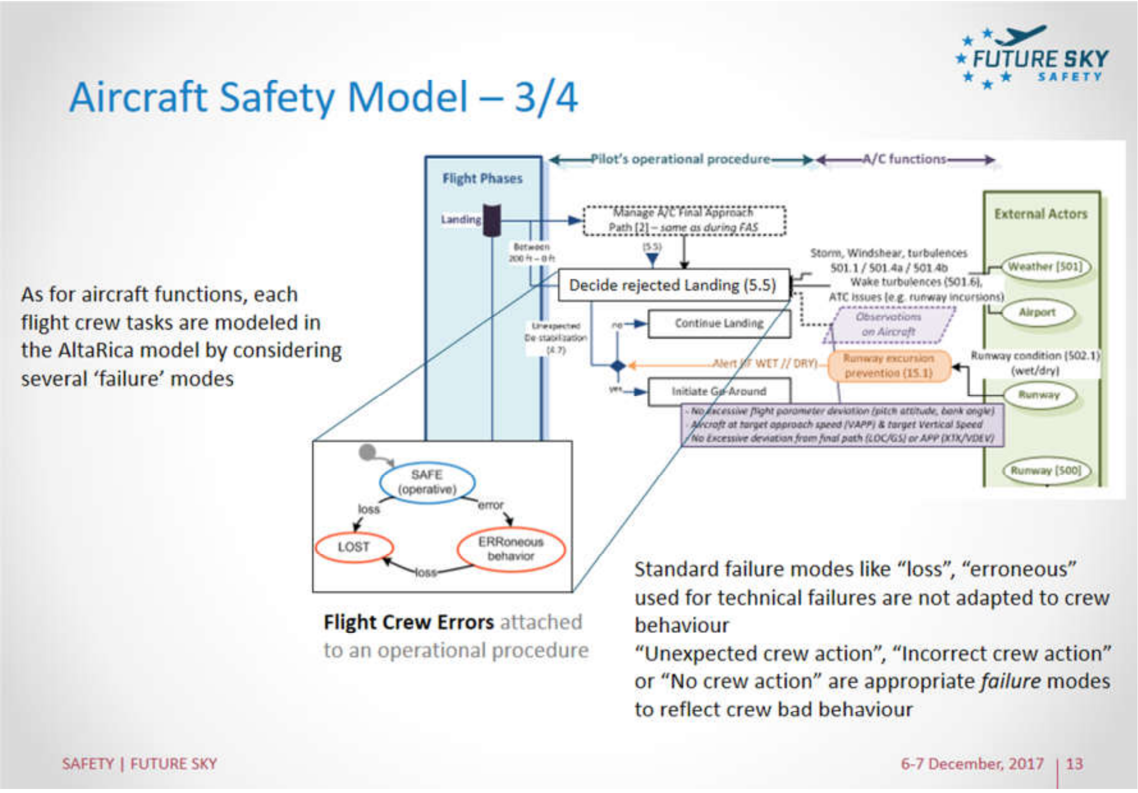

Aircraft Safety Model – 3/4

As for aircraft functions, each flight crew tasks are modeled in the AltaRica model by considering several 'failure' modes

Flight Crew Errors attached to an operational procedure

Standard failure modes like "loss", "erroneous" used for technical failures are not adapted to crew behaviour

"Unexpected crew action", "Incorrect crew action" or "No crew action" are appropriate *failure* modes to reflect crew bad behaviour

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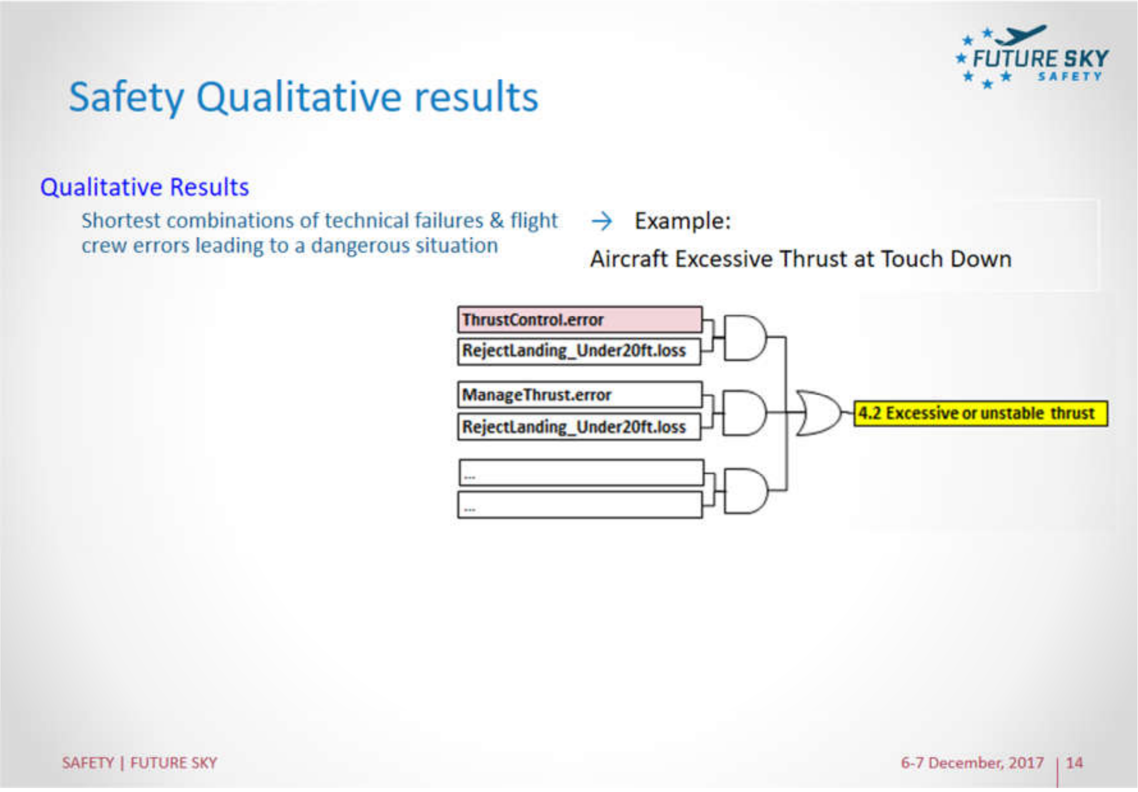

Safety Qualitative results

Qualitative Results

Shortest combinations of technical failures & flight crew errors leading to a dangerous situation

→ Example:

Aircraft Excessive Thrust at Touch Down

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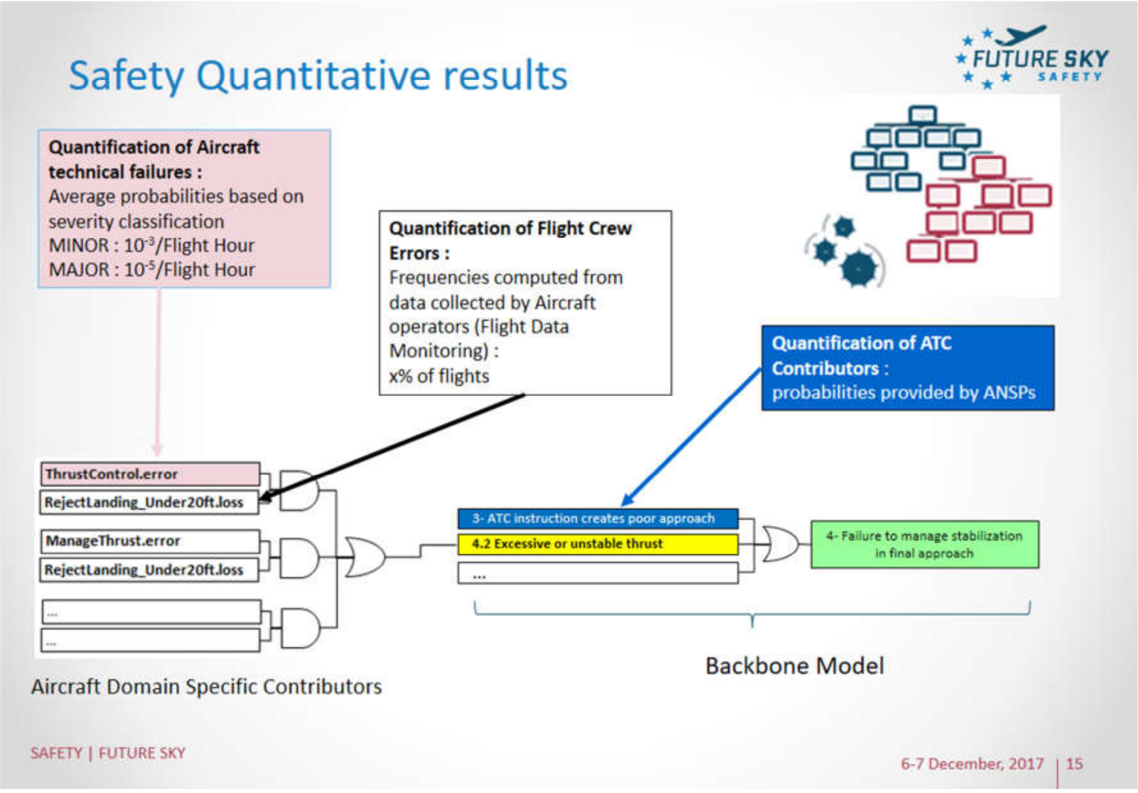


Safety Quantitative results

Quantification of Aircraft technical failures :
Average probabilities based on severity classification
MINOR : 10^{-3}/Flight Hour
MAJOR : 10^{-5}/Flight Hour

Quantification of Flight Crew Errors :
Frequencies computed from data collected by Aircraft operators (Flight Data Monitoring) :
x% of flights

Quantification of ATC Contributors :
probabilities provided by ANSPs

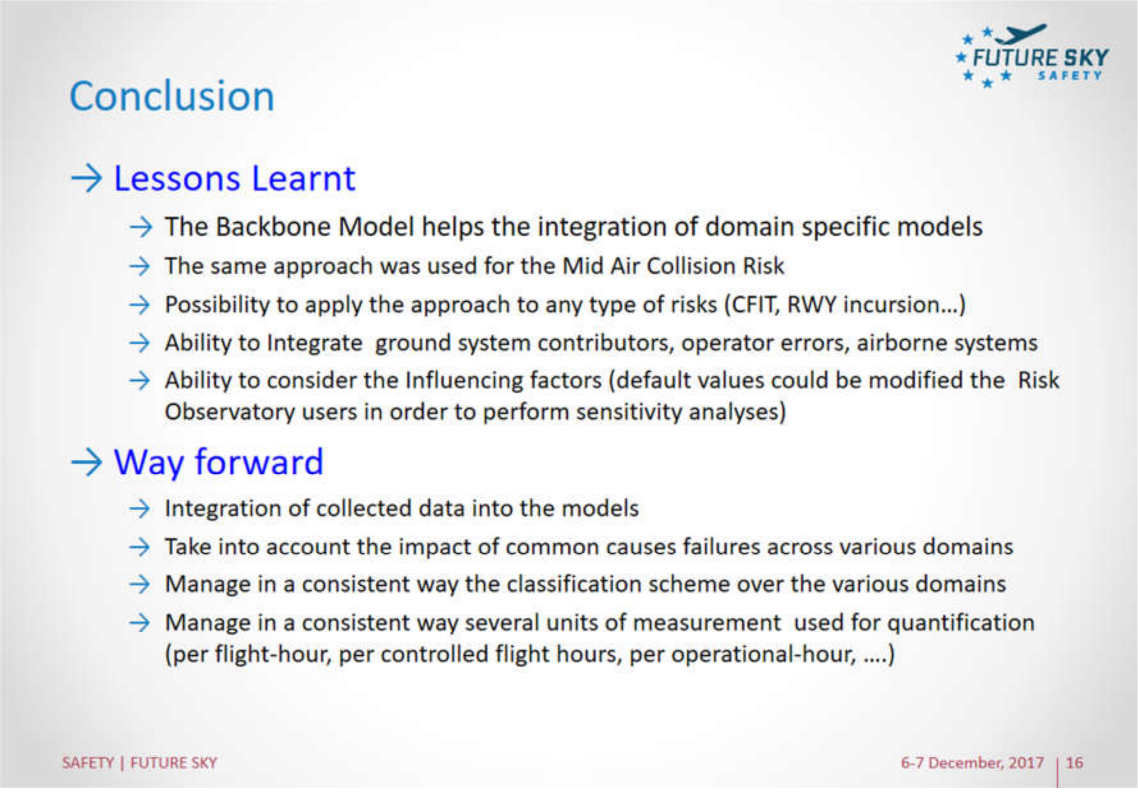
ThrustControl.error
RejectLanding_Under20ft.loss
ManageThrust.error
RejectLanding_Under20ft.loss
...
...

3- ATC instruction creates poor approach
4.2 Excessive or unstable thrust
...

4- Failure to manage stabilization in final approach

Aircraft Domain Specific Contributors

Backbone Model



Conclusion

→ Lessons Learnt

- → The Backbone Model helps the integration of domain specific models
- → The same approach was used for the Mid Air Collision Risk
- → Possibility to apply the approach to any type of risks (CFIT, RWY incursion…)
- → Ability to Integrate ground system contributors, operator errors, airborne systems
- → Ability to consider the Influencing factors (default values could be modified the Risk Observatory users in order to perform sensitivity analyses)

→ Way forward

- → Integration of collected data into the models
- → Take into account the impact of common causes failures across various domains
- → Manage in a consistent way the classification scheme over the various domains
- → Manage in a consistent way several units of measurement used for quantification (per flight-hour, per controlled flight hours, per operational-hour, ….)

Appendix B.6 “P4: Total System Risk Assessment. Software Development” – Fábio Oliveira, CEIIA

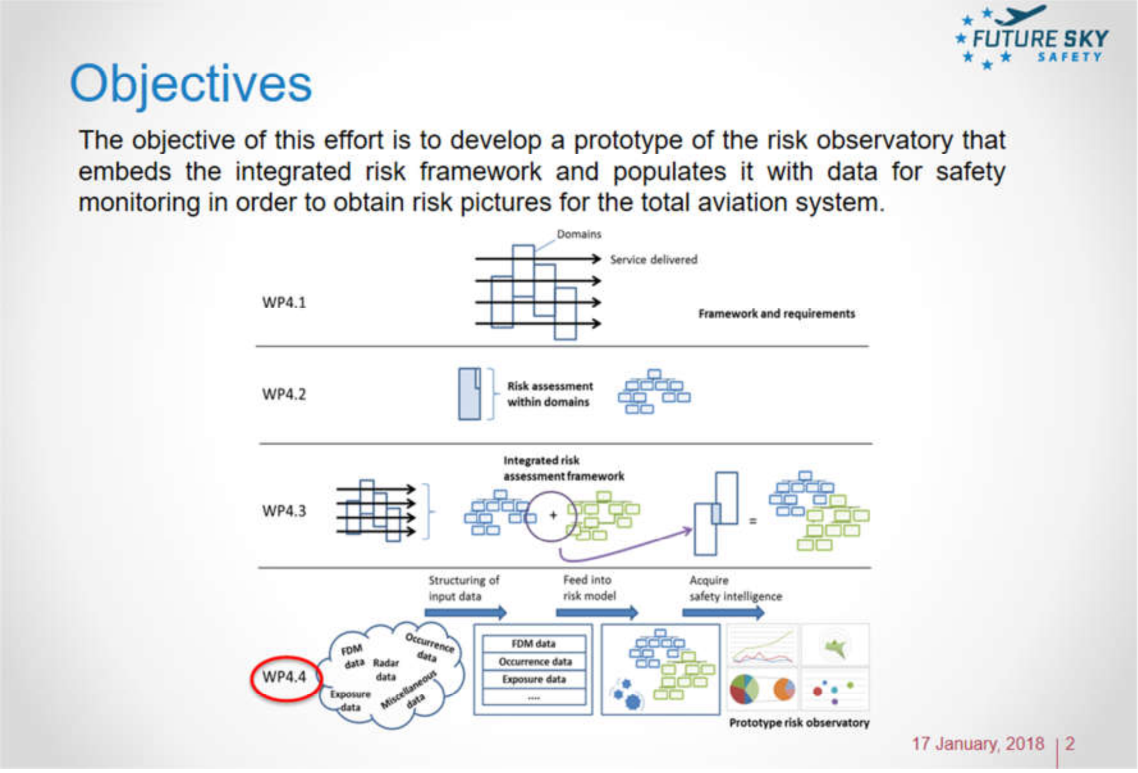
P4 - Total System Risk Assessment

Software Development

Fábio Oliveira (CEIIA)

SAFETY | FUTURE SKY

17 January, 2018



Objectives

The objective of this effort is to develop a prototype of the risk observatory that embeds the integrated risk framework and populates it with data for safety monitoring in order to obtain risk pictures for the total aviation system.

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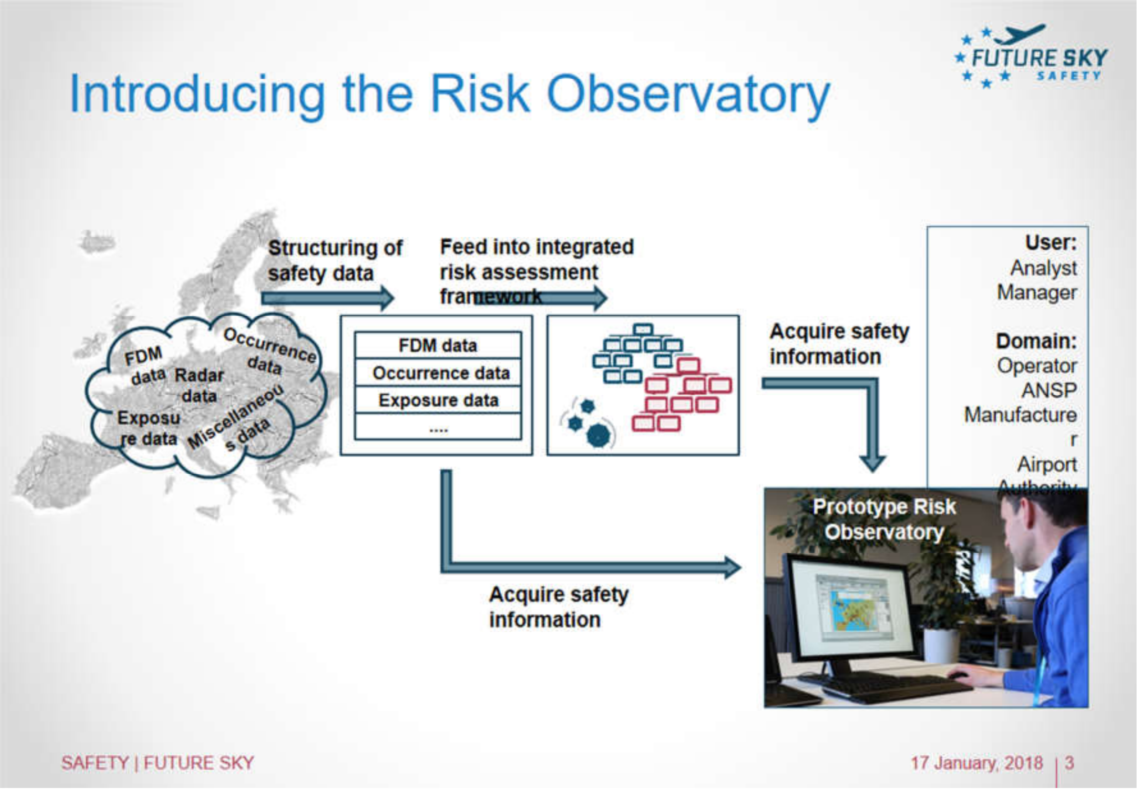


Introducing the Risk Observatory

Structuring of safety data

Feed into integrated risk assessment framework

FDM data
Occurrence data
Exposure data
....

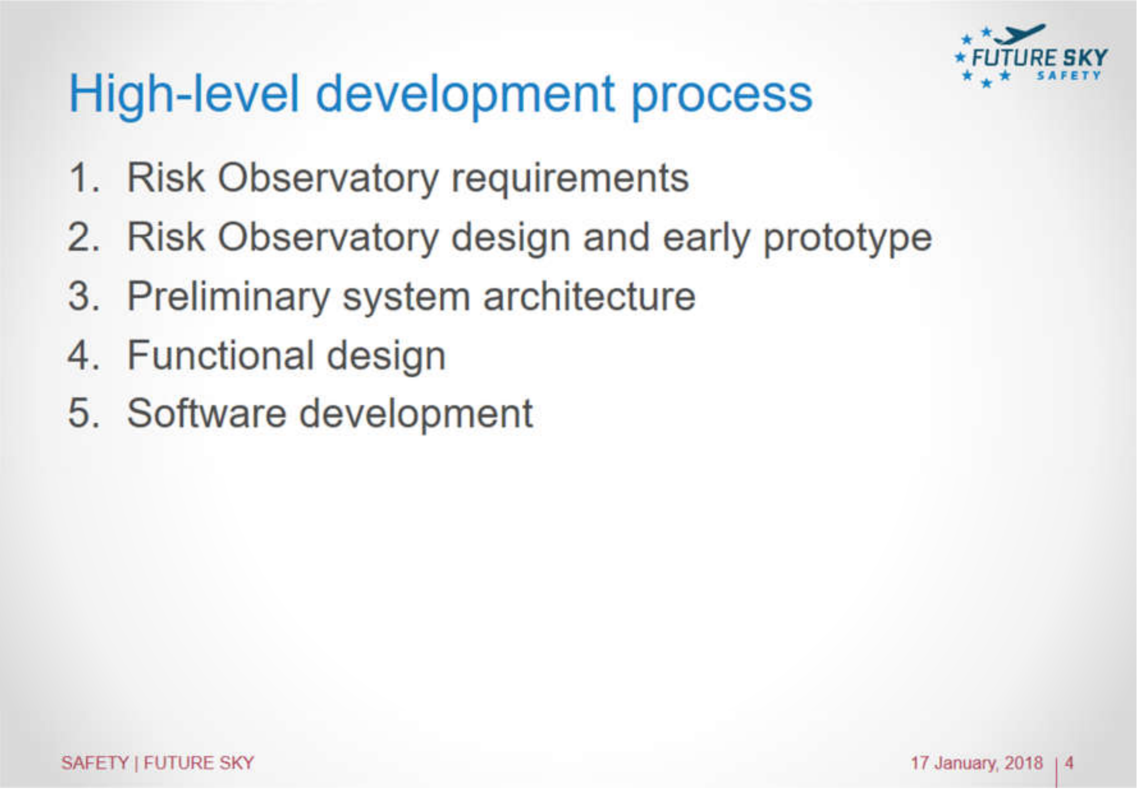
Acquire safety information

User:
Analyst
Manager

Domain:
Operator
ANSP
Manufacture
r
Airport
Authority

Prototype Risk Observatory

Acquire safety information



High-level development process

1. Risk Observatory requirements
2. Risk Observatory design and early prototype
3. Preliminary system architecture
4. Functional design
5. Software development

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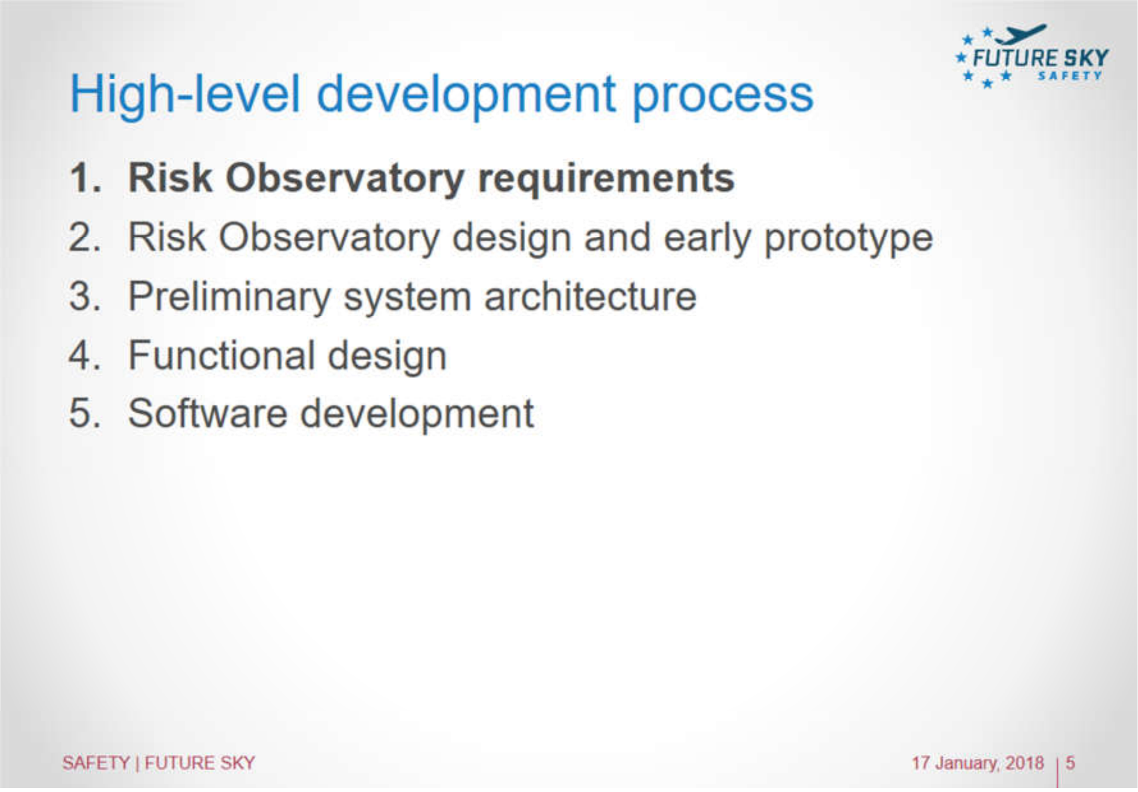

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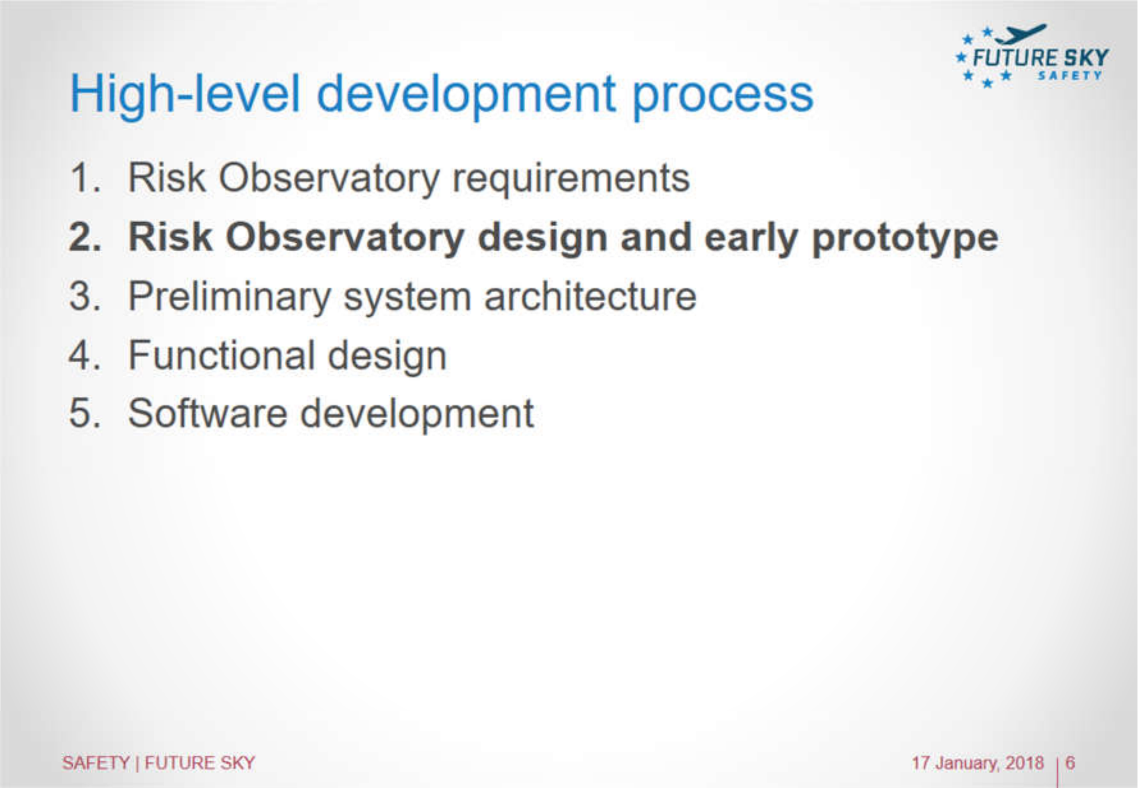

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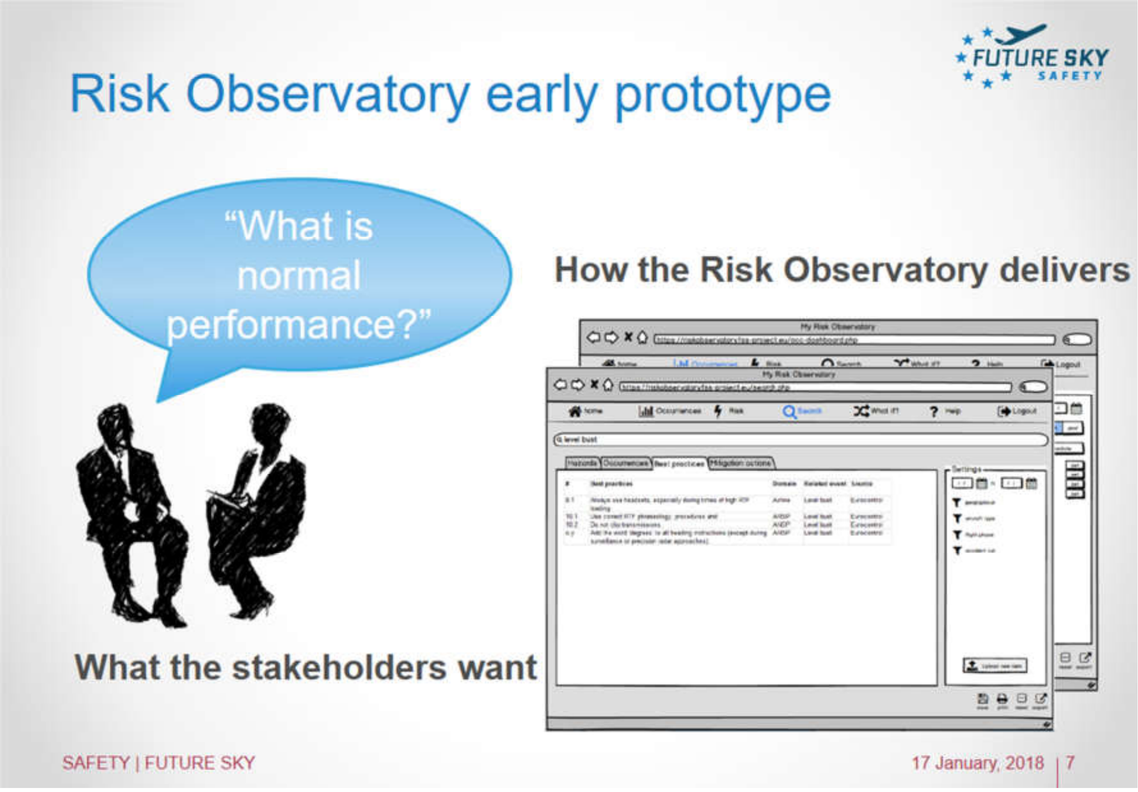

Risk Observatory early prototype

"What is normal performance?"

How the Risk Observatory delivers

What the stakeholders want

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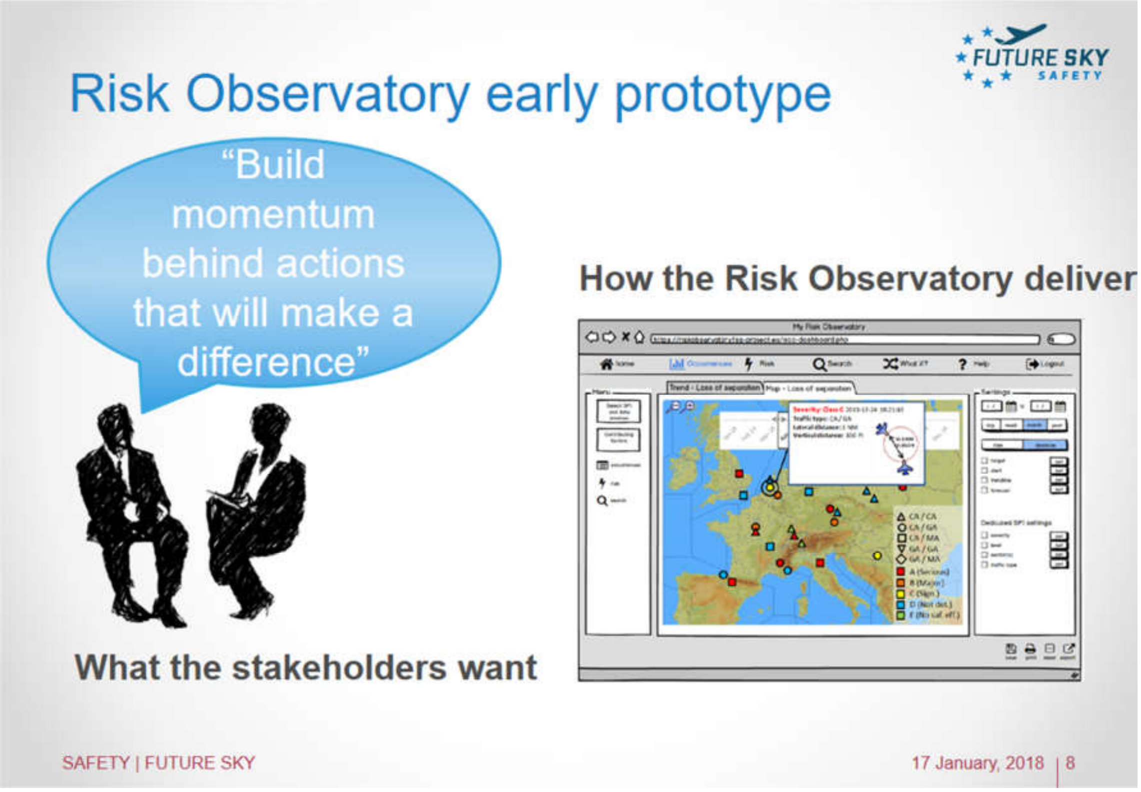

Risk Observatory early prototype

"Build momentum behind actions that will make a difference"

How the Risk Observatory deliver

What the stakeholders want

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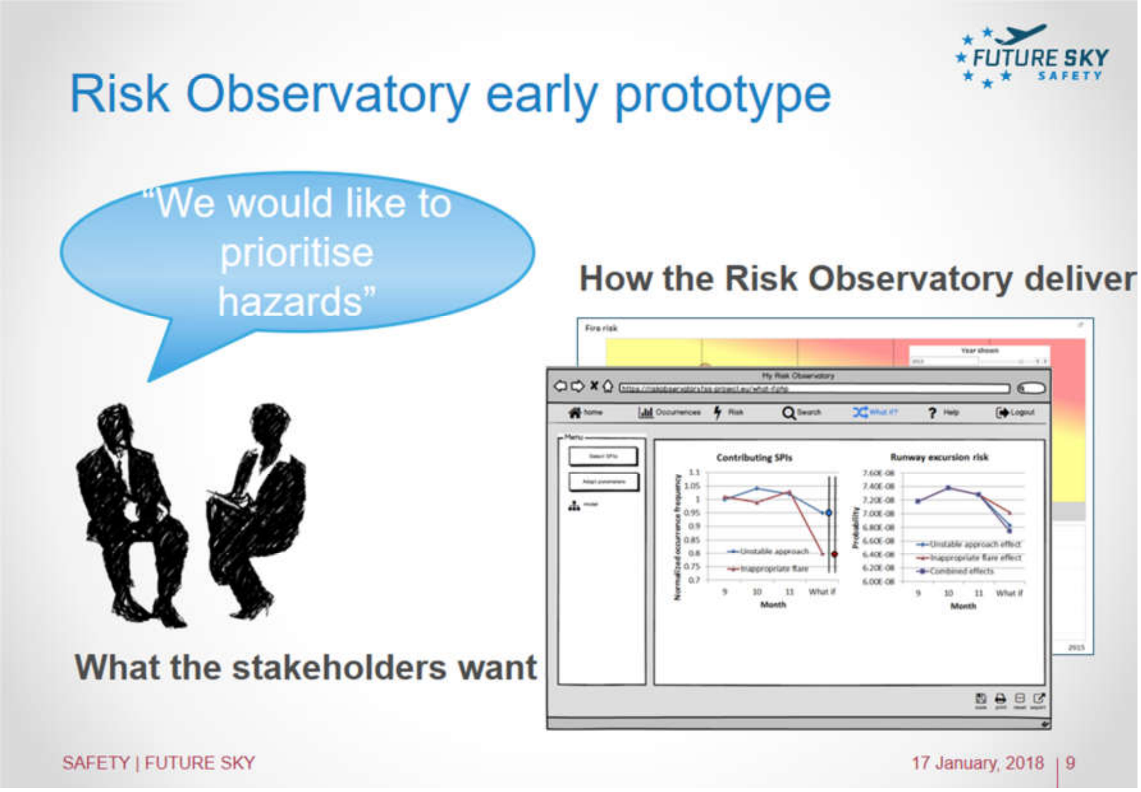

Risk Observatory early prototype

"We would like to prioritise hazards"

What the stakeholders want

How the Risk Observatory deliver

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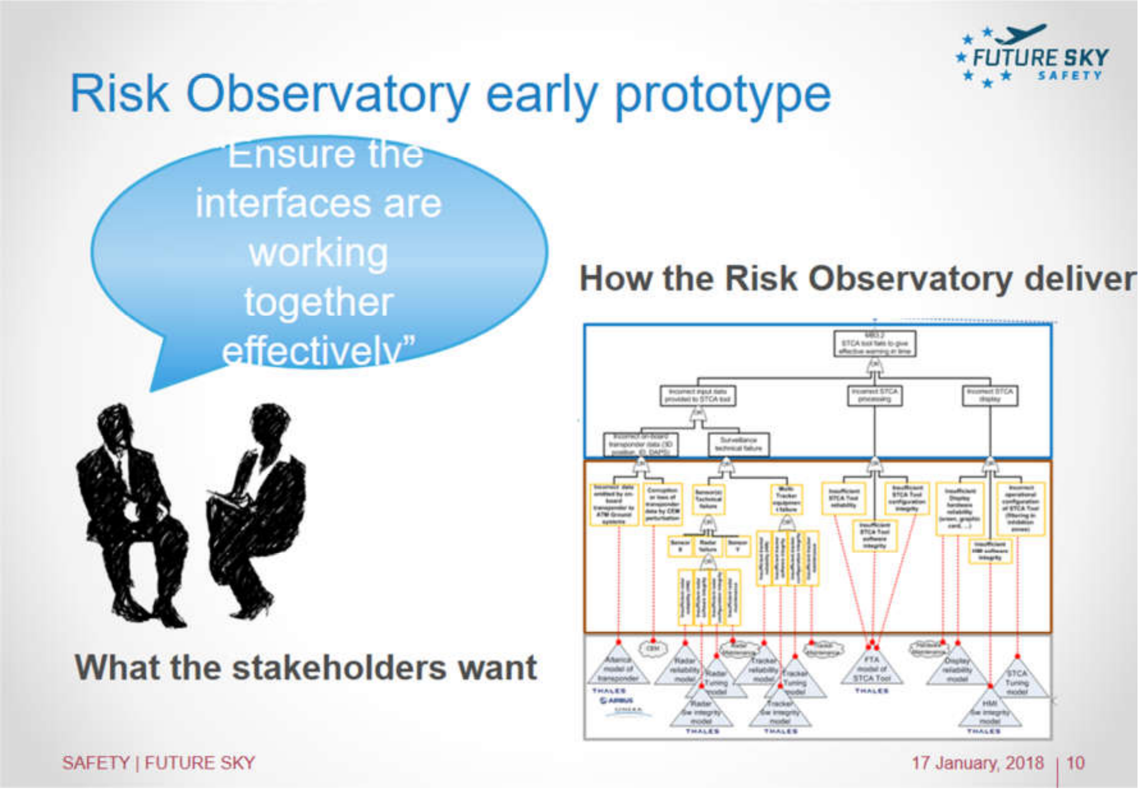

Risk Observatory early prototype

"Ensure the interfaces are working together effectively"

What the stakeholders want

How the Risk Observatory deliver

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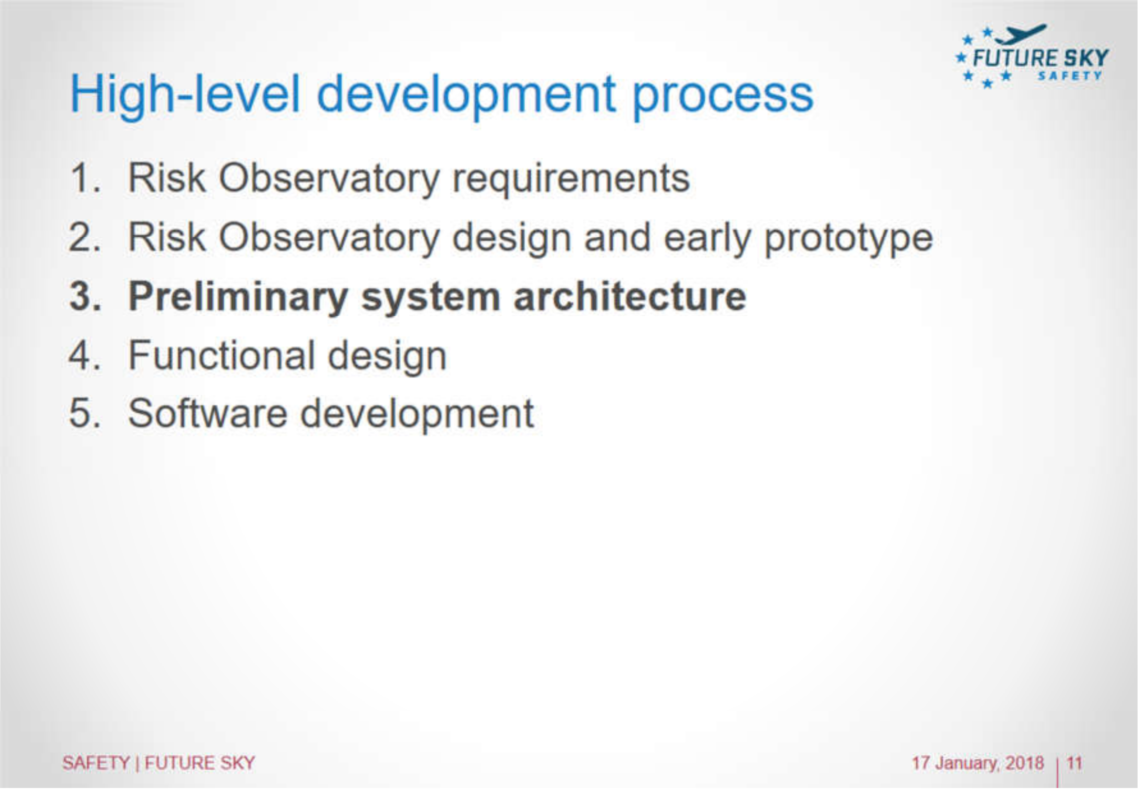

High-level development process

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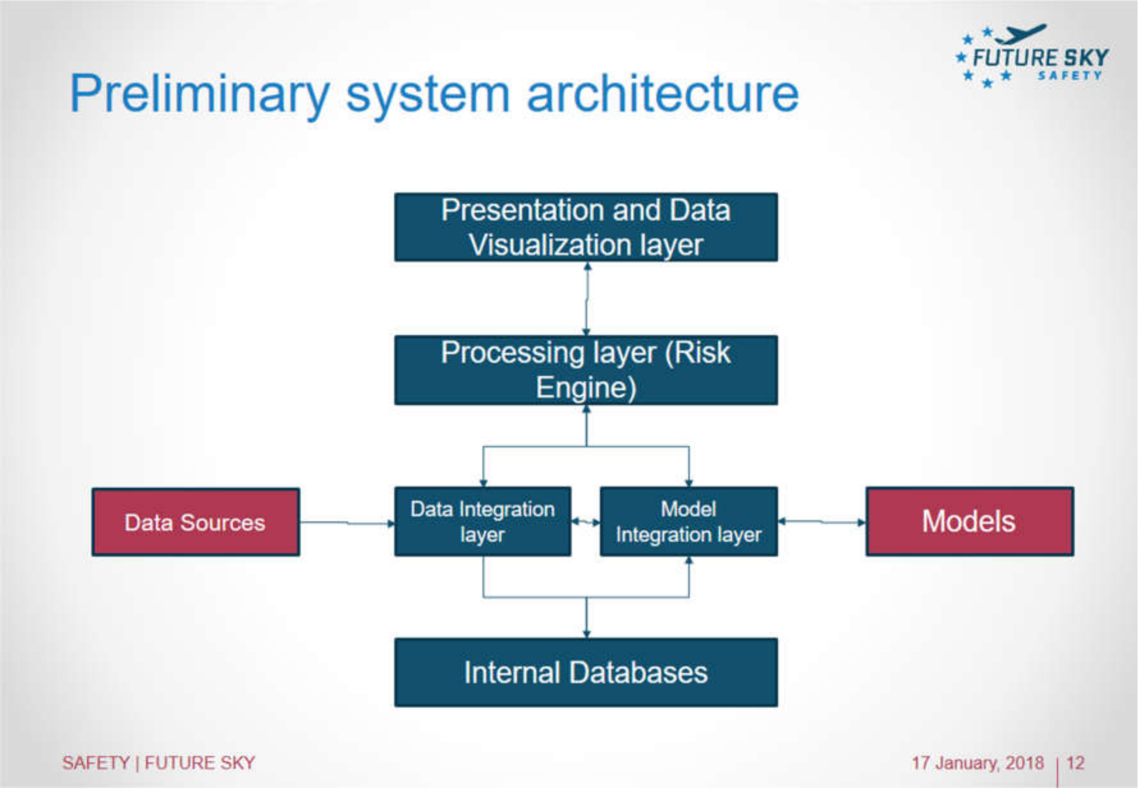

Preliminary system architecture

Presentation and Data Visualization layer

Processing layer (Risk Engine)

Data Sources

Data Integration layer

Model Integration layer

Models

Internal Databases

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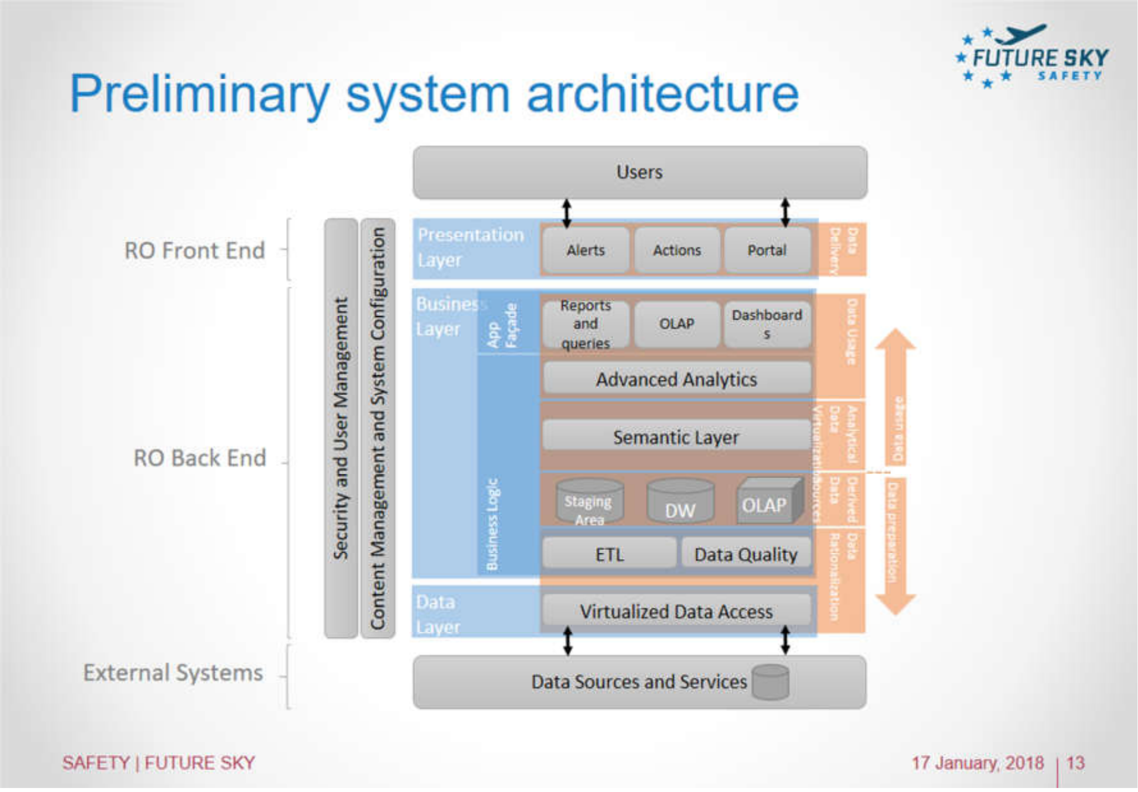
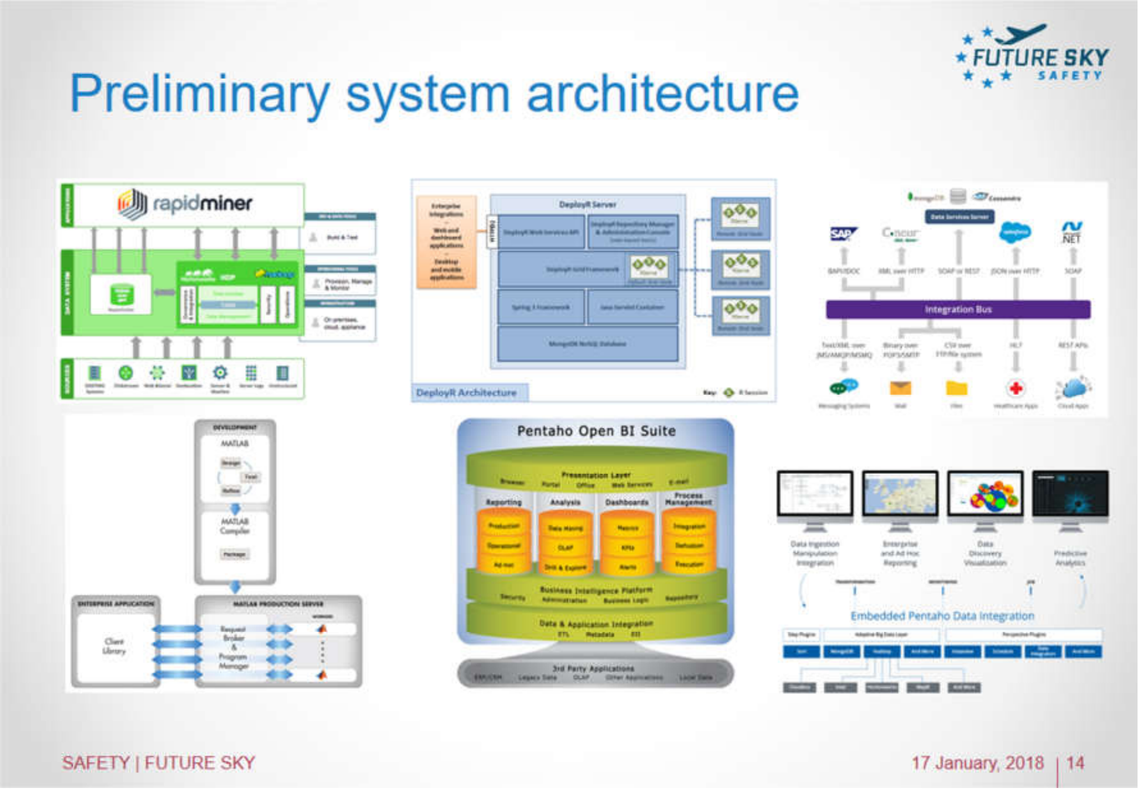
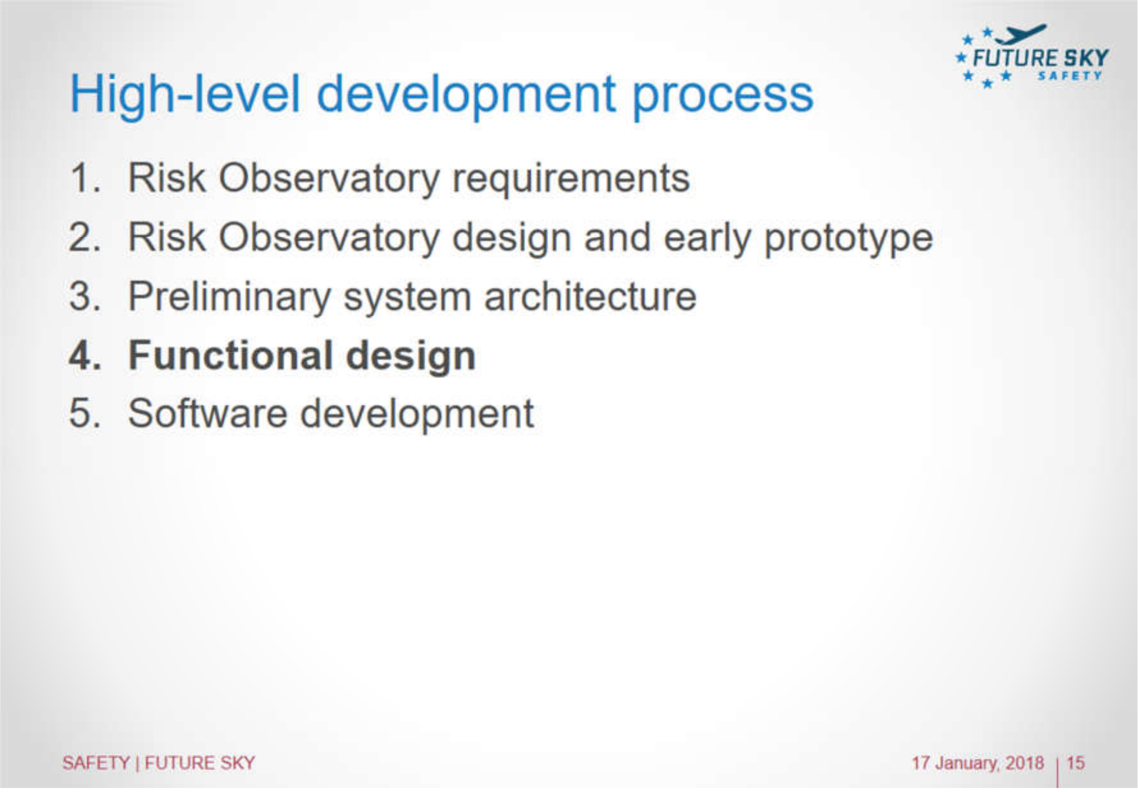


Preliminary system architecture

RO Front End
RO Back End
External Systems
Security and User Management
Content Management and System Configuration
Users
Presentation Layer
Alerts
Actions
Portal
Data Delivery
Business Layer
App Façade
Reports and queries
OLAP
Dashboards
Data Usage
Advanced Analytics
Semantic Layer
Analytical Data Virtualization
Business Logic
Staging Area
DW
OLAP
Derived Data Sources
ETL
Data Quality
Data Rationalization
Data Layer
Virtualized Data Access
Data usage
Data preparation
Data Sources and Services



Preliminary system architecture



High-level development process

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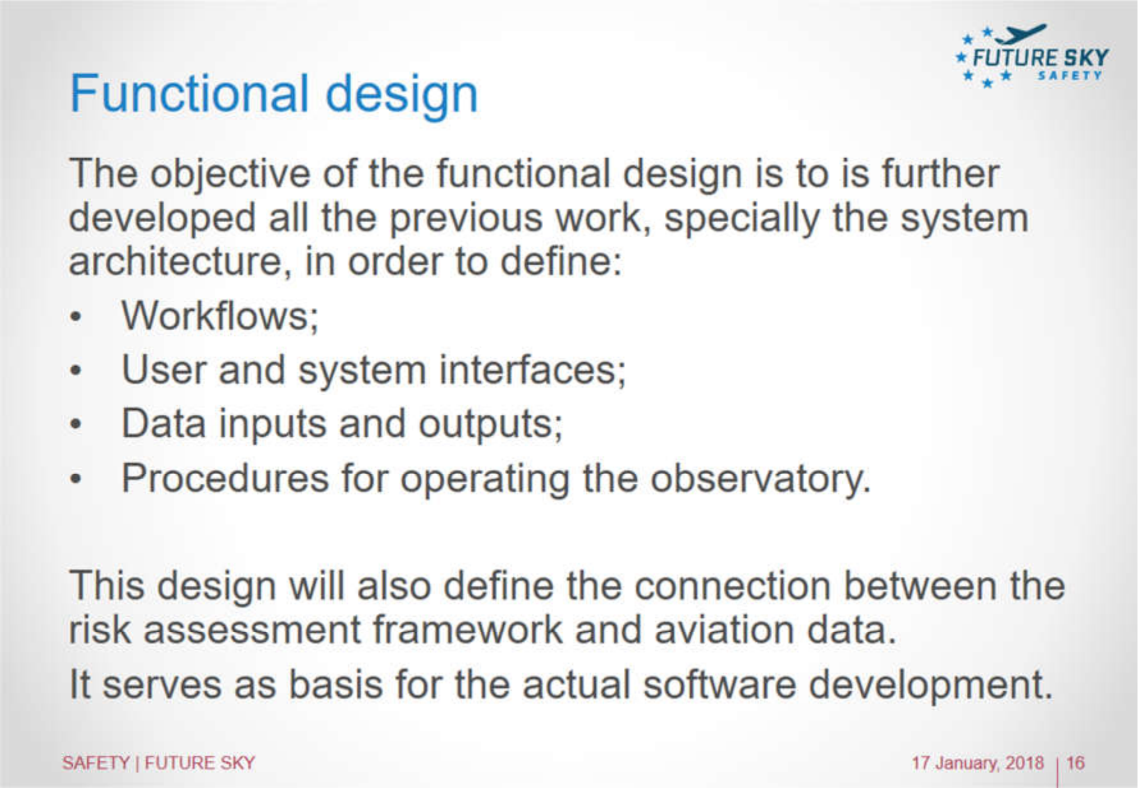

Functional design

The objective of the functional design is to is further developed all the previous work, specially the system architecture, in order to define:

- Workflows;
- User and system interfaces;
- Data inputs and outputs;
- Procedures for operating the observatory.

This design will also define the connection between the risk assessment framework and aviation data.

It serves as basis for the actual software development.

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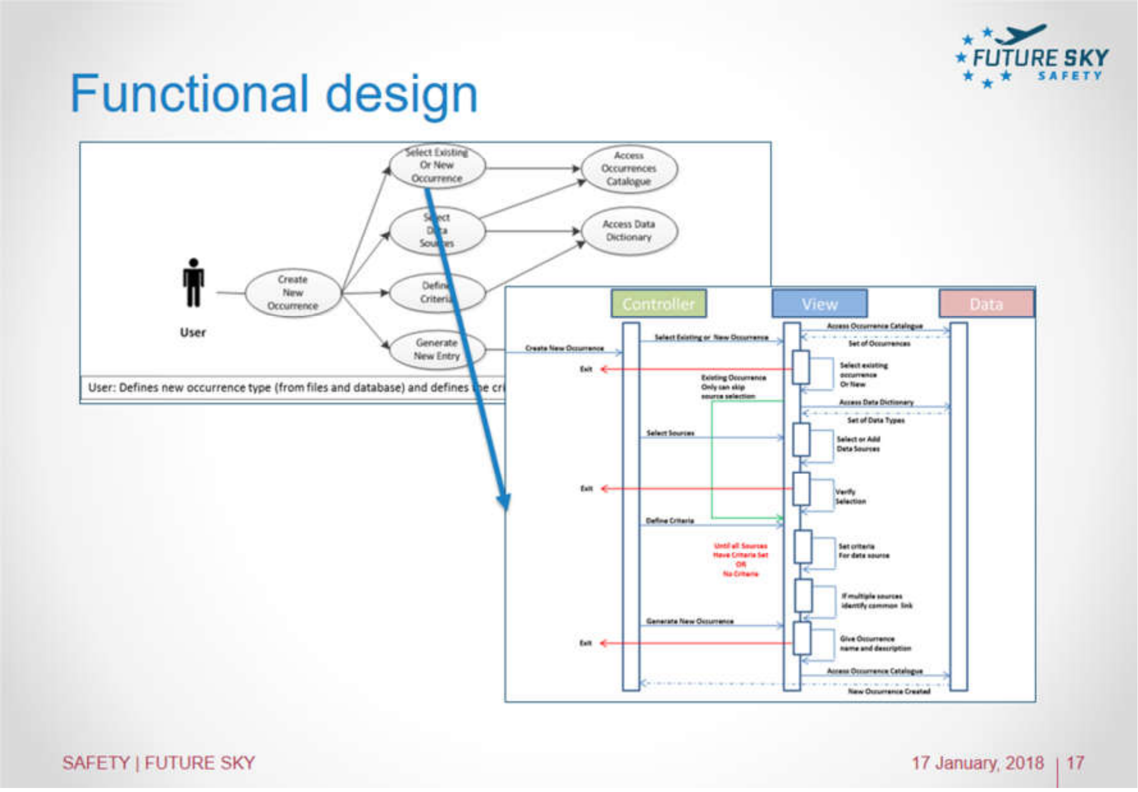
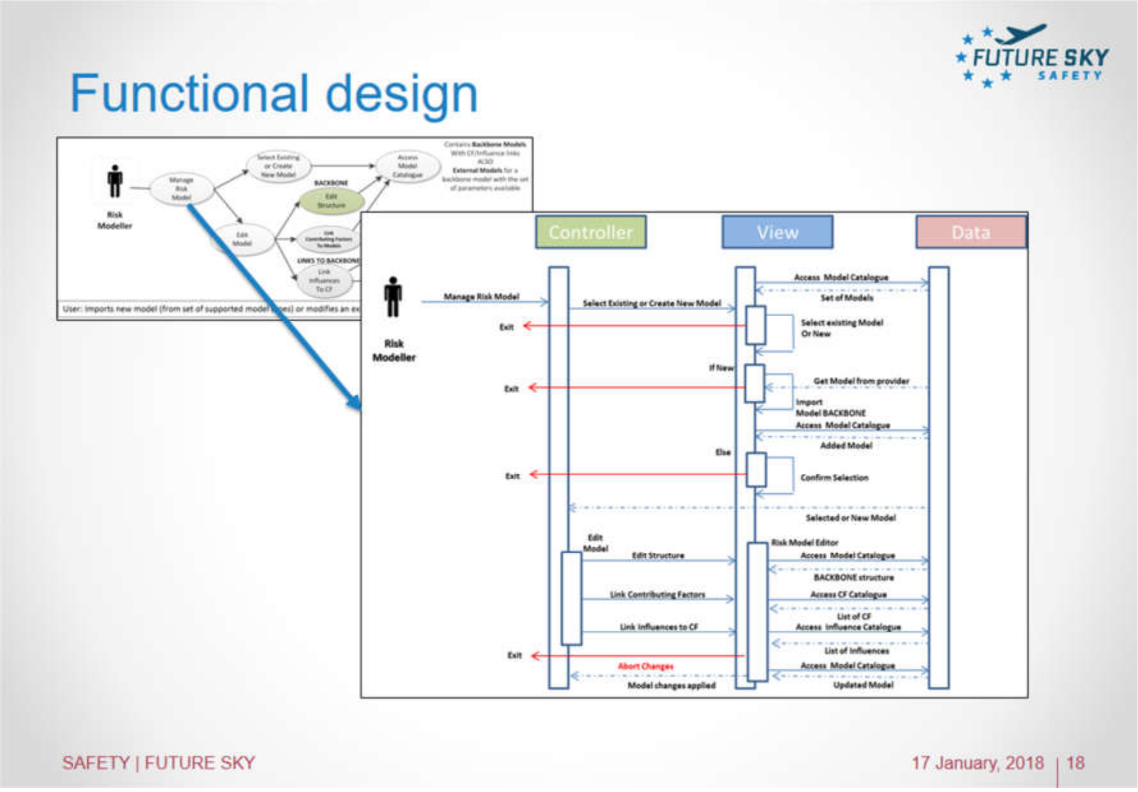
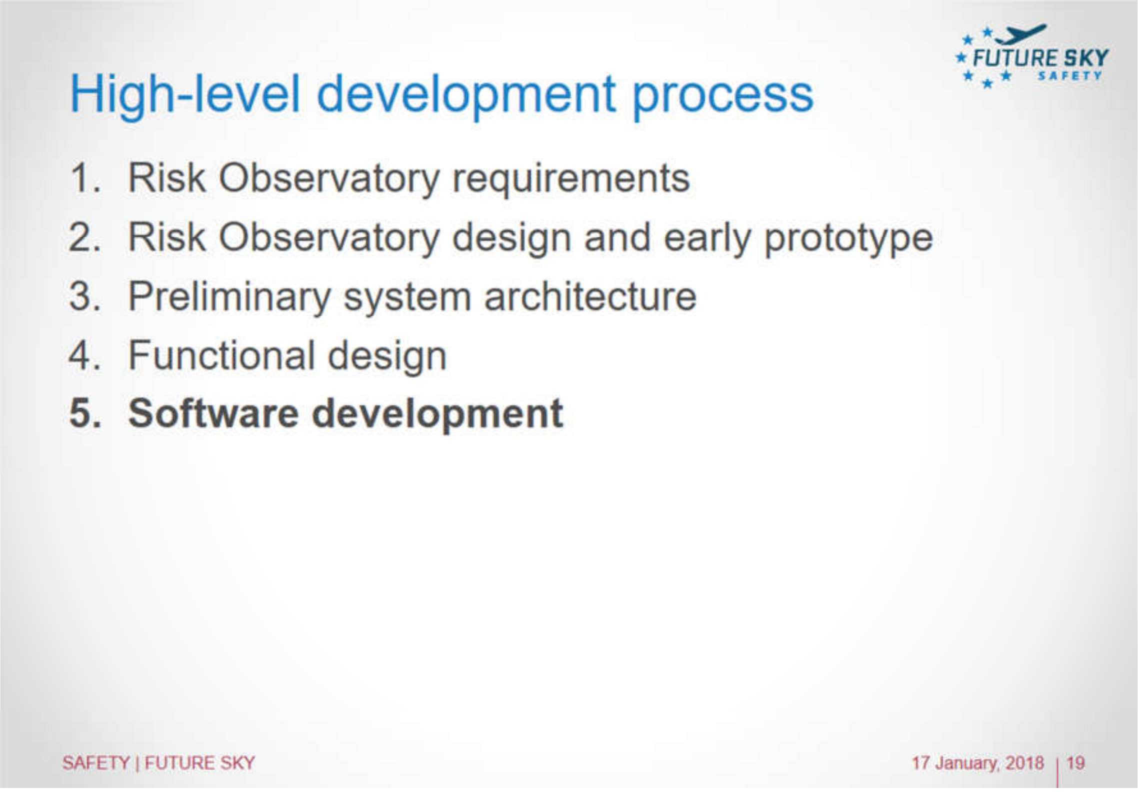


Functional design



Functional design



High-level development process

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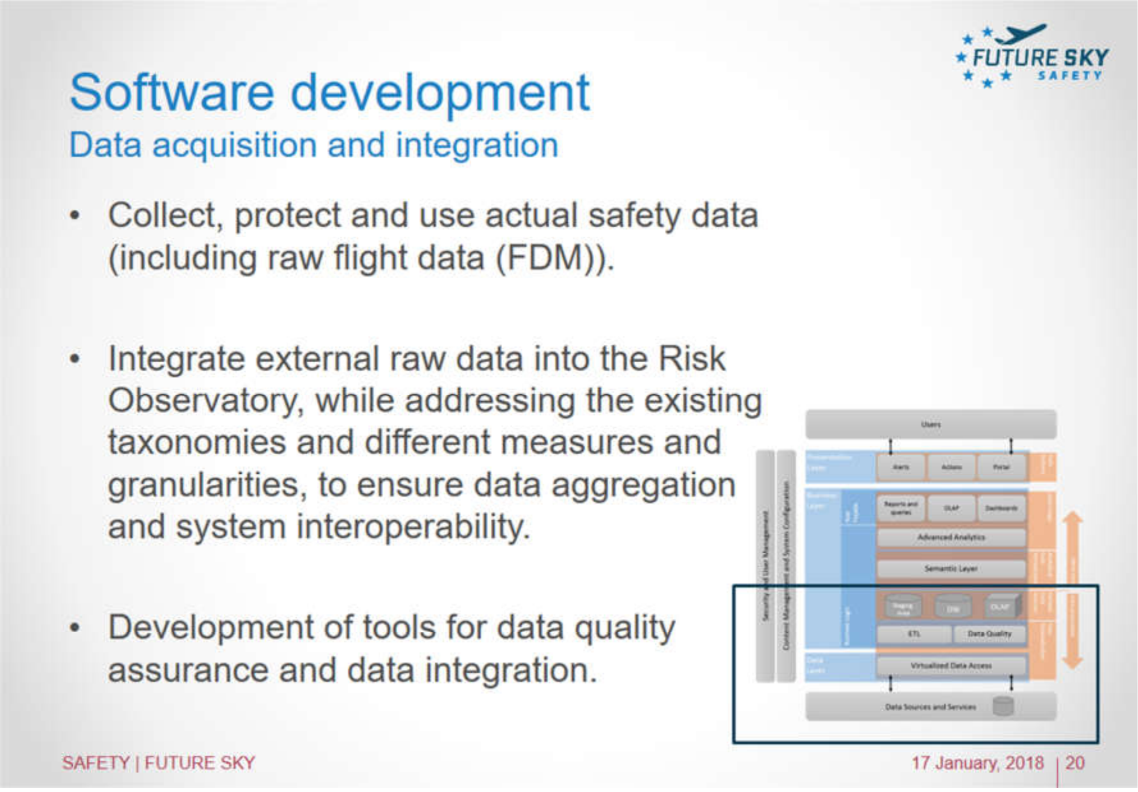

Software development

Data acquisition and integration

- Collect, protect and use actual safety data (including raw flight data (FDM)).
- Integrate external raw data into the Risk Observatory, while addressing the existing taxonomies and different measures and granularities, to ensure data aggregation and system interoperability.
- Development of tools for data quality assurance and data integration.

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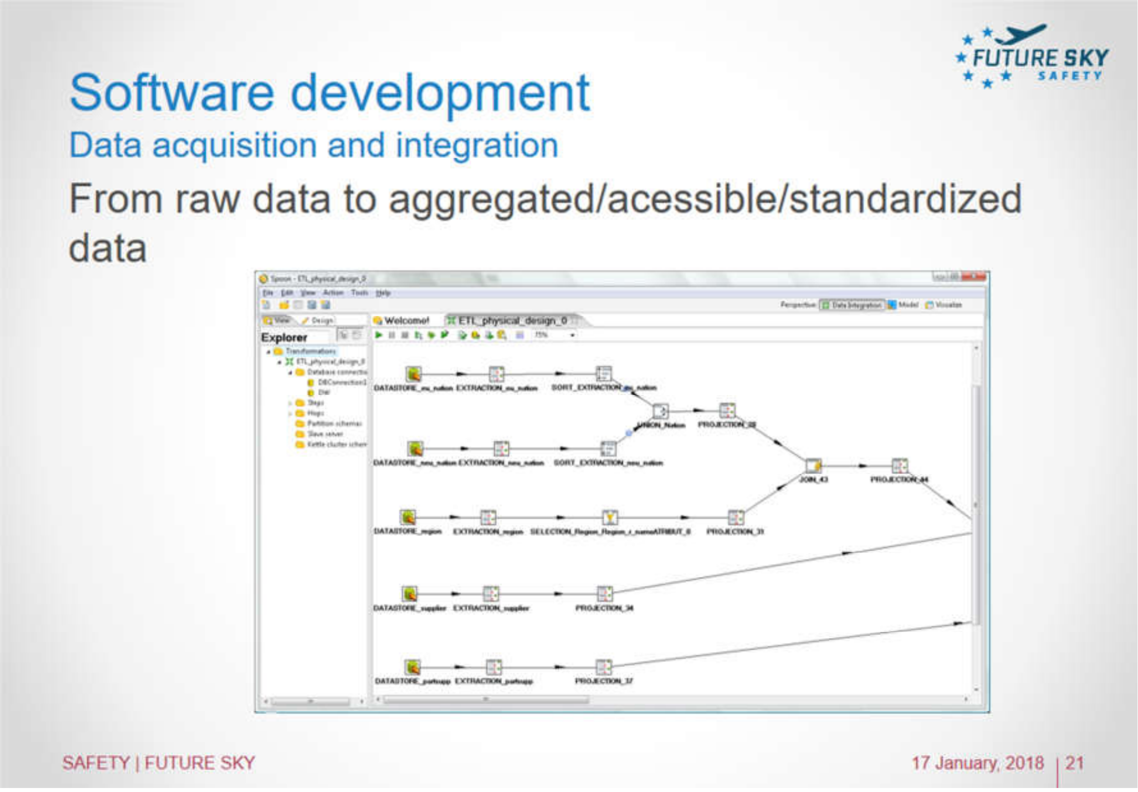

Software development

Data acquisition and integration

From raw data to aggregated/acessible/standardized data

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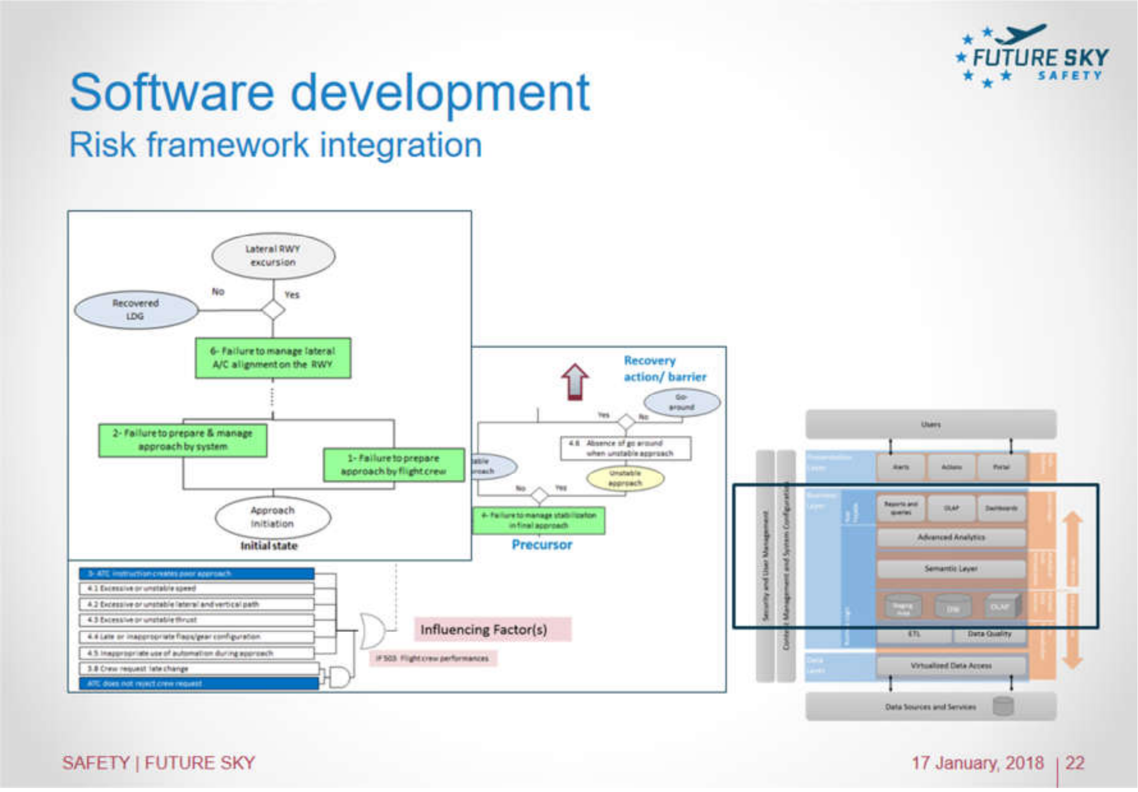

Software development

Risk framework integration

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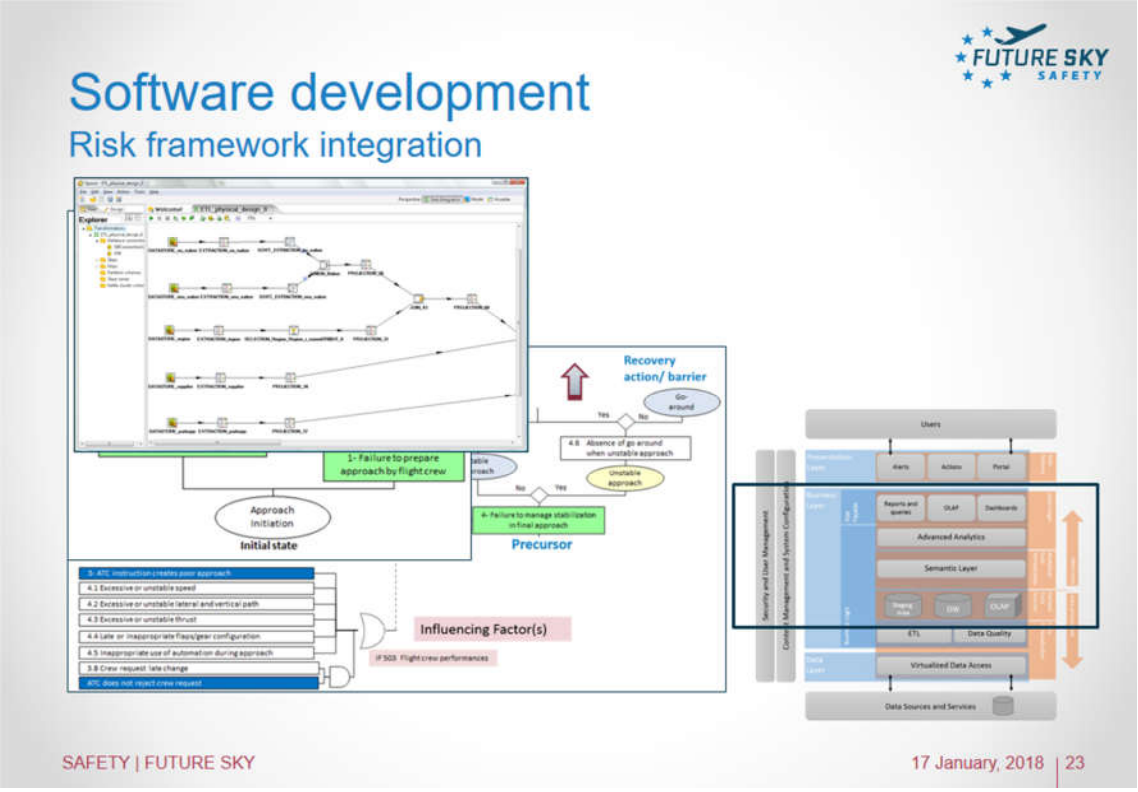

Software development

Risk framework integration

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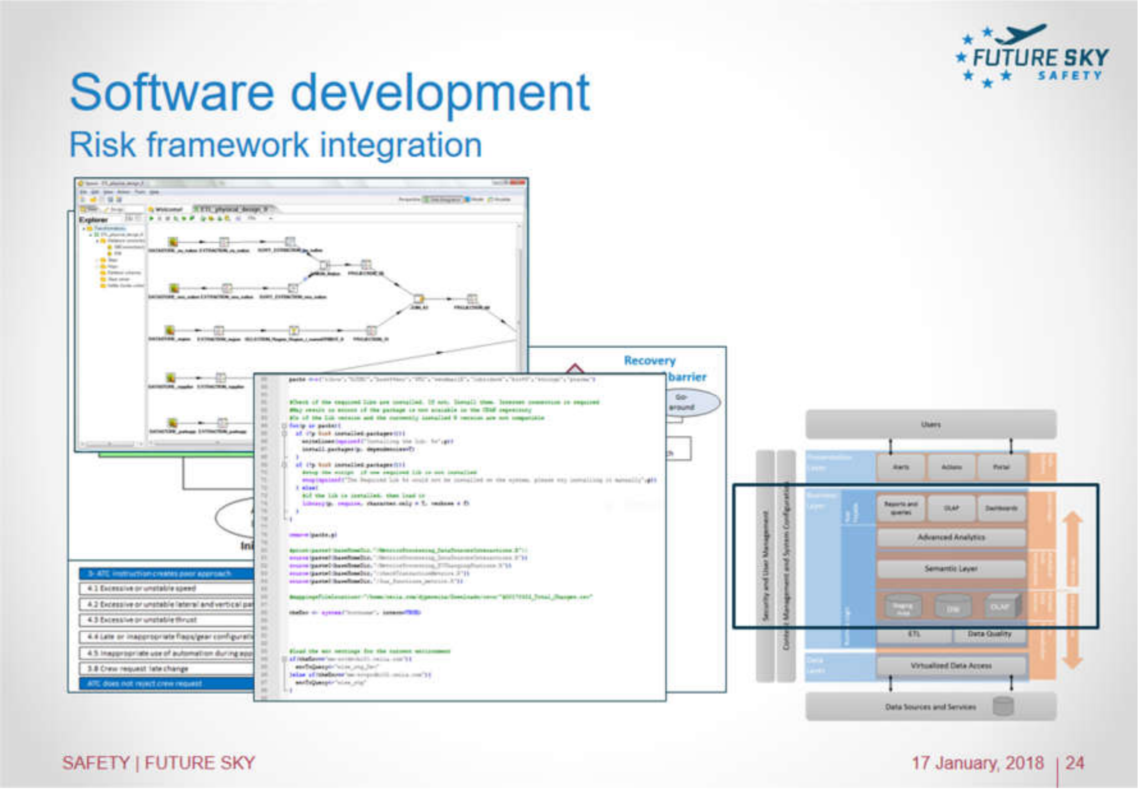

Software development

Risk framework integration

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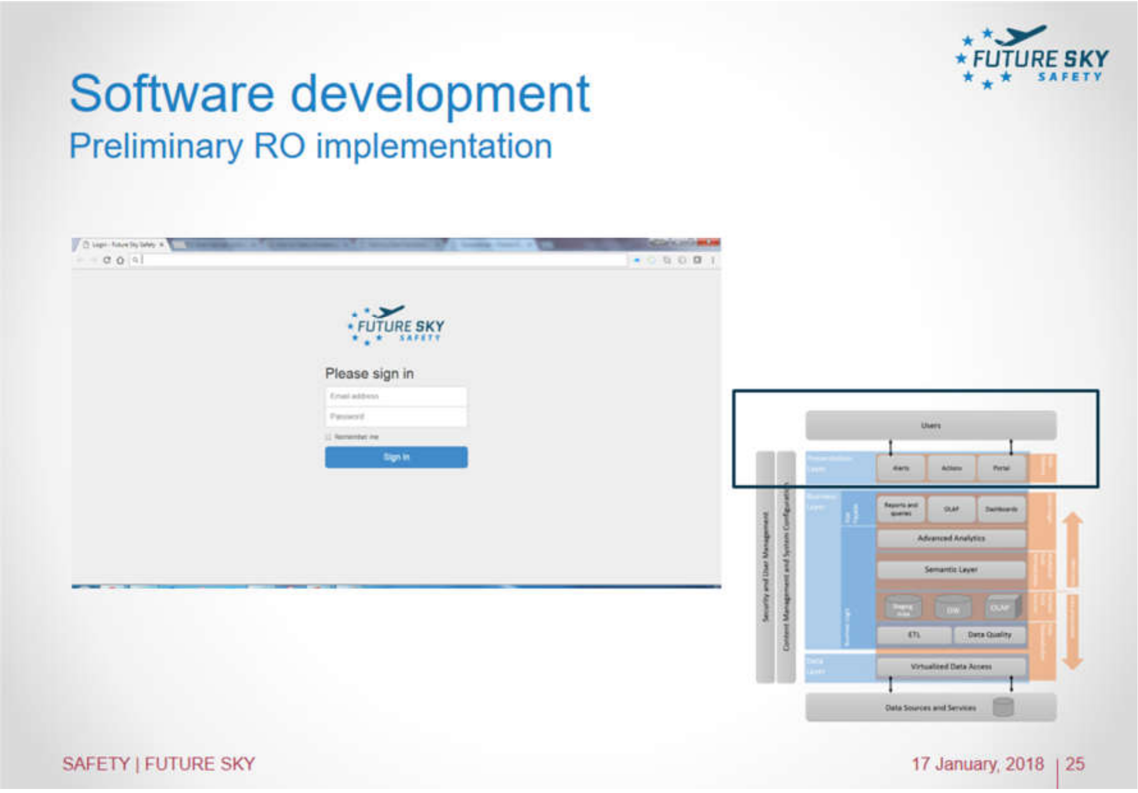

Software development

Preliminary RO implementation

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Software development

Preliminary RO implementation

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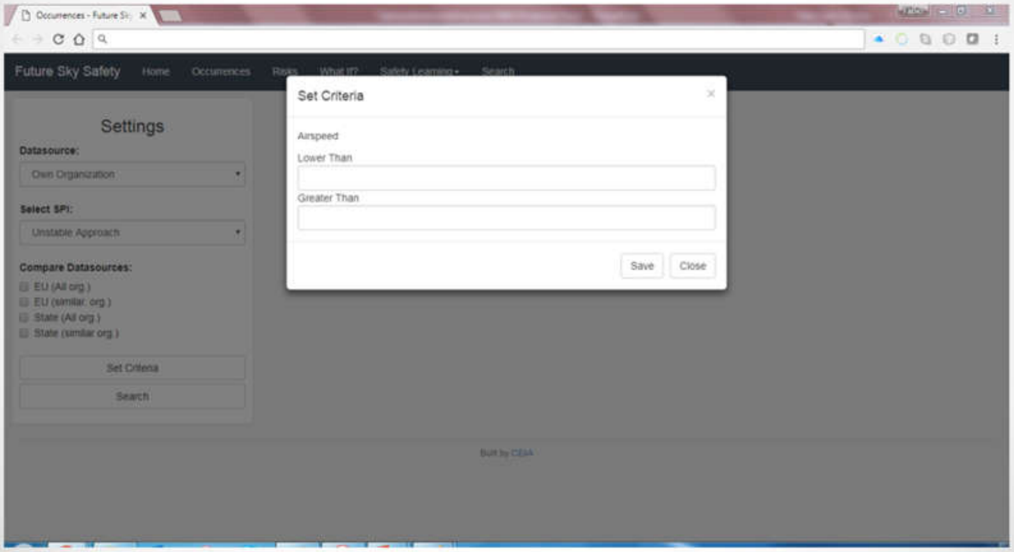
Software development

Preliminary RO implementation



Settings

Datasource: Own Organization

Select SPI: Unstable Approach

Compare Datasources:
- ☐ EU (All org.)
- ☐ EU (similar. org.)
- ☐ State (All org.)
- ☐ State (similar org.)

Set Criteria

Airspeed

Lower Than

Greater Than

Software development

Preliminary RO implementation

Settings

Datasource: Own Organization

Select SPI: Unstable Approach

Compare Datasources:
- ☐ EU (All org.)
- ☐ EU (similar. org.)
- ☐ State (All org.)
- ☐ State (similar org.)

Software development

Preliminary RO implementation

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Appendix B.7 “P5: Resolving the organisational accident” – Barry Kirwan, EUROCONTROL

P5 Resolving the Organisational Accident

Barry Kirwan, P5 Project Manager, EUROCONTROL

2nd FSS Internal Conference

P5 Resolving the Organisational Accident

ECTL lead, 167 MM, 10 Partners, 2015-2017, 5 WPs

→ The next aviation accident is likely to have organisational components, e.g. poor safety culture, poor management decisions, or local actors taking risks when working under pressure, or a poor collective response to an accident by the industry.

→ This Project seeks to redress this situation, resolving the organisational accident.

Advanced SMS – Organisational Safety Capability

Work Packages

- WP5.1 – Safety Intelligence (ECTL/Airbus)
- WP5.2 – Safety Mindfulness (TCD)
- WP5.3 – Safety Culture (LSE)
- WP5.4 – Agile Response Capability (FOI)
- WP5.5 – Advanced SMS (NLR)

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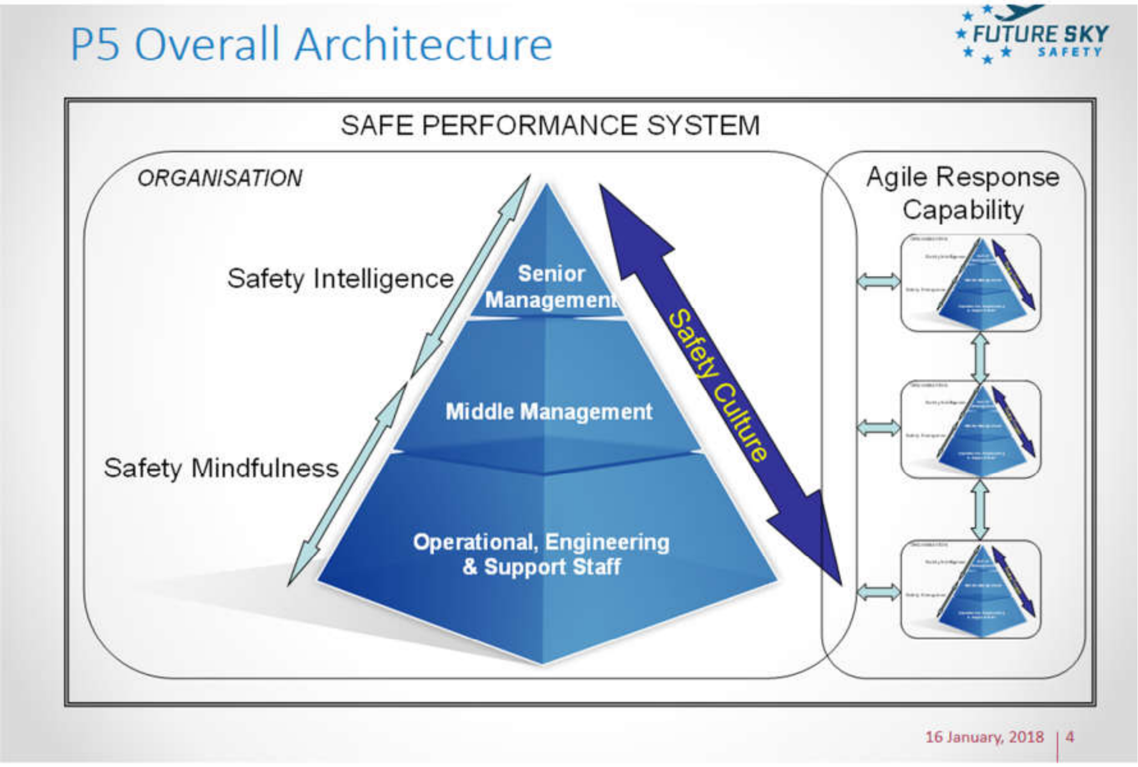

P5 Overall Architecture

SAFE PERFORMANCE SYSTEM

ORGANISATION

Safety Intelligence

Safety Mindfulness

Senior Management

Middle Management

Operational, Engineering & Support Staff

Safety Culture

Agile Response Capability

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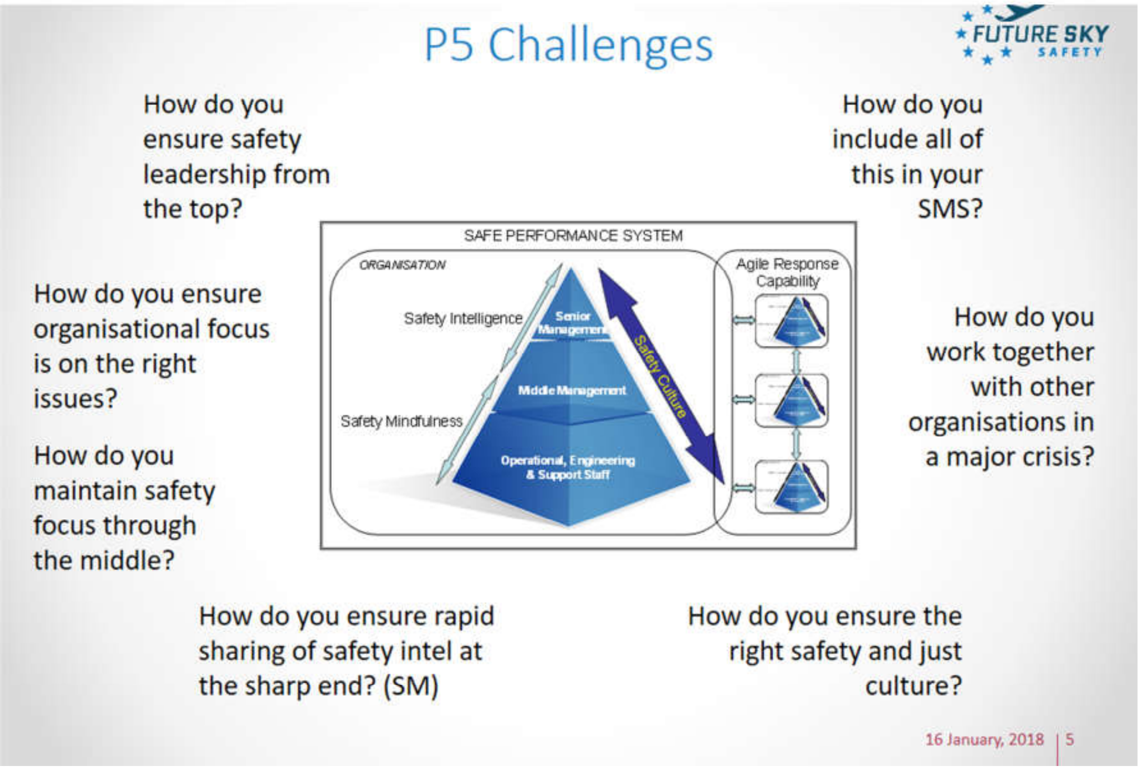

P5 Challenges

How do you ensure safety leadership from the top?

How do you include all of this in your SMS?

How do you ensure organisational focus is on the right issues?

How do you maintain safety focus through the middle?

How do you work together with other organisations in a major crisis?

SAFE PERFORMANCE SYSTEM

ORGANISATION

Safety Intelligence

Safety Mindfulness

Senior Management

Middle Management

Operational, Engineering & Support Staff

Safety Culture

Agile Response Capability

How do you ensure rapid sharing of safety intel at the sharp end? (SM)

How do you ensure the right safety and just culture?

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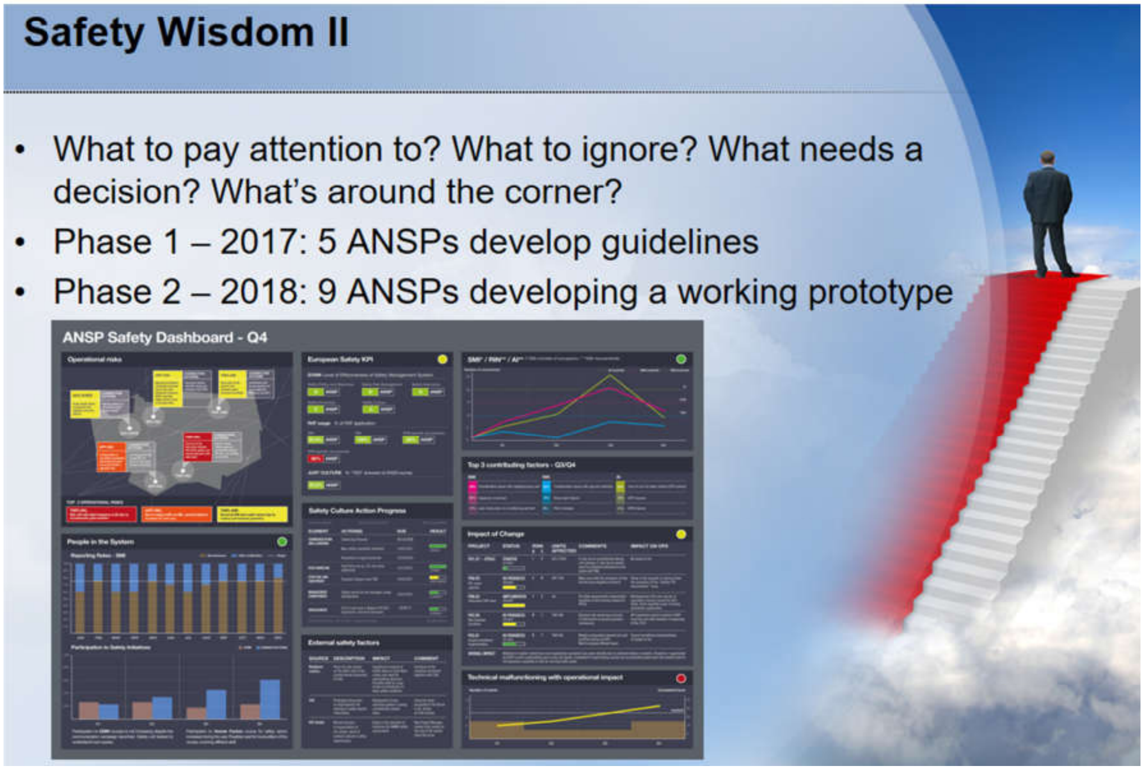
WP1 Safety at the Top

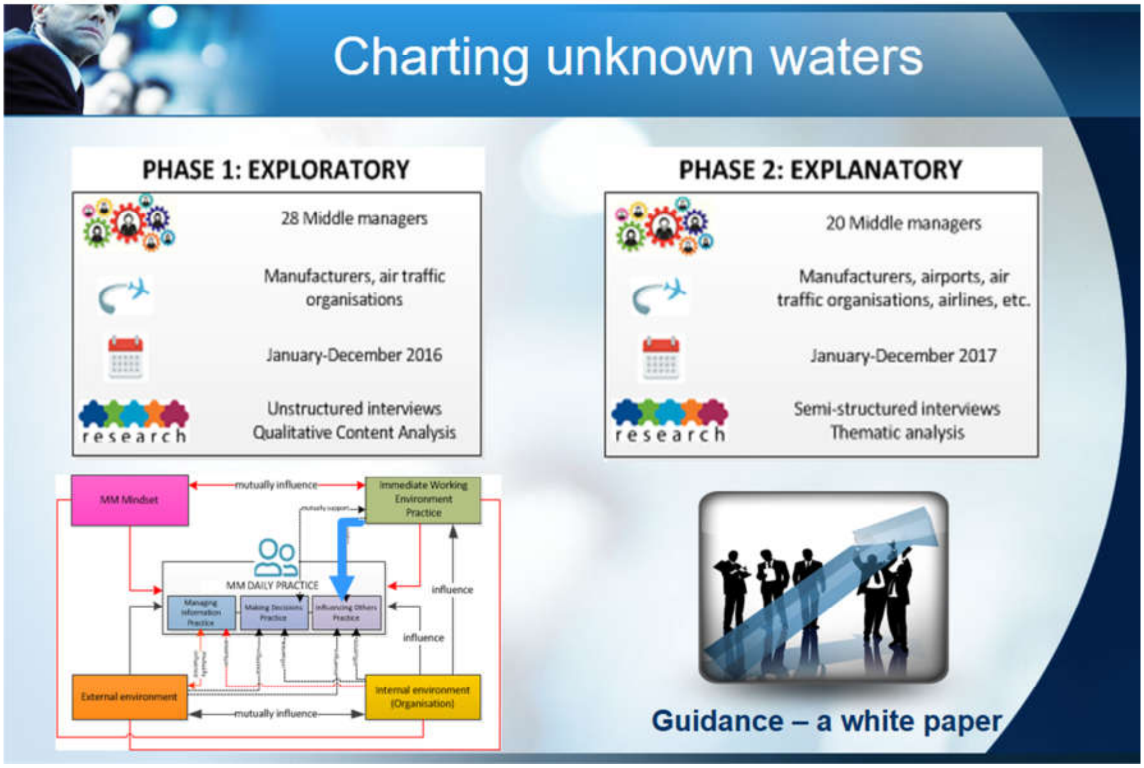
Safety Wisdom: how 16 top executives manage a safe business



Safety Wisdom II

- What to pay attention to? What to ignore? What needs a decision? What's around the corner?
- Phase 1 – 2017: 5 ANSPs develop guidelines
- Phase 2 – 2018: 9 ANSPs developing a working prototype

Middle Managers – an unexplored resource for safety?



Charting unknown waters

PHASE 1: EXPLORATORY

28 Middle managers

Manufacturers, air traffic organisations

January-December 2016

Unstructured interviews
Qualitative Content Analysis

PHASE 2: EXPLANATORY

20 Middle managers

Manufacturers, airports, air traffic organisations, airlines, etc.

January-December 2017

Semi-structured interviews
Thematic analysis

Guidance – a white paper

You just saw something unsafe… Who are you going to call?

WP2 Safety Mindfulness

A safety mindfulness 'app'

- Working with an airline and an ANSP
- An App has been designed, enabling ATCOs to post, update, and retrieve safety-related information useful to help them perform their daily tasks and activities safely.
- The App uses ©*WordPress:* http://www.cihsmindfulness.com
  - Small to large data management.
  - Open-source (i.e. low-cost installation, customisation and maintenance).
  - High level of security

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WP3 Safety Culture

- Major survey with European Cockpit Association : > 7000 pilot replies
  - Overall SC good, but some clear issues (e.g. fatigue)
- Survey with Airbus Design and Boeing Europe
- Surveys with *easyJet* and *Luton Airport*
- Survey with KLM
- Luton Safety Stack

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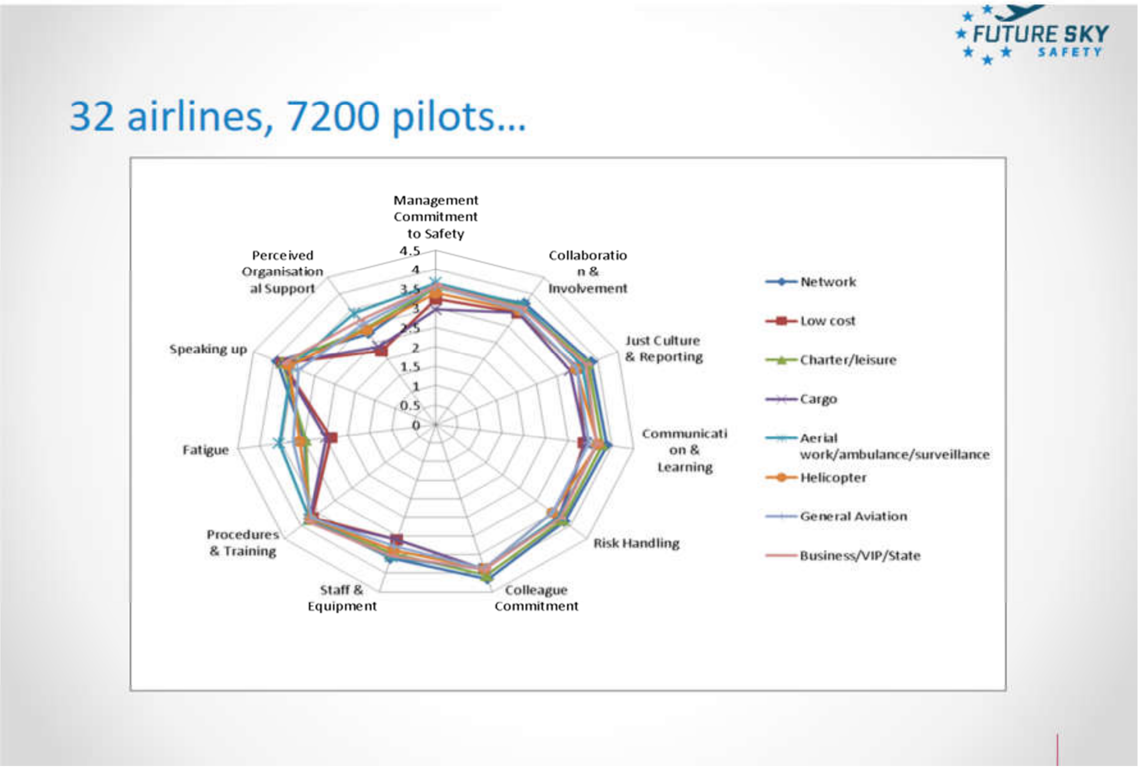

32 airlines, 7200 pilots…

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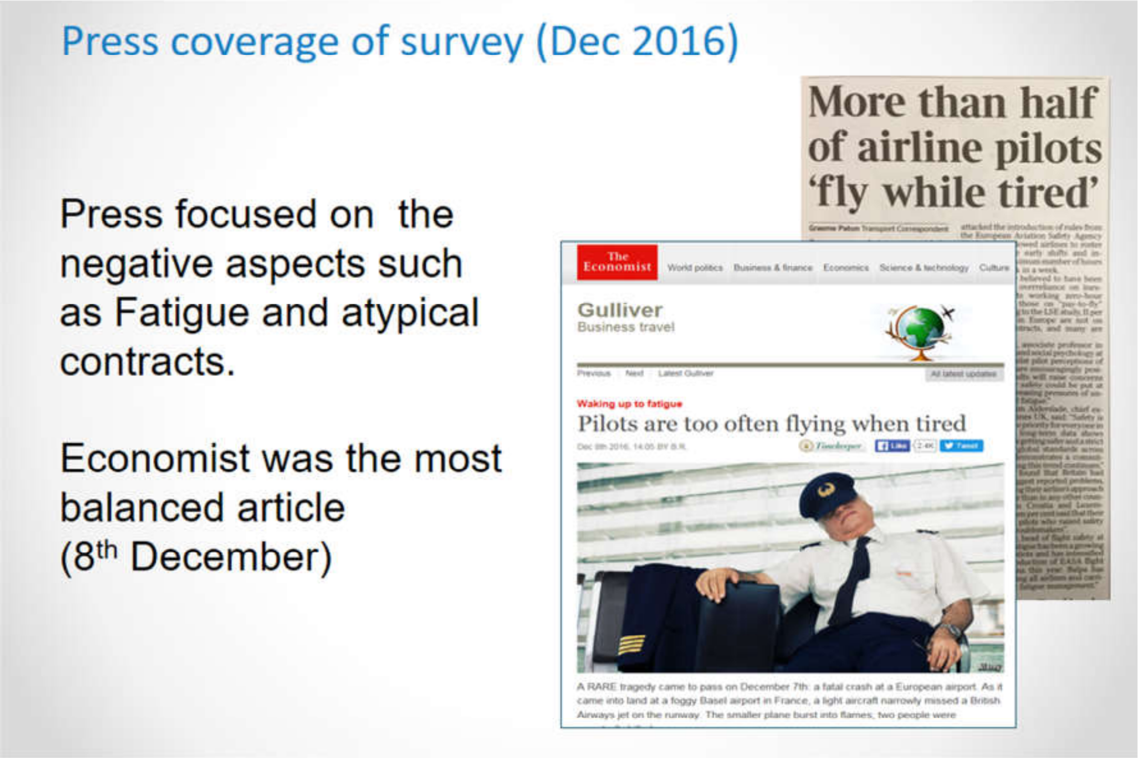


Press coverage of survey (Dec 2016)

Press focused on the negative aspects such as Fatigue and atypical contracts.

Economist was the most balanced article (8th December)

More than half of airline pilots 'fly while tired'

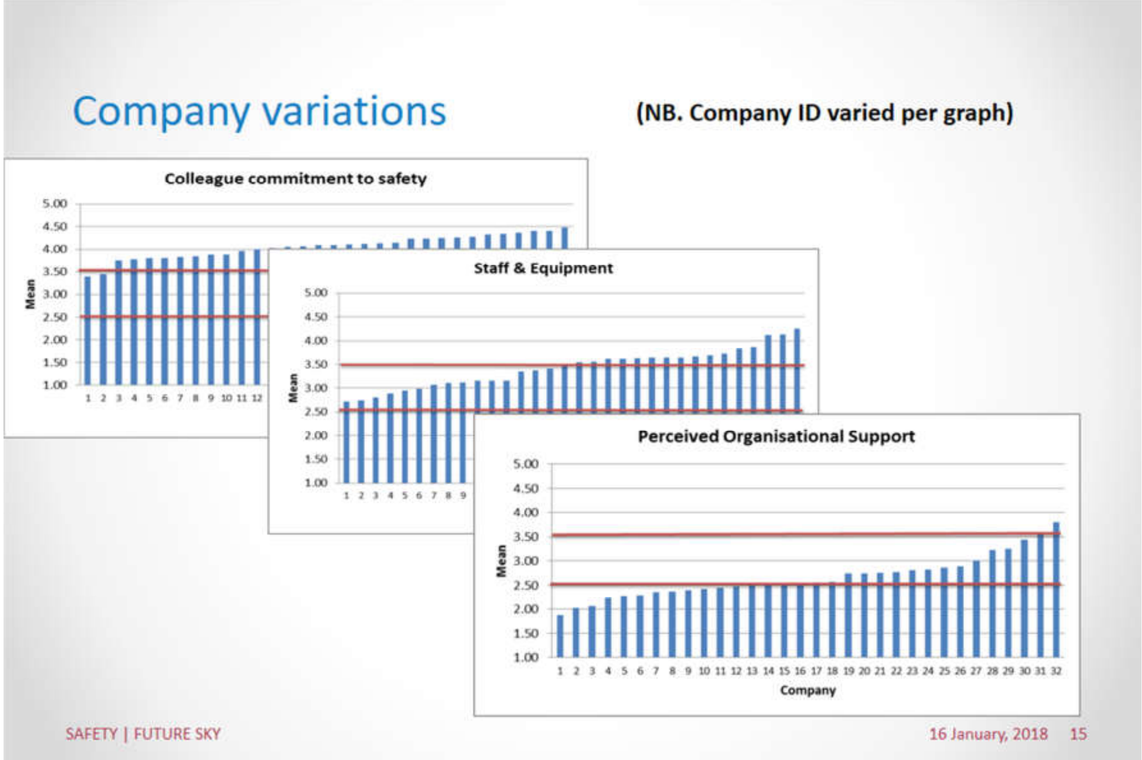
Graeme Paton Transport Correspondent

Waking up to fatigue

Pilots are too often flying when tired

Dec 8th 2016, 14:05 BY B.R.

A RARE tragedy came to pass on December 7th: a fatal crash at a European airport. As it came into land at a foggy Basel airport in France, a light aircraft narrowly missed a British Airways jet on the runway. The smaller plane burst into flames; two people were



Company variations

(NB. Company ID varied per graph)

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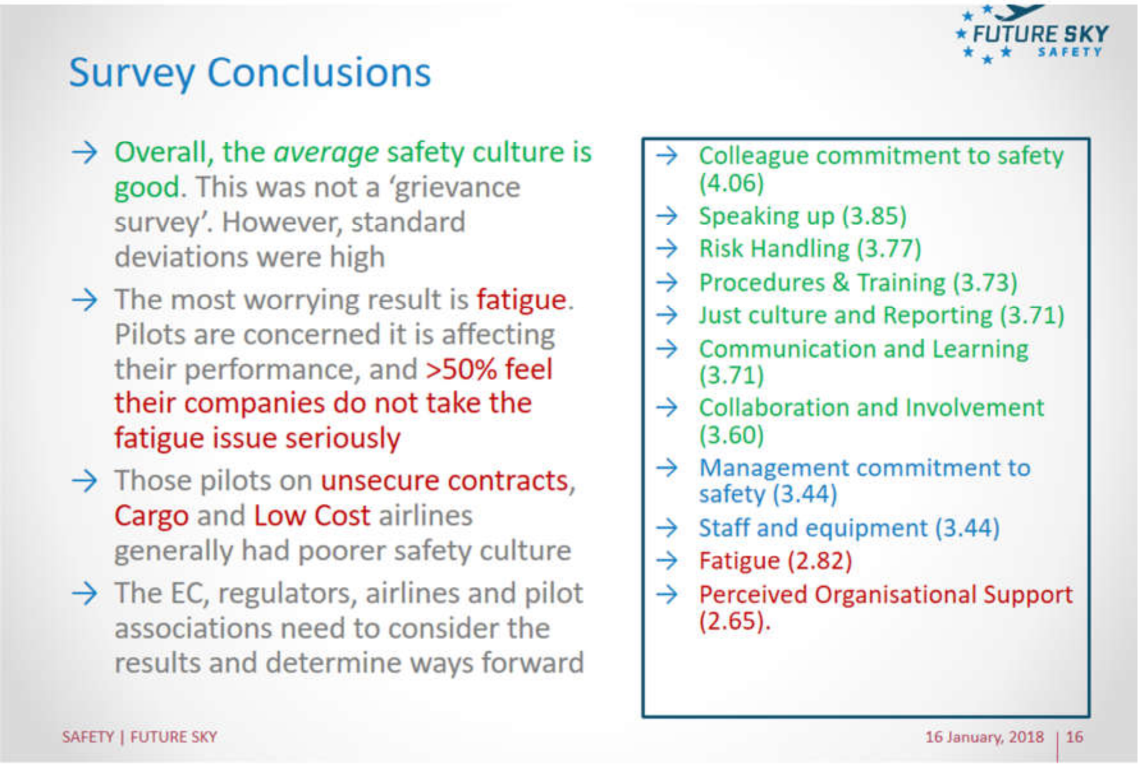

Survey Conclusions

- Overall, the *average* safety culture is good. This was not a 'grievance survey'. However, standard deviations were high
- The most worrying result is fatigue. Pilots are concerned it is affecting their performance, and >50% feel their companies do not take the fatigue issue seriously
- Those pilots on unsecure contracts, Cargo and Low Cost airlines generally had poorer safety culture
- The EC, regulators, airlines and pilot associations need to consider the results and determine ways forward

- Colleague commitment to safety (4.06)
- Speaking up (3.85)
- Risk Handling (3.77)
- Procedures & Training (3.73)
- Just culture and Reporting (3.71)
- Communication and Learning (3.71)
- Collaboration and Involvement (3.60)
- Management commitment to safety (3.44)
- Staff and equipment (3.44)
- Fatigue (2.82)
- Perceived Organisational Support (2.65).

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The Luton Airport Safety Stack

17

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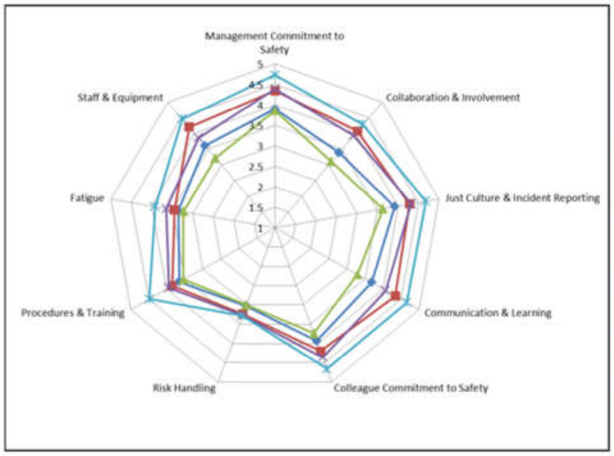
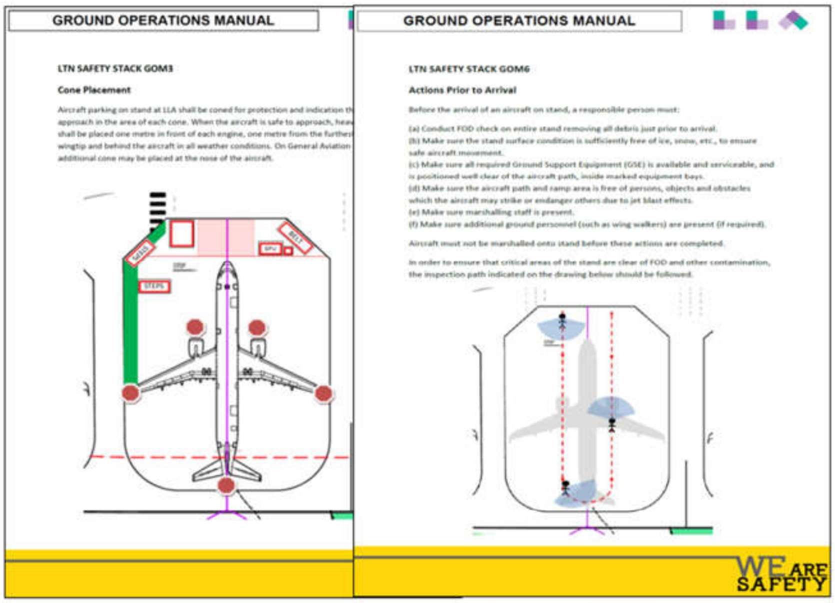
12 organisations now working together on improving safety culture



HARMONISATION OF GROUND HANDLING STANDARDS



GROUND OPERATIONS MANUAL

LTN SAFETY STACK GOM3

Cone Placement

Aircraft parking on stand at LLA shall be coned for protection and indication th
approach in the area of each cone. When the aircraft is safe to approach, hea
shall be placed one metre in front of each engine, one metre from the furthes
wingtip and behind the aircraft in all weather conditions. On General Aviation
additional cone may be placed at the nose of the aircraft.

GROUND OPERATIONS MANUAL

LTN SAFETY STACK GOM6

Actions Prior to Arrival

Before the arrival of an aircraft on stand, a responsible person must:

(a) Conduct FOD check on entire stand removing all debris just prior to arrival.
(b) Make sure the stand surface condition is sufficiently free of ice, snow, etc., to ensure safe aircraft movement.
(c) Make sure all required Ground Support Equipment (GSE) is available and serviceable, and is positioned well clear of the aircraft path, inside marked equipment bays.
(d) Make sure the aircraft path and ramp area is free of persons, objects and obstacles which the aircraft may strike or endanger others due to jet blast effects.
(e) Make sure marshalling staff is present.
(f) Make sure additional ground personnel (such as wing walkers) are present (if required).

Aircraft must not be marshalled onto stand before these actions are completed.

In order to ensure that critical areas of the stand are clear of FOD and other contamination, the inspection path indicated on the drawing below should be followed.

London Luton Airport

GHOST

Civil Aviation Authority

easyJet

Menzies AVIATION

generation easyJet

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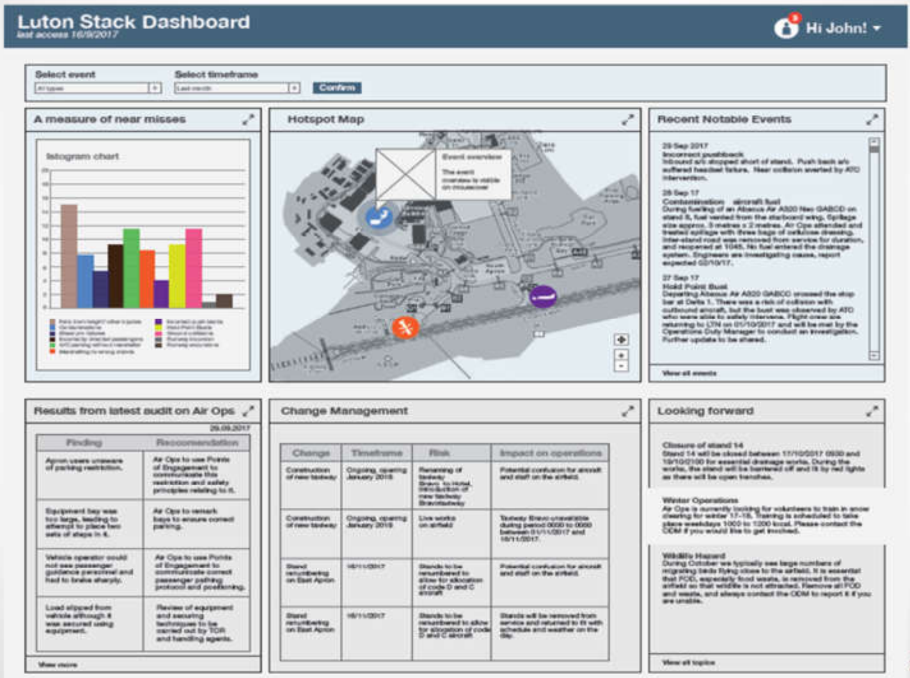
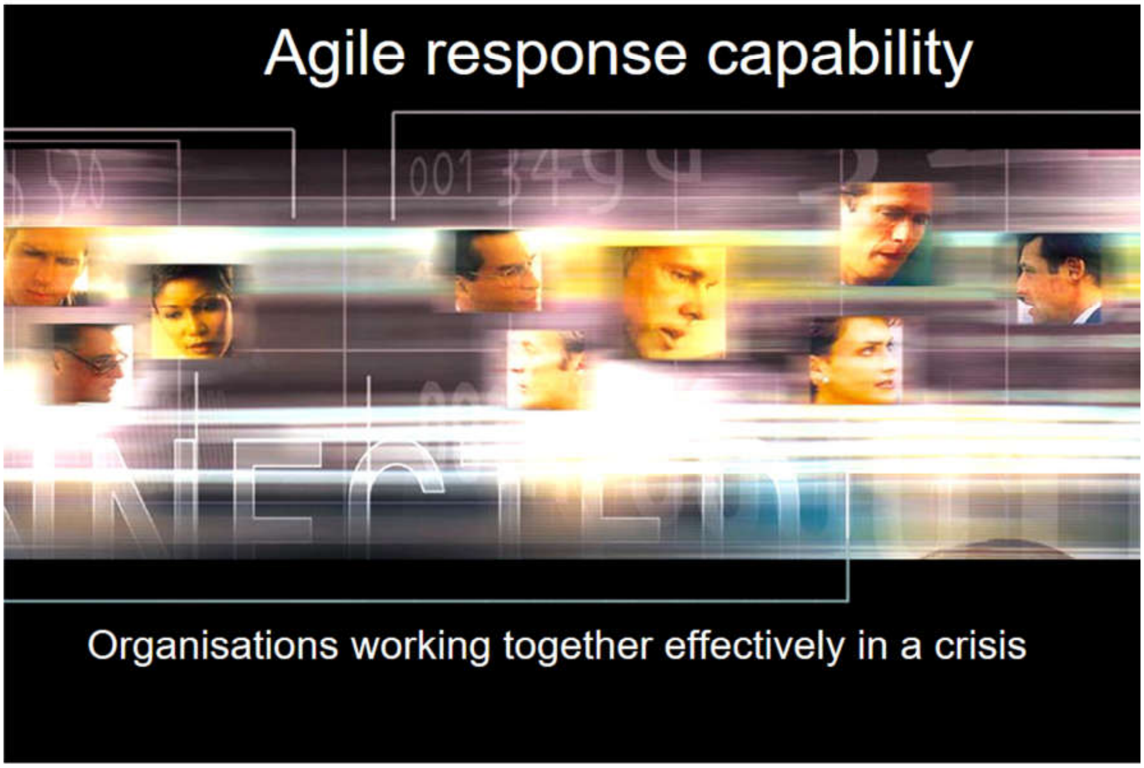
Development of a LTN Safety Stack Dashboard

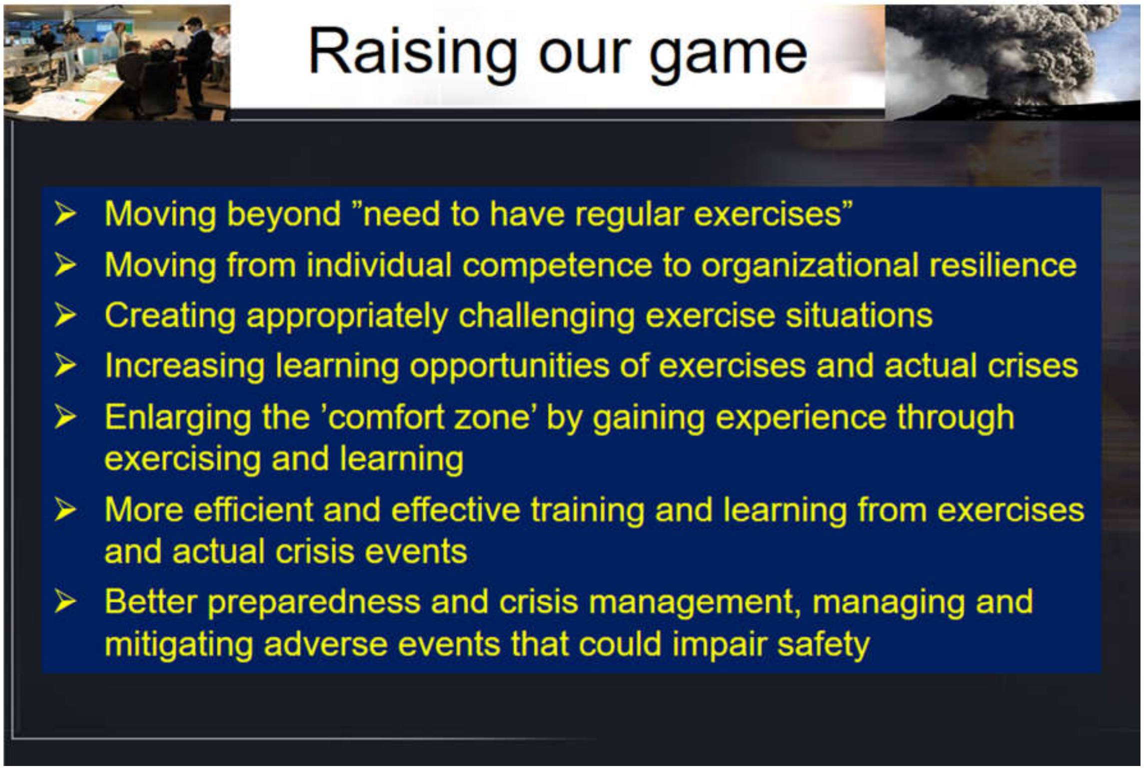


Guess what we’re going to do next…



Agile response capability

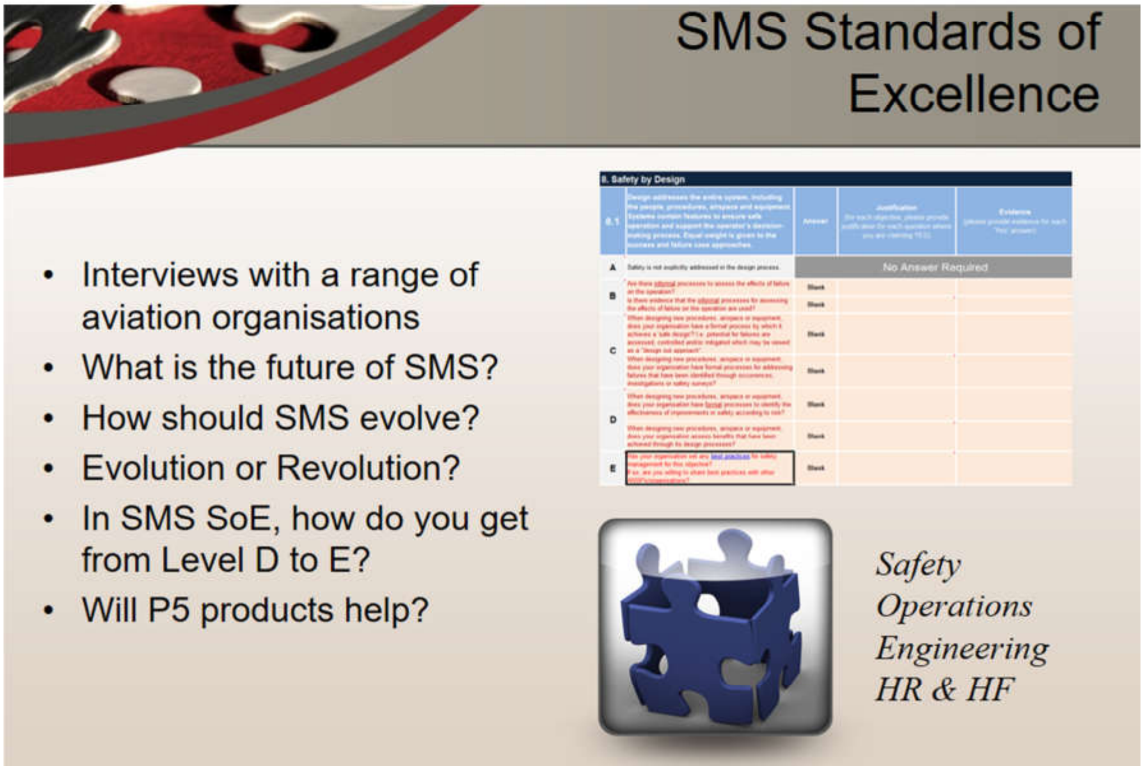
Organisations working together effectively in a crisis



Raising our game

- Moving beyond ”need to have regular exercises”
- Moving from individual competence to organizational resilience
- Creating appropriately challenging exercise situations
- Increasing learning opportunities of exercises and actual crises
- Enlarging the ’comfort zone’ by gaining experience through exercising and learning
- More efficient and effective training and learning from exercises and actual crisis events
- Better preparedness and crisis management, managing and mitigating adverse events that could impair safety

Fitting P5 products into SMS…



SMS Standards of Excellence

- Interviews with a range of aviation organisations
- What is the future of SMS?
- How should SMS evolve?
- Evolution or Revolution?
- In SMS SoE, how do you get from Level D to E?
- Will P5 products help?

Safety
Operations
Engineering
HR & HF

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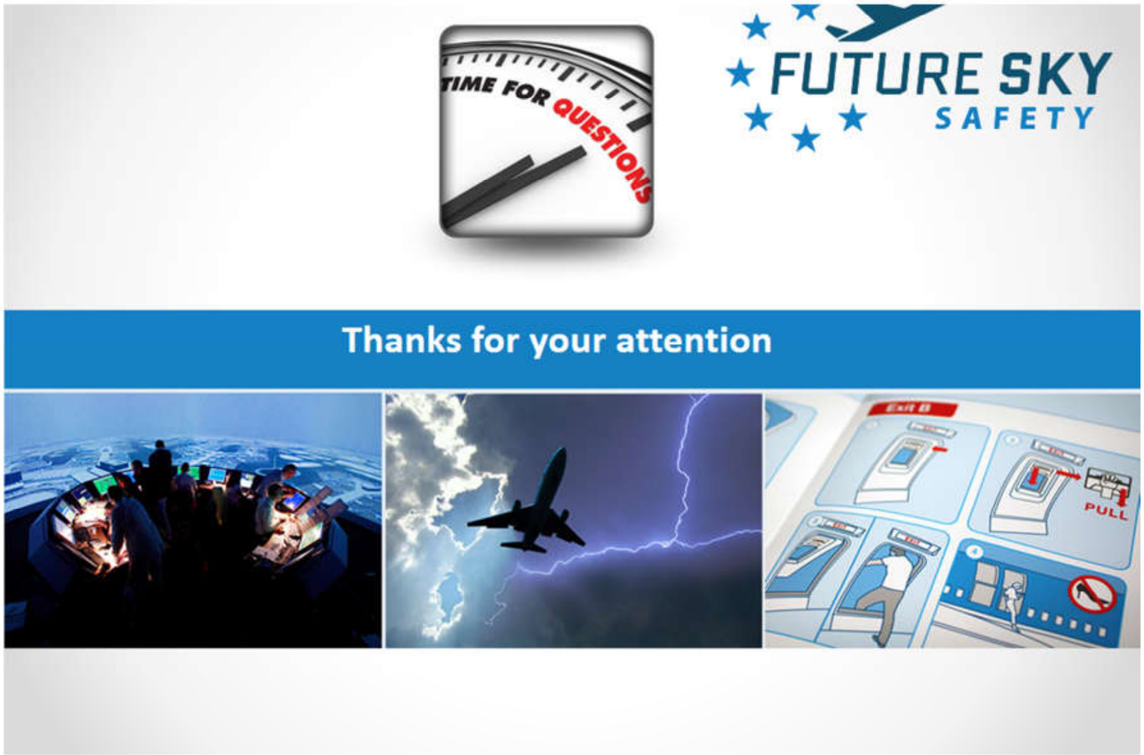
Endgame

Better ways to identify and manage organisational risks



Thanks for your attention

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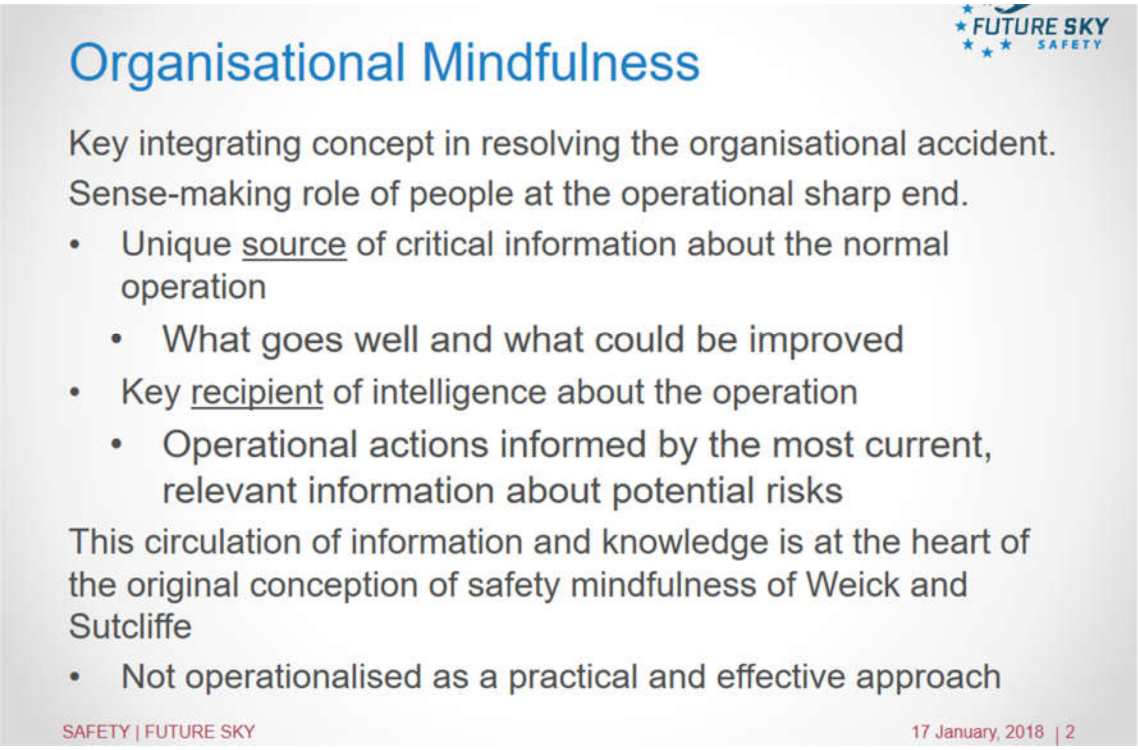
Appendix B.8 "P5: Mindful Governance in aviation. A three-year research activity and outcomes" – Nick Mc Donald, Trinity College Dublin

Mindful Governance in aviation

A three-year research activity and outcomes

Nick Mc Donald
Trinity College Dublin



Organisational Mindfulness

Key integrating concept in resolving the organisational accident.

Sense-making role of people at the operational sharp end.

- Unique source of critical information about the normal operation
  - What goes well and what could be improved
- Key recipient of intelligence about the operation
  - Operational actions informed by the most current, relevant information about potential risks

This circulation of information and knowledge is at the heart of the original conception of safety mindfulness of Weick and Sutcliffe

- Not operationalised as a practical and effective approach

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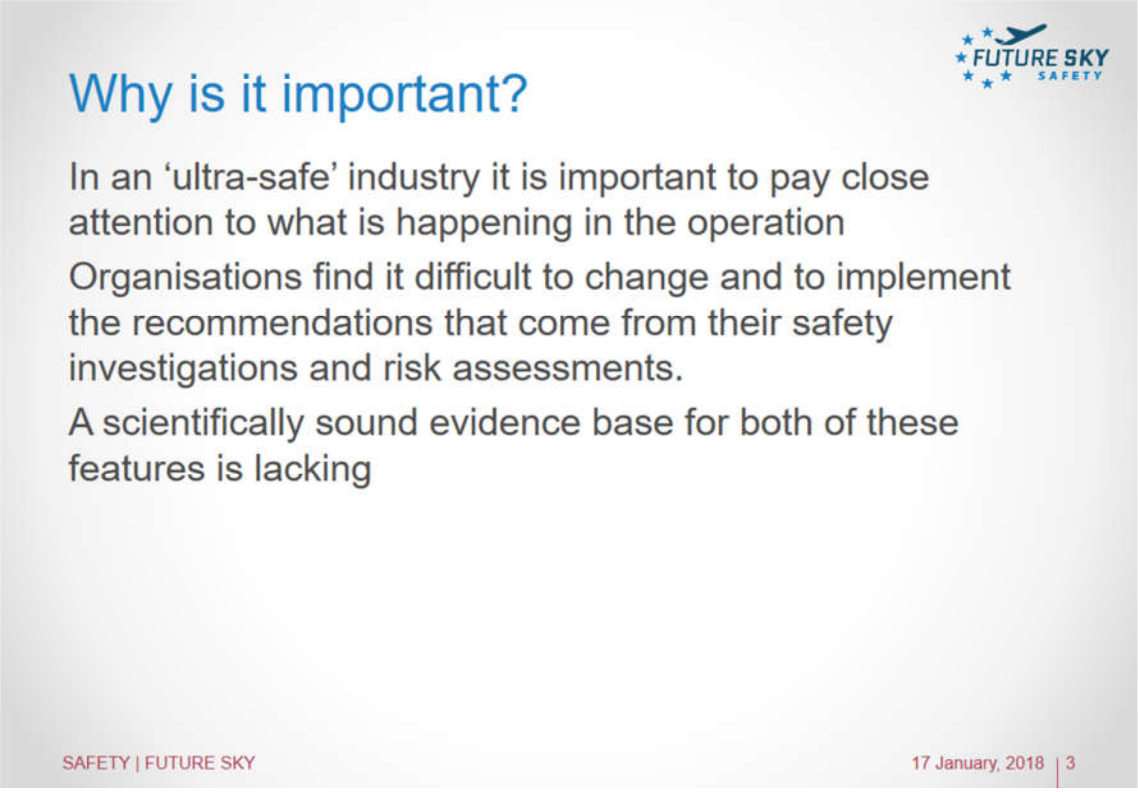


Why is it important?

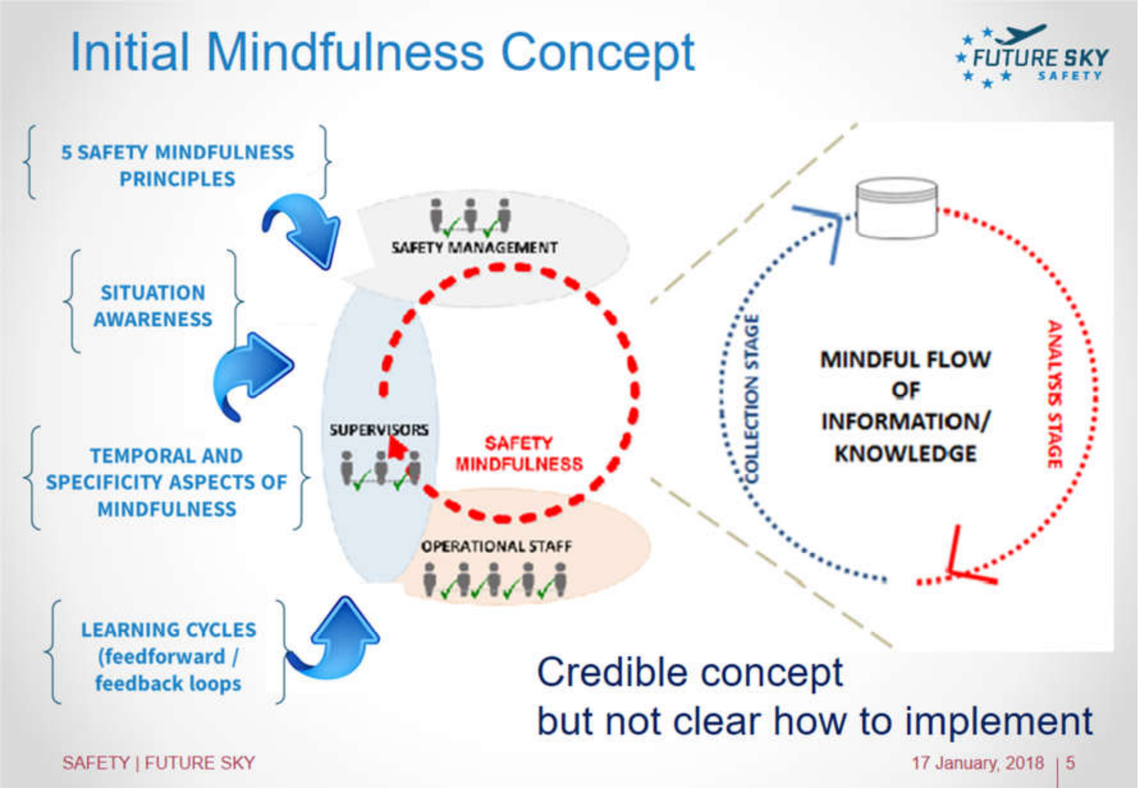
In an 'ultra-safe' industry it is important to pay close attention to what is happening in the operation

Organisations find it difficult to change and to implement the recommendations that come from their safety investigations and risk assessments.

A scientifically sound evidence base for both of these features is lacking

Evolution of the Concept

• • •



Initial Mindfulness Concept

5 SAFETY MINDFULNESS PRINCIPLES

SITUATION AWARENESS

TEMPORAL AND SPECIFICITY ASPECTS OF MINDFULNESS

LEARNING CYCLES (feedforward / feedback loops)

Credible concept
but not clear how to implement

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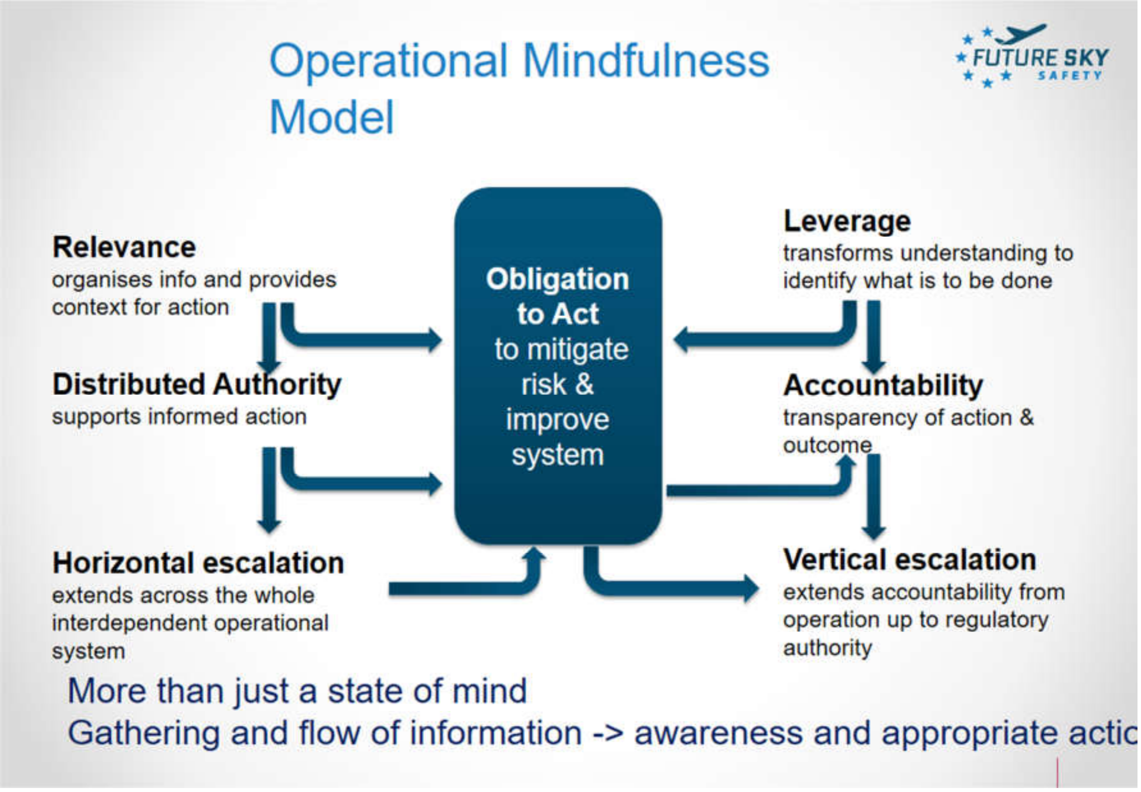


Operational Mindfulness Model

Relevance
organises info and provides context for action

Distributed Authority
supports informed action

Horizontal escalation
extends across the whole interdependent operational system

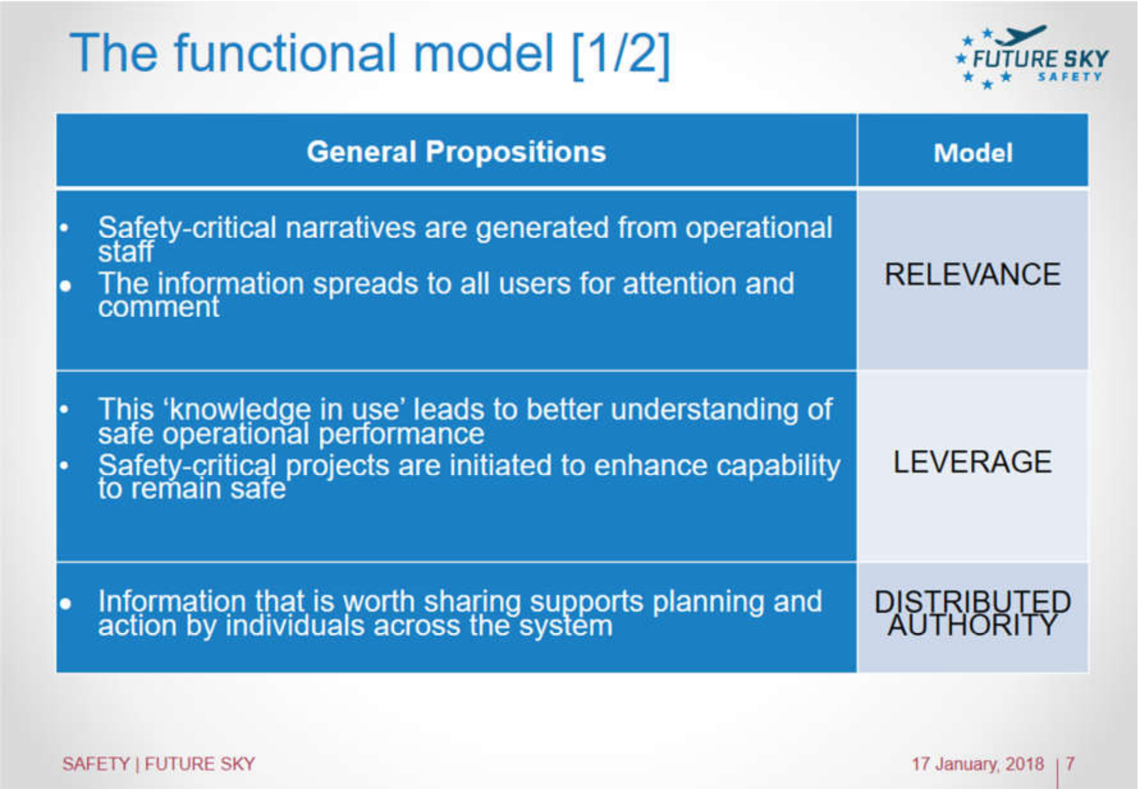
Obligation to Act
to mitigate risk & improve system

Leverage
transforms understanding to identify what is to be done

Accountability
transparency of action & outcome

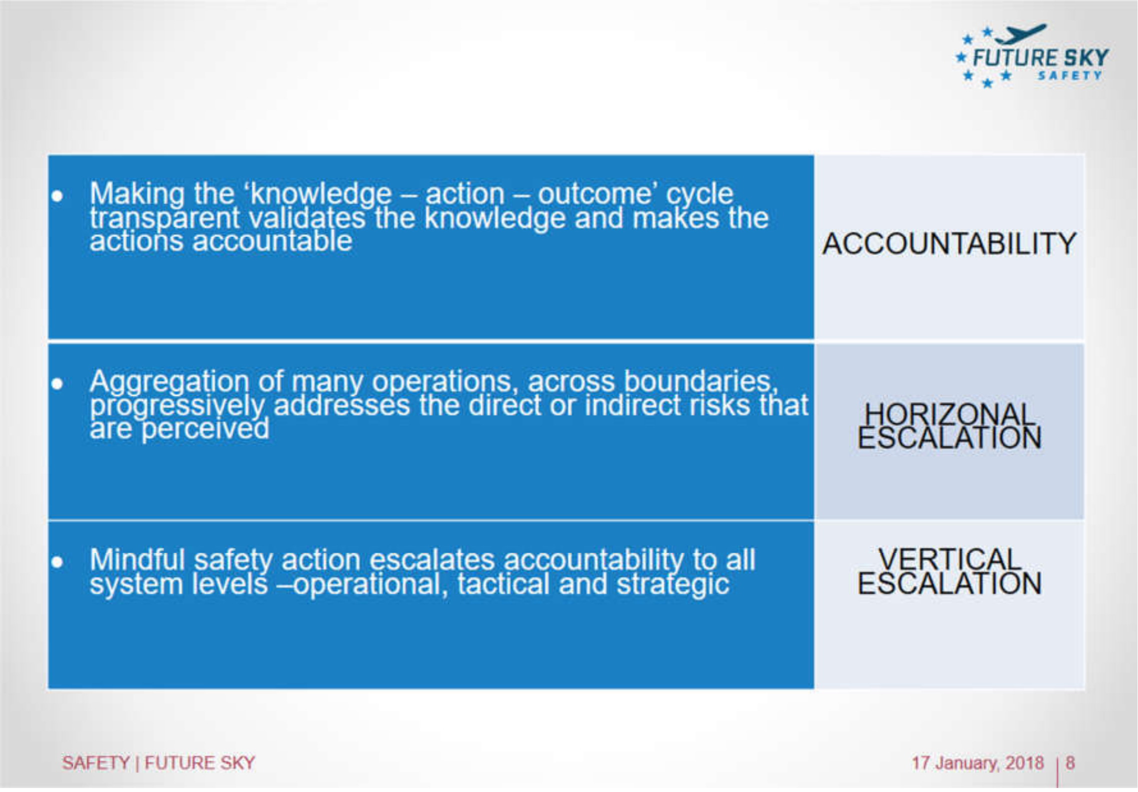
Vertical escalation
extends accountability from operation up to regulatory authority

More than just a state of mind
Gathering and flow of information -> awareness and appropriate actic

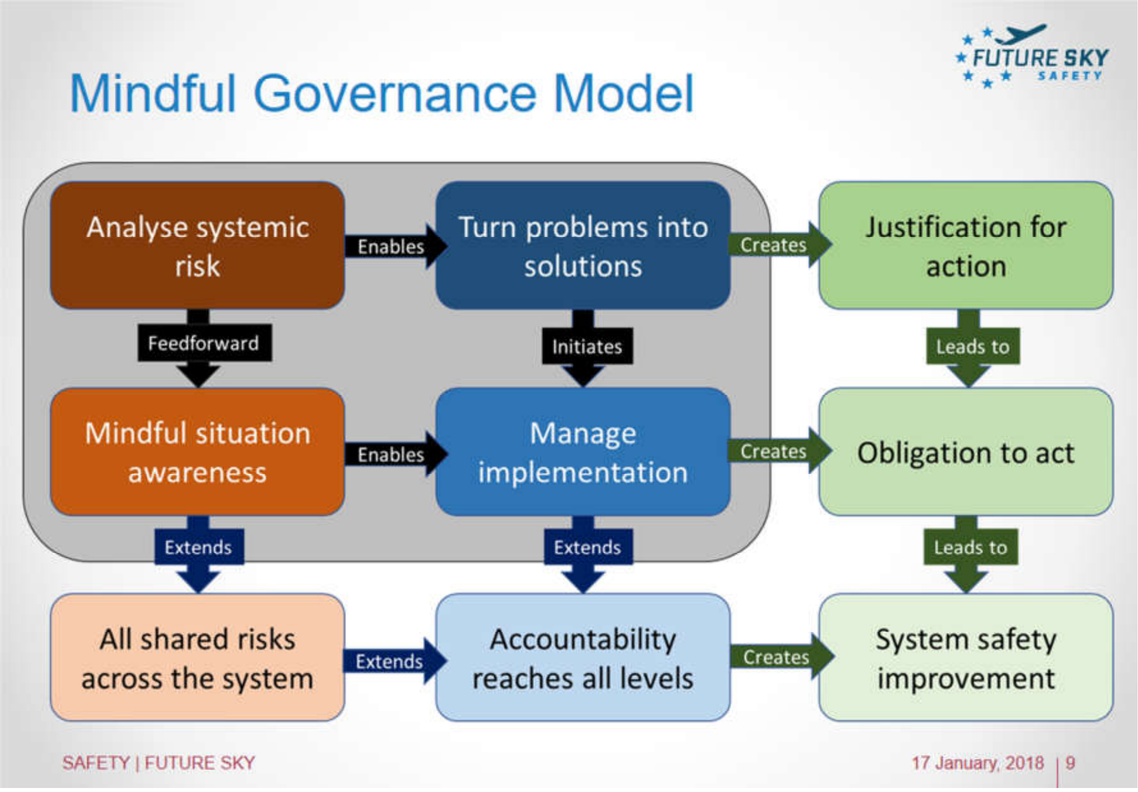


The functional model [1/2]

General Propositions	Model
• Safety-critical narratives are generated from operational staff • The information spreads to all users for attention and comment	RELEVANCE
• This 'knowledge in use' leads to better understanding of safe operational performance • Safety-critical projects are initiated to enhance capability to remain safe	LEVERAGE
• Information that is worth sharing supports planning and action by individuals across the system	DISTRIBUTED AUTHORITY



• Making the 'knowledge – action – outcome' cycle transparent validates the knowledge and makes the actions accountable	ACCOUNTABILITY
• Aggregation of many operations, across boundaries, progressively addresses the direct or indirect risks that are perceived	HORIZONAL ESCALATION
• Mindful safety action escalates accountability to all system levels –operational, tactical and strategic	VERTICAL ESCALATION



Mindful Governance Model

Analyse systemic risk —Enables→ Turn problems into solutions —Creates→ Justification for action

Analyse systemic risk —Feedforward→ Mindful situation awareness

Turn problems into solutions —Initiates→ Manage implementation

Justification for action —Leads to→ Obligation to act

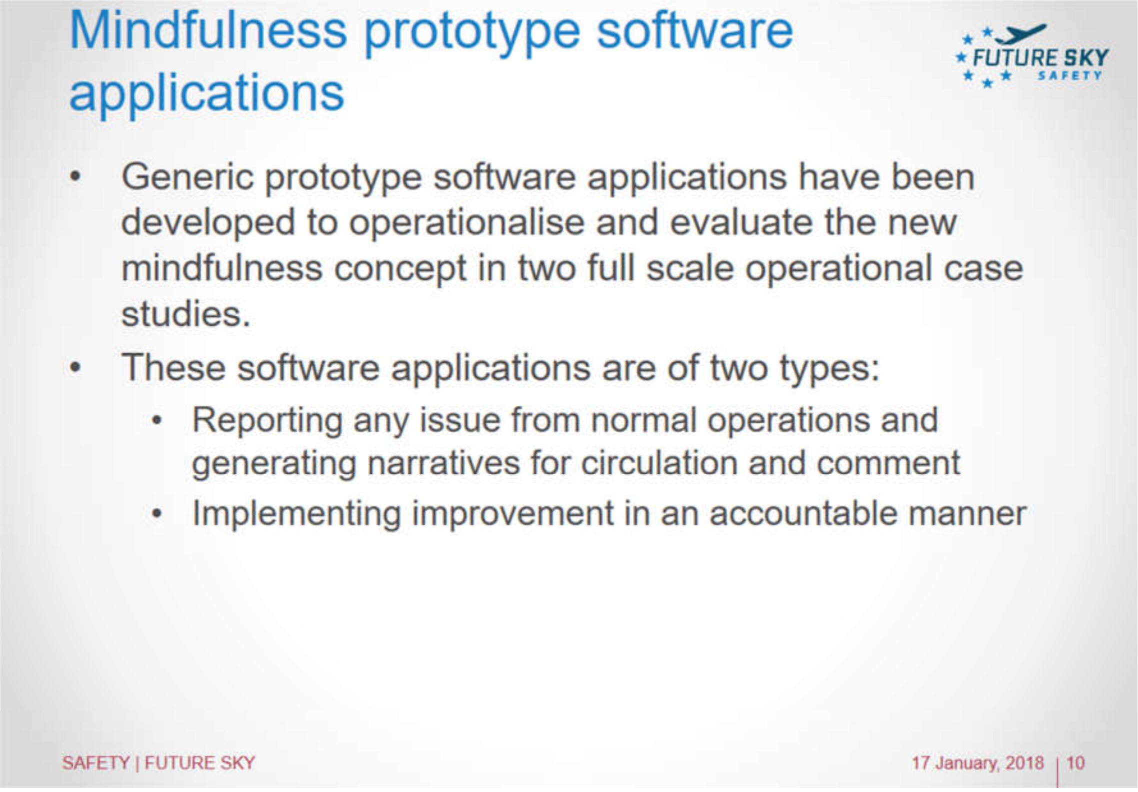
Mindful situation awareness —Enables→ Manage implementation —Creates→ Obligation to act

Mindful situation awareness —Extends→ All shared risks across the system

Manage implementation —Extends→ Accountability reaches all levels

Obligation to act —Leads to→ System safety improvement

All shared risks across the system —Extends→ Accountability reaches all levels —Creates→ System safety improvement



Mindfulness prototype software applications

- Generic prototype software applications have been developed to operationalise and evaluate the new mindfulness concept in two full scale operational case studies.
- These software applications are of two types:
  - Reporting any issue from normal operations and generating narratives for circulation and comment
  - Implementing improvement in an accountable manner

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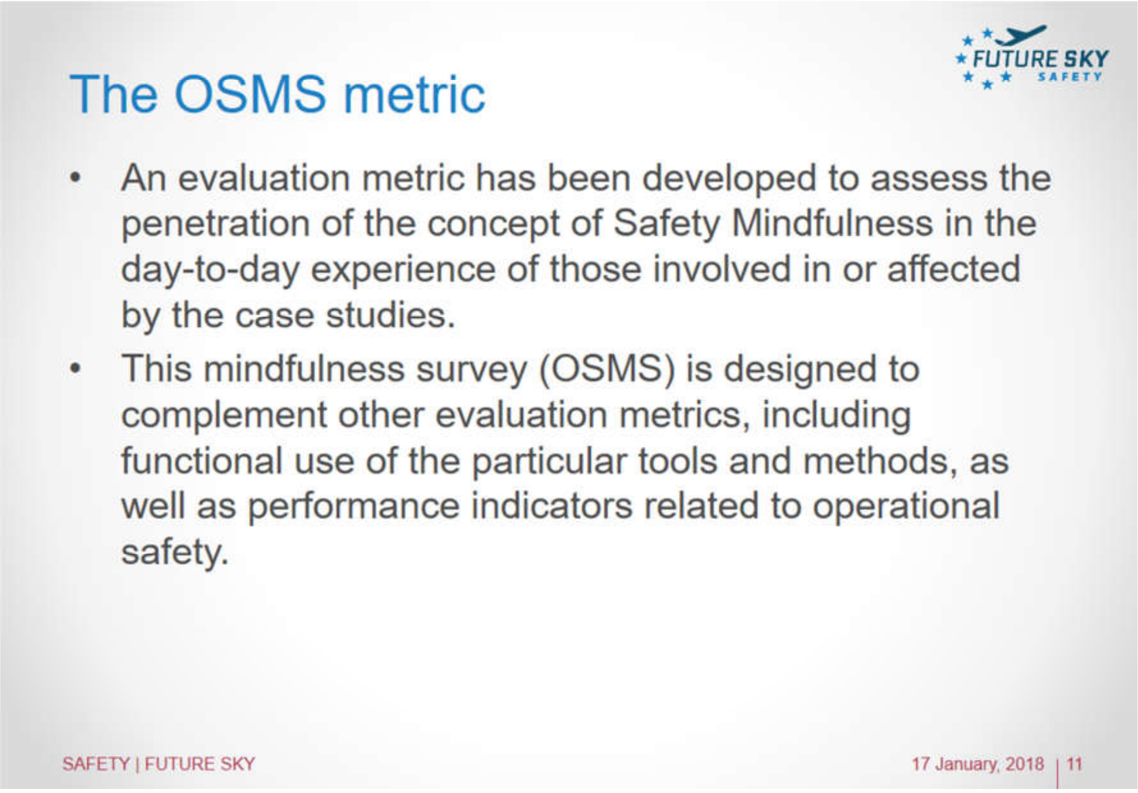
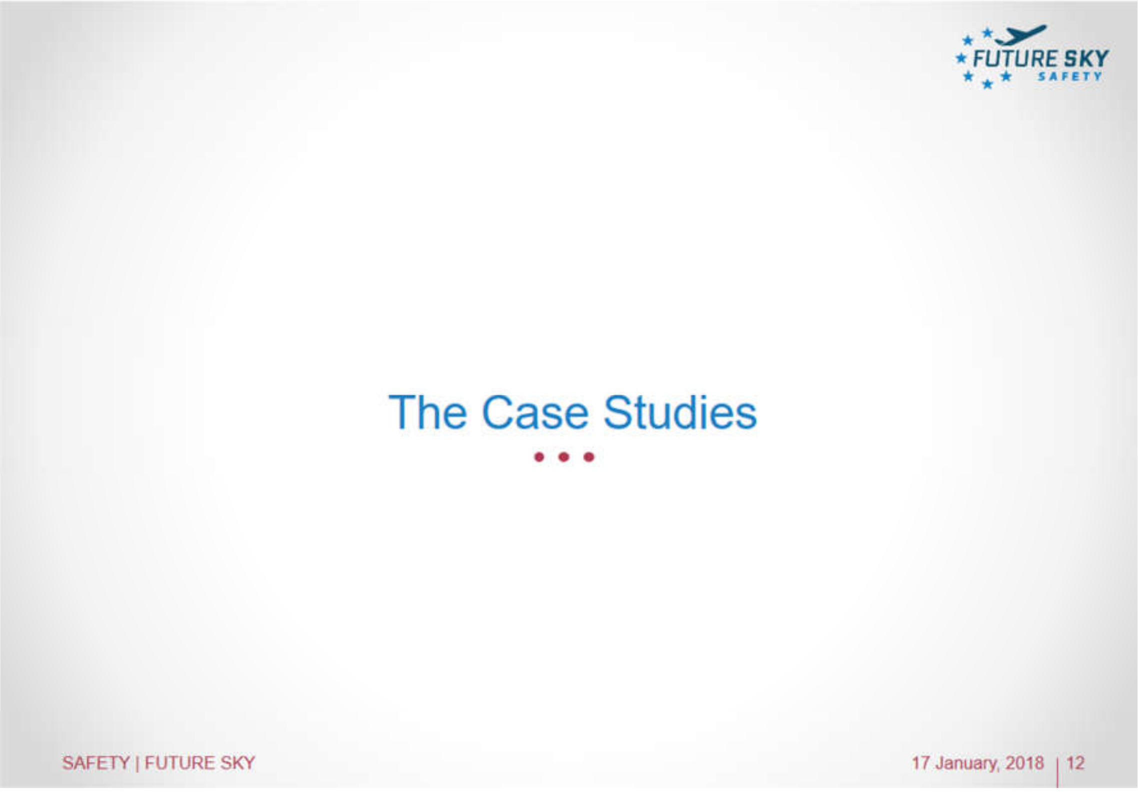


The OSMS metric

- An evaluation metric has been developed to assess the penetration of the concept of Safety Mindfulness in the day-to-day experience of those involved in or affected by the case studies.
- This mindfulness survey (OSMS) is designed to complement other evaluation metrics, including functional use of the particular tools and methods, as well as performance indicators related to operational safety.



The Case Studies

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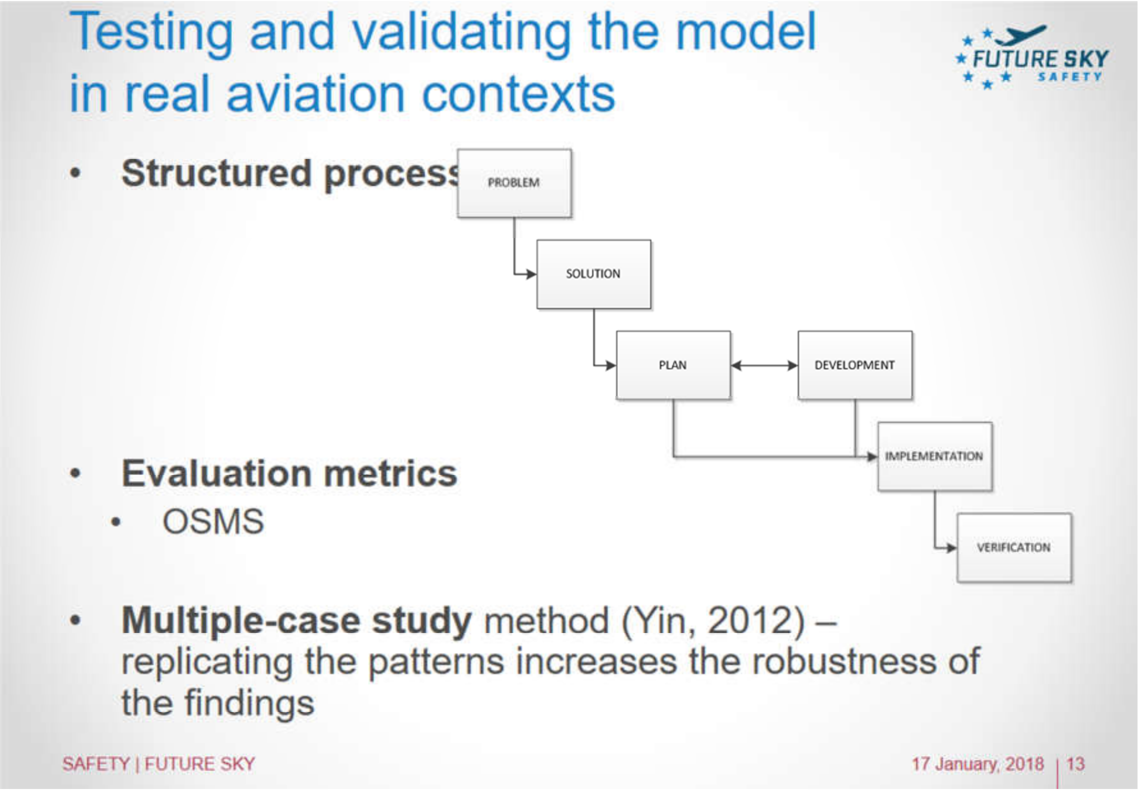
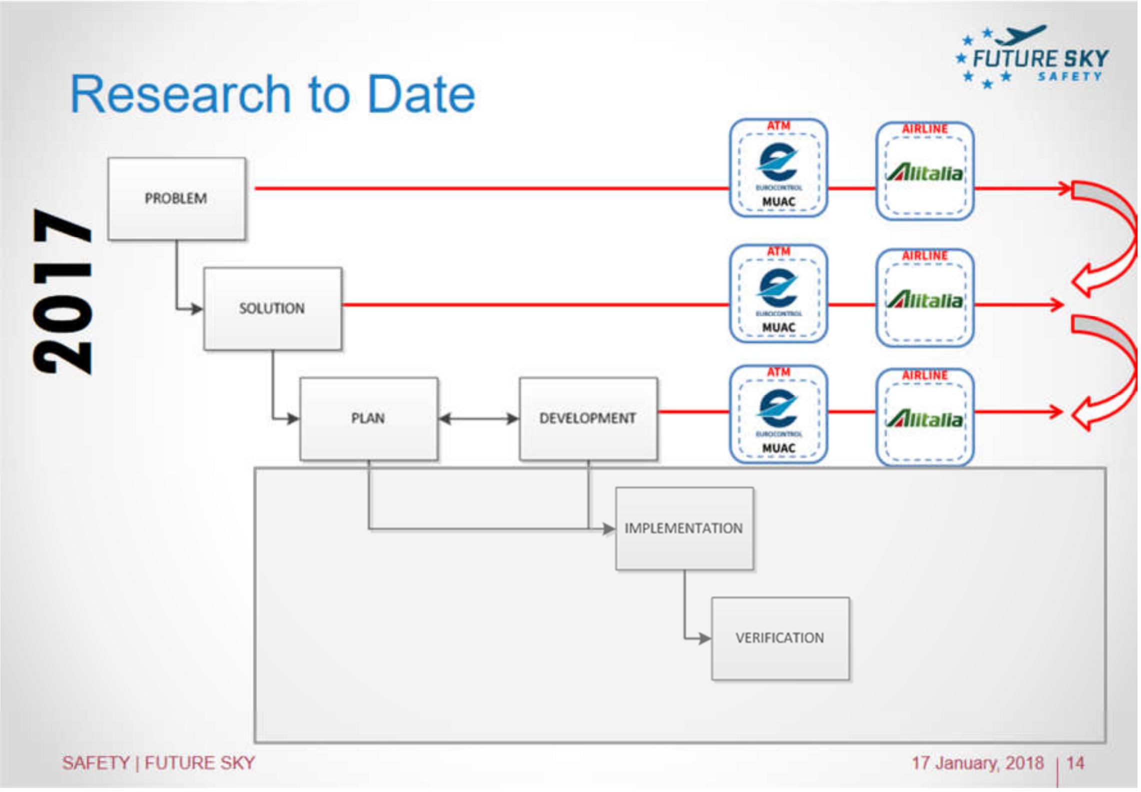
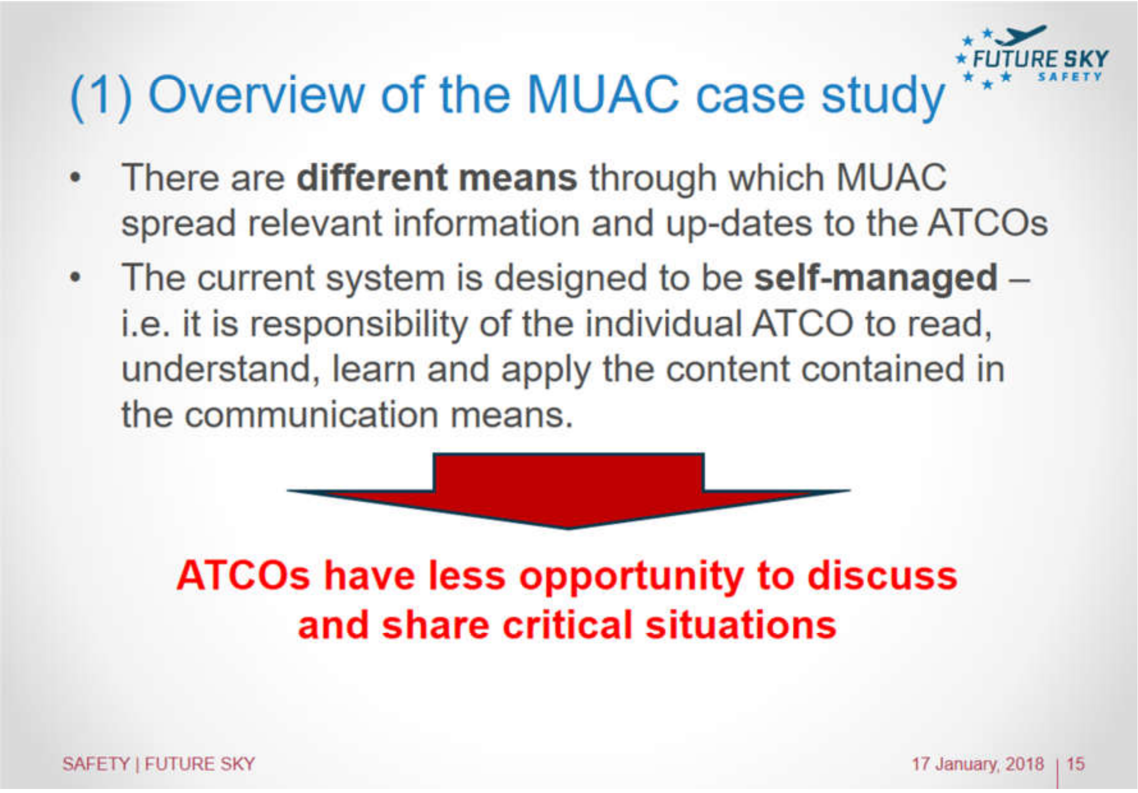


Testing and validating the model in real aviation contexts

- **Structured process**
- **Evaluation metrics**
  - OSMS
- **Multiple-case study** method (Yin, 2012) – replicating the patterns increases the robustness of the findings



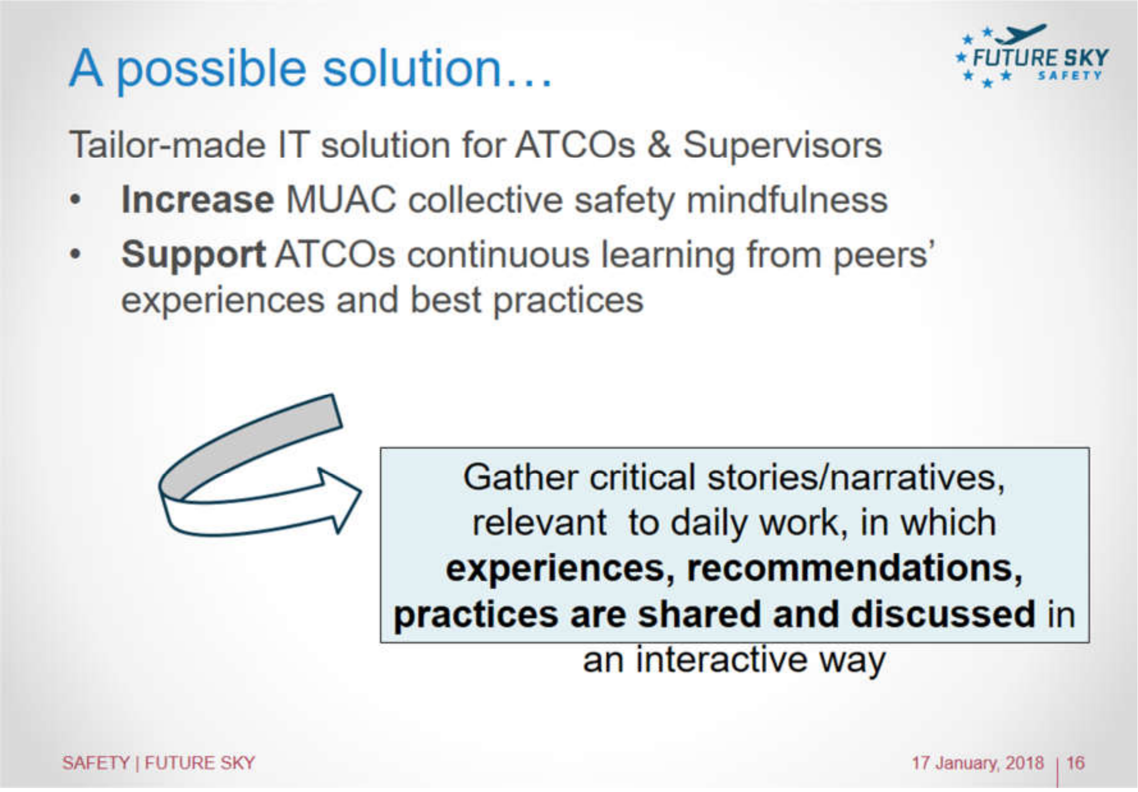
Research to Date



(1) Overview of the MUAC case study

- There are **different means** through which MUAC spread relevant information and up-dates to the ATCOs
- The current system is designed to be **self-managed** – i.e. it is responsibility of the individual ATCO to read, understand, learn and apply the content contained in the communication means.

ATCOs have less opportunity to discuss and share critical situations



A possible solution…

Tailor-made IT solution for ATCOs & Supervisors

- **Increase** MUAC collective safety mindfulness
- **Support** ATCOs continuous learning from peers' experiences and best practices

Gather critical stories/narratives, relevant to daily work, in which **experiences, recommendations, practices are shared and discussed** in an interactive way

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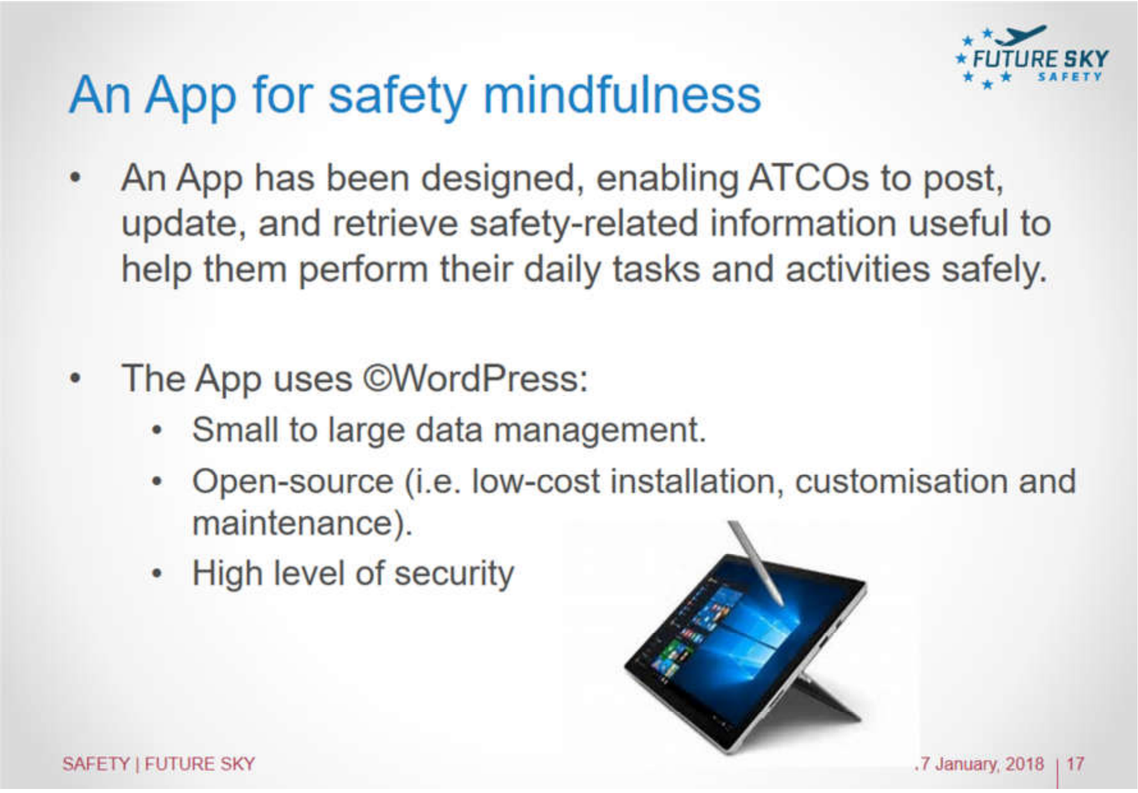
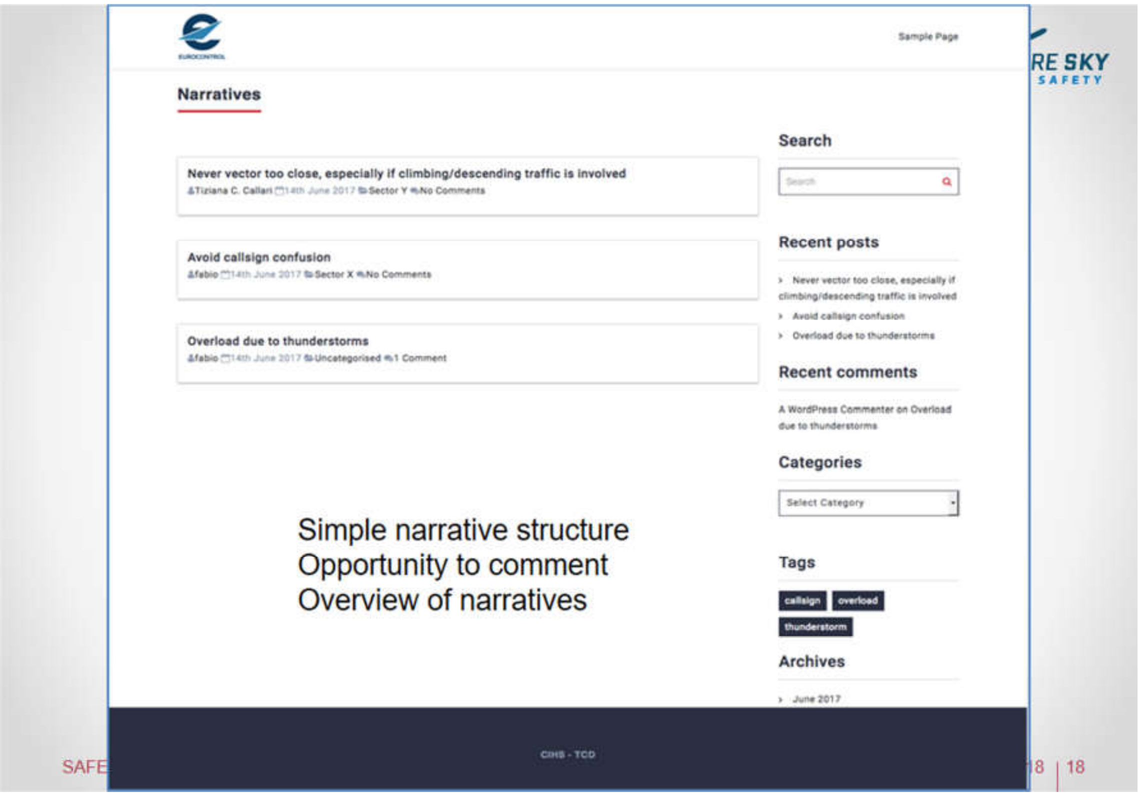


An App for safety mindfulness

- An App has been designed, enabling ATCOs to post, update, and retrieve safety-related information useful to help them perform their daily tasks and activities safely.
- The App uses ©WordPress:
  - Small to large data management.
  - Open-source (i.e. low-cost installation, customisation and maintenance).
  - High level of security



Narratives

Never vector too close, especially if climbing/descending traffic is involved
Tiziana C. Callari 14th June 2017 Sector Y No Comments

Avoid callsign confusion
fabio 14th June 2017 Sector X No Comments

Overload due to thunderstorms
fabio 14th June 2017 Uncategorised 1 Comment

Search

Recent posts

- Never vector too close, especially if climbing/descending traffic is involved
- Avoid callsign confusion
- Overload due to thunderstorms

Recent comments

A WordPress Commenter on Overload due to thunderstorms

Categories

Tags

Archives

- June 2017

Simple narrative structure
Opportunity to comment
Overview of narratives

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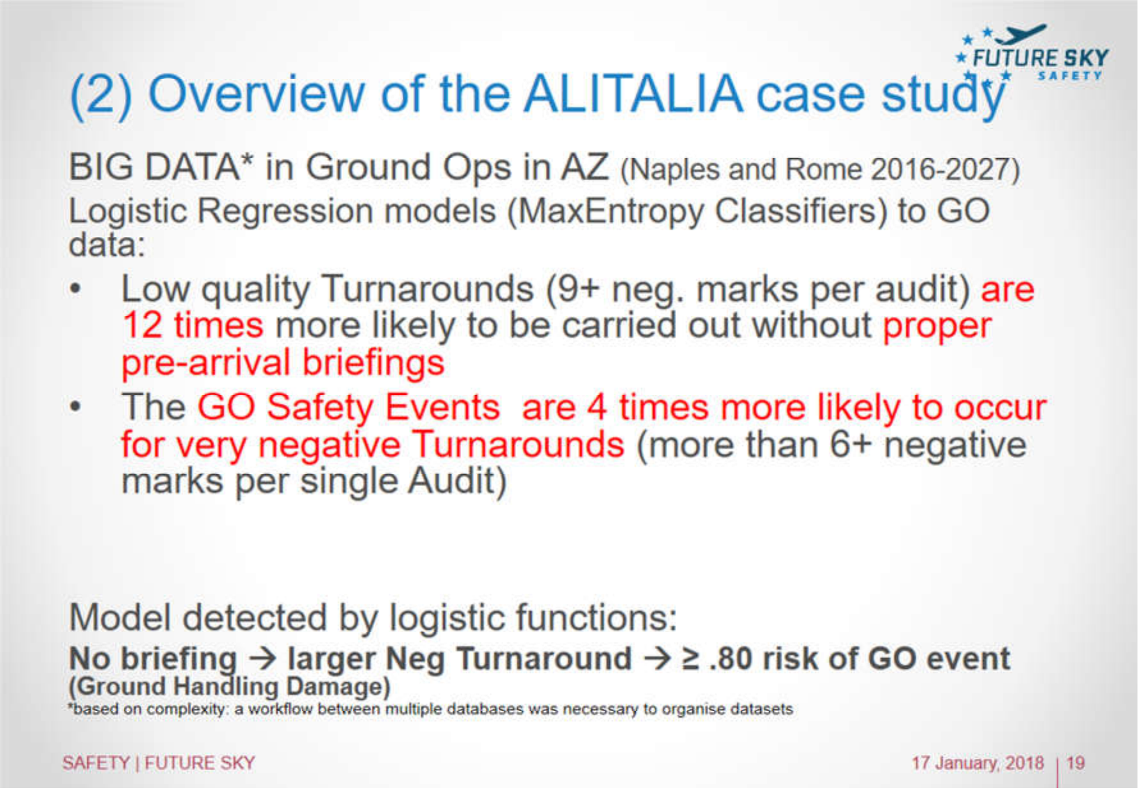


(2) Overview of the ALITALIA case study

BIG DATA* in Ground Ops in AZ (Naples and Rome 2016-2027)

Logistic Regression models (MaxEntropy Classifiers) to GO data:

- Low quality Turnarounds (9+ neg. marks per audit) are 12 times more likely to be carried out without proper pre-arrival briefings
- The GO Safety Events are 4 times more likely to occur for very negative Turnarounds (more than 6+ negative marks per single Audit)

Model detected by logistic functions:

No briefing → larger Neg Turnaround → ≥ .80 risk of GO event (Ground Handling Damage)

*based on complexity: a workflow between multiple databases was necessary to organise datasets

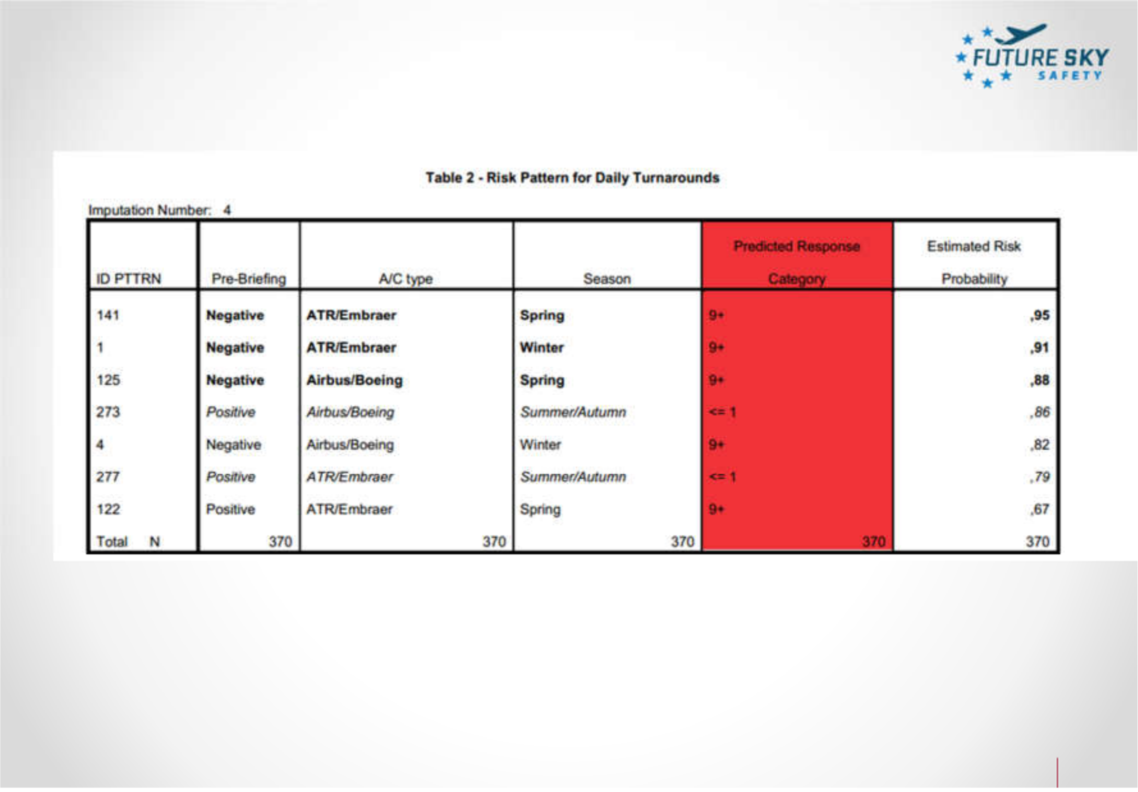


Table 2 - Risk Pattern for Daily Turnarounds

Imputation Number: 4

ID PTTRN	Pre-Briefing	A/C type	Season	Predicted Response Category	Estimated Risk Probability
141	**Negative**	**ATR/Embraer**	**Spring**	9+	**,95**
1	**Negative**	**ATR/Embraer**	**Winter**	9+	**,91**
125	**Negative**	**Airbus/Boeing**	**Spring**	9+	**,88**
273	*Positive*	*Airbus/Boeing*	*Summer/Autumn*	<= 1	*,86*
4	Negative	Airbus/Boeing	Winter	9+	,82
277	*Positive*	*ATR/Embraer*	*Summer/Autumn*	<= 1	*,79*
122	Positive	ATR/Embraer	Spring	9+	,67
Total N	370	370	370	370	370

GO to implement change program in 2018

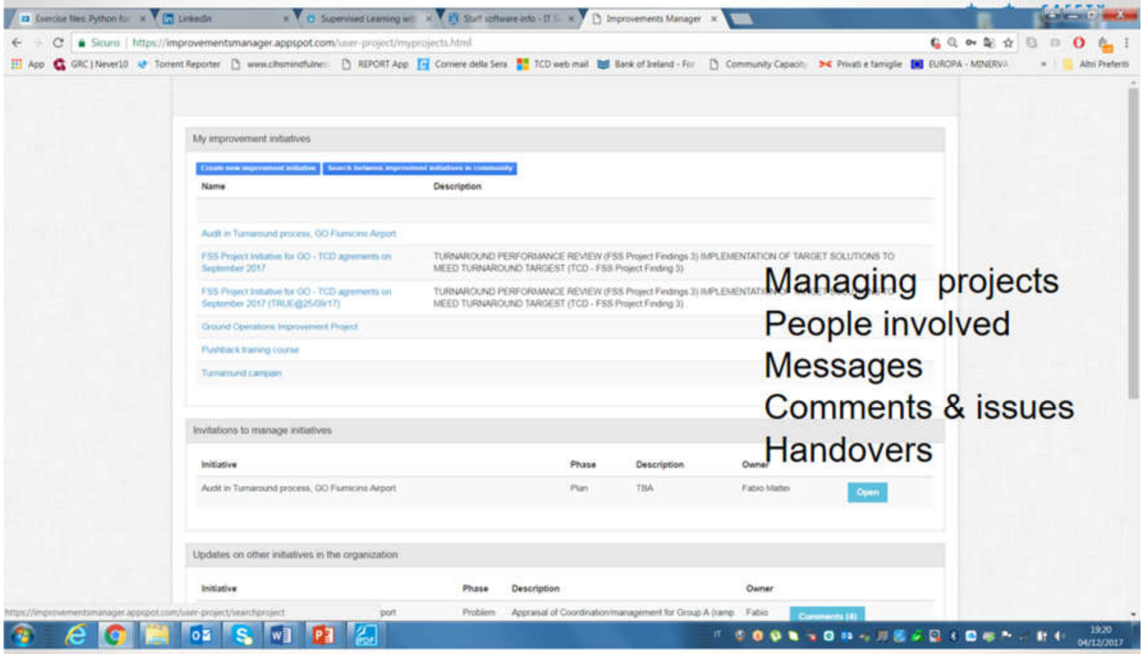
TCD software: Improvement Manager

TCD software: Torrent Reporting

- Focus Groups in December 2017 / January 2018 on pre-briefing and first phases of Turnaround
- Turnaround Safety Bulletins
- Assess need for additional training & procedural change

- Torrent Reporting (Italian version) will replace the current GSR
- Simplify monitoring of ANY GO topic (MOR and Voluntary)
- Use Audio reporting to speed up process

- Change metrics
  - Usability, OSMS, audit findings, safety outcomes



My improvement initiatives

Name	Description
Audit in Turnaround process, GO Fiumicino Airport	
FSS Project Initiative for GO - TCD agreements on September 2017	TURNAROUND PERFORMANCE REVIEW (FSS Project Findings 3) IMPLEMENTATION OF TARGET SOLUTIONS TO MEED TURNAROUND TARGEST (TCD - FSS Project Finding 3)
FSS Project Initiative for GO - TCD agreements on September 2017 (TRUE@25/09/17)	TURNAROUND PERFORMANCE REVIEW (FSS Project Findings 3) IMPLEMENTATI[illegible] MEED TURNAROUND TARGEST (TCD - FSS Project Finding 3)
Ground Operations Improvement Project	
Pushback training course	
Turnaround campain	

Invitations to manage initiatives

Initiative	Phase	Description	Owner	
Audit in Turnaround process, GO Fiumicino Airport	Plan	TBA	Fabio Mattei	Open

Updates on other initiatives in the organization

Initiative	Phase	Description	Owner	
port	Problem	Appraisal of Coordination/management for Group A (ramp	Fabio	Comments (4)

Managing projects
People involved
Messages
Comments & issues
Handovers

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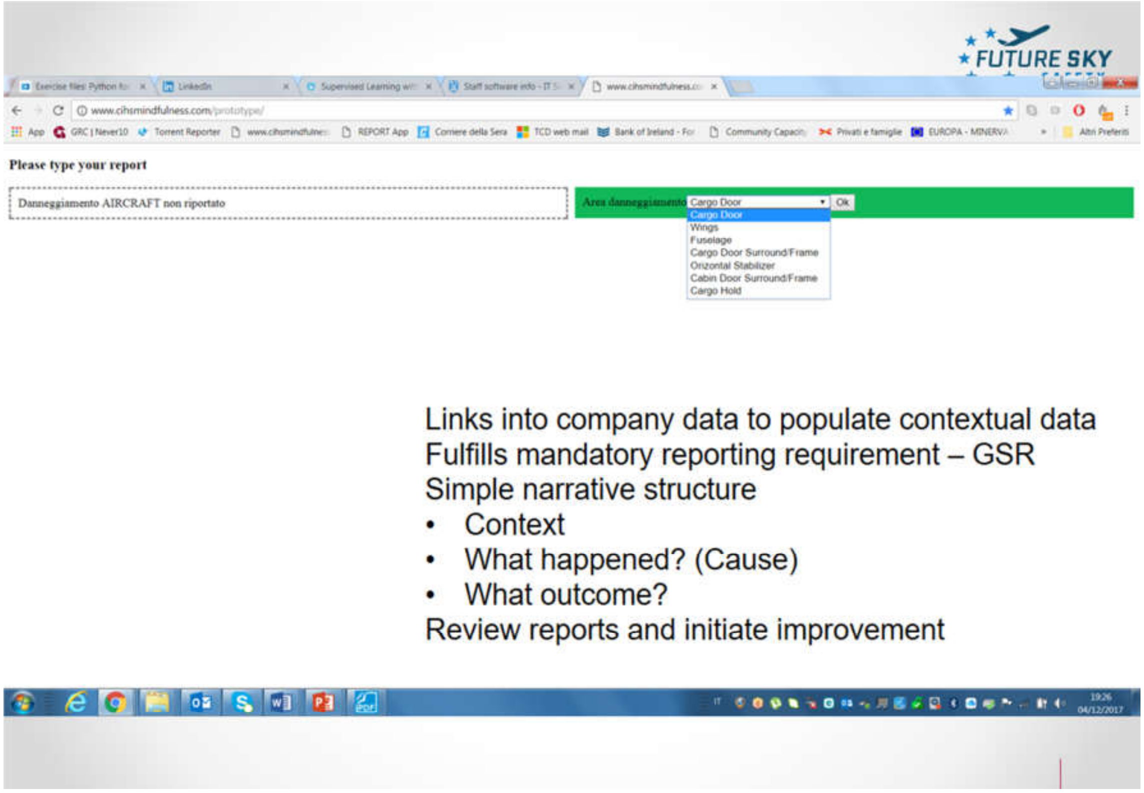


Please type your report

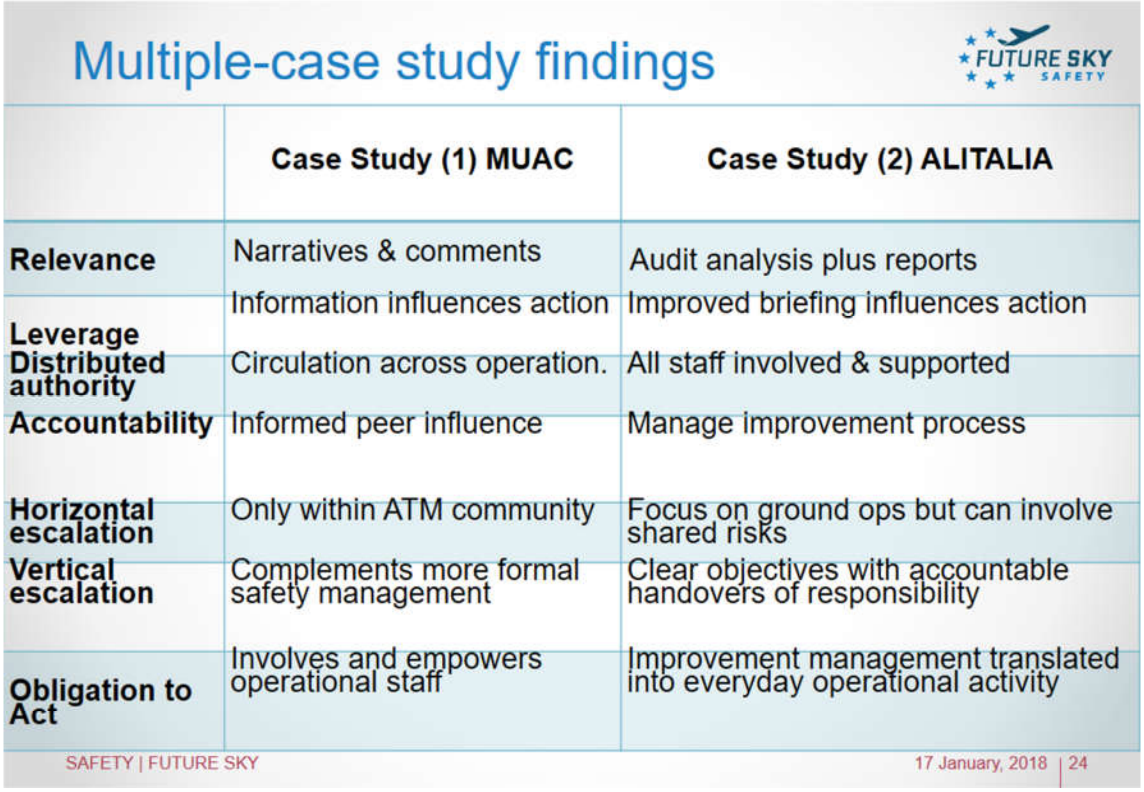
Danneggiamento AIRCRAFT non riportato

Area danneggiamento: Cargo Door

Links into company data to populate contextual data
Fulfills mandatory reporting requirement – GSR
Simple narrative structure

- Context
- What happened? (Cause)
- What outcome?

Review reports and initiate improvement



Multiple-case study findings

	Case Study (1) MUAC	Case Study (2) ALITALIA
Relevance	Narratives & comments	Audit analysis plus reports
Leverage	Information influences action	Improved briefing influences action
Distributed authority	Circulation across operation.	All staff involved & supported
Accountability	Informed peer influence	Manage improvement process
Horizontal escalation	Only within ATM community	Focus on ground ops but can involve shared risks
Vertical escalation	Complements more formal safety management	Clear objectives with accountable handovers of responsibility
Obligation to Act	Involves and empowers operational staff	Improvement management translated into everyday operational activity

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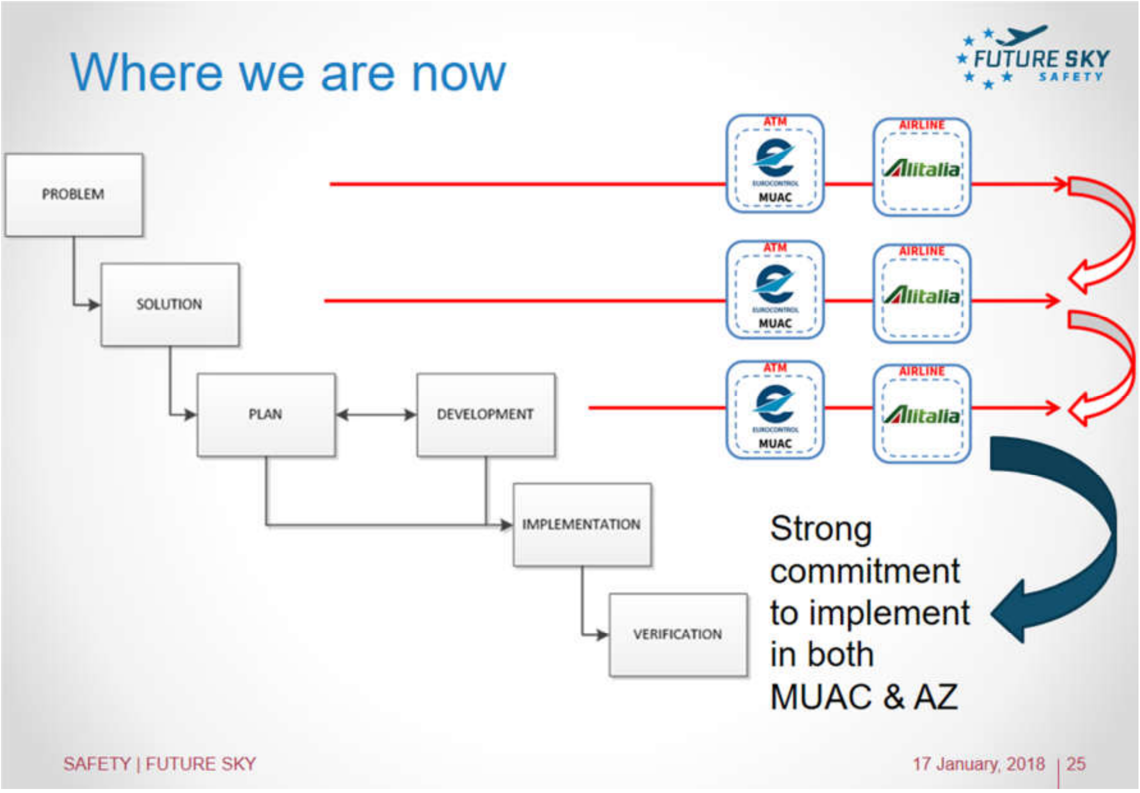
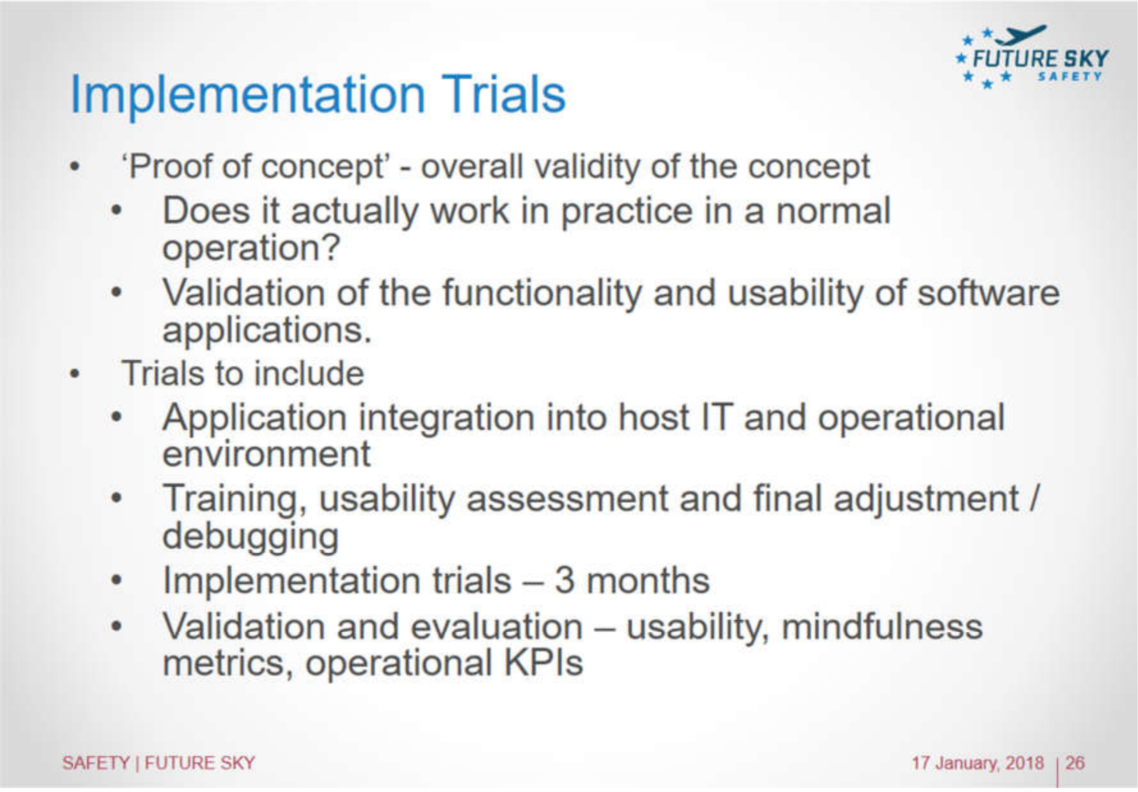


Where we are now

PROBLEM
SOLUTION
PLAN
DEVELOPMENT
IMPLEMENTATION
VERIFICATION

Strong commitment to implement in both MUAC & AZ



Implementation Trials

- 'Proof of concept' - overall validity of the concept
  - Does it actually work in practice in a normal operation?
  - Validation of the functionality and usability of software applications.
- Trials to include
  - Application integration into host IT and operational environment
  - Training, usability assessment and final adjustment / debugging
  - Implementation trials – 3 months
  - Validation and evaluation – usability, mindfulness metrics, operational KPIs

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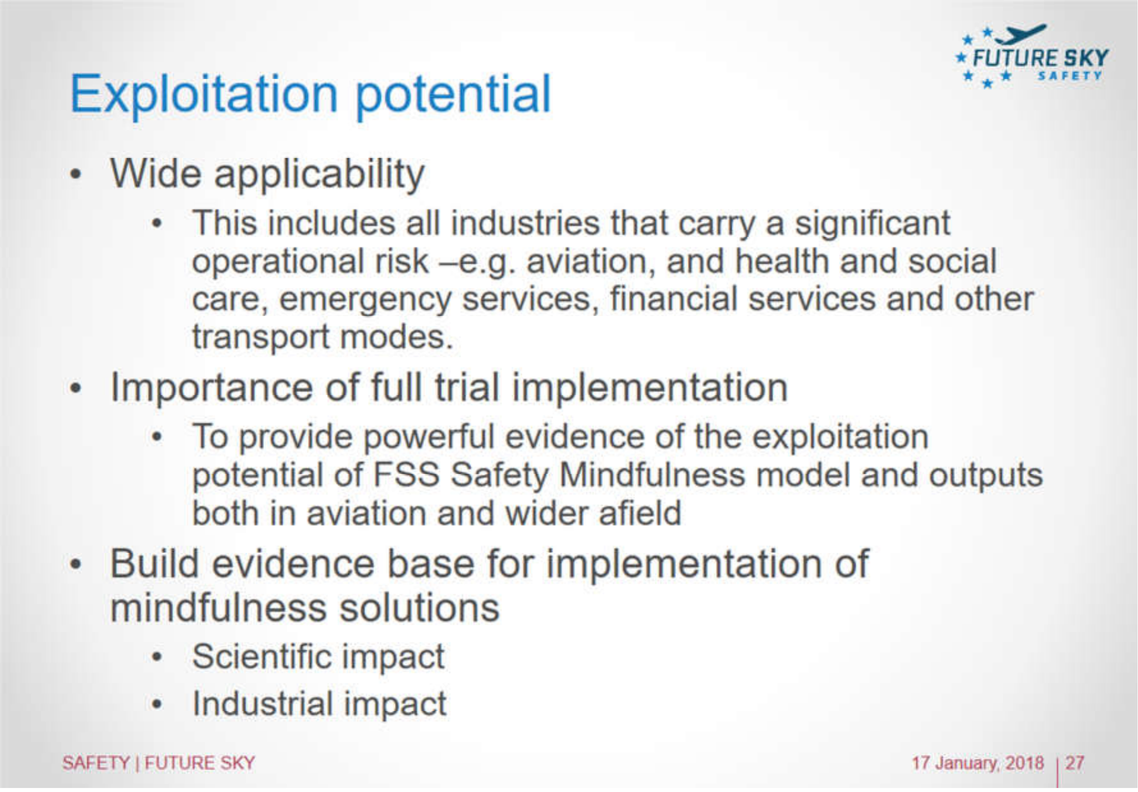

Exploitation potential

- Wide applicability
  - This includes all industries that carry a significant operational risk –e.g. aviation, and health and social care, emergency services, financial services and other transport modes.
- Importance of full trial implementation
  - To provide powerful evidence of the exploitation potential of FSS Safety Mindfulness model and outputs both in aviation and wider afield
- Build evidence base for implementation of mindfulness solutions
  - Scientific impact
  - Industrial impact

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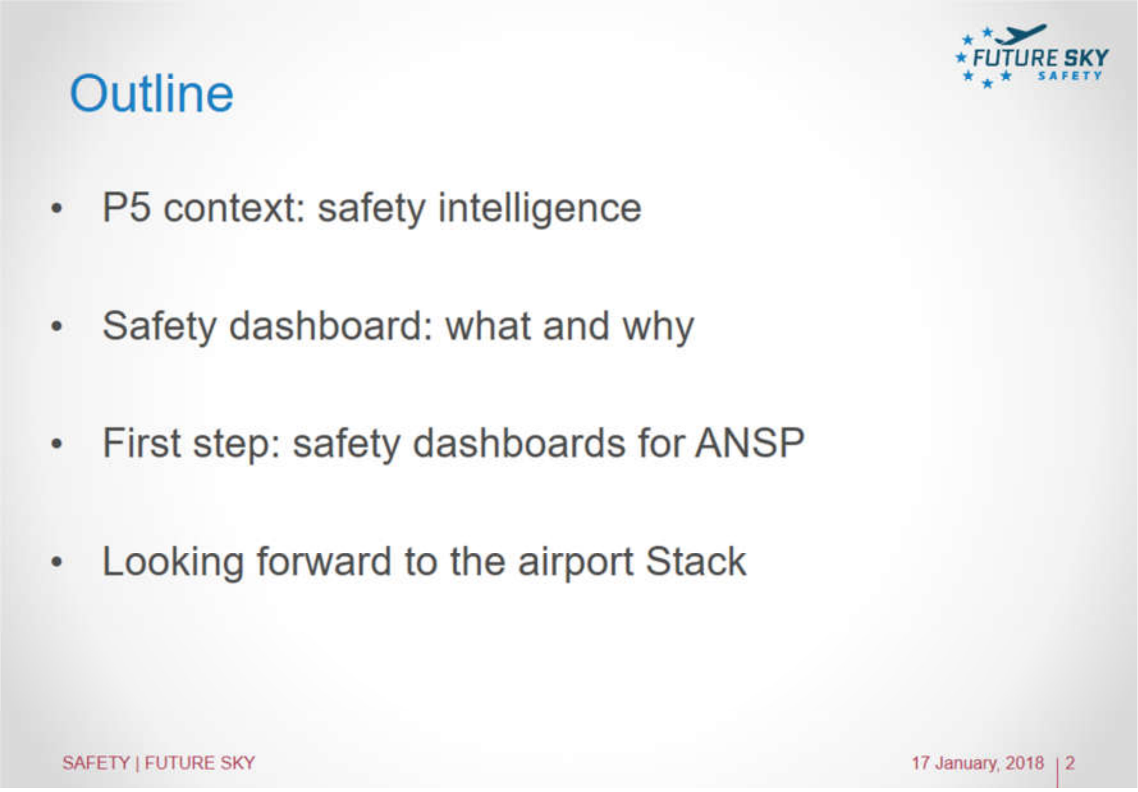
Appendix B.9 "P5: Towards an airport-wide safety dashboard" – Carlo Valbonesi, Deep Blue

Towards an airport-wide safety dashboard

Carlo VALBONESI (DBL) – 7th December 2017, Koln, DLR HQ



Outline

- P5 context: safety intelligence
- Safety dashboard: what and why
- First step: safety dashboards for ANSP
- Looking forward to the airport Stack

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P5 context: safety intelligence

Problem Solving

Safety Knowledge

Social Competence

Safety Intelligence

Figure taken from: EUROCONTROL, *Safety Intelligence for ATM CEOs - A White Paper*, May 2013

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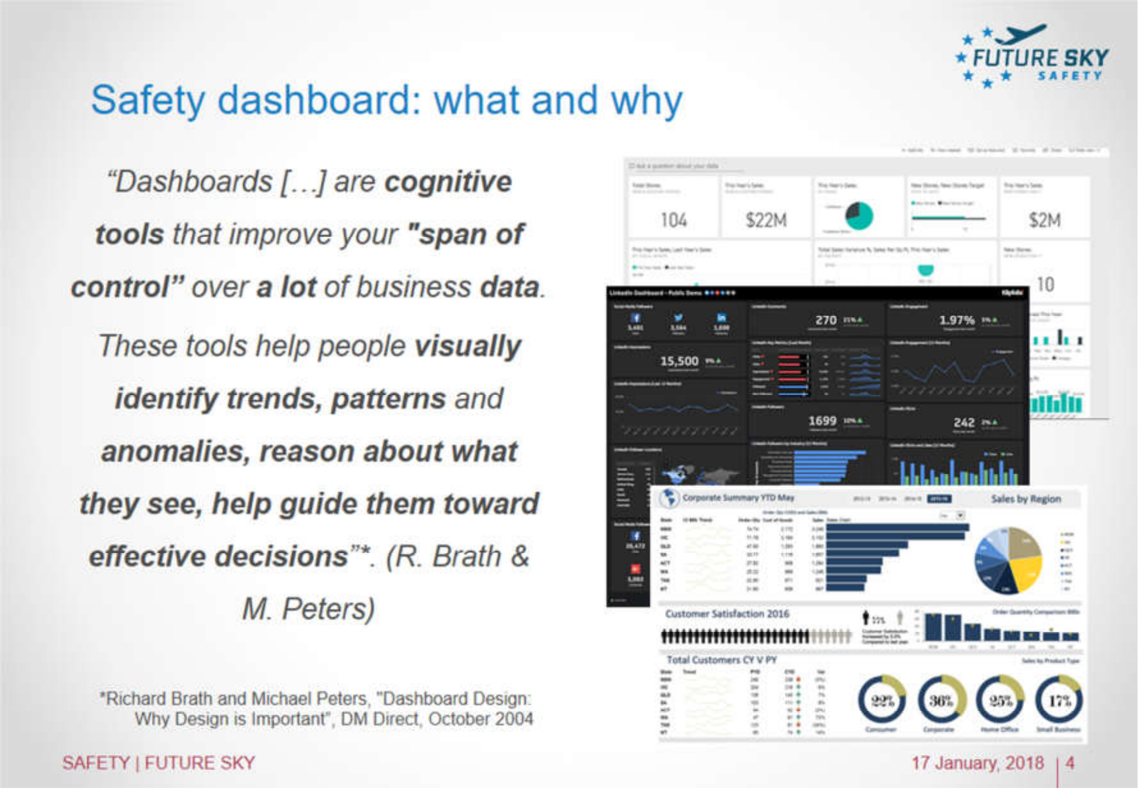

Safety dashboard: what and why

"Dashboards […] are ***cognitive tools*** *that improve your* ***"span of control"*** *over* ***a lot*** *of business* ***data****.*

These tools help people ***visually identify trends, patterns*** *and* ***anomalies, reason about what they see, help guide them toward effective decisions****"*. (R. Brath & M. Peters)*

*Richard Brath and Michael Peters, "Dashboard Design: Why Design is Important", DM Direct, October 2004

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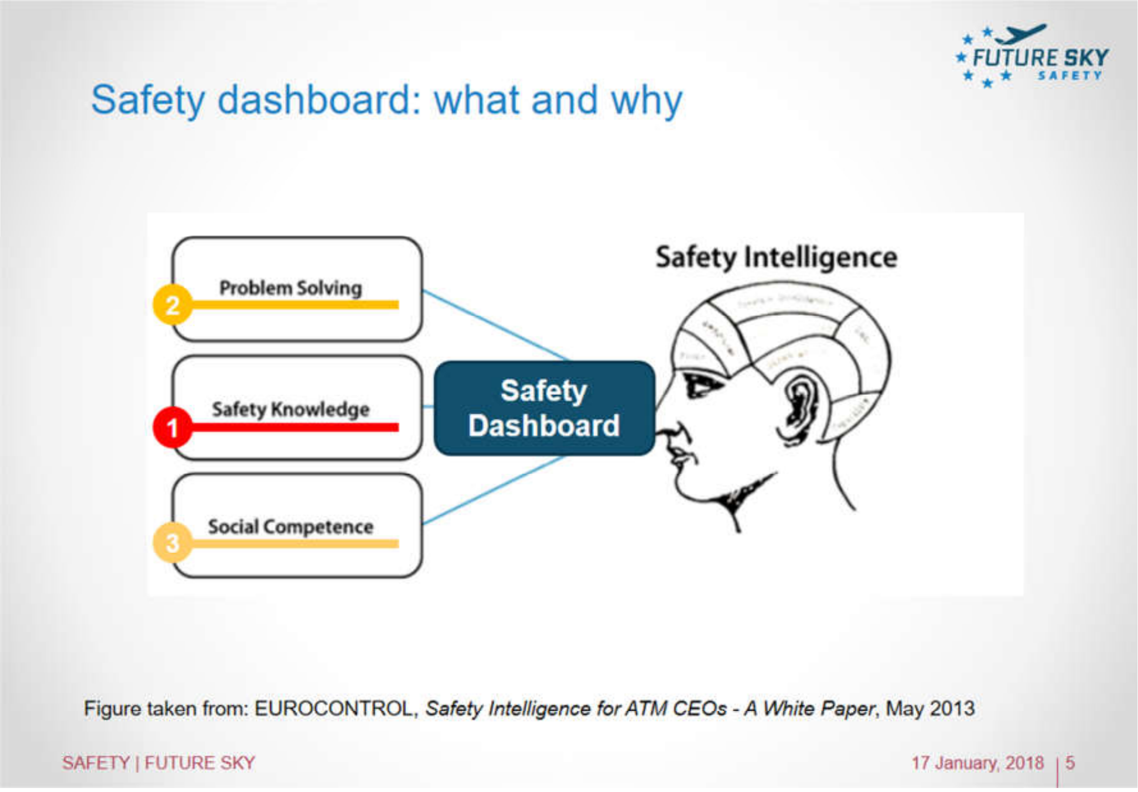

Safety dashboard: what and why

Figure taken from: EUROCONTROL, *Safety Intelligence for ATM CEOs - A White Paper*, May 2013

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First step: safety dashboards for ANSP

Safety Dashboard User group:

- Safety Directors / Managers
- In-person interviews + workshop in Rome

To understand state of play:

- Users
- Process of adoption
- Content
- Scenarios
- Platform
- Level of interactivity
- …

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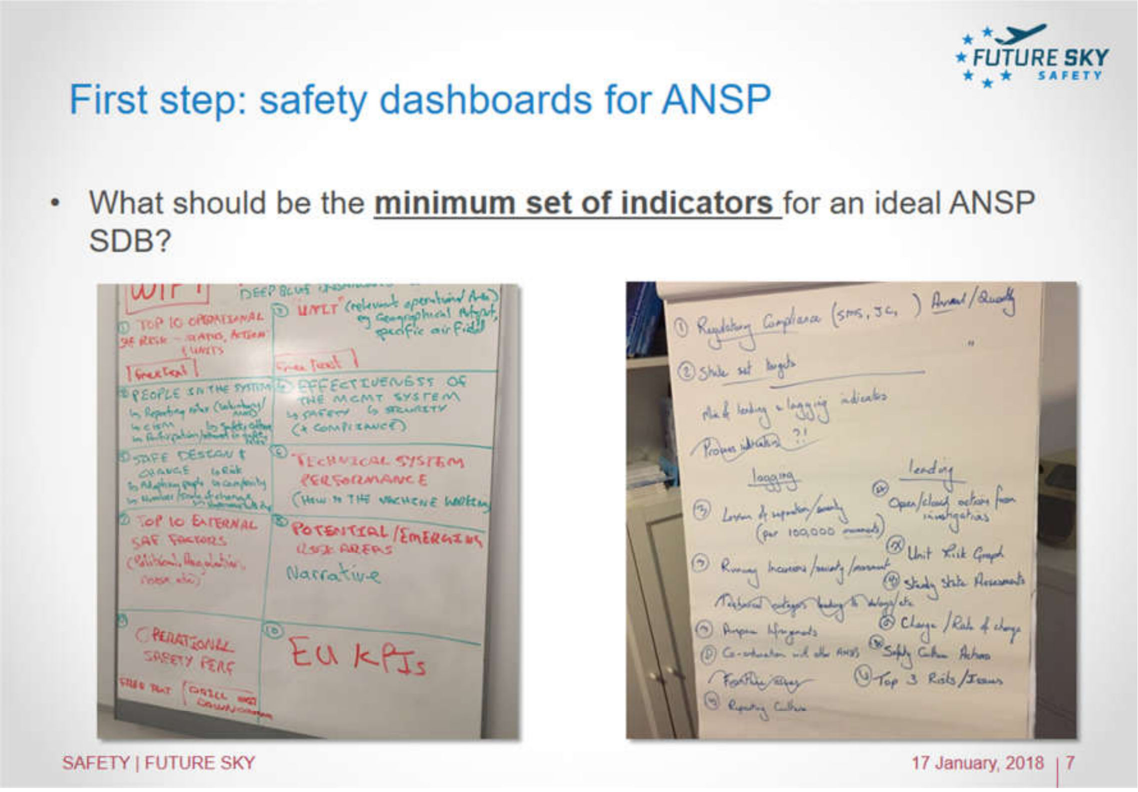

First step: safety dashboards for ANSP

- What should be the **minimum set of indicators** for an ideal ANSP SDB?

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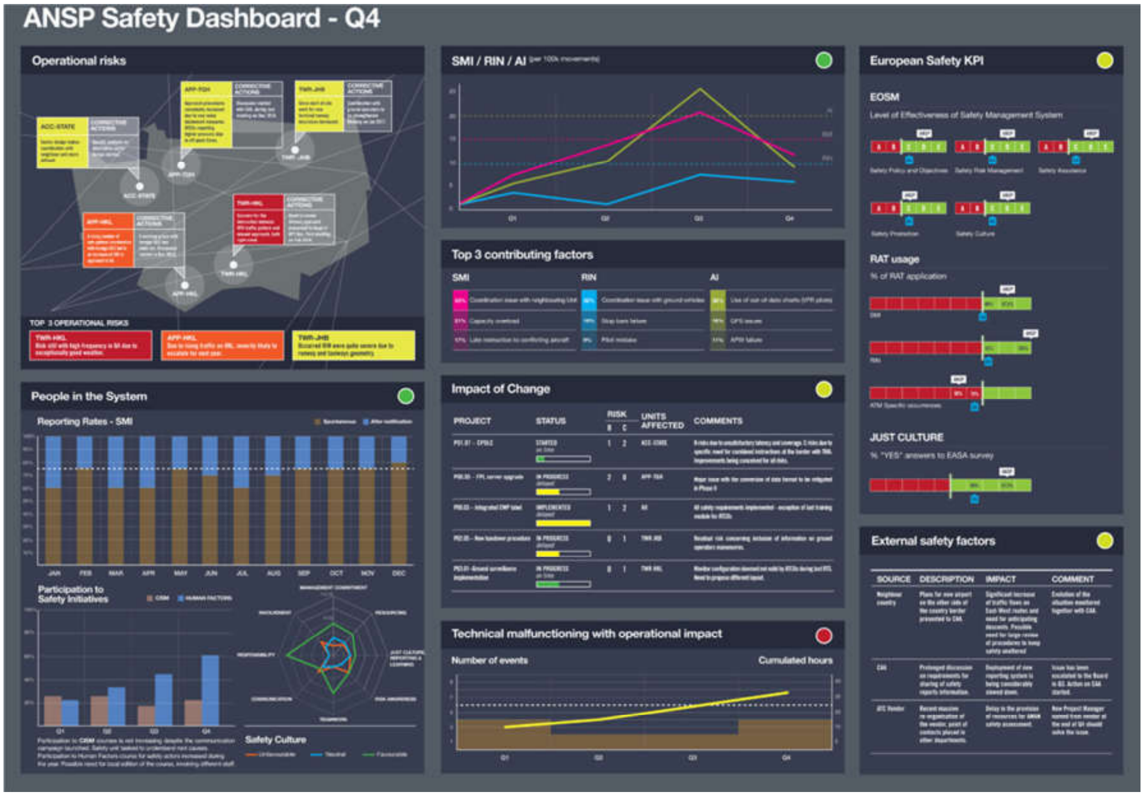

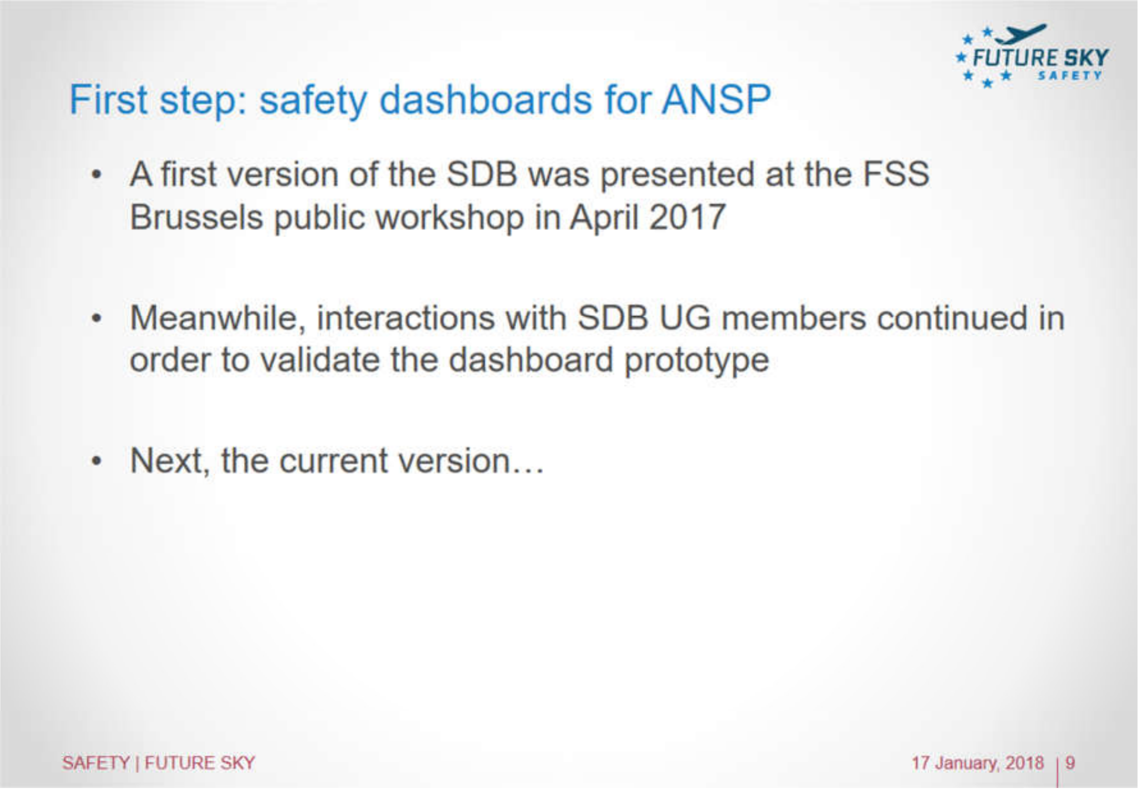

First step: safety dashboards for ANSP

- A first version of the SDB was presented at the FSS Brussels public workshop in April 2017
- Meanwhile, interactions with SDB UG members continued in order to validate the dashboard prototype
- Next, the current version…

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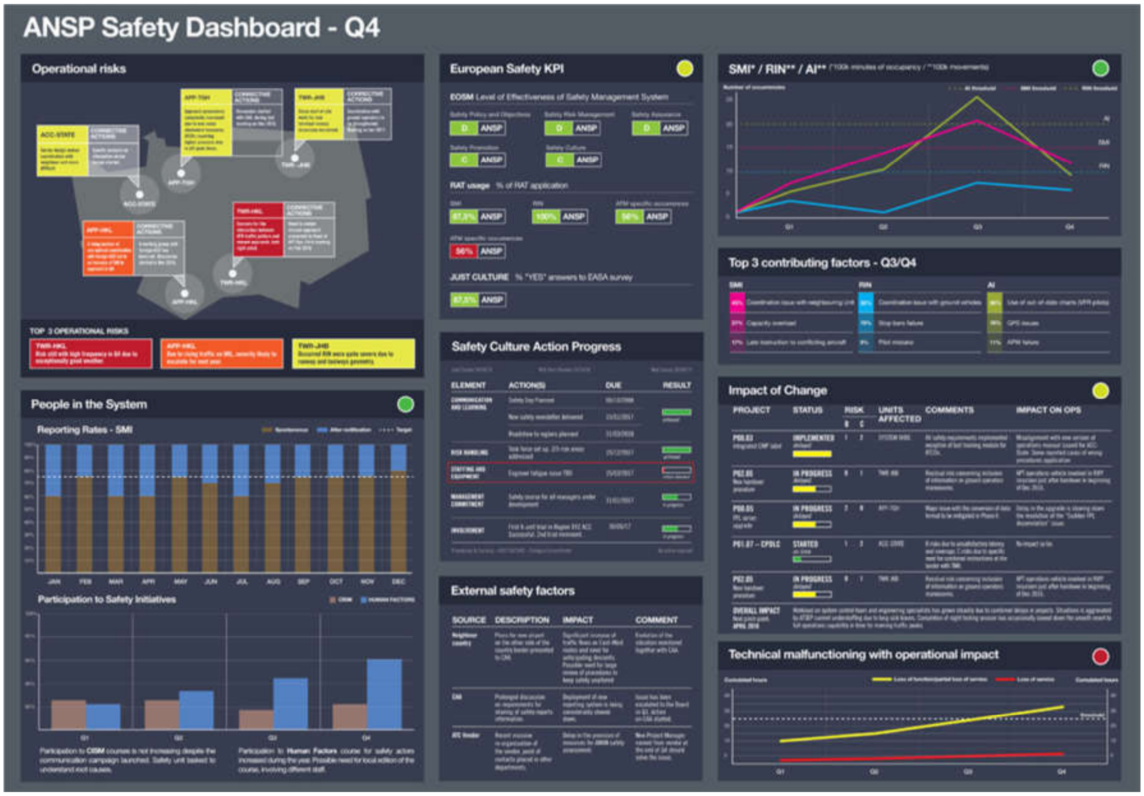

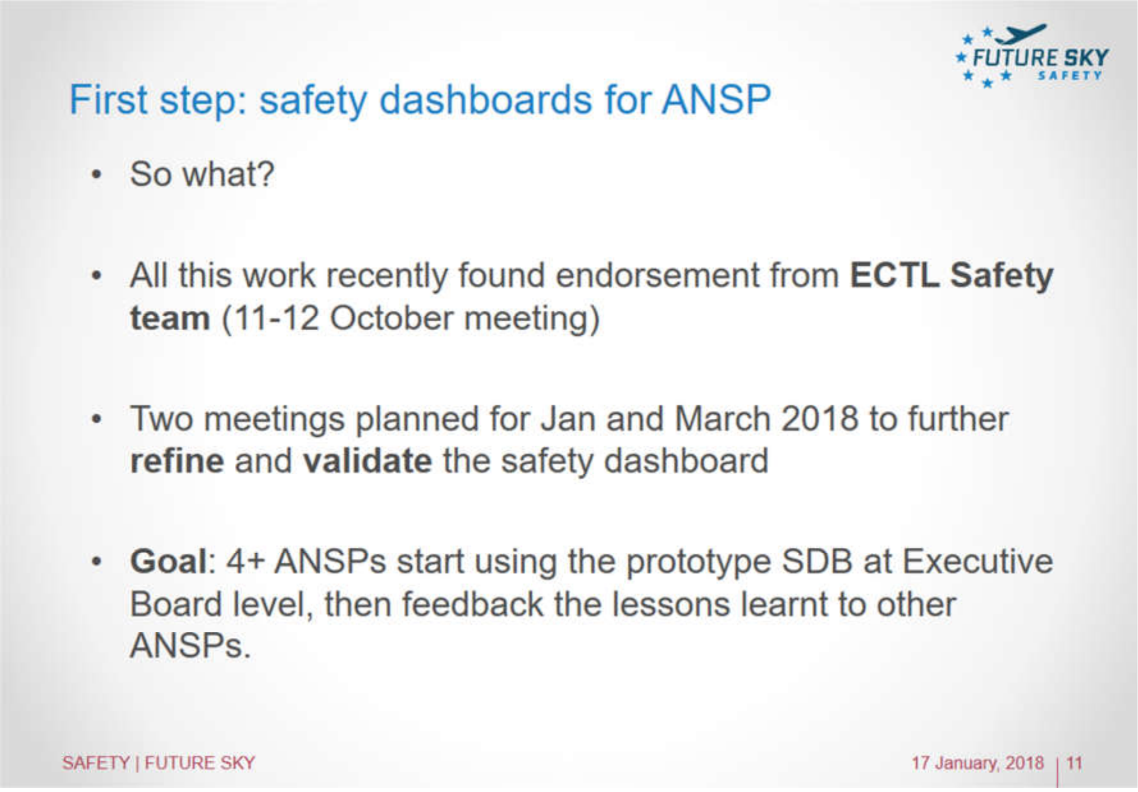

First step: safety dashboards for ANSP

- So what?
- All this work recently found endorsement from **ECTL Safety team** (11-12 October meeting)
- Two meetings planned for Jan and March 2018 to further **refine** and **validate** the safety dashboard
- **Goal**: 4+ ANSPs start using the prototype SDB at Executive Board level, then feedback the lessons learnt to other ANSPs.

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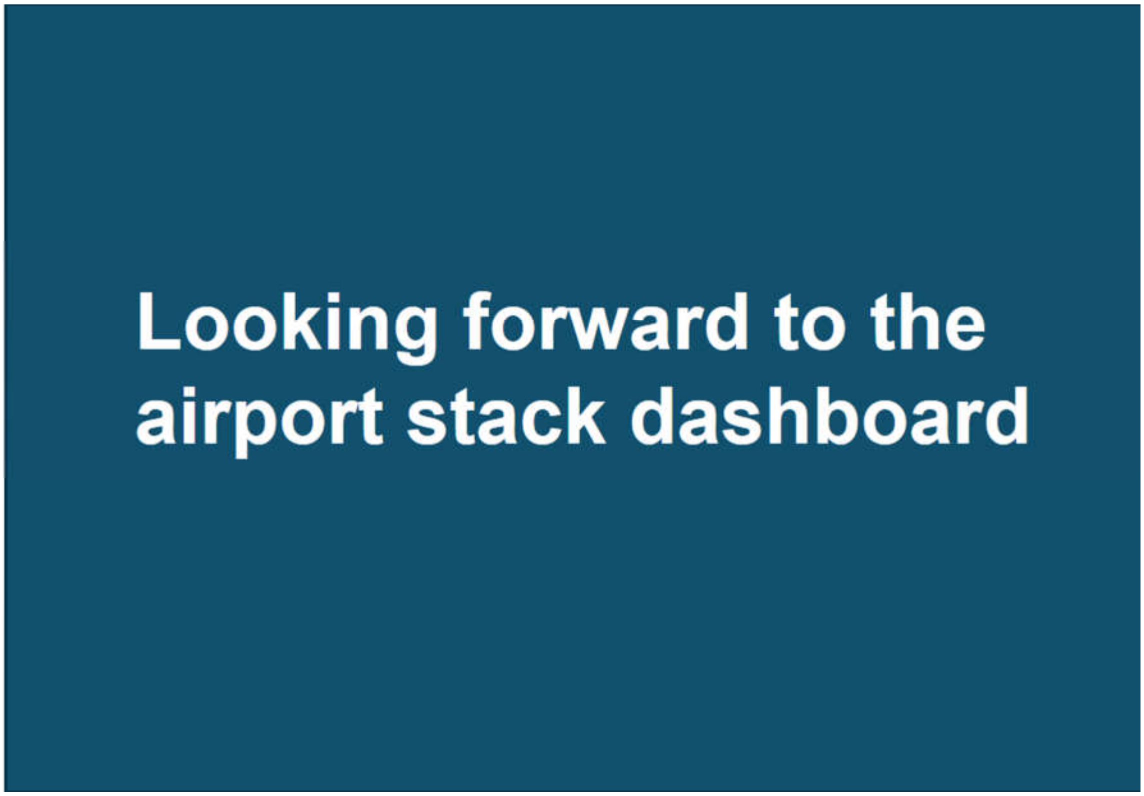

Looking forward to the airport stack dashboard

Looking forward to the airport Stack

- LTN Stack is a **joint effort for safety improvement** undertaken by organisations based in Luton airpot
- Several action lines, from streamlining of procedures, adoption of standard, pooled training etc.
- The work on SDB has raised some interest in the Stack and it is now a strand of work

London Luton Airport

easyJet

WIZZ

MENZIES AVIATION

…and others

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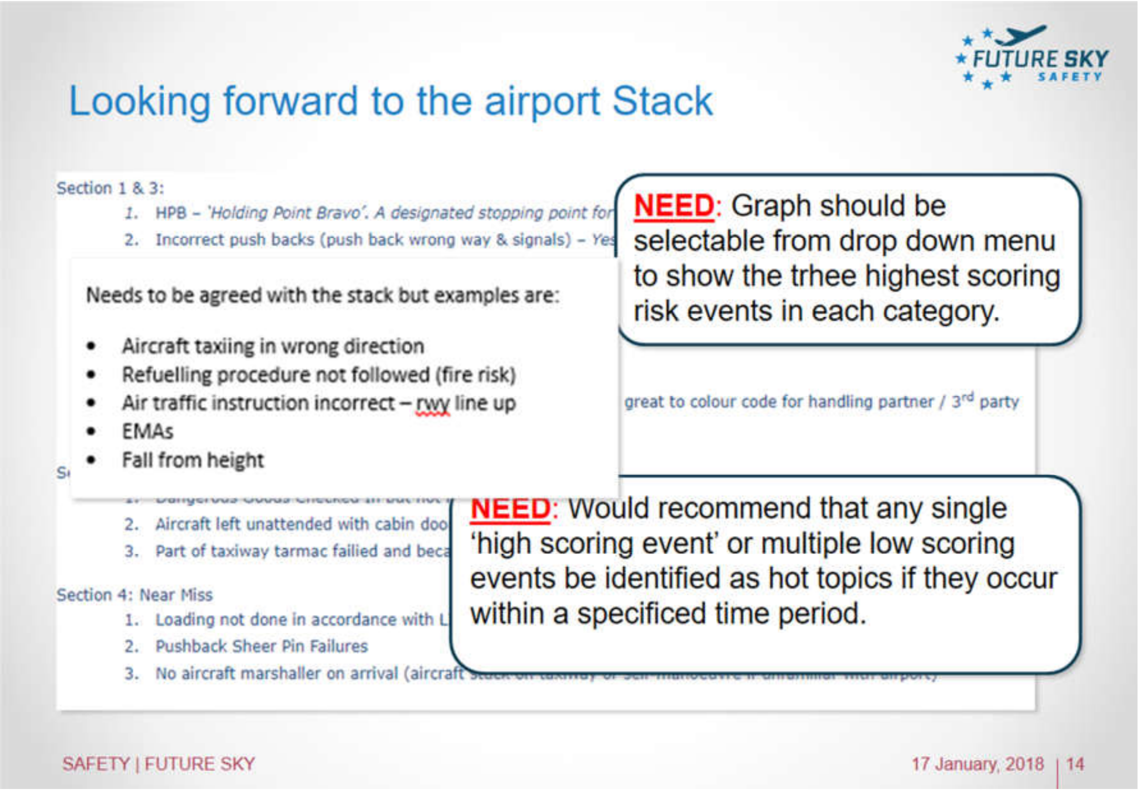

Looking forward to the airport Stack

Section 1 & 3:

1. HPB – *'Holding Point Bravo'. A designated stopping point for*
2. Incorrect push backs (push back wrong way & signals) – Yes

Needs to be agreed with the stack but examples are:

- Aircraft taxiing in wrong direction
- Refuelling procedure not followed (fire risk)
- Air traffic instruction incorrect – rwy line up
- EMAs
- Fall from height

NEED: Graph should be selectable from drop down menu to show the trhee highest scoring risk events in each category.

great to colour code for handling partner / 3rd party

2. Aircraft left unattended with cabin doo
3. Part of taxiway tarmac failied and beca

NEED: Would recommend that any single 'high scoring event' or multiple low scoring events be identified as hot topics if they occur within a specificed time period.

Section 4: Near Miss

1. Loading not done in accordance with L
2. Pushback Sheer Pin Failures
3. No aircraft marshaller on arrival (aircraft

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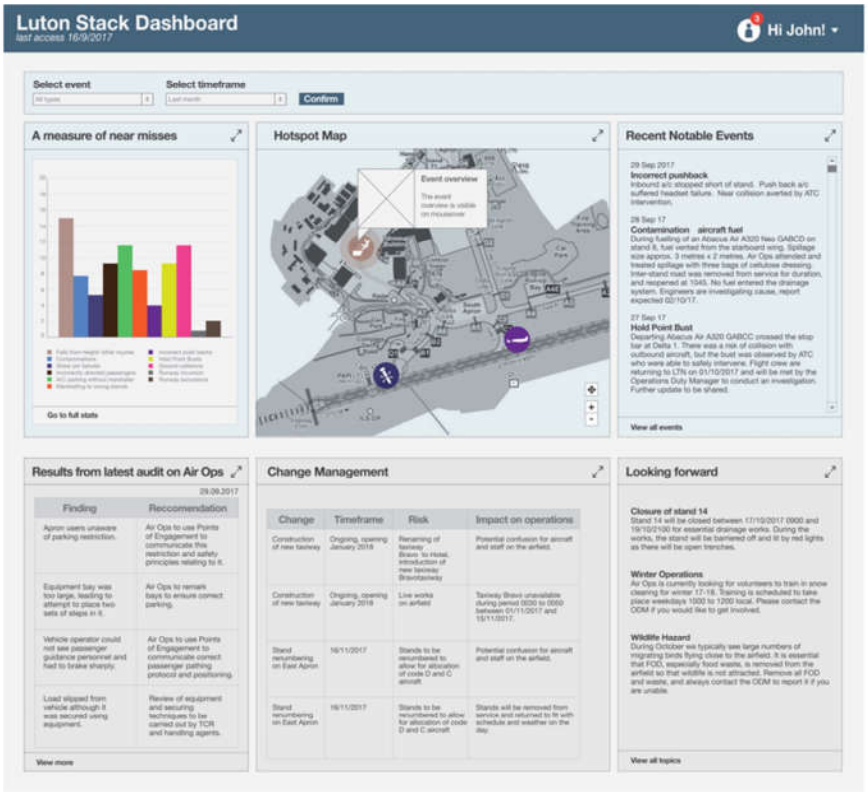


Recent Notable Events

29 Sep 2017
Incorrect pushback
Inbound a/c stopped short of stand. Push back a/c suffered headset failure. Near collision averted by ATC intervention.

28 Sep 17
Contamination aircraft fuel
During fuelling of an Abacus Air A320 Neo GABCD on stand 8, fuel vented from the starboard wing. Spillage size approx. 3 metres x 2 metres. Air Ops attended and treated spillage with three bags of cellulose dressing. Inter-stand road was removed from service for duration, and reopened at 1045. No fuel entered the drainage system. Engineers are investigating cause, report expected 02/10/17.

27 Sep 17
Hold Point Bust
Departing Abacus Air A320 GABCC crossed the stop bar at Delta 1. There was a risk of collision with outbound aircraft, but the bust was observed by ATC who were able to safely intervene. Flight crew are returning to LTN on 01/10/2017 and will be met by the Operations Duty Manager to conduct an investigation. Further update to be shared.

View all events

Results from latest audit on Air Ops

29.09.2017

Finding	Reccomendation
Apron users unaware of parking restriction.	Air Ops to use Points of Engagement to communicate this restriction and safety principles relating to it.
Equipment bay was too large, leading to attempt to place two sets of steps in it.	Air Ops to remark bays to ensure correct parking.
Vehicle operator could not see passenger guidance personnel and had to brake sharply.	Air Ops to use Points of Engagement to communicate correct passenger pathing protocol and positioning.
Load slipped from vehicle although it was secured using equipment.	Review of equipment and securing techniques to be carried out by TCR and handling agents.

View more

Change Management

Change	Timeframe	Risk	Impact on operations
Construction of new taxiway	Ongoing, opening January 2018	Renaming of taxiway Bravo to Hotel, introduction of new taxiway Bravo/taxiway	Potential confusion for aircraft and staff on the airfield.
Construction of new taxiway	Ongoing, opening January 2018	Live works on airfield	Taxiway Bravo unavailable during period 0030 to 0550 between 01/11/2017 and 15/11/2017.
Stand renumbering on East Apron	16/11/2017	Stands to be renumbered to allow for allocation of code D and C aircraft.	Potential confusion for aircraft and staff on the airfield.
Stand renumbering on East Apron	16/11/2017	Stands to be renumbered to allow for allocation of code D and C aircraft.	Stands will be removed from service and returned to fit with schedule and weather on the day.

Looking forward

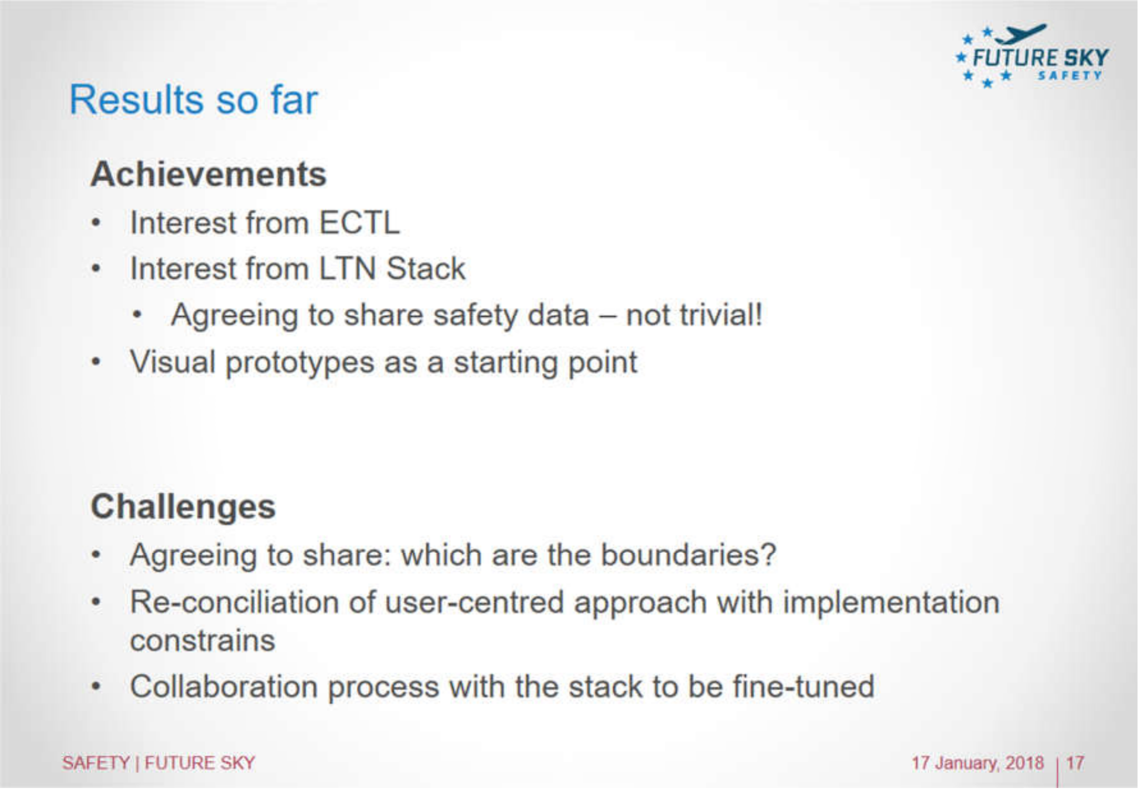
Closure of stand 14
Stand 14 will be closed between 17/10/2017 0900 and 19/10/2100 for essential drainage works. During the works, the stand will be barriered off and lit by red lights as there will be open trenches.

Winter Operations
Air Ops is currently looking for volunteers to train in snow clearing for winter 17-18. Training is scheduled to take place weekdays 1000 to 1200 local. Please contact the ODM if you would like to get involved.

Wildlife Hazard
During October we typically see large numbers of migrating birds flying close to the airfield. It is essential that FOD, especially food waste, is removed from the airfield so that wildlife is not attracted. Remove all FOD and waste, and always contact the ODM to report it if you are unable.

View all topics

DATE	TYPE	DESCRIPTION
20-10-2017	Runway Incursion	Ground handler vehicle crossing runway while BAW123 on final. No go-around issued, a/c landed safely.
28-09-2017	Fall from height	Maintenance worker fell off from elevated platform while performing checks on tail of a/c parked in northern apron, due to swinging. Seriously injured.
15-09-2017	Ground Collision	One aircraft tug collided with catering service during parking manoeuver. Tug driver slightly injured.



Results so far

Achievements

- Interest from ECTL
- Interest from LTN Stack
  - Agreeing to share safety data – not trivial!
- Visual prototypes as a starting point

Challenges

- Agreeing to share: which are the boundaries?
- Re-conciliation of user-centred approach with implementation constrains
- Collaboration process with the stack to be fine-tuned

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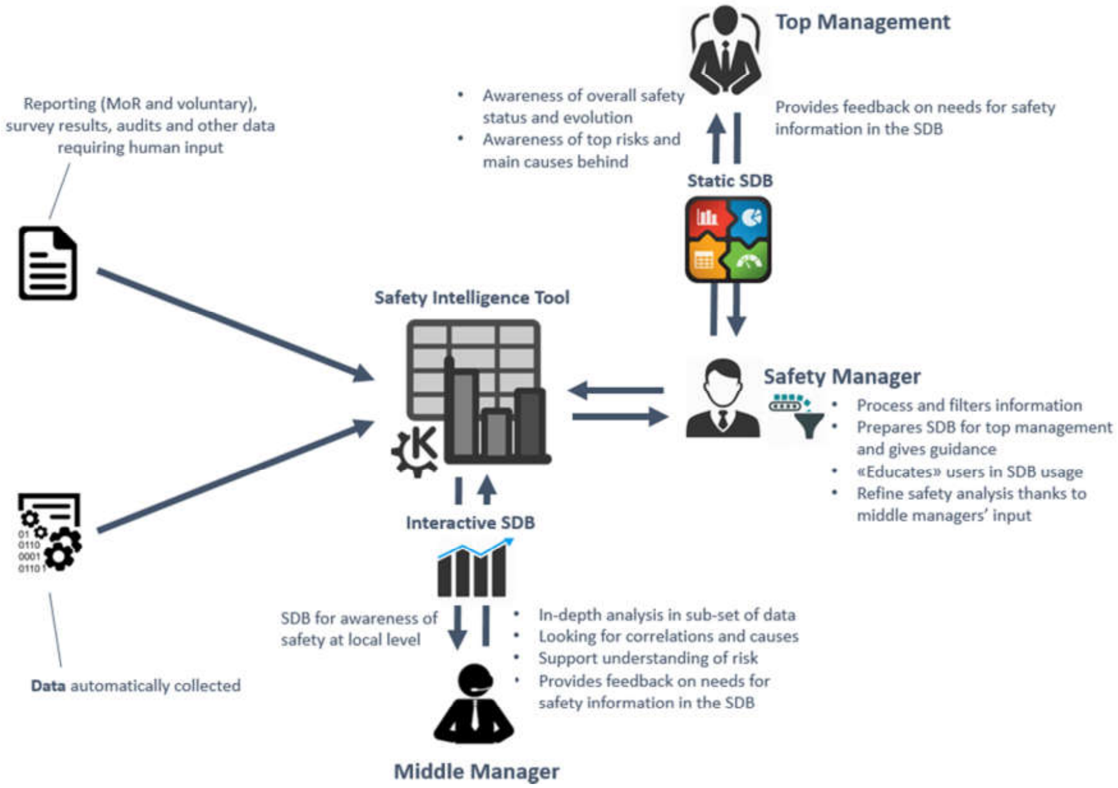
17 January, 2018 | 17



Appendix B.10 "P6: Human performance envelope" – Barry Kirwan, EUROCONTROL

P6 Human Performance Envelope

FUTURE SKY SAFETY – 2nd Consortium Workshop, 6-7 December 2017
Barry Kirwan, EUROCONTROL

FSS P6: Human Performance Envelope

Consortium

DLR Lead
15 Partners
233 PM

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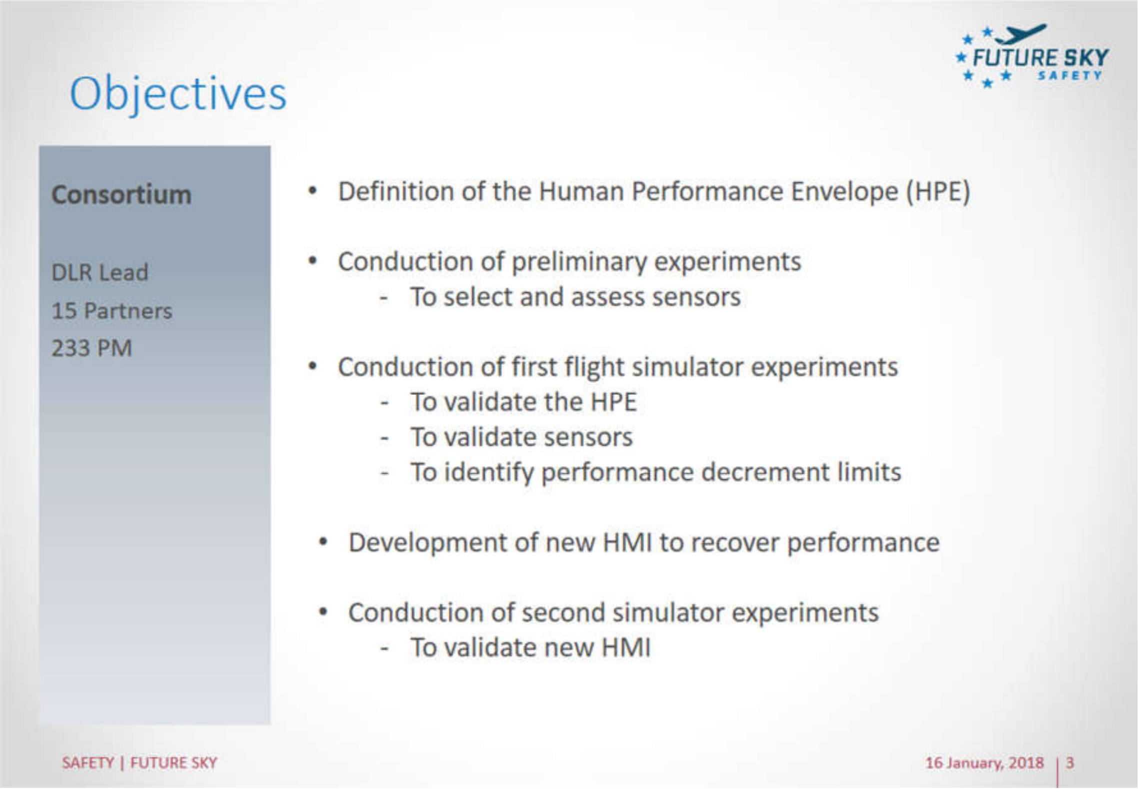
16 January, 2018 | 2



Objectives

Consortium

DLR Lead
15 Partners
233 PM

- Definition of the Human Performance Envelope (HPE)
- Conduction of preliminary experiments
  - To select and assess sensors
- Conduction of first flight simulator experiments
  - To validate the HPE
  - To validate sensors
  - To identify performance decrement limits
- Development of new HMI to recover performance
- Conduction of second simulator experiments
  - To validate new HMI

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16 January, 2018 | 3

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Work Packages

WP 6.2

Conduction of exploratory simulations

T7 - T18

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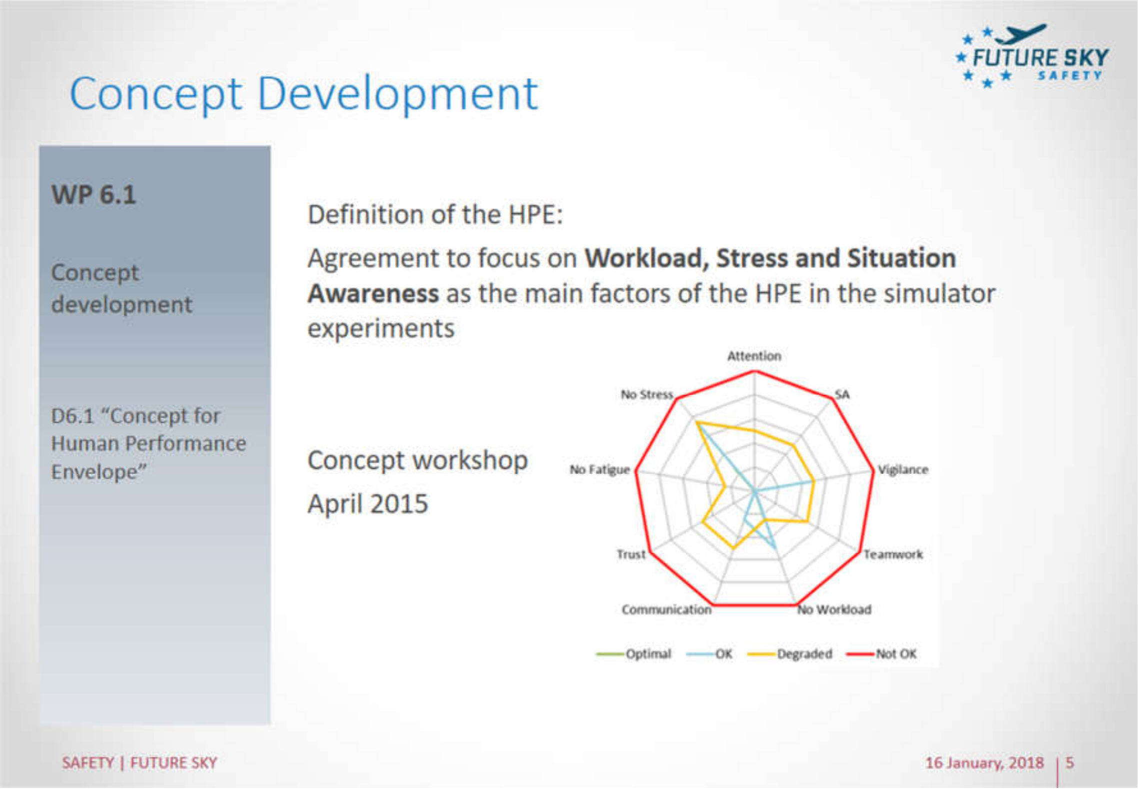
16 January, 2018 | 4



Concept Development

WP 6.1

Concept development

D6.1 “Concept for Human Performance Envelope”

Definition of the HPE:

Agreement to focus on **Workload, Stress and Situation Awareness** as the main factors of the HPE in the simulator experiments

Concept workshop
April 2015

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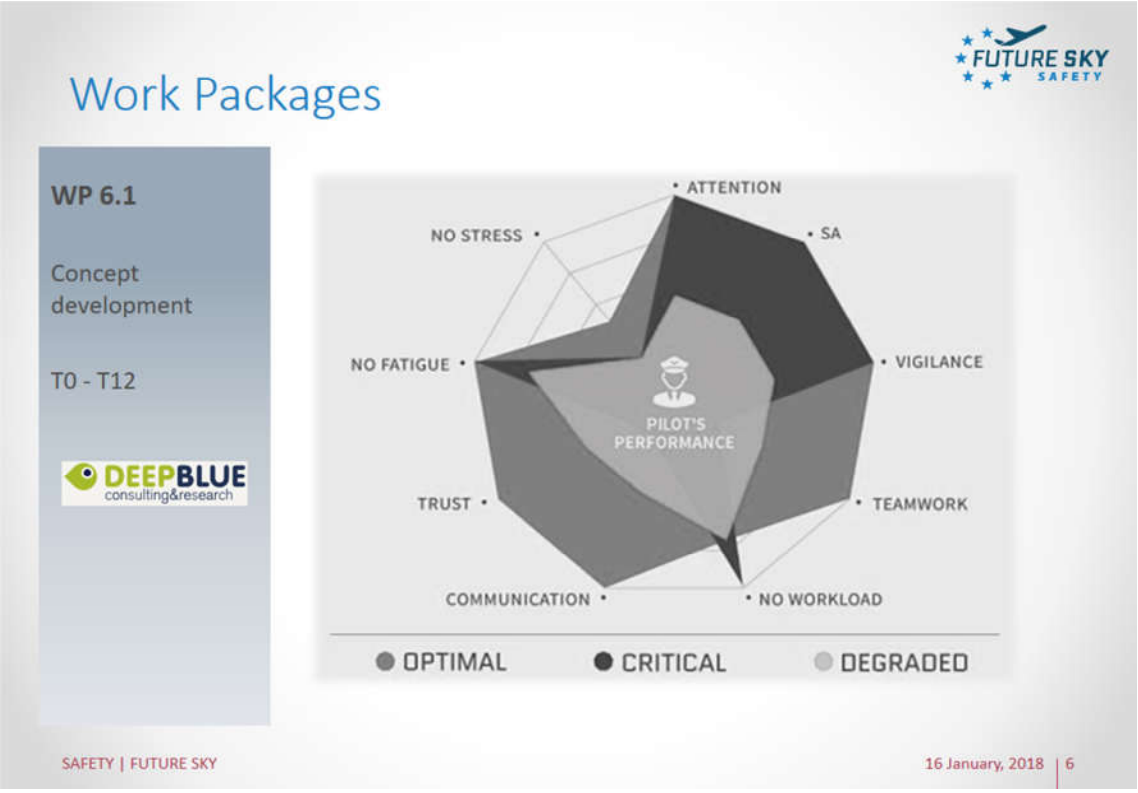

Work Packages

WP 6.1

Concept development

T0 - T12

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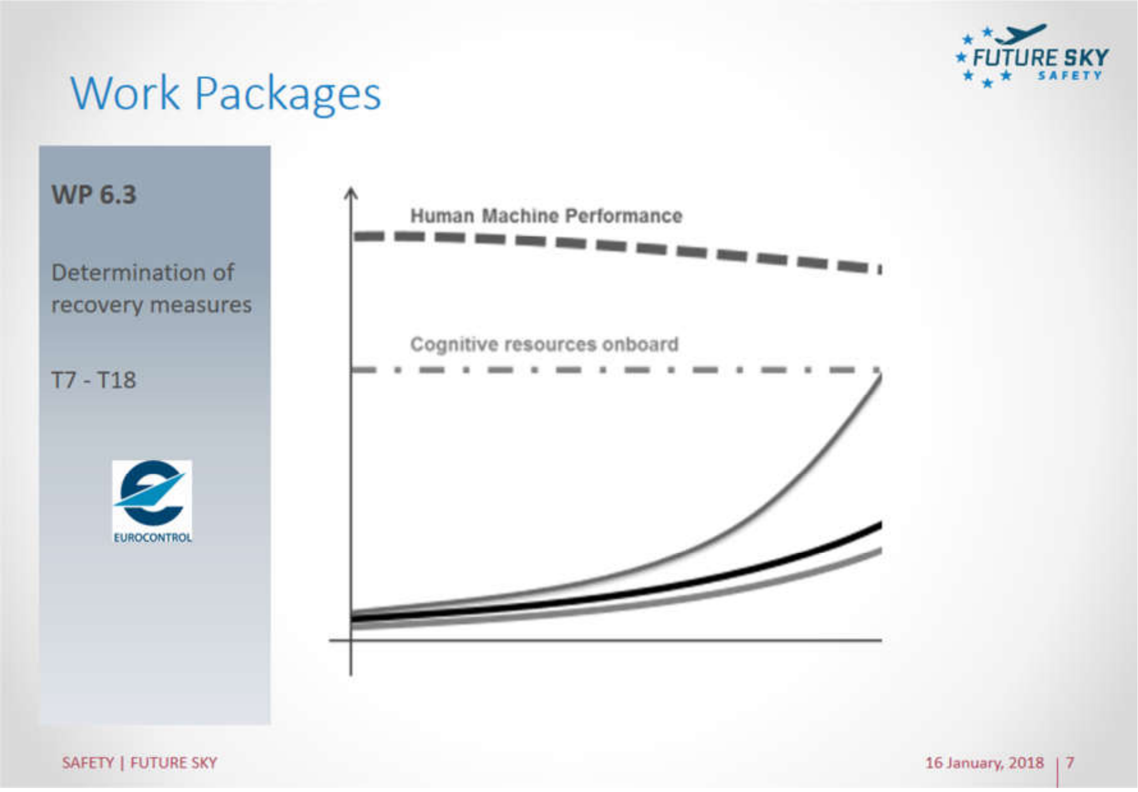

Work Packages

WP 6.3

Determination of recovery measures

T7 - T18

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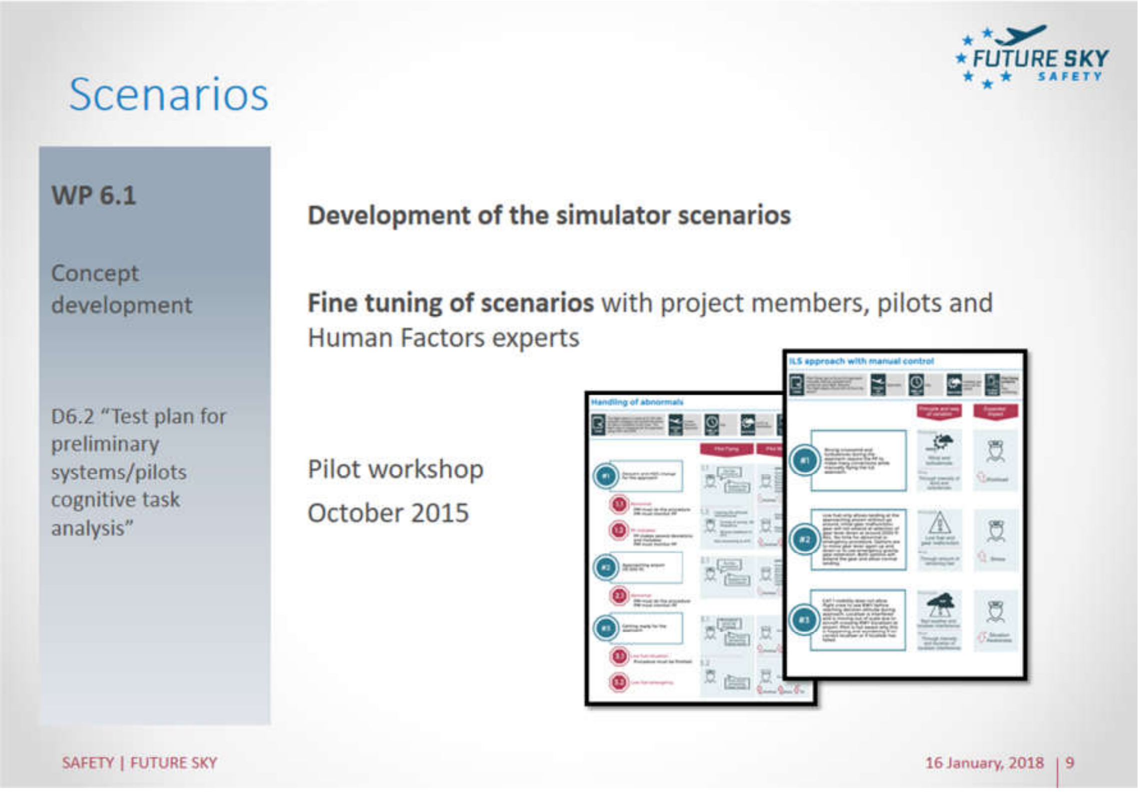
Work Packages

WP 6.4

Evaluation of solutions for augmenting the envelope

T19 – T39

THALES



Scenarios

WP 6.1

Concept development

D6.2 "Test plan for preliminary systems/pilots cognitive task analysis"

Development of the simulator scenarios

Fine tuning of scenarios with project members, pilots and Human Factors experts

Pilot workshop
October 2015

Scenarios

WP 6.1

Concept development

D6.2 "Test plan for preliminary systems/pilots cognitive task analysis"

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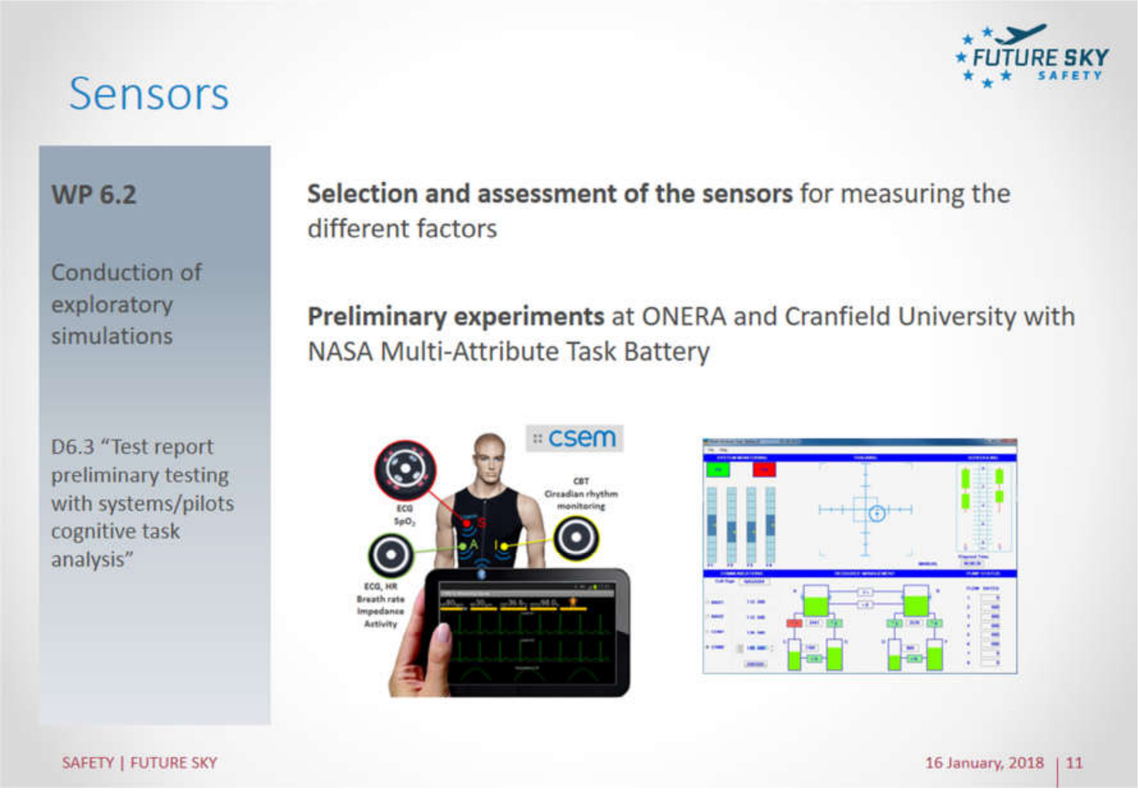

Sensors

WP 6.2

Conduction of exploratory simulations

D6.3 "Test report preliminary testing with systems/pilots cognitive task analysis"

Selection and assessment of the sensors for measuring the different factors

Preliminary experiments at ONERA and Cranfield University with NASA Multi-Attribute Task Battery

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First Simulator Experiments

WP 6.2

Conduction of exploratory simulations

D6.3 "Test report preliminary testing with systems/pilots cognitive task analysis"

Experiments in A320 DLR flight simulator AVES

- 10 Lufthansa crews
- 9 scenarios with varying workload, stress and situation awareness

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First Simulator Experiments

WP 6.2

Conduction of exploratory simulations

D6.3 "Test report preliminary testing with systems/pilots cognitive task analysis"

Subjective Measures:

- ISA, NASA-TLX, SACL, SART, Samn-Perelli

Eye Tracking Data:

- Point of gaze, blink rate, areas of interest, pupil diameter

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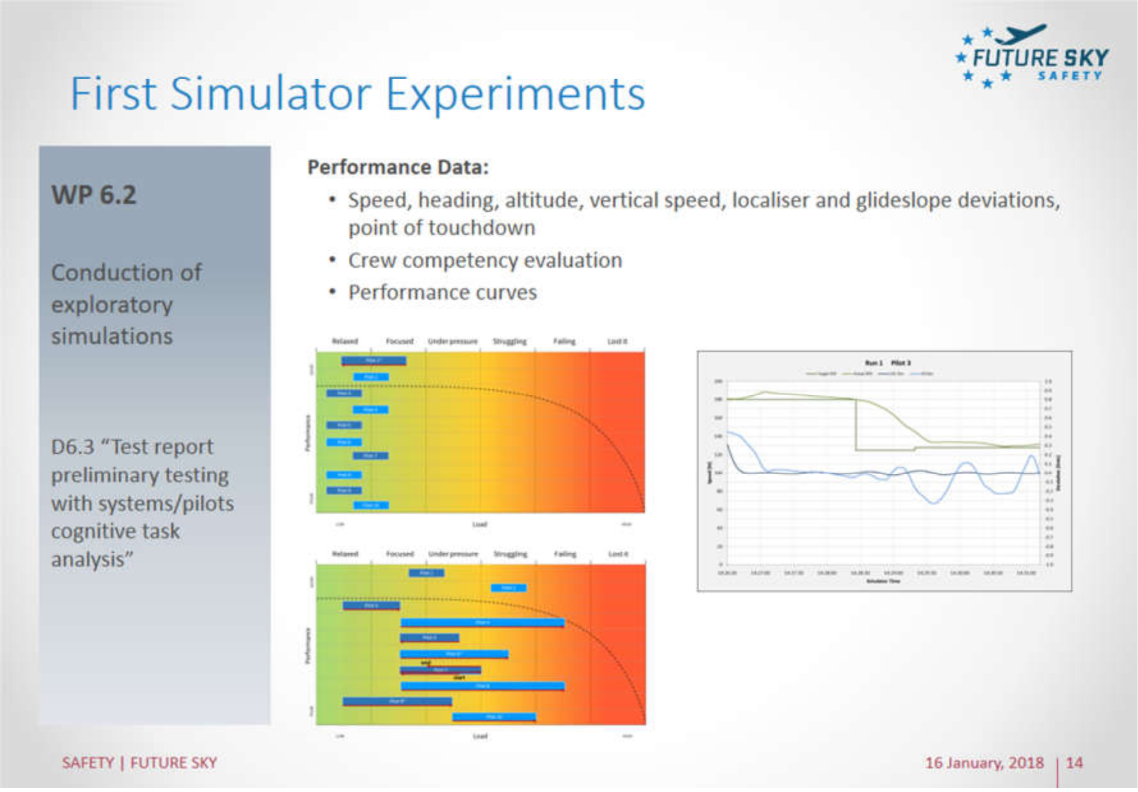


First Simulator Experiments

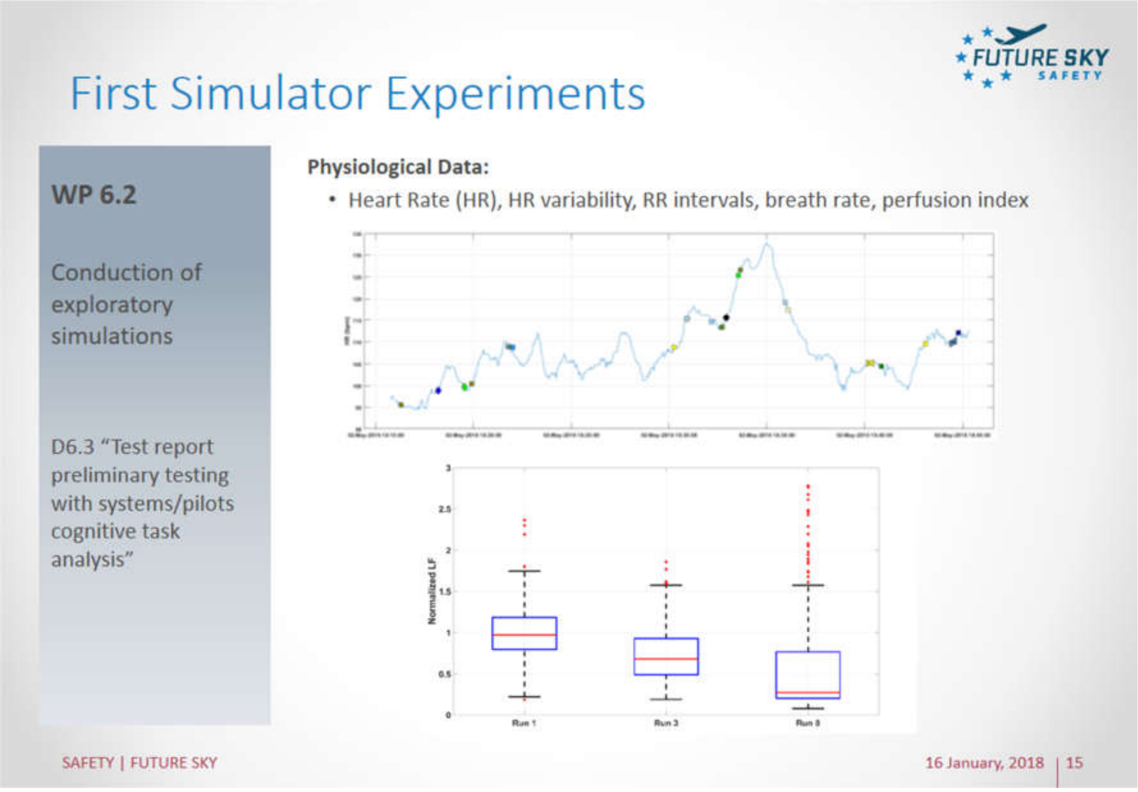
WP 6.2

Conduction of exploratory simulations

D6.3 "Test report preliminary testing with systems/pilots cognitive task analysis"

Performance Data:

- Speed, heading, altitude, vertical speed, localiser and glideslope deviations, point of touchdown
- Crew competency evaluation
- Performance curves



First Simulator Experiments

WP 6.2

Conduction of exploratory simulations

D6.3 "Test report preliminary testing with systems/pilots cognitive task analysis"

Physiological Data:

- Heart Rate (HR), HR variability, RR intervals, breath rate, perfusion index

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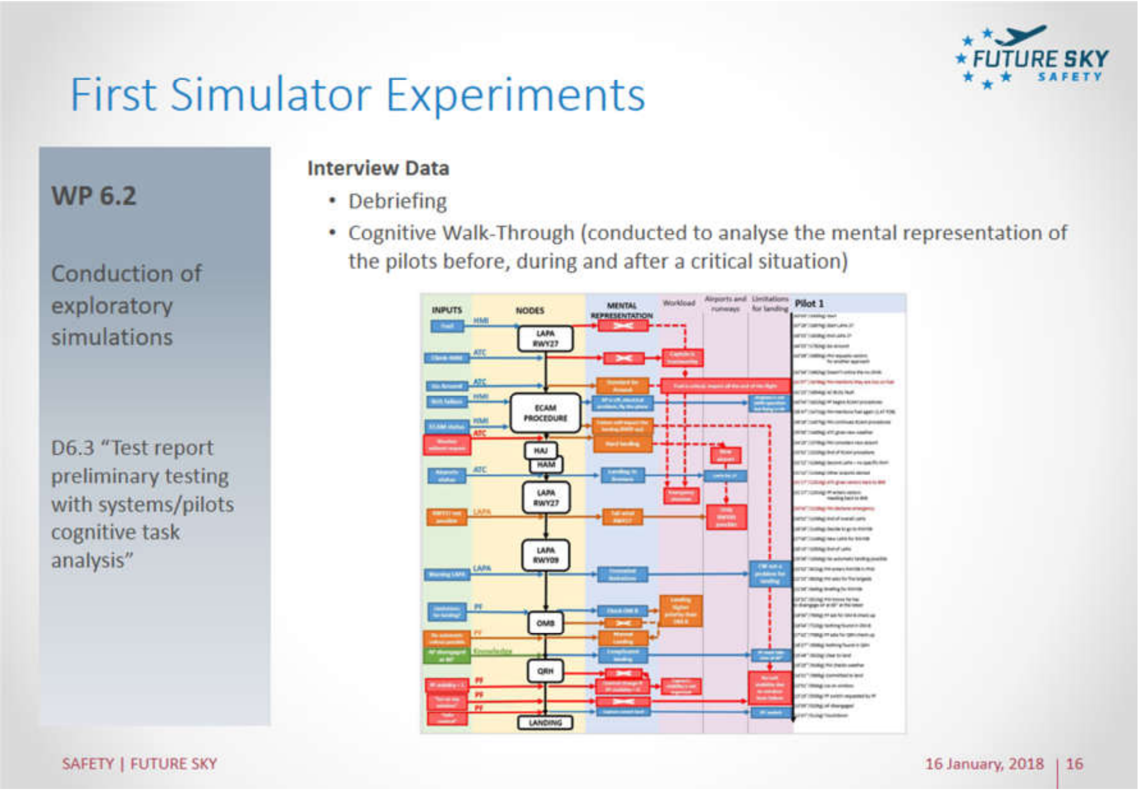


First Simulator Experiments

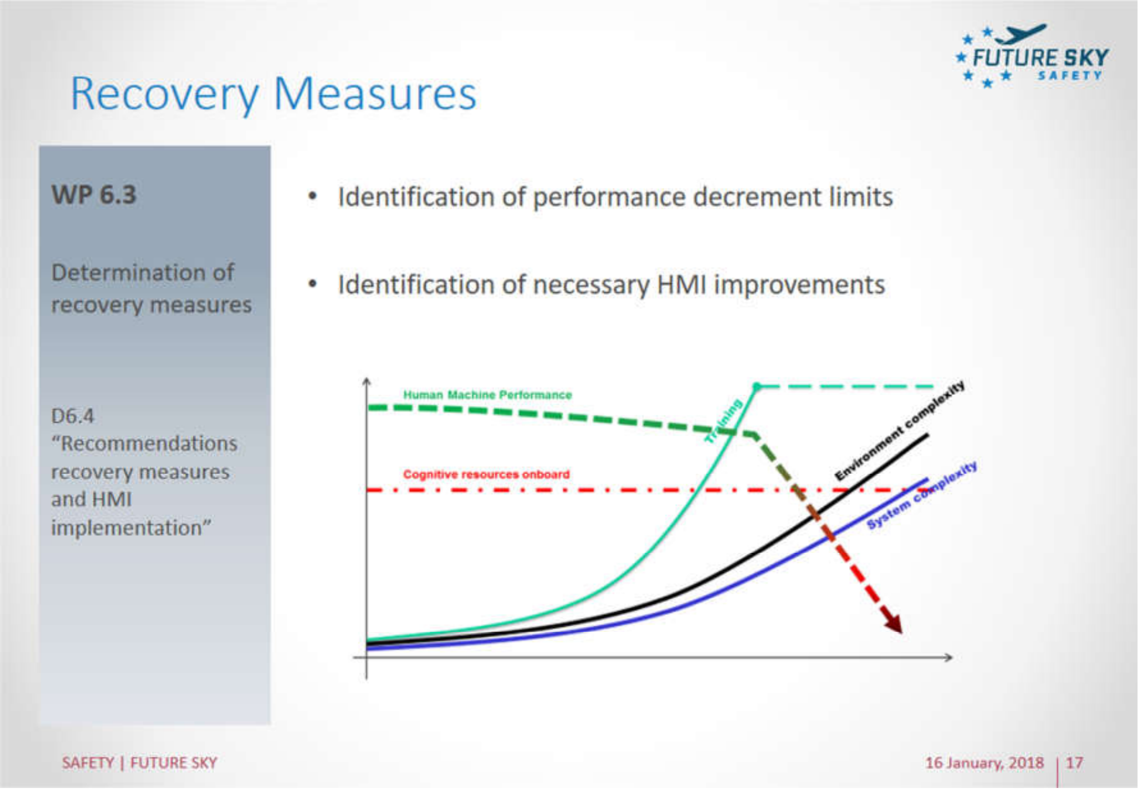
WP 6.2

Conduction of exploratory simulations

D6.3 "Test report preliminary testing with systems/pilots cognitive task analysis"

Interview Data

- Debriefing
- Cognitive Walk-Through (conducted to analyse the mental representation of the pilots before, during and after a critical situation)



Recovery Measures

WP 6.3

Determination of recovery measures

D6.4 "Recommendations recovery measures and HMI implementation"

- Identification of performance decrement limits
- Identification of necessary HMI improvements

Development of New HMI

WP 6.3

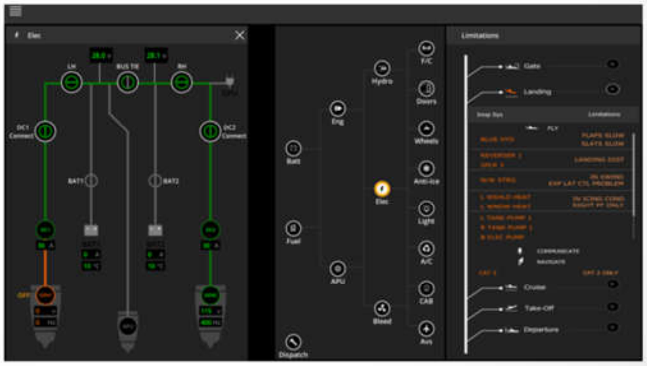
WP 6.4

Determination of recovery measures

Evaluation of solutions for augmenting the envelope

New HMI present information about:

- Limitations of the aircraft
- Operational consequences of the limitations
- Available options



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Development of New HMI

WP 6.3

WP 6.4

Determination of recovery measures

Evaluation of solutions for augmenting the envelope

- New HMI were integrated in Thales Avionics 2020 Cockpit Simulator

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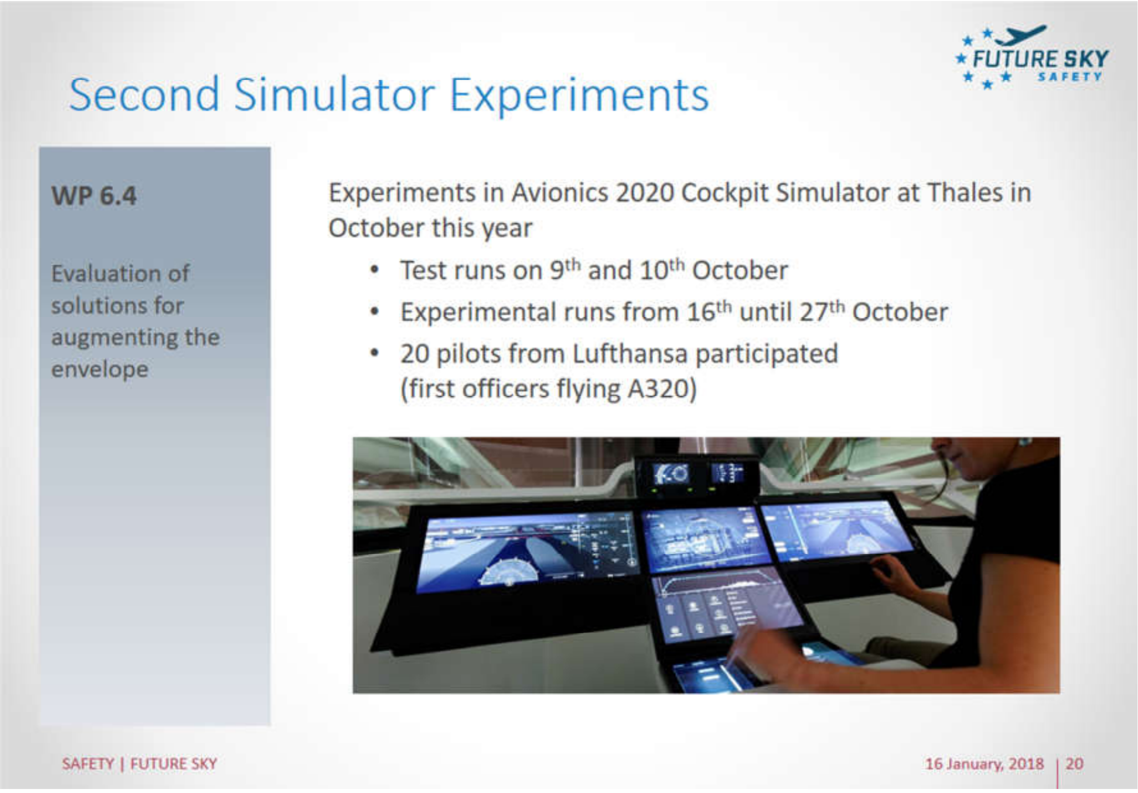

Second Simulator Experiments

WP 6.4

Evaluation of solutions for augmenting the envelope

Experiments in Avionics 2020 Cockpit Simulator at Thales in October this year

- Test runs on 9th and 10th October
- Experimental runs from 16th until 27th October
- 20 pilots from Lufthansa participated (first officers flying A320)

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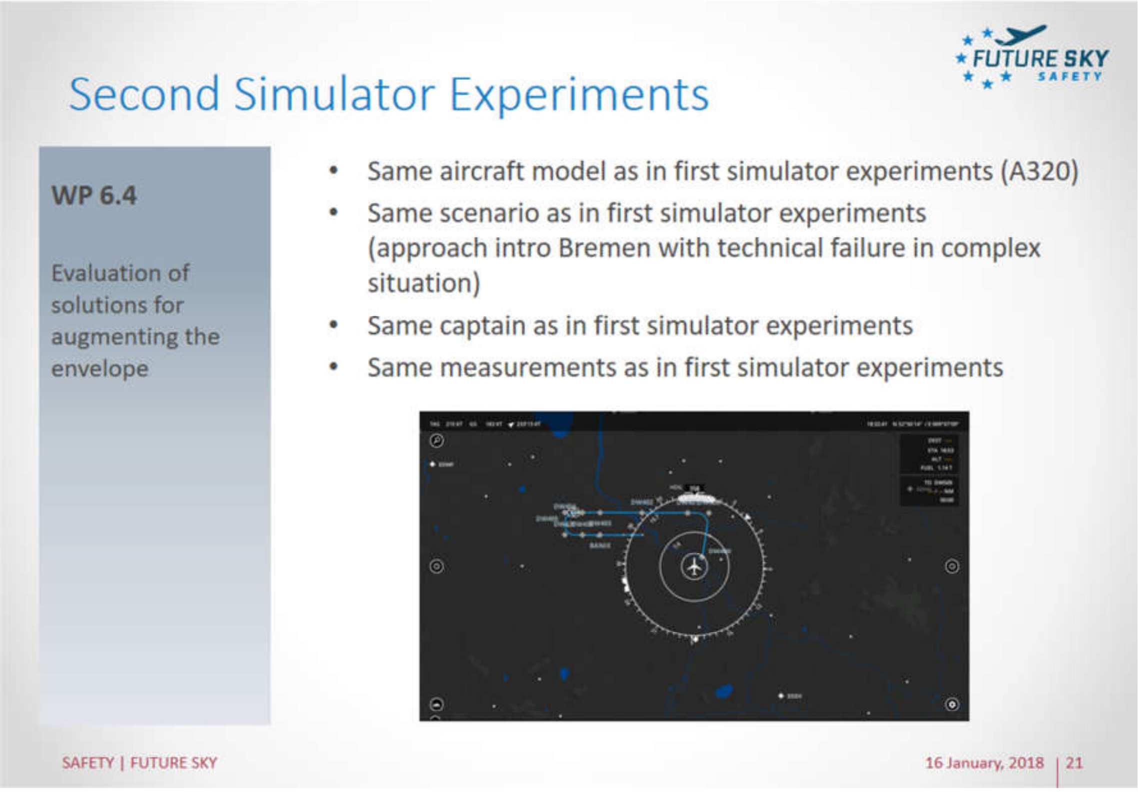

Second Simulator Experiments

WP 6.4

Evaluation of solutions for augmenting the envelope

- Same aircraft model as in first simulator experiments (A320)
- Same scenario as in first simulator experiments (approach intro Bremen with technical failure in complex situation)
- Same captain as in first simulator experiments
- Same measurements as in first simulator experiments

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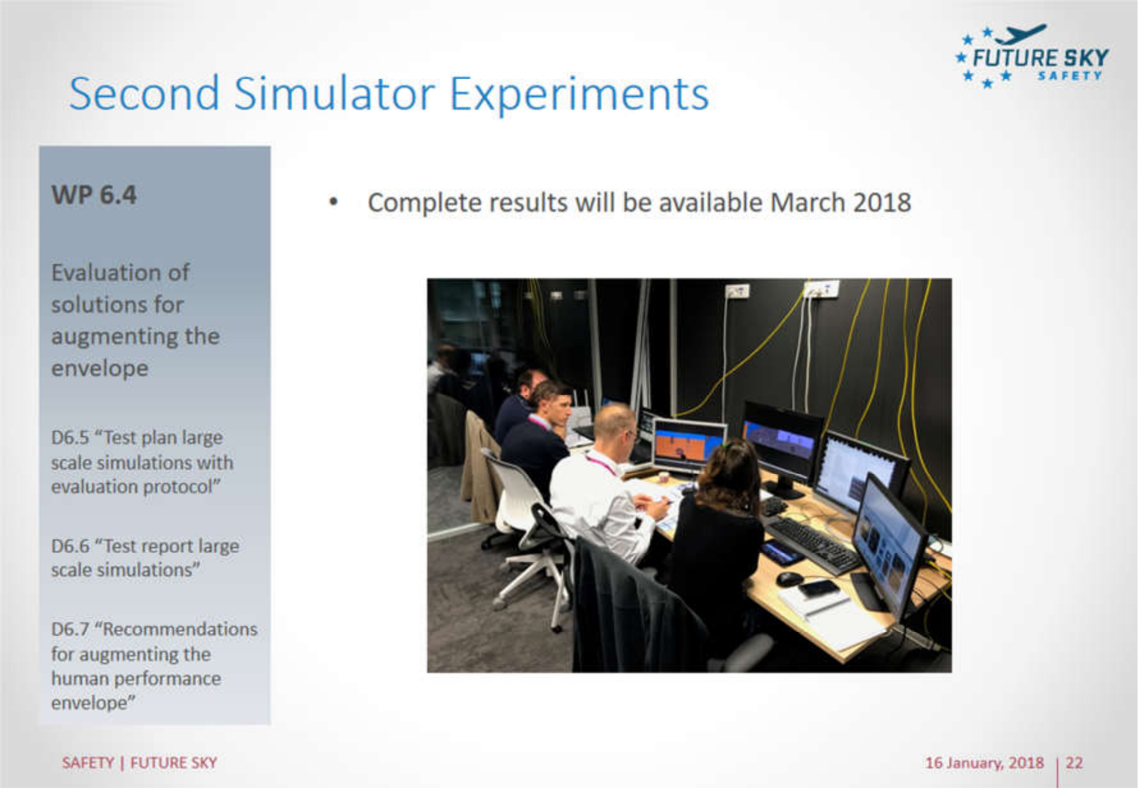

Second Simulator Experiments

WP 6.4

Evaluation of solutions for augmenting the envelope

D6.5 “Test plan large scale simulations with evaluation protocol”

D6.6 “Test report large scale simulations”

D6.7 “Recommendations for augmenting the human performance envelope”

- Complete results will be available March 2018

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Appendix B.11 “P6: Can we exploit technology to measure the Human Performance Envelope?” – Jim Nixon, Cranfield University

Can we exploit technology to measure the Human Performance Envelope?

Dr Jim Nixon

www.cranfield.ac.uk

1

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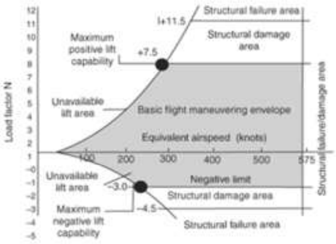
The aircraft performance envelope



Interface design (1980s style)

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We're much more sophisticated now…

And so are our aircraft…

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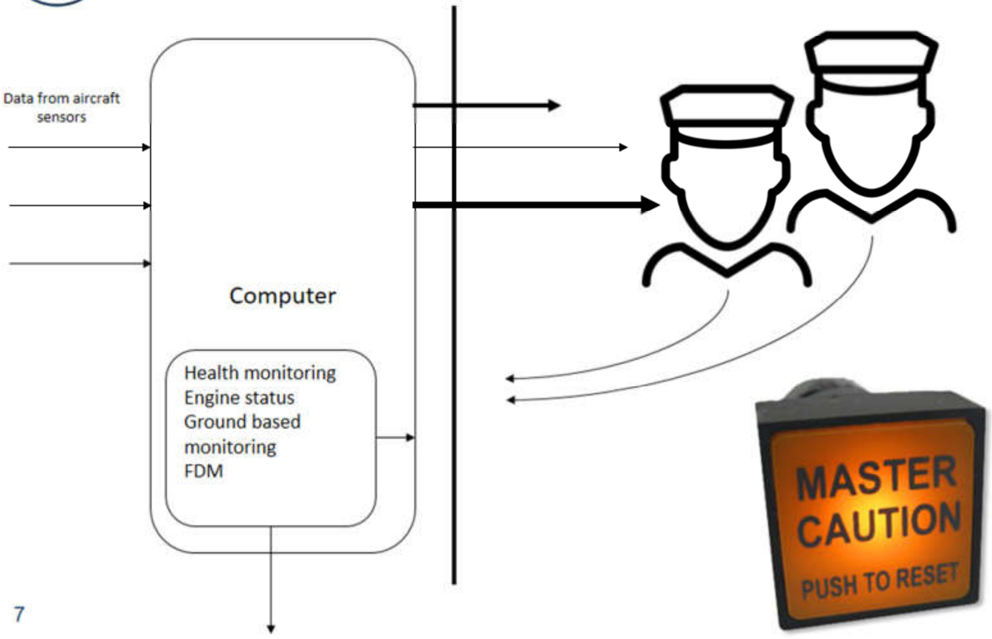
The aircraft knows more than it lets on



Data from aircraft sensors

Computer

Health monitoring
Engine status
Ground based monitoring
FDM

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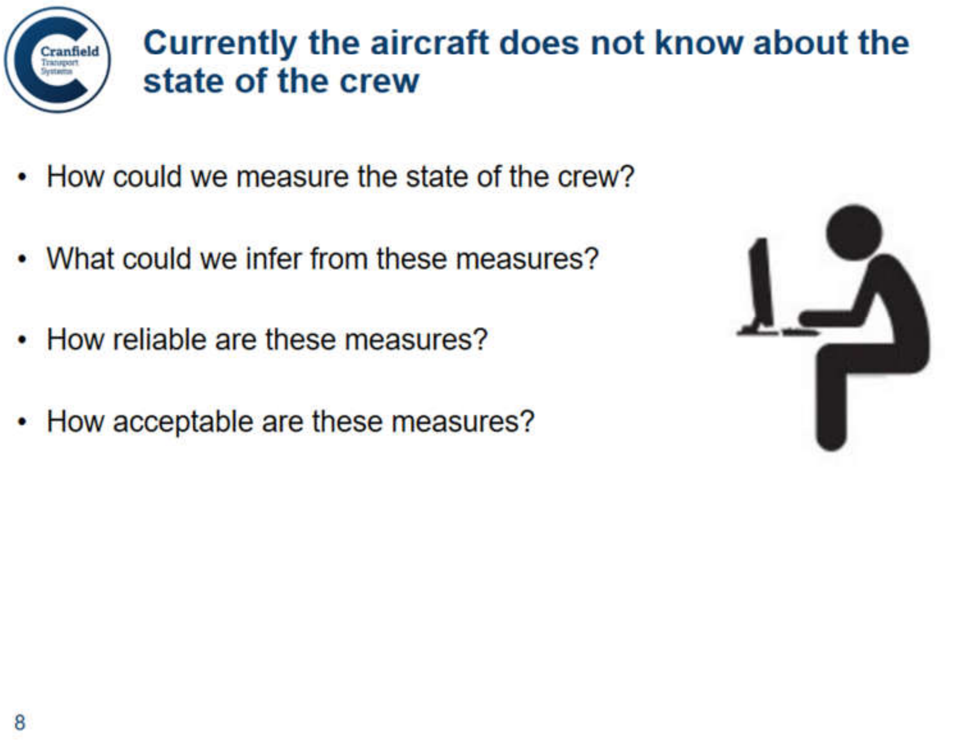
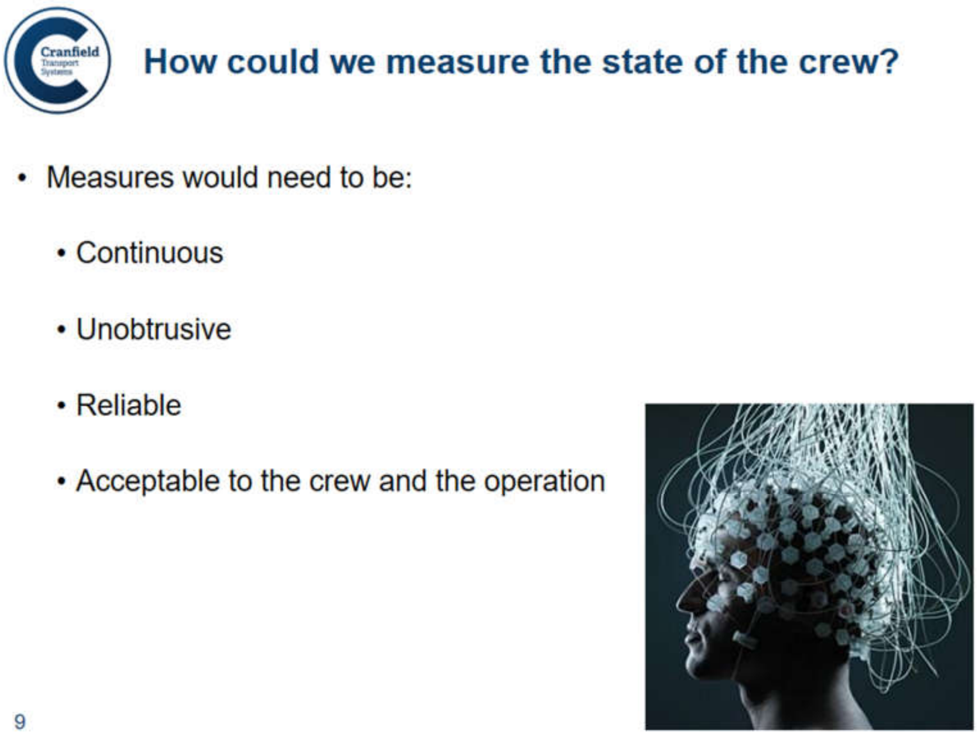


Currently the aircraft does not know about the state of the crew

- How could we measure the state of the crew?
- What could we infer from these measures?
- How reliable are these measures?
- How acceptable are these measures?

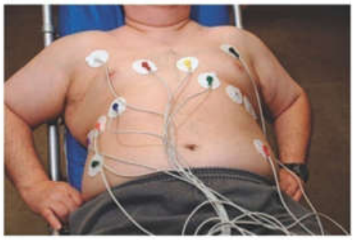


How could we measure the state of the crew?

- Measures would need to be:
  - Continuous
  - Unobtrusive
  - Reliable
  - Acceptable to the crew and the operation

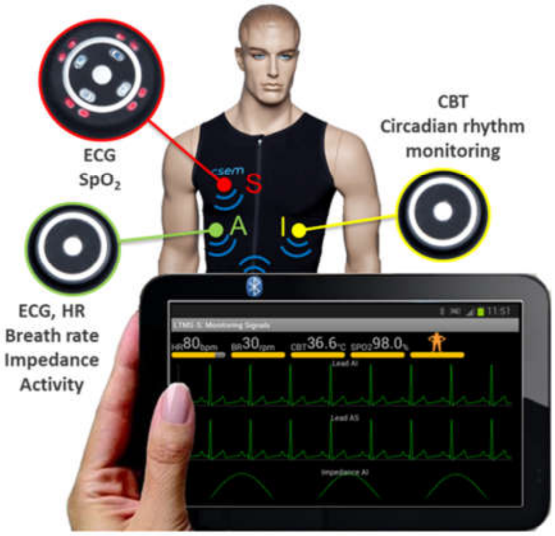
Physiological measures

Measuring electrical signals from the heart



fitbit

ECG Technology

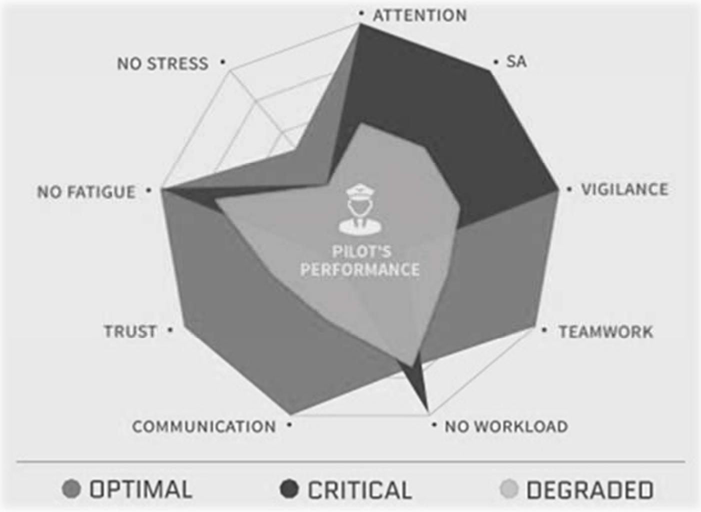


EEG

Eyes

Depth sensing cameras

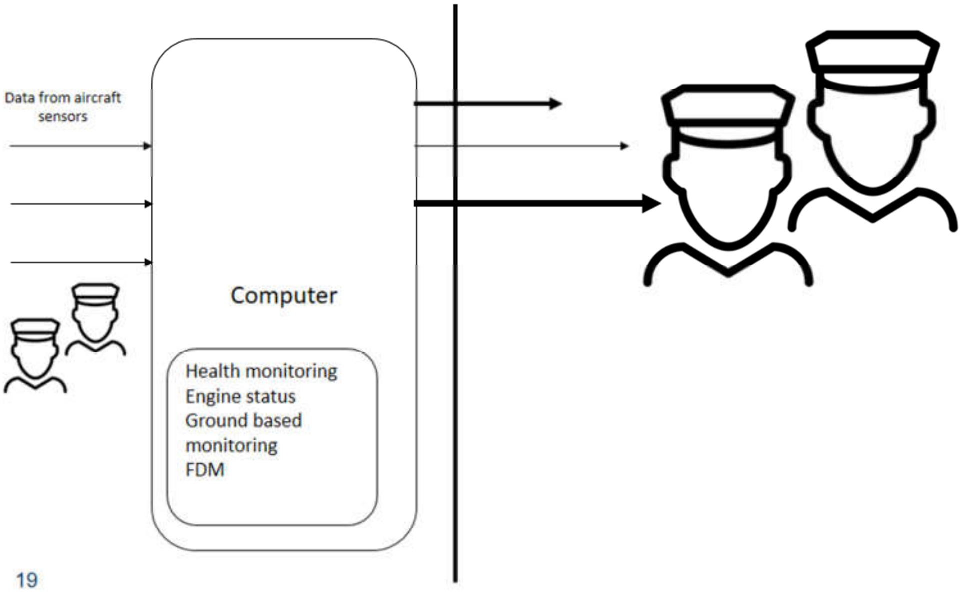
What could we infer from these measures?



How reliable are these measures?

Acceptable to the crew and the operation?

Can we exploit technology to measure the Human Performance Envelope?

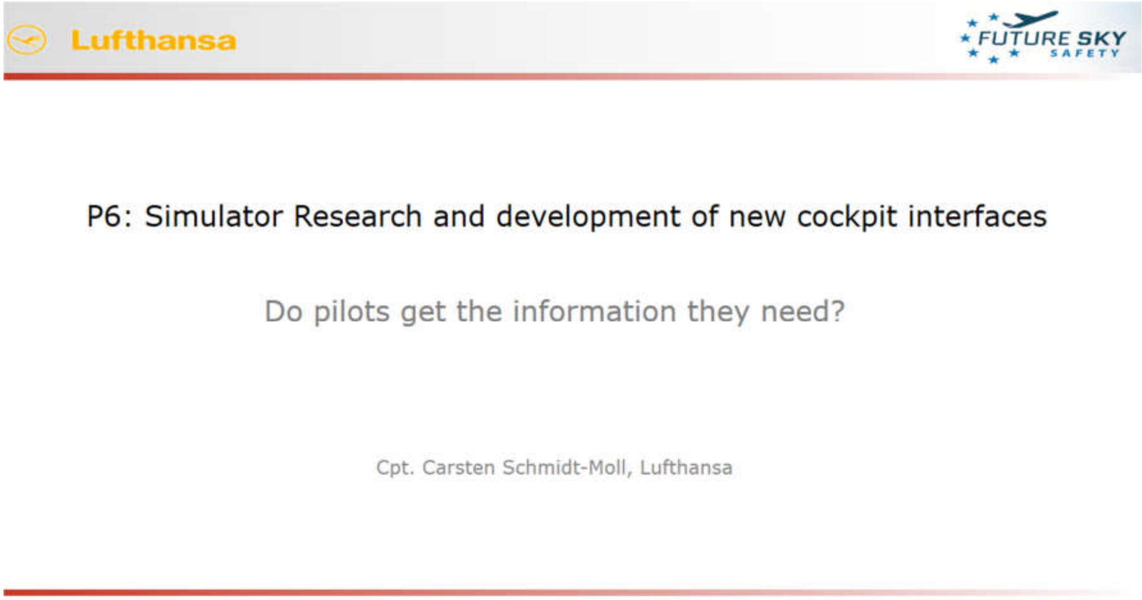


Data from aircraft sensors

Computer

Health monitoring
Engine status
Ground based monitoring
FDM

Appendix B.12 "P6: Simulator Research and development of new cockpit interfaces. Do pilots get the information they need?" – Cpt. Carsten Schmidt-Moll, Lufthansa



Lufthansa

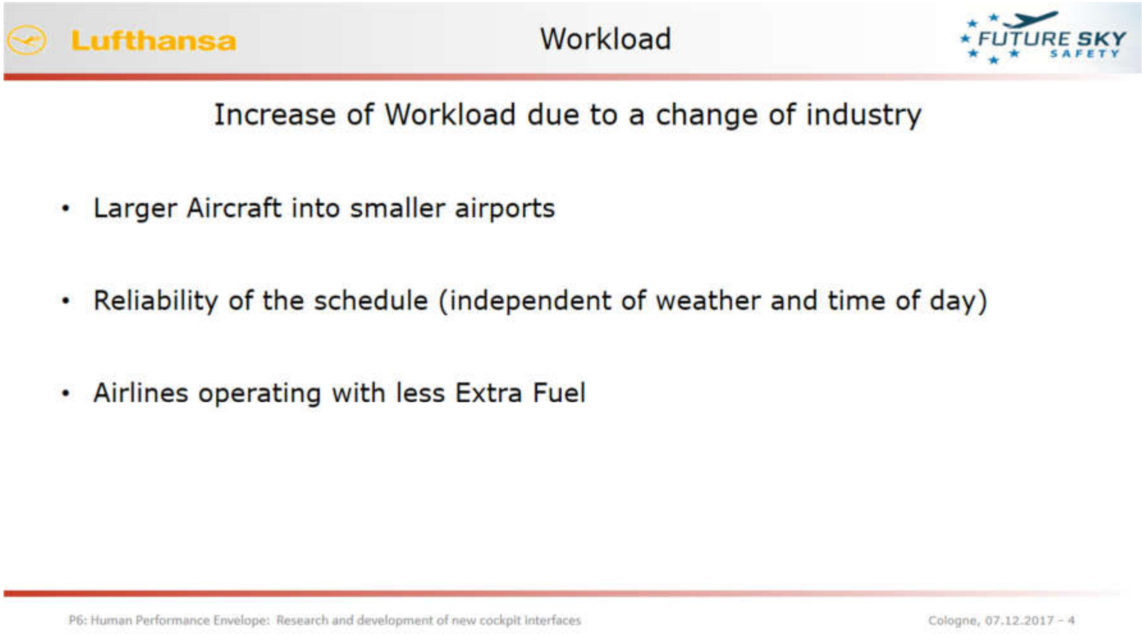
P6: Simulator Research and development of new cockpit interfaces

Do pilots get the information they need?

Cpt. Carsten Schmidt-Moll, Lufthansa

A full scope simulator

New Cockpit Interfaces



Lufthansa

Workload

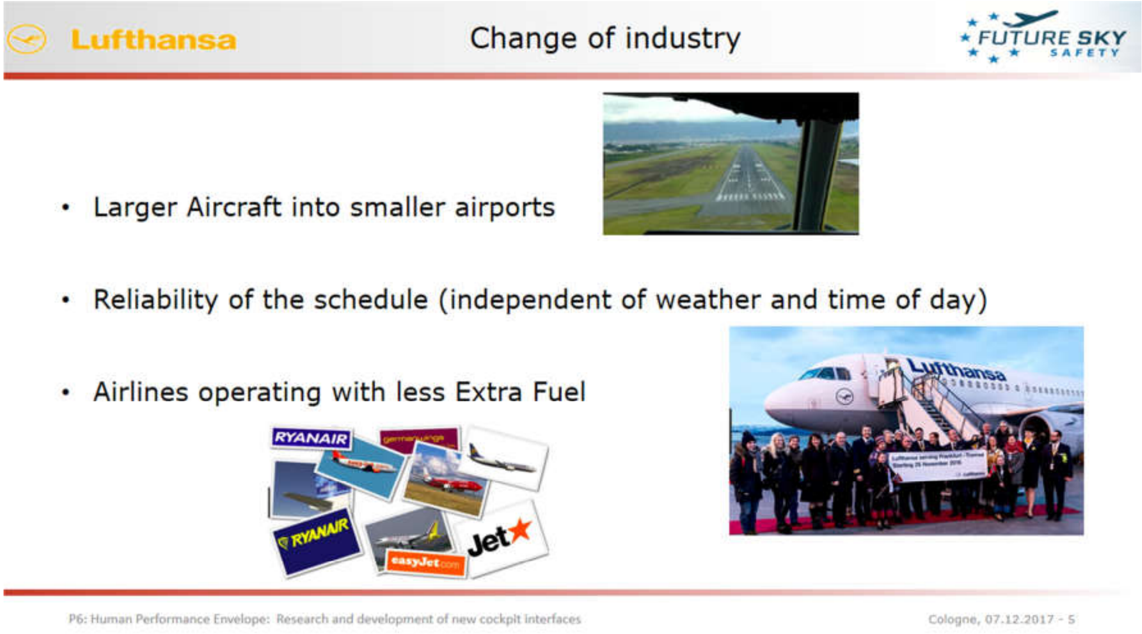
FUTURE SKY SAFETY

Increase of Workload due to a change of industry

- Larger Aircraft into smaller airports
- Reliability of the schedule (independent of weather and time of day)
- Airlines operating with less Extra Fuel

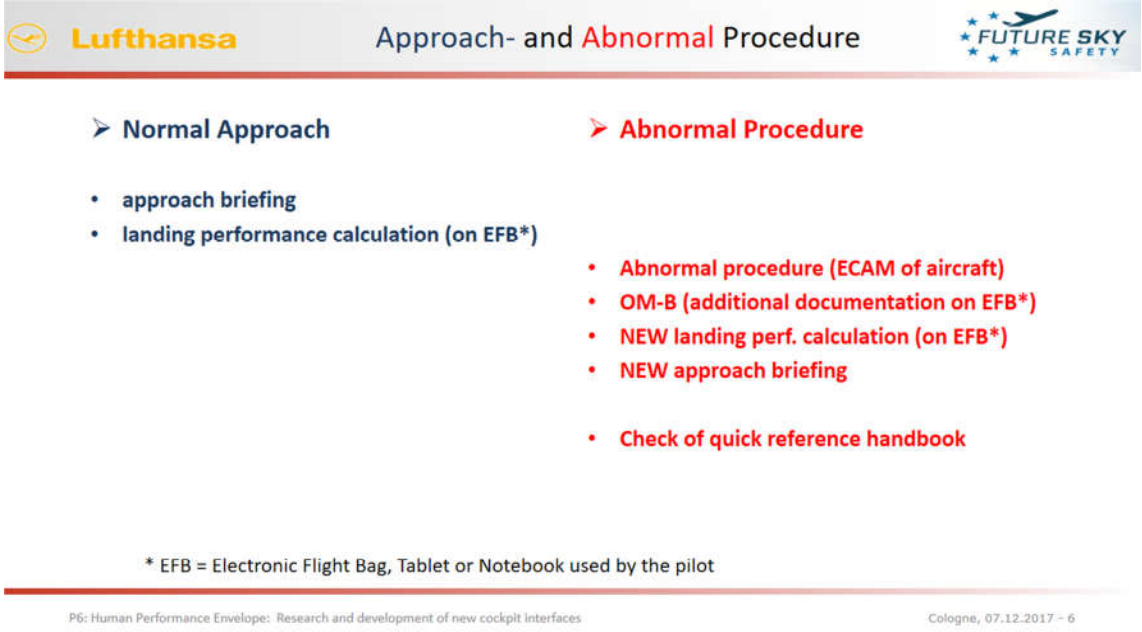
P6: Human Performance Envelope: Research and development of new cockpit interfaces

Cologne, 07.12.2017 – 4



Change of industry

- Larger Aircraft into smaller airports
- Reliability of the schedule (independent of weather and time of day)
- Airlines operating with less Extra Fuel



Approach- and Abnormal Procedure

Normal Approach

- approach briefing
- landing performance calculation (on EFB*)

Abnormal Procedure

- Abnormal procedure (ECAM of aircraft)
- OM-B (additional documentation on EFB*)
- NEW landing perf. calculation (on EFB*)
- NEW approach briefing

- Check of quick reference handbook

* EFB = Electronic Flight Bag, Tablet or Notebook used by the pilot

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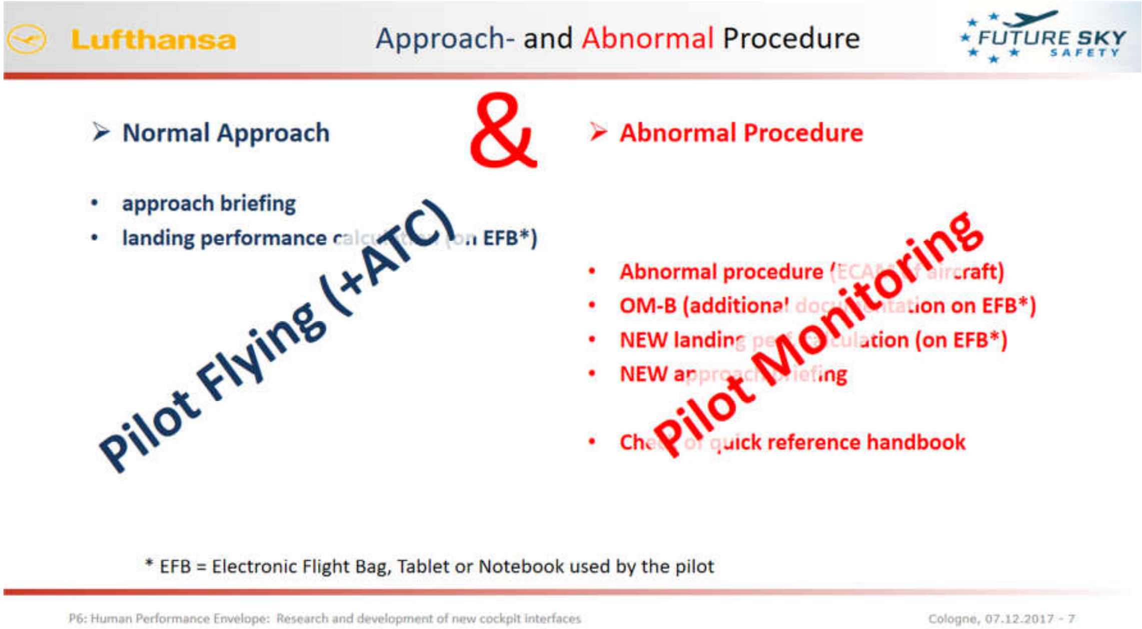


Approach- and Abnormal Procedure

- Normal Approach

&

- Abnormal Procedure

- approach briefing
- landing performance calculation (on EFB*)

Pilot Flying (+ATC)

- Abnormal procedure (ECAM of aircraft)
- OM-B (additional documentation on EFB*)
- NEW landing perf. calculation (on EFB*)
- NEW approach briefing

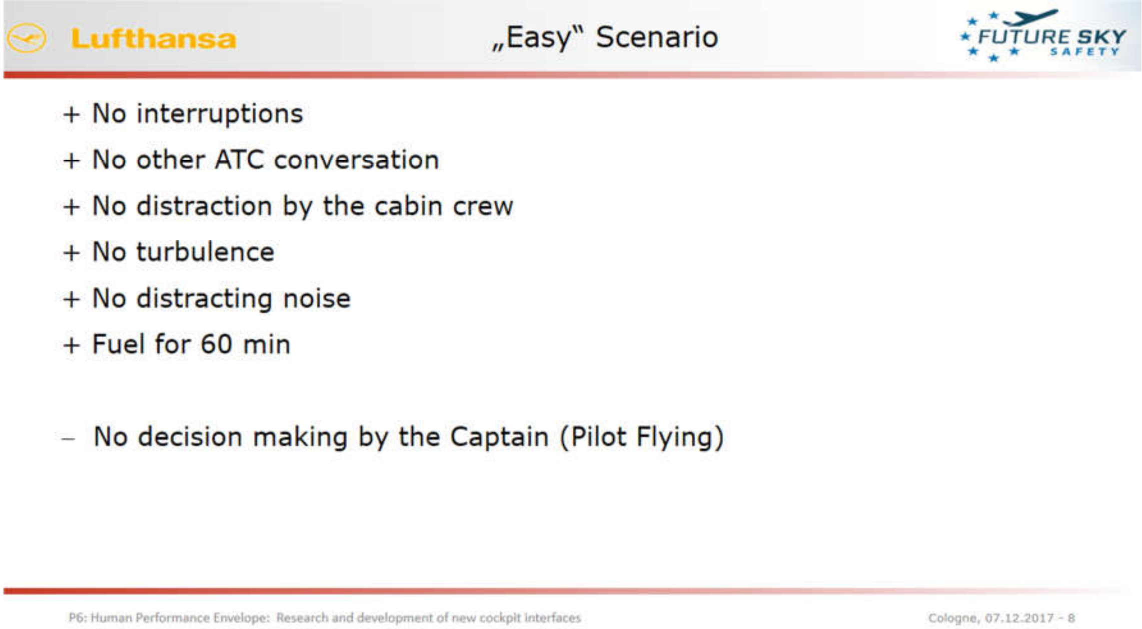
- Check of quick reference handbook

Pilot Monitoring

* EFB = Electronic Flight Bag, Tablet or Notebook used by the pilot

P6: Human Performance Envelope: Research and development of new cockpit interfaces

Cologne, 07.12.2017 - 7



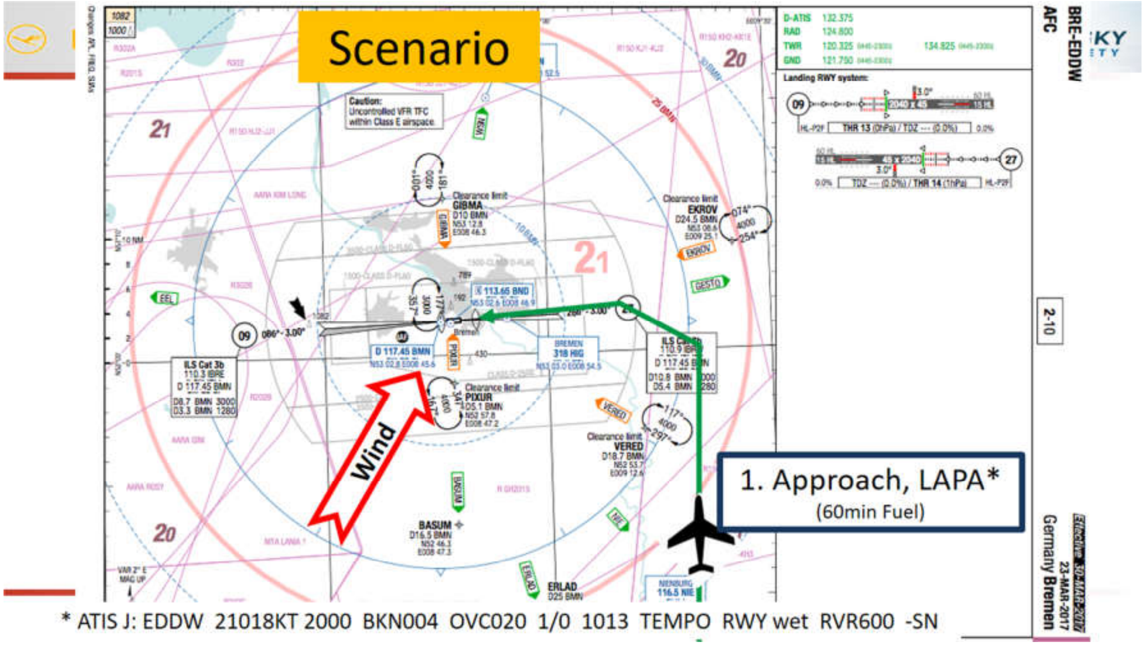
„Easy“ Scenario

\+ No interruptions
\+ No other ATC conversation
\+ No distraction by the cabin crew
\+ No turbulence
\+ No distracting noise
\+ Fuel for 60 min

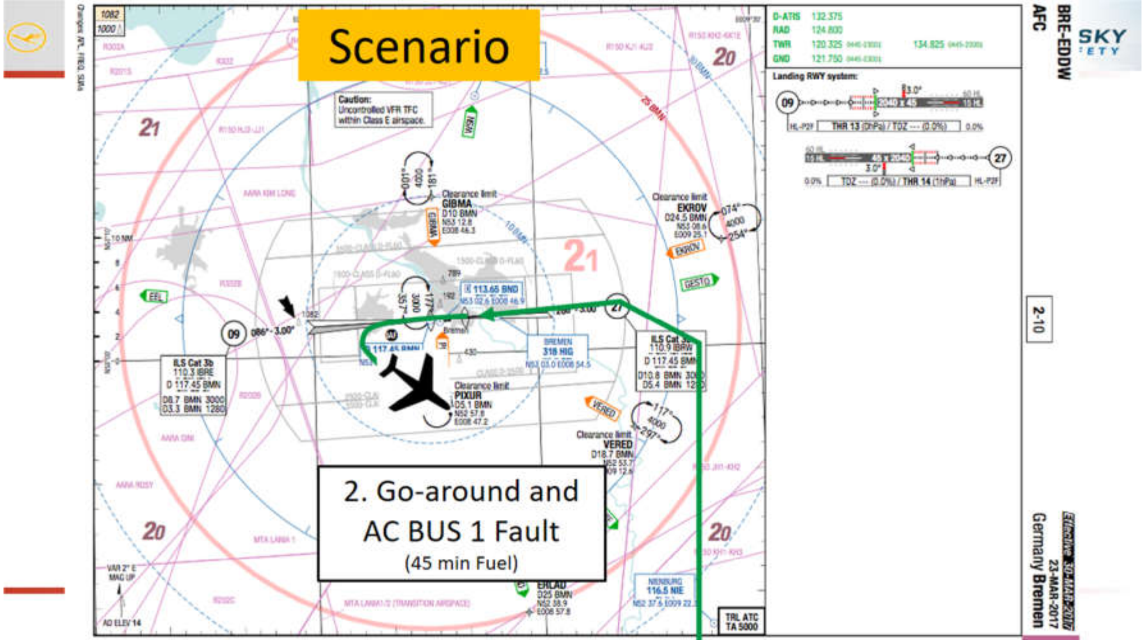
– No decision making by the Captain (Pilot Flying)

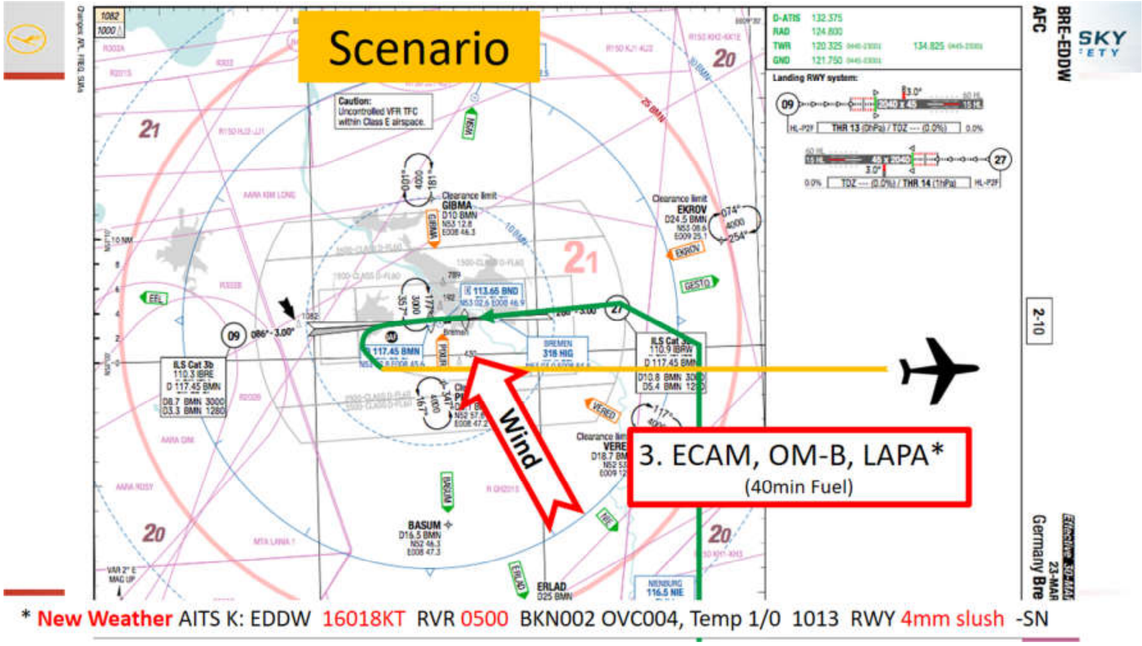
P6: Human Performance Envelope: Research and development of new cockpit interfaces

Cologne, 07.12.2017 - 8



* ATIS J: EDDW 21018KT 2000 BKN004 OVC020 1/0 1013 TEMPO RWY wet RVR600 -SN

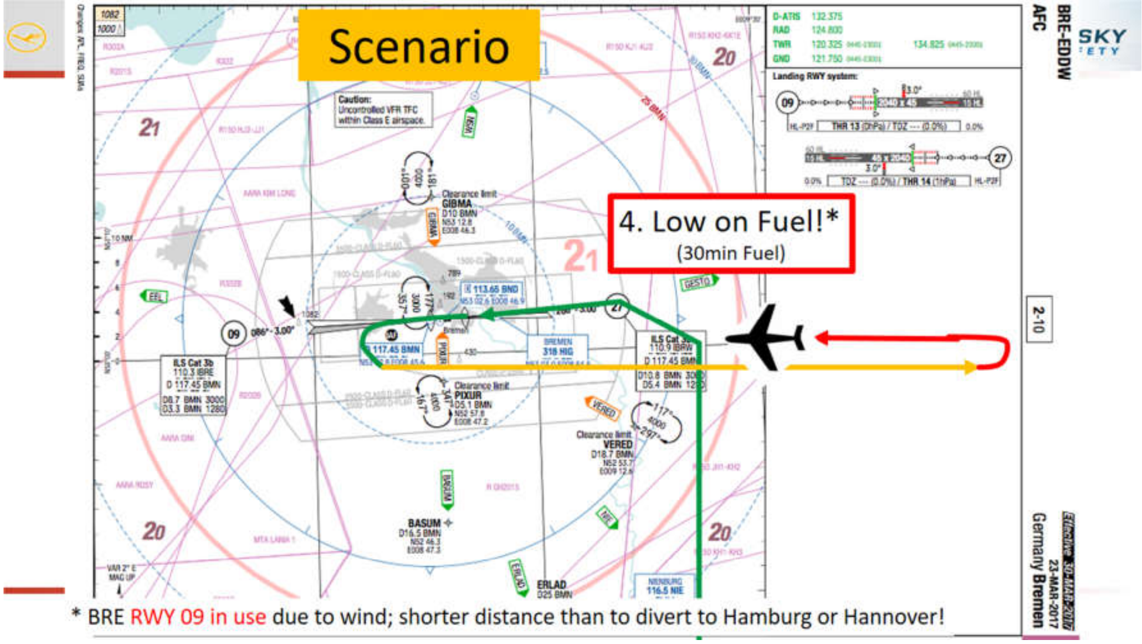




Scenario

3. ECAM, OM-B, LAPA*
(40min Fuel)

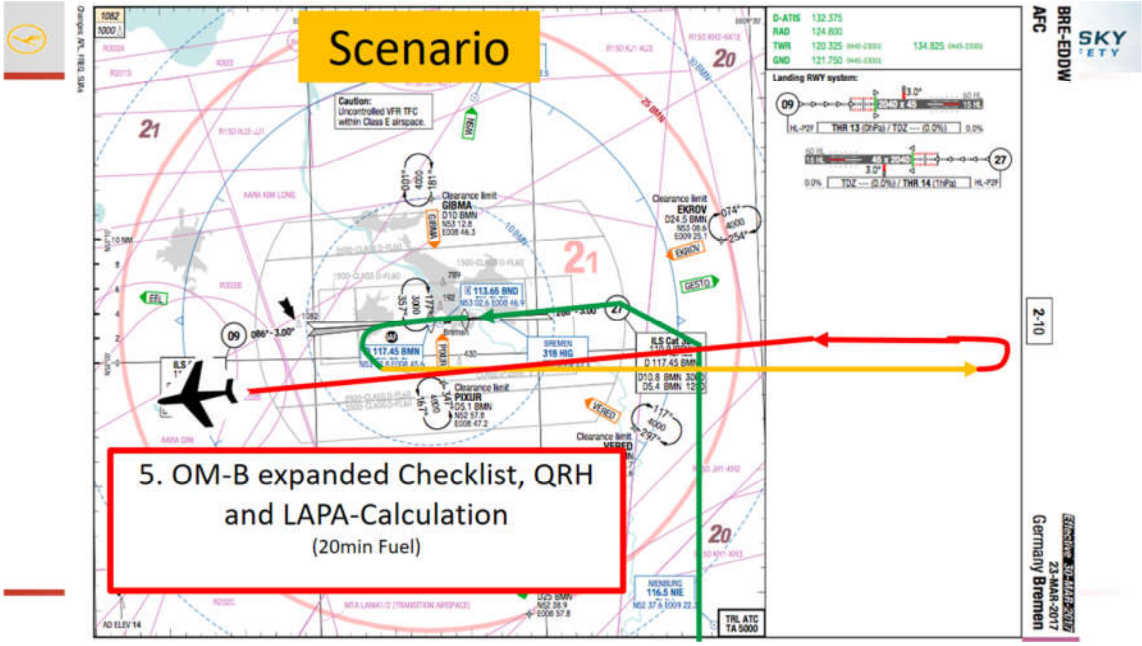
* New Weather AITS K: EDDW 16018KT RVR 0500 BKN002 OVC004, Temp 1/0 1013 RWY 4mm slush -SN



Scenario

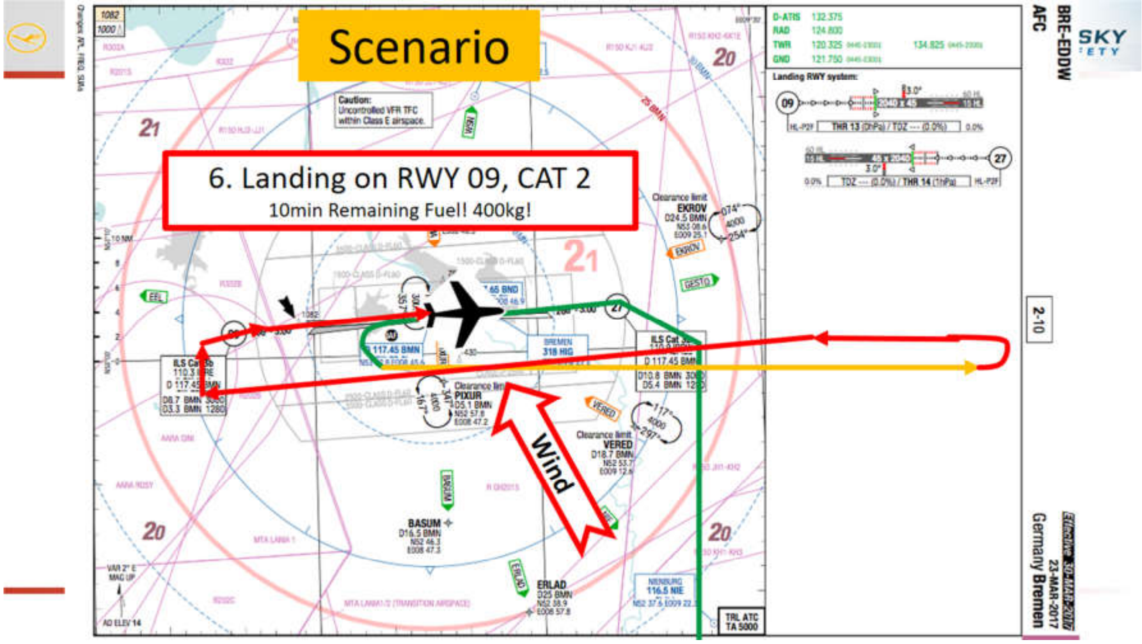
4. Low on Fuel!*
(30min Fuel)

* BRE RWY 09 in use due to wind; shorter distance than to divert to Hamburg or Hannover!



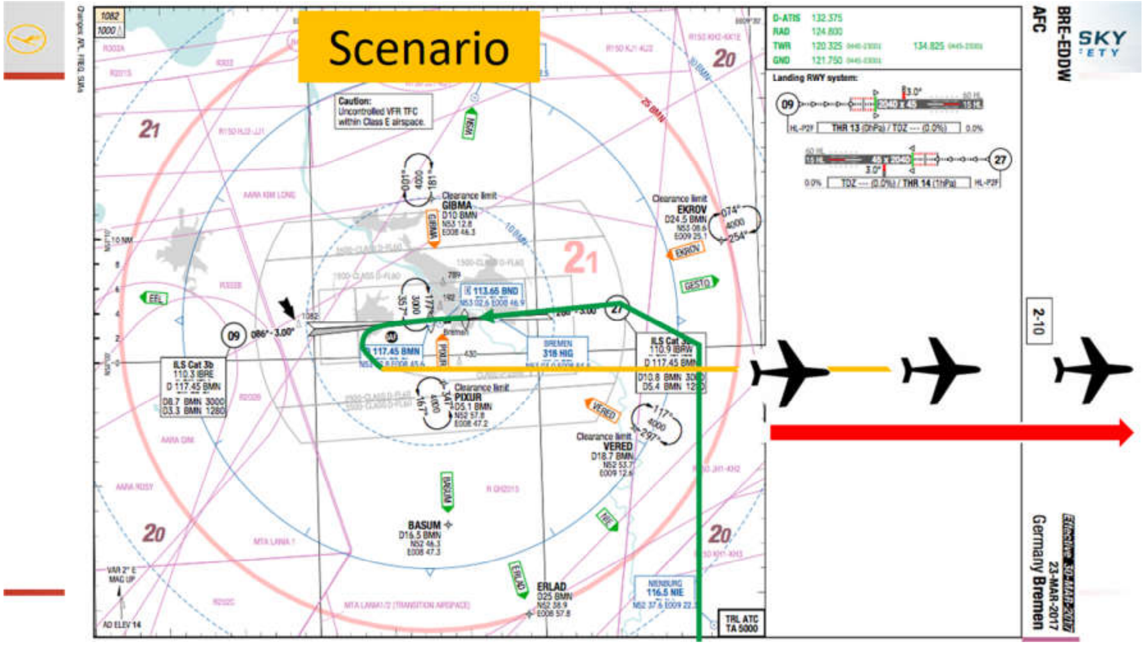
Scenario

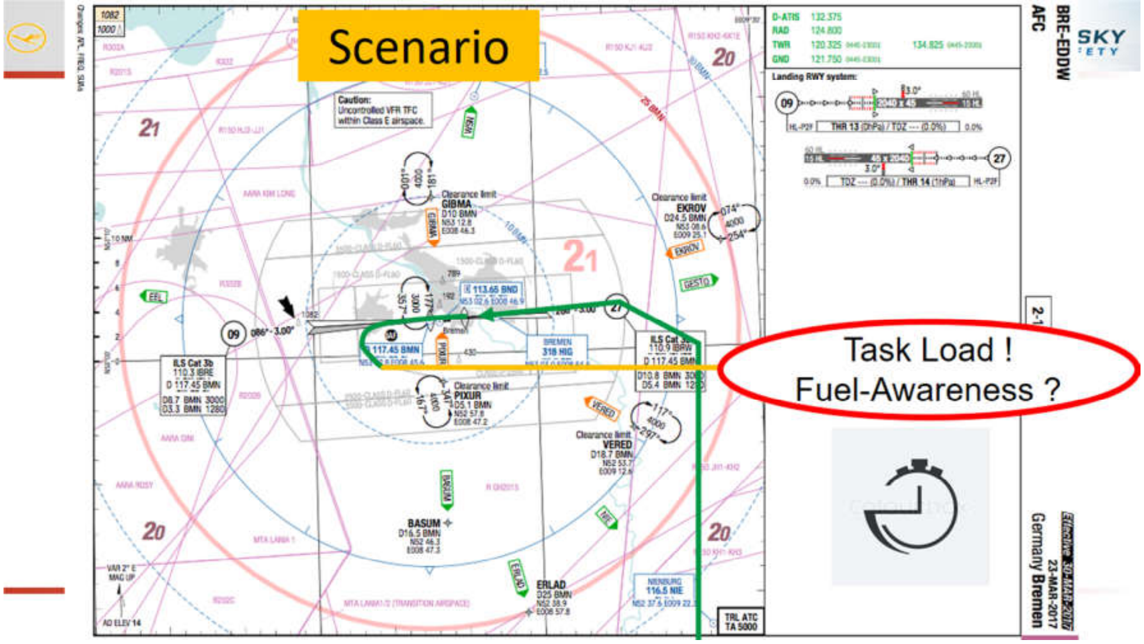
5. OM-B expanded Checklist, QRH and LAPA-Calculation
(20min Fuel)

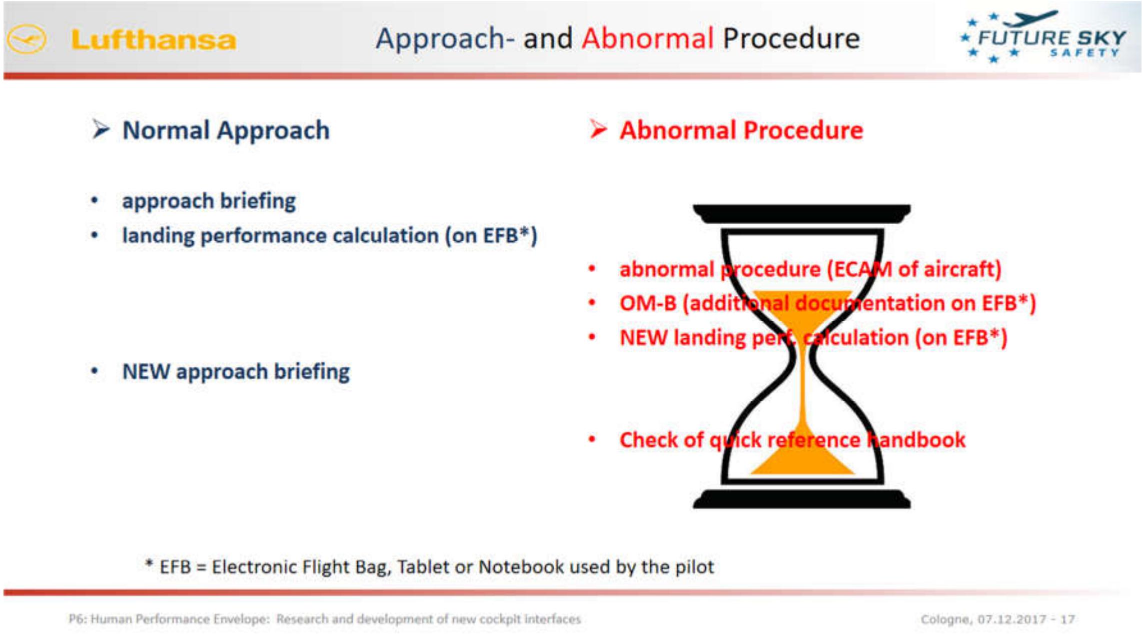


Scenario

6. Landing on RWY 09, CAT 2
10min Remaining Fuel! 400kg!


Scenario
BRE-EDDW
AFC
2-10
Germany Bremen
23-MAR-2017


Scenario
Task Load !
Fuel-Awareness ?
BRE-EDDW
AFC
Germany Bremen
23-MAR-2017



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Approach- and Abnormal Procedure

Normal Approach

- approach briefing
- landing performance calculation (on EFB*)
- NEW approach briefing

Abnormal Procedure

- abnormal procedure (ECAM of aircraft)
- OM-B (additional documentation on EFB*)
- NEW landing perf. calculation (on EFB*)
- Check of quick reference handbook

* EFB = Electronic Flight Bag, Tablet or Notebook used by the pilot

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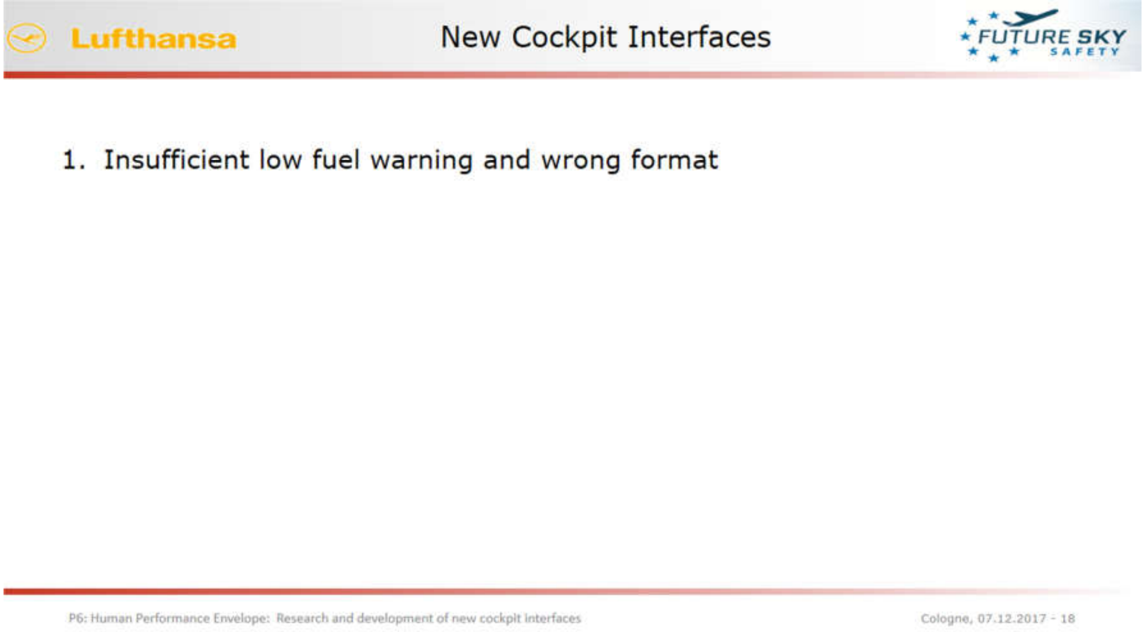

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New Cockpit Interfaces

1. Insufficient low fuel warning and wrong format

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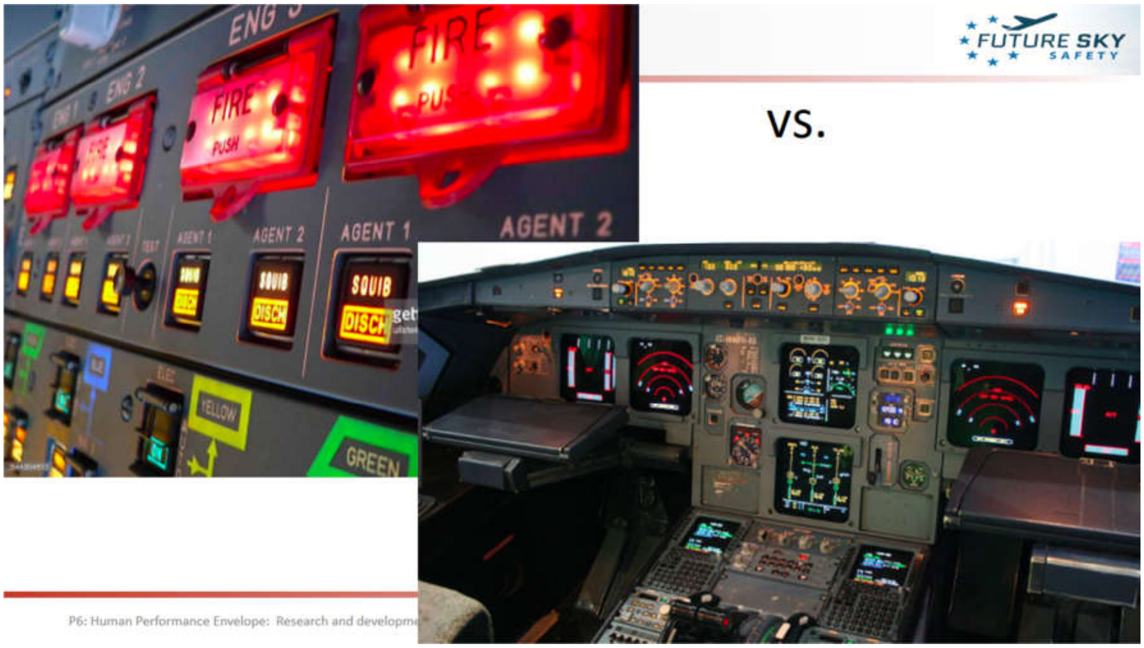
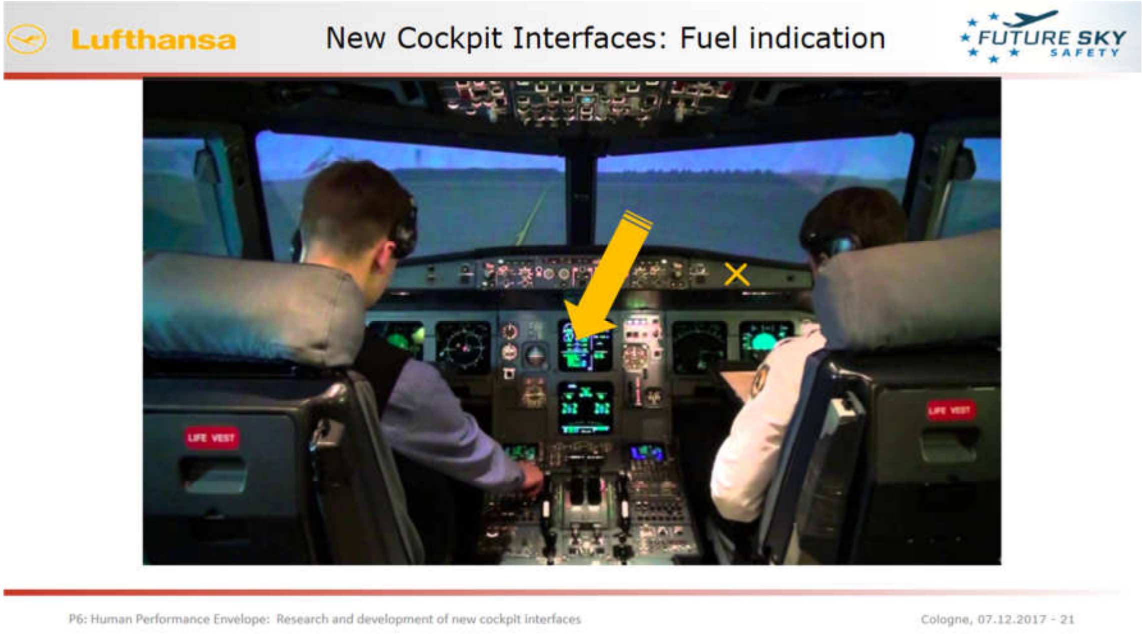


VS.

P6: Human Performance Envelope: Research and developm

VS.

P6: Human Performance Envelope: Research and developm



New Cockpit Interfaces: Fuel indication

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Fuel indication: right place - right format

1. Fuel into Primary Flight Display **(PFD)**
2. Remaining flight time in **minutes**, not in kg

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Time needed for a hike

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Time vs. calories

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New Cockpit Interfaces

1. Insufficient low fuel warning and wrong format
2. Manufacturer does not recommend to skip a procedure (OM-B: Premature termination/ disregarding abnormal procedures: „… In any case, the basic procedures must be followed. …“)

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New Cockpit Interfaces

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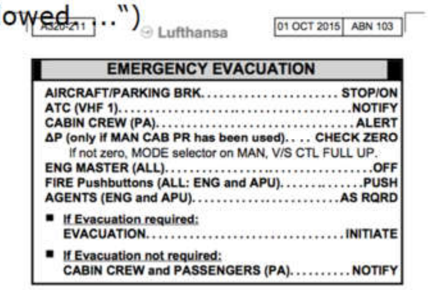

A320-211 Lufthansa 01 OCT 2015 ABN 103

EMERGENCY EVACUATION

AIRCRAFT/PARKING BRK. . . . . STOP/ON
ATC (VHF 1). . . . . NOTIFY
CABIN CREW (PA). . . . . ALERT
ΔP (only if MAN CAB PR has been used). . . . CHECK ZERO
If not zero, MODE selector on MAN, V/S CTL FULL UP.
ENG MASTER (ALL). . . . . OFF
FIRE Pushbuttons (ALL: ENG and APU). . . . . PUSH
AGENTS (ENG and APU). . . . . AS RQRD

- If Evacuation required:
  EVACUATION. . . . . INITIATE
- If Evacuation not required:
  CABIN CREW and PASSENGERS (PA). . . . . NOTIFY

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New HMI for „out of the box"-scenarios

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Knowledge Based Behaviour

NAV UNRELIABLE AIR SPEED INDICATION
ACTIVATE
.IF SAFE CONDUCT OF FLIGHT IMPACTED :
CONFIRM
-AP ....DISCONNECT
-A/THR ....DISCONNECT
-FD ....DISCONNECT
-ALL THR LEVERS CLB

	PITCH ATT TRGT
BELOW FL 100	12.5°
BETWEEN FL 100 & FL 250	10°
ABOVE FL 250	5°

-PITCH ATT TRGT ....ADJUST
-FLAPS & L/G : MAINTAIN CURRENT CONF
-SPEED BRAKES ....CHECK RETRACTED
RISK OF UNDUE OVERSPEED WARNING
.[DON'T UNRELIABLE AIR SPEED PROC ..APPLY

EICAS Caution and Advisory Messages:

DET FIRE/OVHT 1
HYD OVHT SYS 1
BLEED 1 OVHT
BLEED HP ENG 1
BLD 1 OVHT/PRV
ENG 1 OVHT LP A
ENG 1 OVHT LP B
ENG 1 FIRE LP A
ENG 1 FIRE LP B
OVHT ENG 1 NAC
FUEL SPAR VLV 1
ENG 1 VIB

New Cockpit Interfaces

1. Insufficient low fuel warning and wrong format
2. Manufacturer does not recommend to skip a procedure (OM-B: Premature termination/ disregarding abnormal procedures: „… In any case, the basic procedures must be followed. …“)
3. Pilots do not get the important and relevant information

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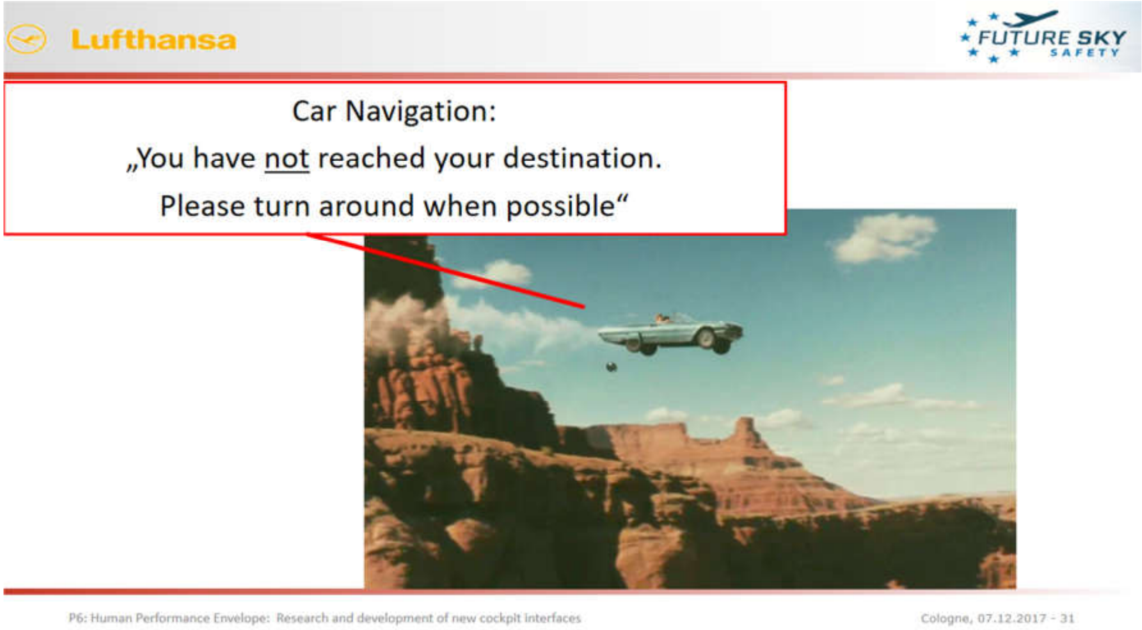

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Car Navigation:

„You have not reached your destination.

Please turn around when possible“

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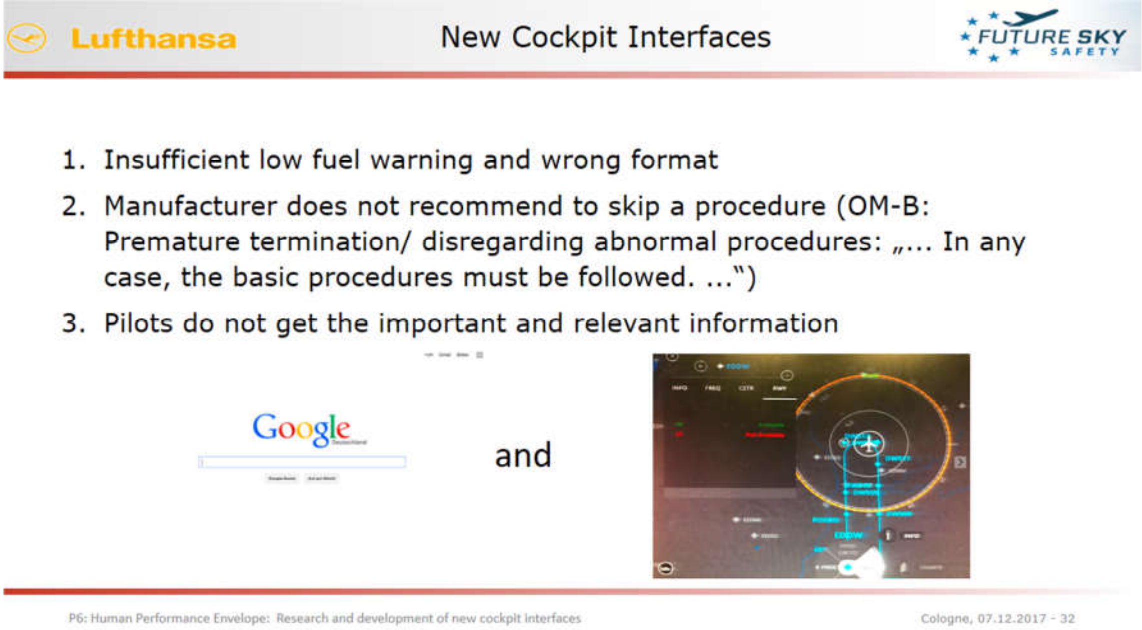

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New Cockpit Interfaces

1. Insufficient low fuel warning and wrong format
2. Manufacturer does not recommend to skip a procedure (OM-B: Premature termination/ disregarding abnormal procedures: „… In any case, the basic procedures must be followed. …“)
3. Pilots do not get the important and relevant information

and

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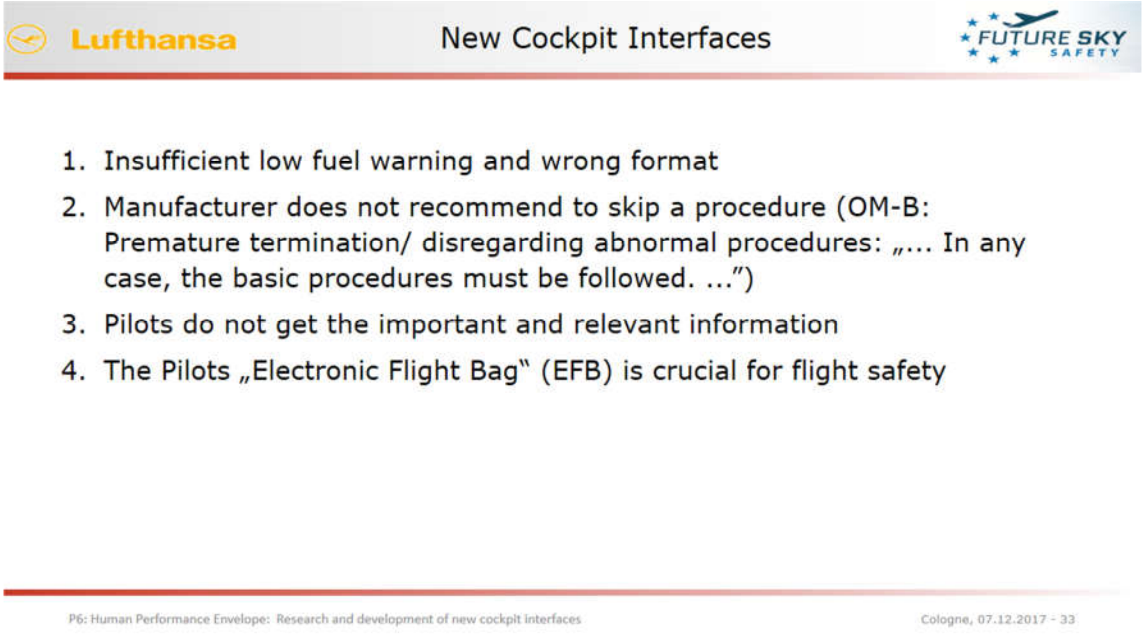

New Cockpit Interfaces

1. Insufficient low fuel warning and wrong format
2. Manufacturer does not recommend to skip a procedure (OM-B: Premature termination/ disregarding abnormal procedures: „... In any case, the basic procedures must be followed. ...")
3. Pilots do not get the important and relevant information
4. The Pilots „Electronic Flight Bag" (EFB) is crucial for flight safety

P6: Human Performance Envelope: Research and development of new cockpit interfaces

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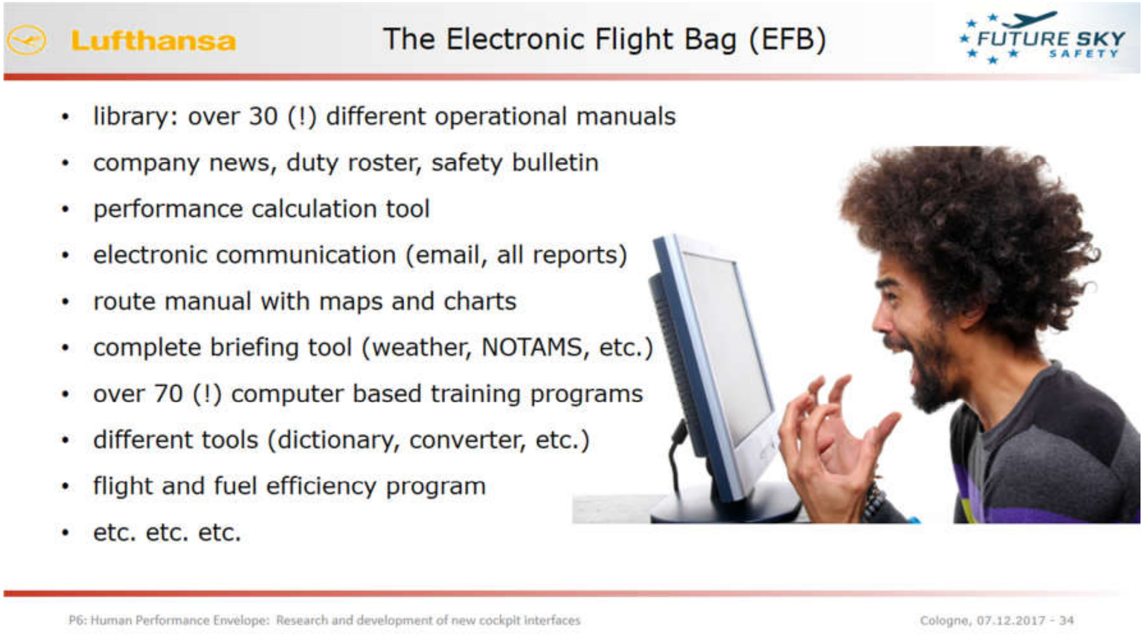

The Electronic Flight Bag (EFB)

- library: over 30 (!) different operational manuals
- company news, duty roster, safety bulletin
- performance calculation tool
- electronic communication (email, all reports)
- route manual with maps and charts
- complete briefing tool (weather, NOTAMS, etc.)
- over 70 (!) computer based training programs
- different tools (dictionary, converter, etc.)
- flight and fuel efficiency program
- etc. etc. etc.

P6: Human Performance Envelope: Research and development of new cockpit interfaces

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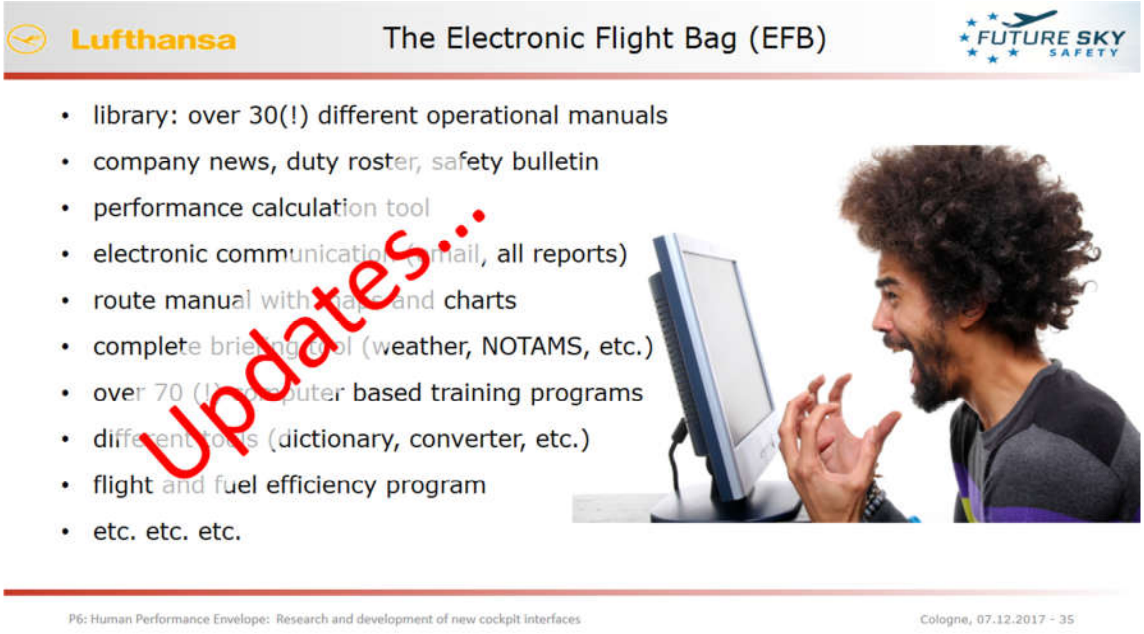

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The Electronic Flight Bag (EFB)

- library: over 30(!) different operational manuals
- company news, duty roster, safety bulletin
- performance calculation tool
- electronic communication (mail, all reports)
- route manual with map and charts
- complete briefing tool (weather, NOTAMS, etc.)
- over 70 (!) computer based training programs
- different tools (dictionary, converter, etc.)
- flight and fuel efficiency program
- etc. etc. etc.

Updates…

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HMI for the electronic flight bag (EFB)

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The good news

SAILPLANE FLYING

ITS ALL QUIET AND PEACEFUL...

UNTIL YOU LOOK IN THE REAR-VIEW MIRROR

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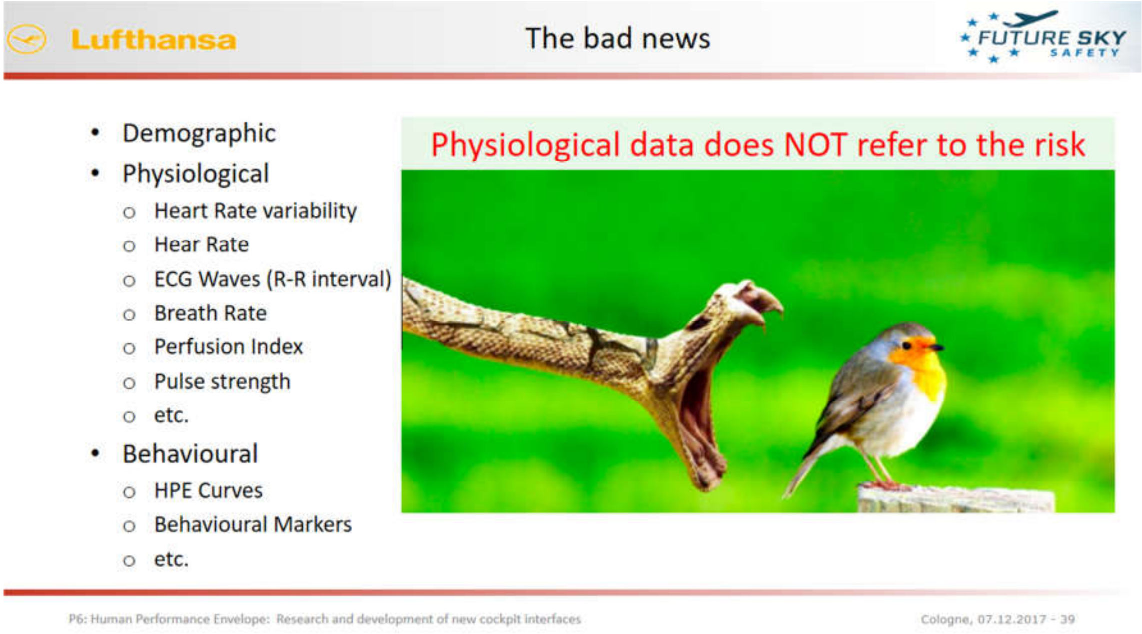
The good news

Pilots can pass away happily

P6: Human Performance Envelope: Research and development of new cockpit interfaces

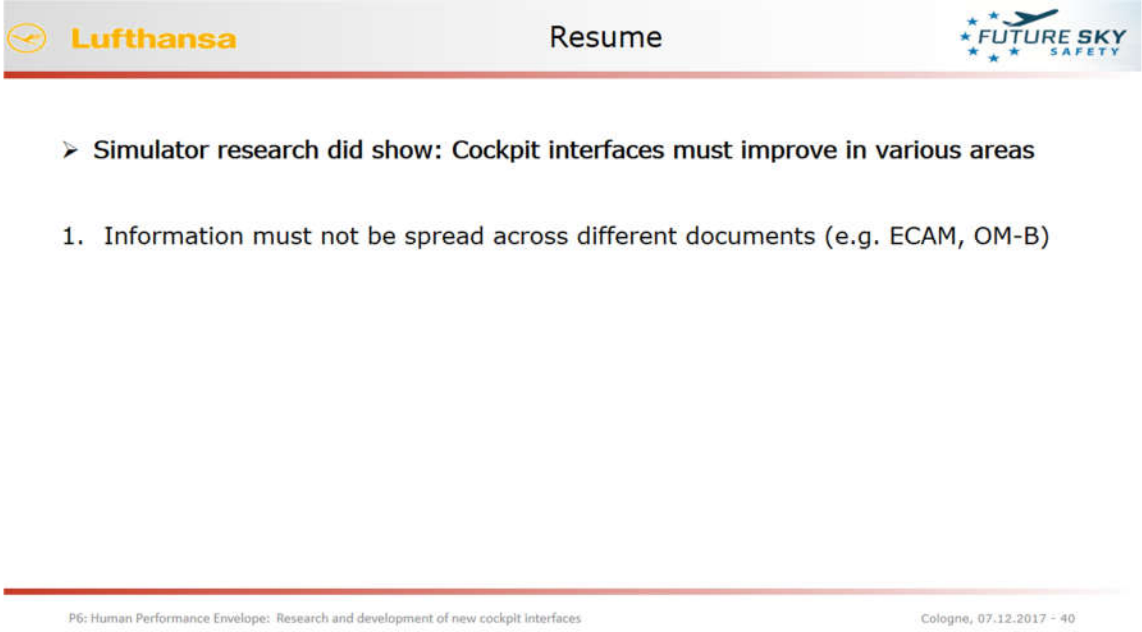
Cologne, 07.12.2017 - 38



The bad news

- Demographic
- Physiological
  - Heart Rate variability
  - Hear Rate
  - ECG Waves (R-R interval)
  - Breath Rate
  - Perfusion Index
  - Pulse strength
  - etc.
- Behavioural
  - HPE Curves
  - Behavioural Markers
  - etc.

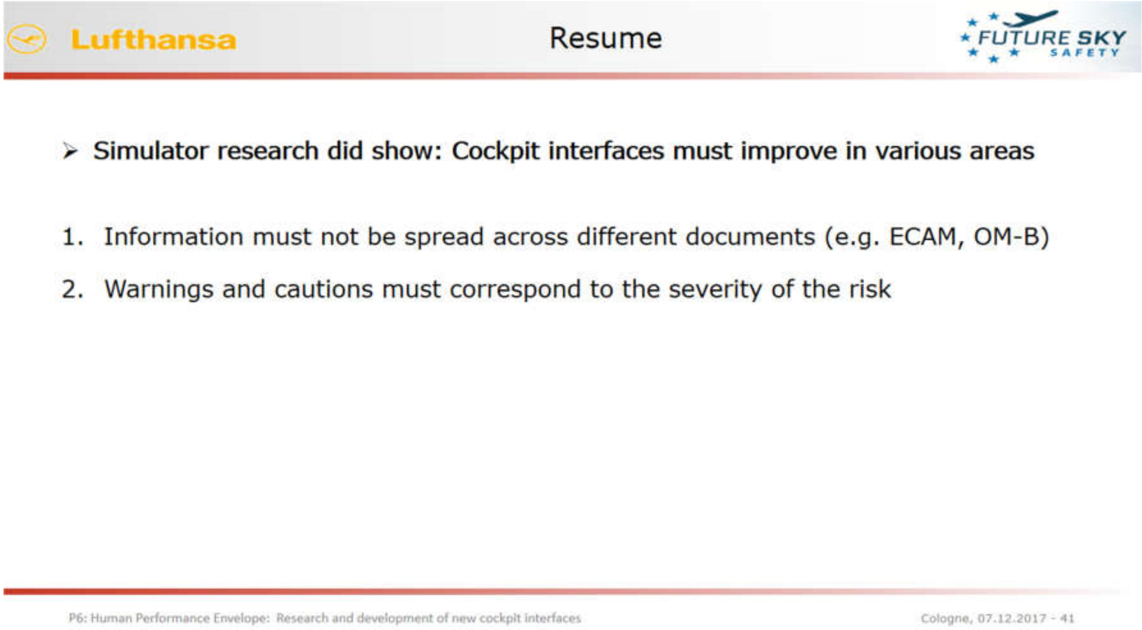
Physiological data does NOT refer to the risk



Resume

- ➢ Simulator research did show: Cockpit interfaces must improve in various areas

1. Information must not be spread across different documents (e.g. ECAM, OM-B)



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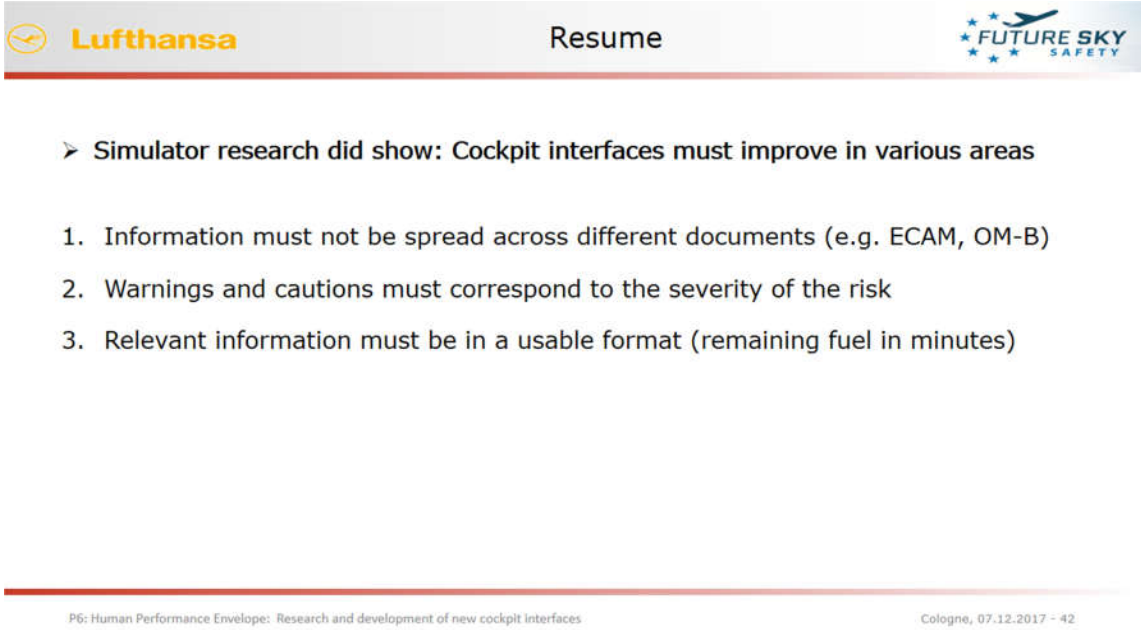
Resume

- ➢ Simulator research did show: Cockpit interfaces must improve in various areas

1. Information must not be spread across different documents (e.g. ECAM, OM-B)
2. Warnings and cautions must correspond to the severity of the risk



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Resume

- ➢ Simulator research did show: Cockpit interfaces must improve in various areas

1. Information must not be spread across different documents (e.g. ECAM, OM-B)
2. Warnings and cautions must correspond to the severity of the risk
3. Relevant information must be in a usable format (remaining fuel in minutes)

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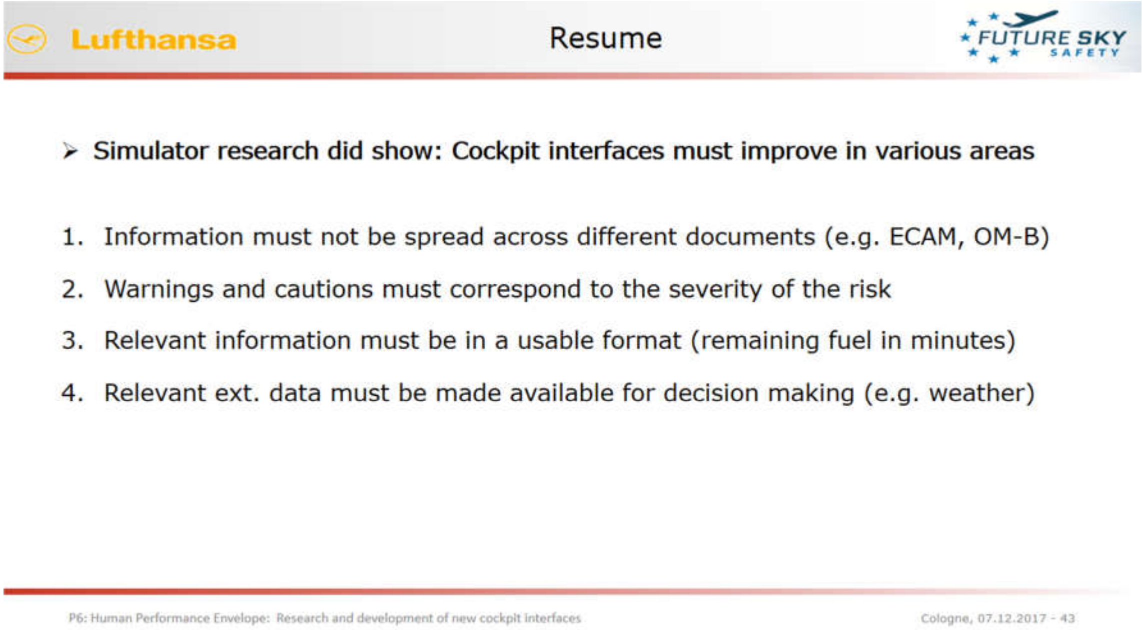

Resume

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4. Relevant ext. data must be made available for decision making (e.g. weather)

P6: Human Performance Envelope: Research and development of new cockpit interfaces

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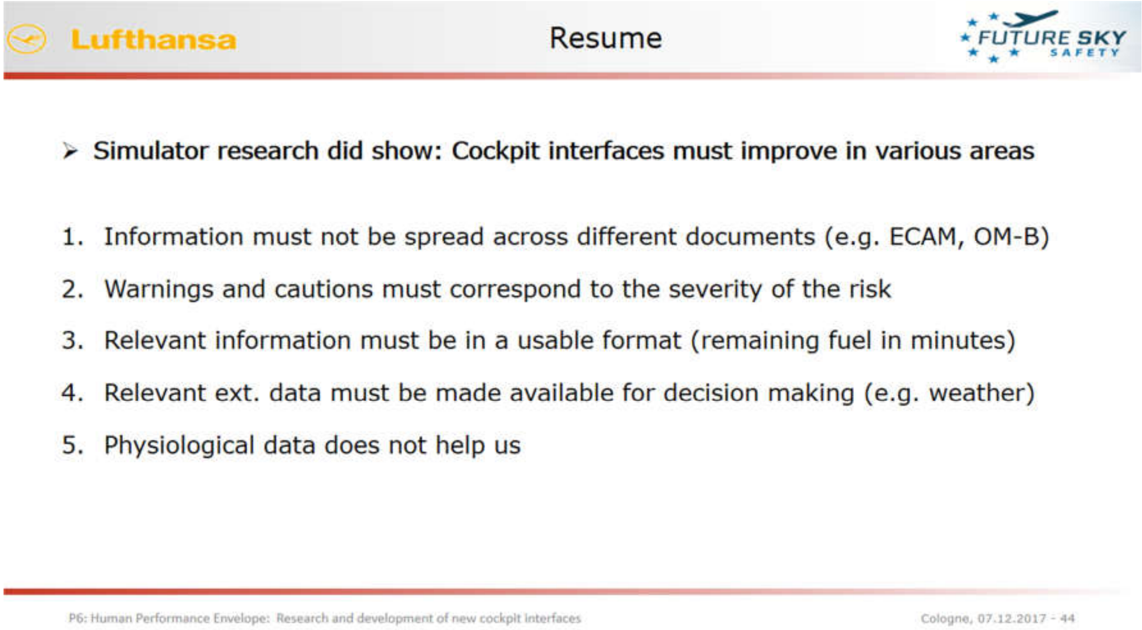

Resume

- Simulator research did show: Cockpit interfaces must improve in various areas

1. Information must not be spread across different documents (e.g. ECAM, OM-B)
2. Warnings and cautions must correspond to the severity of the risk
3. Relevant information must be in a usable format (remaining fuel in minutes)
4. Relevant ext. data must be made available for decision making (e.g. weather)
5. Physiological data does not help us

P6: Human Performance Envelope: Research and development of new cockpit interfaces

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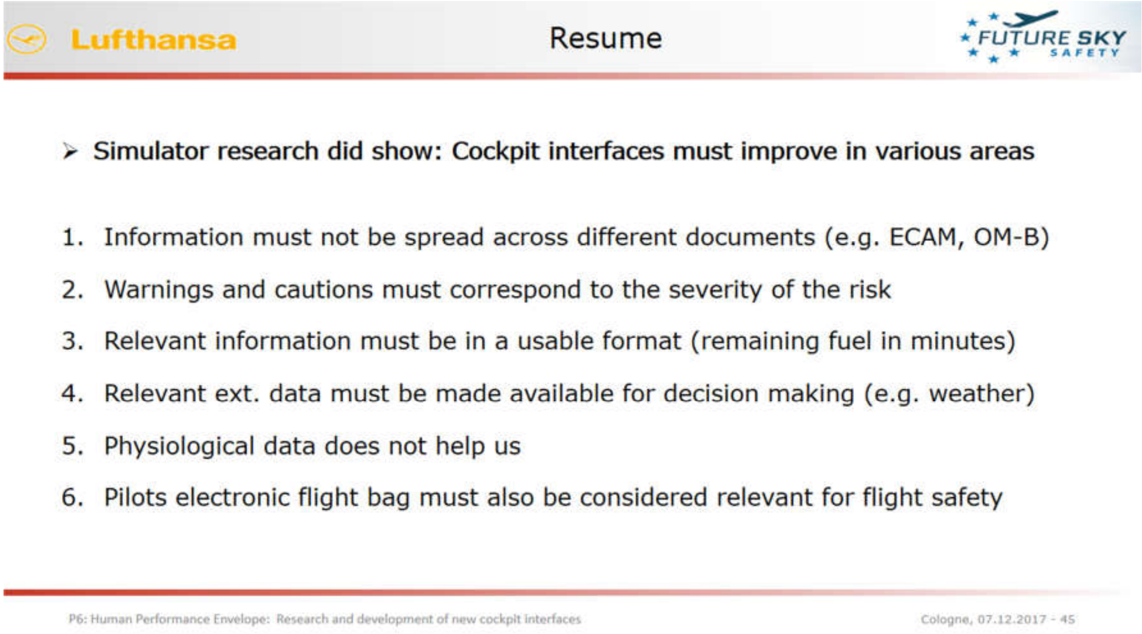

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Resume

➢ **Simulator research did show: Cockpit interfaces must improve in various areas**

1. Information must not be spread across different documents (e.g. ECAM, OM-B)
2. Warnings and cautions must correspond to the severity of the risk
3. Relevant information must be in a usable format (remaining fuel in minutes)
4. Relevant ext. data must be made available for decision making (e.g. weather)
5. Physiological data does not help us
6. Pilots electronic flight bag must also be considered relevant for flight safety

P6: Human Performance Envelope: Research and development of new cockpit interfaces

Cologne, 07.12.2017 - 45

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The team - Thank you all!

Thank you for your attention

P6: Human Performance Envelope: Research and development of new cockpit interfaces

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Appendix B.13 "P7: Mitigating risks of fire, smoke and fumes" – Eric Deletombe, ONERA

FSS Workshop 2 – 07/12/2017
P7 Mitigating Risks of FS&F

Eric Deletombe / ONERA – The French Aerospace Lab
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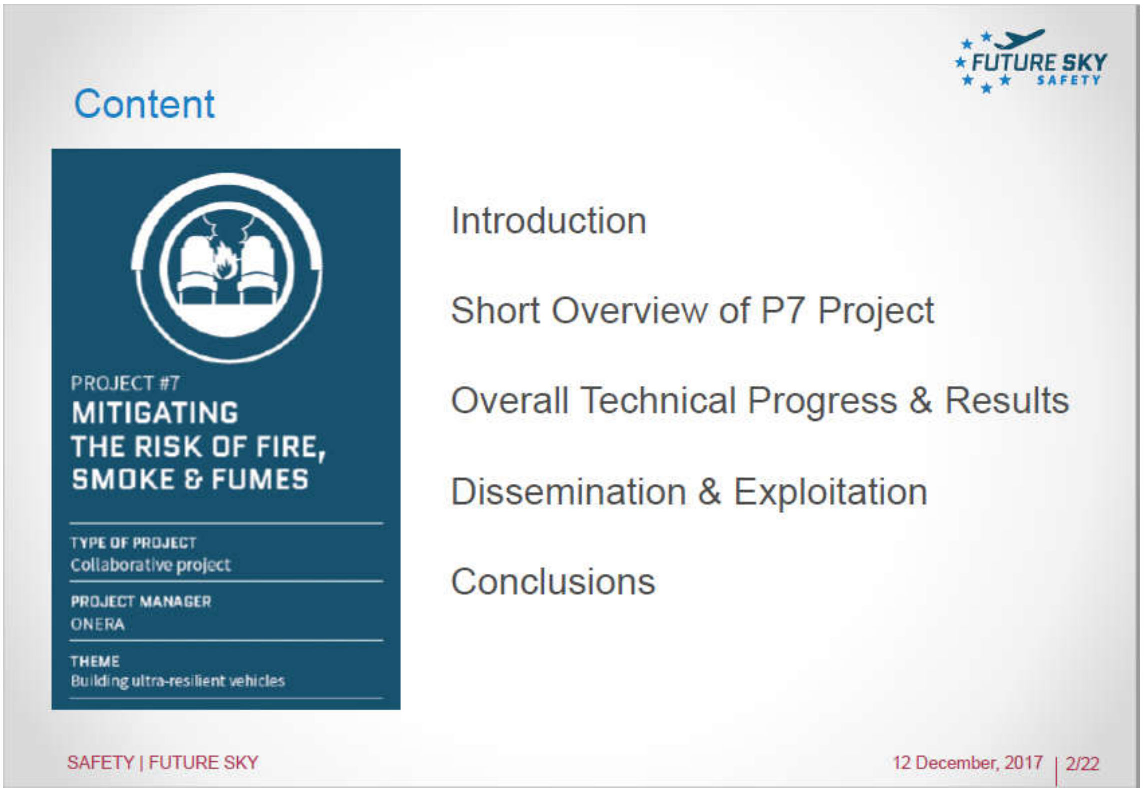
+33 (0)3 20 49 69 36



Content

PROJECT #7
MITIGATING THE RISK OF FIRE, SMOKE & FUMES

TYPE OF PROJECT
Collaborative project

PROJECT MANAGER
ONERA

THEME
Building ultra-resilient vehicles

Introduction

Short Overview of P7 Project

Overall Technical Progress & Results

Dissemination & Exploitation

Conclusions

SAFETY | FUTURE SKY

12 December, 2017 | 2/22

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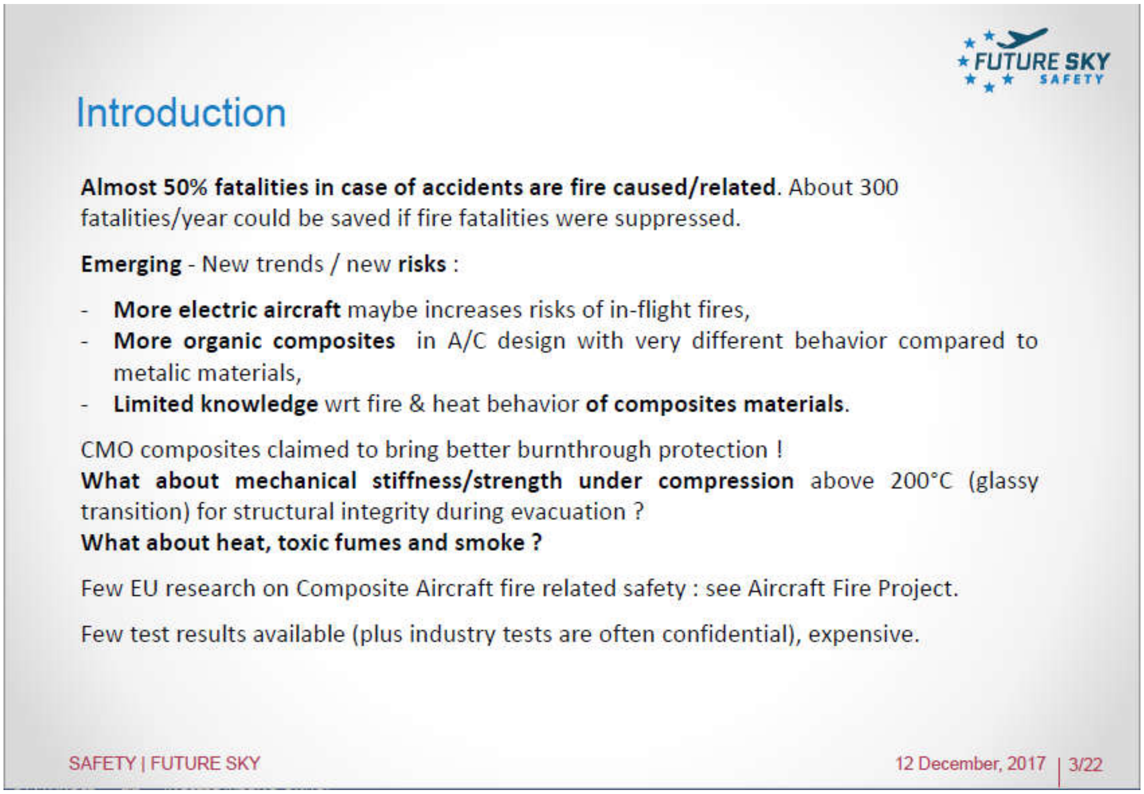


Introduction

Almost 50% fatalities in case of accidents are fire caused/related. About 300 fatalities/year could be saved if fire fatalities were suppressed.

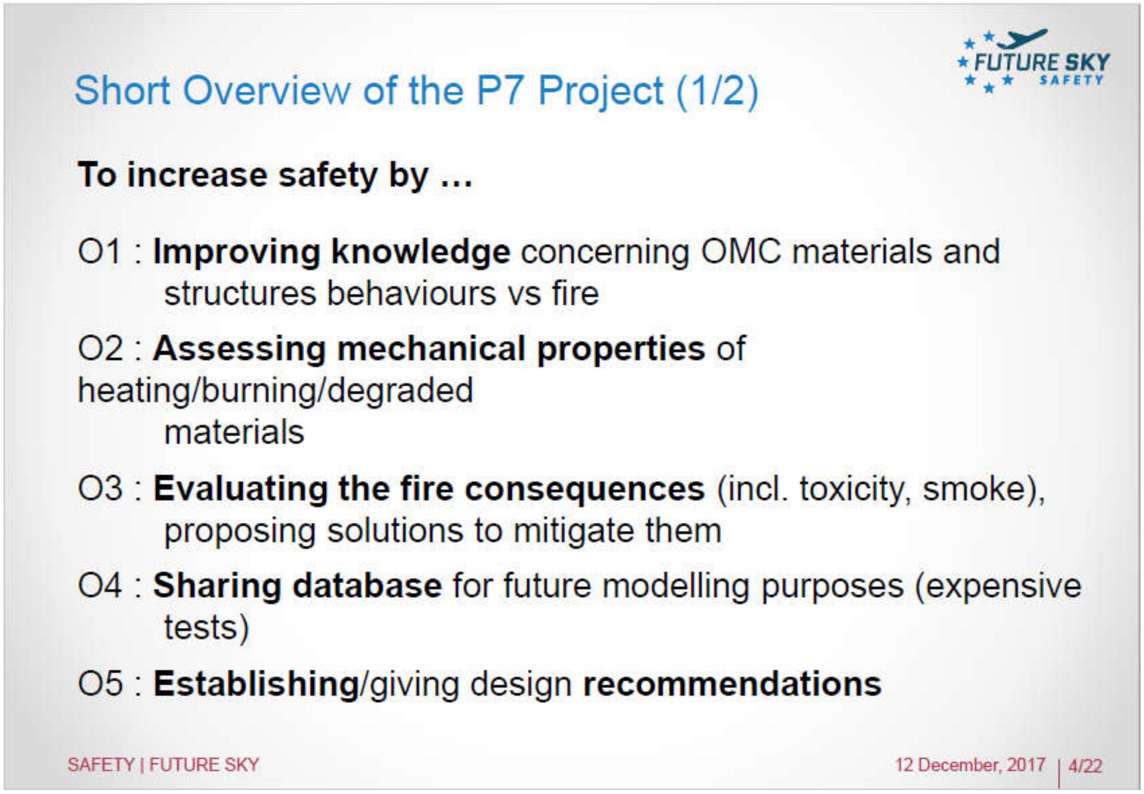
Emerging - New trends / new **risks** :

- **More electric aircraft** maybe increases risks of in-flight fires,
- **More organic composites** in A/C design with very different behavior compared to metalic materials,
- **Limited knowledge** wrt fire & heat behavior **of composites materials**.

CMO composites claimed to bring better burnthrough protection !
What about mechanical stiffness/strength under compression above 200°C (glassy transition) for structural integrity during evacuation ?
What about heat, toxic fumes and smoke ?

Few EU research on Composite Aircraft fire related safety : see Aircraft Fire Project.

Few test results available (plus industry tests are often confidential), expensive.



Short Overview of the P7 Project (1/2)

To increase safety by …

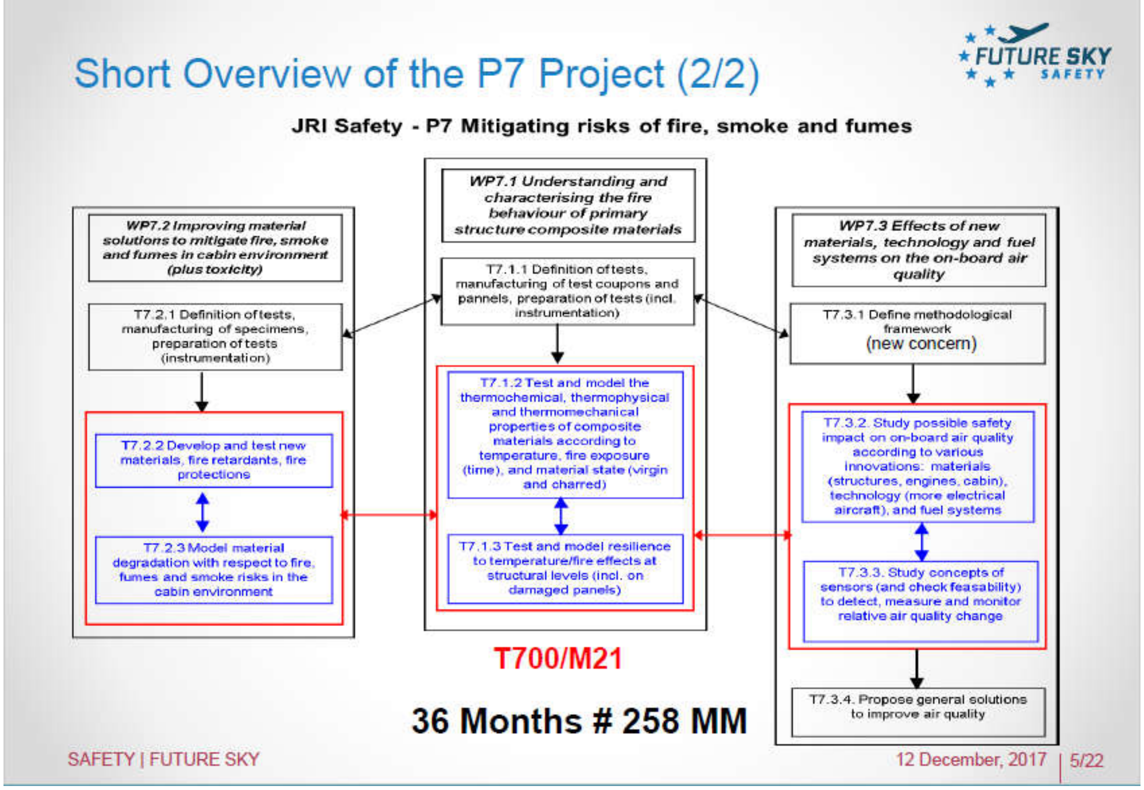
O1 : **Improving knowledge** concerning OMC materials and structures behaviours vs fire

O2 : **Assessing mechanical properties** of heating/burning/degraded materials

O3 : **Evaluating the fire consequences** (incl. toxicity, smoke), proposing solutions to mitigate them

O4 : **Sharing database** for future modelling purposes (expensive tests)

O5 : **Establishing**/giving design **recommendations**



Short Overview of the P7 Project (2/2)

JRI Safety - P7 Mitigating risks of fire, smoke and fumes

WP7.2 Improving material solutions to mitigate fire, smoke and fumes in cabin environment (plus toxicity)

T7.2.1 Definition of tests, manufacturing of specimens, preparation of tests (instrumentation)

T7.2.2 Develop and test new materials, fire retardants, fire protections

T7.2.3 Model material degradation with respect to fire, fumes and smoke risks in the cabin environment

WP7.1 Understanding and characterising the fire behaviour of primary structure composite materials

T7.1.1 Definition of tests, manufacturing of test coupons and pannels, preparation of tests (incl. instrumentation)

T7.1.2 Test and model the thermochemical, thermophysical and thermomechanical properties of composite materials according to temperature, fire exposure (time), and material state (virgin and charred)

T7.1.3 Test and model resilience to temperature/fire effects at structural levels (incl. on damaged panels)

T700/M21

WP7.3 Effects of new materials, technology and fuel systems on the on-board air quality

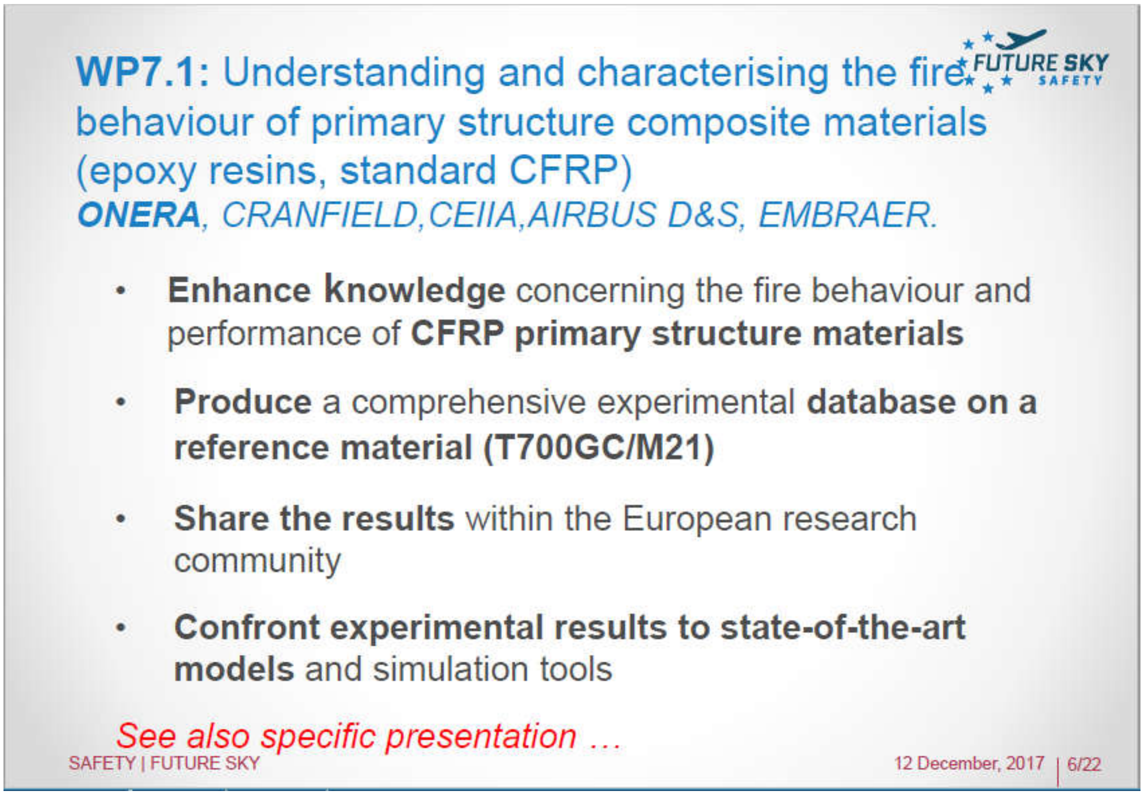
T7.3.1 Define methodological framework (new concern)

T7.3.2. Study possible safety impact on on-board air quality according to various innovations: materials (structures, engines, cabin), technology (more electrical aircraft), and fuel systems

T7.3.3. Study concepts of sensors (and check feasability) to detect, measure and monitor relative air quality change

T7.3.4. Propose general solutions to improve air quality

36 Months # 258 MM



WP7.1: Understanding and characterising the fire behaviour of primary structure composite materials (epoxy resins, standard CFRP)

***ONERA**, CRANFIELD,CEIIA,AIRBUS D&S, EMBRAER.*

- **Enhance knowledge** concerning the fire behaviour and performance of **CFRP primary structure materials**
- **Produce** a comprehensive experimental **database on a reference material (T700GC/M21)**
- **Share the results** within the European research community
- **Confront experimental results to state-of-the-art models** and simulation tools

See also specific presentation …

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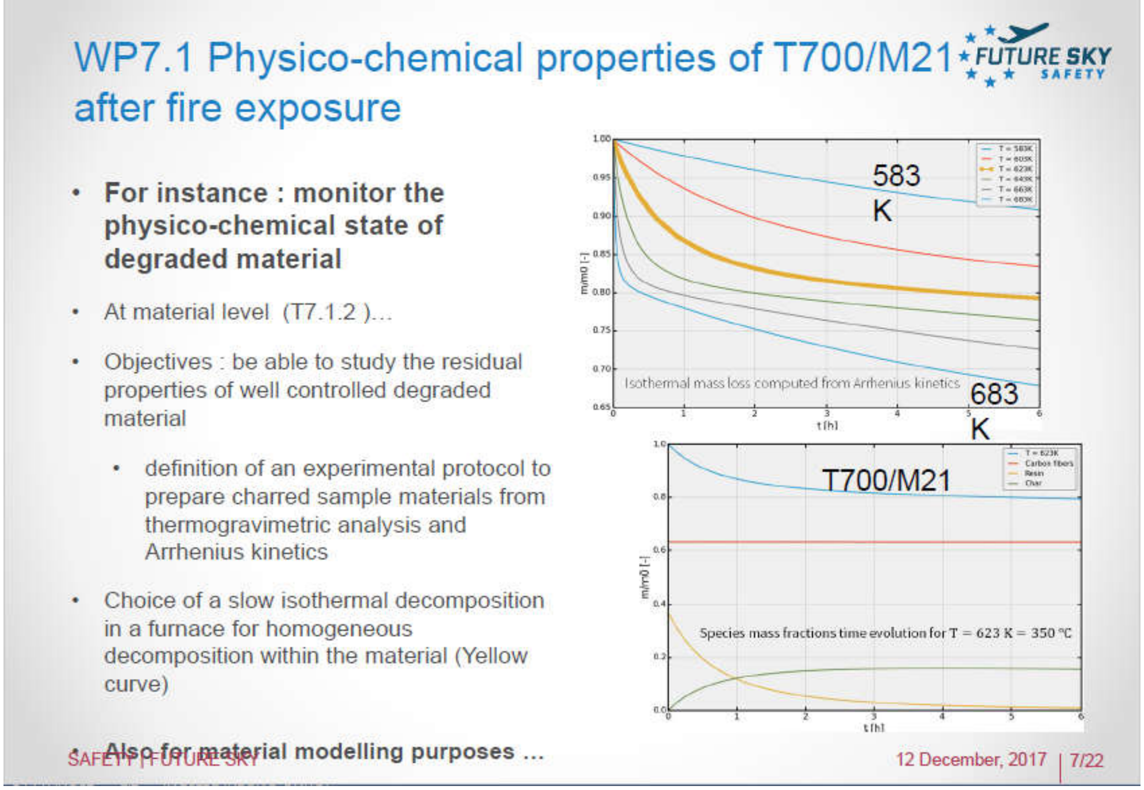
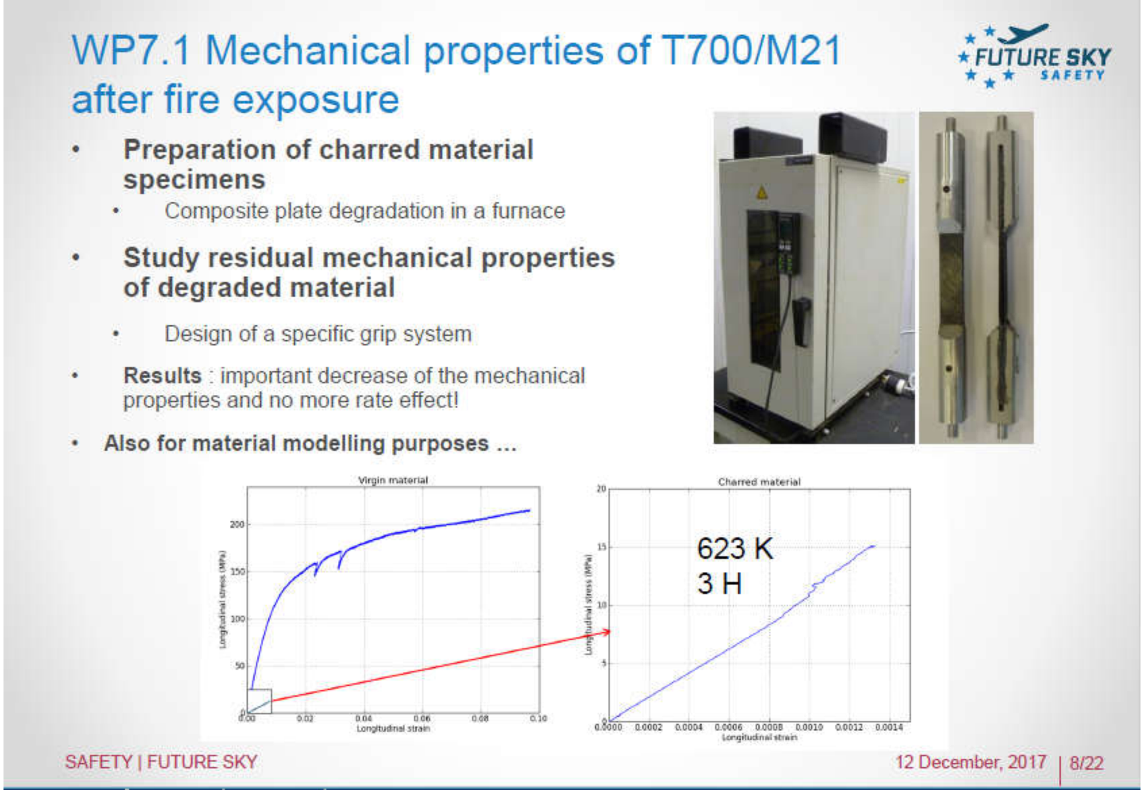


WP7.1 Physico-chemical properties of T700/M21 after fire exposure

- **For instance : monitor the physico-chemical state of degraded material**
- At material level (T7.1.2)…
- Objectives : be able to study the residual properties of well controlled degraded material
  - definition of an experimental protocol to prepare charred sample materials from thermogravimetric analysis and Arrhenius kinetics
- Choice of a slow isothermal decomposition in a furnace for homogeneous decomposition within the material (Yellow curve)
- **Also for material modelling purposes …**



WP7.1 Mechanical properties of T700/M21 after fire exposure

- **Preparation of charred material specimens**
  - Composite plate degradation in a furnace
- **Study residual mechanical properties of degraded material**
  - Design of a specific grip system
- **Results** : important decrease of the mechanical properties and no more rate effect!
- **Also for material modelling purposes …**

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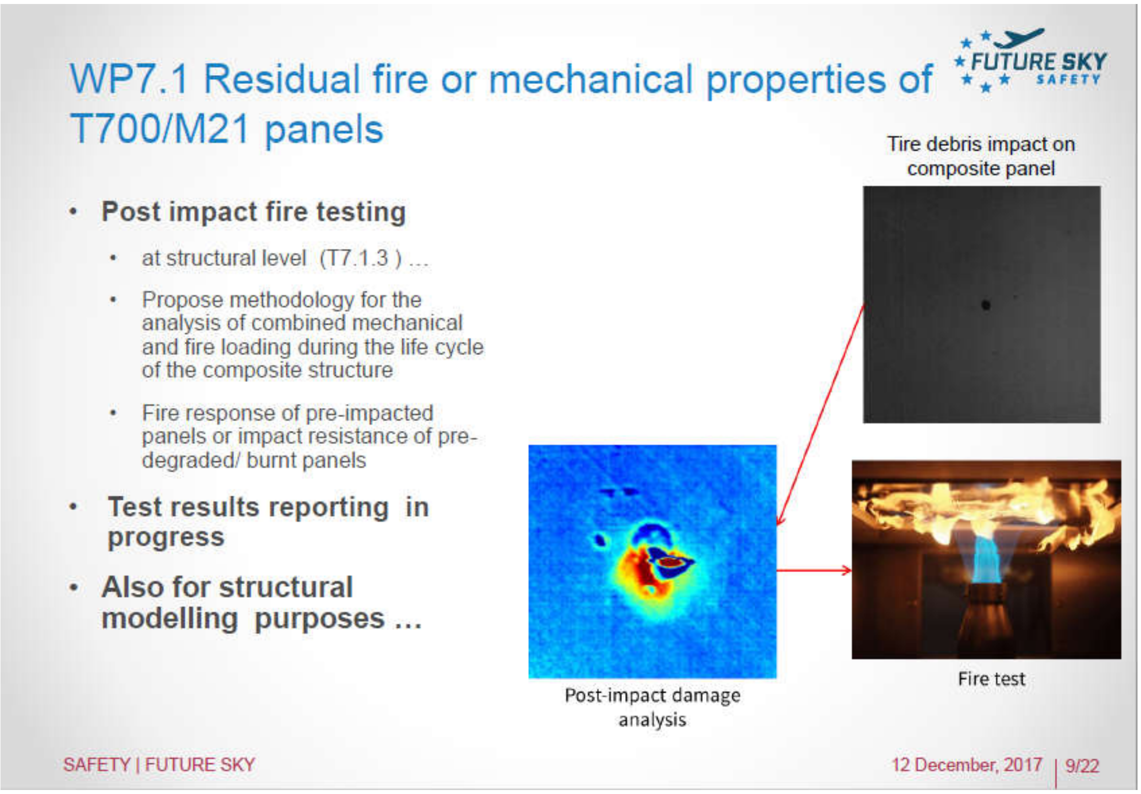

WP7.1 Residual fire or mechanical properties of T700/M21 panels

- **Post impact fire testing**
  - at structural level (T7.1.3) …
  - Propose methodology for the analysis of combined mechanical and fire loading during the life cycle of the composite structure
  - Fire response of pre-impacted panels or impact resistance of pre-degraded/ burnt panels
- **Test results reporting in progress**
- **Also for structural modelling purposes …**

Tire debris impact on composite panel

Post-impact damage analysis

Fire test

SAFETY | FUTURE SKY

12 December, 2017 | 9/22

WP7.2 : Improving material solutions to mitigate fire, smoke and fumes in cabin environment (plus toxicity)

DLR, *VZLU, ALENIA, CAA*

- Enhance passengers safety through the **development and assessment of new material solutions** that mitigate risks of fire, smoke and fumes in the cabin environment
- **Assess new solutions** at material and structural levels **wrt current industrial safety requirements** using standard experimental methods and state-of-the art simulation tools
- Study novel highly fire resistant materials **addressing the main mechanisms that improve the fire resistance at material level**

See also P7 exploitation measure & VZLU poster …

SAFETY | FUTURE SKY

12 December, 2017 | 10/22

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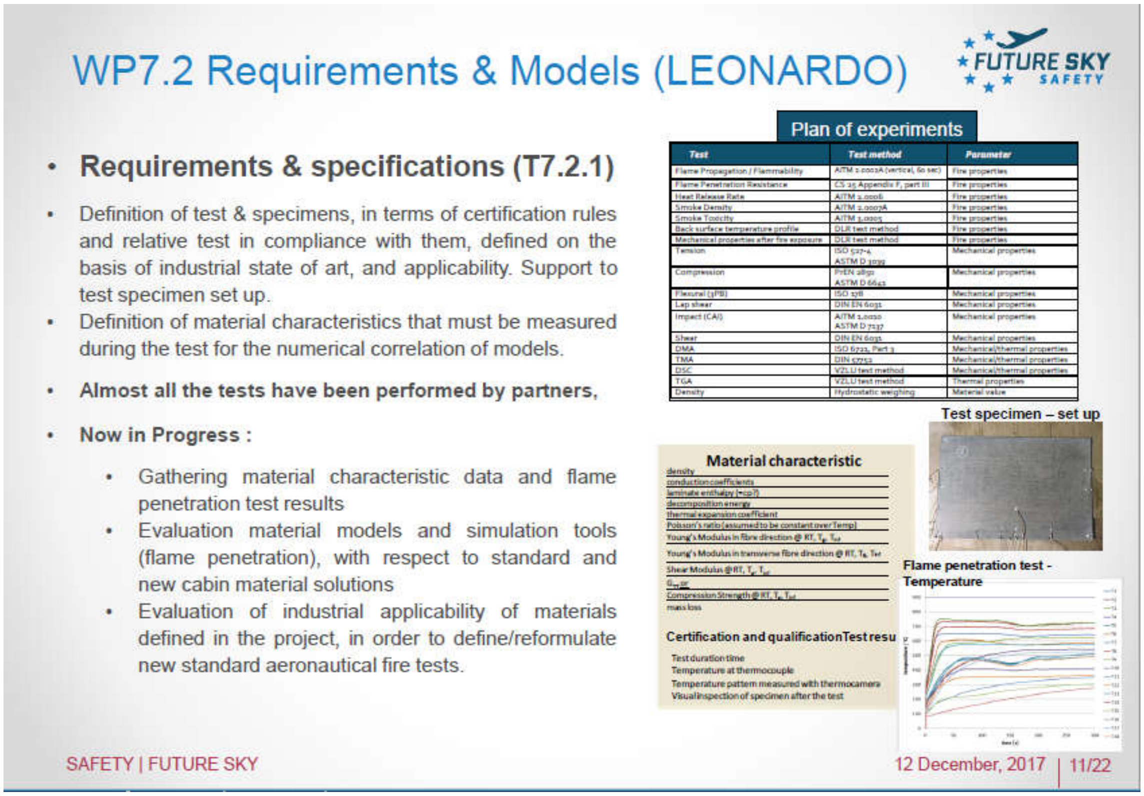


WP7.2 Requirements & Models (LEONARDO)

- **Requirements & specifications (T7.2.1)**
- Definition of test & specimens, in terms of certification rules and relative test in compliance with them, defined on the basis of industrial state of art, and applicability. Support to test specimen set up.
- Definition of material characteristics that must be measured during the test for the numerical correlation of models.
- **Almost all the tests have been performed by partners,**
- **Now in Progress :**
  - Gathering material characteristic data and flame penetration test results
  - Evaluation material models and simulation tools (flame penetration), with respect to standard and new cabin material solutions
  - Evaluation of industrial applicability of materials defined in the project, in order to define/reformulate new standard aeronautical fire tests.

Plan of experiments

Test	Test method	Parameter
Flame Propagation / Flammability	AITM 2.0002A (vertical, 60 sec)	Fire properties
Flame Penetration Resistance	CS 25 Appendix F, part III	Fire properties
Heat Release Rate	AITM 2.0006	Fire properties
Smoke Density	AITM 2.0007A	Fire properties
Smoke Toxicity	AITM 3.0005	Fire properties
Back surface temperature profile	DLR test method	Fire properties
Mechanical properties after fire exposure	DLR test method	Fire properties
Tension	ISO 527-4 ASTM D 3039	Mechanical properties
Compression	PrEN 2850 ASTM D 6641	Mechanical properties
Flexural (3PB)	ISO 178	Mechanical properties
Lap shear	DIN EN 6031	Mechanical properties
Impact (CAI)	AITM 1.0010 ASTM D 7137	Mechanical properties
Shear	DIN EN 6031	Mechanical properties
DMA	ISO 6721, Part 3	Mechanical/thermal properties
TMA	DIN 53752	Mechanical/thermal properties
DSC	VZLU test method	Mechanical/thermal properties
TGA	VZLU test method	Thermal properties
Density	Hydrostatic weighing	Material value

Test specimen – set up

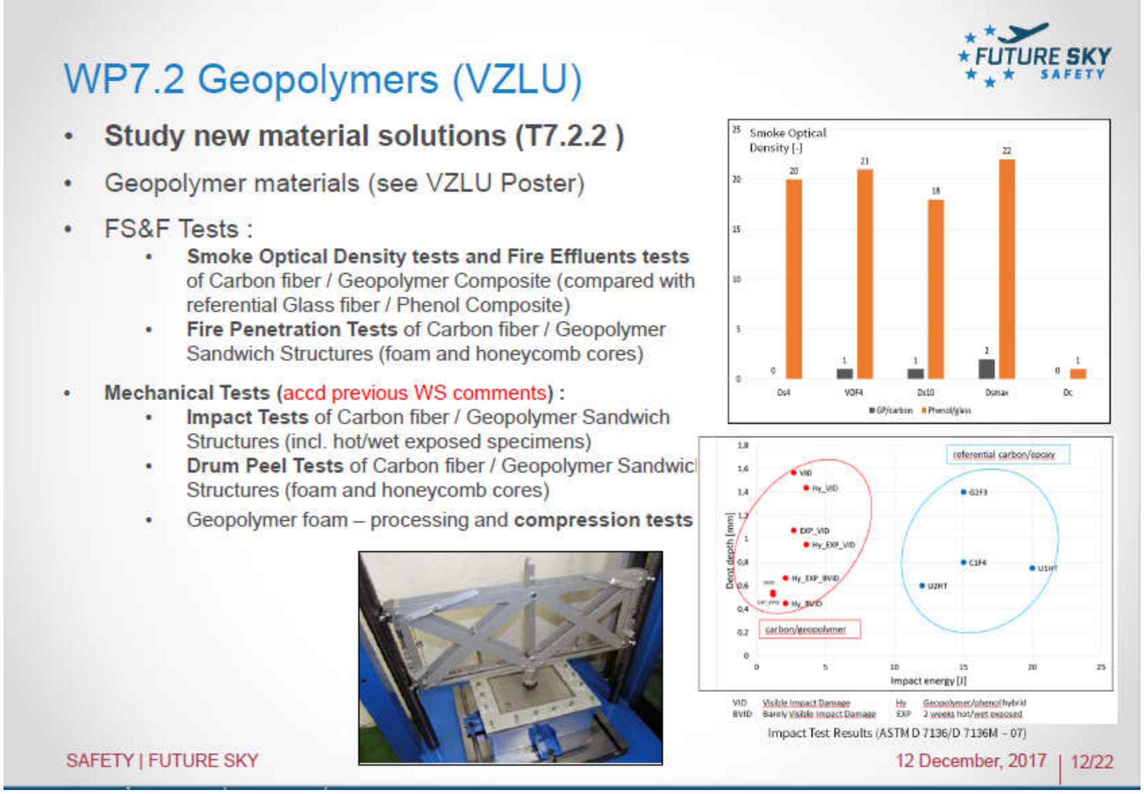
Material characteristic

density
conduction coefficients
laminate enthalpy (=cp?)
decomposition energy
thermal expansion coefficient
Poisson's ratio (assumed to be constant over Temp)
Young's Modulus in fibre direction @ RT, T_g, T_{id}
Young's Modulus in transverse fibre direction @ RT, T_g, T_{id}
Shear Modulus @ RT, T_g, T_{id}
G_{TT} or
Compression Strength @ RT, T_g, T_{id}
mass loss

Certification and qualification Test resu

Test duration time
Temperature at thermocouple
Temperature pattern measured with thermocamera
Visual inspection of specimen after the test

Flame penetration test - Temperature



WP7.2 Geopolymers (VZLU)

- **Study new material solutions (T7.2.2)**
- Geopolymer materials (see VZLU Poster)
- FS&F Tests :
  - **Smoke Optical Density tests and Fire Effluents tests** of Carbon fiber / Geopolymer Composite (compared with referential Glass fiber / Phenol Composite)
  - **Fire Penetration Tests** of Carbon fiber / Geopolymer Sandwich Structures (foam and honeycomb cores)
- **Mechanical Tests** (accd previous WS comments) **:**
  - **Impact Tests** of Carbon fiber / Geopolymer Sandwich Structures (incl. hot/wet exposed specimens)
  - **Drum Peel Tests** of Carbon fiber / Geopolymer Sandwic Structures (foam and honeycomb cores)
  - Geopolymer foam – processing and **compression tests**

VID Visible Impact Damage
BVID Barely Visible Impact Damage
Hy Geopolymer/phenol hybrid
EXP 2 weeks hot/wet exposed

Impact Test Results (ASTM D 7136/D 7136M – 07)

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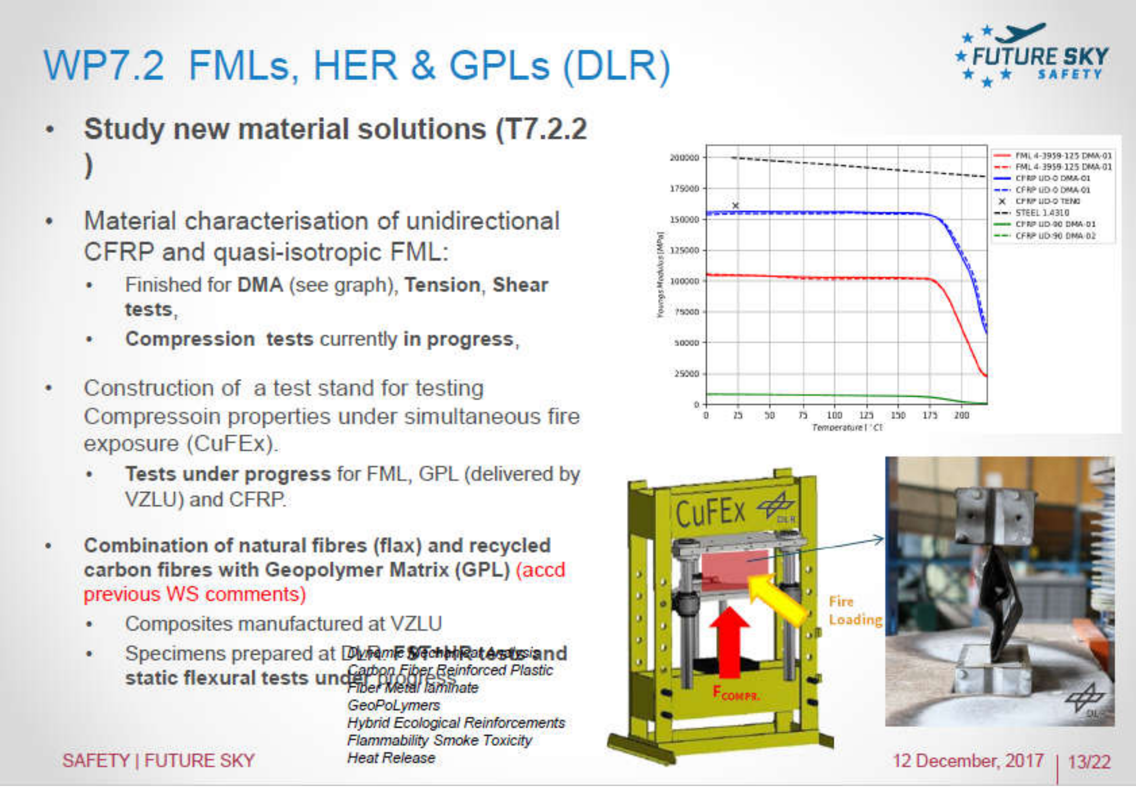

WP7.2 FMLs, HER & GPLs (DLR)

- **Study new material solutions (T7.2.2)**
- Material characterisation of unidirectional CFRP and quasi-isotropic FML:
  - Finished for **DMA** (see graph), **Tension**, **Shear tests**,
  - **Compression tests** currently **in progress**,
- Construction of a test stand for testing Compressoin properties under simultaneous fire exposure (CuFEx).
  - **Tests under progress** for FML, GPL (delivered by VZLU) and CFRP.
- **Combination of natural fibres (flax) and recycled carbon fibres with Geopolymer Matrix (GPL)** (accd previous WS comments)
  - Composites manufactured at VZLU
  - Specimens prepared at DLR. **FST+HR tests and static flexural tests under progress**

Dynamic Mechanical Analysis
Carbon Fiber Reinforced Plastic
Fiber Metal laminate
GeoPoLymers
Hybrid Ecological Reinforcements
Flammability Smoke Toxicity
Heat Release

WP7.3 : effects of new materials, technology and fuel systems on the on-board air quality

NLR, *CEIIA, CRANFIELD, EMBRAER, CAA*

- Investigate **opportunities** offered by technical developments **to study air quality**
- **Focus on safety considerations**
- Thorough **understanding of sources** and recent developments as basis for integrated solutions
- **Sensing technology investigation**
- **Industrial framework** for monitoring of air quality

See also specific presentation …

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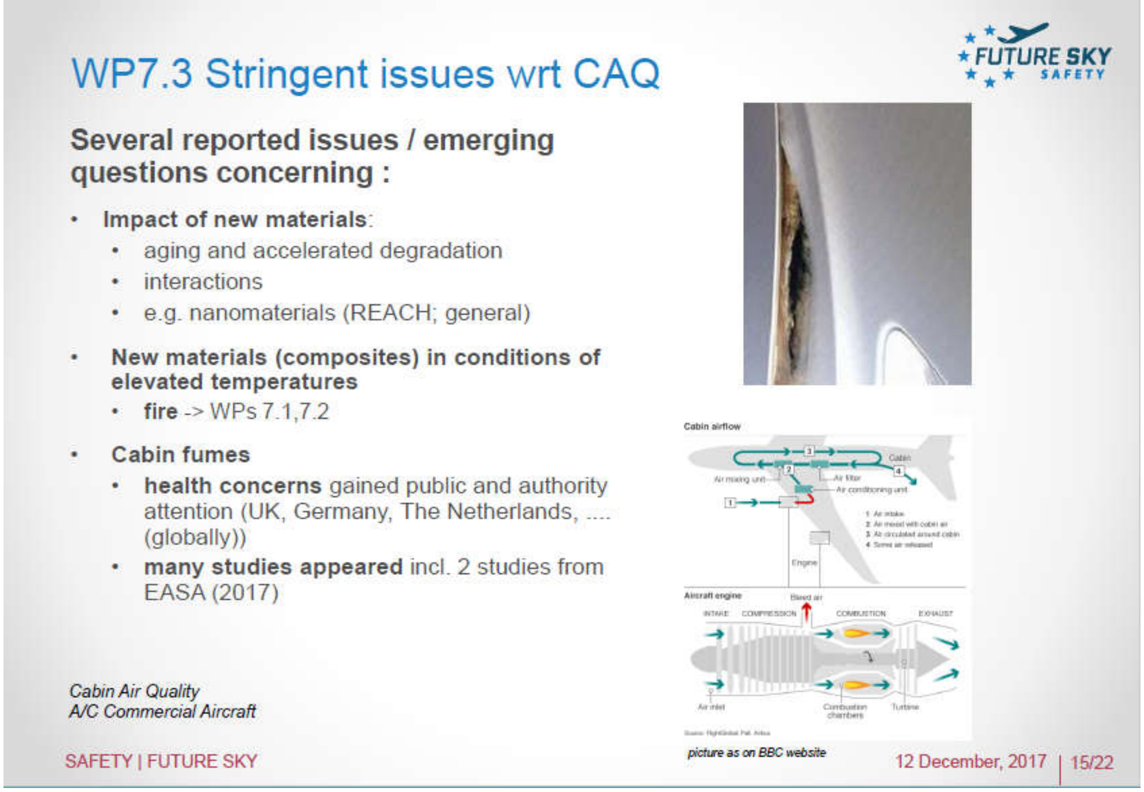


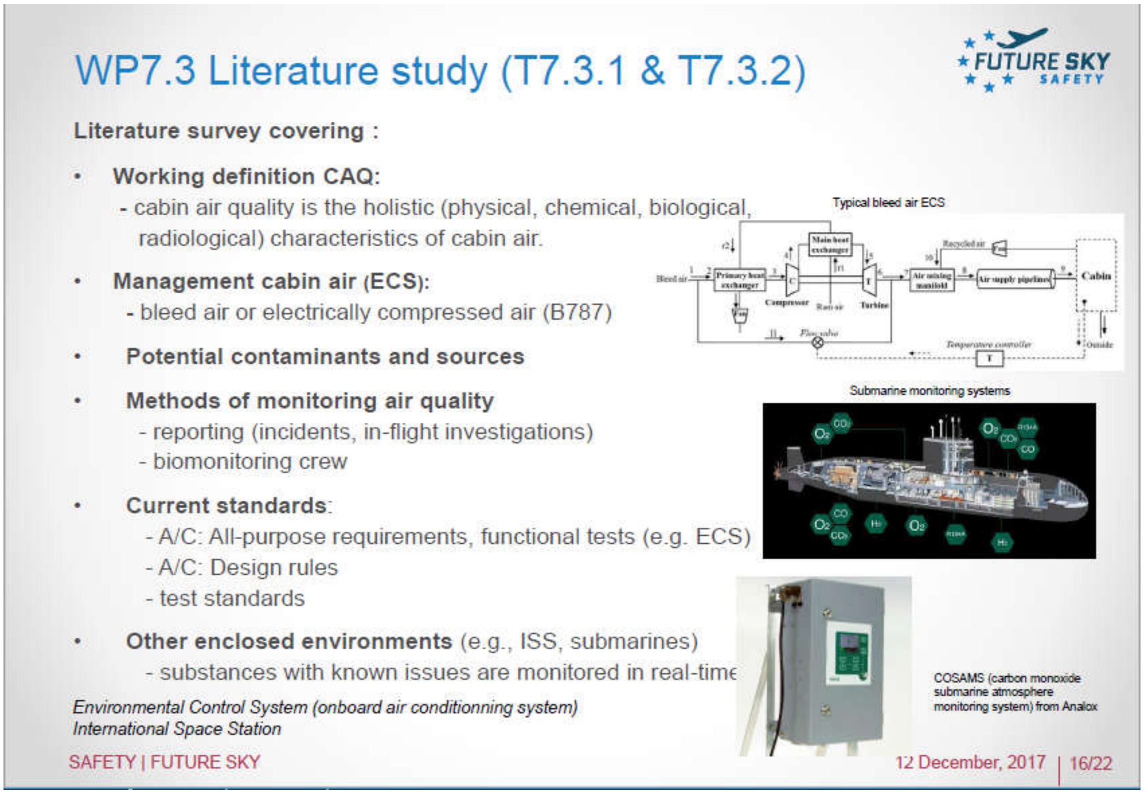
WP7.3 Stringent issues wrt CAQ

Several reported issues / emerging questions concerning :

- **Impact of new materials**:
  - aging and accelerated degradation
  - interactions
  - e.g. nanomaterials (REACH; general)
- **New materials (composites) in conditions of elevated temperatures**
  - **fire** -> WPs 7.1,7.2
- **Cabin fumes**
  - **health concerns** gained public and authority attention (UK, Germany, The Netherlands, …. (globally))
  - **many studies appeared** incl. 2 studies from EASA (2017)

Cabin Air Quality
A/C Commercial Aircraft

picture as on BBC website



WP7.3 Literature study (T7.3.1 & T7.3.2)

Literature survey covering :

- **Working definition CAQ:**
  - cabin air quality is the holistic (physical, chemical, biological, radiological) characteristics of cabin air.
- **Management cabin air** (**ECS**):
  - bleed air or electrically compressed air (B787)
- **Potential contaminants and sources**
- **Methods of monitoring air quality**
  - reporting (incidents, in-flight investigations)
  - biomonitoring crew
- **Current standards**:
  - A/C: All-purpose requirements, functional tests (e.g. ECS)
  - A/C: Design rules
  - test standards
- **Other enclosed environments** (e.g., ISS, submarines)
  - substances with known issues are monitored in real-time

Environmental Control System (onboard air conditionning system)
International Space Station

Typical bleed air ECS

Submarine monitoring systems

COSAMS (carbon monoxide submarine atmosphere monitoring system) from Analox

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WP7.3 New concepts of sensors (T7.3.3)

Candidate sensors to study and/or monitoring CAQ :

- **Suggested ideal criteria:**
  - small, light, easy to use, inexpensive, sensitive
- **Real-time commercial sensors:**
  - cabin environment is challenging: On-board conditions. a/c safetv. ....
  - low cost is coming up rapidly
- **Delayed analysis commercial sensors:**
  - correct sampling strategy required
- **Research sensors**
  - smaller, wider range, etc
  - specificity and repeatability continues to be challenge
  - MEMS, e-noses, ..

In relation with industrial framework for cabin air quality (D7.11)

- see specific presentation …

Micro ElectroMechanical Systems

R. Z. C. Spicer et. al, *Relate Air Quality …report* (2004)

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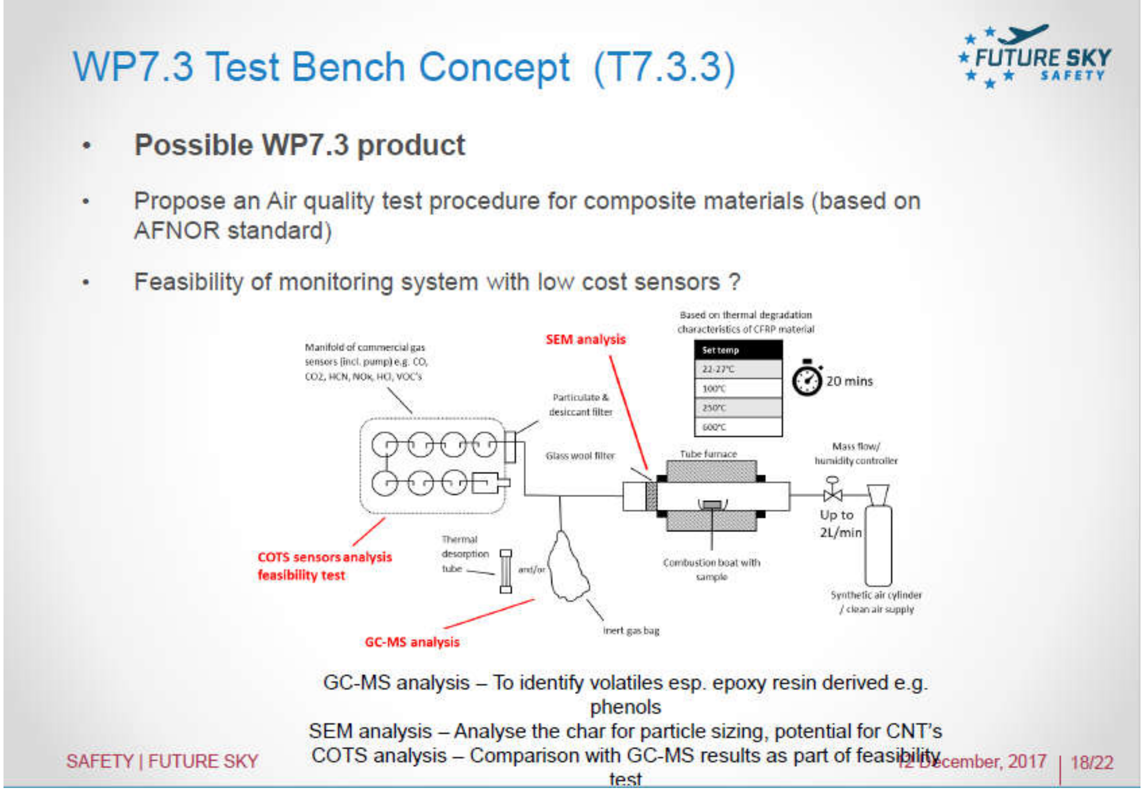

WP7.3 Test Bench Concept (T7.3.3)

- **Possible WP7.3 product**
- Propose an Air quality test procedure for composite materials (based on AFNOR standard)
- Feasibility of monitoring system with low cost sensors ?

Set temp
22-27°C
100°C
250°C
600°C

GC-MS analysis – To identify volatiles esp. epoxy resin derived e.g. phenols
SEM analysis – Analyse the char for particle sizing, potential for CNT's
COTS analysis – Comparison with GC-MS results as part of feasibility test

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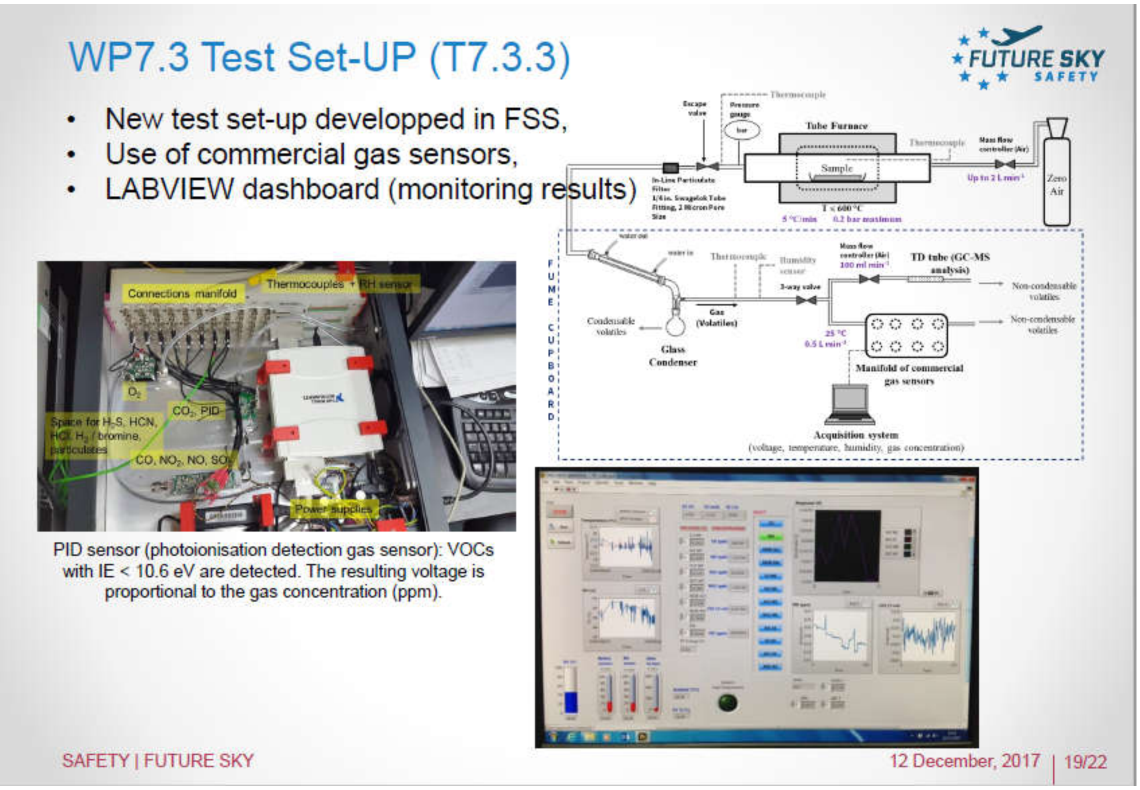

WP7.3 Test Set-UP (T7.3.3)

- New test set-up developped in FSS,
- Use of commercial gas sensors,
- LABVIEW dashboard (monitoring results)

PID sensor (photoionisation detection gas sensor): VOCs with IE < 10.6 eV are detected. The resulting voltage is proportional to the gas concentration (ppm).

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FSS P7 – Dissemination & Events

- Presentations in 5 Conferences : EU, USA
- Organisation of 1 mini-symposium
- FSS Internal & Public Workshops
- OPTICS dissemination event

} > 1000 people

Robin Hron, František Martaus, Martin Kadlec, Roman Růžek, Geopolymer Laminate Peel Resistance of Adhesive Bonds with Foam and Honeycomb Cores, 17th International Multidisciplinary Scientific GeoConference (SGEM 2017), 27-30 November, 2017, Vienna.

Robin Hron, František Martaus, Martin Kadlec, Mechanical Properties of Fibre Reinforced Geopolymer Composites Exposed to Operating Fluids, 2nd International Conference on Innovative and Smart Materials (ICISM 2017), December 11-13, 2017, Paris.

+ Several papers to be submitted for publication in 2018 …

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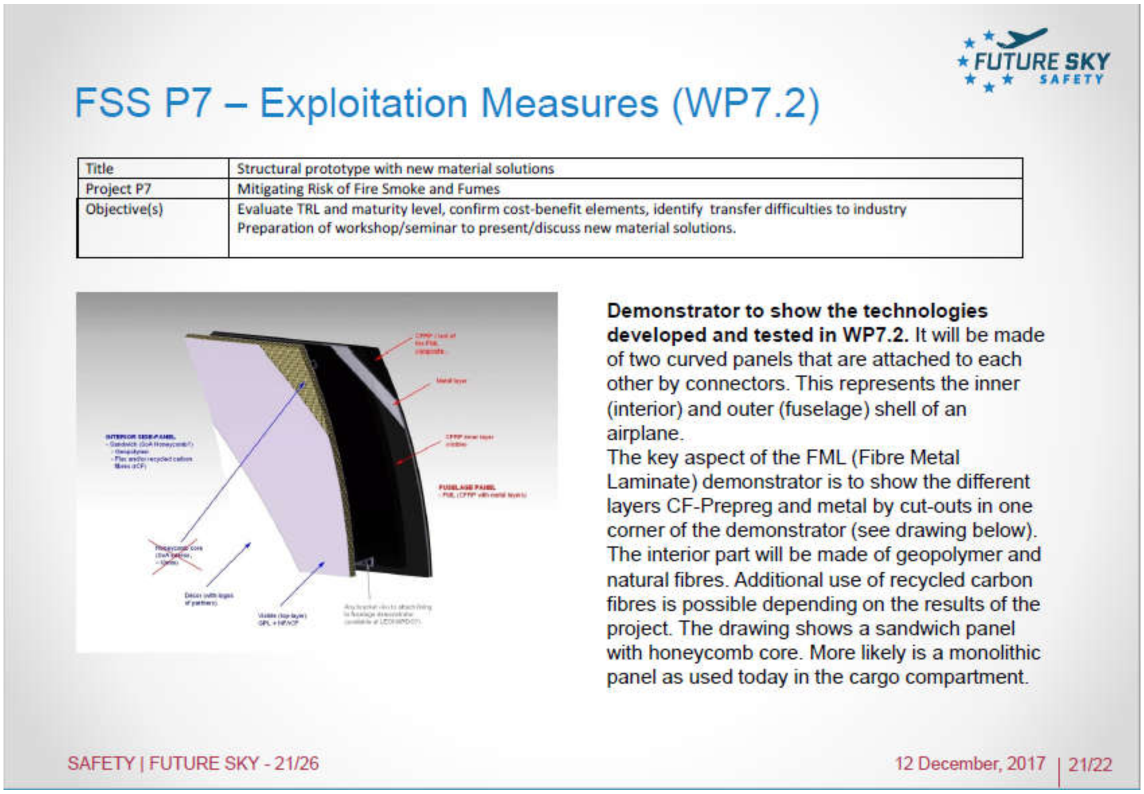
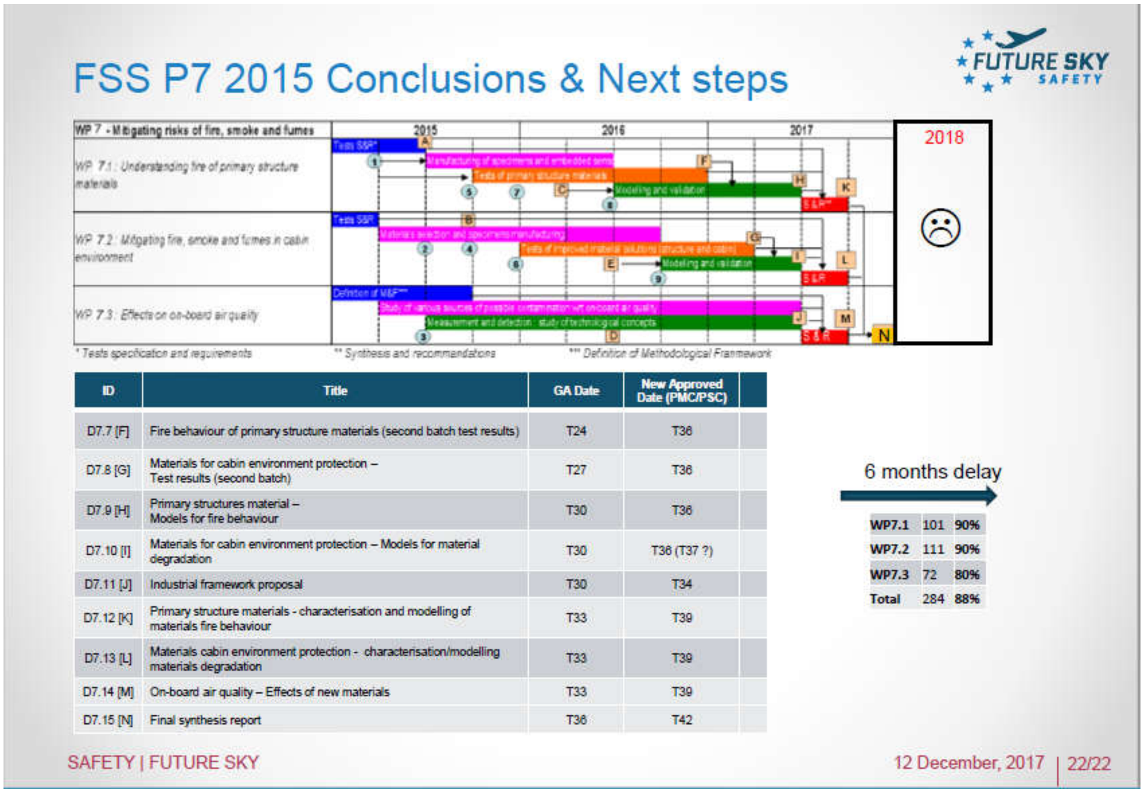


FSS P7 – Exploitation Measures (WP7.2)

Title	Structural prototype with new material solutions
Project P7	Mitigating Risk of Fire Smoke and Fumes
Objective(s)	Evaluate TRL and maturity level, confirm cost-benefit elements, identify transfer difficulties to industry Preparation of workshop/seminar to present/discuss new material solutions.

Demonstrator to show the technologies developed and tested in WP7.2. It will be made of two curved panels that are attached to each other by connectors. This represents the inner (interior) and outer (fuselage) shell of an airplane.
The key aspect of the FML (Fibre Metal Laminate) demonstrator is to show the different layers CF-Prepreg and metal by cut-outs in one corner of the demonstrator (see drawing below). The interior part will be made of geopolymer and natural fibres. Additional use of recycled carbon fibres is possible depending on the results of the project. The drawing shows a sandwich panel with honeycomb core. More likely is a monolithic panel as used today in the cargo compartment.



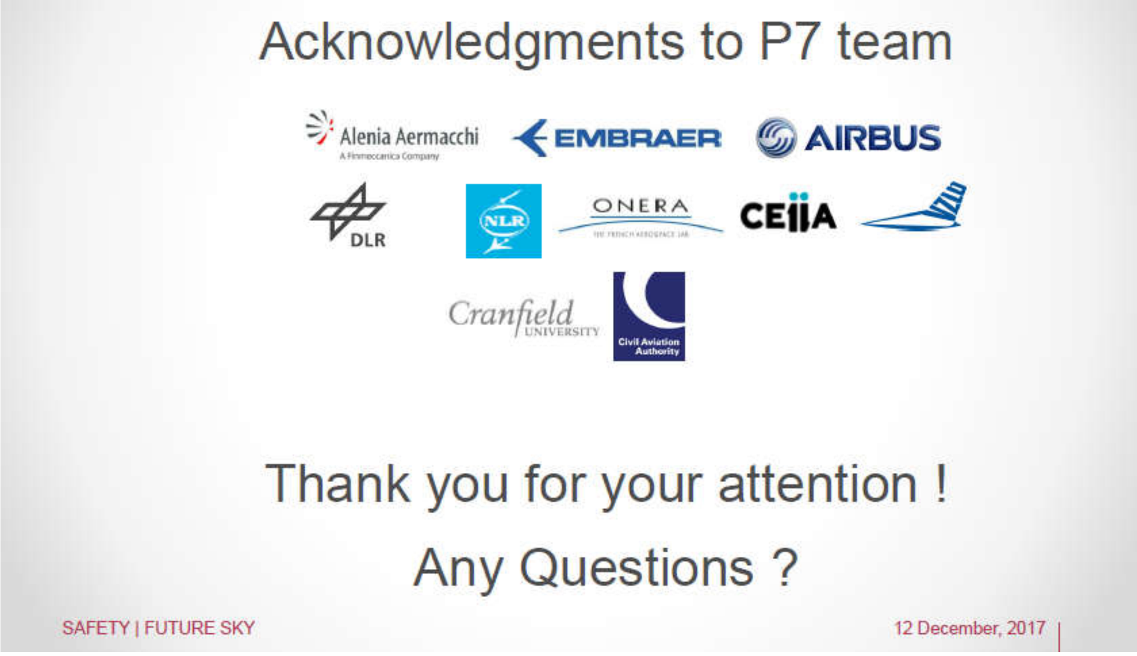
FSS P7 2015 Conclusions & Next steps

* Tests specification and requirements ** Synthesis and recommendations *** Definition of Methodological Framework

ID	Title	GA Date	New Approved Date (PMC/PSC)	
D7.7 [F]	Fire behaviour of primary structure materials (second batch test results)	T24	T36	
D7.8 [G]	Materials for cabin environment protection – Test results (second batch)	T27	T36	
D7.9 [H]	Primary structures material – Models for fire behaviour	T30	T36	
D7.10 [I]	Materials for cabin environment protection – Models for material degradation	T30	T36 (T37 ?)	
D7.11 [J]	Industrial framework proposal	T30	T34	
D7.12 [K]	Primary structure materials - characterisation and modelling of materials fire behaviour	T33	T39	
D7.13 [L]	Materials cabin environment protection - characterisation/modelling materials degradation	T33	T39	
D7.14 [M]	On-board air quality – Effects of new materials	T33	T39	
D7.15 [N]	Final synthesis report	T36	T42	

6 months delay →

WP7.1	101	**90%**
WP7.2	111	**90%**
WP7.3	72	**80%**
Total	284	**88%**



Acknowledgments to P7 team

Thank you for your attention !

Any Questions ?

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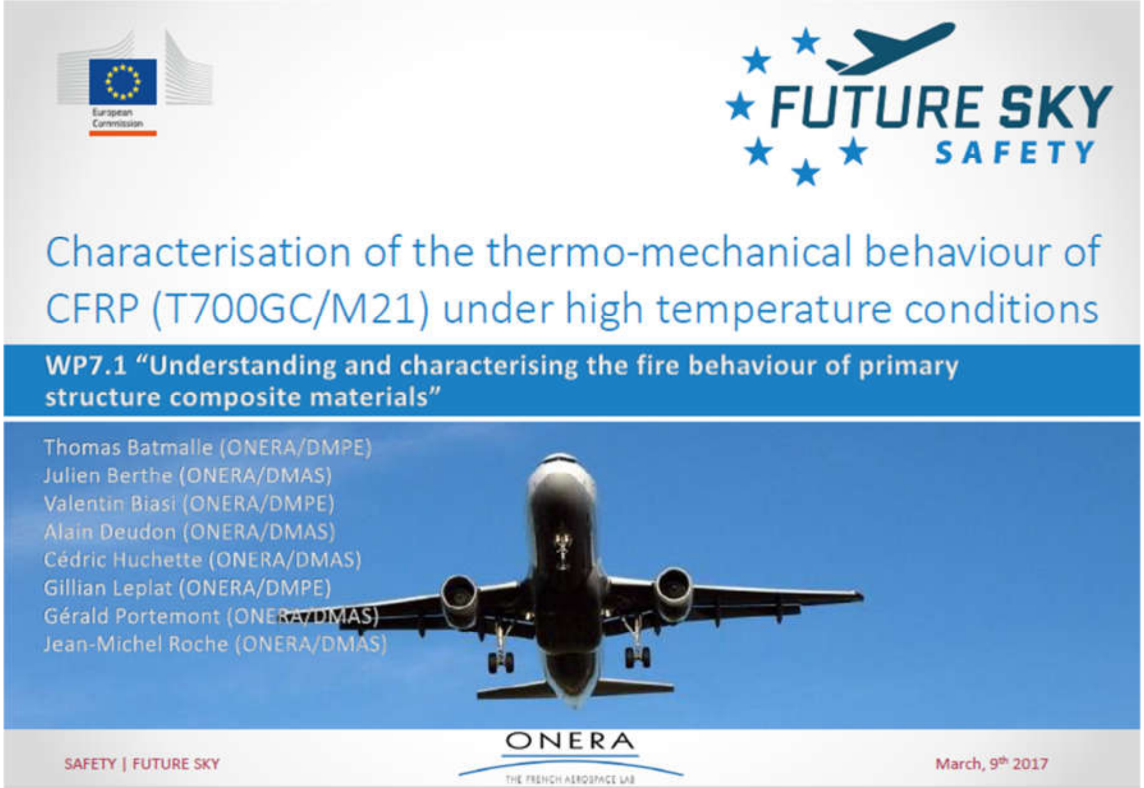
Appendix B.14 “P7: Characterisation of the thermo-mechanical behaviour of CFRP (T700GC/M21) under high temperature conditions” – Eric Deletombe, ONERA



Characterisation of the thermo-mechanical behaviour of CFRP (T700GC/M21) under high temperature conditions

WP7.1 “Understanding and characterising the fire behaviour of primary structure composite materials”

Thomas Batmalle (ONERA/DMPE)
Julien Berthe (ONERA/DMAS)
Valentin Biasi (ONERA/DMPE)
Alain Deudon (ONERA/DMAS)
Cédric Huchette (ONERA/DMAS)
Gillian Leplat (ONERA/DMPE)
Gérald Portemont (ONERA/DMAS)
Jean-Michel Roche (ONERA/DMAS)

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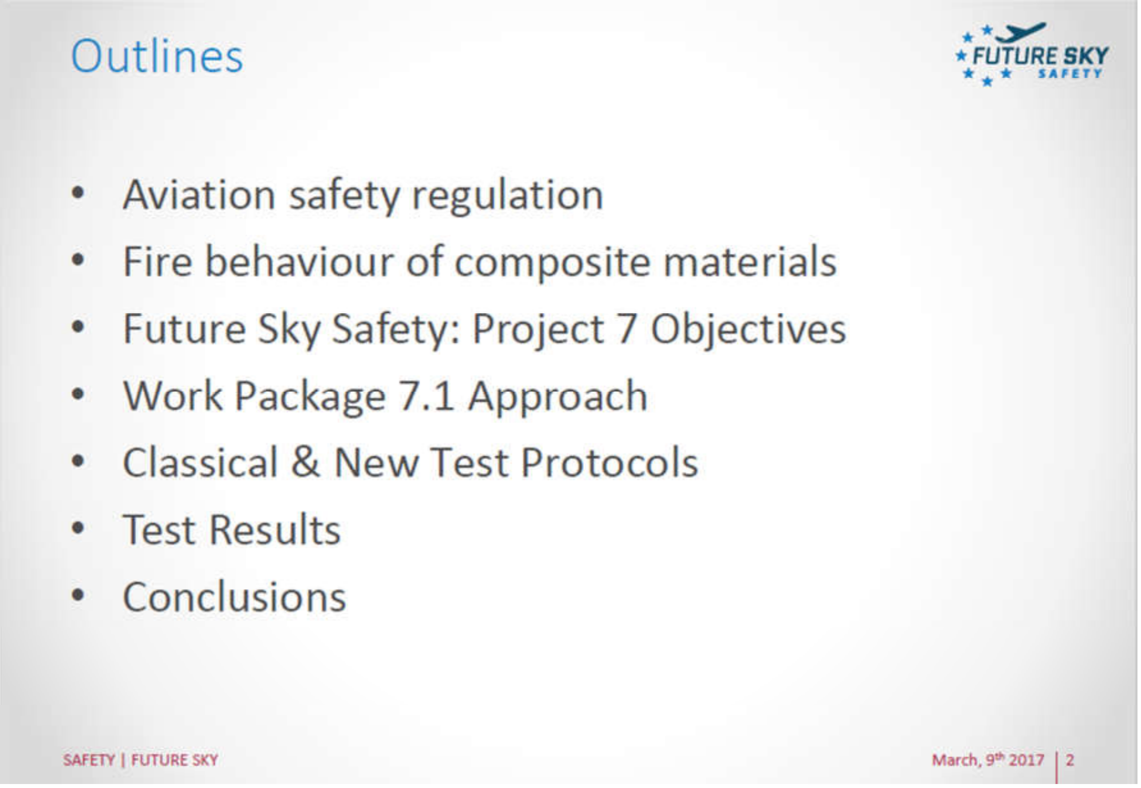
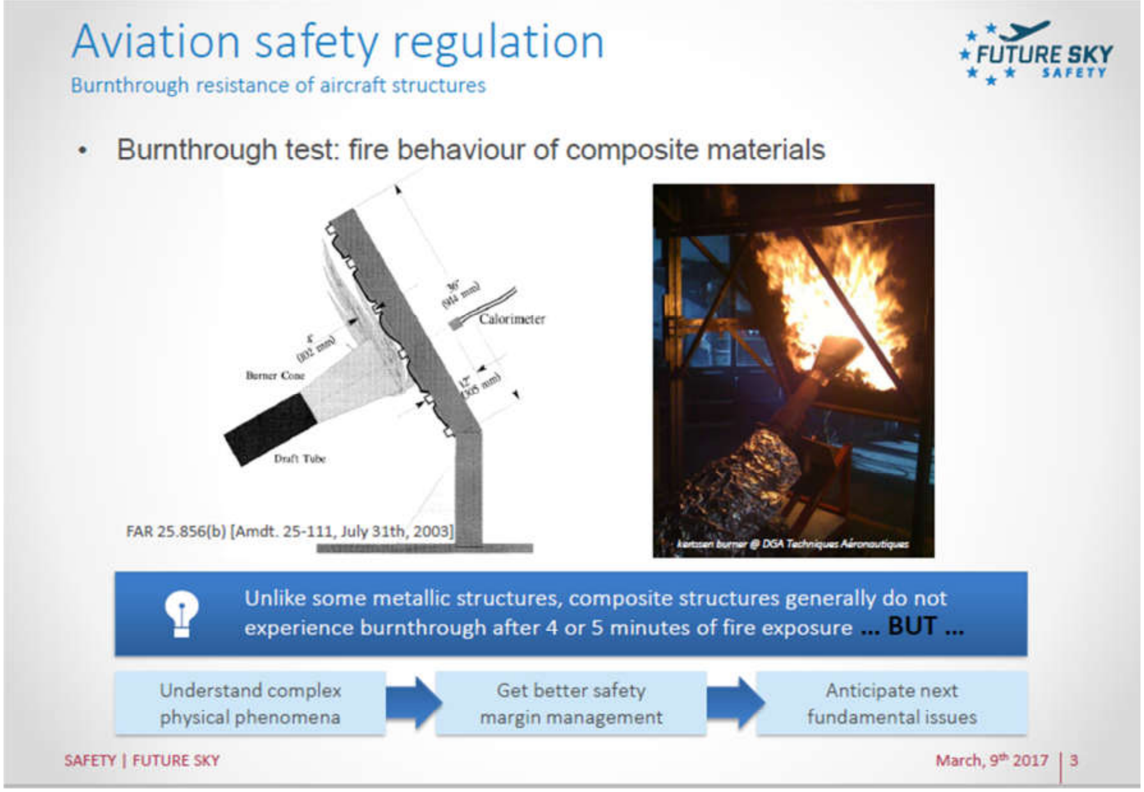


Outlines

- Aviation safety regulation
- Fire behaviour of composite materials
- Future Sky Safety: Project 7 Objectives
- Work Package 7.1 Approach
- Classical & New Test Protocols
- Test Results
- Conclusions



Aviation safety regulation

Burnthrough resistance of aircraft structures

- Burnthrough test: fire behaviour of composite materials

FAR 25.856(b) [Amdt. 25-111, July 31th, 2003]

kerosen burner @ DGA Techniques Aéronautiques

Unlike some metallic structures, composite structures generally do not experience burnthrough after 4 or 5 minutes of fire exposure ... **BUT** ...

Understand complex physical phenomena → Get better safety margin management → Anticipate next fundamental issues

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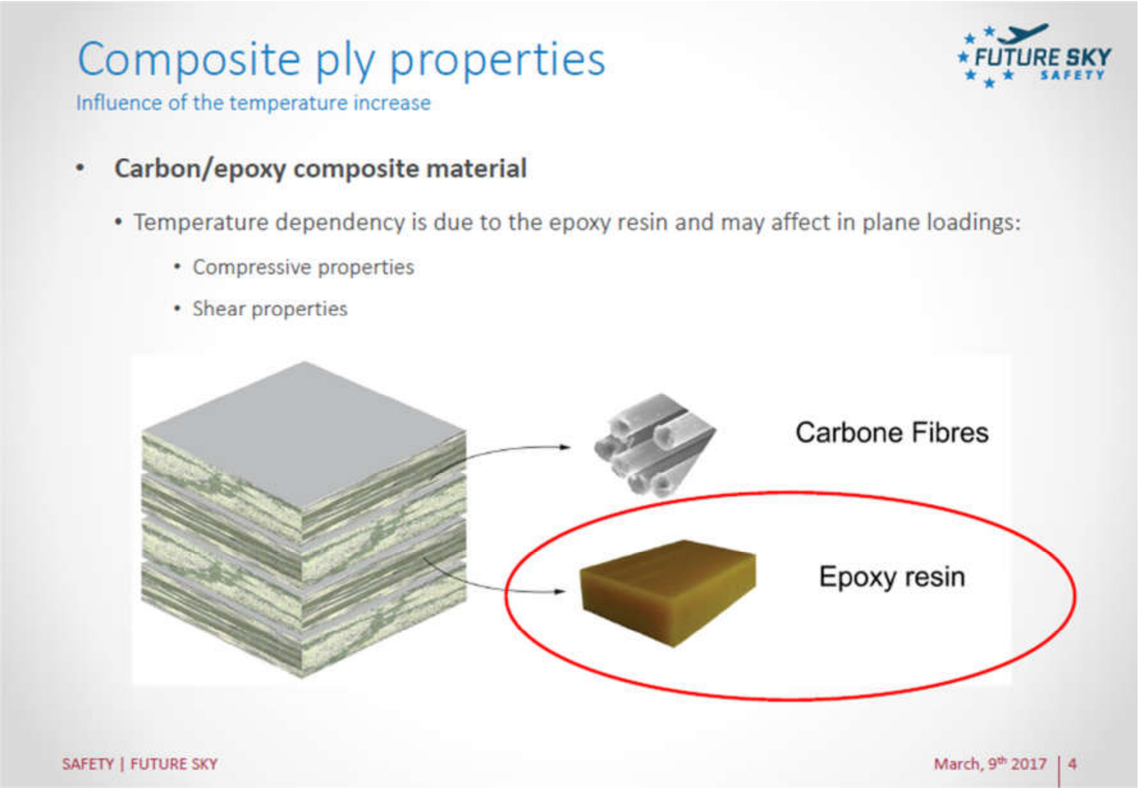

Composite ply properties

Influence of the temperature increase

- **Carbon/epoxy composite material**
  - Temperature dependency is due to the epoxy resin and may affect in plane loadings:
    - Compressive properties
    - Shear properties

Carbone Fibres

Epoxy resin

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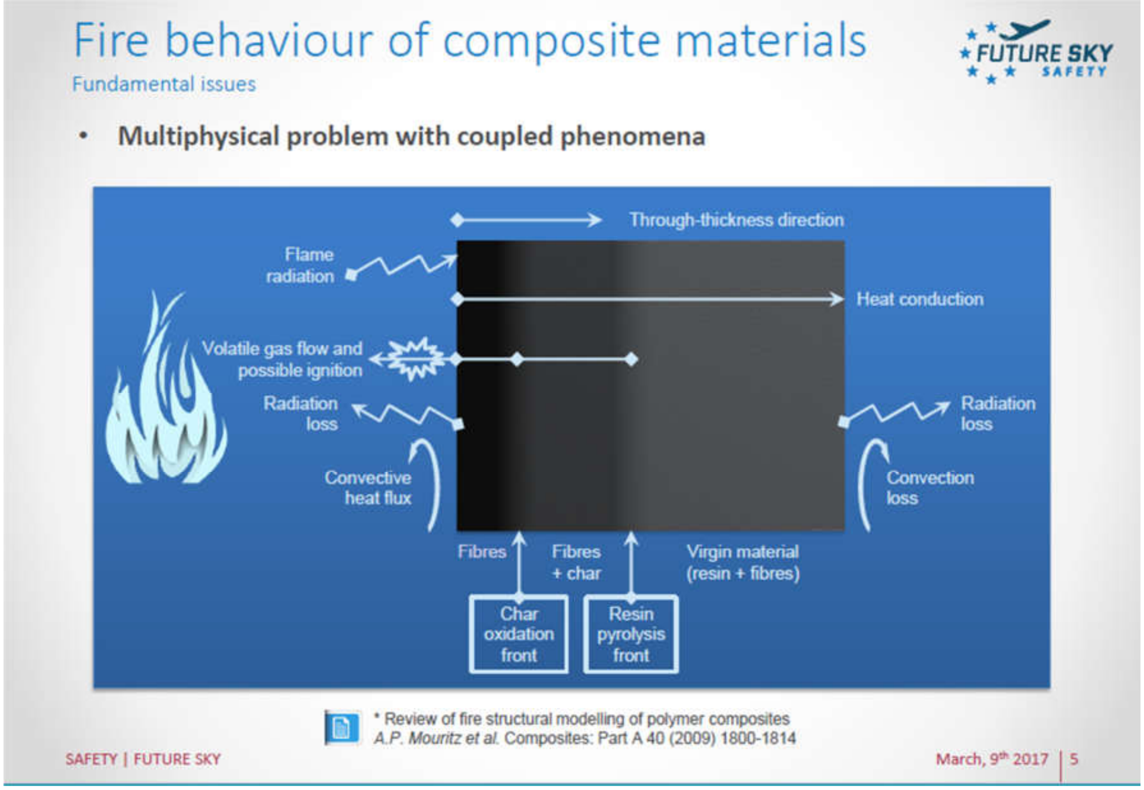

Fire behaviour of composite materials

Fundamental issues

- **Multiphysical problem with coupled phenomena**

Through-thickness direction

Flame radiation

Heat conduction

Volatile gas flow and possible ignition

Radiation loss

Radiation loss

Convective heat flux

Convection loss

Fibres

Fibres + char

Virgin material (resin + fibres)

Char oxidation front

Resin pyrolysis front

* Review of fire structural modelling of polymer composites
A.P. Mouritz et al. Composites: Part A 40 (2009) 1800-1814

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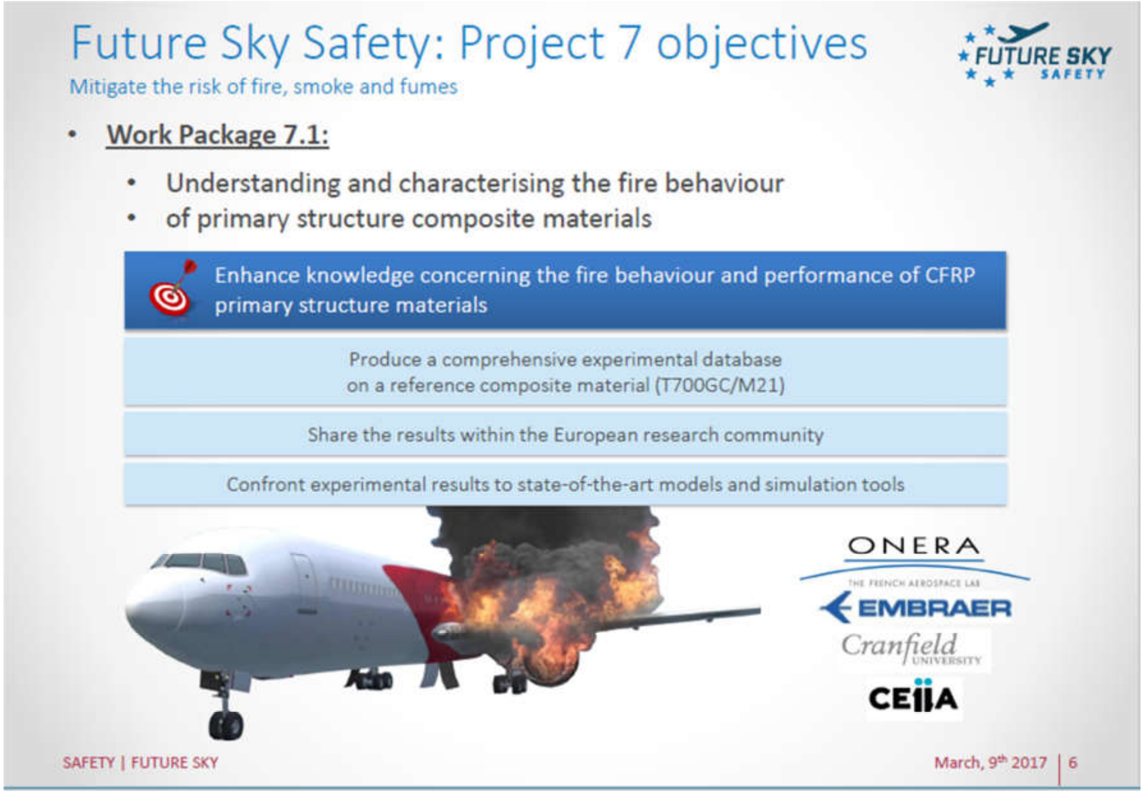

Future Sky Safety: Project 7 objectives

Mitigate the risk of fire, smoke and fumes

- Work Package 7.1:
  - Understanding and characterising the fire behaviour
  - of primary structure composite materials

Enhance knowledge concerning the fire behaviour and performance of CFRP primary structure materials

Produce a comprehensive experimental database on a reference composite material (T700GC/M21)

Share the results within the European research community

Confront experimental results to state-of-the-art models and simulation tools

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Work Package 7.1 Approach

Understanding and characterizing the fire behaviour of primary structure composite materials thanks to classical (standard) and new test protocols

Thermal properties
Pyrolysis behaviour

Chemical properties

Produce a comprehensive experimental database on a reference material (T700GC/M21)

Fire behaviour

Mechanical and Thermo-mechanical behaviour

Numerical simulation tools

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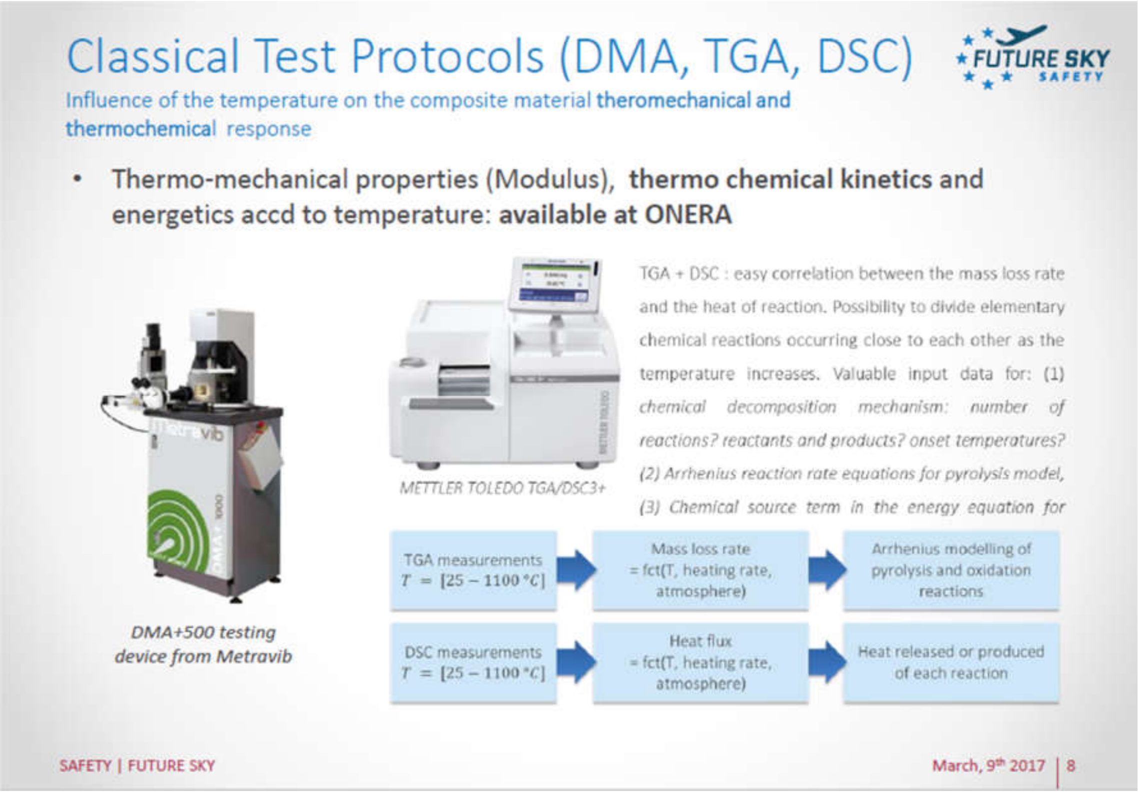

Classical Test Protocols (DMA, TGA, DSC)

Influence of the temperature on the composite material **theromechanical and thermochemical** response

- Thermo-mechanical properties (Modulus), **thermo chemical kinetics and** energetics accd to temperature: **available at ONERA**

DMA+500 testing device from Metravib

METTLER TOLEDO TGA/DSC3+

TGA + DSC : easy correlation between the mass loss rate and the heat of reaction. Possibility to divide elementary chemical reactions occurring close to each other as the temperature increases. Valuable input data for: (1) *chemical decomposition mechanism: number of reactions? reactants and products? onset temperatures? (2) Arrhenius reaction rate equations for pyrolysis model, (3) Chemical source term in the energy equation for*

TGA measurements $T = [25 - 1100\ °C]$ → Mass loss rate = fct(T, heating rate, atmosphere) → Arrhenius modelling of pyrolysis and oxidation reactions

DSC measurements $T = [25 - 1100\ °C]$ → Heat flux = fct(T, heating rate, atmosphere) → Heat released or produced of each reaction

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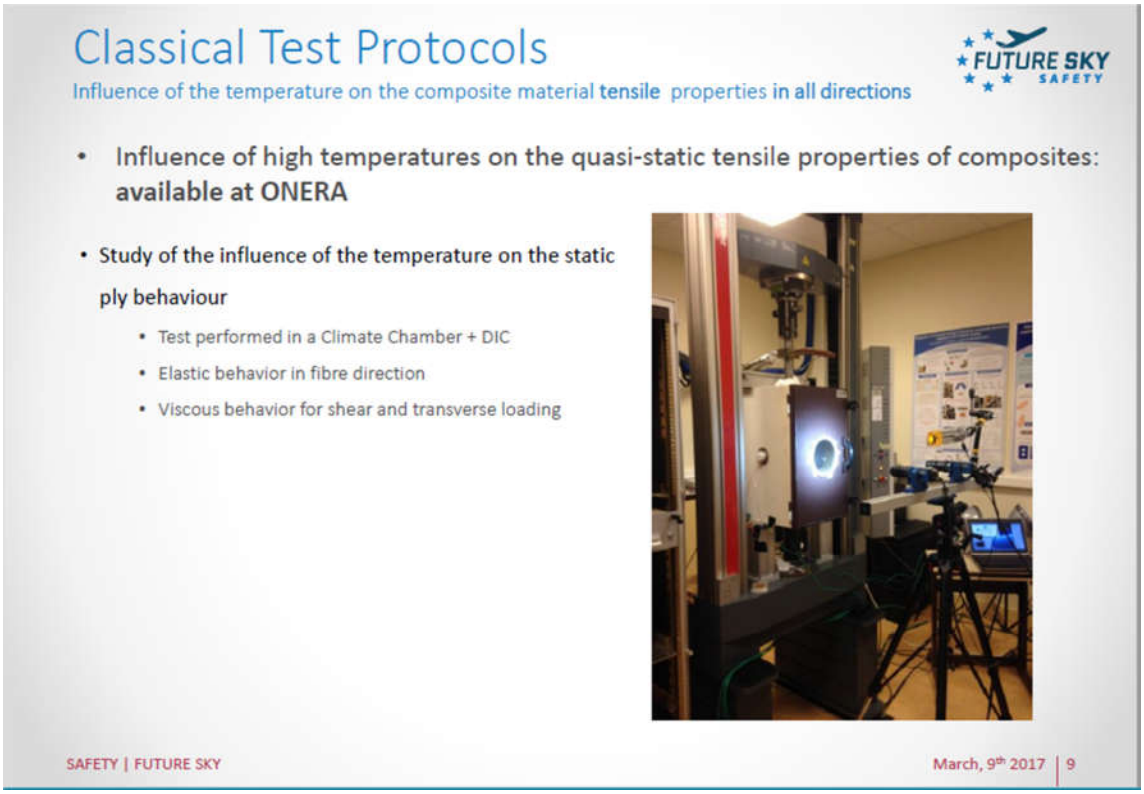

Classical Test Protocols

Influence of the temperature on the composite material **tensile** properties **in all directions**

- Influence of high temperatures on the quasi-static tensile properties of composites: available at ONERA

- Study of the influence of the temperature on the static ply behaviour
  - Test performed in a Climate Chamber + DIC
  - Elastic behavior in fibre direction
  - Viscous behavior for shear and transverse loading

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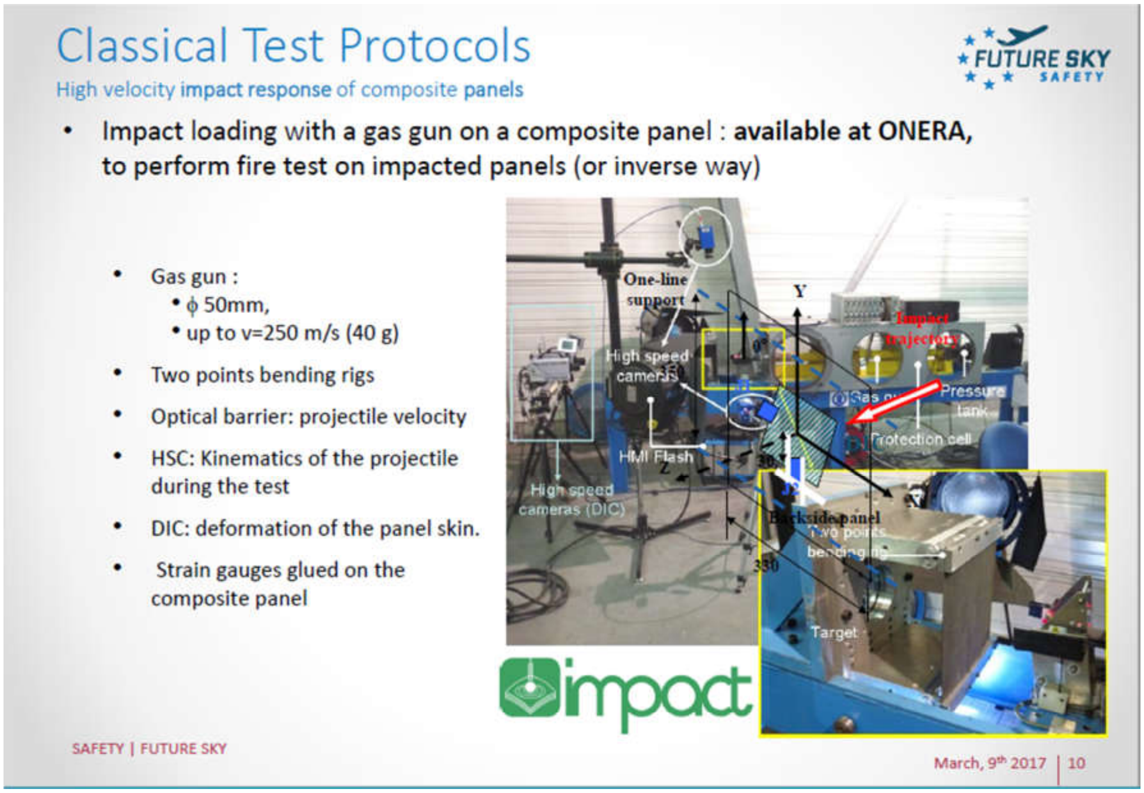

Classical Test Protocols

High velocity **impact response** of composite **panels**

- Impact loading with a gas gun on a composite panel : **available at ONERA,** to perform fire test on impacted panels (or inverse way)

- Gas gun :
  - ϕ 50mm,
  - up to v=250 m/s (40 g)
- Two points bending rigs
- Optical barrier: projectile velocity
- HSC: Kinematics of the projectile during the test
- DIC: deformation of the panel skin.
- Strain gauges glued on the composite panel

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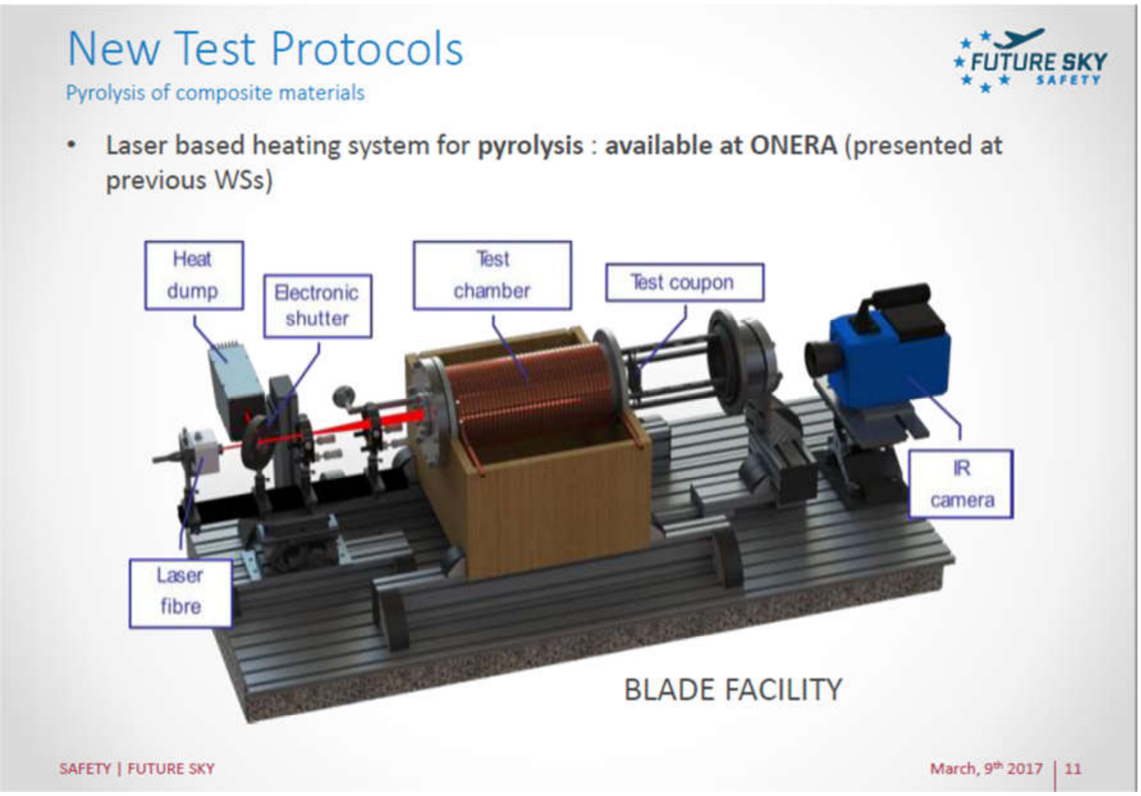

New Test Protocols

Pyrolysis of composite materials

- Laser based heating system for **pyrolysis** : **available at ONERA** (presented at previous WSs)

BLADE FACILITY

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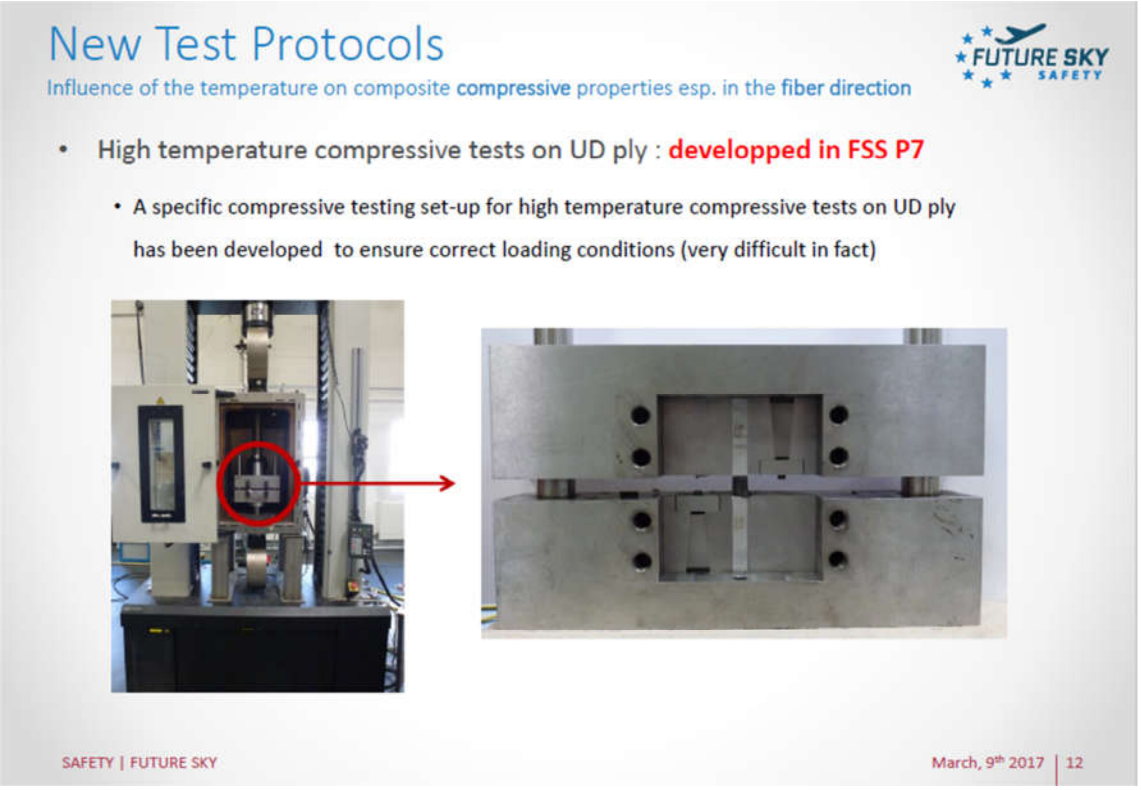
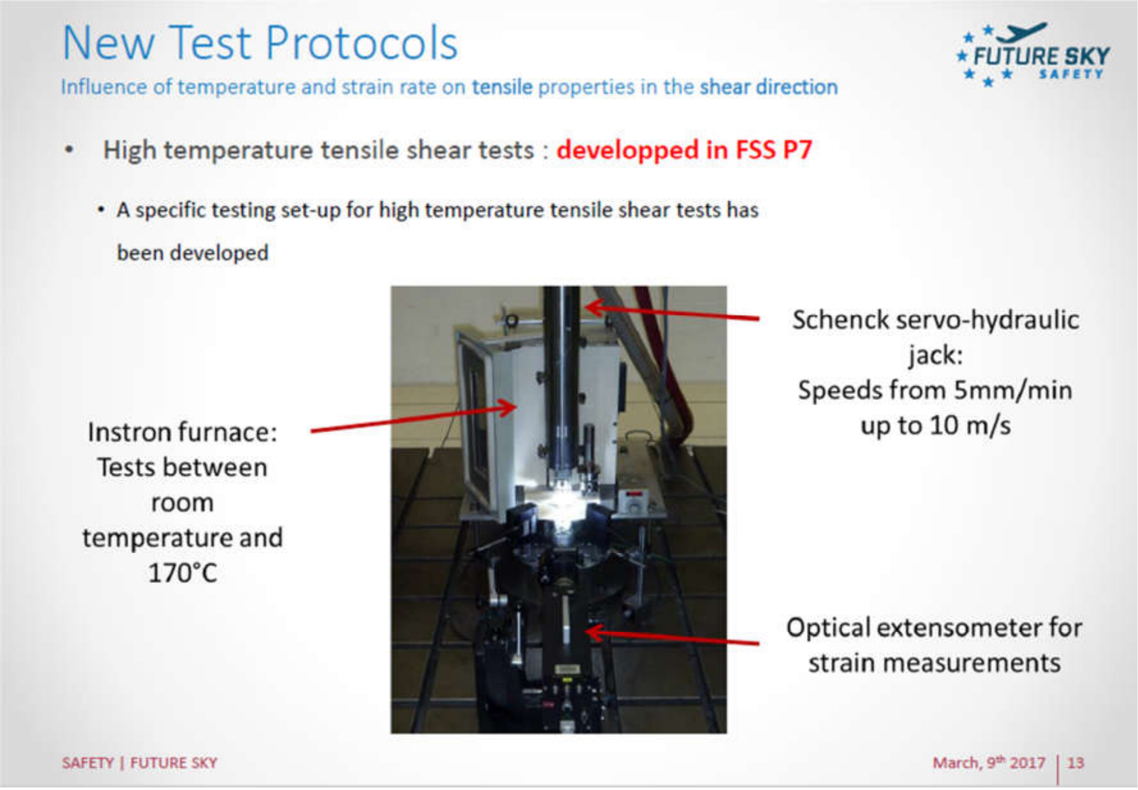


New Test Protocols

Influence of the temperature on composite **compressive** properties esp. in the **fiber direction**

- High temperature compressive tests on UD ply : **developped in FSS P7**
  - A specific compressive testing set-up for high temperature compressive tests on UD ply has been developed to ensure correct loading conditions (very difficult in fact)



New Test Protocols

Influence of temperature and strain rate on **tensile** properties in the **shear direction**

- High temperature tensile shear tests : **developped in FSS P7**
  - A specific testing set-up for high temperature tensile shear tests has been developed

Instron furnace:
Tests between room temperature and 170°C

Schenck servo-hydraulic jack:
Speeds from 5mm/min up to 10 m/s

Optical extensometer for strain measurements

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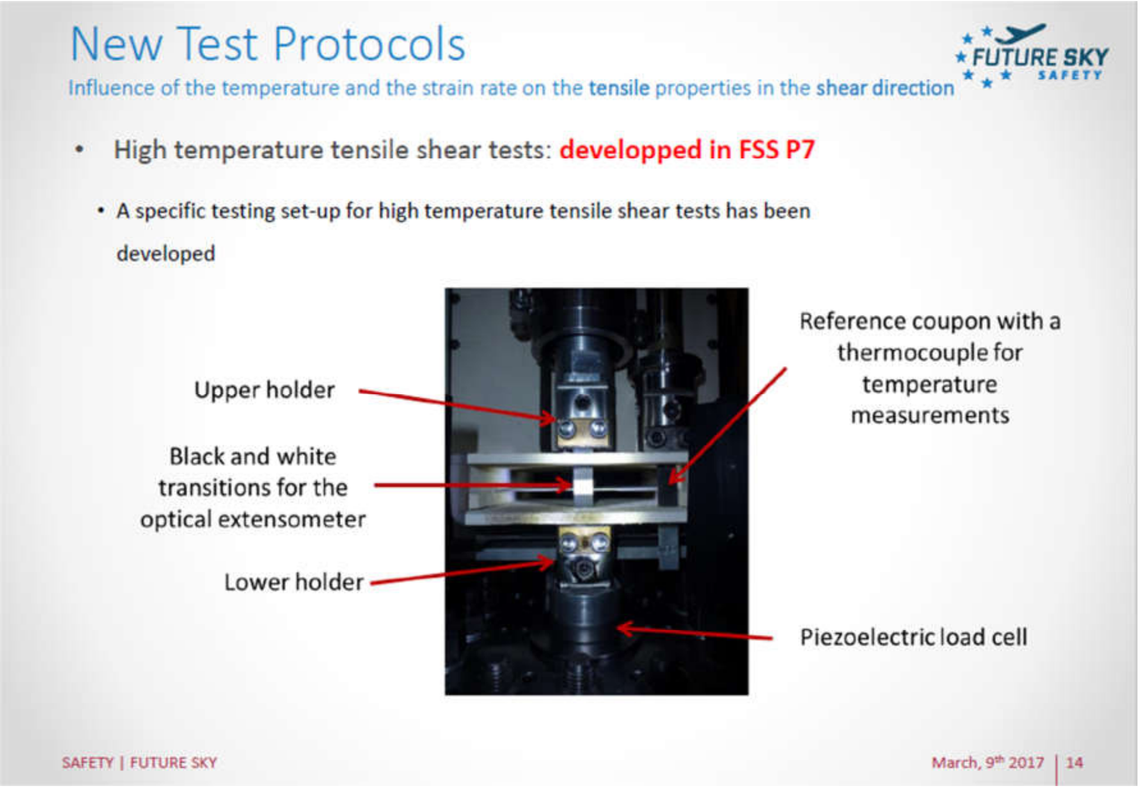

New Test Protocols

Influence of the temperature and the strain rate on the **tensile** properties in the **shear direction**

- High temperature tensile shear tests: **developped in FSS P7**
  - A specific testing set-up for high temperature tensile shear tests has been developed

Upper holder

Black and white transitions for the optical extensometer

Lower holder

Reference coupon with a thermocouple for temperature measurements

Piezoelectric load cell

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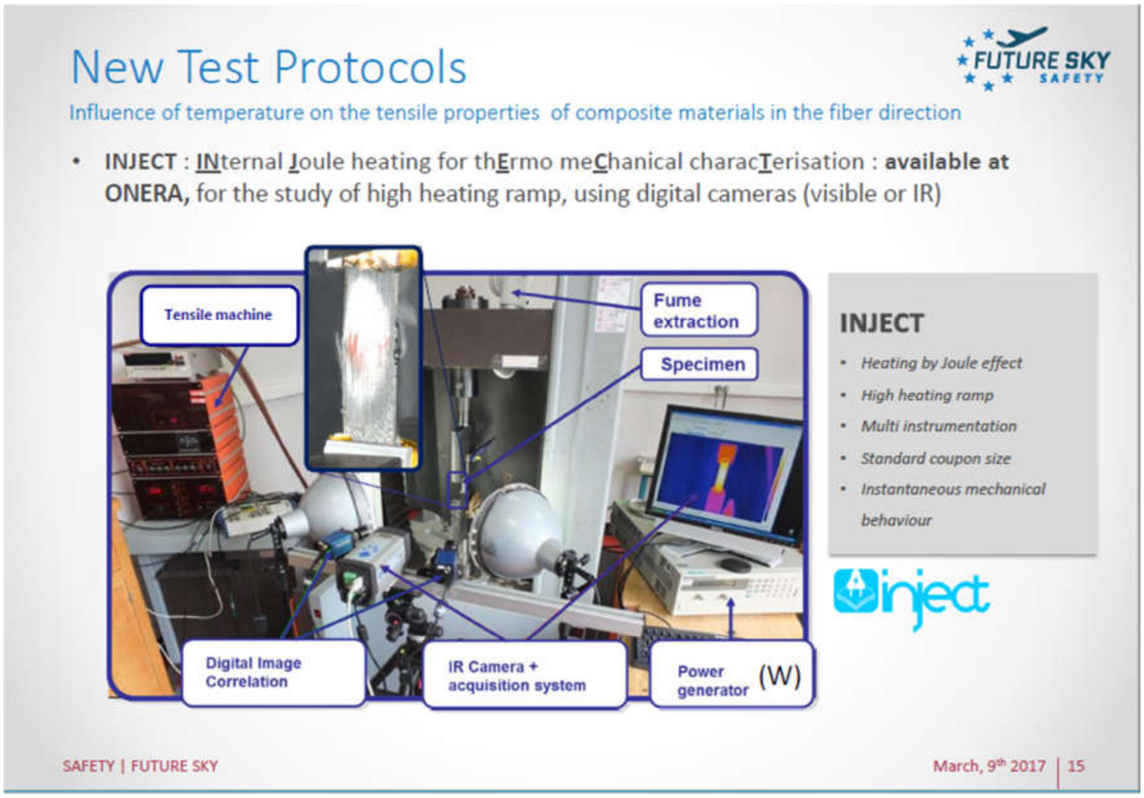

New Test Protocols

Influence of temperature on the tensile properties of composite materials in the fiber direction

- **INJECT** : <u>IN</u>ternal <u>J</u>oule heating for th<u>E</u>rmo me<u>C</u>hanical charac<u>T</u>erisation : **available at ONERA,** for the study of high heating ramp, using digital cameras (visible or IR)

Tensile machine

Fume extraction

Specimen

Digital Image Correlation

IR Camera + acquisition system

Power generator (W)

INJECT

- *Heating by Joule effect*
- *High heating ramp*
- *Multi instrumentation*
- *Standard coupon size*
- *Instantaneous mechanical behaviour*

inject

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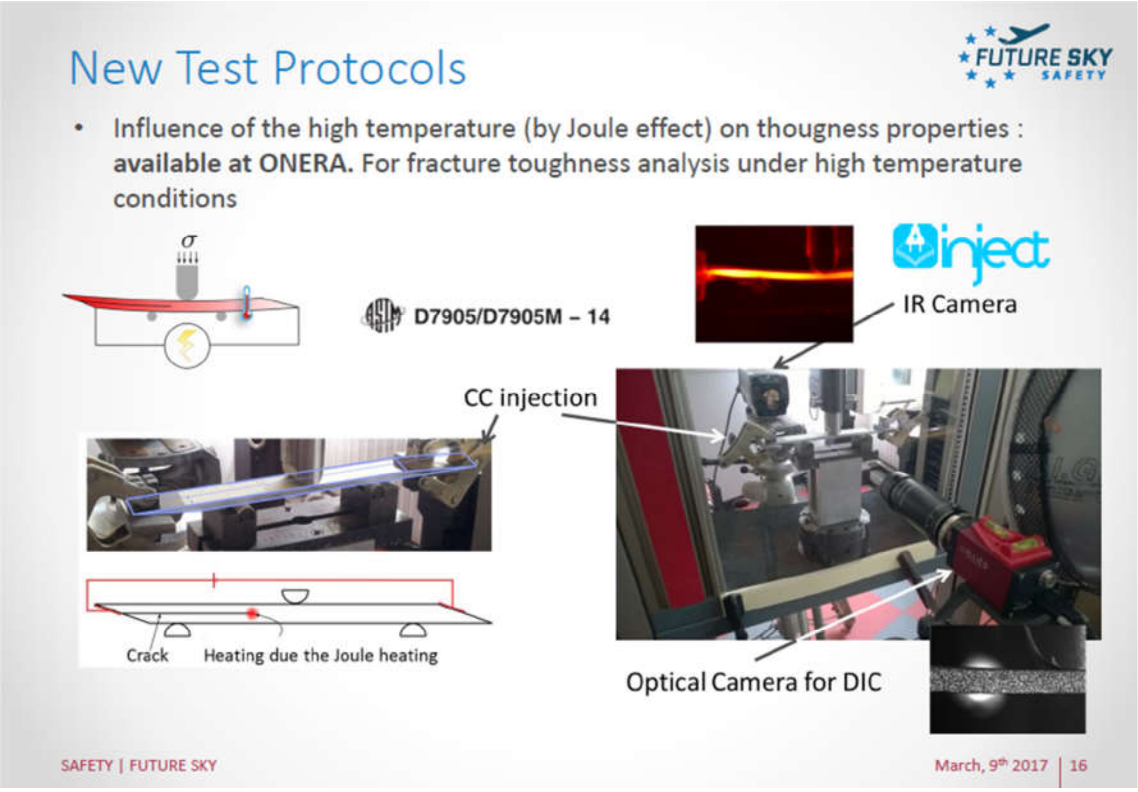
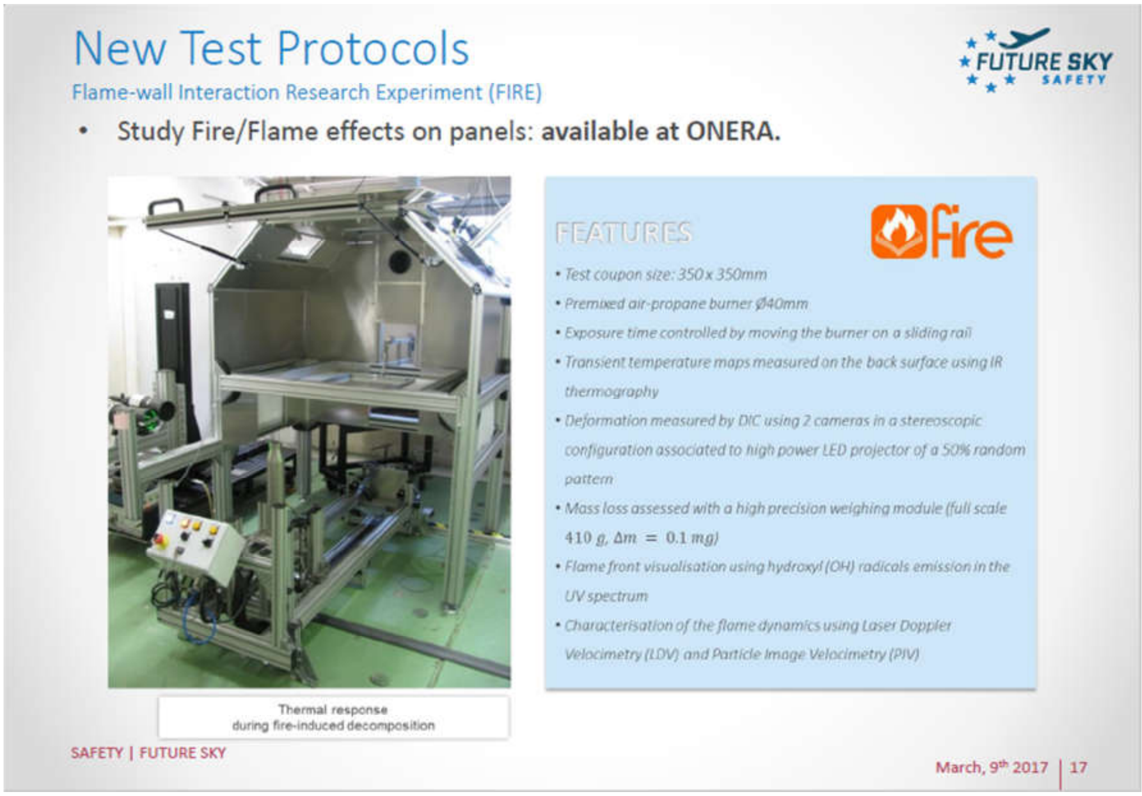


New Test Protocols

- Influence of the high temperature (by Joule effect) on thougness properties : **available at ONERA.** For fracture toughness analysis under high temperature conditions



New Test Protocols

Flame-wall Interaction Research Experiment (FIRE)

- Study Fire/Flame effects on panels: **available at ONERA.**

FEATURES

- *Test coupon size: 350 x 350mm*
- *Premixed air-propane burner Ø40mm*
- *Exposure time controlled by moving the burner on a sliding rail*
- *Transient temperature maps measured on the back surface using IR thermography*
- *Deformation measured by DIC using 2 cameras in a stereoscopic configuration associated to high power LED projector of a 50% random pattern*
- *Mass loss assessed with a high precision weighing module (full scale $410\ g$, $\Delta m = 0.1\ mg$)*
- *Flame front visualisation using hydroxyl (OH) radicals emission in the UV spectrum*
- *Characterisation of the flame dynamics using Laser Doppler Velocimetry (LDV) and Particle Image Velocimetry (PIV)*

Thermal response
during fire-induced decomposition

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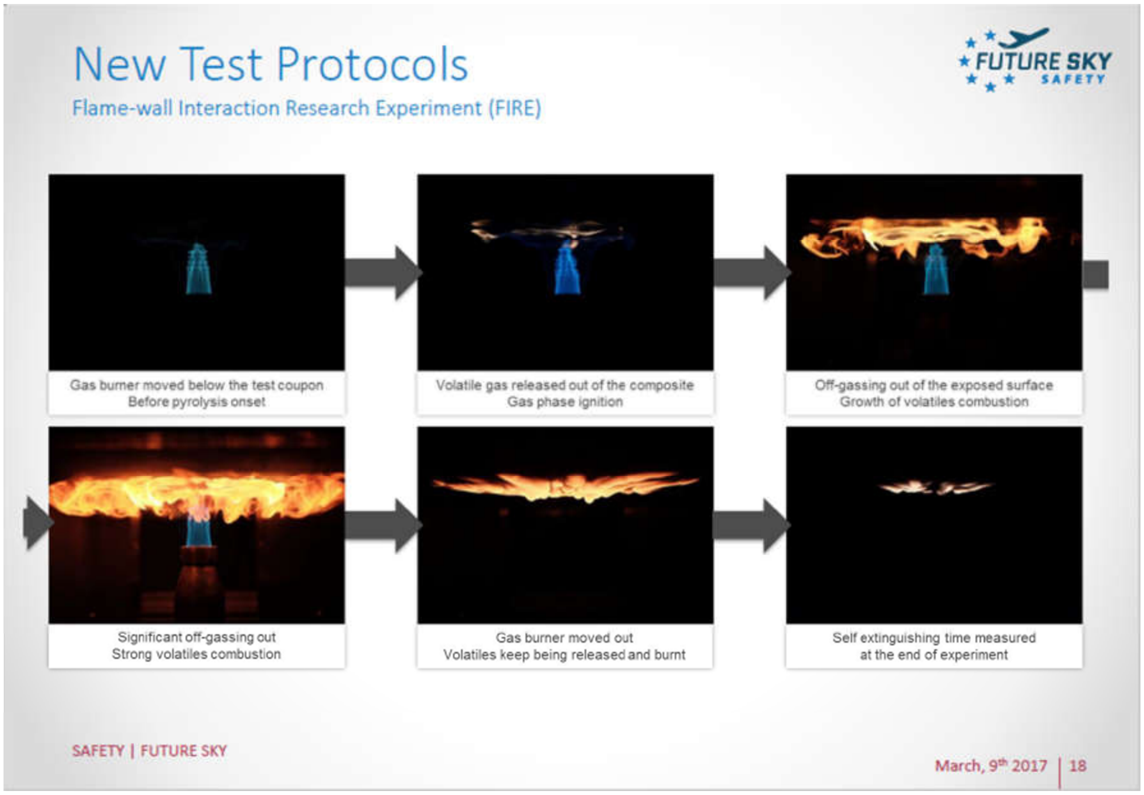

New Test Protocols

Flame-wall Interaction Research Experiment (FIRE)

Gas burner moved below the test coupon
Before pyrolysis onset

Volatile gas released out of the composite
Gas phase ignition

Off-gassing out of the exposed surface
Growth of volatiles combustion

Significant off-gassing out
Strong volatiles combustion

Gas burner moved out
Volatiles keep being released and burnt

Self extinguishing time measured
at the end of experiment

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Outlines

- Aviation safety regulation
- Fire behaviour of composite materials
- Future Sky Safety: Project 7 Objectives
- Work Package 7.1 Approach
- Classical & New Test Protocols
- Test Results (thermal & thermo-chemical properties of Composite Materials)
- Conclusions

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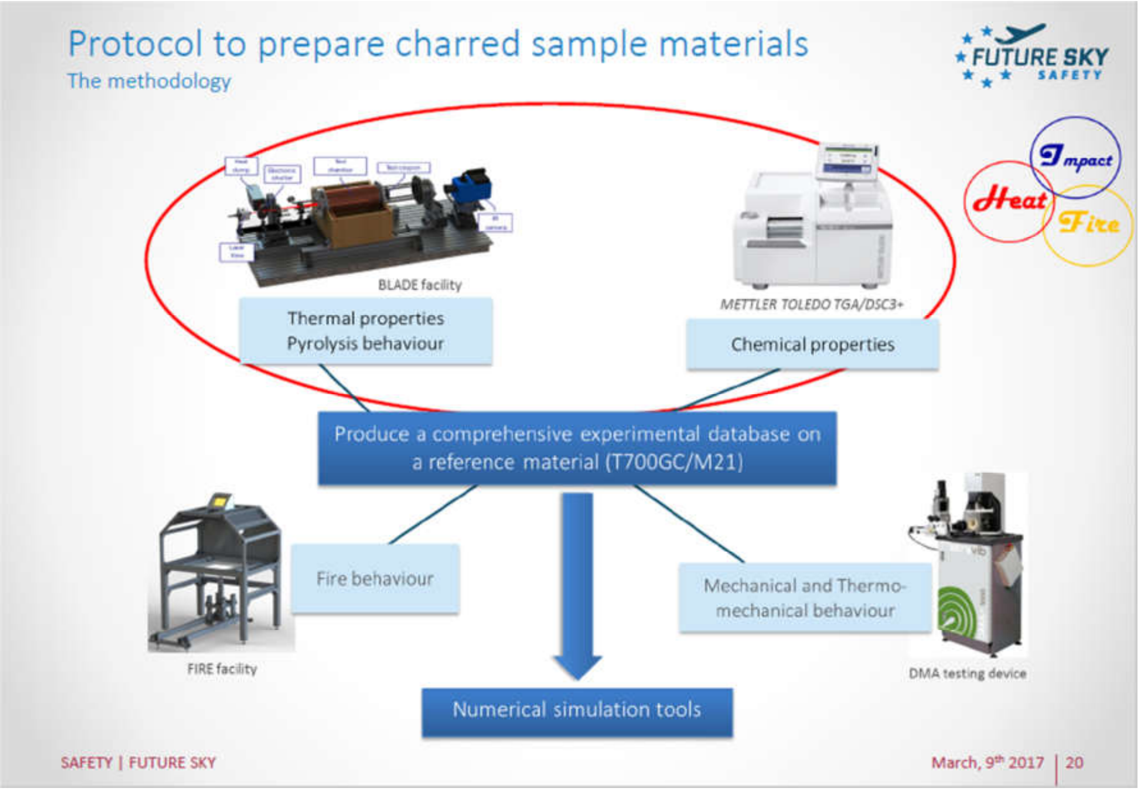

Protocol to prepare charred sample materials

The methodology

Thermal properties
Pyrolysis behaviour

Chemical properties

Produce a comprehensive experimental database on a reference material (T700GC/M21)

Fire behaviour

Mechanical and Thermo-mechanical behaviour

Numerical simulation tools

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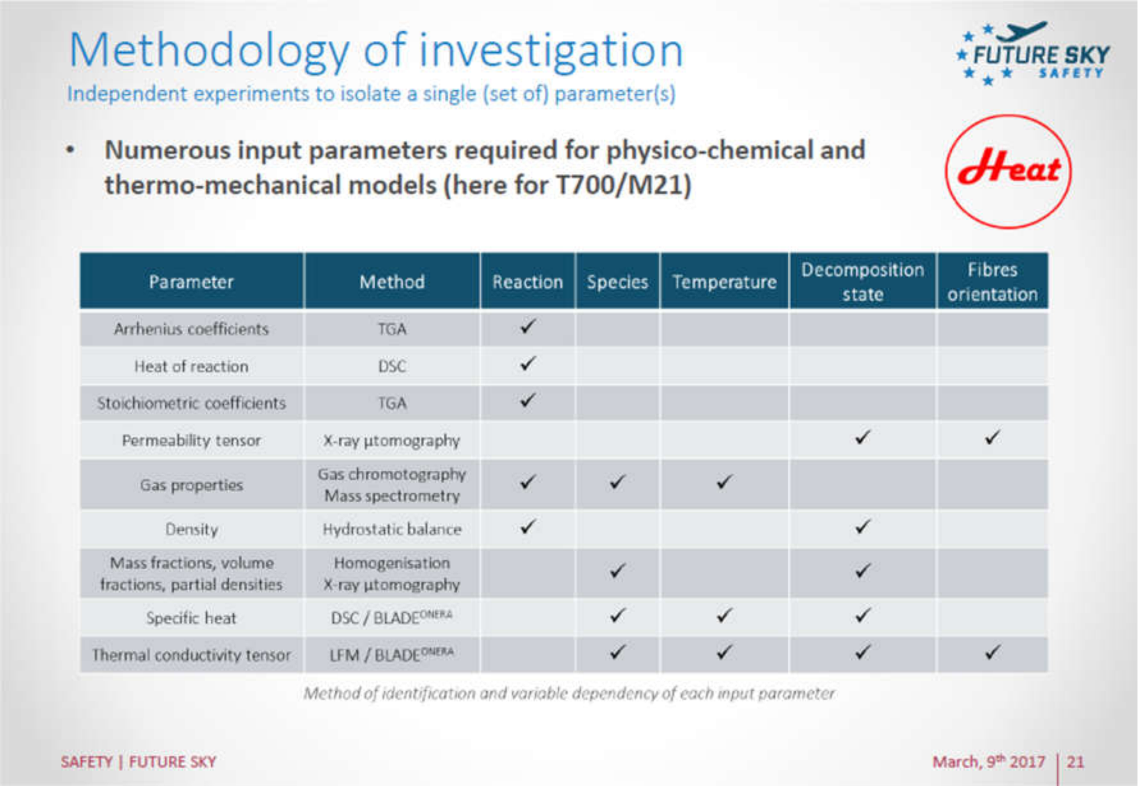

Methodology of investigation

Independent experiments to isolate a single (set of) parameter(s)

- **Numerous input parameters required for physico-chemical and thermo-mechanical models (here for T700/M21)**

Parameter	Method	Reaction	Species	Temperature	Decomposition state	Fibres orientation
Arrhenius coefficients	TGA	✓				
Heat of reaction	DSC	✓				
Stoichiometric coefficients	TGA	✓				
Permeability tensor	X-ray µtomography				✓	✓
Gas properties	Gas chromotography Mass spectrometry	✓	✓	✓		
Density	Hydrostatic balance	✓			✓	
Mass fractions, volume fractions, partial densities	Homogenisation X-ray µtomography		✓		✓	
Specific heat	DSC / BLADE^{ONERA}		✓	✓	✓	
Thermal conductivity tensor	LFM / BLADE^{ONERA}		✓	✓	✓	✓

Method of identification and variable dependency of each input parameter

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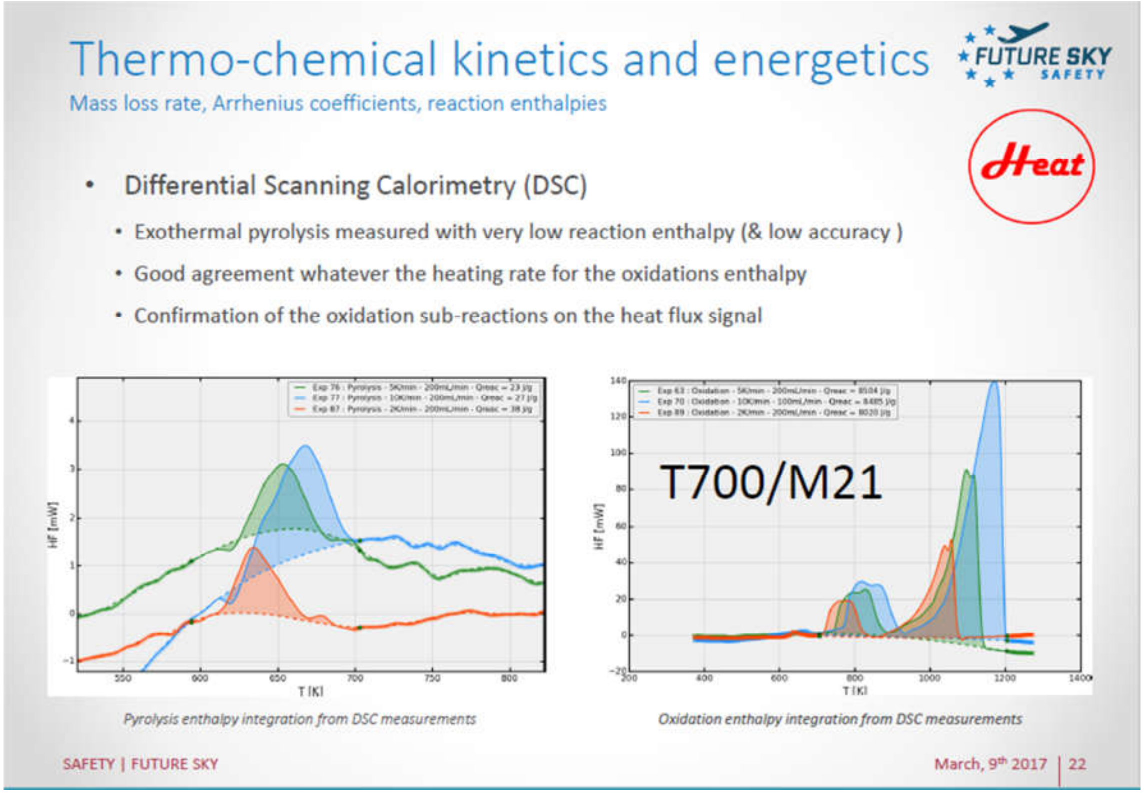

Thermo-chemical kinetics and energetics

Mass loss rate, Arrhenius coefficients, reaction enthalpies

- Differential Scanning Calorimetry (DSC)
  - Exothermal pyrolysis measured with very low reaction enthalpy (& low accuracy)
  - Good agreement whatever the heating rate for the oxidations enthalpy
  - Confirmation of the oxidation sub-reactions on the heat flux signal

Pyrolysis enthalpy integration from DSC measurements

Oxidation enthalpy integration from DSC measurements

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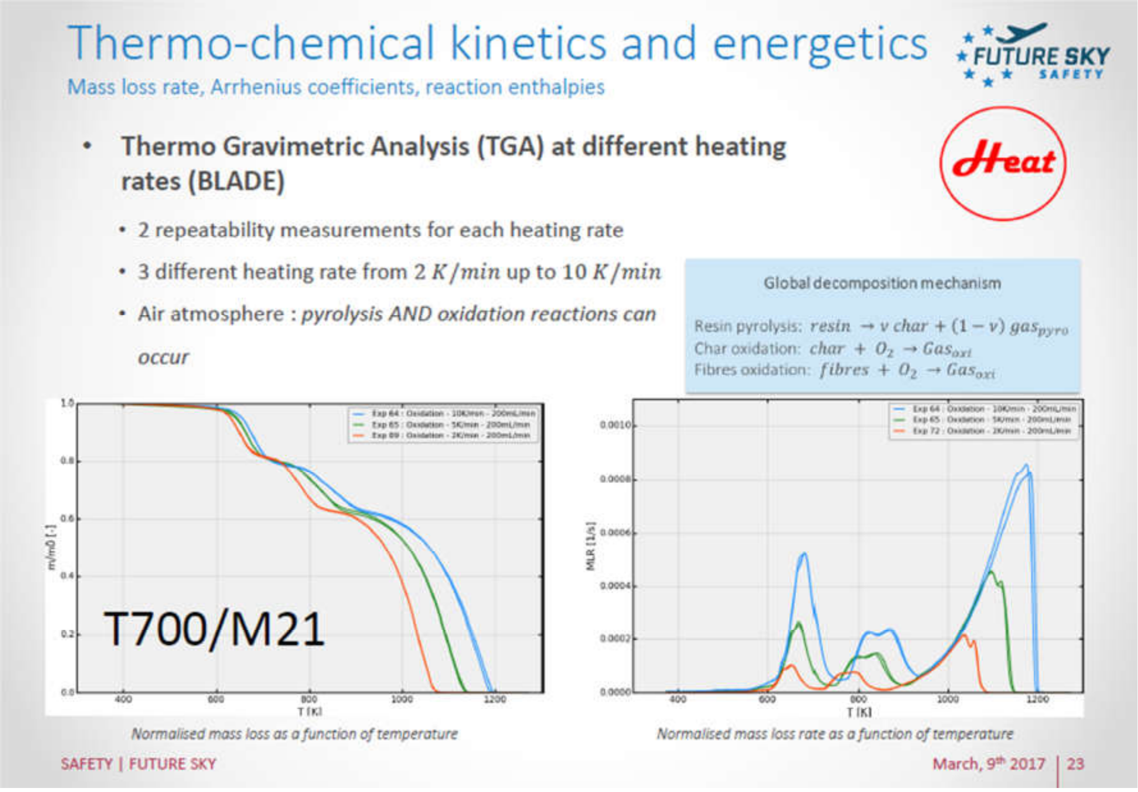

Thermo-chemical kinetics and energetics

Mass loss rate, Arrhenius coefficients, reaction enthalpies

- **Thermo Gravimetric Analysis (TGA) at different heating rates (BLADE)**
  - 2 repeatability measurements for each heating rate
  - 3 different heating rate from 2 K/min up to 10 K/min
  - Air atmosphere : *pyrolysis AND oxidation reactions can occur*

Global decomposition mechanism

Resin pyrolysis: $resin \rightarrow v\,char + (1-v)\ gas_{pyro}$
Char oxidation: $char\ +\ O_2\ \rightarrow Gas_{oxi}$
Fibres oxidation: $fibres\ +\ O_2\ \rightarrow Gas_{oxi}$

Normalised mass loss as a function of temperature

Normalised mass loss rate as a function of temperature

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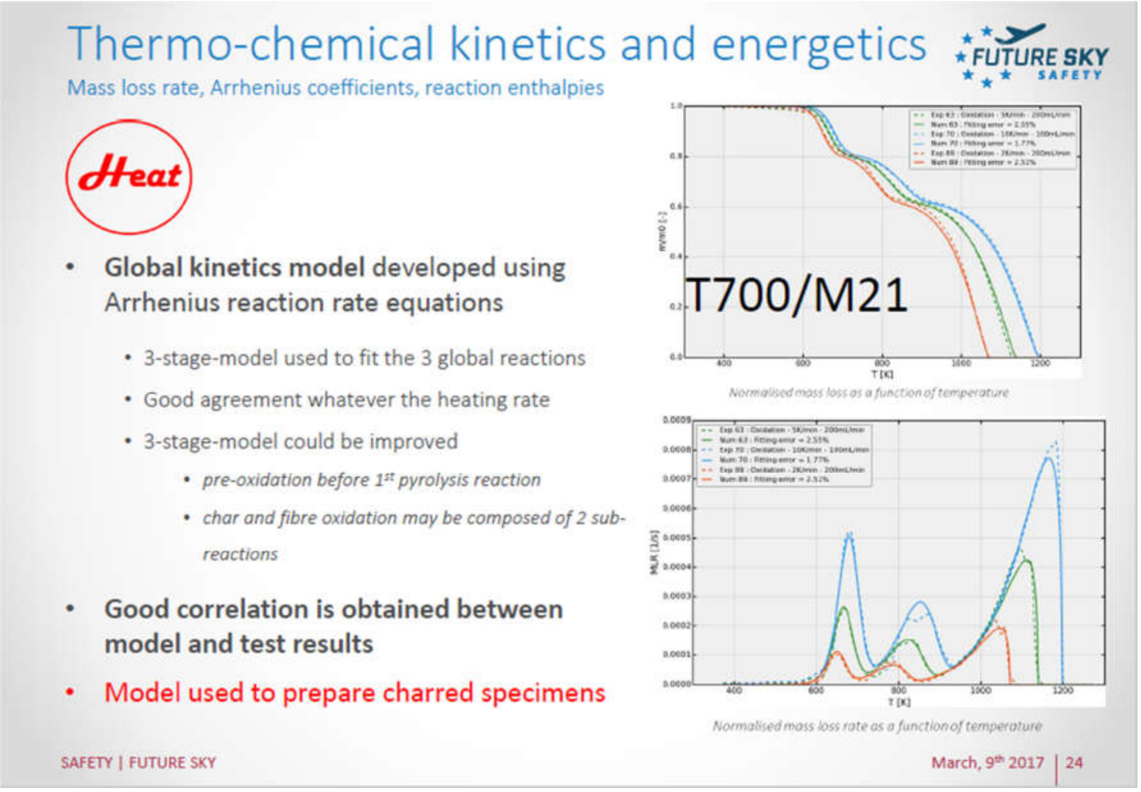

Thermo-chemical kinetics and energetics

Mass loss rate, Arrhenius coefficients, reaction enthalpies

- **Global kinetics model developed using** Arrhenius reaction rate equations
  - 3-stage-model used to fit the 3 global reactions
  - Good agreement whatever the heating rate
  - 3-stage-model could be improved
    - *pre-oxidation before 1st pyrolysis reaction*
    - *char and fibre oxidation may be composed of 2 sub-reactions*
- **Good correlation is obtained between model and test results**
- **Model used to prepare charred specimens**

Normalised mass loss as a function of temperature

Normalised mass loss rate as a function of temperature

Outlines

- Aviation safety regulation
- Fire behaviour of composite materials
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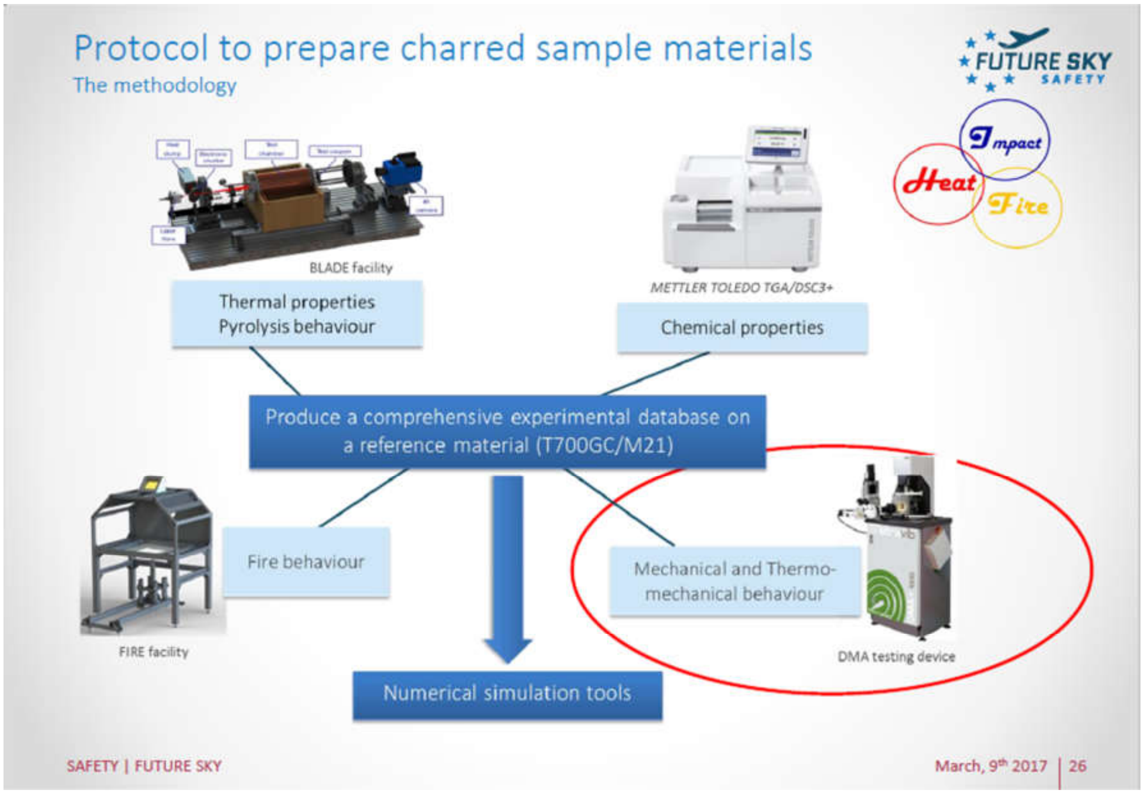
- Classical & New Test Protocols
- Test Results (Mechanical Properties of Virgin Materials)
- Conclusions



Protocol to prepare charred sample materials

The methodology

Thermal properties
Pyrolysis behaviour

Chemical properties

Produce a comprehensive experimental database on a reference material (T700GC/M21)

Fire behaviour

Mechanical and Thermo-mechanical behaviour

Numerical simulation tools

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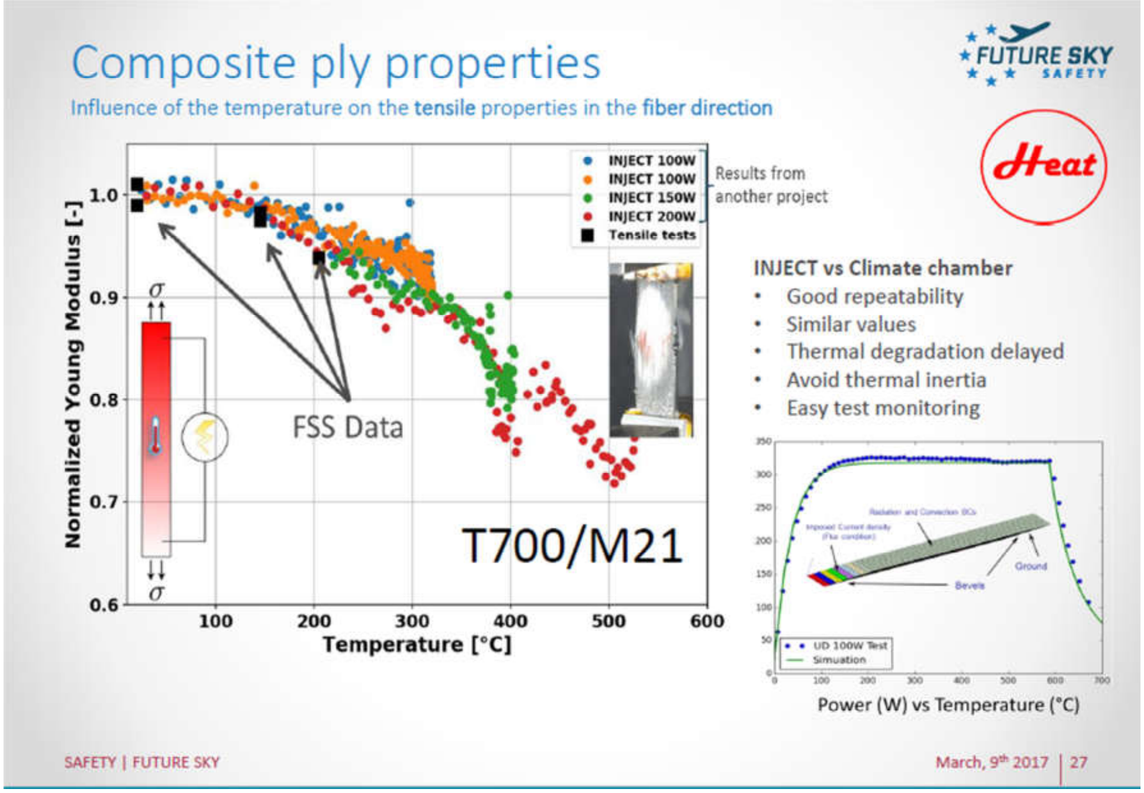

Composite ply properties

Influence of the temperature on the **tensile** properties in the **fiber direction**

Results from another project

INJECT vs Climate chamber

- Good repeatability
- Similar values
- Thermal degradation delayed
- Avoid thermal inertia
- Easy test monitoring

Power (W) vs Temperature (°C)

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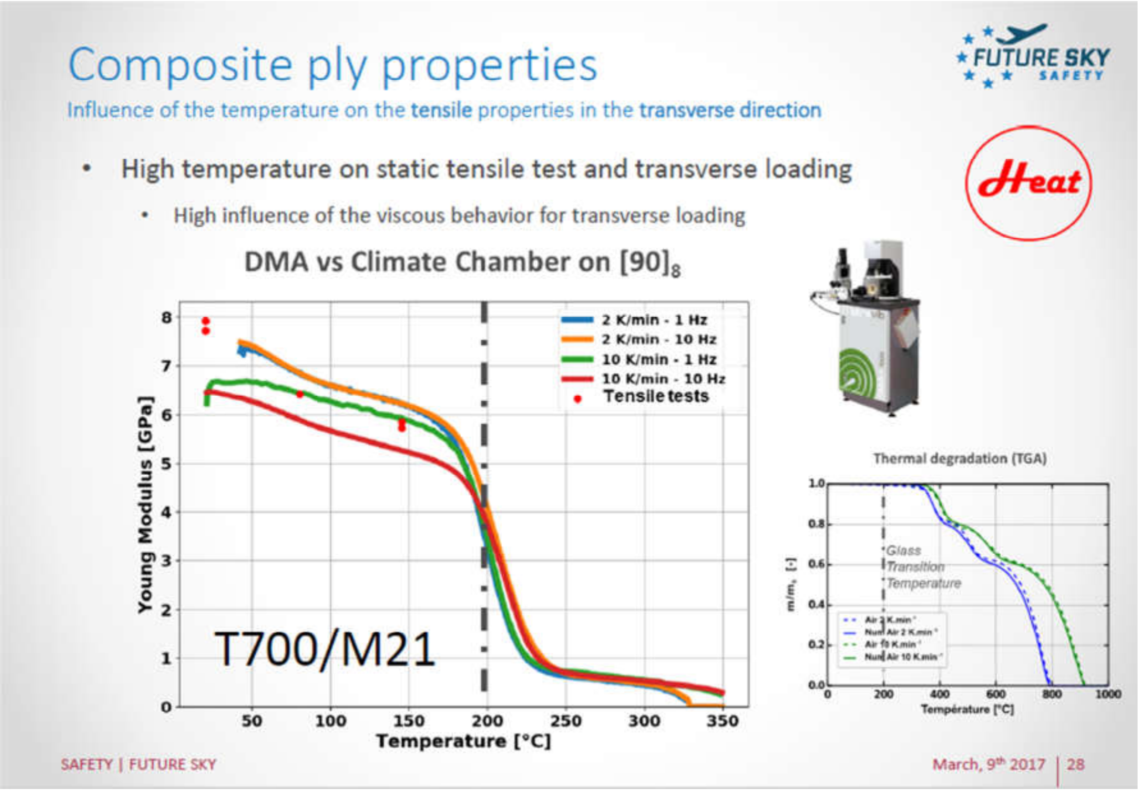

Composite ply properties

Influence of the temperature on the **tensile** properties in the **transverse direction**

- High temperature on static tensile test and transverse loading
  - High influence of the viscous behavior for transverse loading

DMA vs Climate Chamber on $[90]_8$

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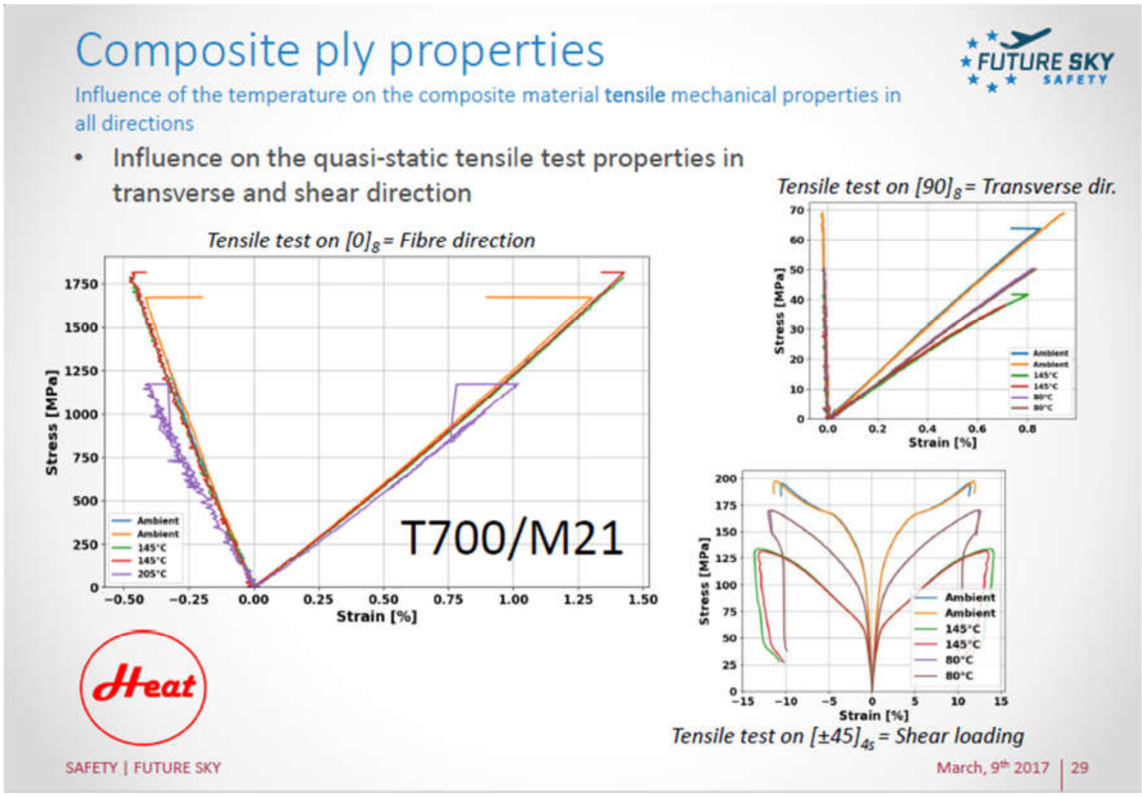

Composite ply properties

Influence of the temperature on the composite material **tensile** mechanical properties in all directions

- Influence on the quasi-static tensile test properties in transverse and shear direction

Tensile test on $[0]_8$ = Fibre direction

Tensile test on $[90]_8$ = Transverse dir.

Tensile test on $[\pm45]_{4s}$ = Shear loading

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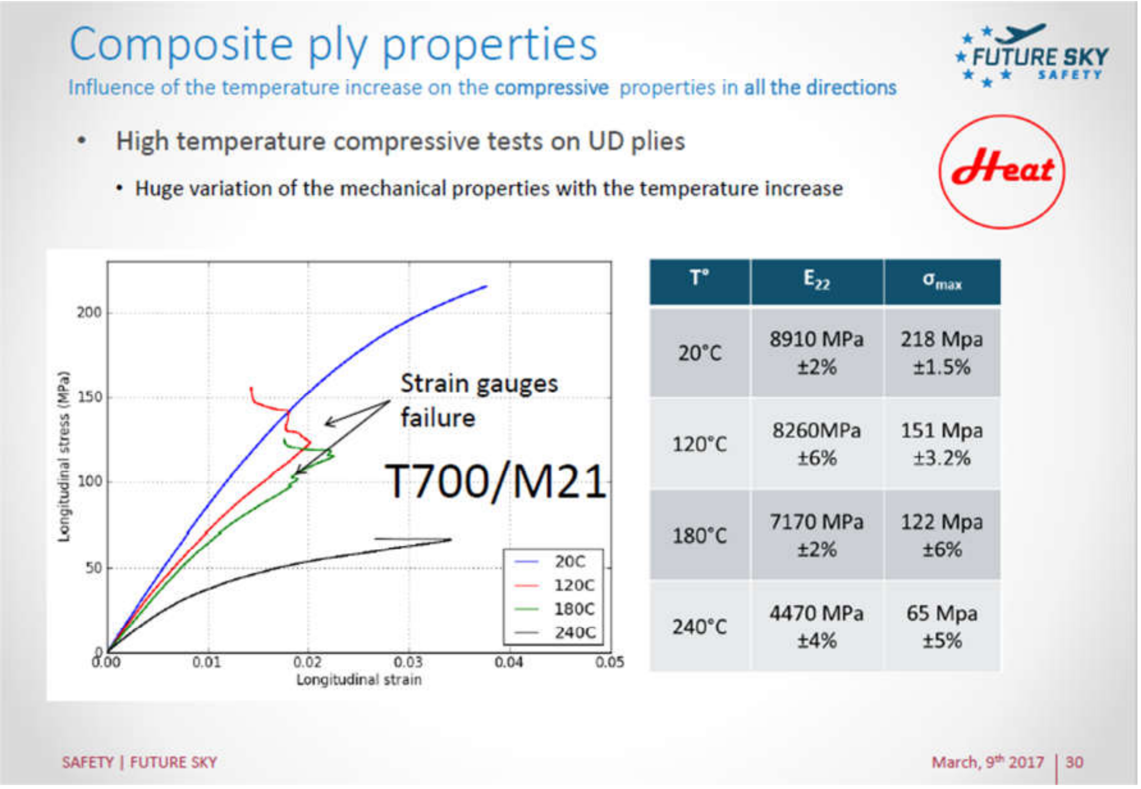

Composite ply properties

Influence of the temperature increase on the **compressive** properties in **all the directions**

- High temperature compressive tests on UD plies
  - Huge variation of the mechanical properties with the temperature increase

T°	E_{22}	σ_{max}
20°C	8910 MPa ±2%	218 Mpa ±1.5%
120°C	8260MPa ±6%	151 Mpa ±3.2%
180°C	7170 MPa ±2%	122 Mpa ±6%
240°C	4470 MPa ±4%	65 Mpa ±5%

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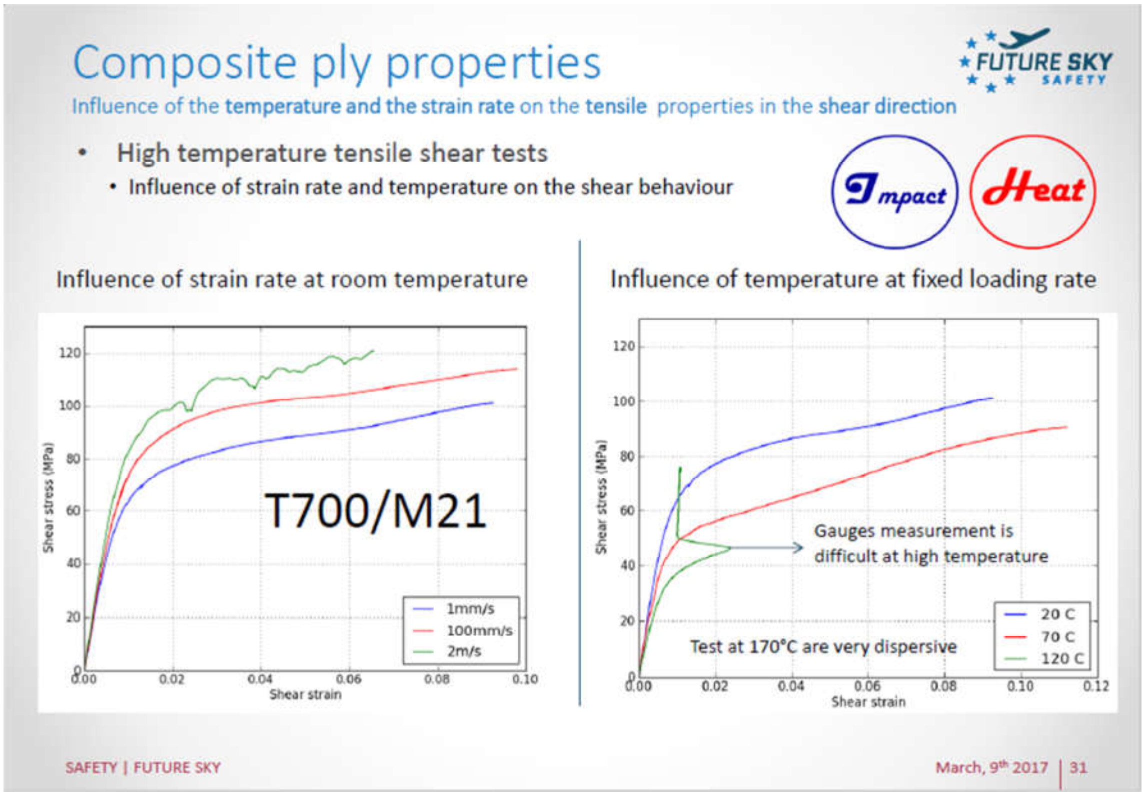

Composite ply properties

Influence of the **temperature and the strain rate** on the **tensile** properties in the **shear direction**

- High temperature tensile shear tests
  - Influence of strain rate and temperature on the shear behaviour

Influence of strain rate at room temperature

Influence of temperature at fixed loading rate

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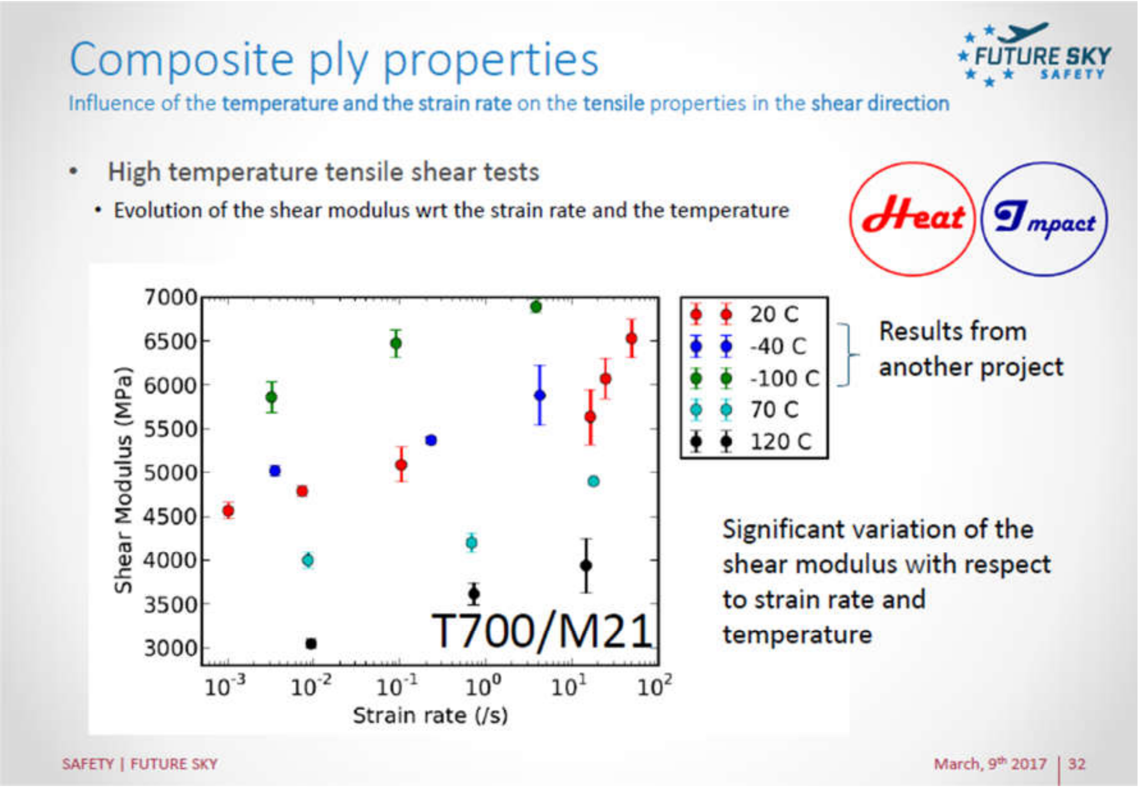

Composite ply properties

Influence of the **temperature and the strain rate** on the **tensile** properties in the **shear direction**

- High temperature tensile shear tests
  - Evolution of the shear modulus wrt the strain rate and the temperature

Results from another project

Significant variation of the shear modulus with respect to strain rate and temperature

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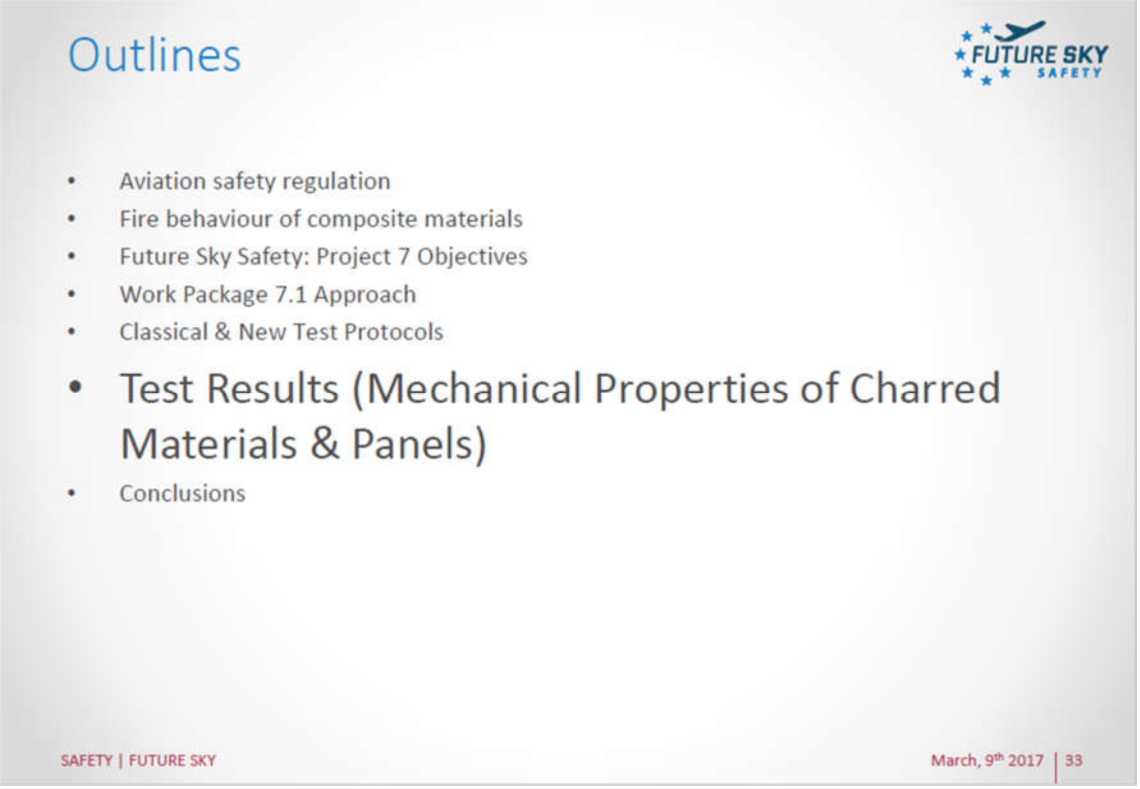

Outlines

- Aviation safety regulation
- Fire behaviour of composite materials
- Future Sky Safety: Project 7 Objectives
- Work Package 7.1 Approach
- Classical & New Test Protocols
- **Test Results (Mechanical Properties of Charred Materials & Panels)**
- Conclusions

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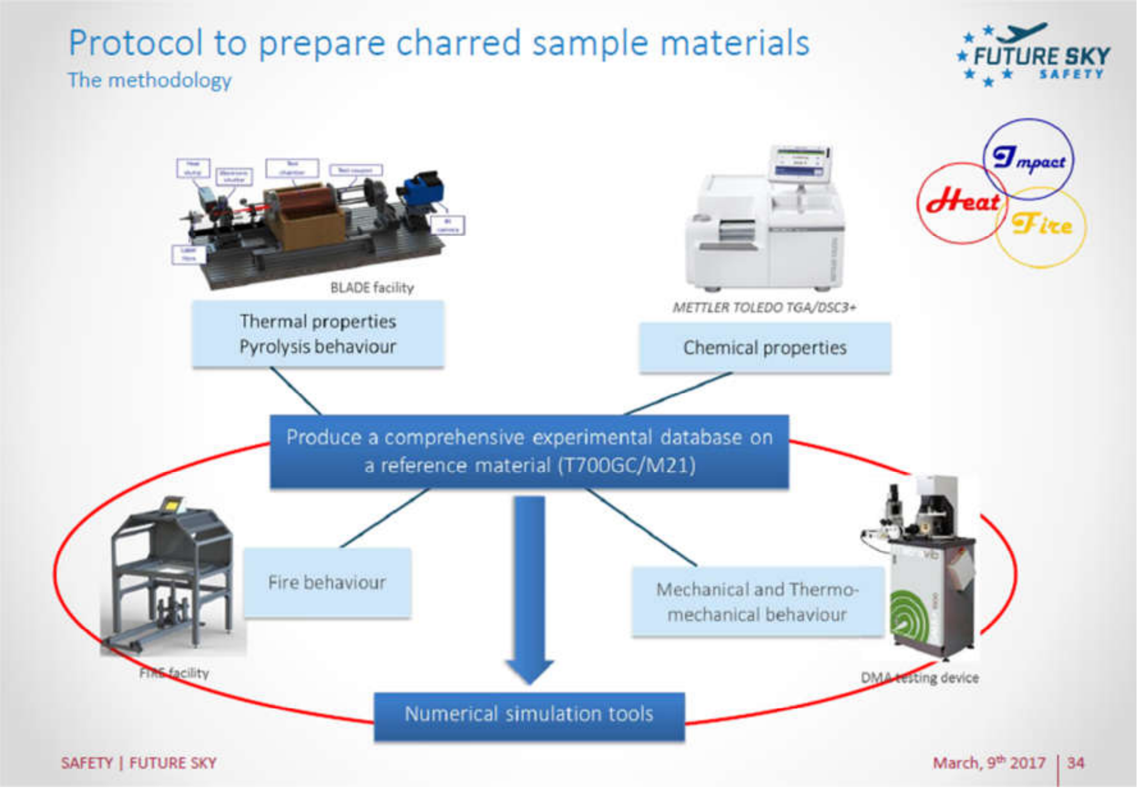

Protocol to prepare charred sample materials

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Chemical properties

Produce a comprehensive experimental database on a reference material (T700GC/M21)

Fire behaviour

Mechanical and Thermo-mechanical behaviour

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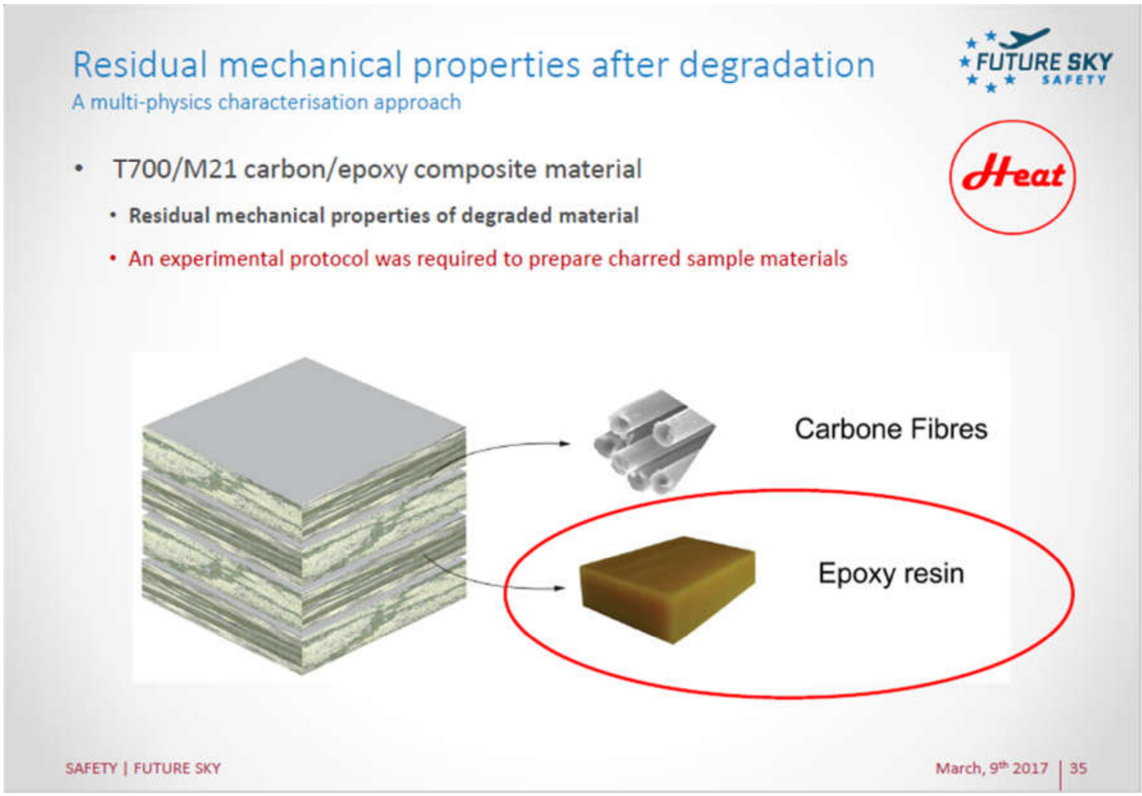
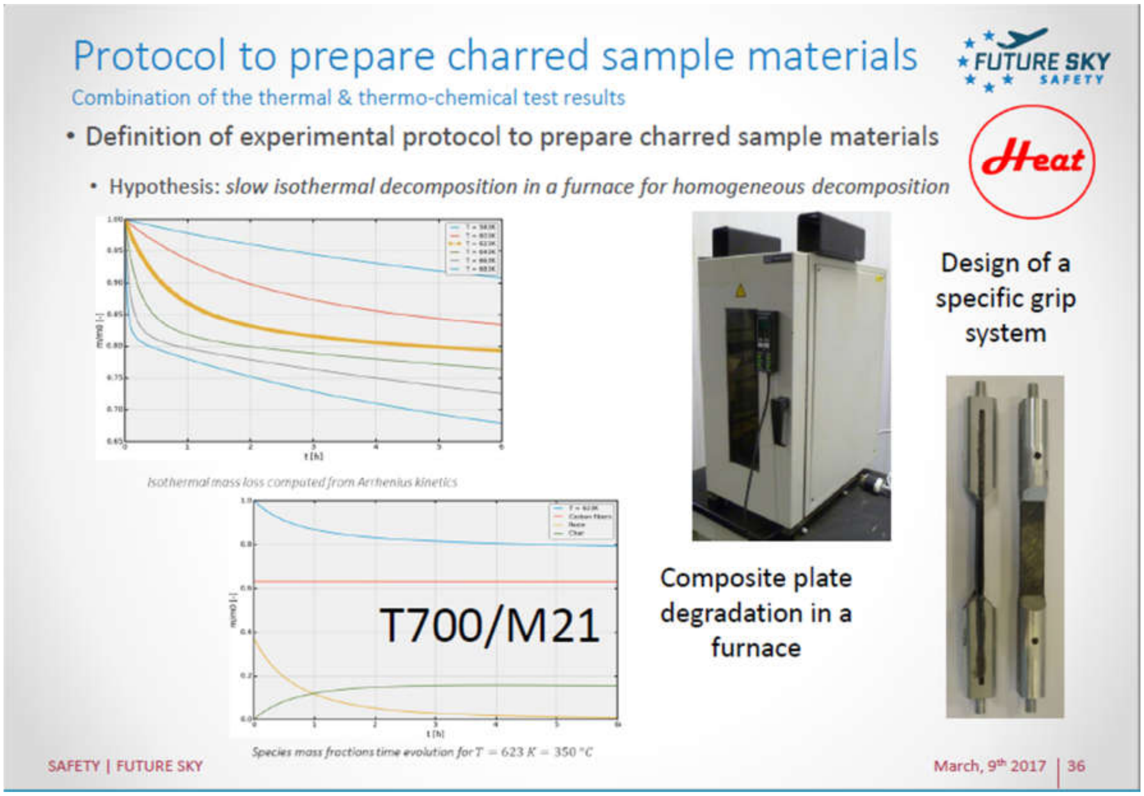


Residual mechanical properties after degradation

A multi-physics characterisation approach

- T700/M21 carbon/epoxy composite material
  - **Residual mechanical properties of degraded material**
  - An experimental protocol was required to prepare charred sample materials



Protocol to prepare charred sample materials

Combination of the thermal & thermo-chemical test results

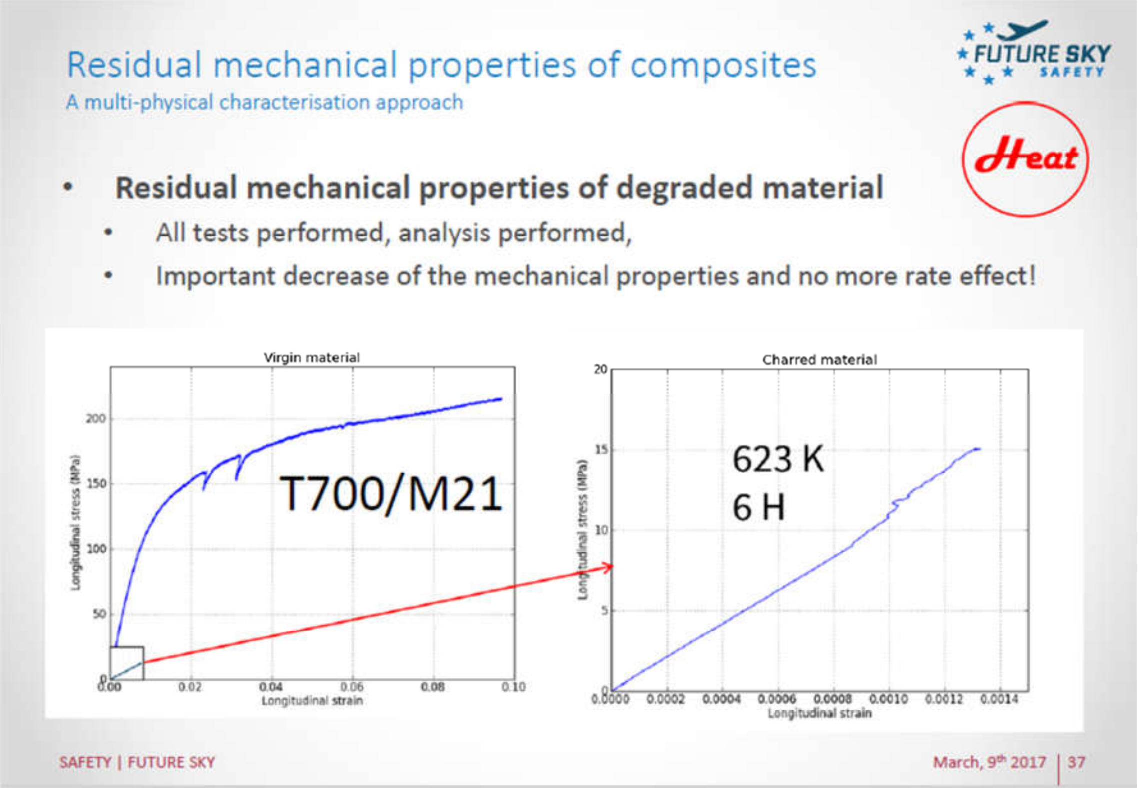
- Definition of experimental protocol to prepare charred sample materials
  - Hypothesis: *slow isothermal decomposition in a furnace for homogeneous decomposition*

Isothermal mass loss computed from Arrhenius kinetics

Species mass fractions time evolution for T = 623 K = 350 °C

Composite plate degradation in a furnace

Design of a specific grip system



Residual mechanical properties of composites

A multi-physical characterisation approach

- **Residual mechanical properties of degraded material**
  - All tests performed, analysis performed,
  - Important decrease of the mechanical properties and no more rate effect!

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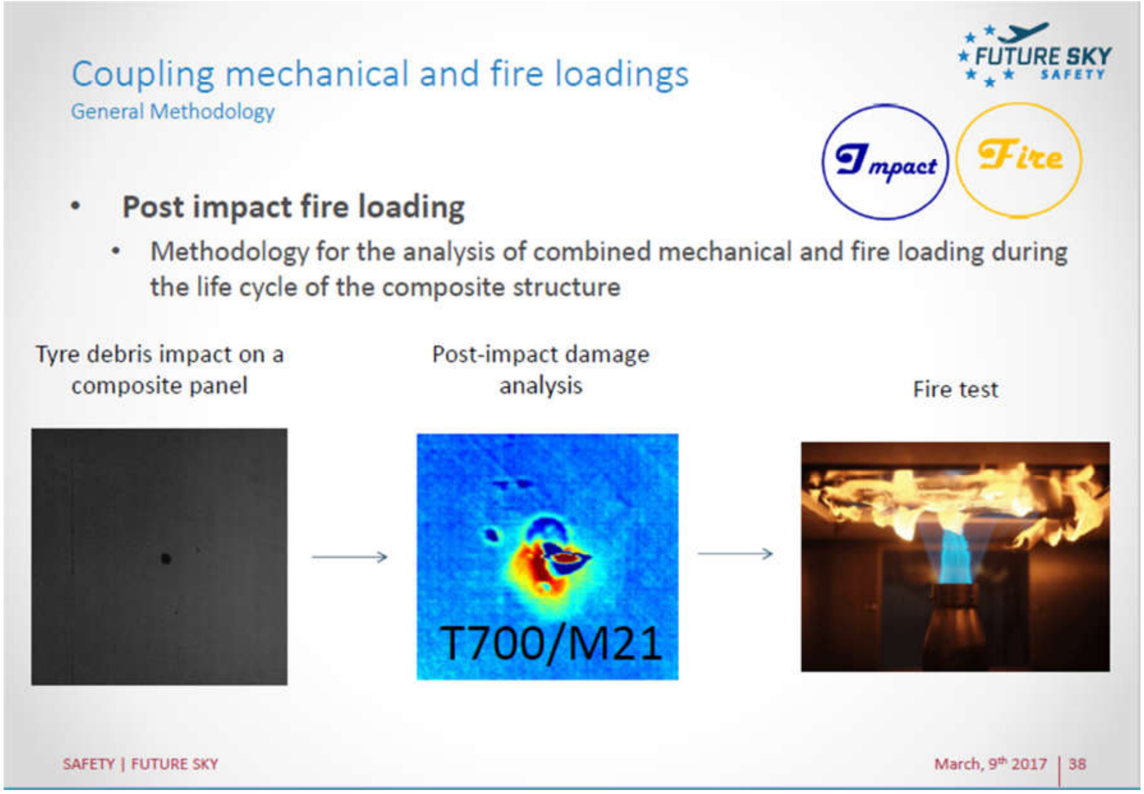
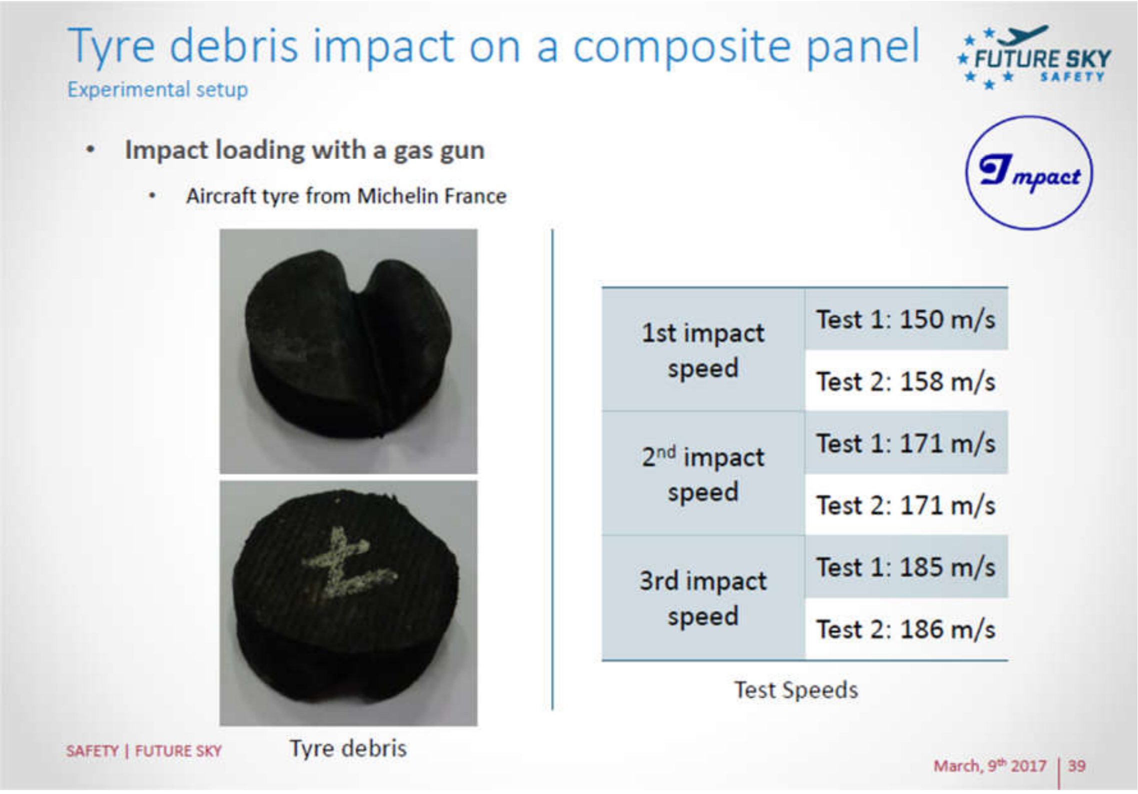


Coupling mechanical and fire loadings

General Methodology

- **Post impact fire loading**
  - Methodology for the analysis of combined mechanical and fire loading during the life cycle of the composite structure

Tyre debris impact on a composite panel → Post-impact damage analysis → Fire test



Tyre debris impact on a composite panel

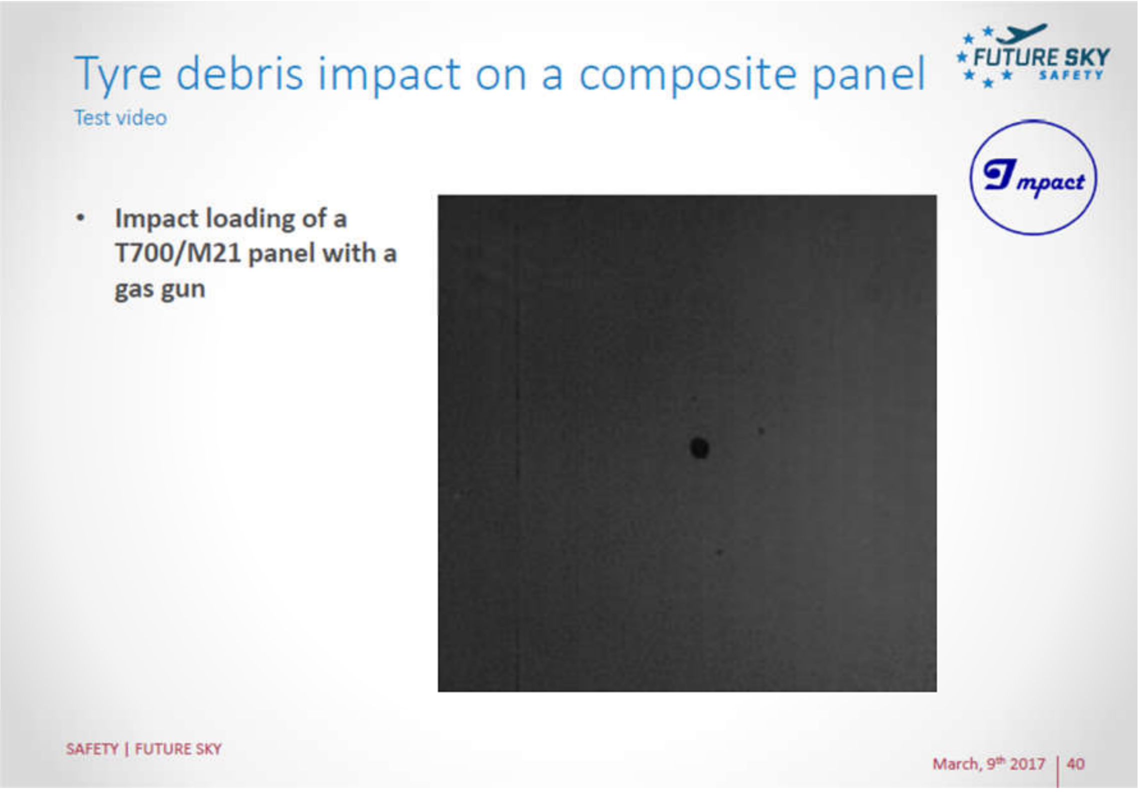
Experimental setup

- **Impact loading with a gas gun**
  - Aircraft tyre from Michelin France

Tyre debris

1st impact speed	Test 1: 150 m/s
	Test 2: 158 m/s
2nd impact speed	Test 1: 171 m/s
	Test 2: 171 m/s
3rd impact speed	Test 1: 185 m/s
	Test 2: 186 m/s

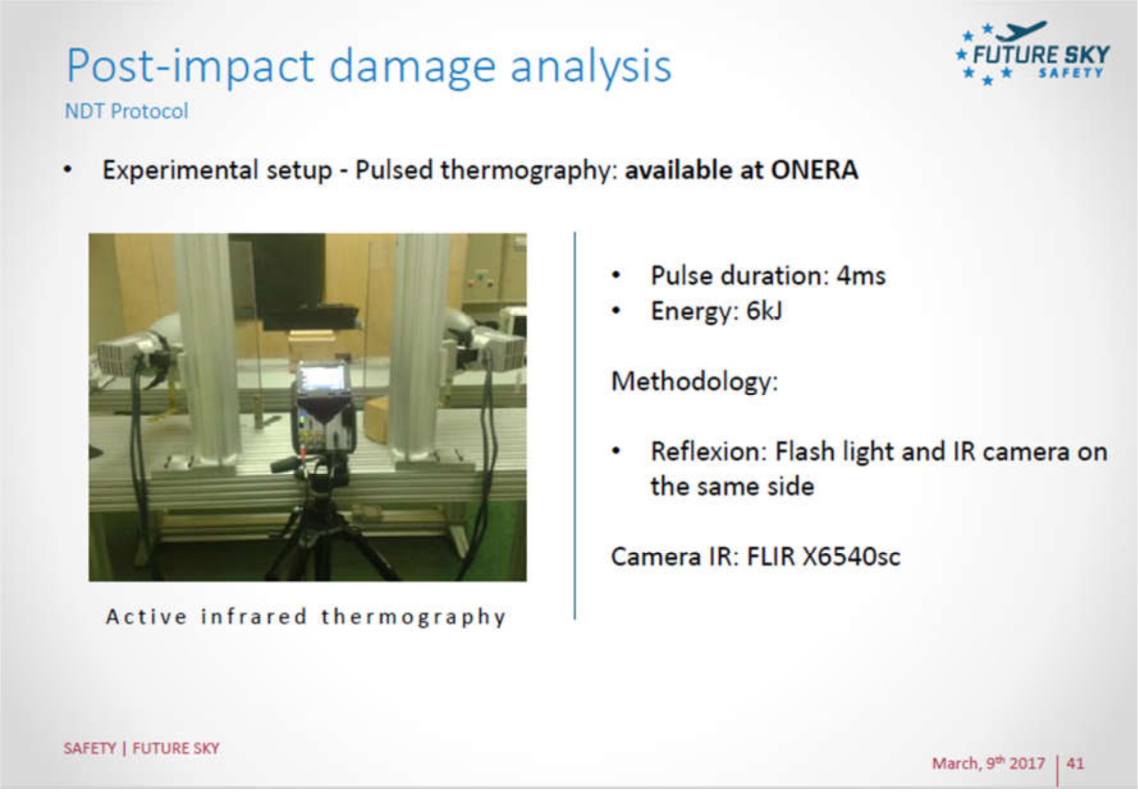
Test Speeds



Tyre debris impact on a composite panel

Test video

- Impact loading of a T700/M21 panel with a gas gun



Post-impact damage analysis

NDT Protocol

- Experimental setup - Pulsed thermography: **available at ONERA**

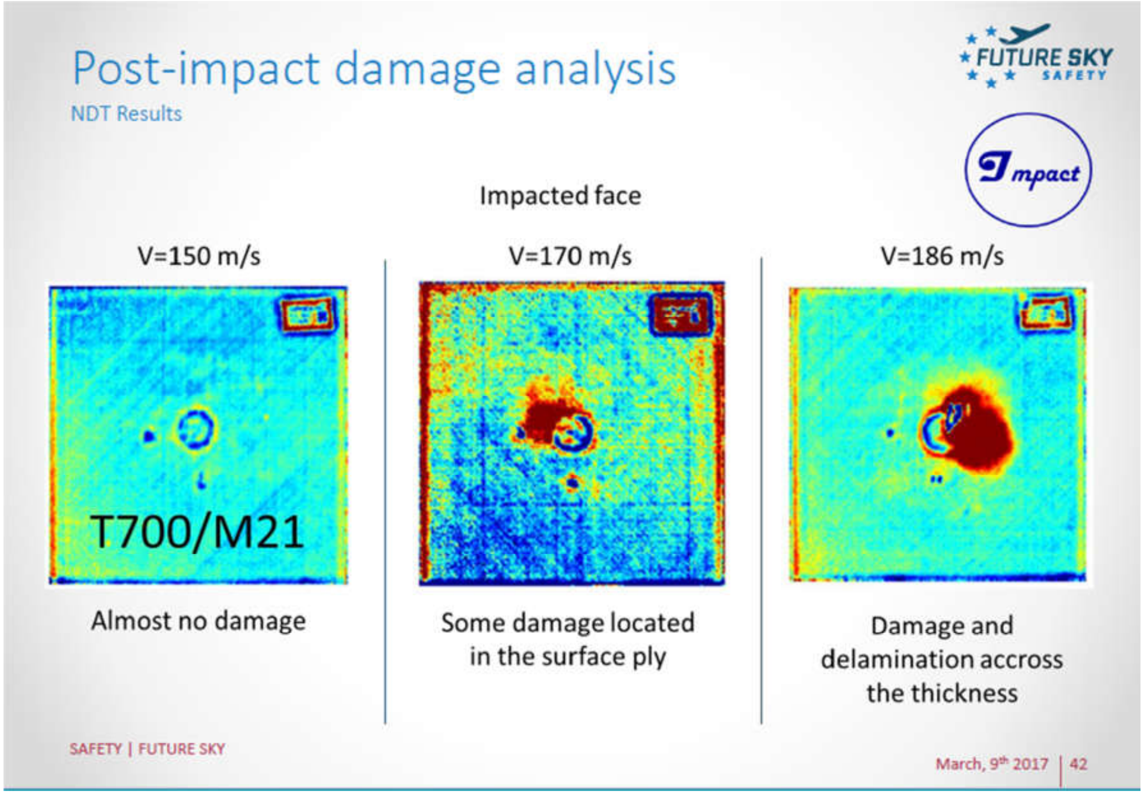
Active infrared thermography

- Pulse duration: 4ms
- Energy: 6kJ

Methodology:

- Reflexion: Flash light and IR camera on the same side

Camera IR: FLIR X6540sc

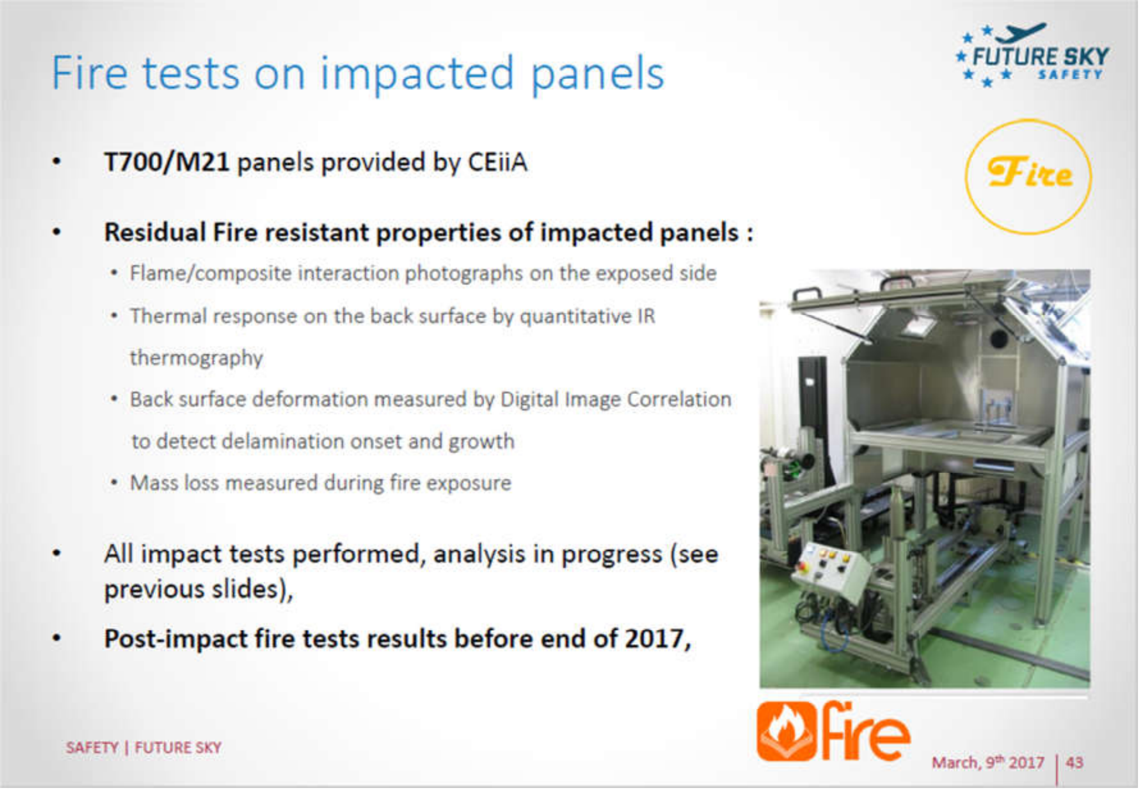


Post-impact damage analysis

NDT Results

Impacted face

V=150 m/s	V=170 m/s	V=186 m/s
Almost no damage	Some damage located in the surface ply	Damage and delamination accross the thickness



Fire tests on impacted panels

- **T700/M21** panels provided by CEiiA
- **Residual Fire resistant properties of impacted panels :**
  - Flame/composite interaction photographs on the exposed side
  - Thermal response on the back surface by quantitative IR thermography
  - Back surface deformation measured by Digital Image Correlation to detect delamination onset and growth
  - Mass loss measured during fire exposure
- All impact tests performed, analysis in progress (see previous slides),
- **Post-impact fire tests results before end of 2017,**

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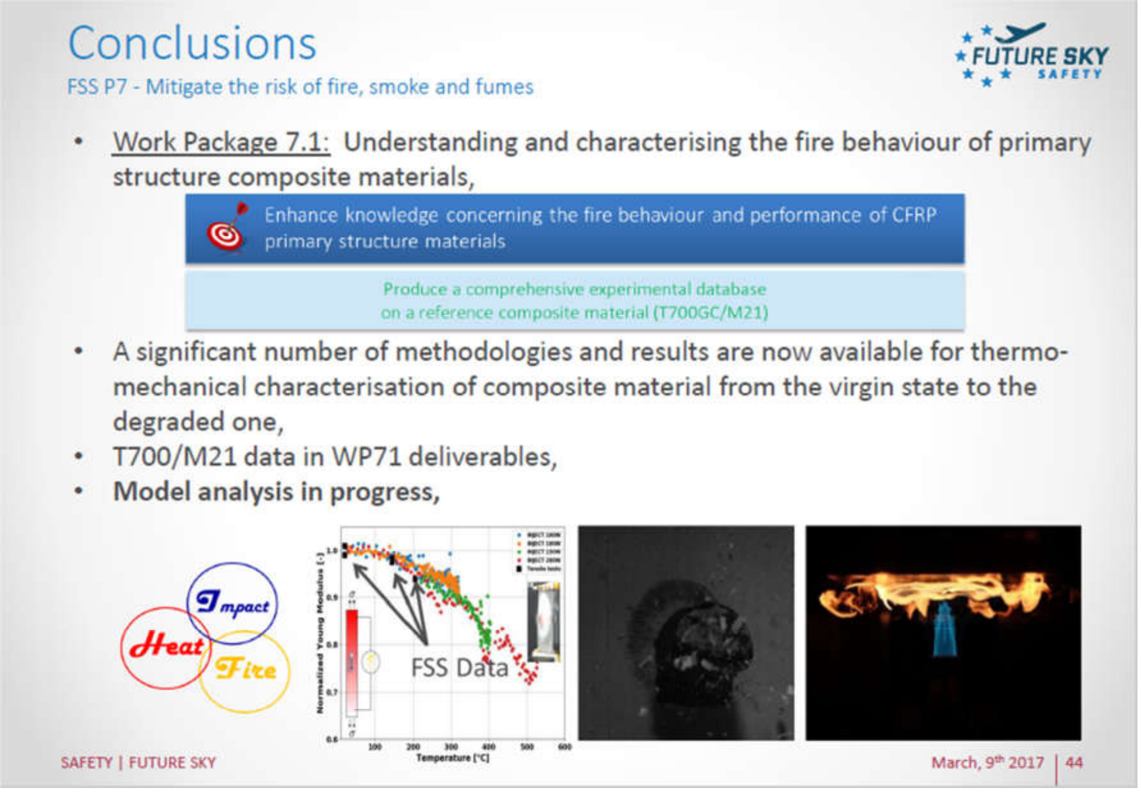

Conclusions

FSS P7 - Mitigate the risk of fire, smoke and fumes

- Work Package 7.1: Understanding and characterising the fire behaviour of primary structure composite materials,

Enhance knowledge concerning the fire behaviour and performance of CFRP primary structure materials

Produce a comprehensive experimental database on a reference composite material (T700GC/M21)

- A significant number of methodologies and results are now available for thermo-mechanical characterisation of composite material from the virgin state to the degraded one,
- T700/M21 data in WP71 deliverables,
- **Model analysis in progress,**

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Consortium

Stichting Nationaal Lucht- en Ruimtevaartlaboratorium
Deutsches Zentrum für Luft- und Raumfahrt
Office national d'études et de recherches aérospatiales
Centro para a Excelência e Inovação na Indústria Automóvel
Centro Italiano Ricerche Aerospaziali
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Totalförsvarets FOrskningsInstitut
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Civil Aviation Authority UK
Airbus SAS
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Thales Air Systems SA
Deep Blue SRL
Technische Universität München
Deutsche Lufthansa Aktiengesellschaft
Service Technique de l'Aviation Civile
Embraer Portugal Estruturas em Compositos SA
Russian Central Aerohydrodynamic Institute TsAGI
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Sistemi Innovativi per il Controllo del Traffico Aereo

http://www.futuresky-safety.eu

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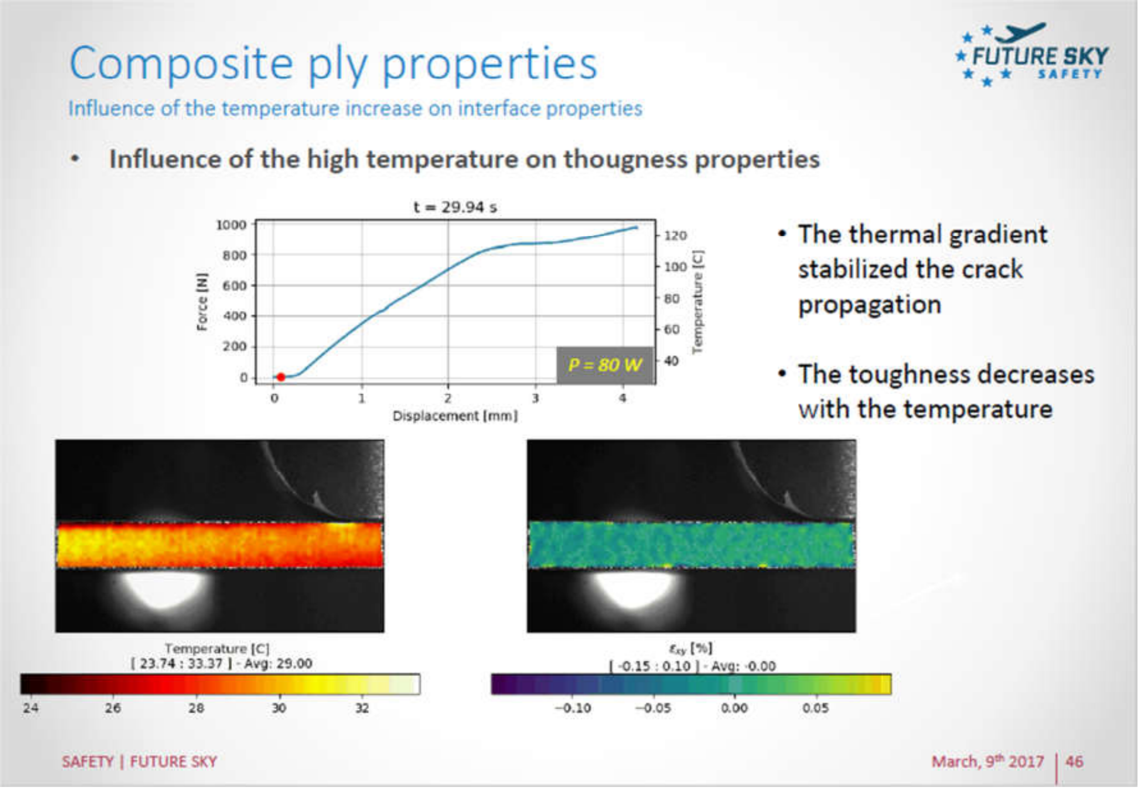
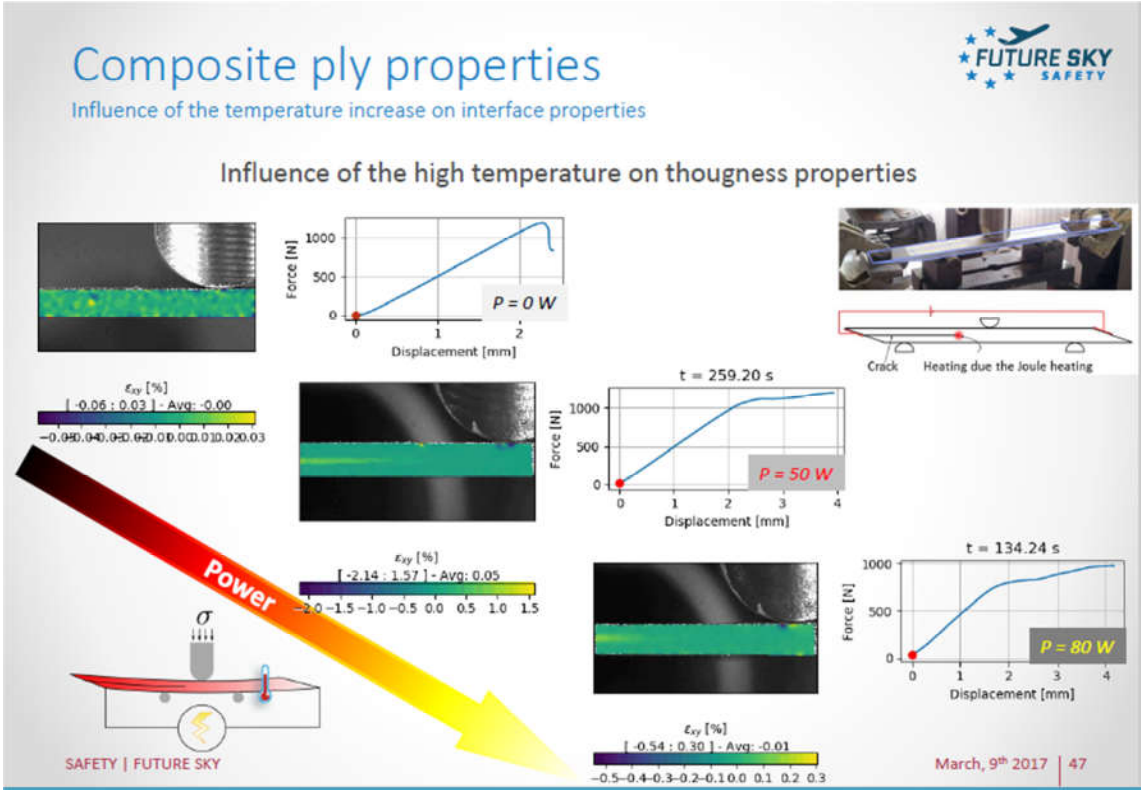


Composite ply properties

Influence of the temperature increase on interface properties

- Influence of the high temperature on thougness properties

- The thermal gradient stabilized the crack propagation
- The toughness decreases with the temperature



Composite ply properties

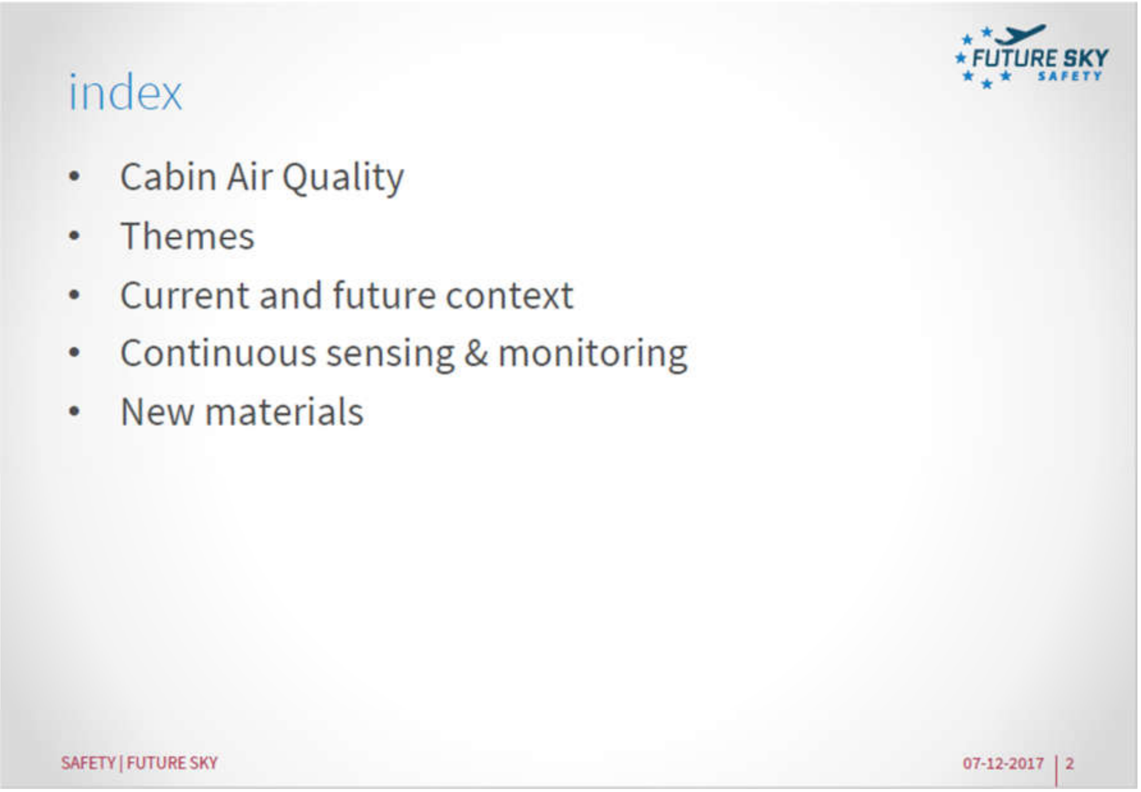
Influence of the temperature increase on interface properties

Influence of the high temperature on thougness properties

Appendix B.15 "P7: Cabin Air Quality – overview of issues and future directions" – Ricardo Reis, Embraer

Cabin Air Quality- overview of issues and future directions

WP 7.3 Industrial Framework
Ricardo Reis – Embraer Portugal



index

- Cabin Air Quality
- Themes
- Current and future context
- Continuous sensing & monitoring
- New materials

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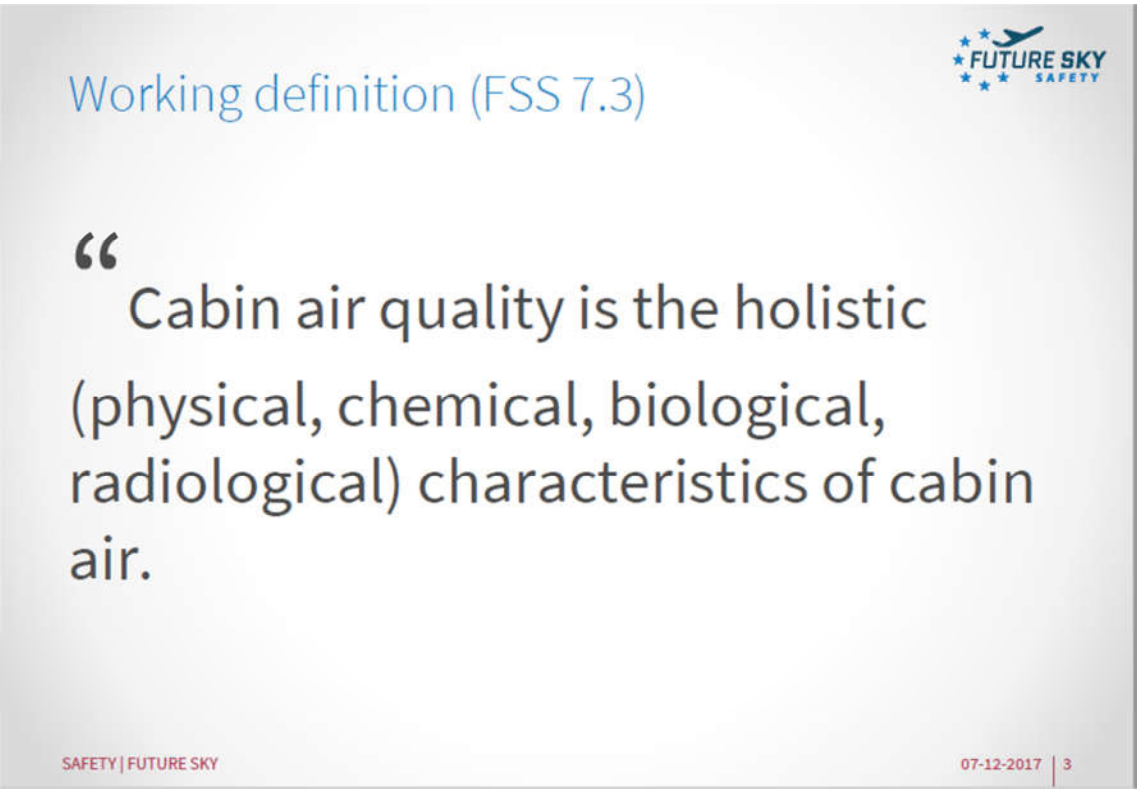

Working definition (FSS 7.3)

> “Cabin air quality is the holistic (physical, chemical, biological, radiological) characteristics of cabin air.

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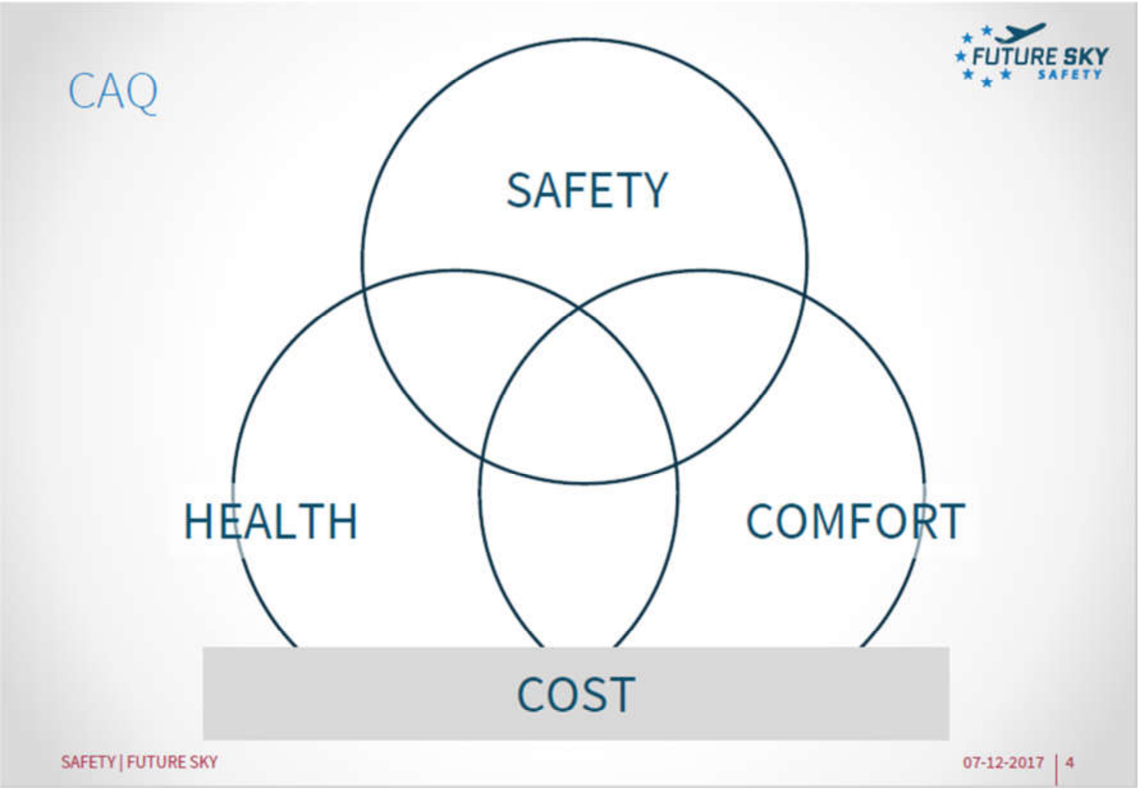

CAQ

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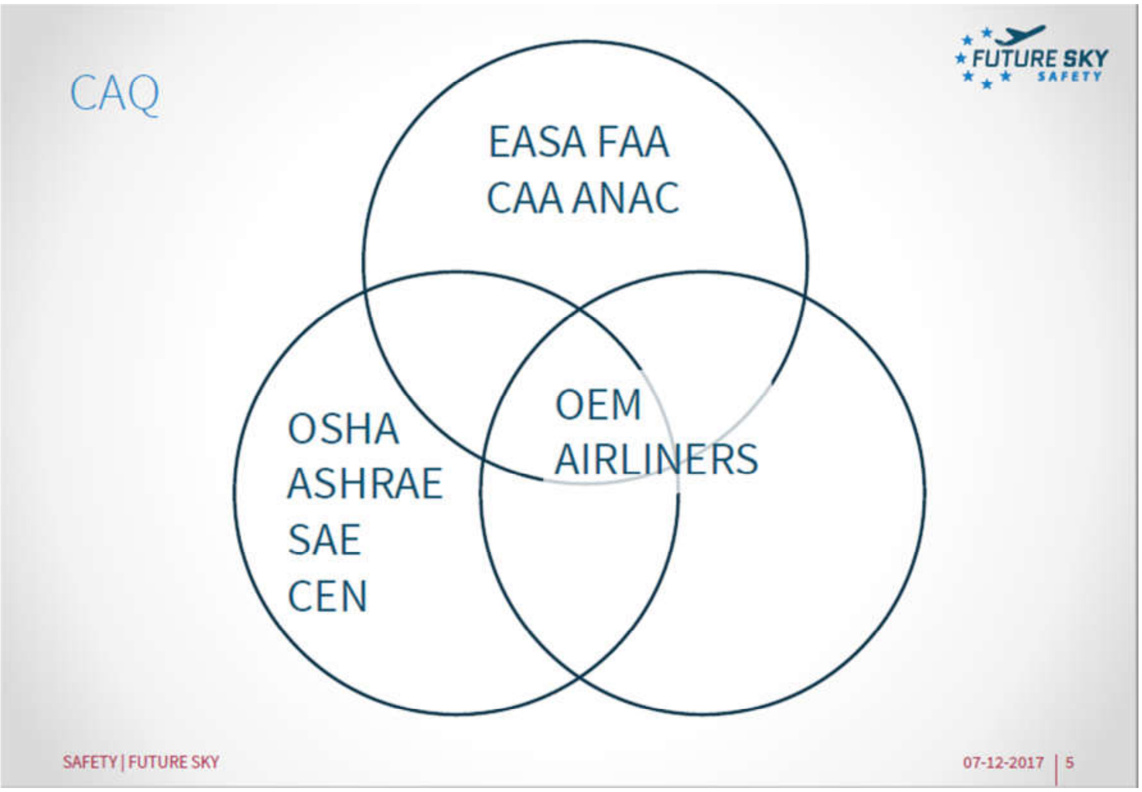
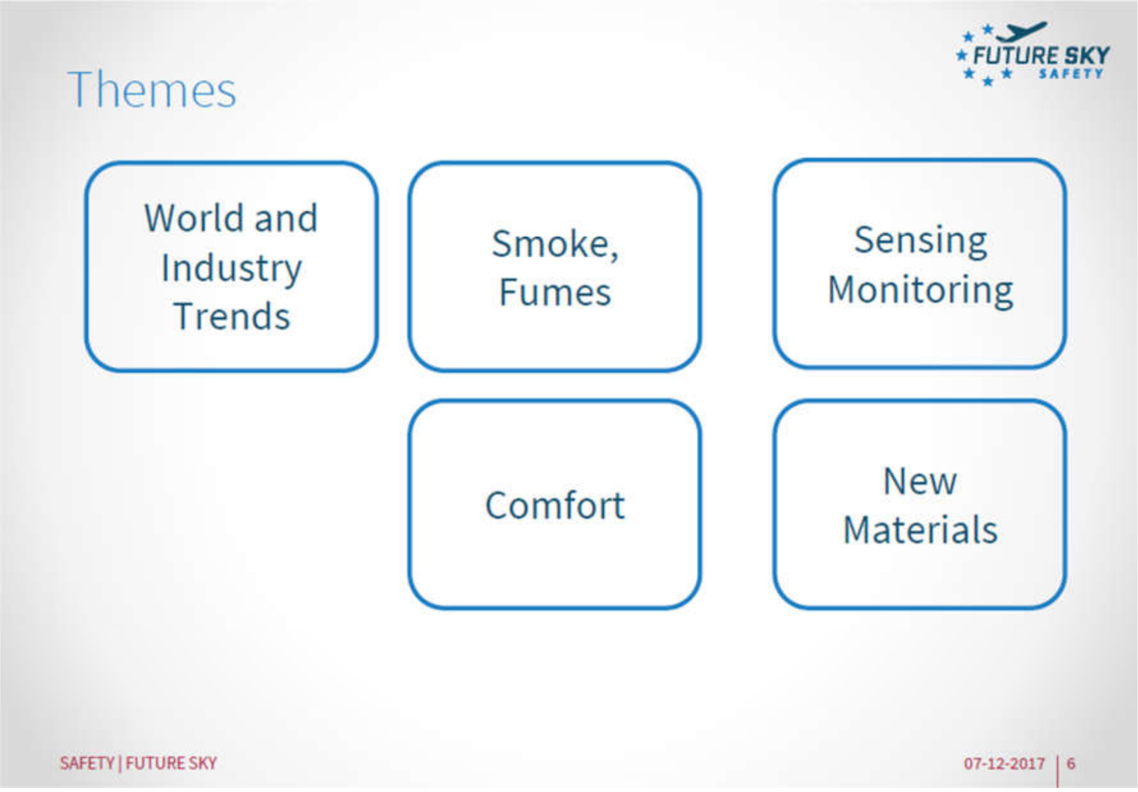


CAQ

EASA FAA
CAA ANAC

OSHA
ASHRAE
SAE
CEN

OEM
AIRLINERS



Themes

- World and Industry Trends
- Smoke, Fumes
- Sensing Monitoring
- Comfort
- New Materials

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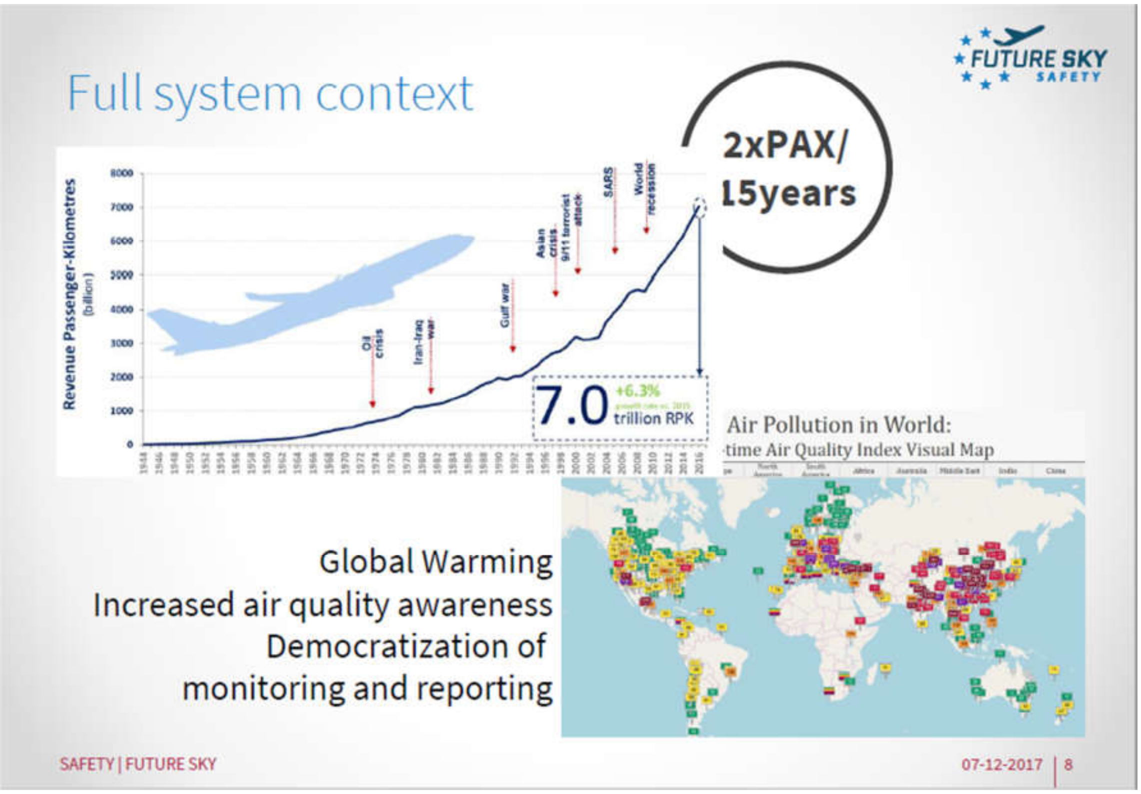

Full system context

2xPAX/
15years

Global Warming
Increased air quality awareness
Democratization of
monitoring and reporting

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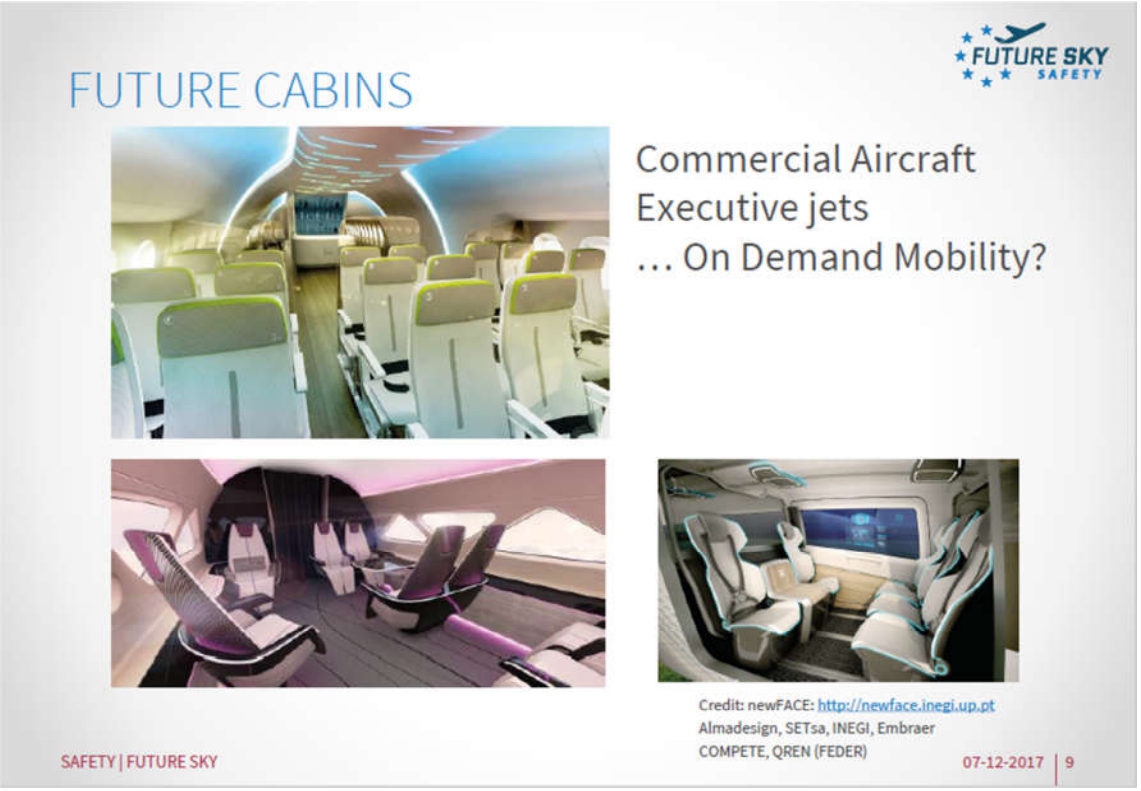

FUTURE CABINS

Commercial Aircraft
Executive jets
… On Demand Mobility?

Credit: newFACE: http://newface.inegi.up.pt
Almadesign, SETsa, INEGI, Embraer
COMPETE, QREN (FEDER)

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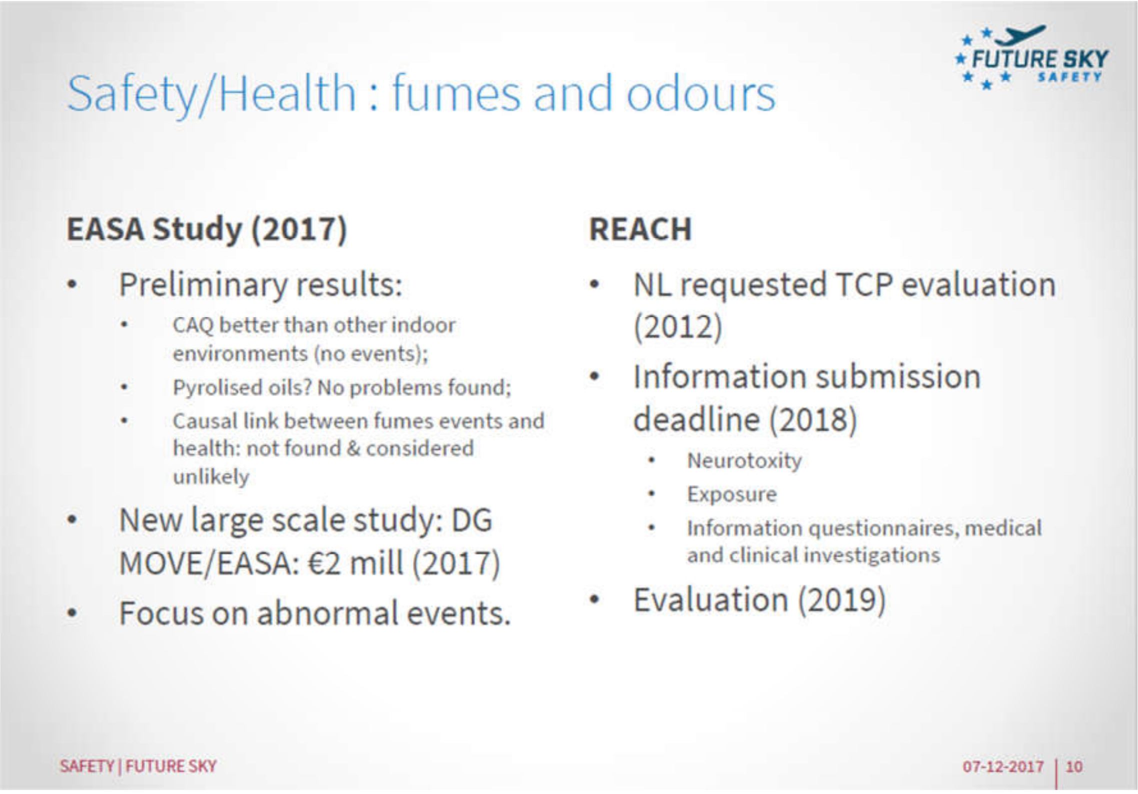

Safety/Health : fumes and odours

EASA Study (2017)

- Preliminary results:
  - CAQ better than other indoor environments (no events);
  - Pyrolised oils? No problems found;
  - Causal link between fumes events and health: not found & considered unlikely
- New large scale study: DG MOVE/EASA: €2 mill (2017)
- Focus on abnormal events.

REACH

- NL requested TCP evaluation (2012)
- Information submission deadline (2018)
  - Neurotoxity
  - Exposure
  - Information questionnaires, medical and clinical investigations
- Evaluation (2019)

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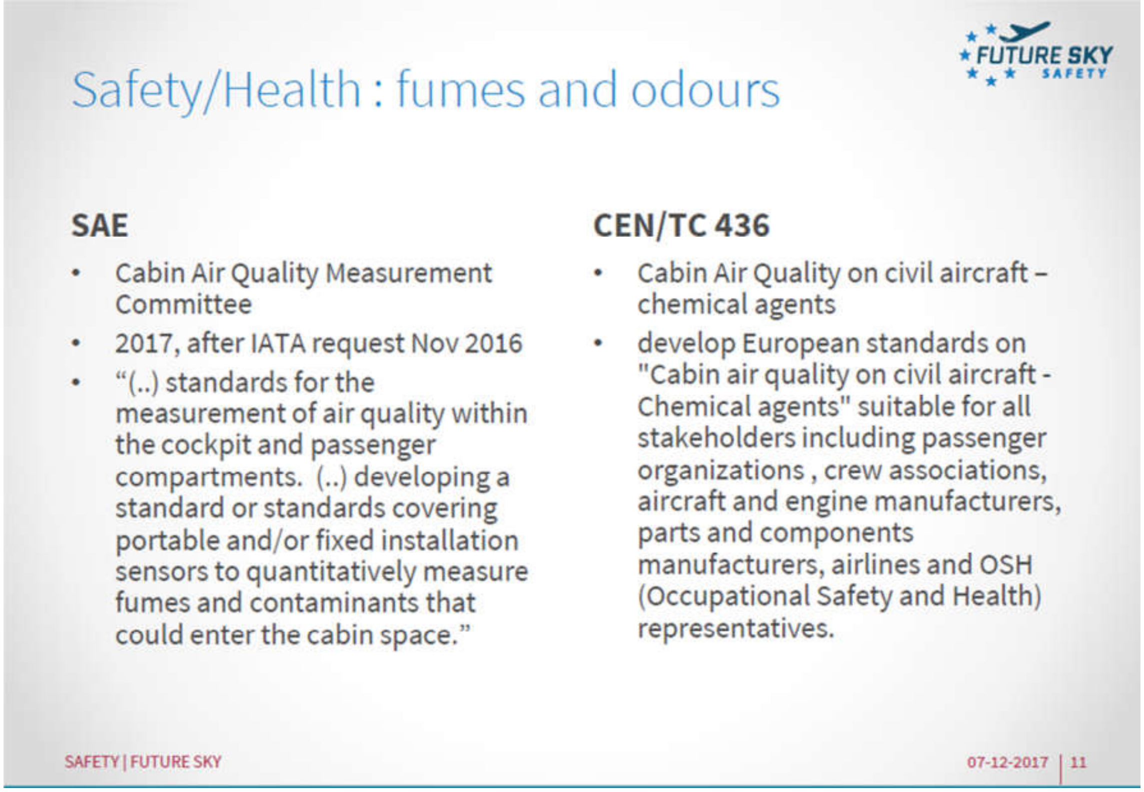

Safety/Health : fumes and odours

SAE

- Cabin Air Quality Measurement Committee
- 2017, after IATA request Nov 2016
- “(..) standards for the measurement of air quality within the cockpit and passenger compartments. (..) developing a standard or standards covering portable and/or fixed installation sensors to quantitatively measure fumes and contaminants that could enter the cabin space.”

CEN/TC 436

- Cabin Air Quality on civil aircraft – chemical agents
- develop European standards on "Cabin air quality on civil aircraft - Chemical agents" suitable for all stakeholders including passenger organizations , crew associations, aircraft and engine manufacturers, parts and components manufacturers, airlines and OSH (Occupational Safety and Health) representatives.

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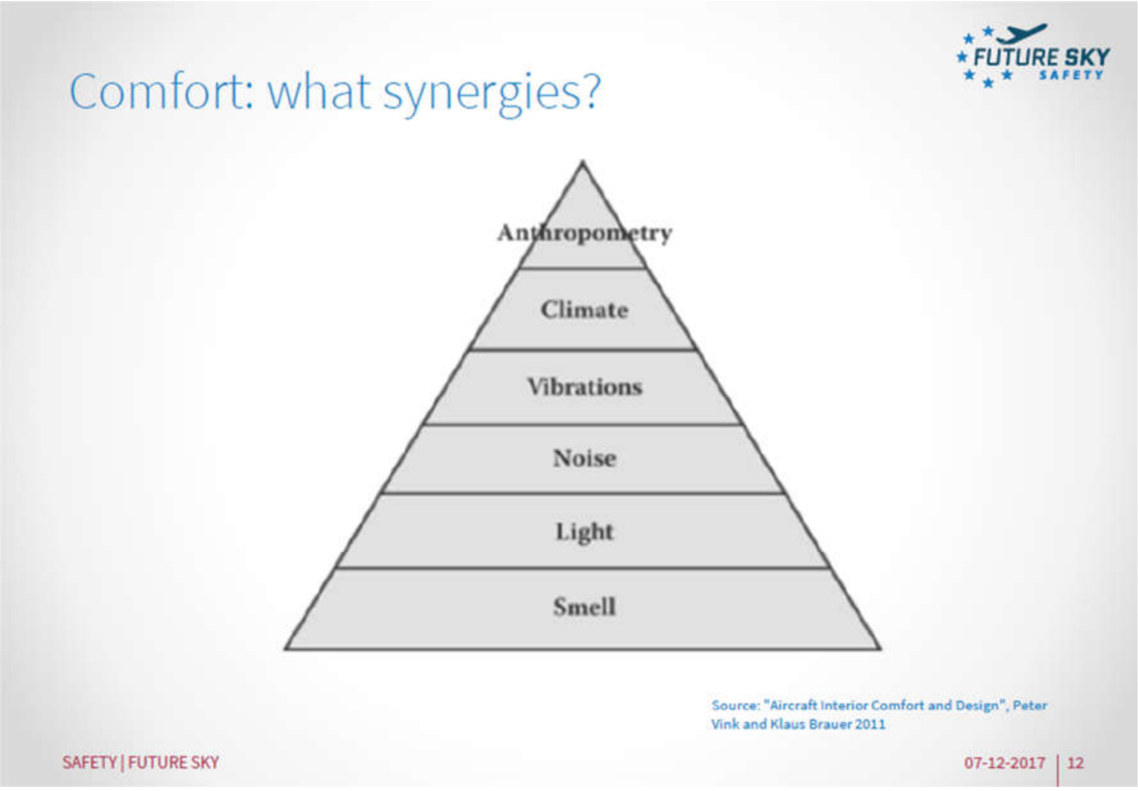

Comfort: what synergies?

Anthropometry
Climate
Vibrations
Noise
Light
Smell

Source: "Aircraft Interior Comfort and Design", Peter Vink and Klaus Brauer 2011

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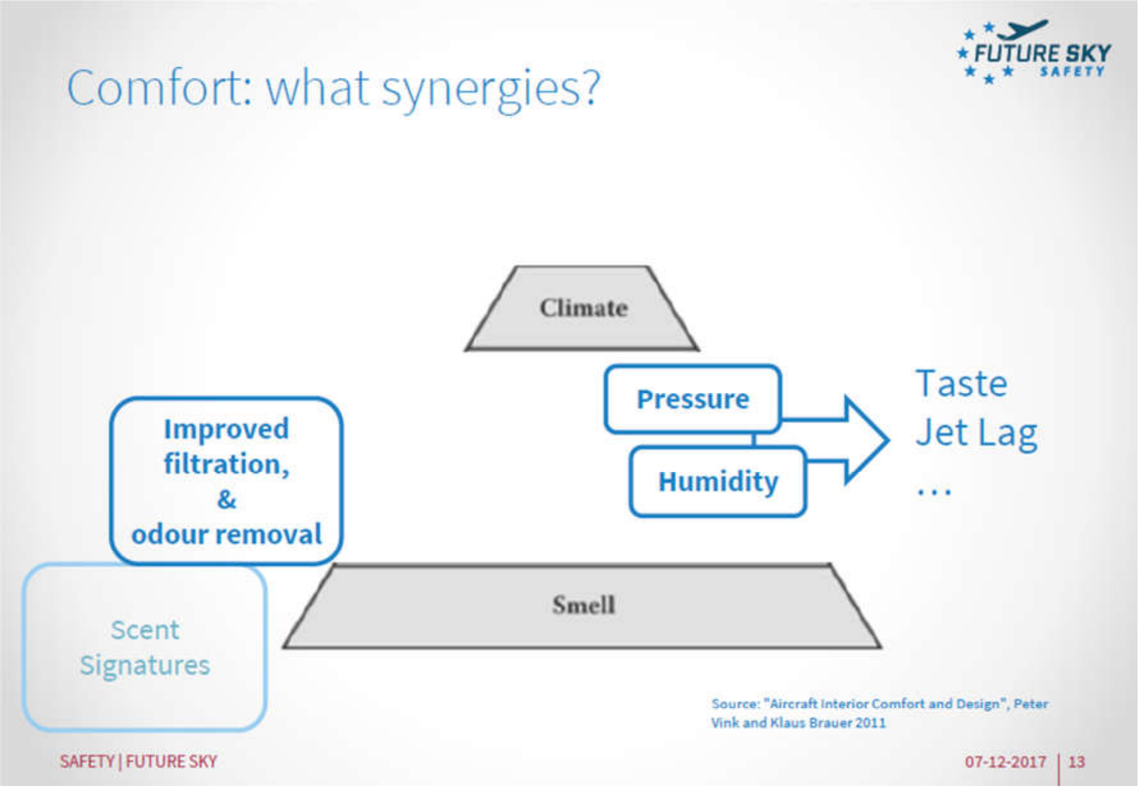

Comfort: what synergies?

Climate

Pressure

Humidity

Taste
Jet Lag
…

Improved filtration, & odour removal

Scent Signatures

Smell

Source: "Aircraft Interior Comfort and Design", Peter Vink and Klaus Brauer 2011

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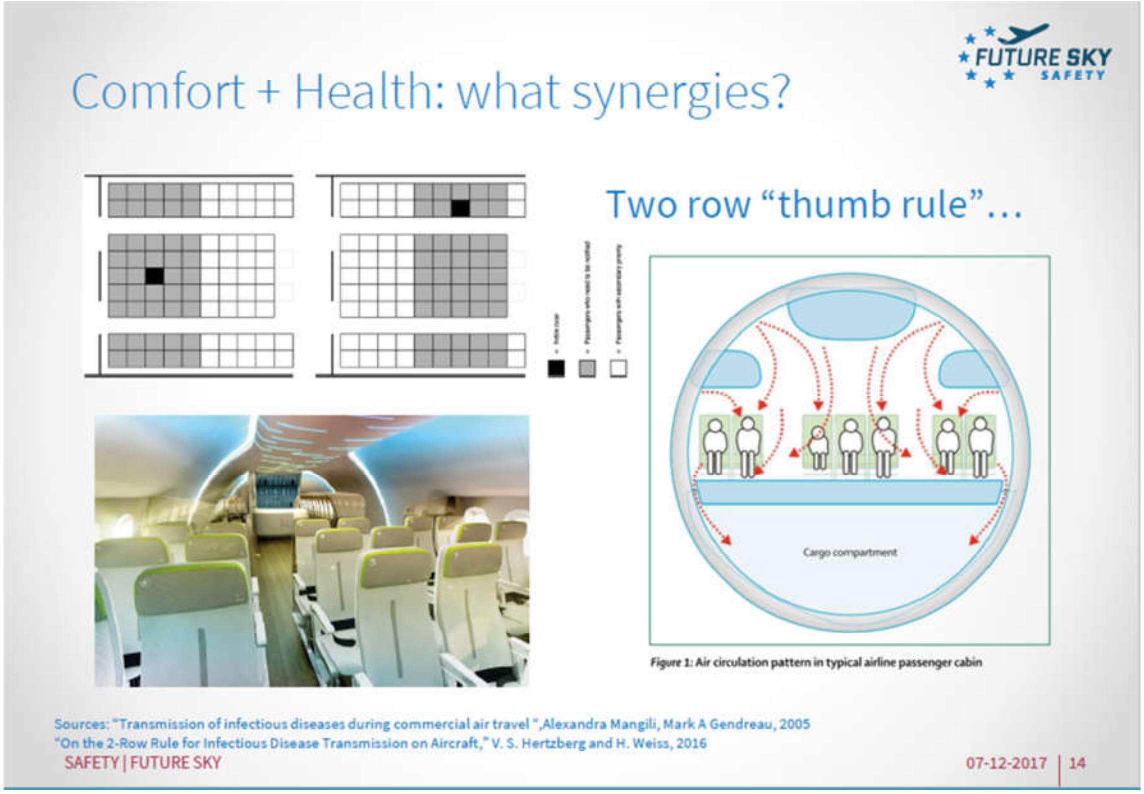

Comfort + Health: what synergies?

Two row "thumb rule"…

Figure 1: Air circulation pattern in typical airline passenger cabin

Sources: "Transmission of infectious diseases during commercial air travel ",Alexandra Mangili, Mark A Gendreau, 2005
"On the 2-Row Rule for Infectious Disease Transmission on Aircraft," V. S. Hertzberg and H. Weiss, 2016

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Benchmark : Automotive

- Change of perceptions: "new car smell"
- Defense against outside pollution: Tesla bio defense mode, Volvo CleanZone

Sources: Volvo

Sources: Tesla

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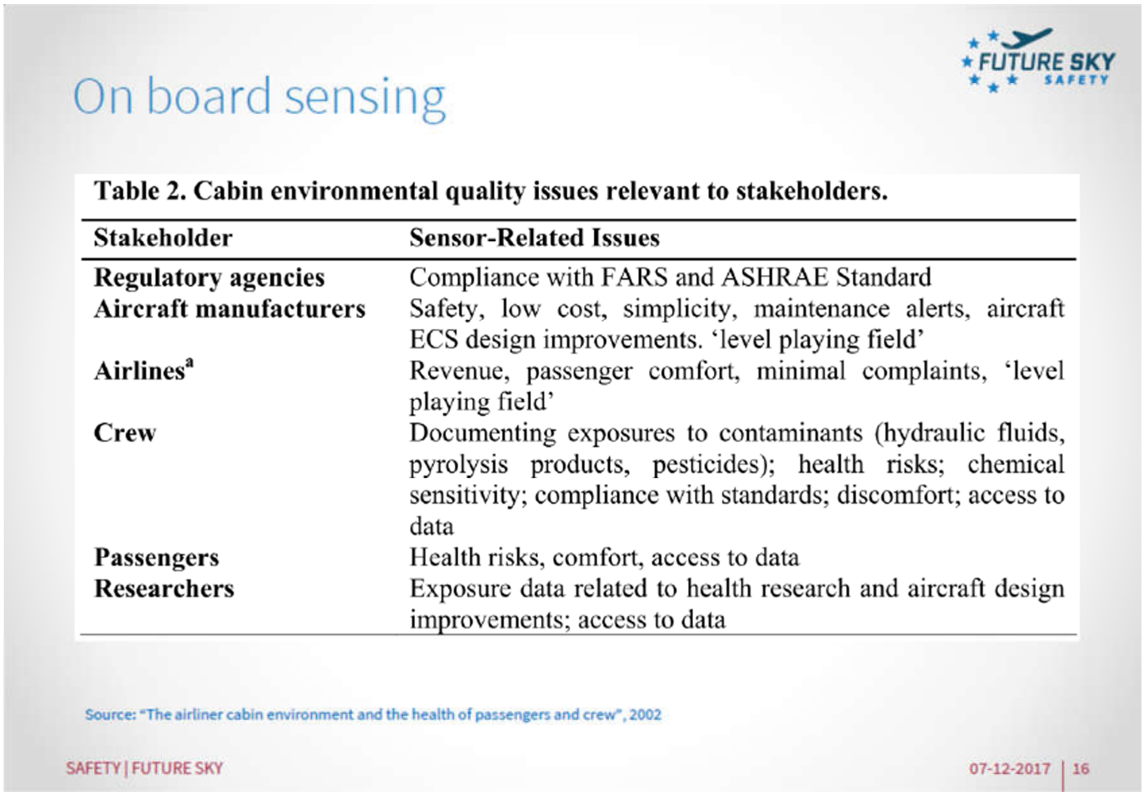

On board sensing

Table 2. Cabin environmental quality issues relevant to stakeholders.

Stakeholder	Sensor-Related Issues
Regulatory agencies	Compliance with FARS and ASHRAE Standard
Aircraft manufacturers	Safety, low cost, simplicity, maintenance alerts, aircraft ECS design improvements. 'level playing field'
Airlines[a]	Revenue, passenger comfort, minimal complaints, 'level playing field'
Crew	Documenting exposures to contaminants (hydraulic fluids, pyrolysis products, pesticides); health risks; chemical sensitivity; compliance with standards; discomfort; access to data
Passengers	Health risks, comfort, access to data
Researchers	Exposure data related to health research and aircraft design improvements; access to data

Source: "The airliner cabin environment and the health of passengers and crew", 2002

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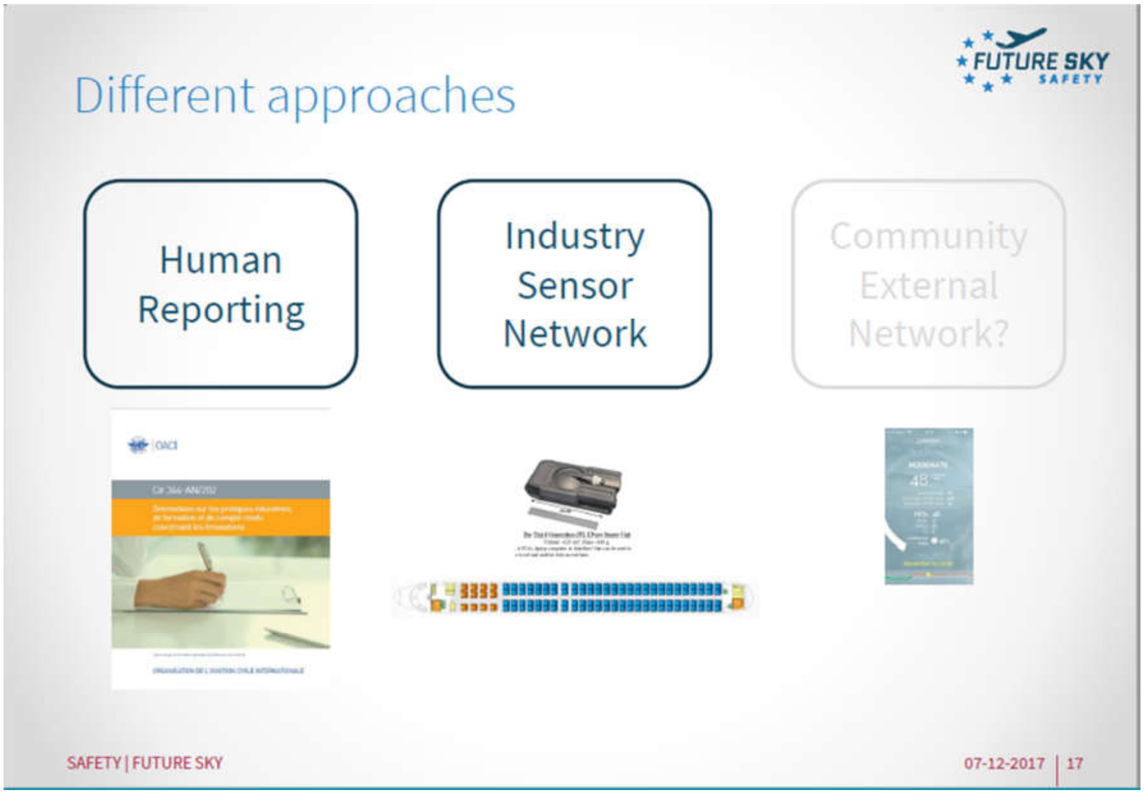

Different approaches

Human Reporting

Industry Sensor Network

Community External Network?

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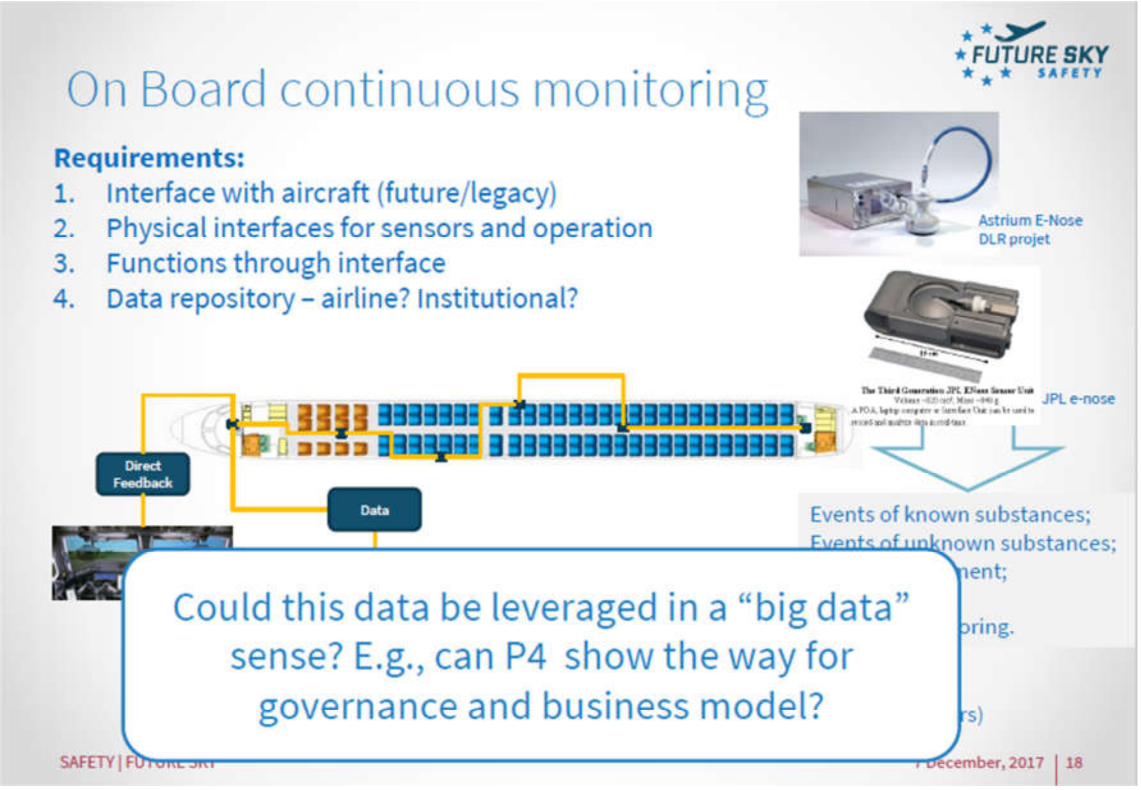

On Board continuous monitoring

Requirements:

1. Interface with aircraft (future/legacy)
2. Physical interfaces for sensors and operation
3. Functions through interface
4. Data repository – airline? Institutional?

Events of known substances;
Events of unknown substances;
nent;

pring.

rs)

Could this data be leveraged in a "big data" sense? E.g., can P4 show the way for governance and business model?

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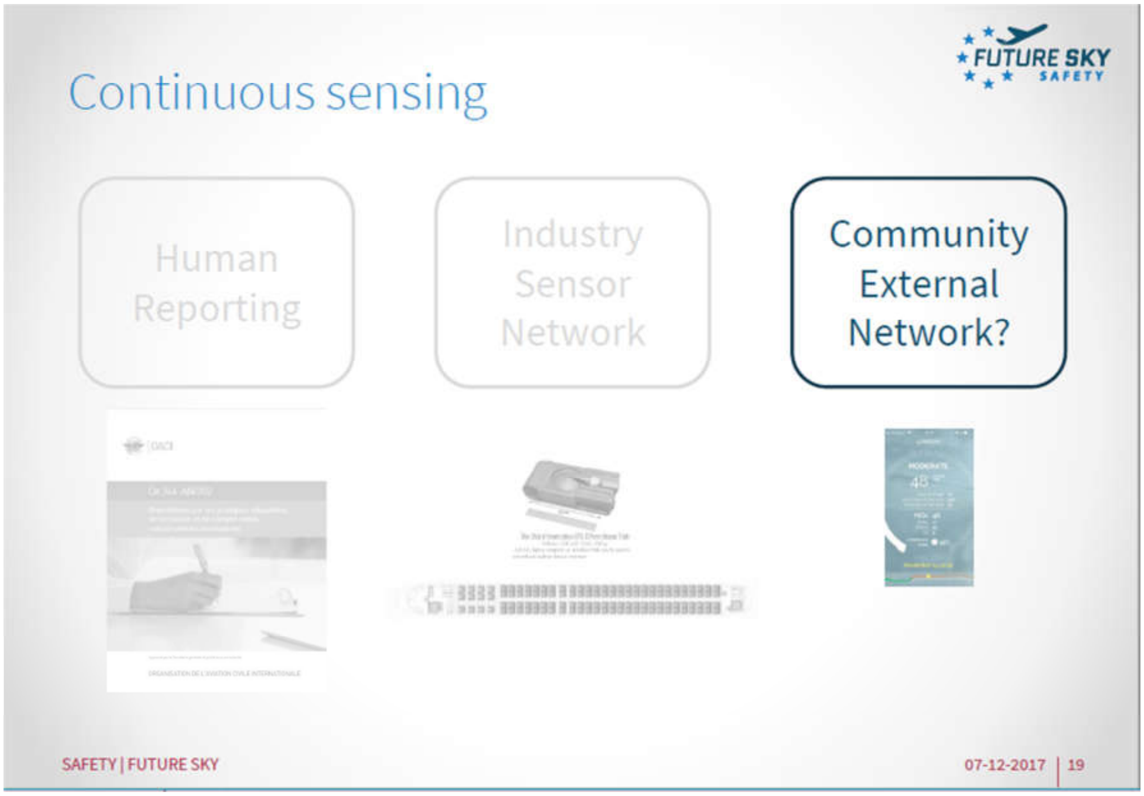

Continuous sensing

Human Reporting

Industry Sensor Network

Community External Network?

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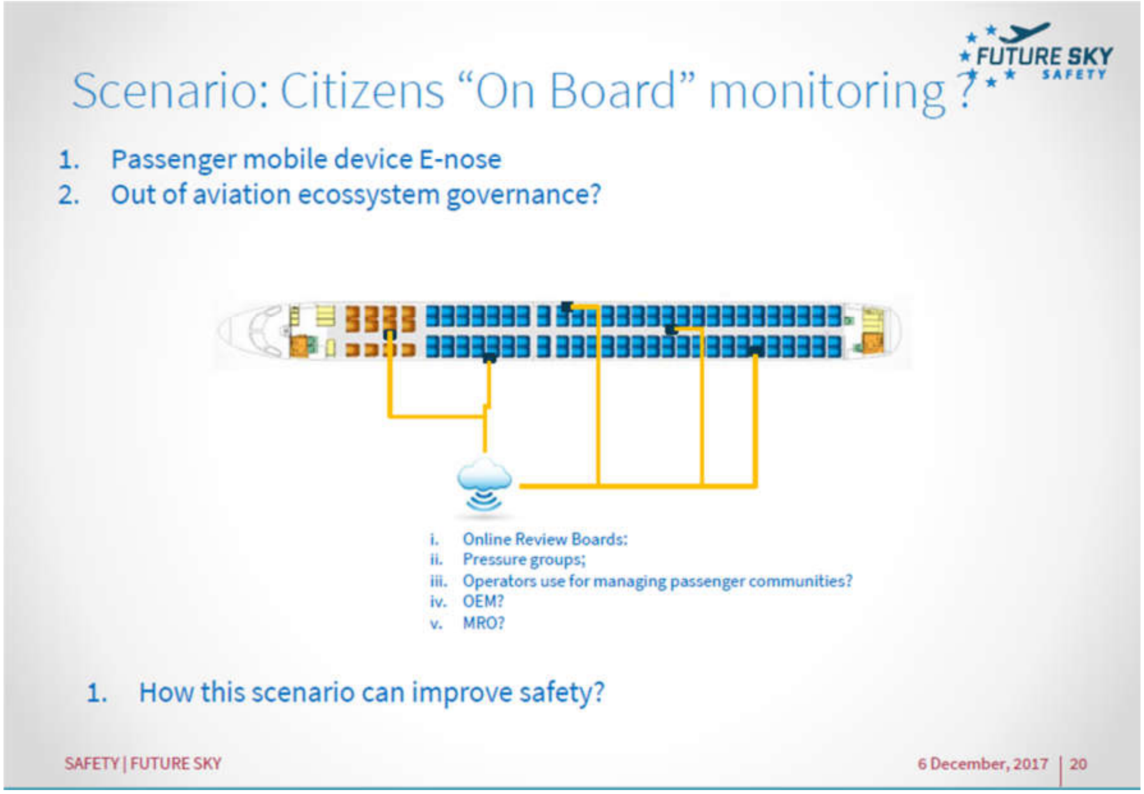

Scenario: Citizens "On Board" monitoring ?

1. Passenger mobile device E-nose
2. Out of aviation ecossystem governance?

i. Online Review Boards;
ii. Pressure groups;
iii. Operators use for managing passenger communities?
iv. OEM?
v. MRO?

1. How this scenario can improve safety?

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Benchmarking Citizens Labs

Rethorical question: How to incorporate with a "citizens lab" for indoor space air quality monitoring?

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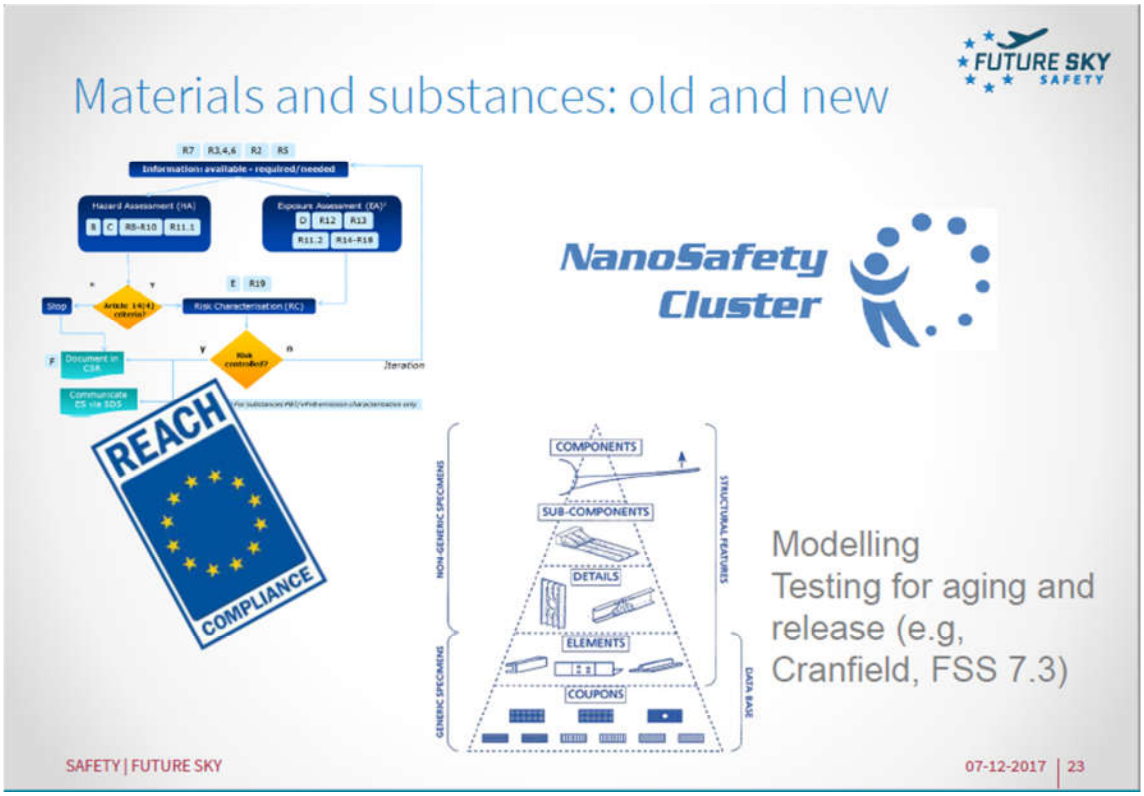
Materials and substances: old and new

APPLICATIONS

- Structural
- Isolation: thermal, acoustic
- Furnishing
- IFE

TYPES

- Composites;
- Nano materials;
- Metamaterials;
- Flexible electronics



Materials and substances: old and new

Modelling
Testing for aging and release (e.g, Cranfield, FSS 7.3)

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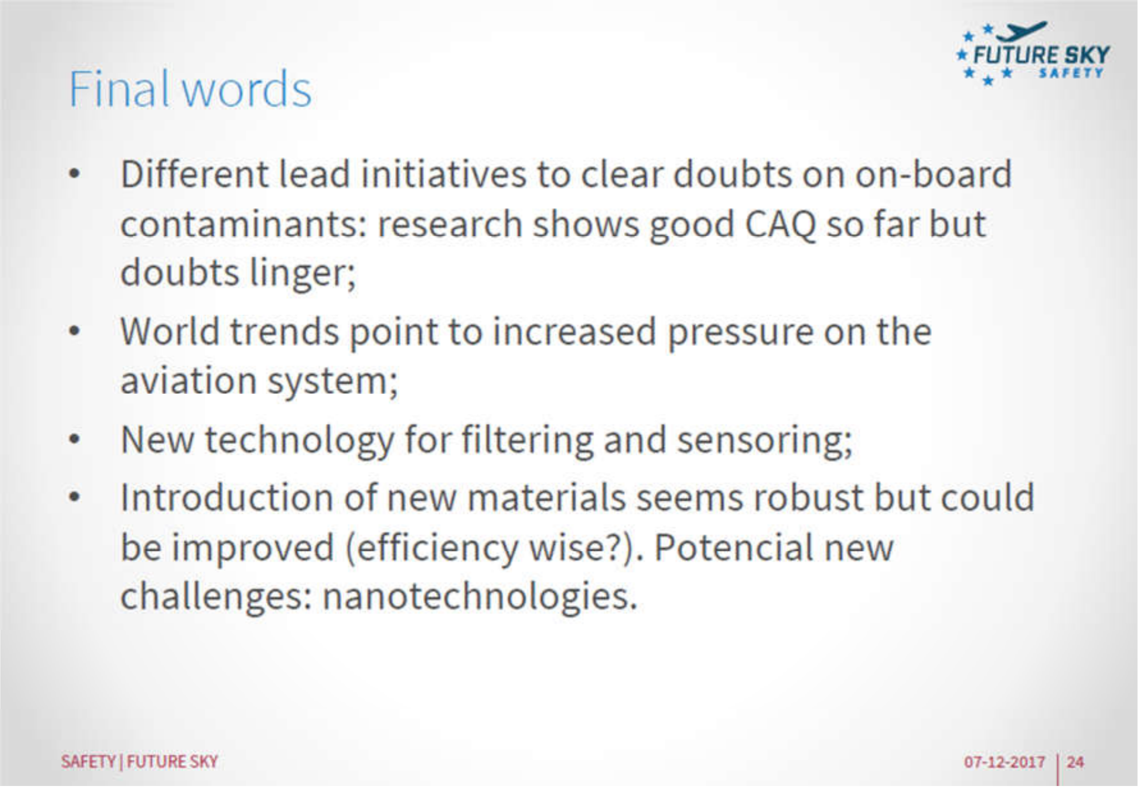

Final words

- Different lead initiatives to clear doubts on on-board contaminants: research shows good CAQ so far but doubts linger;
- World trends point to increased pressure on the aviation system;
- New technology for filtering and sensoring;
- Introduction of new materials seems robust but could be improved (efficiency wise?). Potencial new challenges: nanotechnologies.

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FUTURE SKY SAFETY

Consortium

Stichting Nationaal Lucht- en Ruimtevaartlaboratorium
Deutsches Zentrum für Luft- und Raumfahrt
Office national d'études et de recherches aérospatiales
Centro para a Excelência e Inovação na Indústria Automóvel
Centro Italiano Ricerche Aerospaziali
Centre Suisse d'Electronique et Microtechnique SA
Institutul National de Cercetari Aerospatiale "Elie Carafoli"
Instituto Nacional de Técnica Aeroespacial
Výzkumný a zkušební letecký ústav, a.s.
Totalförsvarets FOrskningsInstitut
European Organisation for the Safety of Air Navigation
Civil Aviation Authority UK
Airbus SAS
Airbus Operations SAS
Airbus Defence and Space
Thales Avionics SAS
Thales Air Systems SA
Deep Blue SRL
Technische Universität München
Deutsche Lufthansa Aktiengesellschaft
Service Technique de l'Aviation Civile
Embraer Portugal Estruturas em Compositos SA
Russian Central Aerohydrodynamic Institute TsAGI
Ente Nazionale di Assistenza al Volo Spa
Boeing Research and Technology Europe SLU
London School of Economics and Political Science
Alenia Aermacchi
Cranfield University
Trinity College Dublin
Zodiac Aerosafety Systems
Institut Polytechnique de Bordeaux
Koninklijke Luchtvaart Maatschappij
Sistemi Innovativi per il Controllo del Traffico Aereo

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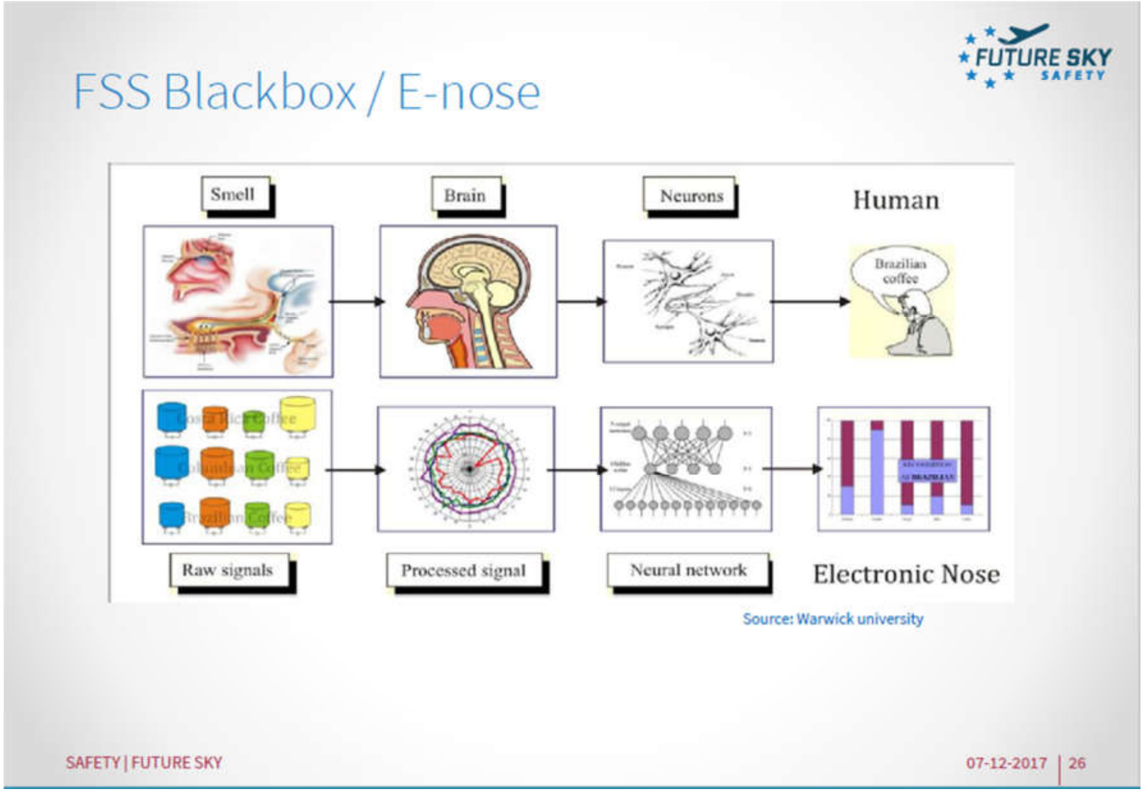
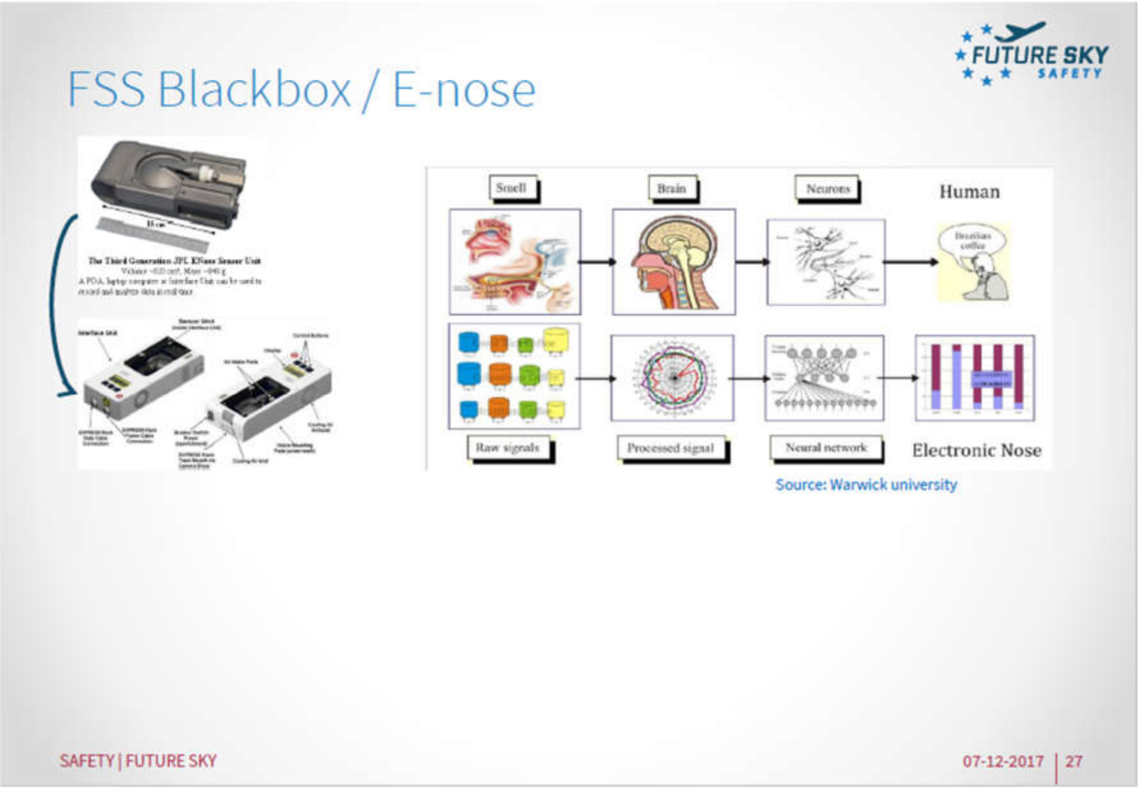


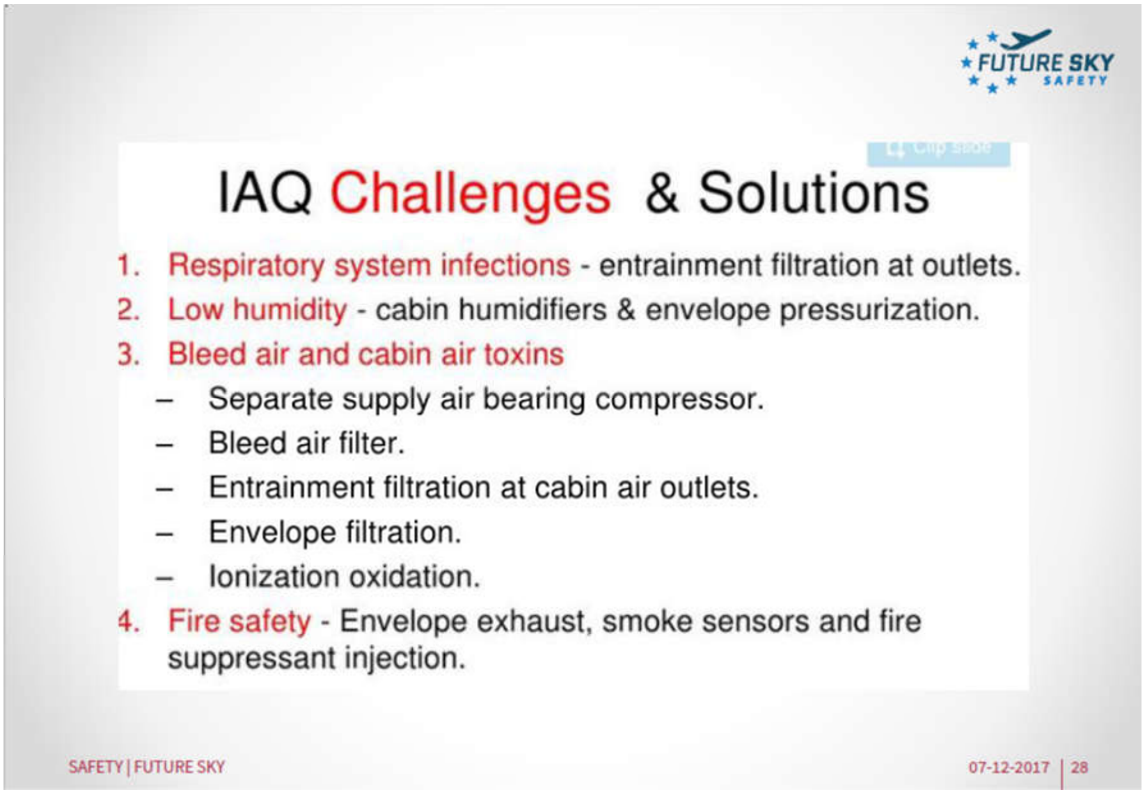
FSS Blackbox / E-nose

Source: Warwick university



FSS Blackbox / E-nose

Source: Warwick university



IAQ Challenges & Solutions

1. Respiratory system infections - entrainment filtration at outlets.
2. Low humidity - cabin humidifiers & envelope pressurization.
3. Bleed air and cabin air toxins
   - Separate supply air bearing compressor.
   - Bleed air filter.
   - Entrainment filtration at cabin air outlets.
   - Envelope filtration.
   - Ionization oxidation.
4. Fire safety - Envelope exhaust, smoke sensors and fire suppressant injection.

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Appendix C Posters

Appendix C.1 “P1: Coordination of Institutionally Funded Safety Research”

Project #1
COORDINATION OF INSTITUTIONALLY FUNDED SAFETY RESEARCH

COORDINATION OF INSTITUTIONALLY FUNDED SAFETY RESEARCH

The focus of P1 is to create a shared insight among the Research Establishments of the ongoing and planned safety research, in order to achieve coordination in the planning and conduct of new safety research projects and to create cooperative research projects in which multiple Research Establishments work together. This goal will be achieved by producing an annual Aviation Safety Research Plan for the participating institutions that will also be shared with the main European stakeholders. The coordination of institutionally funded safety research will be especially driven by this ASRP by identifying missing links and new institutionally funded safety research topics.

2015 and ongoing
- **DLR-ONERA**: HOTAS
- **DLR-ONERA**: ADAWI
- **DLR-NLR**: multiple works

2016
- **DLR-ONERA**: Modelling of operator's behaviour
- **DLR, NLR, ONERA, CIRA**: Aircraft Wake Turbulence
- **DLR-CSEM**: Human Performance Envelope in the ATC Context

2017
- **CEIIA, CIRA, DLR, ILOT, NLR, ONERA & VZLU**: Safety embedded in aircraft design and operations
- **CEIIA, CIRA, DLR, NLR & ONERA**: Helicopter safety
- **CIRA, CSEM, DLR, INCAS, INTA, ONERA & VZLU**: Icing
- **CIRA, DLR, INTA, NLR & ONERA**: Remotely Piloted Aircraft Systems (RPAS) safety (excl. ATM)

2018
- **CIRA, DLR, INCAS & ONERA**: Volcanic ash
- **CEIIA, CIRA, DLR, INTA, NLR & ONERA**: Remotely Piloted Aircraft Systems (RPAS) safety (excl. ATM)
- **CEIIA, CIRA, CSEM, DLR, INCAS, NLR, ONERA & VZLU**: Health monitoring

2019
- Small autonomous electric AC
- Advanced flight envelope protection
- Human Performance envelope
- Mitigating the risk of fire, smoke and fumes
- Remotely Piloted Aircraft Systems (RPAS) safety (excl. ATM)

Results:
- Coordination Workshops (75 scientists & 6 representatives from the European Commission participated)
- Communication Platform for EREA partners (with currently more than 140 publications)
- Personnel Exchanges
- Annual Aviation Safety Research Plans
  - Annual assessment of safety research projects in EREA establishments
  - Review of European Safety Roadmaps
  - EREA Programme Manager Survey
- Evaluation of leverage effect
- Generic Collaboration Agreement
- Cooperation activities include:
  - Rotorcraft landing on ships (CIRA, DLR, NLR & ONERA)
  - Human Performance Envelope in the ATC context (CSEM & DLR)
  - RPAS safety roadmap

Palaiseau 2nd Future Sky Safety Workshop; 01 – 02 February 2017

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

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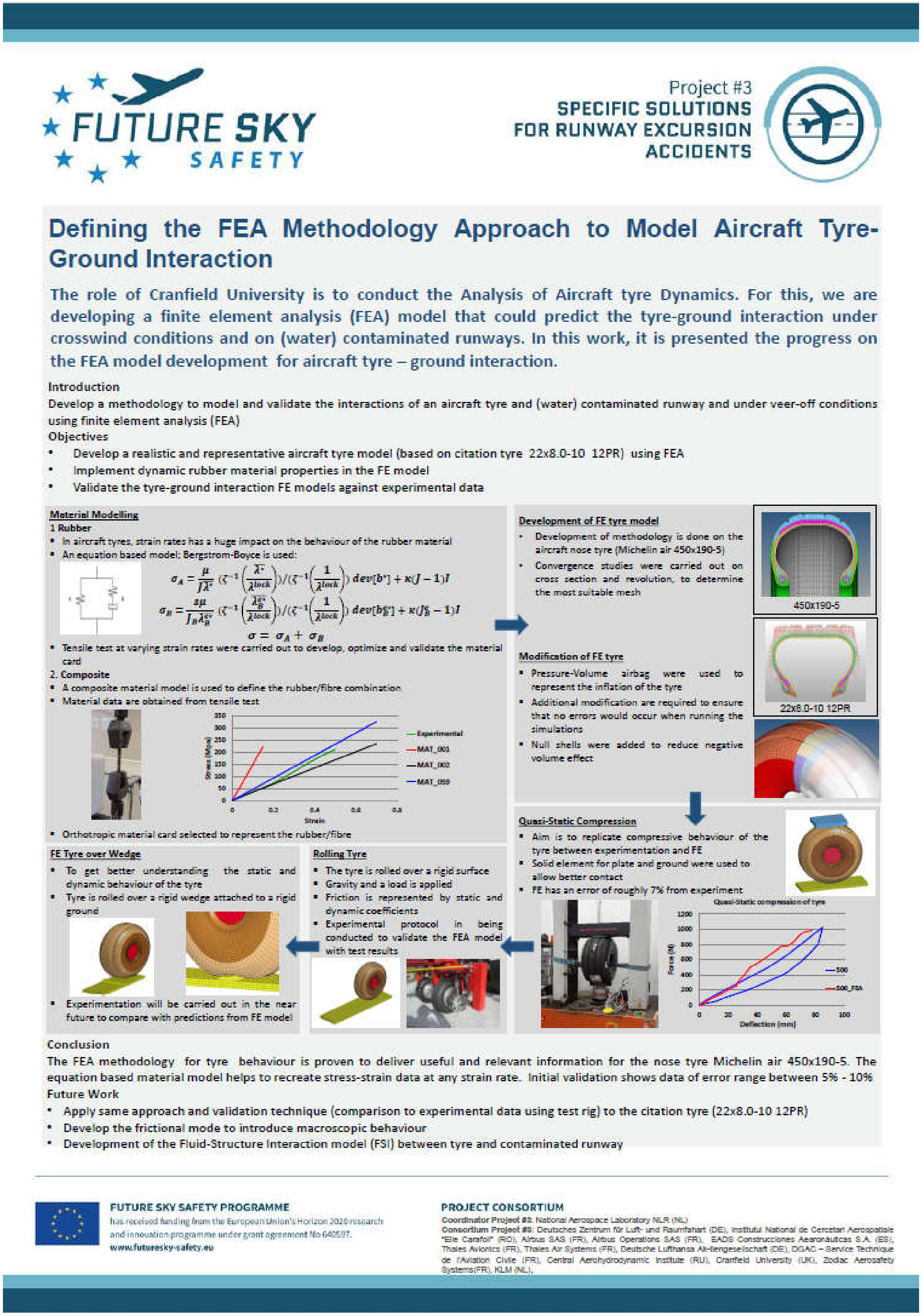
Appendix C.2 “P3: Solutions for runway excursions”



Project #3
SPECIFIC SOLUTIONS
FOR RUNWAY EXCURSION
ACCIDENTS

Defining the FEA Methodology Approach to Model Aircraft Tyre-Ground Interaction

The role of Cranfield University is to conduct the Analysis of Aircraft tyre Dynamics. For this, we are developing a finite element analysis (FEA) model that could predict the tyre-ground interaction under crosswind conditions and on (water) contaminated runways. In this work, it is presented the progress on the FEA model development for aircraft tyre – ground interaction.

Introduction

Develop a methodology to model and validate the interactions of an aircraft tyre and (water) contaminated runway and under veer-off conditions using finite element analysis (FEA)

Objectives

- Develop a realistic and representative aircraft tyre model (based on citation tyre 22x8.0-10 12PR) using FEA
- Implement dynamic rubber material properties in the FE model
- Validate the tyre-ground interaction FE models against experimental data

Material Modelling

1 Rubber

- In aircraft tyres, strain rates has a huge impact on the behaviour of the rubber material
- An equation based model; Bergstrom-Boyce is used:

$$\sigma_A = \frac{\mu}{J\bar{\lambda}^*}\,(\zeta^{-1}\left(\frac{\bar{\lambda}^*}{\lambda^{lock}}\right))/(\zeta^{-1}\left(\frac{1}{\lambda^{lock}}\right))\,dev[b^*] + \kappa(J-1)I$$

$$\sigma_B = \frac{s\mu}{J_B\bar{\lambda}_B^{e*}}\,(\zeta^{-1}\left(\frac{\bar{\lambda}_B^{e*}}{\lambda^{lock}}\right))/(\zeta^{-1}\left(\frac{1}{\lambda^{lock}}\right))\,dev[b_B^{e*}] + \kappa(J_B^e-1)I$$

$$\sigma = \sigma_A + \sigma_B$$

- Tensile test at varying strain rates were carried out to develop, optimize and validate the material card

2. Composite

- A composite material model is used to define the rubber/fibre combination
- Material data are obtained from tensile test
- Orthotropic material card selected to represent the rubber/fibre

Development of FE tyre model

- Development of methodology is done on the aircraft nose tyre (Michelin air 450x190-5)
- Convergence studies were carried out on cross section and revolution, to determine the most suitable mesh

Modification of FE tyre

- Pressure-Volume airbag were used to represent the inflation of the tyre
- Additional modification are required to ensure that no errors would occur when running the simulations
- Null shells were added to reduce negative volume effect

Quasi-Static Compression

- Aim is to replicate compressive behaviour of the tyre between experimentation and FE
- Solid element for plate and ground were used to allow better contact
- FE has an error of roughly 7% from experiment

Rolling Tyre

- The tyre is rolled over a rigid surface
- Gravity and a load is applied
- Friction is represented by static and dynamic coefficients
- Experimental protocol in being conducted to validate the FEA model with test results

FE Tyre over Wedge

- To get better understanding the static and dynamic behaviour of the tyre
- Tyre is rolled over a rigid wedge attached to a rigid ground
- Experimentation will be carried out in the near future to compare with predictions from FE model

Conclusion

The FEA methodology for tyre behaviour is proven to deliver useful and relevant information for the nose tyre Michelin air 450x190-5. The equation based material model helps to recreate stress-strain data at any strain rate. Initial validation shows data of error range between 5% - 10%

Future Work

- Apply same approach and validation technique (comparison to experimental data using test rig) to the citation tyre (22x8.0-10 12PR)
- Develop the frictional mode to introduce macroscopic behaviour
- Development of the Fluid-Structure Interaction model (FSI) between tyre and contaminated runway

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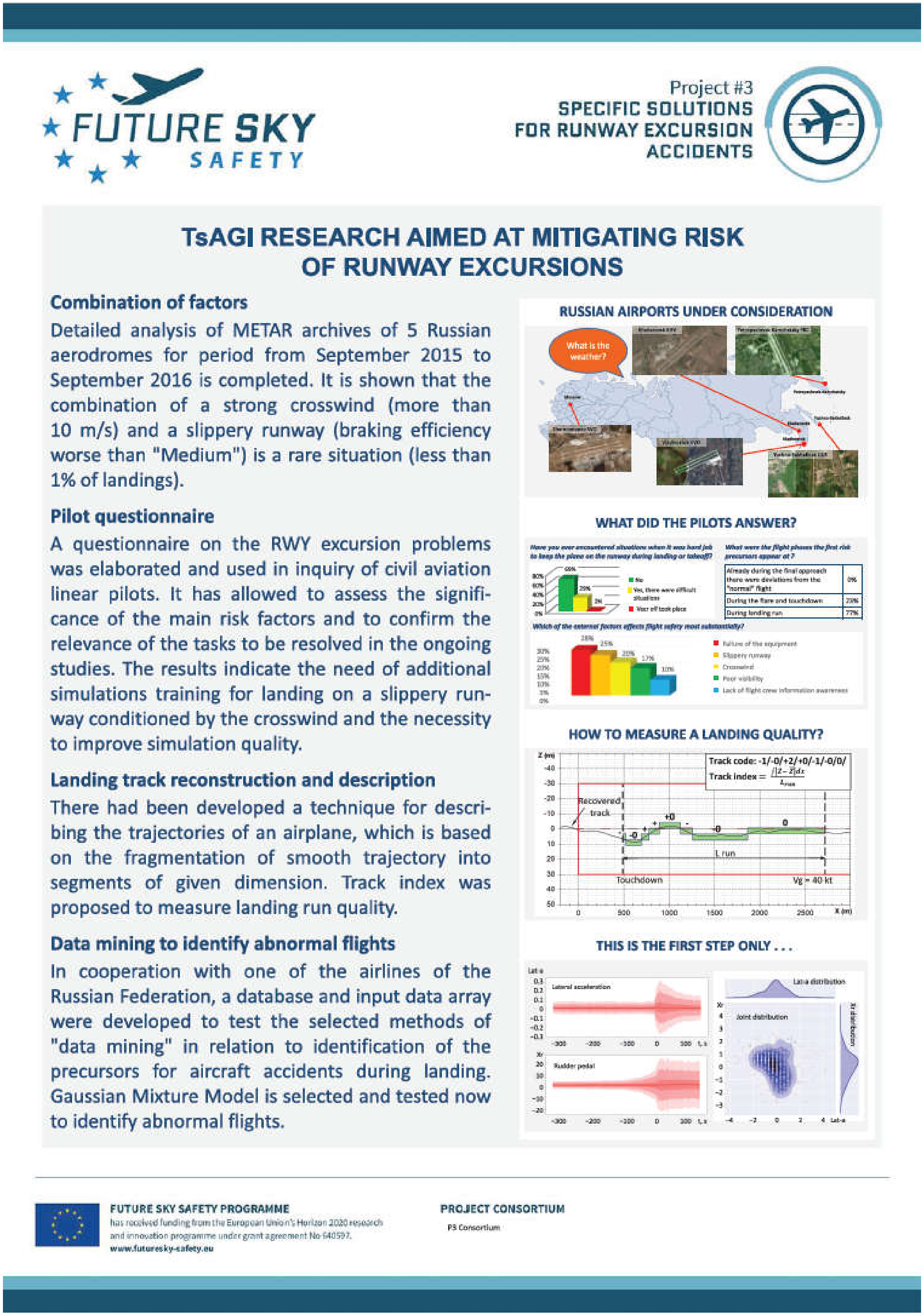
PROJECT CONSORTIUM
Coordinator Project #3: National Aerospace Laboratory NLR (NL)
Consortium Project #3: Deutsches Zentrum für Luft- und Raumfahrt (DE), Institutul National de Cercetari Aerospatiale "Elie Carafoli" (RO), Airbus SAS (FR), Airbus Operations SAS (FR), EADS Construcciones Aeronáuticas S.A. (ES), Thales Avionics (FR), Thales Air Systems (FR), Deutsche Lufthansa Ak-tiengesellschaft (DE), DGAC – Service Technique de l'Aviation Civile (FR), Central Aerohydrodynamic Institute (RU), Cranfield University (UK), Zodiac Aerosafety Systems(FR), KLM (NL),



Project #3
SPECIFIC SOLUTIONS FOR RUNWAY EXCURSION ACCIDENTS

TsAGI RESEARCH AIMED AT MITIGATING RISK OF RUNWAY EXCURSIONS

Combination of factors

Detailed analysis of METAR archives of 5 Russian aerodromes for period from September 2015 to September 2016 is completed. It is shown that the combination of a strong crosswind (more than 10 m/s) and a slippery runway (braking efficiency worse than "Medium") is a rare situation (less than 1% of landings).

Pilot questionnaire

A questionnaire on the RWY excursion problems was elaborated and used in inquiry of civil aviation linear pilots. It has allowed to assess the significance of the main risk factors and to confirm the relevance of the tasks to be resolved in the ongoing studies. The results indicate the need of additional simulations training for landing on a slippery runway conditioned by the crosswind and the necessity to improve simulation quality.

Landing track reconstruction and description

There had been developed a technique for describing the trajectories of an airplane, which is based on the fragmentation of smooth trajectory into segments of given dimension. Track index was proposed to measure landing run quality.

Data mining to identify abnormal flights

In cooperation with one of the airlines of the Russian Federation, a database and input data array were developed to test the selected methods of "data mining" in relation to identification of the precursors for aircraft accidents during landing. Gaussian Mixture Model is selected and tested now to identify abnormal flights.

RUSSIAN AIRPORTS UNDER CONSIDERATION

WHAT DID THE PILOTS ANSWER?

Have you ever encountered situations when it was hard job to keep the plane on the runway during landing or takeoff?

What were the flight phases the first risk precursors appear at ?

Already during the final approach there were deviations from the "normal" flight	0%
During the flare and touchdown	23%
During landing run	77%

Which of the external factors effects flight safety most substantially?

HOW TO MEASURE A LANDING QUALITY?

Track code: -1/-0/+2/+0/-1/-0/0/

$$\text{Track index} = \frac{\int |Z-\bar{Z}|\,dx}{L_{run}}$$

THIS IS THE FIRST STEP ONLY . . .

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PROJECT CONSORTIUM
P3 Consortium

Project #3
SPECIFIC SOLUTIONS
FOR RUNWAY EXCURSION
ACCIDENTS

WP 3.1 Crosswind and slippery runways

Task 3.1.4 Models and analysis for dynamic interaction between aircraft/pilot and ground

D 3.16 : Global simulation of a short time A/C trajectory on ground using multiphysics approch

Authors: Stefan BOGOS, Florentin Sperlea, Adrian TOADER, Gabriel COJOCARU, Alina CHIRA- National Institute for Aerospace Research (INCAS), ROMANIA

1. *The Research Objectives* is related to a proper dynamic A/C control model that simulate landing ground roll operation, in critical conditions of veer off on slippery runways and crosswind, fig. 1. These Objectives will imply:

- *Evaluation of the A/C dynamics and trajectory in veer-off conditions.*
- *A study about the effect of* ***Thrust Reverse engine jet Control*** *(TRC) to mitigate the lateral deviation and to stabilize A/C on the runway.*

2. A confident aerodynamic CFD simulation, at large sideslip angles, gives the aerodynamic coefficients and the pressure distribution, for a generic aircraft configuration, fig. 2.

3. *Fixed Thrust Reverser Effect* in crosswind on slippery runways is presented in fig. 3. When selecting reverse thrust with some crab angle, the reverse thrust results in two force components: a stopping force aligned with aircraft's direction of travel (runway centerline) and a side force, perpendicular to the runway centerline, *which further increases the aircraft's tendency to skid sideways.*

4. *Mobile Thrust Reverse Vector Control.* The main idea of the Thrust Reverse Control (TRC) is to correct the skidding on the runway, in the slippery extreme condition of total slip, by creating a lateral force, Y_{T1} and Y_{T2}, using a controlled deflection of the thruster reverser fences angle, δ_{TRC} and to control the permanent effect of rotation around the center of gravity, fig 4. This side force is opposite with crosswind direction and *decreases the aircraft's tendency to skid sideways.*


Fixed Thrust Reverse, fig 4
Mobile Thrust Reverse control, fig. 4

5. *The Mechanics equations, in matrix form,* for the specific forces and moments related to the A/C dynamics in ground roll , fig. 5, are written for the impulse theorem and the angular momentum theorem in the following forms:

- *the impulse theorem:*

$$\begin{bmatrix} M & 0 & 0 \\ 0 & M & 0 \\ 0 & 0 & M \end{bmatrix}\begin{bmatrix} a_{0x} \\ a_{0y} \\ a_{0z} \end{bmatrix}+\begin{bmatrix} 0 & M\zeta & M\eta \\ -M\zeta & 0 & M\xi \\ -M\eta & -M\xi & 0 \end{bmatrix}\begin{bmatrix} \varepsilon_x \\ \varepsilon_y \\ \varepsilon_z \end{bmatrix}+\begin{bmatrix} 0 & -\omega_z & \omega_y \\ \omega_z & 0 & -\omega_x \\ -\omega_y & \omega_x & 0 \end{bmatrix}\begin{bmatrix} 0 & M\zeta & M\eta \\ -M\zeta & 0 & M\xi \\ -M\eta & -M\xi & 0 \end{bmatrix}\begin{bmatrix} \omega_x \\ \omega_y \\ \omega_z \end{bmatrix}=\begin{bmatrix} \sum R_x \\ \sum R_y \\ \sum R_z \end{bmatrix}$$

- *the angular momentum theorem:*

$$\begin{bmatrix} 0 & -M\zeta & M\eta \\ M\zeta & 0 & -M\xi \\ -M\eta & M\xi & 0 \end{bmatrix}\begin{bmatrix} a_{0x} \\ a_{0y} \\ a_{0z} \end{bmatrix}+\begin{bmatrix} J_x & -J_{xy} & -J_{xz} \\ -J_{yx} & J_y & -J_{yz} \\ -J_{zx} & -J_{zy} & J_z \end{bmatrix}\begin{bmatrix} \varepsilon_x \\ \varepsilon_y \\ \varepsilon_z \end{bmatrix}+\begin{bmatrix} 0 & -\omega_z & \omega_y \\ \omega_z & 0 & -\omega_x \\ -\omega_y & \omega_x & 0 \end{bmatrix}\begin{bmatrix} J_x & -J_{xy} & -J_{xz} \\ -J_{yx} & J_y & -J_{yz} \\ -J_{zx} & -J_{zy} & J_z \end{bmatrix}\begin{bmatrix} \omega_x \\ \omega_y \\ \omega_z \end{bmatrix}=\begin{bmatrix} \sum M_x \\ \sum M_y \\ \sum M_z \end{bmatrix}$$


As the nose landing gear touches the ground, the plane then veers off to the right

Fig. 1 Veer of in crosswind at Landing

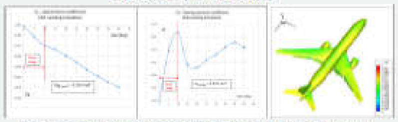
Fig. 2 Non linear aerodynamic coefficients at large sideslip angles, CFD simulation

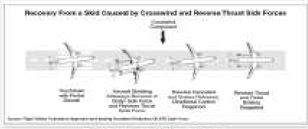

Fig. 3 Fixed Thrust Reverse Effect

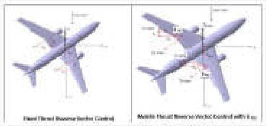

Fig. 4 Mobile Thrust Reverse Vector Control

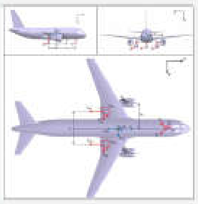
Fig. 5 Forces and Moments for A/C in Ground roll in crosswind

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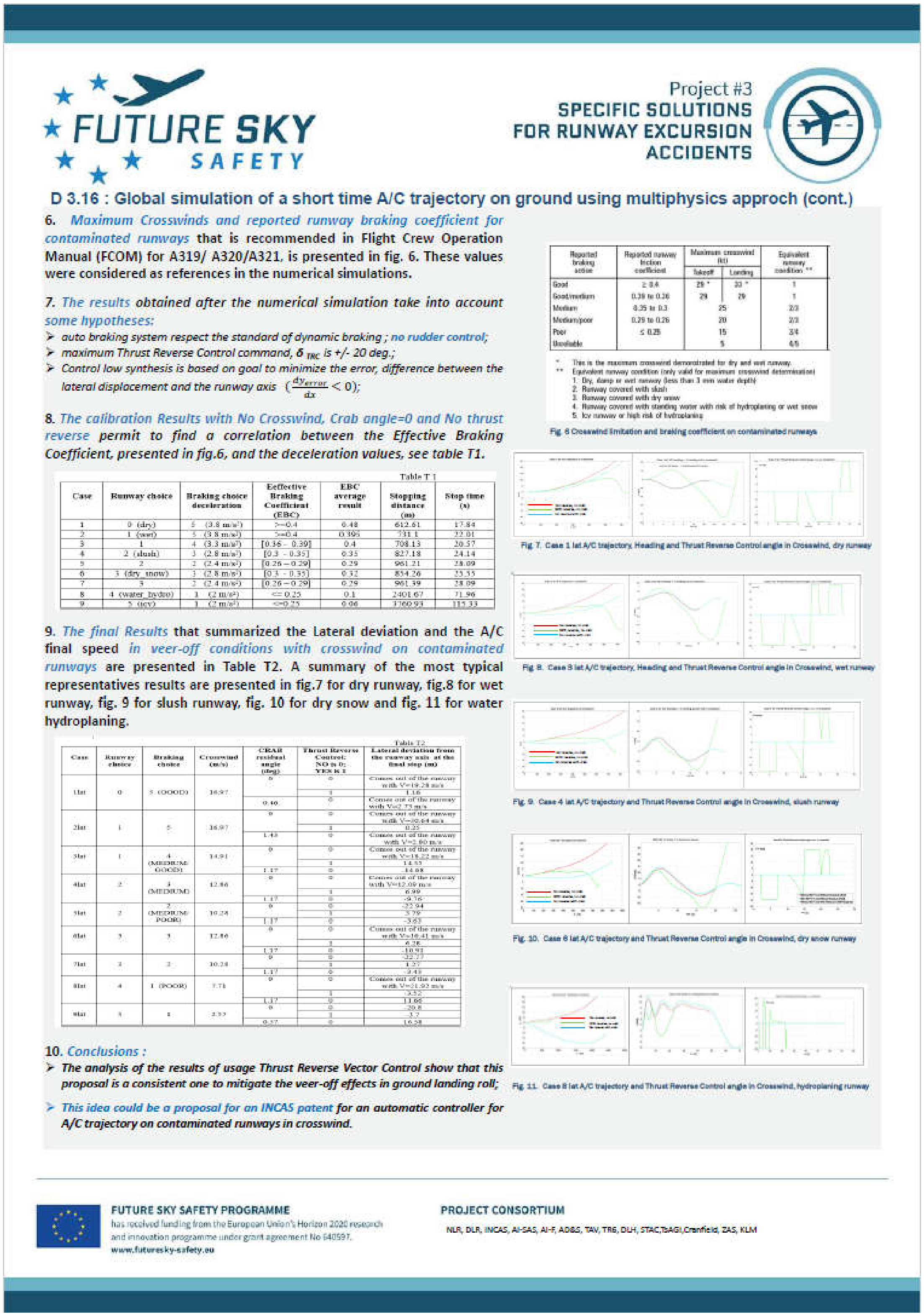

Project #3
SPECIFIC SOLUTIONS
FOR RUNWAY EXCURSION
ACCIDENTS

D 3.16 : Global simulation of a short time A/C trajectory on ground using multiphysics approch (cont.)

6. *Maximum Crosswinds and reported runway braking coefficient for contaminated runways* that is recommended in Flight Crew Operation Manual (FCOM) for A319/ A320/A321, is presented in fig. 6. These values were considered as references in the numerical simulations.

7. *The results* obtained after the numerical simulation take into account *some hypotheses:*

- *auto braking system respect the standard of dynamic braking ; no rudder control;*
- *maximum Thrust Reverse Control command, δ_{TRC} is +/- 20 deg.;*
- *Control low synthesis is based on goal to minimize the error, difference between the lateral displacement and the runway axis* $(\frac{dy_{error}}{dx} < 0)$;

8. *The calibration Results with No Crosswind, Crab angle=0 and No thrust reverse permit to find a correlation between the Effective Braking Coefficient, presented in fig.6, and the deceleration values, see table T1.*

Reported braking action	Reported runway friction coefficient	Maximum crosswind (kt)		Equivalent runway condition **
		Takeoff	Landing	
Good	≥ 0.4	29 *	33 *	1
Good/medium	0.39 to 0.36	29	29	1
Medium	0.35 to 0.3	25		2/3
Medium/poor	0.29 to 0.26	20		2/3
Poor	≤ 0.25	15		3/4
Unreliable		5		4/5

* This is the maximum crosswind demonstrated for dry and wet runway.
** Equivalent runway condition (only valid for maximum crosswind determination)
1. Dry, damp or wet runway (less than 3 mm water depth)
2. Runway covered with slush
3. Runway covered with dry snow
4. Runway covered with standing water with risk of hydroplaning or wet snow
5. Icy runway or high risk of hydroplaning

Fig. 6 Crosswind limitation and braking coefficient on contaminated runways

Table T 1

Case	Runway choice	Braking choice deceleration	Eeffective Braking Coefficient (EBC)	EBC average result	Stopping distance (m)	Stop time (s)
1	0 (dry)	5 (3.8 m/s^2)	>=0.4	0.48	612.61	17.84
2	1 (wet)	5 (3.8 m/s^2)	>=0.4	0.395	731.1	22.01
3	1	4 (3.3 m/s^2)	[0.36 – 0.39]	0.4	708.13	20.57
4	2 (slush)	3 (2.8 m/s^2)	[0.3 - 0.35]	0.35	827.18	24.14
5	2	2 (2.4 m/s^2)	[0.26 – 0.29]	0.29	961.21	28.09
6	3 (dry_snow)	3 (2.8 m/s^2)	[0.3 - 0.35]	0.32	854.26	25.55
7	3	2 (2.4 m/s^2)	[0.26 – 0.29]	0.29	961.39	28.09
8	4 (water_hydro)	1 (2 m/s^2)	<= 0.25	0.1	2401.67	71.96
9	5 (icy)	1 (2 m/s^2)	<=0.25	0.06	3760.93	115.33

9. *The final Results* that summarized the Lateral deviation and the A/C final speed *in veer-off conditions with crosswind on contaminated runways* are presented in Table T2. A summary of the most typical representatives results are presented in fig.7 for dry runway, fig.8 for wet runway, fig. 9 for slush runway, fig. 10 for dry snow and fig. 11 for water hydroplaning.

Table T2

Case	Runway choice	Braking choice	Crosswind (m/s)	CRAB residual angle (deg)	Thrust Reverse Control: NO is 0; YES is 1	Lateral deviation from the runway axis at the final stop (m)
1lat	0	5 (GOOD)	16.97	0	0	Comes out of the runway with V=19.28 m/s
					1	1.16
				0.46	0	Comes out of the runway with V=2.73 m/s
2lat	1	5	16.97	0	0	Comes out of the runway with V=20.64 m/s
					1	0.25
				1.43	0	Comes out of the runway with V=2.80 m/s
3lat	1	4 (MEDIUM/ GOOD)	14.91	0	0	Comes out of the runway with V=18.22 m/s
					1	14.53
				1.17	0	-14.68
4lat	2	3 (MEDIUM)	12.86	0	0	Comes out of the runway with V=12.09 m/s
					1	6.99
				1.17	0	-9.76
5lat	2	2 (MEDIUM/ POOR)	10.24	0	0	-22.94
					1	3.79
				1.17	0	-3.63
6lat	3	3	12.86	0	0	Comes out of the runway with V=18.41 m/s
					1	6.28
				1.17	0	-10.93
7lat	3	2	10.24	0	0	-22.77
					1	1.27
				1.17	0	-2.43
8lat	4	1 (POOR)	7.71	0	0	Comes out of the runway with V=21.92 m/s
					1	-3.52
				1.17	0	11.68
9lat	5	1	2.57	0	0	-20.8
					1	-3.7
				0.57	0	16.58

Fig. 7. Case 1 lat A/C trajectory, Heading and Thrust Reverse Control angle in Crosswind, dry runway

Fig. 8. Case 3 lat A/C trajectory, Heading and Thrust Reverse Control angle in Crosswind, wet runway

Fig. 9. Case 4 lat A/C trajectory and Thrust Reverse Control angle in Crosswind, slush runway

Fig. 10. Case 6 lat A/C trajectory and Thrust Reverse Control angle in Crosswind, dry snow runway

Fig. 11. Case 8 lat A/C trajectory and Thrust Reverse Control angle in Crosswind, hydroplaning runway

10. *Conclusions :*

- *The analysis of the results of usage Thrust Reverse Vector Control show that this proposal is a consistent one to mitigate the veer-off effects in ground landing roll;*
- *This idea could be a proposal for an INCAS patent for an automatic controller for A/C trajectory on contaminated runways in crosswind.*

FUTURE SKY SAFETY PROGRAMME
has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 640597.
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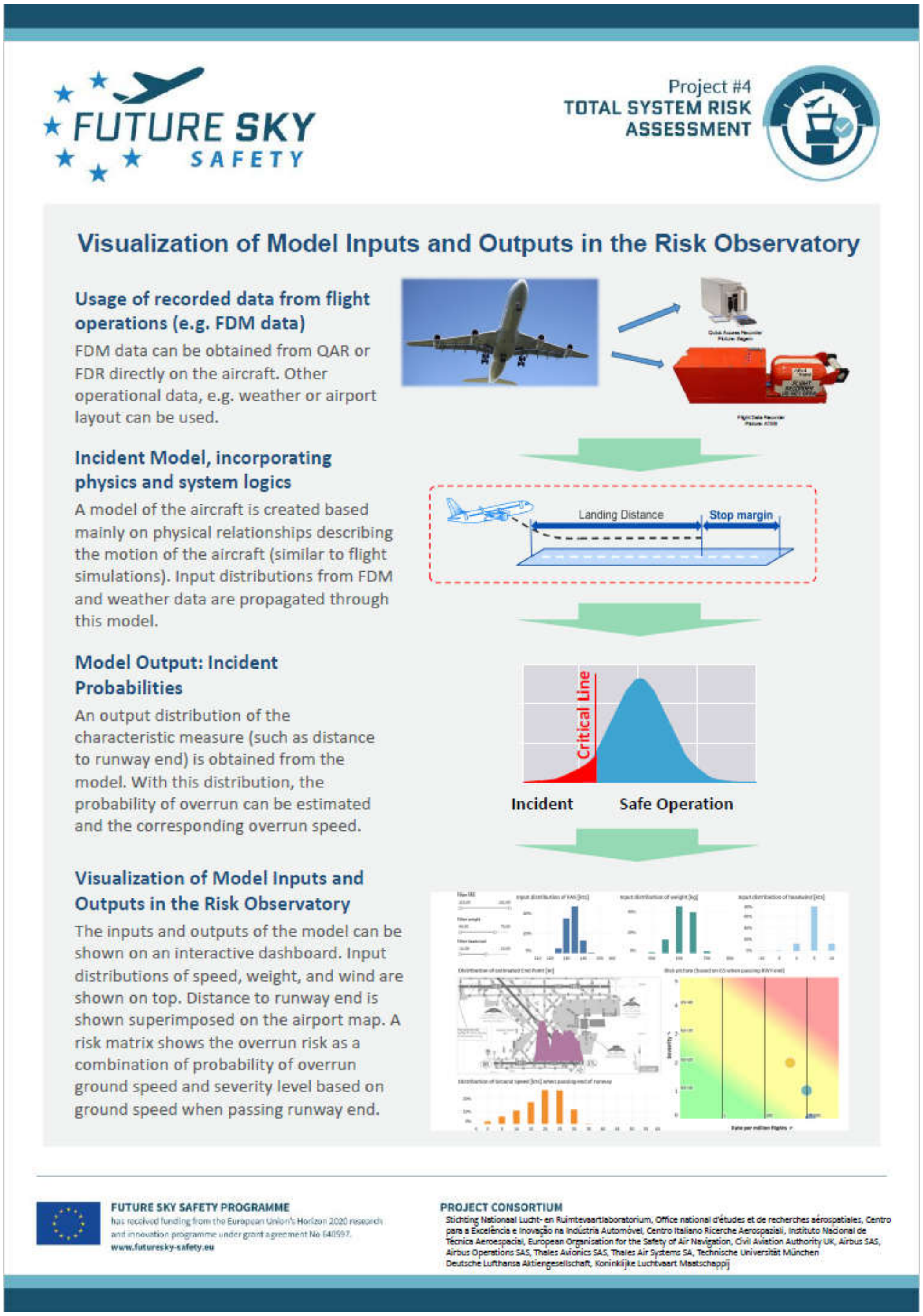
PROJECT CONSORTIUM
NLR, DLR, INCAS, AI-SAS, AI-F, AD&S, TAV, TRG, DLH, STAC,TsAGI,Cranfield, ZAS, KLM

Appendix C.3 “P4: Total system risk assessment”



Project #4
TOTAL SYSTEM RISK ASSESSMENT

Visualization of Model Inputs and Outputs in the Risk Observatory

Usage of recorded data from flight operations (e.g. FDM data)

FDM data can be obtained from QAR or FDR directly on the aircraft. Other operational data, e.g. weather or airport layout can be used.

Incident Model, incorporating physics and system logics

A model of the aircraft is created based mainly on physical relationships describing the motion of the aircraft (similar to flight simulations). Input distributions from FDM and weather data are propagated through this model.

Model Output: Incident Probabilities

An output distribution of the characteristic measure (such as distance to runway end) is obtained from the model. With this distribution, the probability of overrun can be estimated and the corresponding overrun speed.

Visualization of Model Inputs and Outputs in the Risk Observatory

The inputs and outputs of the model can be shown on an interactive dashboard. Input distributions of speed, weight, and wind are shown on top. Distance to runway end is shown superimposed on the airport map. A risk matrix shows the overrun risk as a combination of probability of overrun ground speed and severity level based on ground speed when passing runway end.

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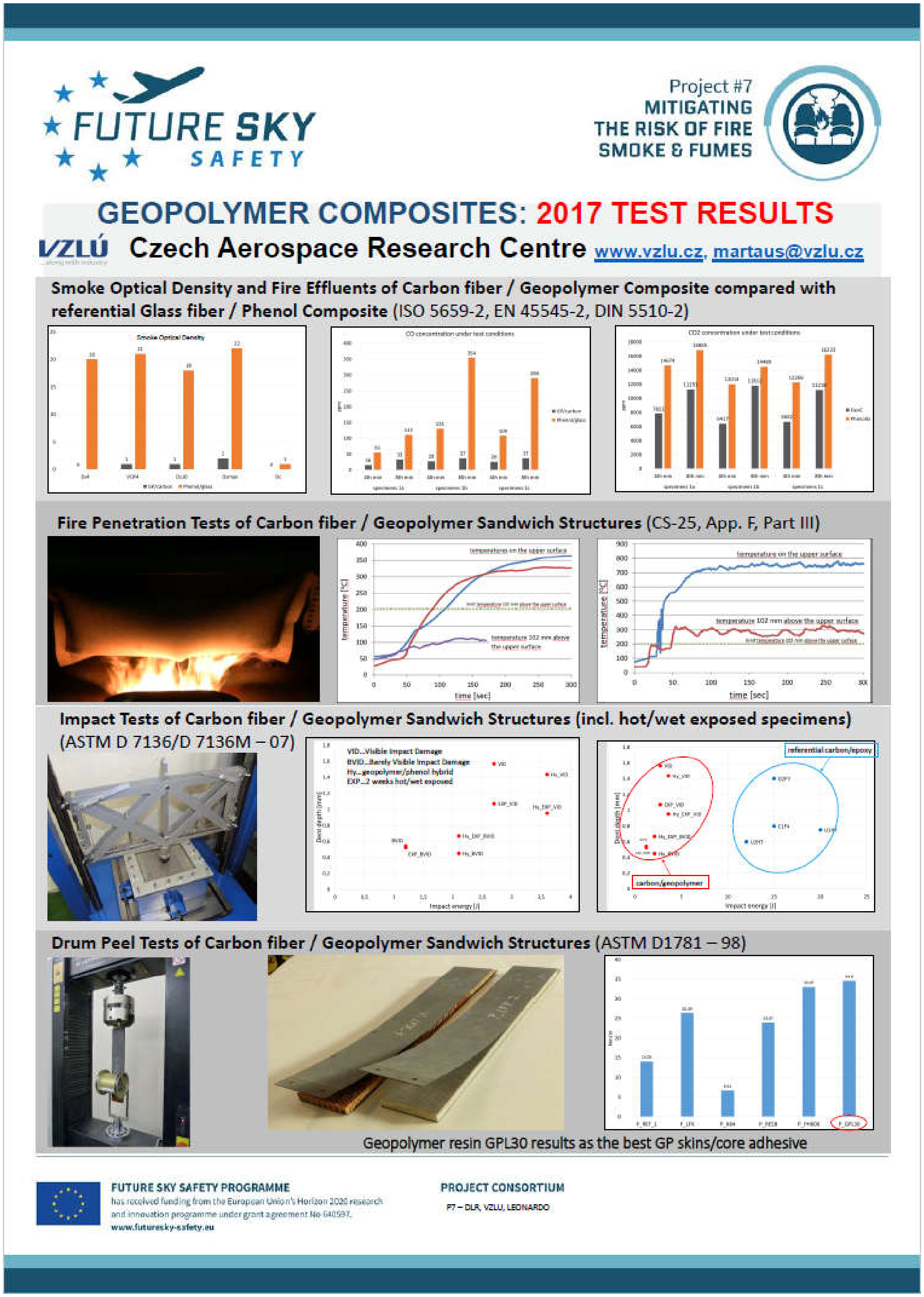
PROJECT CONSORTIUM
Stichting Nationaal Lucht- en Ruimtevaartlaboratorium, Office national d'études et de recherches aérospatiales, Centro para a Excelência e Inovação na Indústria Automóvel, Centro Italiano Ricerche Aerospaziali, Instituto Nacional de Técnica Aeroespacial, European Organisation for the Safety of Air Navigation, Civil Aviation Authority UK, Airbus SAS, Airbus Operations SAS, Thales Avionics SAS, Thales Air Systems SA, Technische Universität München Deutsche Lufthansa Aktiengesellschaft, Koninklijke Luchtvaart Maatschappij

Appendix C.4 "P7: Mitigating risks of fire, smoke and fumes"



Project #7
MITIGATING
THE RISK OF FIRE
SMOKE & FUMES

GEOPOLYMER COMPOSITES: 2017 TEST RESULTS

VZLÚ Czech Aerospace Research Centre www.vzlu.cz, martaus@vzlu.cz

Smoke Optical Density and Fire Effluents of Carbon fiber / Geopolymer Composite compared with referential Glass fiber / Phenol Composite (ISO 5659-2, EN 45545-2, DIN 5510-2)

Fire Penetration Tests of Carbon fiber / Geopolymer Sandwich Structures (CS-25, App. F, Part III)

Impact Tests of Carbon fiber / Geopolymer Sandwich Structures (incl. hot/wet exposed specimens) (ASTM D 7136/D 7136M – 07)

Drum Peel Tests of Carbon fiber / Geopolymer Sandwich Structures (ASTM D1781 – 98)

Geopolymer resin GPL30 results as the best GP skins/core adhesive

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PROJECT CONSORTIUM
P7 – DLR, VZLU, LEONARDO

Appendix D Photos


German Aerospace Center (DLR)
DLR

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