Smart Intelligent Aircraft Structures

Ricerca, Innovazione e Certificazione d'Impresa:
Elementi di sviluppo dell'Industria Aerospaziale Campana

Il Progetto SARISTU – Un efficiente e vincente esempio d'integrazione Ricerca – Industria Campana

Scuola Politecnica e delle Scienze di Base – Università degli Studi di Napoli «Federico II»

12.06.2015

E. Monaco – Dipartimento di Ingegneria Industriale – Università degli Studi di Napoli «Federico II»

SARISTU

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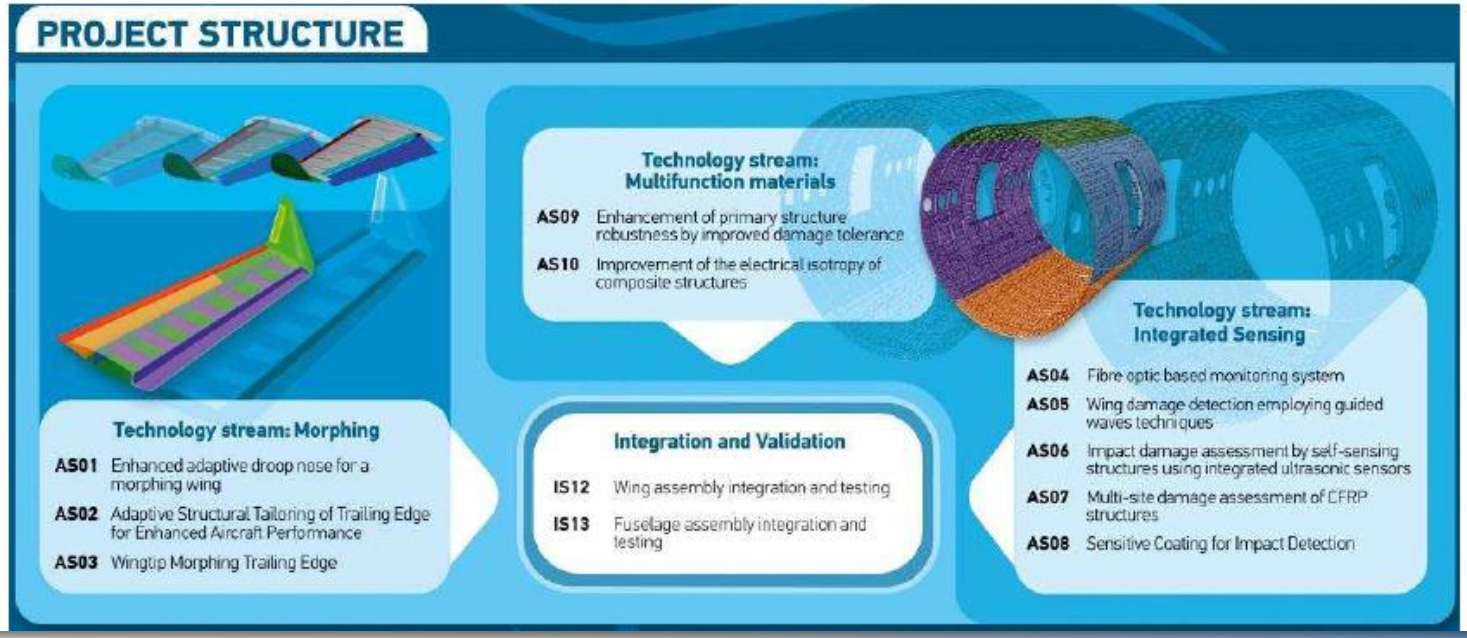
What is SARISTU

- SARISTU – Smart Intelligent Aircraft Structures
- Level 2, large-scale integrating project which aims at achieving reductions in aircraft weight and operational costs, as well as an improvement in the flight profile specific aerodynamic performance.
- 64 partners from 16 countries

What is SARISTU

- Total budget about 51 M€, partially funded by the European Commission
- Duration of 48 months, expected to be completed by August 2015.
- Focus on integration activities in three distinct technological areas: airfoil Conformal Morphing, self-sensing and multifunctional structures through the use of nanoreinforced resins



What is SARISTU

OBJECTIVES

SARISTU (Smart Intelligent Aircraft Structures) focuses on the **cost reduction of air travel** through a variety of individual applications as well as their combination. For the first time ever in smart material concepts, SARISTU offers the opportunity to virtually and physically assess the interaction of different technological solutions and their combined effects at aircraft level.

Specifically, the joint integration of different conformal morphing concepts in a laminar wing is intended to improve aircraft performance through a **6% drag reduction**, with a positive effect on fuel consumption and required take-off fuel load. A side effect will be a decrease of up to 6dB(A) of the **airframe generated noise**, thus reducing the impact of air traffic noise in the vicinity of airports.

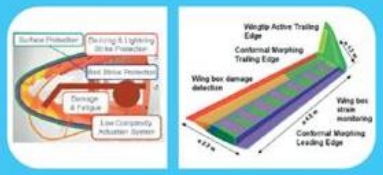
Another important objective is to **limit the integration cost of Structural Health Monitoring (SHM) systems** by moving the system integration as far forward in the manufacturing chain as possible. In this manner, SHM integration becomes a feasible concept to enable **in-service inspection cost reductions of up to 1%**.

Finally, the incorporation of Carbon Nanotubes into aeronautical resins is expected to enable **weight savings of up to 3%** when compared to the unmodified skin/stringer/frame system, while a combination of technologies is expected to **decrease Electrical Structure Network installation costs by up to 15%**.

PROJECT STRUCTURE

Technology stream: Morphing

- **AS01** Enhanced adaptive droop nose for a morphing wing
- **AS02** Adaptive Structural Tailoring of Trailing Edge for Enhanced Aircraft Performance
- **AS03** Wingtip Morphing Trailing Edge



Integration and Validation

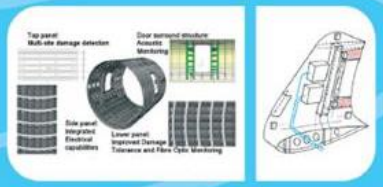
- **IS12** Wing assembly integration and testing
- **IS13** Fuselage assembly integration and testing

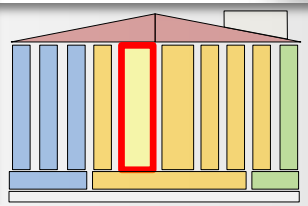
Technology stream: Integrated Sensing

- **AS04** Fibre optic based monitoring system
- **AS05** Wing damage detection employing guided waves techniques
- **AS06** Impact damage assessment by self-sensing structures using integrated ultrasonic sensors
- **AS07** Multi-site damage assessment of CFRP structures
- **AS08** Sensitive Coating for Impact Detection

Technology stream: Multifunction materials

- **AS09** Enhancement of primary structure robustness by improved damage tolerance
- **AS10** Improvement of the electrical isotropy of composite structures





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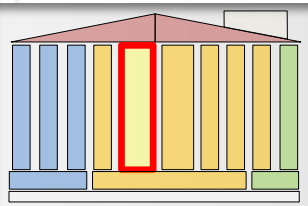
What is SARISTU

Wing Integration

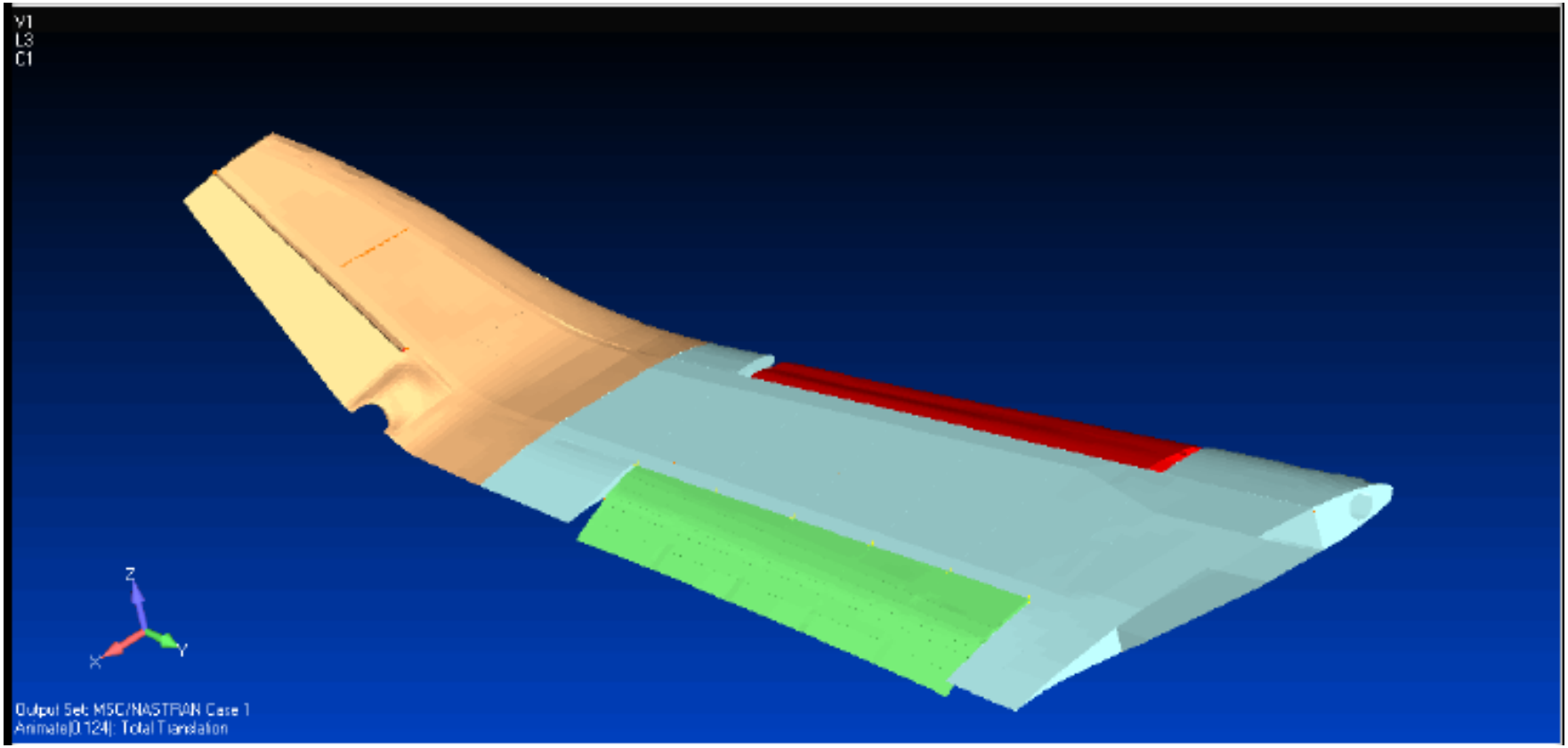
- Morphing technology integration on a typical outboard wing is expected to achieve a total additional **fuel consumption reduction of 6%**
- and **reduce the impact of air traffic noise by 6 dB(A)**

Fuselage Integration

- Damage detection capabilities for operational **cost reductions regarding structure inspection by 1%,**
- The feasibility of combining Structural Health Monitoring (SHM) with nanoreinforced resins for Damage Tolerance improvement for **weight savings exceeding 3%,**
- And an **Electrical Structure Network installation cost reduced by 15%**

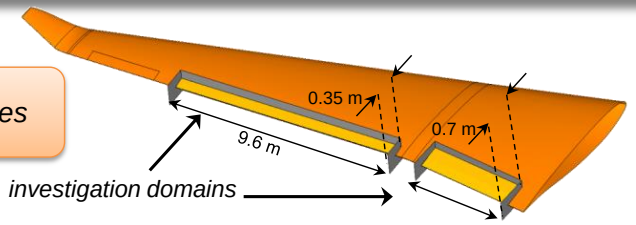


Wing integration (Alenia leader)



AS02: Adaptive Trailing Edge

Application scenario 2, adaptive TE: *key partners and roles*



Preliminary design path

Alenia Aermacchi

Definition of Requirements & Specifications

AIRBUS

Aerodynamic design

Design of the morph. structure

Design of systems

ONERA

TE box

CIRA

Actuation & control

Fraunhofer

Skin

INASCO

Sensing

V&V path

Stressed layout emission / Aeroelastic assessment

Executive drawings and manufacturing of prototypes

Experimental tests

mare engineering

INNOWATTECH

AERnnova engineering

ATARD

CIRA

Fraunhofer

AERnnova engineering

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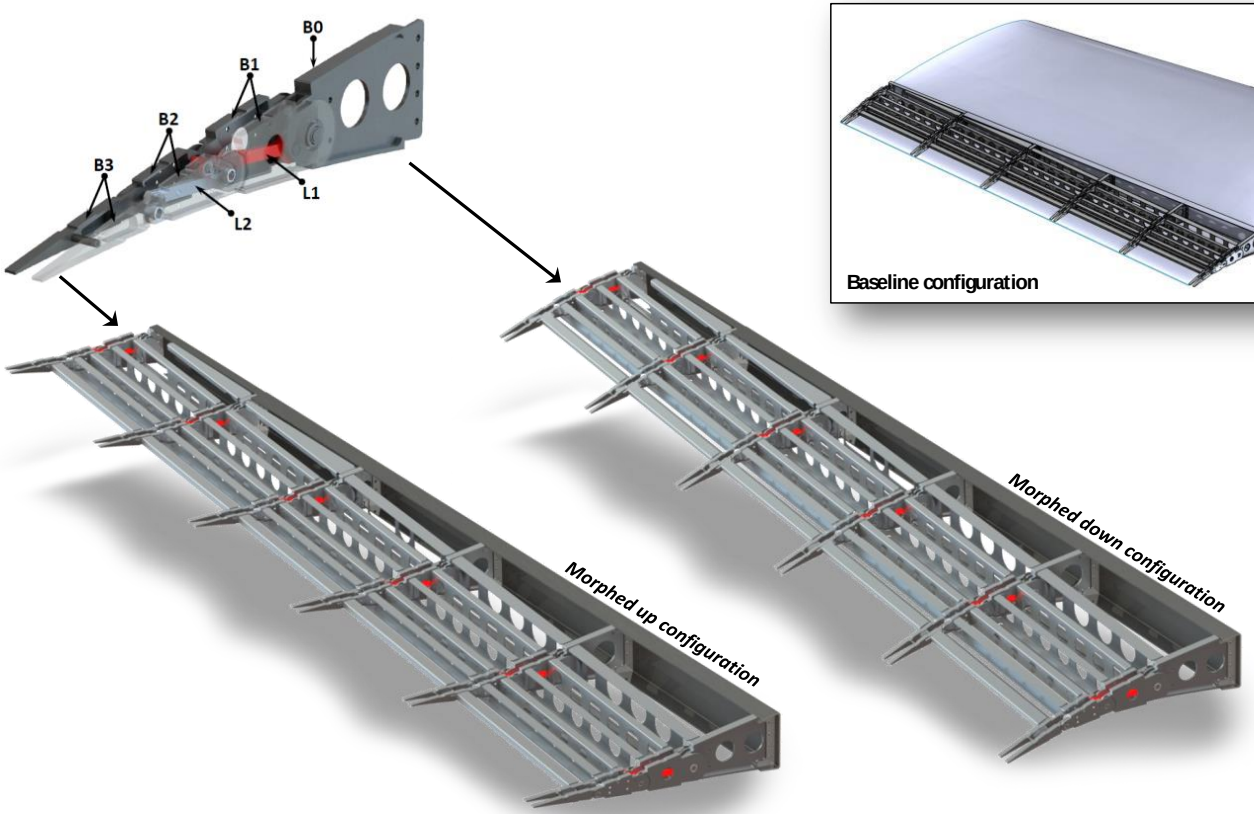
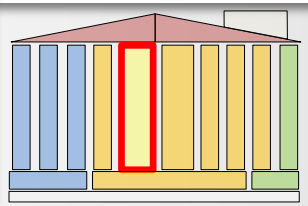
AS02: Adaptive Trailing Edge

Application scenario 2, adaptive TE: *the inner structure*





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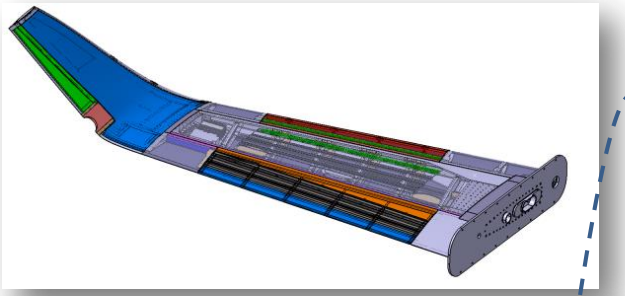
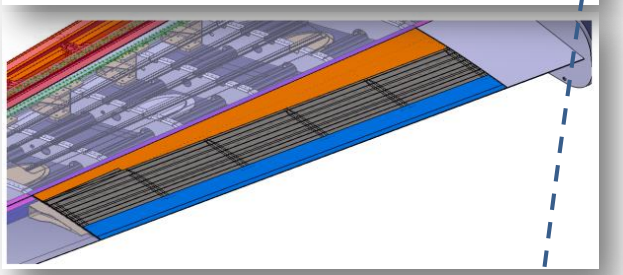
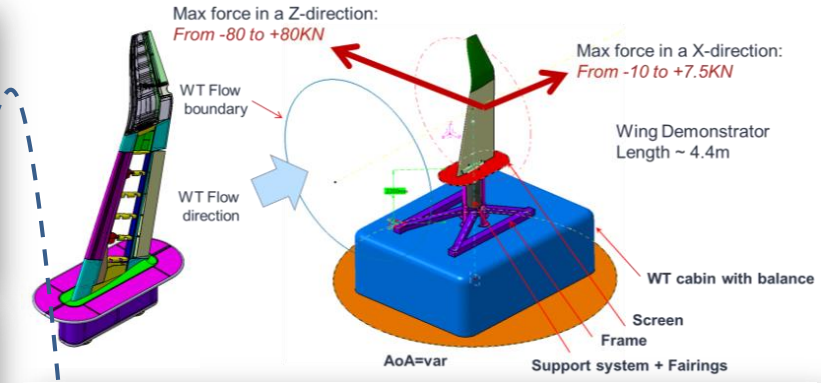
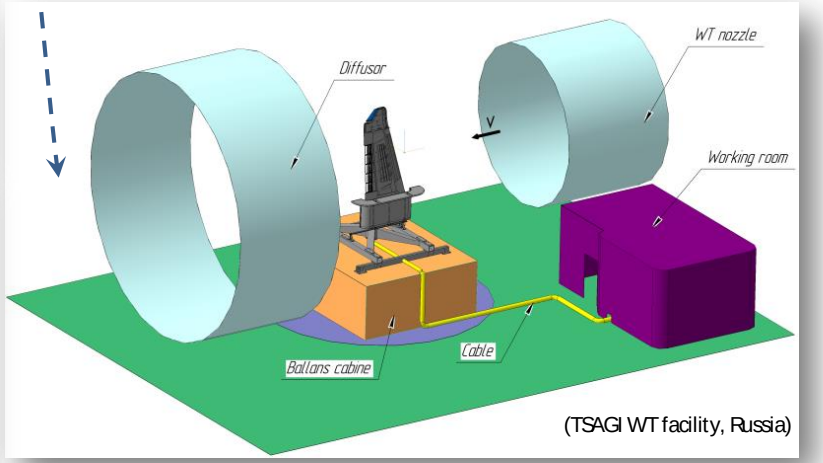
AS02: Adaptive Trailing Edge

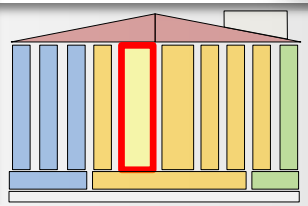
From AS02 to IS12: for the firs time ever, a true scale wing segment equipped with 3 fully functional morphing devices is tested in one of the largest WT of the world !



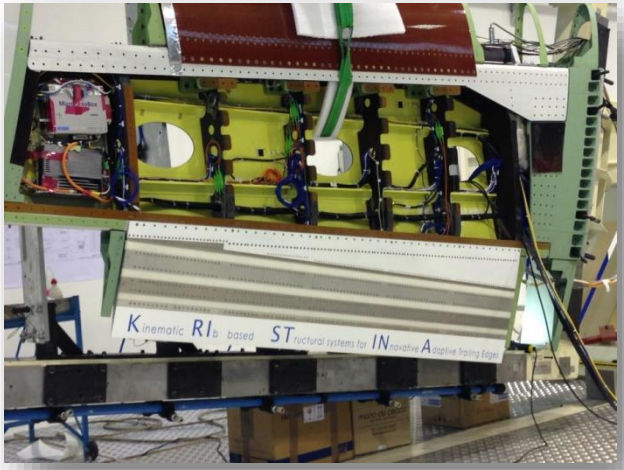


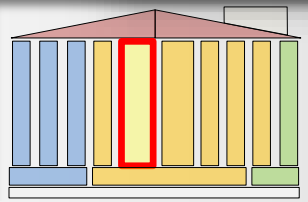






AS02: Adaptive Trailing Edge





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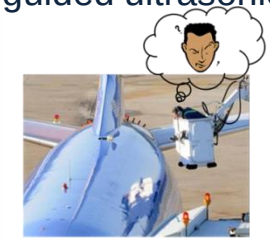
SHM by guided waves: Overview

Scenario Overview and Description

Design, manufacturing and implementation of a composite wing damage detection system based on guided ultrasonic wave measurements techniques.



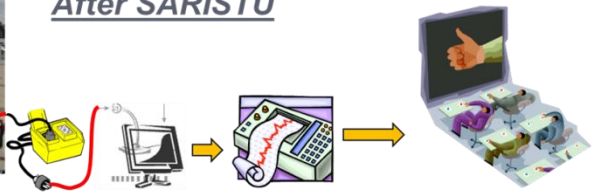
Before SARISTU

Return into Operation

Maintenance Task Required

SARISTU MTR PRESENTATION AS07

After SARISTU



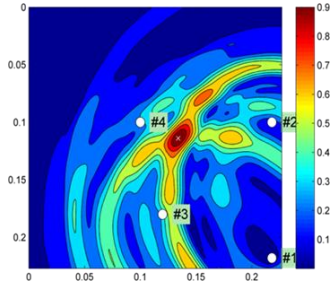
Single level inspection + SHM instead than two levels (level 1 technician + NDT expert)

…or somehow hybrid alternatives?

The major benefit is a drastically reduced inspection time of the selected part to be monitored, if compared to available NDT.

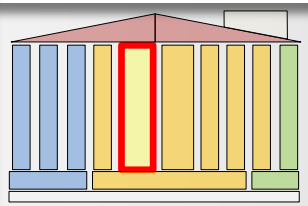
Concept Illustration

Clusters of high frequency ultrasonic sensor arrays are located in critical areas of a structure to analyze the characteristics of the guided waves propagating from a controlled source. The appearance of a defect modifies the elastic waves propagating as well as its reflections on the flaws. Analyzing the signals received by sensors is possible to correlate structural perturbations to acquired signals.



Scenario Objectives

Develop and test methodologies and technologies to detect BVID and VID on reinforced skin of a composite wing, integrating/installing arrays of sensors sensible to stress guided waves travelling within the structural sub-components.



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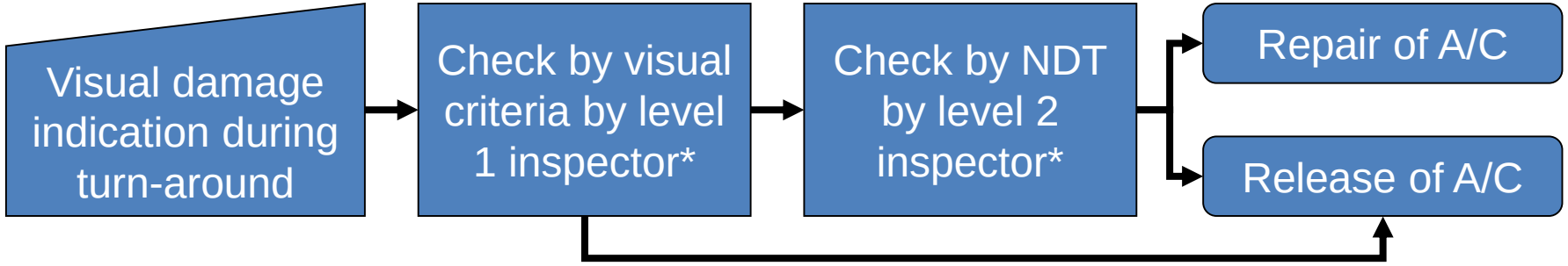
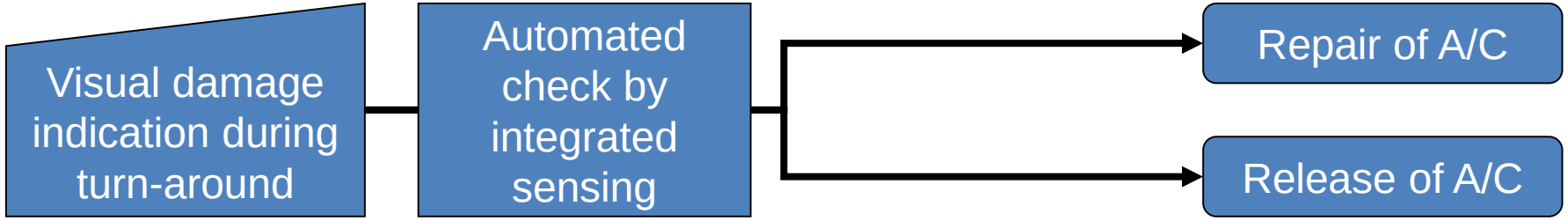
SHM by guided waves: Overview

- Damage assessment process to be challenged (simplified)



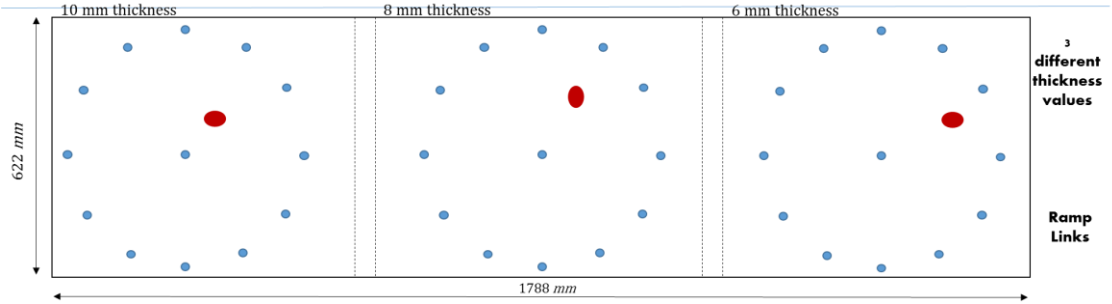
* Level 1 inspector available at larger airports
Level 2 inspector only available at certain bases (need to fly in in most cases)

- Damage assessment process using integrated sensing

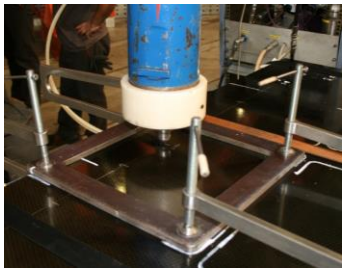


Highlights – damage detection on unstiffened plates

BAB Varying thicknesses panel



DROP WEIGHT TESTING

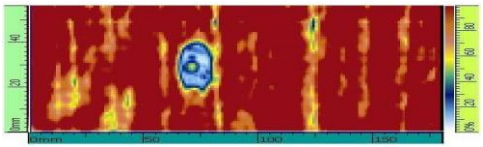


1 INCH TIP

155 Joules	110 Joules	85 Joules

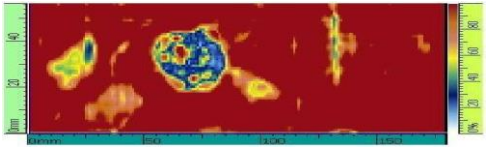
C-SCAN INVESTIGATION

10 mm thickness



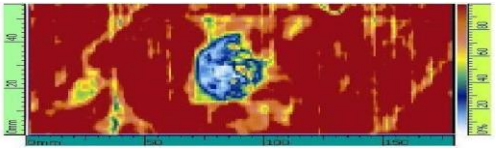
18 x 22 mm

8 mm thickness

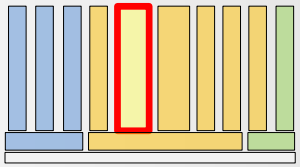


24 x 23 mm

6 mm thickness



26 x 25 mm



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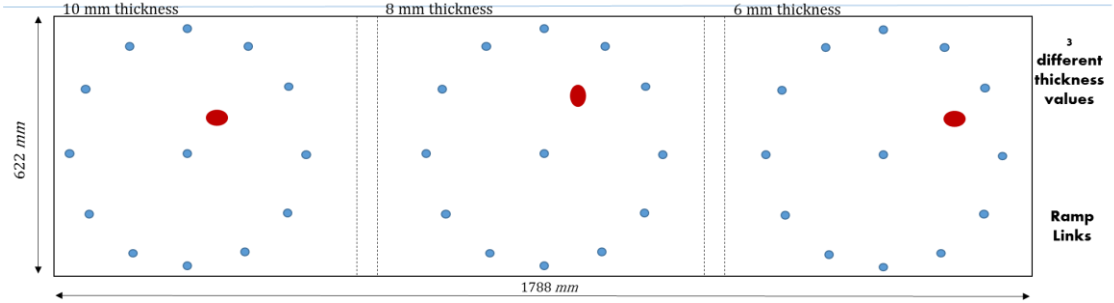
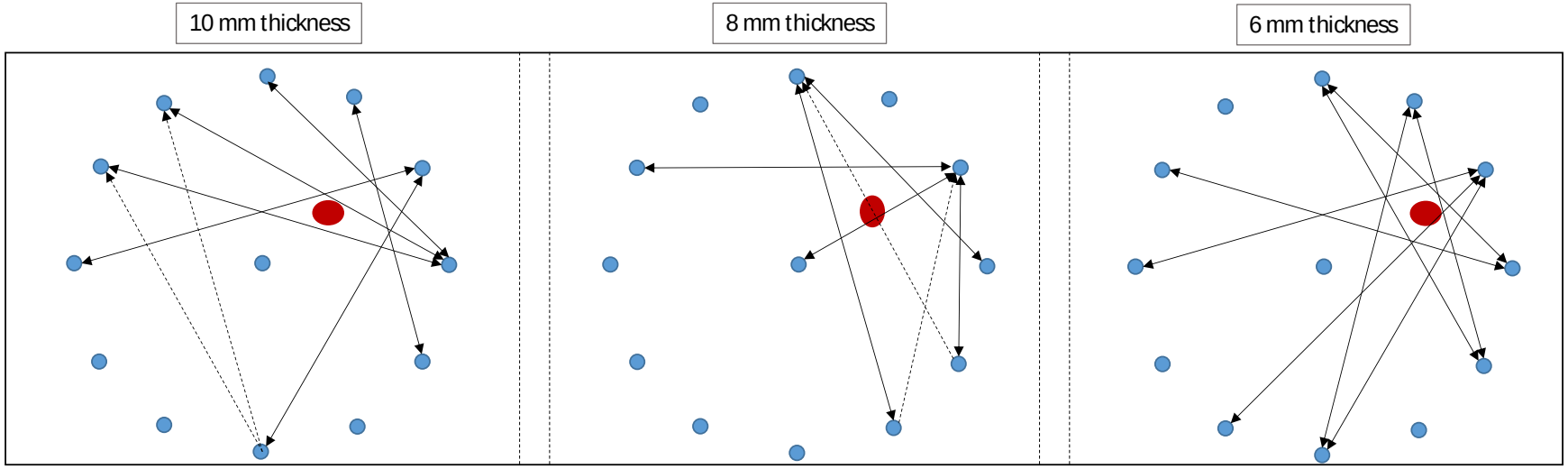
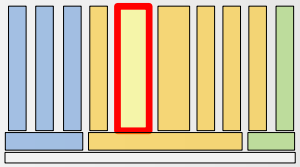
Highlights – damage detection on unstiffened plates

BAB Varying thicknesses panel





From the plot of the measurement paths, it is envisioned that the damages appear always in the region with the maximum number of damaged paths. Even the combination of a very simple representation with the statistical definition of detection threshold has the potential to detect damage and the area of interest



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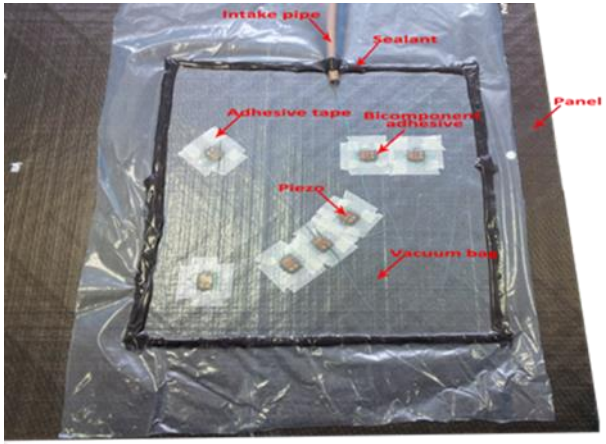
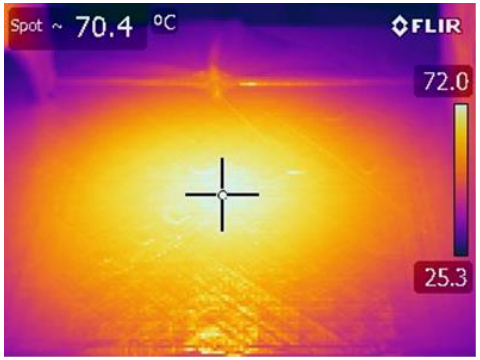
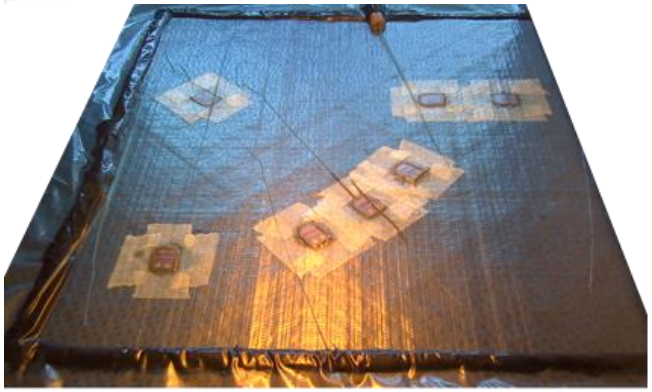
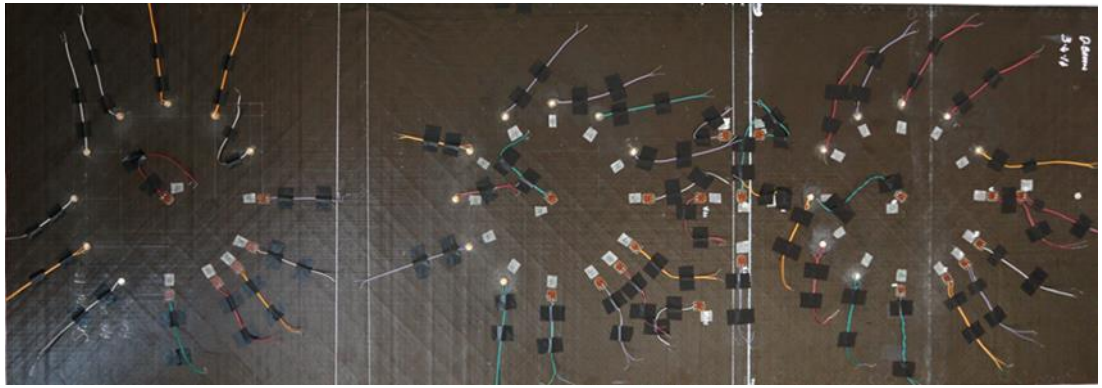
Highlights – Sensors installation (secondary bonding)

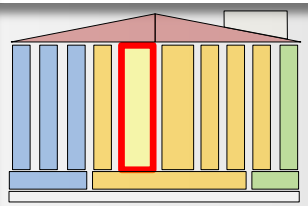
- **Secondary bonding procedure tested on varying thicknesses BAB panel representing final layup of GTD lower wing panel – Procedure shared with Alenia for IS12 application.**











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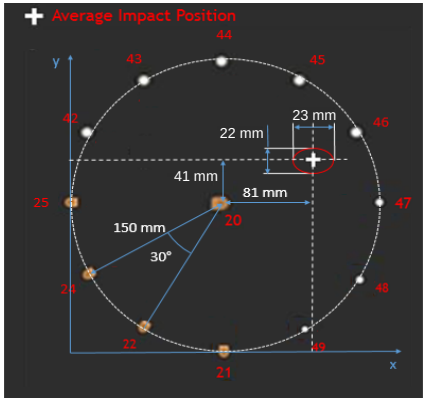
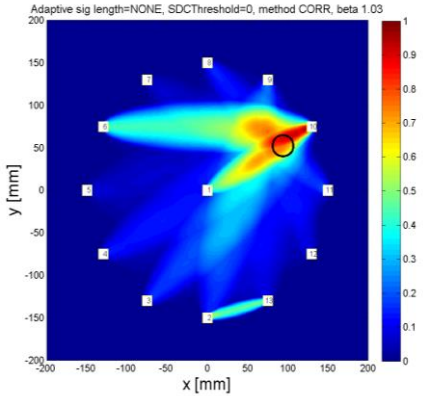
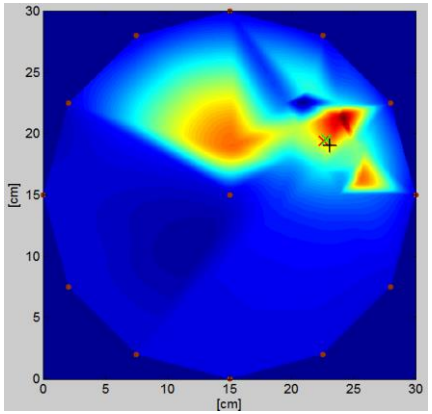
Highlights – Statistical definition of damage detection threshold level



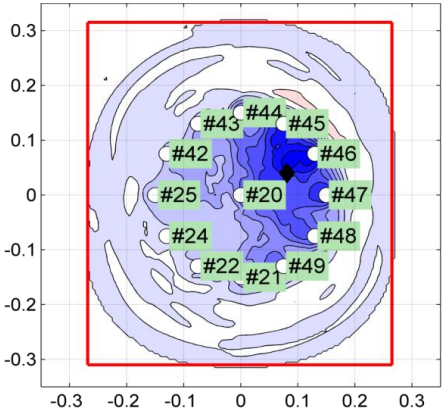
BAB varying thicknesses panel: 6mm bay



KUL tomographic approach results



UNINA tomographic approach results

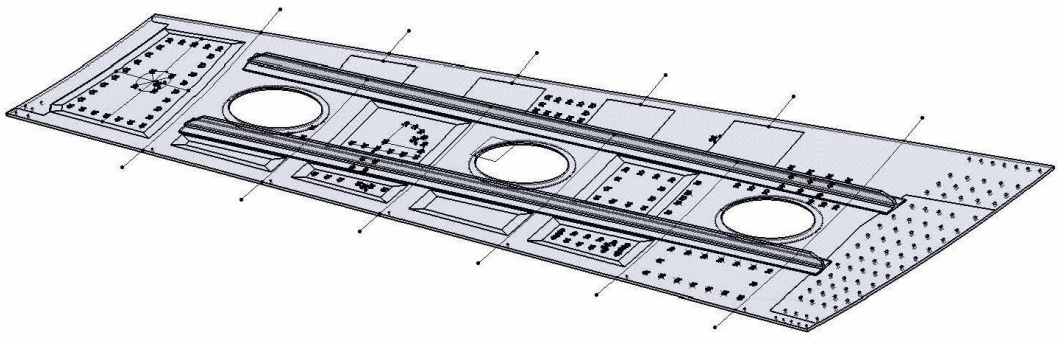


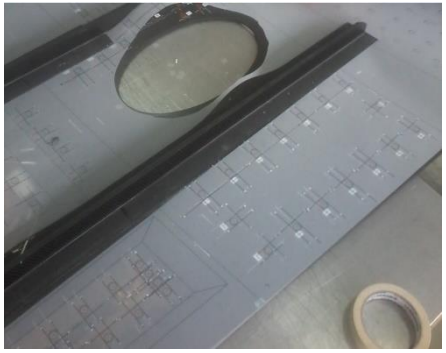
UNIBO Wave scattering approach results

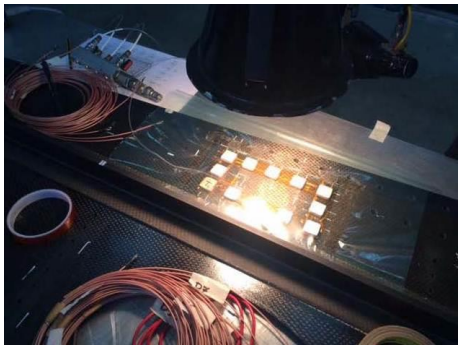
Comparison of SHM experimental methodologies results on 6mm impacted bay of BAB varying thicknesses panel. Methodologies have beein applied to the same acquired signals and «filtered» by the mean of the statistical thresholds approaches.

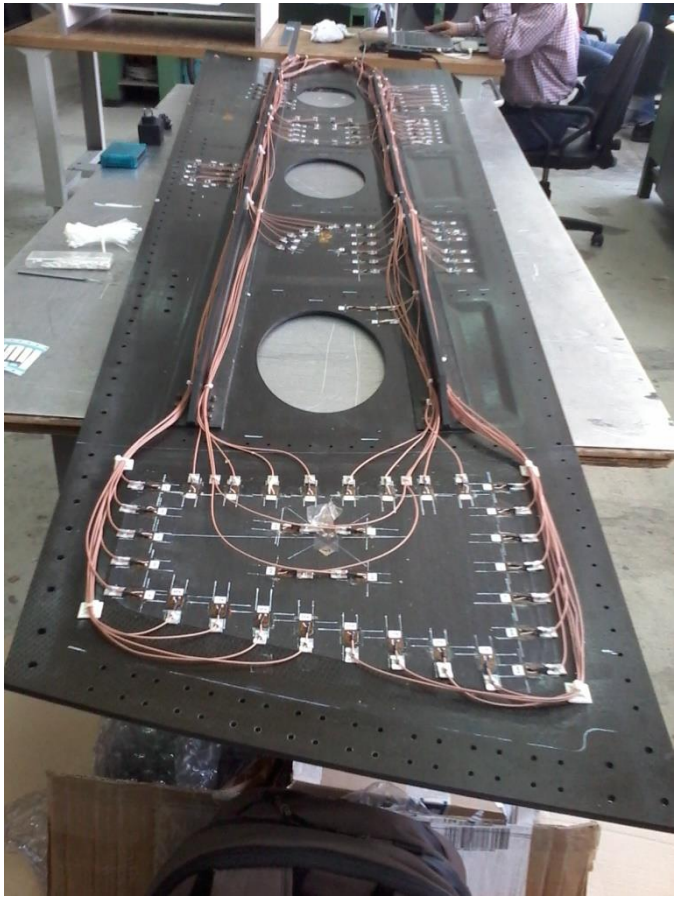
Highlights – Sensors installation (secondary bonding)

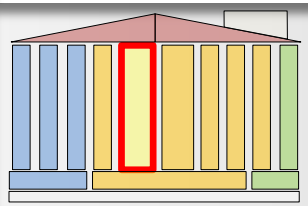
- **Secondary bonding of sensors on IS12 lower wing panel with AS05 procedure.**



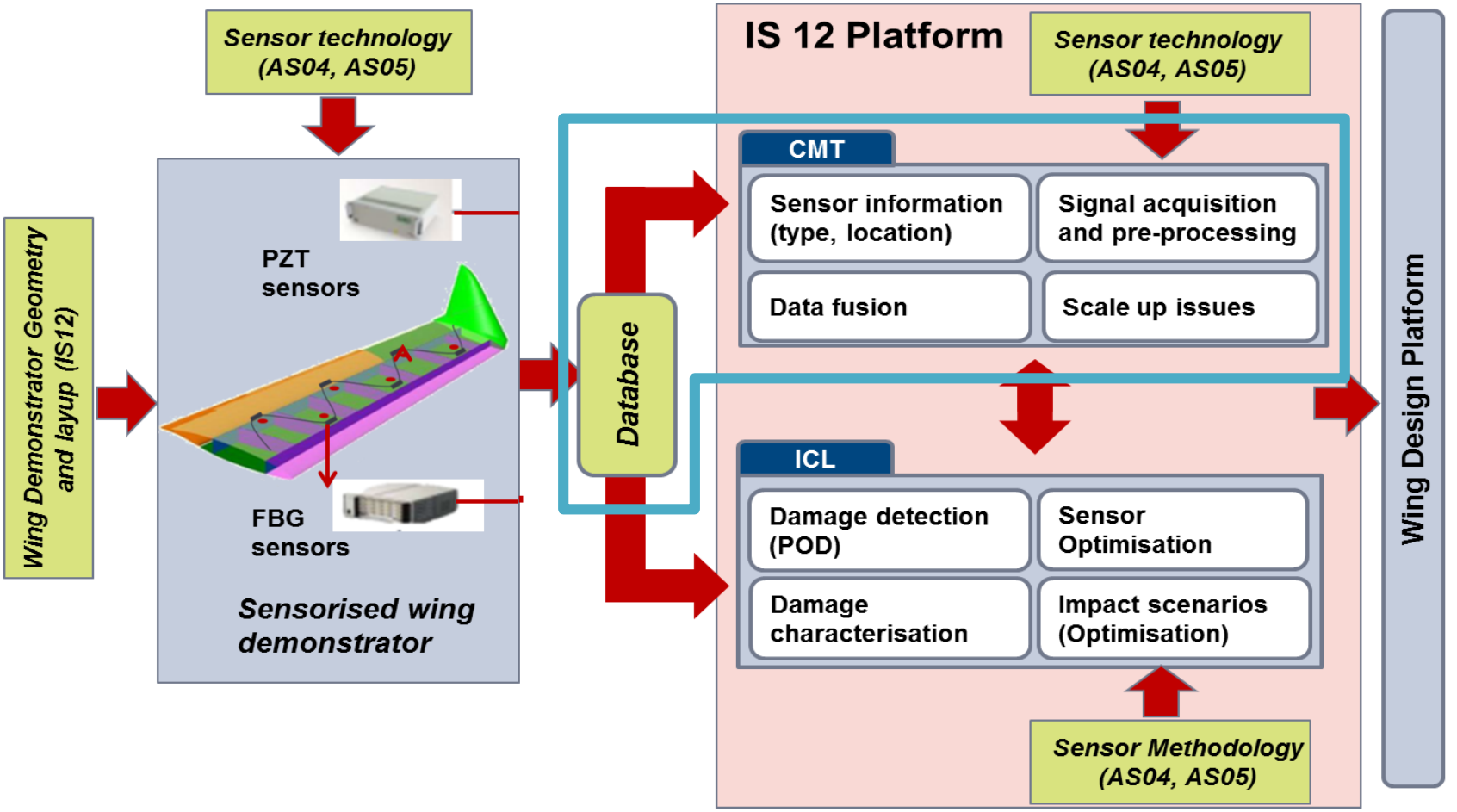








Highlights – Platforms integration for IS12



Conclusions

SARISTU represent probably the most effective research project in Aeronautics in Europe for the number of relevant innovations developed that will be implemented in next future aircrafts as well as for the highest level of collaborations and enthusiasm among the most relevant players of the European Aeronautical World.

Among the Projects winning aspects it is possible to identify as the most relevant a unique combination of German overall management and Italian industries and research organization capabilities.