GROUP FOR AERONAUTICAL RESEARCH AND TECHNOLOGY IN EUROPE

FRANCE GERMANY ITALY THE NETHERLANDS SPAIN SWEDEN UNITED KINGDOM

GARTEUR Structures and Materials

Key themes and impact highlights

Bert Thuis

GARTEUR 50th Anniversary

Italian Air Force Academy, Pozzuoli, Italy

5th October 2023

Outline of the presentation

- Introduction to Garteur Structures & Materials Group
- Membership and Industrial Points of Contacts
- Some examples of recent Action Groups
- Overview of Exploratory Groups
- Future and impact of Structures and Materials

Structures & Materials Group

- Active in initiating and organizing aeronautics oriented research on materials, structures and structural dynamics.

- Research on ***materials*** is related to material systems primarily for the airframe but also landing gear and engines and includes:
  - Polymers
  - Metals
  - Fibre reinforced composites

- Research on ***structures*** is devoted to computational mechanics, loads and design methodologies

- Research on ***structural dynamics*** is devoted to response to shock and impact loading

Structures & Materials Group
Membership and Industrial Points of Contacts

GoR SM members

▪ NETHERLANDS	NLR	B. Thuis (chairman)
▪ SPAIN	INTA	J. San Millan (vice-chairman)
▪ FRANCE	ONERA	F. Roudolff
▪ GERMANY	DLR	P. Wierach
▪ ITALY	Univ. Della Campania	A. Riccio
▪ SWEDEN	FOI	M. Dalenbring
▪ SWEDEN	RISE	R. Olsson

Industrial Points of Contact

▪ SWEDEN	SAAB	T. Ireman
▪ GERMANY	Airbus Operations	C. Weimer
▪ GERMANY	Airbus Defense & Space	T. Körwien
▪ UK	QinetiQ	A. Foreman

SM/AG-34 Damage repair with composites

Objective:

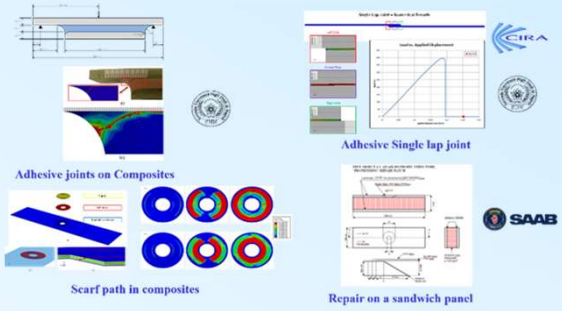
To define effective repair technologies for aircraft structures through the development of numerical/experimental methodologies

Partners involved:

University of Campania, CIRA, RISE Sicomp, FOI, Imperial College London, NLR, Consiglio Nationale delle Richerche, INTA, Norwegian University of Science and Technology, Lulea University of technology and SAAB.

Topics:

- Repair criteria
- Design of (bonded) patches
- Analysis of the repair
- Manufacturing and testing repairs
- Repair strategies and effective repair methods



SM/AG-34 Damage repair with composites

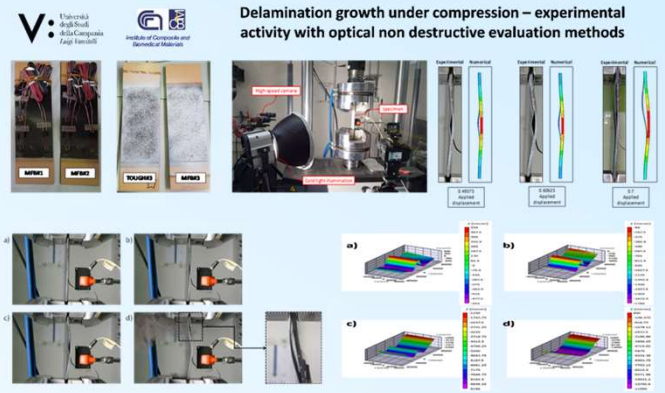
Results:

The effective outcomes of this action group can be summarized in: minimized down-time of the aircraft for repair operations, minimize costs for repair, promote the repair of components instead of substitution and reduce certification costs and of the time for certification for repaired structures.

The main challenges that were addressed consisted of:

- Failure mechanisms in bonded repairs
- Repair design procedures for structural details (e.g. stringer run-outs)
- Delamination growth and fatigue behavior

Action Group was closed in November 2021 and the final report was published



SM/AG-35 Fatigue and damage tolerance assessment of hybrid structures

Objective:

To develop a joint “best practice” approach for the testing of hybrid (metal-composite) airframe structural components.

Partners involved:

FOI, Fokker Aerostructures, NLR, DLR, Technische Universität Kaiserslautern and SAAB.

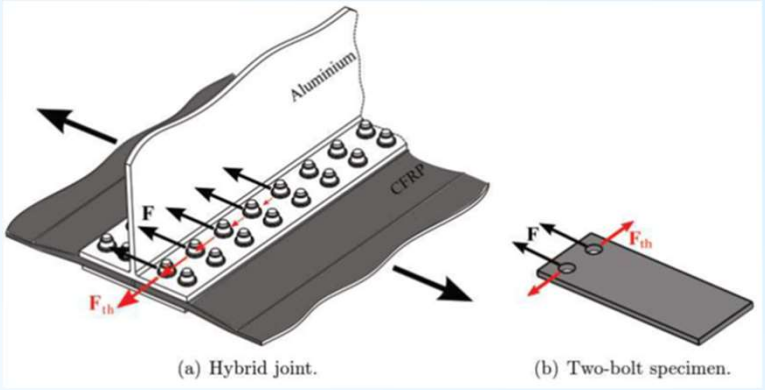
Topic 1: Environmental influences

Long term stability and degradation of bonded joints and fibre metal laminates due to environmental influences by aging of joints in humid environments.

SM/AG-35 Fatigue and damage tolerance assessment of hybrid structures

Topic 2: Determination of the optimum way to account for thermal loads in a non-thermal test set-up of hybrid airframe structural components

- When are thermal loads significant enough to be considered for fatigue and damage tolerance justification?

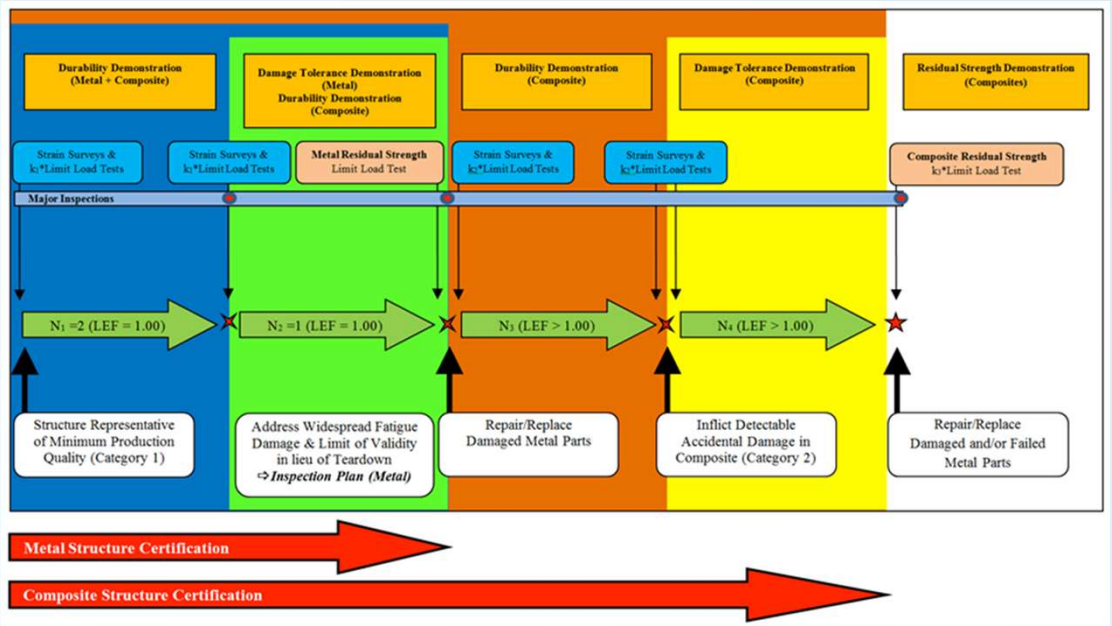


Mechanically and thermally induced bolt loads in a composite plate in a hybrid bolted joint and a simple two-bolt specimen

SM/AG-35 Fatigue and damage tolerance assessment of hybrid structures

Topic 3: Loading aspects of full scale fatigue and damage tolerance tests

Which aspects should be taken into account via environmental factors on the applied loads in case of testing hybrid structures at ambient conditions (not taken into account temperature effects and in-service moisture content)?



Action Group AG-35 was closed in February 2022 and the final report was published

SM/AG-36 Additive layer manufacturing

Objective:

To develop AM processes for novel ***high performance aluminium alloys (e.g. 7000 series and Scalmalloy®)*** and to achieve static and/or dynamic performances that are equal but preferably higher than the current Al-Alloys.

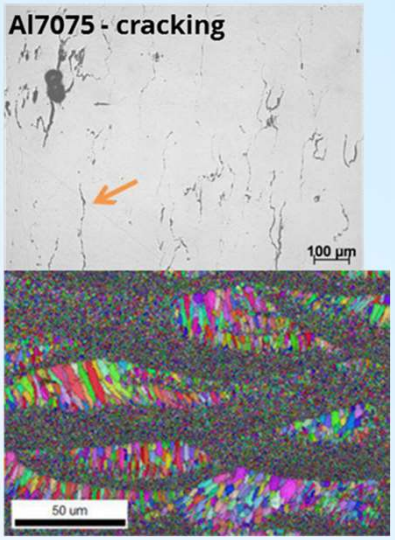
Partners involved:

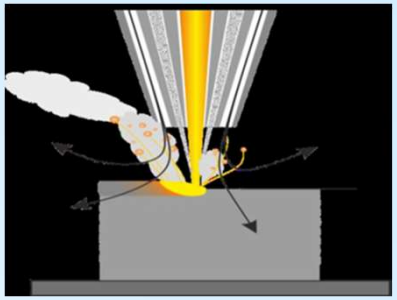
NLR, ONERA, University of Campania, INTA and Airbus

Activities:

- Literature study
- Process optimisation for Liquid Power Bed Fusion (LPBF)
- Property characterization LPBF
- Exploration of AL-Alloy Directed Energy Deposition (DED)

SM/AG-36 was launched in January 2022





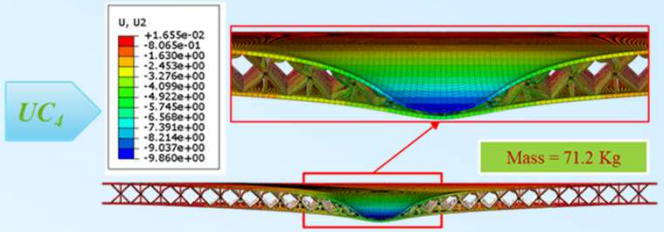
SM/AG-37 Characterization and optimisation of shock absorbers for industrial applications

Objective:

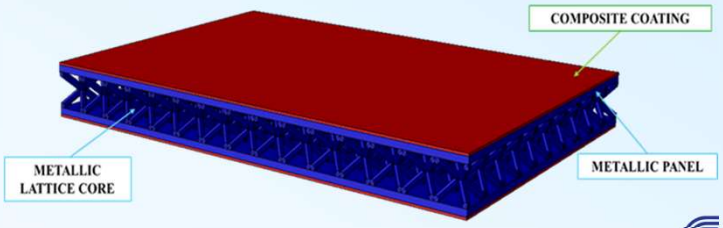
Design and verification of shock absorbers composite / metal hybrid structures capable to increase the absorbed energy and to reduce the acceleration peaks in case of a crash event

Partners Involved:

University of Campania, NLR, ONERA, DLR, CIRA



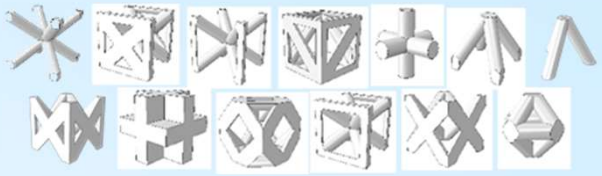
SM/AG-37 started in 2023:

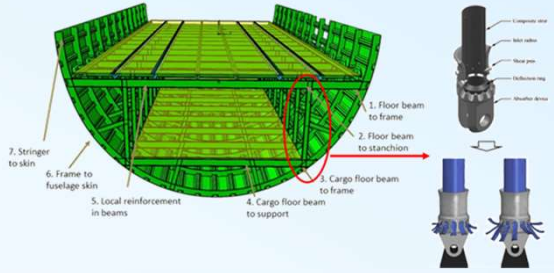


SM/AG-37 Characterization and optimisation of shock absorbers for civil aircraft fuselages

Activities:

- Investigation on the key components which require the integration with shock absorber
- Identification and classification of the shock absorbers (material and geometry)
- Material investigation (Alternative materials, Hybridization)
- Integration strategies
- Unit cell optimization (weight minimization and/or shock absorbing capability maximization)
- Analytical methods for designing hybrid shock absorber
- Numerical analysis and design
- Thermal stress analysis
- Experimental tests and validation





SM/EG-45 Characterization and modelling of CMC submitted to severe thermo-mechanical loading

Objective:

Characterization of the mechanical properties and modelling of Composites with Ceramic Matrix (CMC) submitted to high mechanical loadings and extreme thermal conditions.

Partners involved:

ONERA and DLR

Activities:

- Comprehension of the damage and failure mechanisms under static and fatigue loading at very high temperatures;
- Definition of standard tests for the measurement of mechanical properties (behaviour, damage, failure) at very high temperatures;
- Proposition of damage and failure models to predict behaviour, damage, failure and fatigue lifetime of composite materials;
- Testing and simulation of CMC composite structures under static or fatigue loading (evaluation of predictive capabilities of models).

SM/EG-48 Structural health monitoring for liquid hydrogen aircraft tanks

Objective:

To develop Structural Health Monitoring methods for composite LH2 tanks at temperatures around -253 ^{0}C.

Partners Involved:

ONERA, NLR, DLR, INCAS (Romania), and possibly Saab and the University of Campania.

The exploratory group started their activities in 2022.

The future and impact of Structures and Materials

- Structures and Materials play a very important role in realizing the challenges the aerospace community will face in the coming years both for civil and military applications.

- For civil aerospace ambitious sustainability targets have to been set (net-zero carbon emissions by 2050)
- Structures and Materials will have an important role in realizing these targets and hence creating impact e.g.:
  - Novel airframe configurations will be required – strutted wing, blended wing, high aspect ratio wing
  - New propulsion and energy storing concepts – LH2 (20 K solutions)
  - Ultra-efficient lightweight components: Non traditional laminates in composites, Multi-Metal additive manufacturing
  - Sustainable materials and processes; e.g. thermoplastics and thermoplastic welding

The future and impact of Structures and Materials

The recent geopolitical satiation is pushing research and development in the field of structures and materials for military aerospace applications e.g.:

- Development of alternatives for strategic rare earth materials like titanium
- Materials and design concepts for hypersonic vehicles
- Development of multi-functional composites: e.g. integration of antennas and stealth characteristics, blast and armor protection
- Exploiting the potential of additive manufacturing techniques for meta-materials
- Development of high-entropy alloys

Conclusion