International Working Group on Methods for Structural Integrity Assessment for Aerospace Structures

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Motivation

Targets for future commercial aircraft structures:

- Increased efficiency
  - Lower fuel burn
  - Lower drag

  → Lower weight and higher stress levels

- Decreased costs
  - Lower manufacturing costs
  - Lower maintenance costs
  - Lower repair costs

  → Advanced manufacturing and maintenance concepts

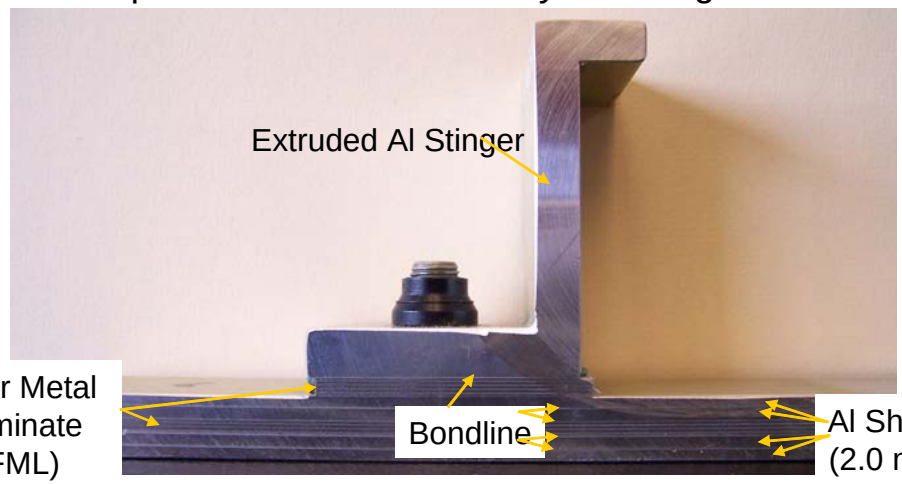
- Increased passenger comfort
  - Higher cabin pressure
  - Higher cabin humidity

  → Better damage tolerance and corrosion resistance

Alcoa Interests

- Alcoa R&D efforts are aligned to develop best ***structural solutions*** for future aerospace applications.
  - Combination of advanced materials (aluminum alloys, fiber metal laminates and fibers), innovative design concepts, novel manufacturing methods, and sensor technologies has the potential to deliver break-through weight and cost savings.
  - SHM work focused on promising sensor systems for these solutions and integrating sensors into the design to take full advantage of SHM enabled structure.
  - Working to develop analysis capabilities to handle advanced structures

Example of Alcoa Advanced Hybrid Wing Structure



Current Structural Integrity Approaches

- Damage tolerance assessments based on linear elastic fracture mechanics (LEFM) principles.
- Has worked well for 1970s and 1980s metallic design principles
- Assumes self-similar crack propagation – no crack turning or flapping
- Correction factors based on large scale test are needed to predict large damage capability (2-bay crack) on current fuselage designs (Boeing 777 and Airbus A340 and A380).
- Not readily applicable to advanced manufacturing concepts – integral or welded structures

Formation of Working Group

- **Working group on Methods for Structural Integrity Assessment for Aerospace Structures was proposed at end of workshop on this topic held at GKSS in Germany October 24 and 25, 2006.**

- **37 participants from 8 countries representing aircraft manufacturers, research institutions, universities and material suppliers.**

- **Group identified:**
  - **Structural design trends**
  - **Need for improved analysis methods**
  - **Hurdles to implementation of advanced analysis approaches**

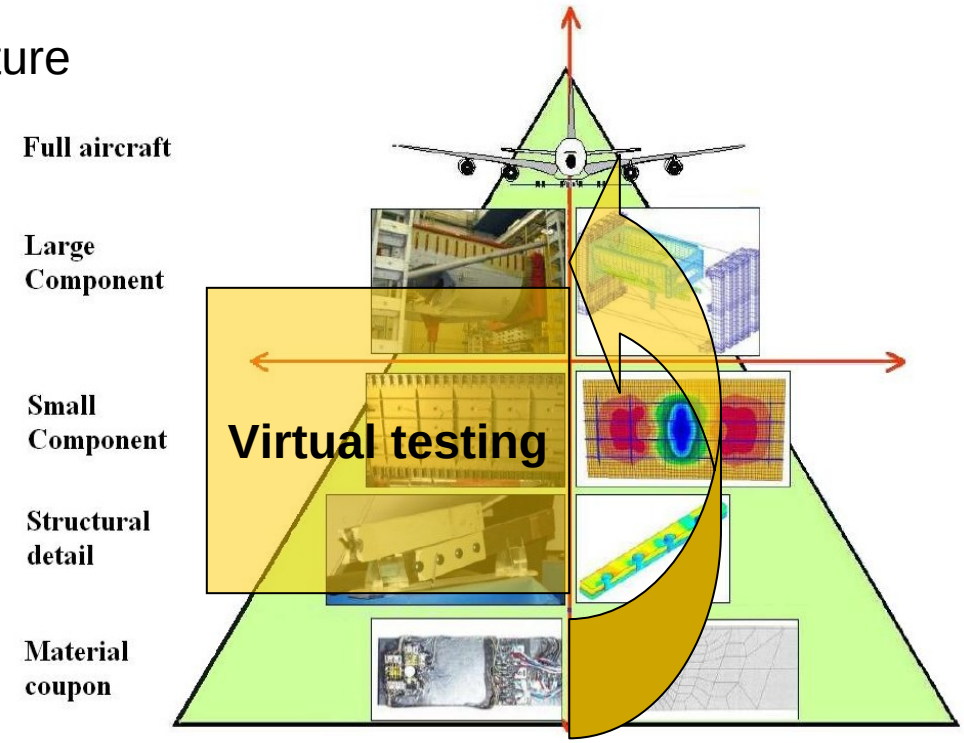
Structural Design Trends

- **Current Industry Trends:**
  - Increased focus on replacing testing with simulation
  - Use of integral and bonded structures
  - Desire to reduce uncertainty in design allowables

- **Need for improved analysis approaches to handle different failure modes.**
- **Demonstrated capability to go from coupon level material data to predicting structural detail or component behavior.**

What are we trying to understand/predict?

- Load vs. stable crack extension characteristics for different materials and design concepts, including effects of:
  - Specimen size and type
  - Anisotropy
  - Transfer from coupon to structure
- Maximum load carrying capability of structure
  - Failure mode
  - Transfer from coupon to structure
- Crack trajectory and branching
- **Ultimate goals:**
  - Reduce large structural tests through improved simulation
  - Reduce uncertainty in design allowables and material properties



Analysis Methods and Design Concepts For Thin-Walled Structures

- **Analysis methods in use or under development**
  - Linear Elastic Fracture Mechanics
  - Crack Tip Opening Displacement - δ_5
  - Crack Tip Opening Angle - CTOA
  - Cohesive Zone Model
  - Ductile Damage Model

- **Design concepts in use or under development**
  - Welded structures
  - Metal laminate and Fiber Metal Laminates (FML)
  - Composite structures
  - Selective reinforcement, bonded crack retarders
  - Integrated SHM systems

Purpose of Working Group

- **Develop consensus between industry and researchers on common methods for the structural integrity assessment of aerospace structures.**
- **Prepare a basis for standardization of structural assessment using advanced methods.**
- **Potential Topics (to be selected by working group)**
  - **Advanced methods for designing and ensuring structural integrity of aerospace structures.**
  - **Simulation tools: Classical fracture mechanics, damage mechanics, crack propagation models, FE techniques**
  - **Test philosophies: Optimization of test effort by combining simulation, small scale tests and limited large scale tests**
  - **NDI techniques, SHM**

Working Group Process

- Volunteer participants from industry, research institutions and academia.
- Participants select common problem to solve – start with one problem, for which validation test data is available.
- Participants analyze problem using preferred method and compare analysis approaches and results.
- Working group develops analysis recommendations and best practices and shares with broader community.

Current Status

- **Coordinators for working group have been named:**
  - **Prof. Karl-Heinz Schwalbe – GKSS**
  - **Dr. Markus Heinimann – Alcoa Technical Center**
- **Call for volunteer participants has been distributed.**
- **Recruiting participants, generating list of topics, collecting suggestions for available test data.**
- **Initial meetings planned to coincide with major conferences (ICAF, ESIS, etc.) to minimize travel.**
- **Always looking for participants – anybody interested?**

Summary

- International working group on methods for structural integrity assessment of aerospace structures is being formed.
- Purpose is to develop recommendations and best practices for structural integrity assessments of advanced aerospace structures.
- Improved predictions tools for prognostics and design for SHM enabled structures are areas of interest.
- Please see me if you are interested.

Thanks!