

# ***European Bonded Structure Meeting @ EASA***

*13<sup>th</sup> to 14<sup>th</sup> of June 2013, Köln*



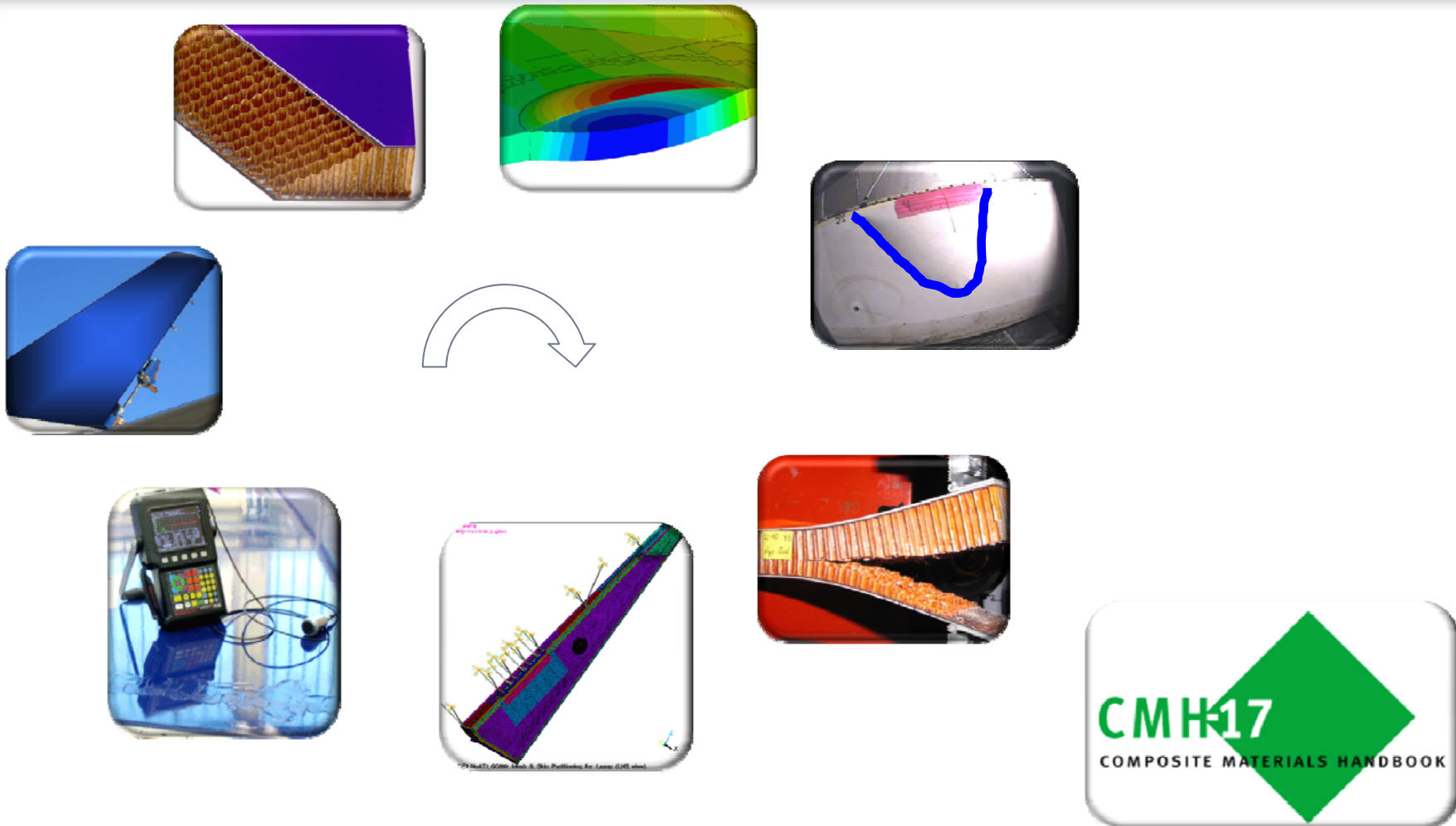
## ***Airbus Rudder Experience***

### ***Focus – Sandwich Disbond Growth due to GAG-Cycle***

Presented by  
Ralf Hilgers

# Airbus Rudder Experience

## Focus – Sandwich Disbond Growth due to GAG-Cycle



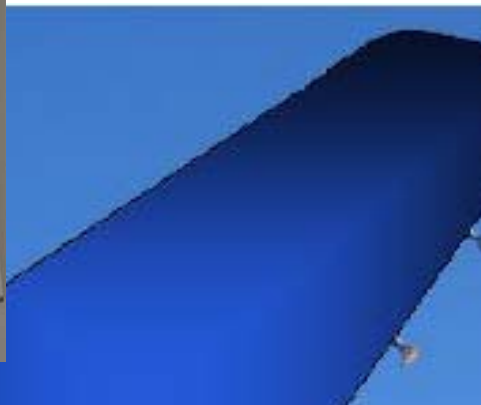
# Airbus Rudder Experience

## Focus – Sandwich Disbond Growth due to GAG-Cycle



# Airbus Rudder In-Service Experience

## In-Service Occurrences with Sandwich Structures triggered Comprehensive Studies



**Cause: Sandwich Damage Growth due to GAG-Cycle**

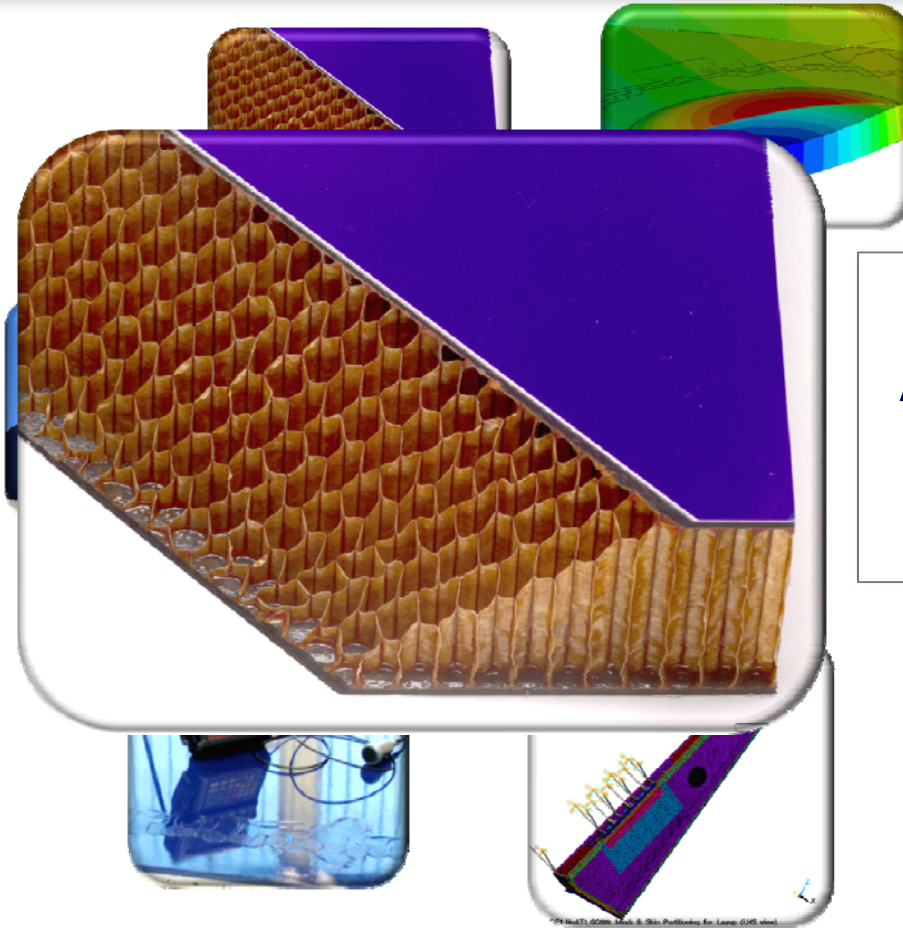
**Airworthiness importance of the subject for primary structures**

**Maintenance Inspection Program**



# Airbus Rudder Experience

## Focus – Sandwich Disbond Growth due to GAG-Cycle

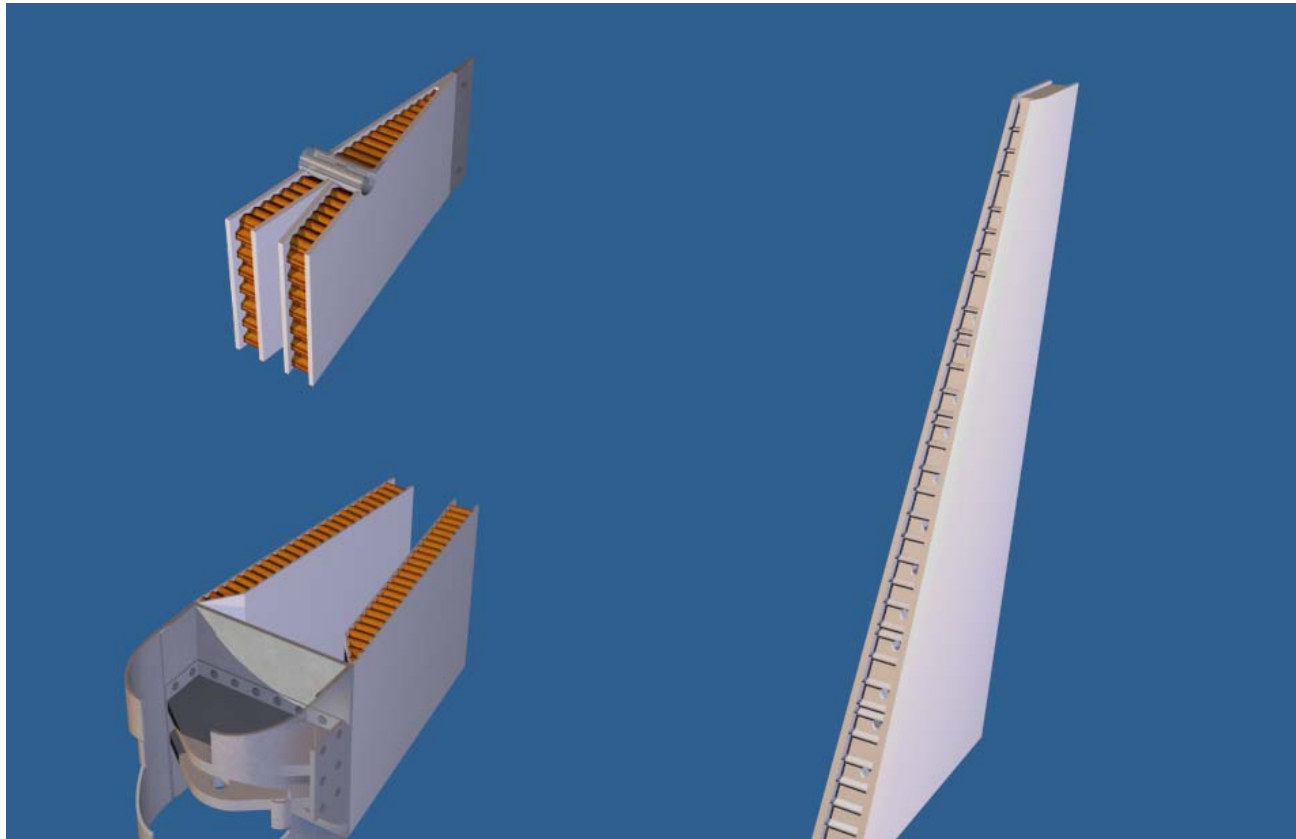


### Airbus Sandwich Rudder Design



# Airbus Sandwich Rudder Design

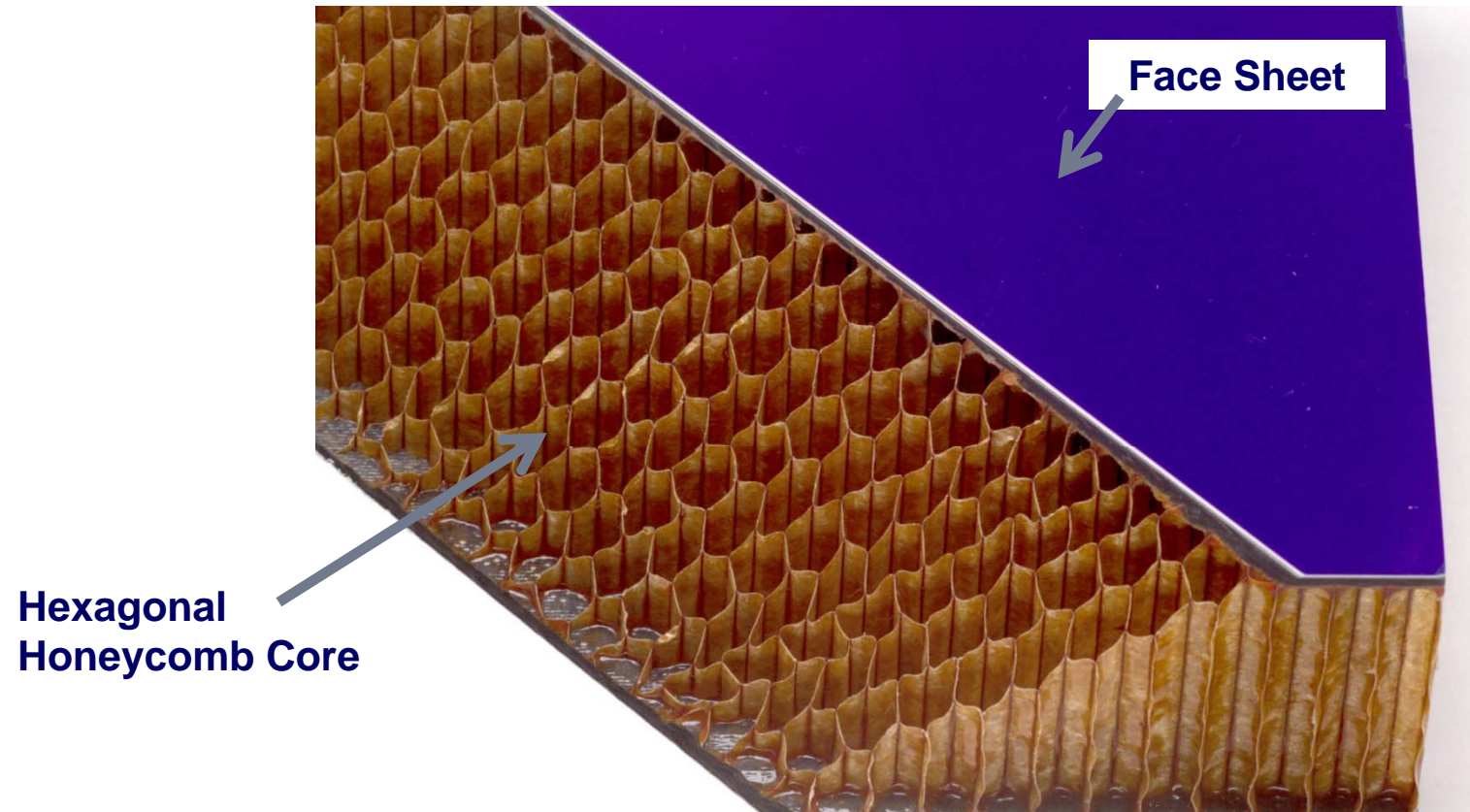
## Rudder Design Principle



**> 30 Years of In-Service Experience**

# Airbus Sandwich Rudder Design

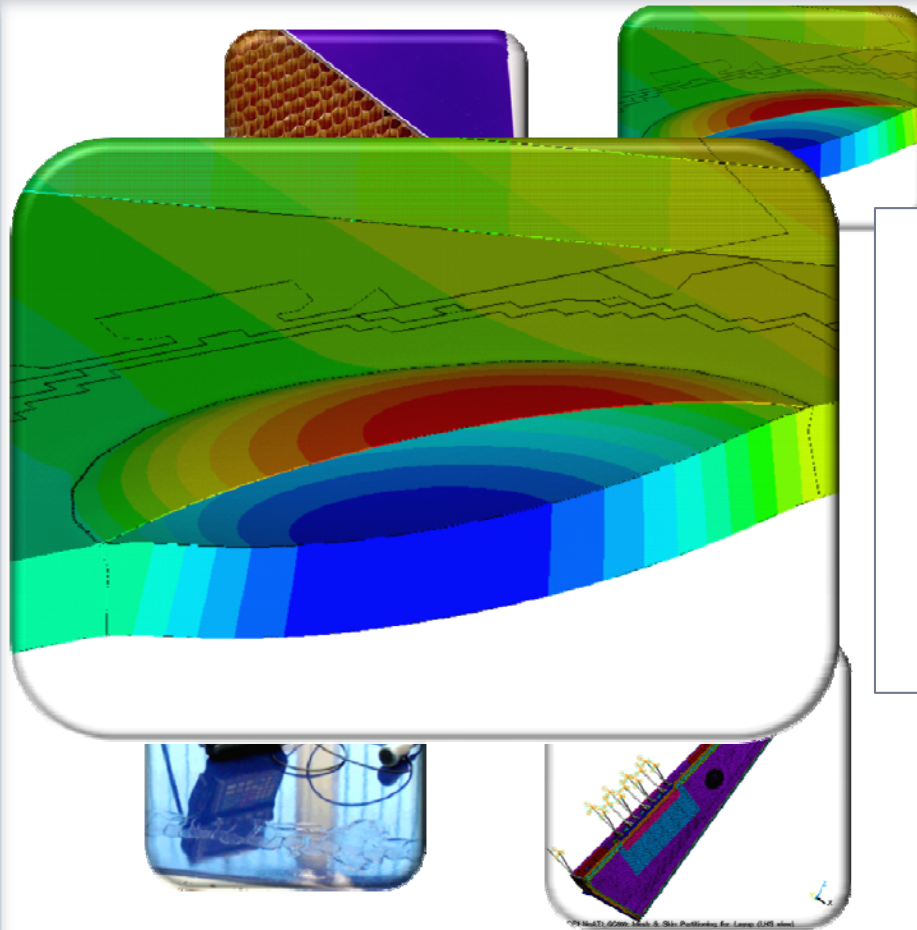
## Lightweight Honeycomb Sandwich Design Principle



**Key Elements → Stiffness & Core Fracture Toughness**

# Airbus Rudder Experience

## Focus – Sandwich Disbond Growth due to GAG-Cycle



**GAG-Cycle  
Ground-Air-Ground  
&  
Relevant Damage Types**

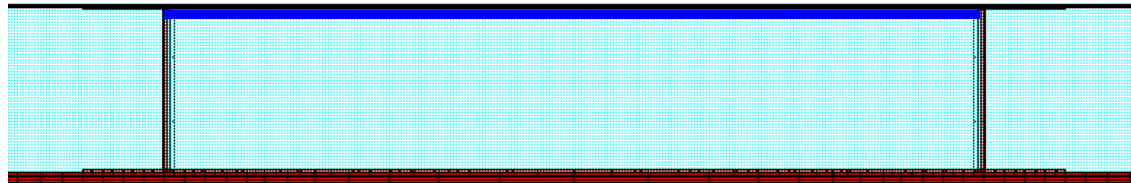




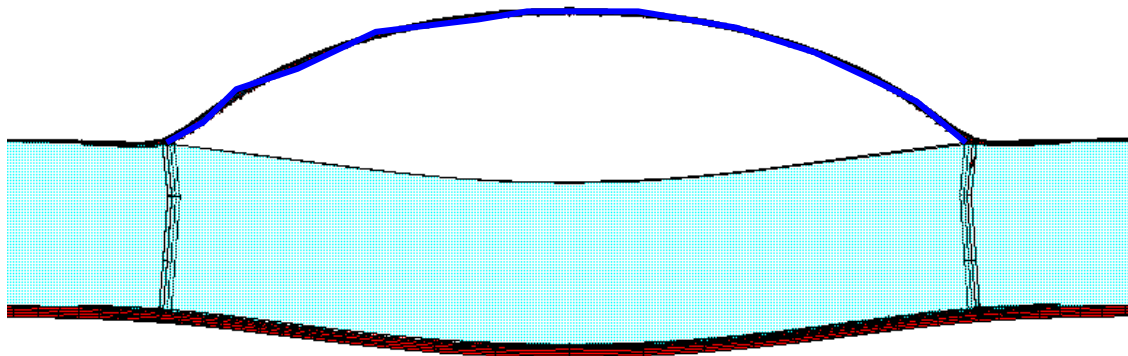
# GAG-Cycle

## GAG-Cycle [Ground-Air-Ground Cycle]

Section cut thru a sandwich



**A/C on Ground**

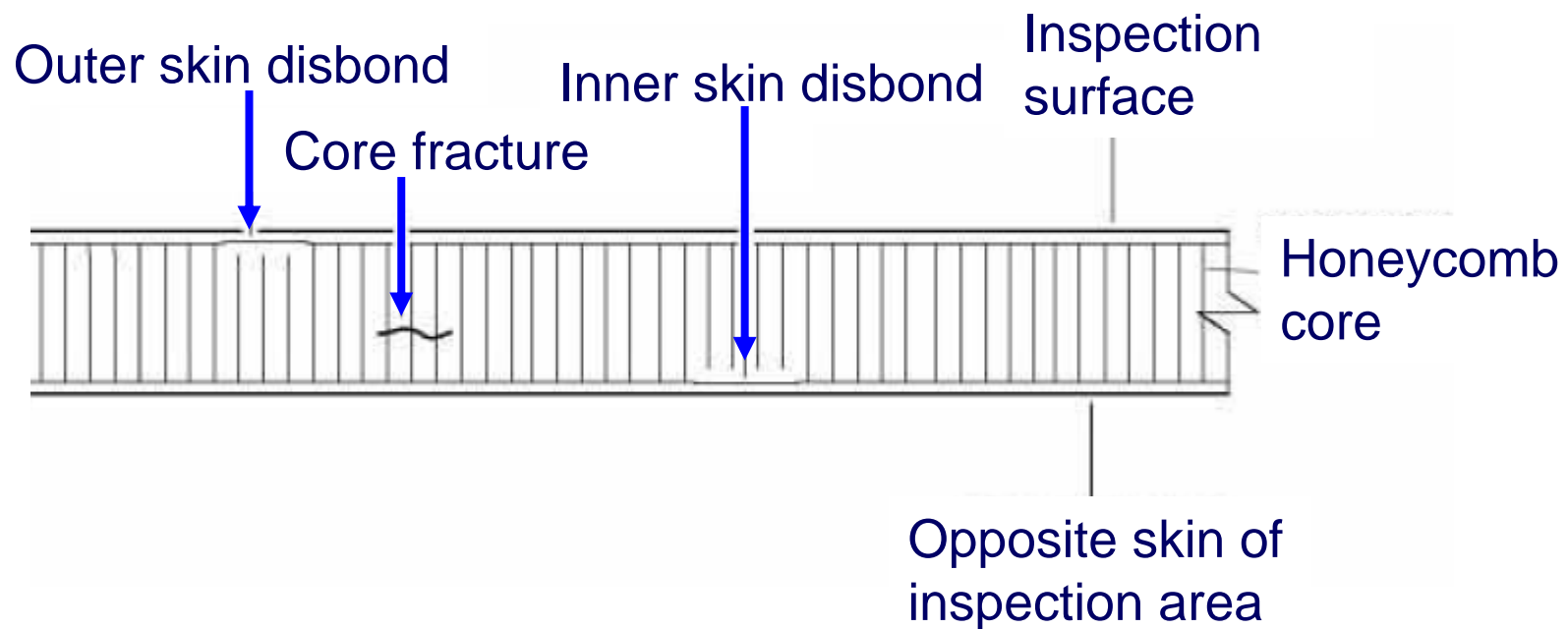


**At flight altitude**

**GAG-Cycle & In-Plane Loading → contributor for sandwich damage growth**

# Damage Types relevant for GAG-Cycle

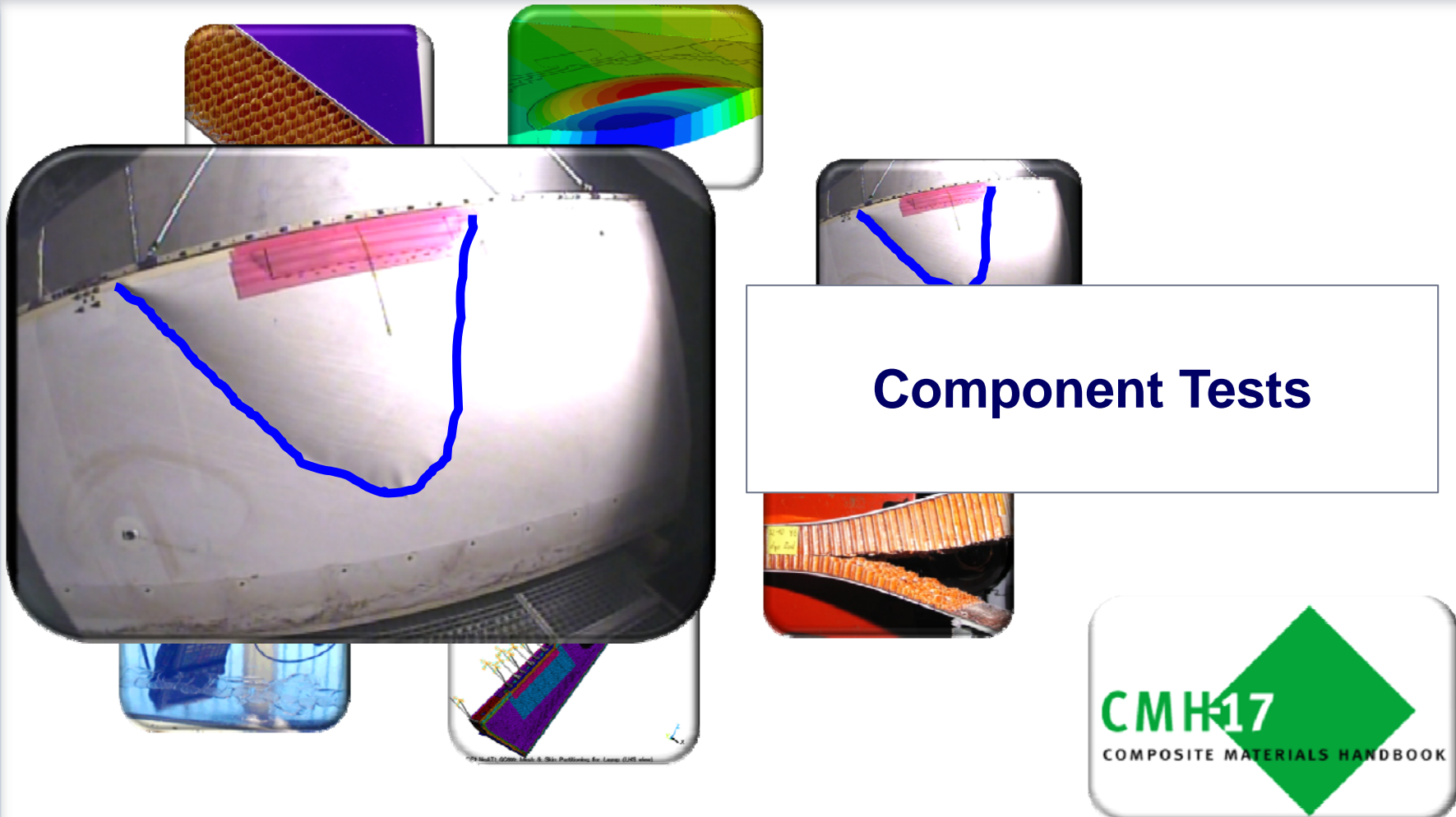
## Honeycomb core damage types prone to GAG-cycle damage growth



**Internal sandwich damages are non-visible from outside**

# Airbus Rudder Experience

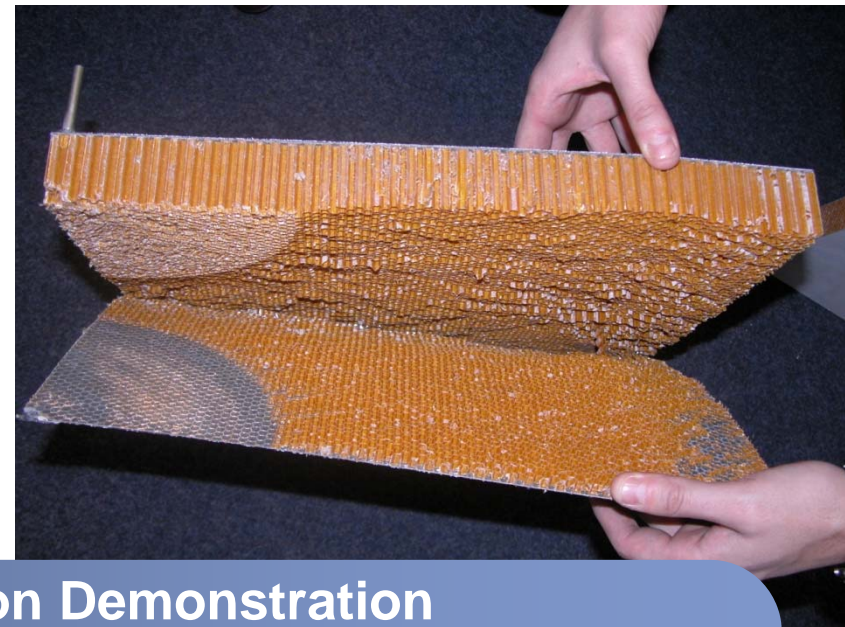
## Focus – Sandwich Disbond Growth due to GAG-Cycle



# Component GAG-Cycle Test

## Sandwich Disbond Panel GAG-Cycle Tests

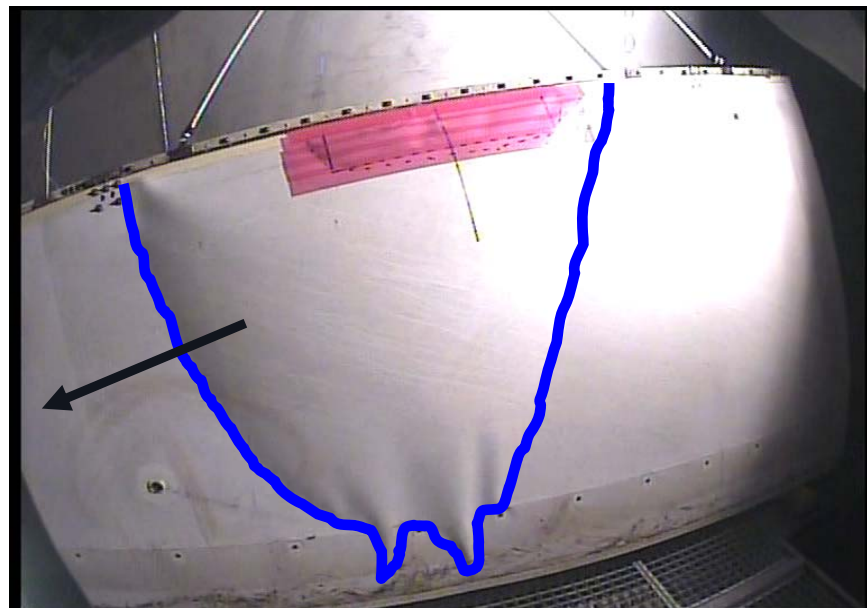
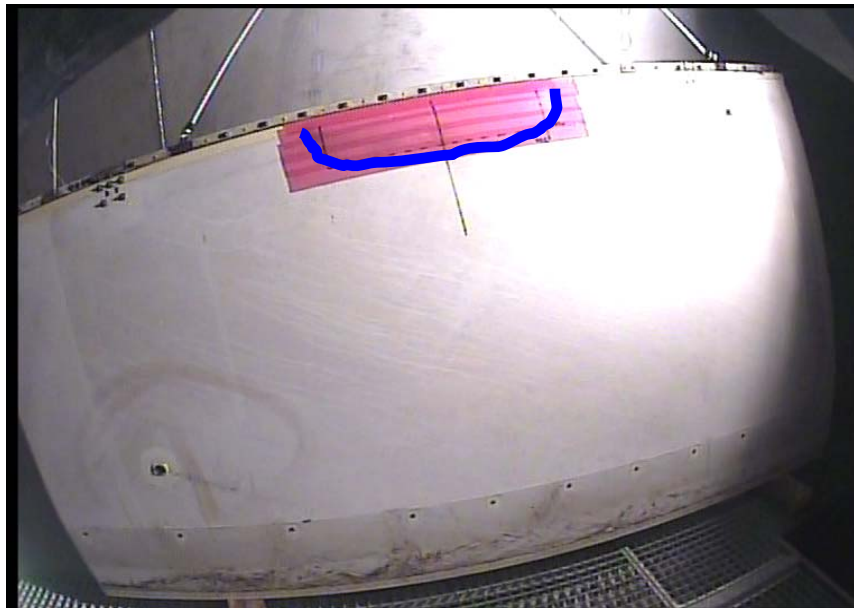
- Single GAG-Cycle Tests
- Fatigue GAG-Cycle Tests



**Disbond Propagation Demonstration**  
**Fracture Mode → Honeycomb core fracture**

# Component GAG-Cycle Test

## Large Side Shell Disbond Test



**Beyond critical size rapid disbond propagation**

Video 



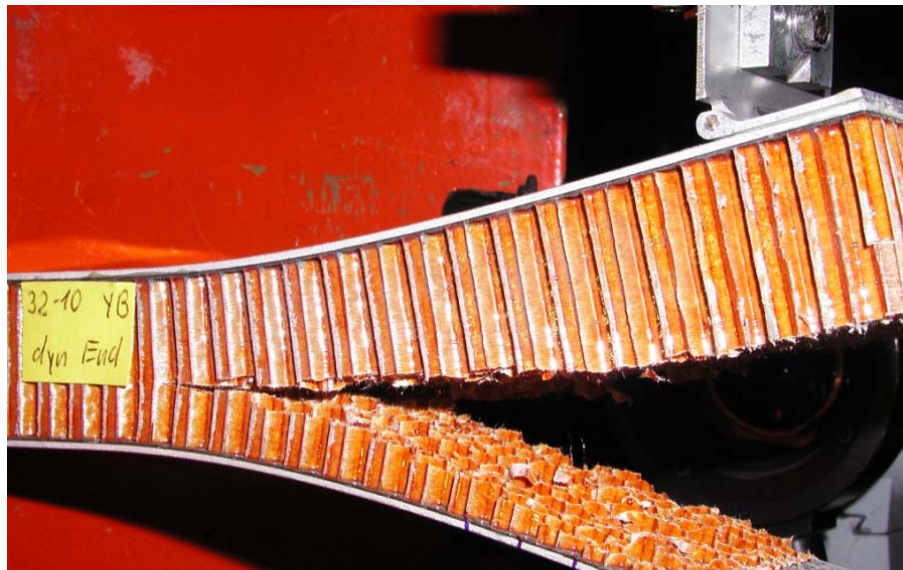
# Airbus Rudder Experience

## Focus – Sandwich Disbond Growth due to GAG-Cycle



# Coupon G1C test

**Key Property to characterize the sandwich disbond and residual life**

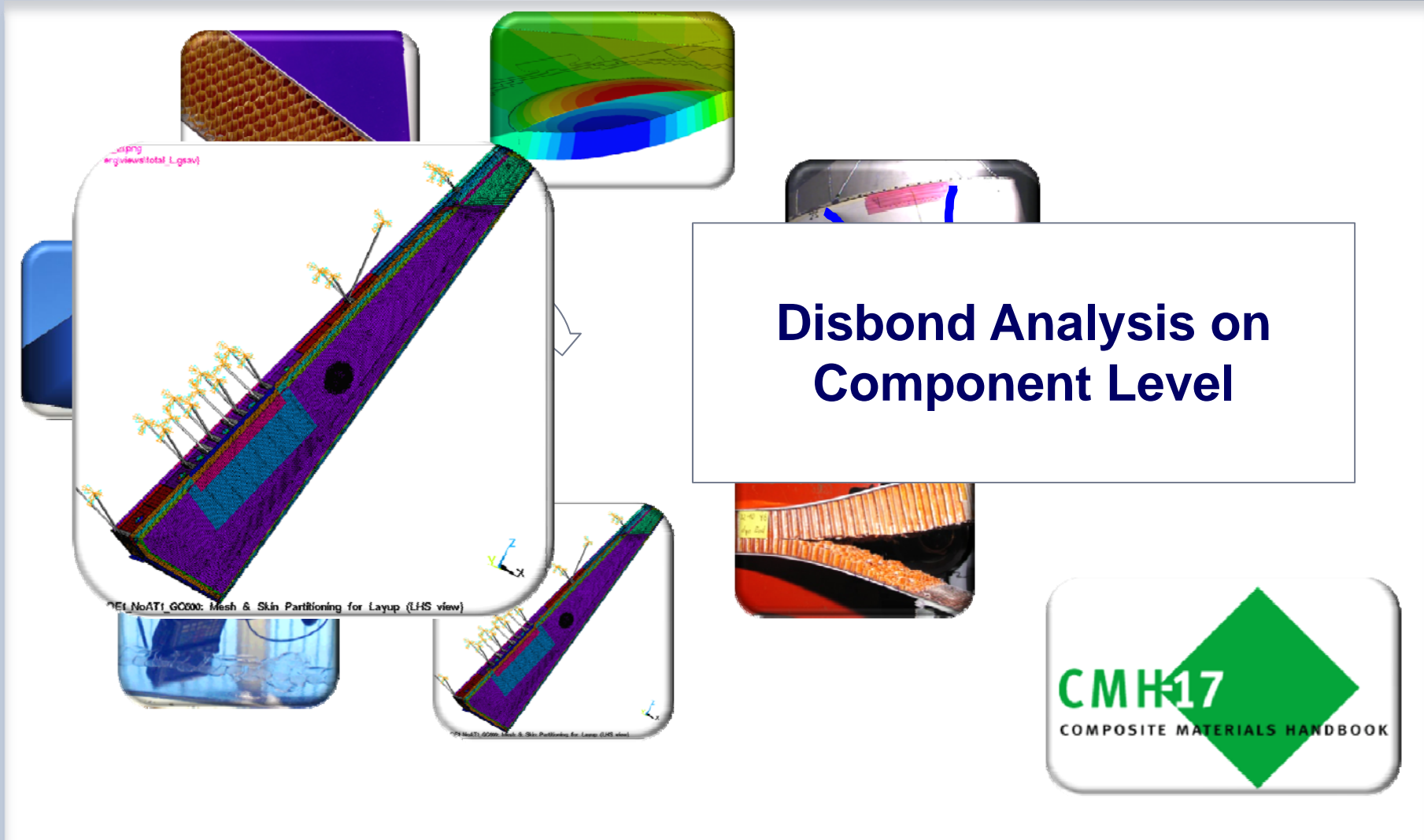


**Fracture Toughness & Fracture Mode observed at Component Test**

**Coupon test is key to determine static fracture toughness as well fatigue behavior → Maintenance Interval**

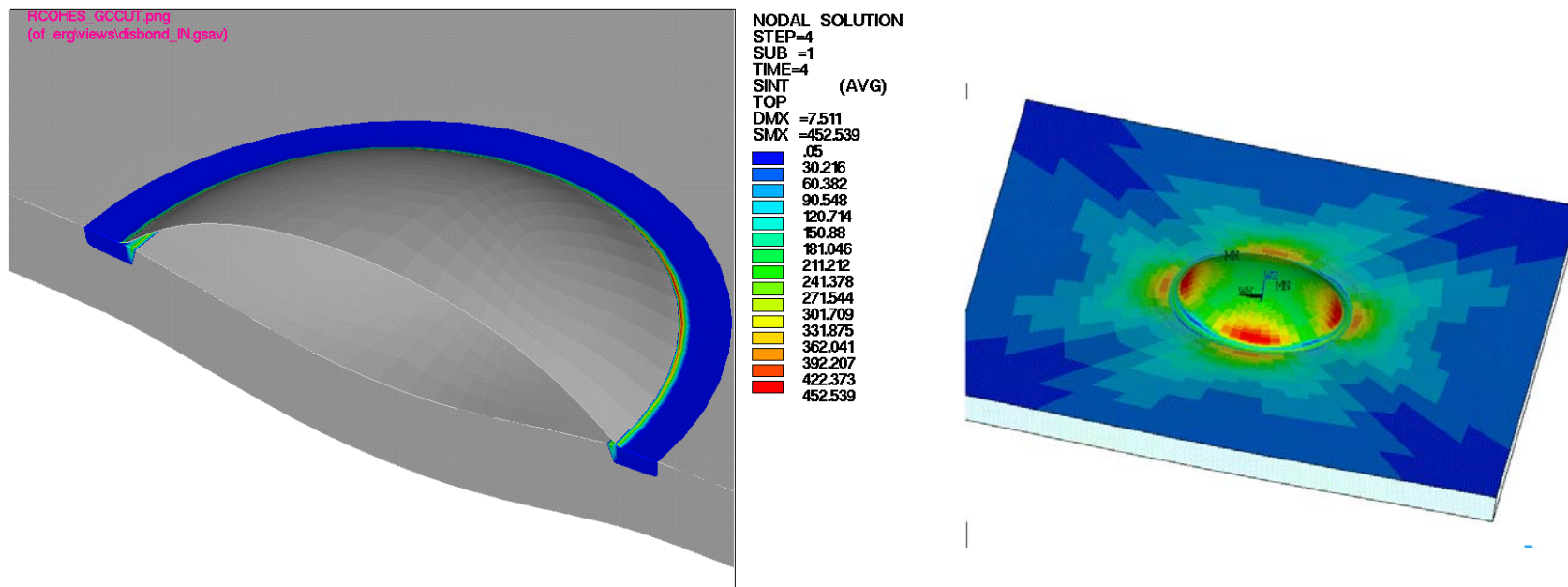
# Airbus Rudder Experience

## Focus – Sandwich Disbond Growth due to GAG-Cycle



# Disbond Analysis on Component Level

## Energy release rate ERR [J/m<sup>2</sup>] along disbond border

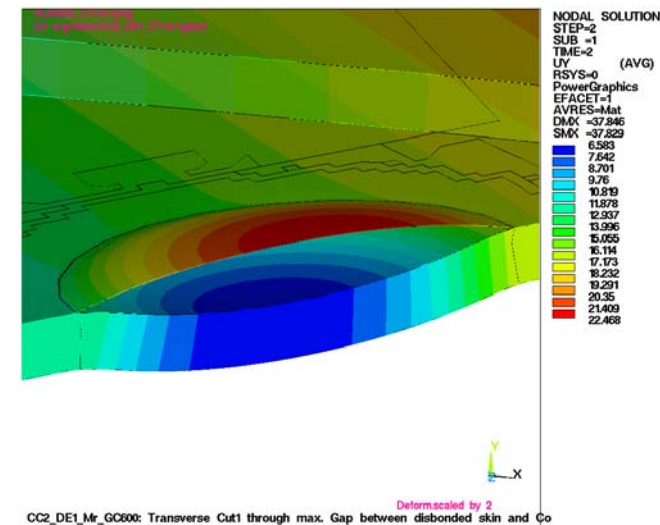
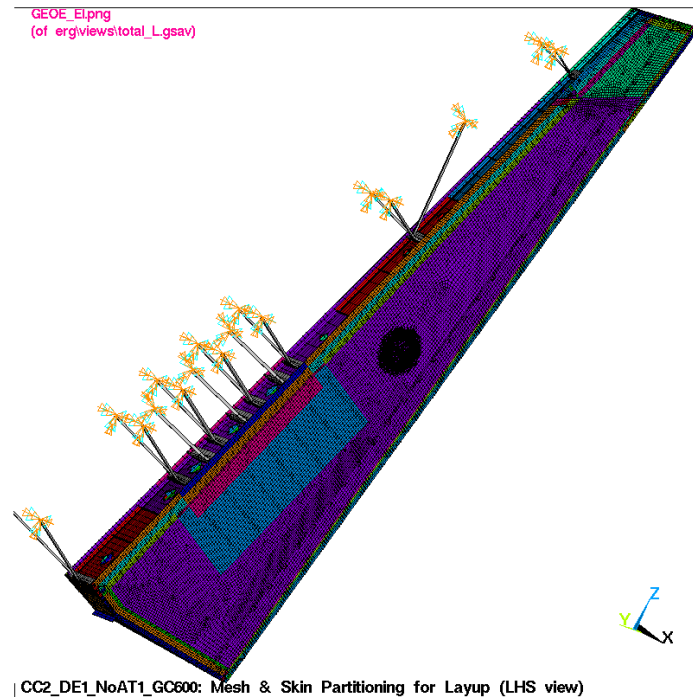


**GAG-Cycle Simulation**  
**Study of ERR for different Sizes & Panel Configurations**



# Disbond Analysis on Component Level

## Disbond Analysis at rudder



Combination of GAG-Cycle & In-Plane Loading



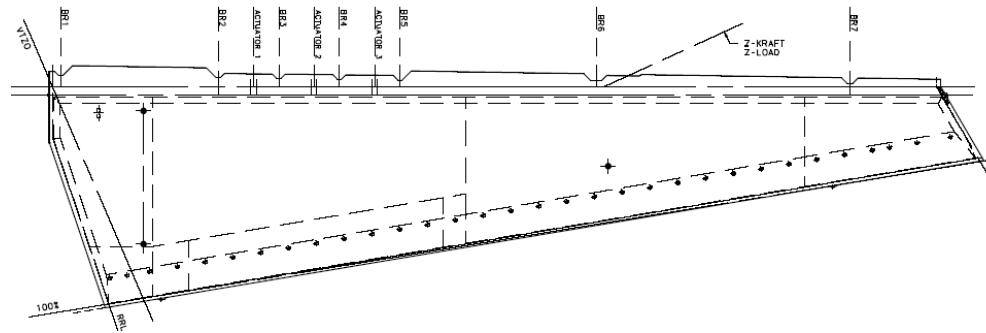
# Airbus Rudder Experience

## Focus – Sandwich Disbond Growth due to GAG-Cycle



# NDI - Inspection

## Inspection methods & capabilities



**Disbond typically non-visible**

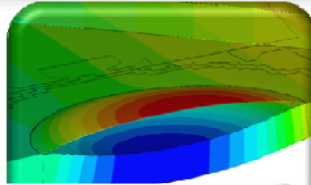
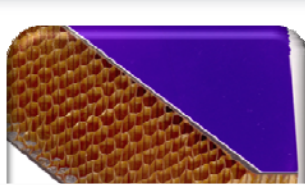
**Detectability size (40 or 100mm diameter)**

**Rear side disbond detection**

**Maintenance Inspection Program**

# Airbus Rudder Experience

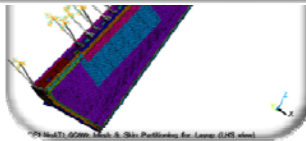
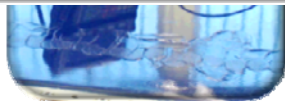
## Focus – Sandwich Disbond Growth due to GAG-Cycle



**CMH-17**

COMPOSITE MATERIALS HANDBOOK

### Honeycomb Sandwich Disbond Growth Team



**CMH-17**

COMPOSITE MATERIALS HANDBOOK

# CMH-17 Sandwich Disbond Growth Team

**Industry, University & AA Forum**

**Airbus shares subject and its relevancy for Airworthiness**

**Key Element → Sandwich Fracture Toughness**

**Standard Coupon Test Method → SCB**

**Sandwich GAG-Cycle Test**

**Analysis on Coupon & Component Level**

**Fracture Mode & Environmental Effects**

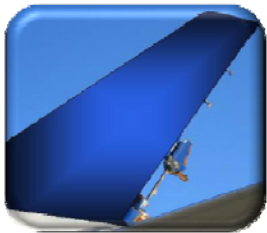
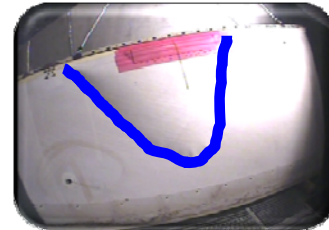
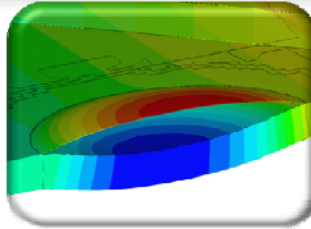
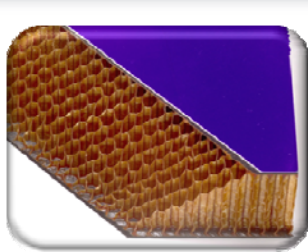
**Part influence (flat, curved, pressurized fuselage)**

**GAG-Cycle & In-Plane Loading**

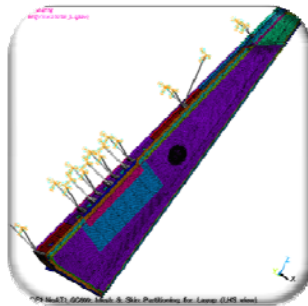
**Expected outcome: CMH-17 Chapter & Subject addressed by  
AA**

# Airbus Rudder Experience

## Focus – Sandwich Disbond Growth due to GAG-Cycle



## Conclusion





# Conclusion

**Airbus Investigations on Sandwich Damage Growth due to GAG-Cycle**

**Test & Analysis**

**Maintenance Inspection Program**

**Airbus addressed the Airworthiness Importance of the Subject**

**Airbus shared the subject during several FAA conferences**

**CMH-17 Group → Forum to spread & precise subject**

**Public description of the phenomenon**

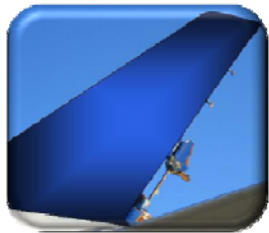
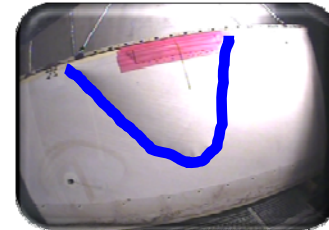
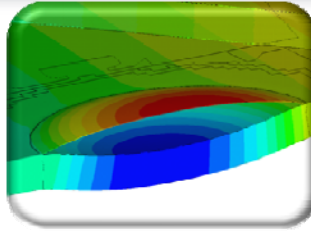
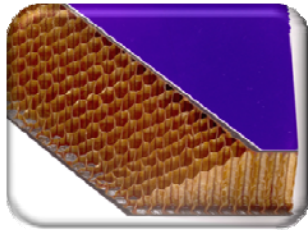
**Standard Fracture Toughness Test Method**

**Recommendations for future AA-Regulation**

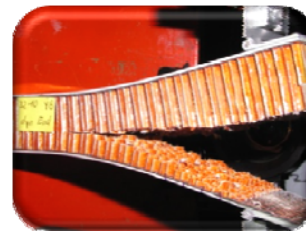
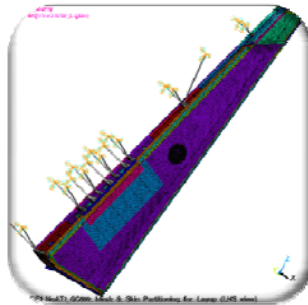
**Need to increase composite repair awareness and repair knowledge**

# Airbus Rudder Experience

## Focus – Sandwich Disbond Growth due to GAG-Cycle



## Questions





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