Development supported by simulation of a test bench for the validation of a composite horizontal tail plane structure

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SABCA

Presentation outline

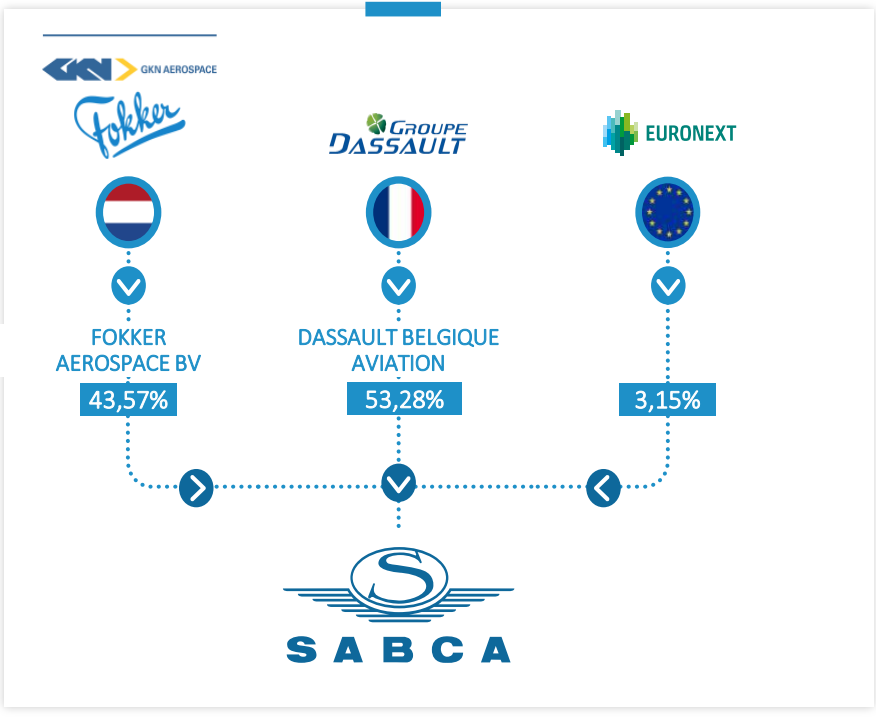
1. Introduction to SABCA
2. Context of the development
3. Demonstrator design
4. Test setup
5. Test loads derivation & test sequence
6. Detailed model
7. Sizing and interface validation
8. Next steps
9. Acknowledgment

SABCA PROPRIETARY - CONFIDENTIAL IN USE

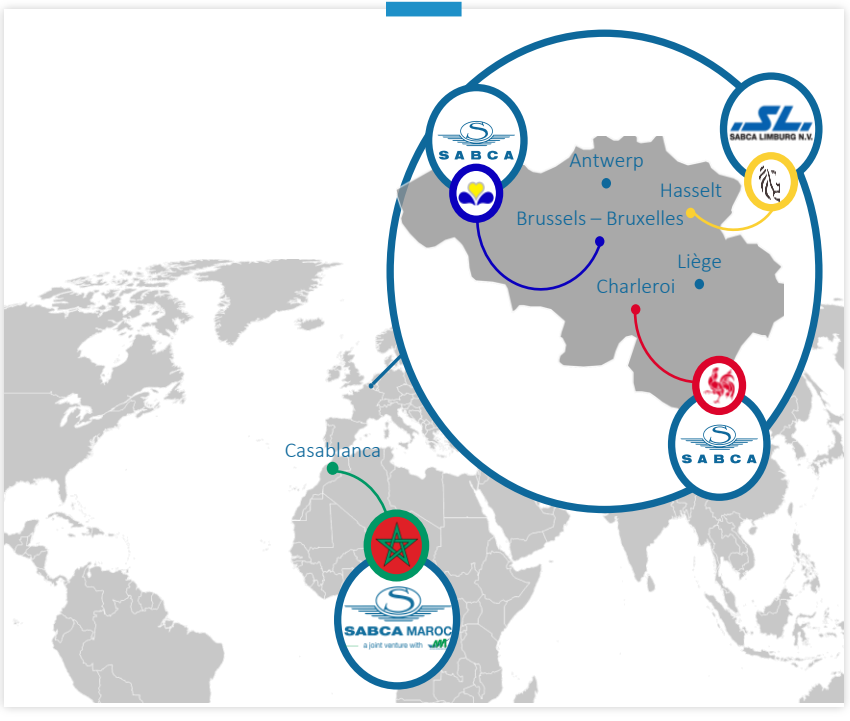
Shareholder & Plans

> Facts & Figures

LONG-TERM, STABLE AEROSPACE SHAREHOLDERS



LOCATIONS IN THE 3 BELGIAN REGIONS + IN MOROCCO



Brussels

> PLANTS

Established in **1920**

680 employees

1,120,000 Sq. feet
105,000 m^2

- Group HQ
- Engineering Dept.
- Metal Manufacturing
- Testing
- Actuators
- Electronics
- Surface Treatment

Gosselies

> plants

Established in **1955**

292 employees

540,000 Sq. feet
50,000 m^2

- Aircraft & Helicopter MRO&U
- Engineering Department
- Direct Access to Runway
- Own Control Tower
- Painting Facility

Lummen

> plants

Established in **1992**

90 employees

215,000 Sq. feet
20,000 m^2

- Composite Systems
- Engineering Department
- 16ft X 49ft Autoclave
- Automatic Tape Layer

Morocco

> PLants

Established in **2012**

70 employees

- Aero structure Assembly
- Joint Venture with AAA
- African Footprint

Focus on Integrated composite structures

> Integrated assemblies

- 3 Autoclaves
  - Max. Usable Ø: 5500 mm
  - Max. Outside Ø : 6100 mm
  - Max. Length: 15000 mm
- 2 Automated tape layers
- Automated Trimming
- Robotised Ultra Sonic Inspection

Up to **15 m / 49 ft**
Composite structures

Commercial and transport Aircraft

> Aerostructures

FUSELAGE & TAILPLANE


AIRBUS A320 FAMILY


AIRBUS A330


AIRBUS A380

METAL


EQUIPPED TAILCONE


REAR LOWER SHELL


VERTICAL TAIL RIBS

CFRP

WING HIGH-LIFT

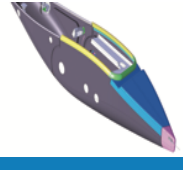

AIRBUS A400M


AIRBUS A350XWB


FLAP SUPPORT MECHANISMS


FLAP SUPPORT STRUCTURE


INTEGRATED FLAP SKINS


FLAP SUPPORT FAIRINGS

Business & Regional Jet

> Aerostructures

FUSELAGE & TAILPLANE

GULFSTREAM G650

DASSAULT FALCON JETS

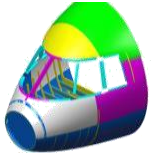
DASSAULT F5X

DORNIER 728

METAL

METALLIC FLOOR

FUSELAGE ELEMENT



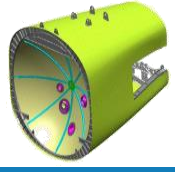
FUSELAGE ELEMENT

HTP SKINS & SPARS

HTP SKINS

HTP SKINS & SPARS

CFRP



FUSELAGE ELEMENT

Context of the development

- Main aim of the project for SABCA is to develop more integrated structures based on an out-of-autoclave (OOA), closed mould process, specifically SQRTM

Objectives :

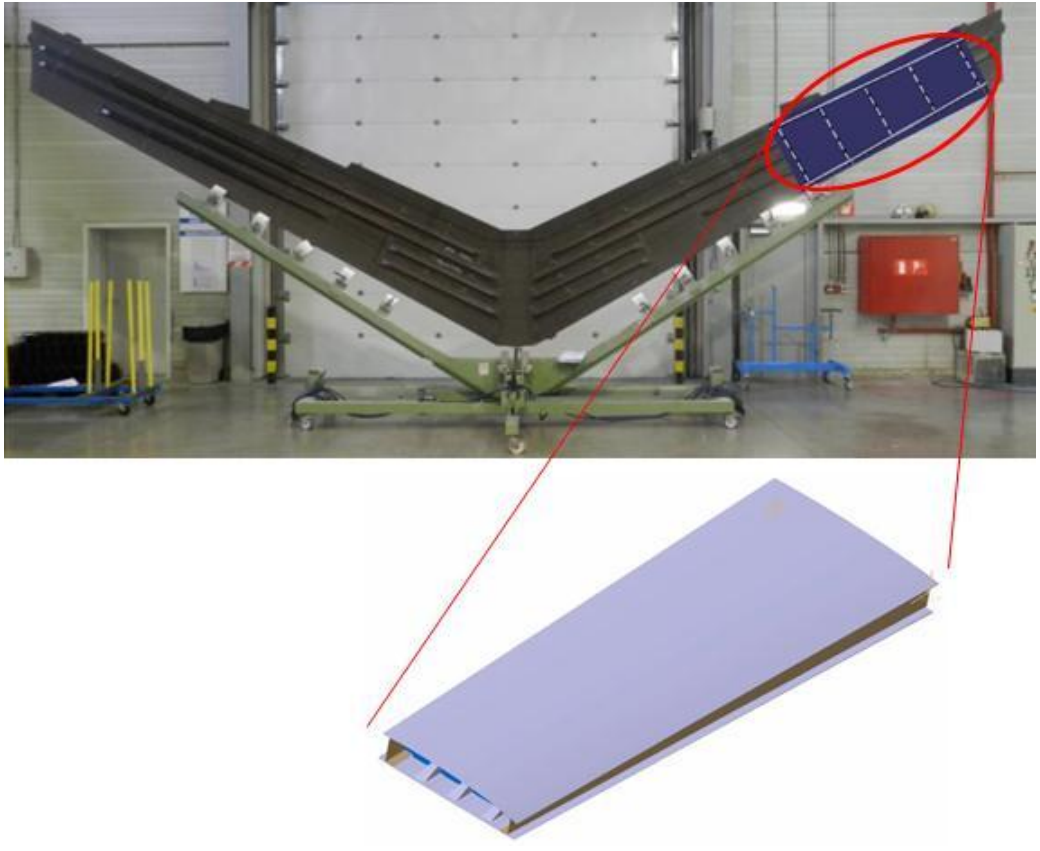
- Reduction of assembly time and fastener count (cost and weight)
- Better quality because of OOA parts (surface quality and tolerances, repeatability)
- Approach net shape ideal

Challenges :

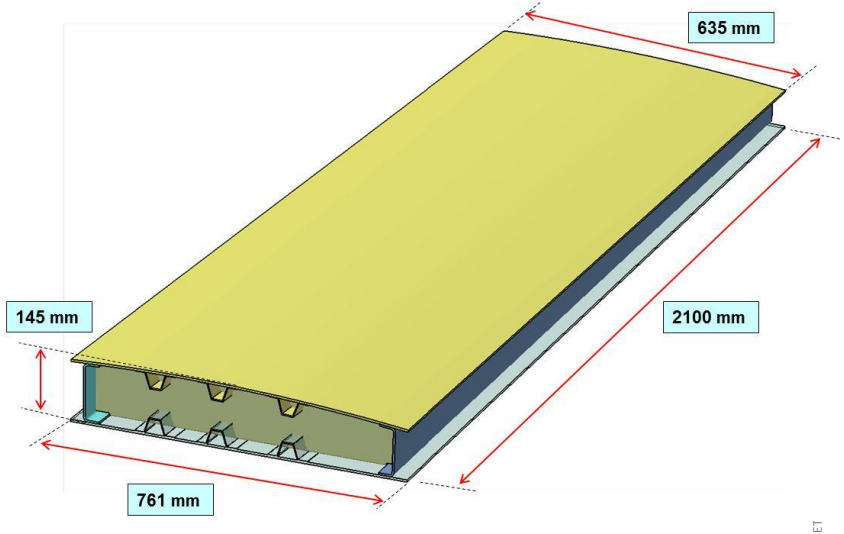
- Find right level of integration (structure must still be inspectable and repairable)
- Post-curing deformation of the integrated part
- Handling of potentially large preforms and blocks of closed moulds

Demonstrator design

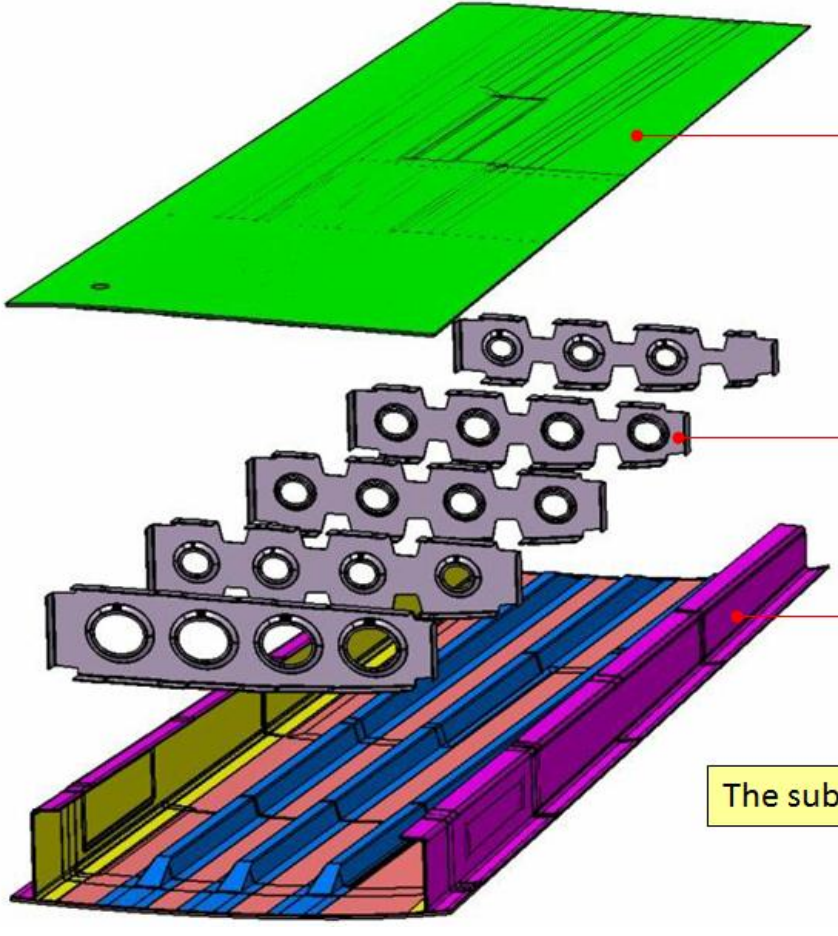
- Selection of a wingbox type structure representative of a SABCA production



Chordwise : true length
Lengthwise : long enough to capture post-cure deformation issues
Geometry : some simplification, but varying thicknesses and double curvature kept



Demonstrator design



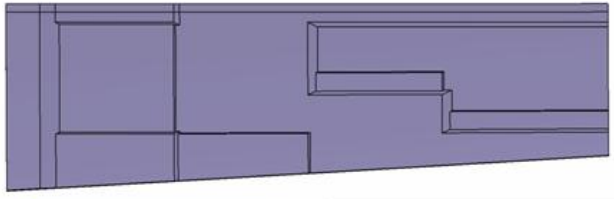
ATL laid panel / autoclave cured / thermoset

Thermo-formed ribs / thermoplastic

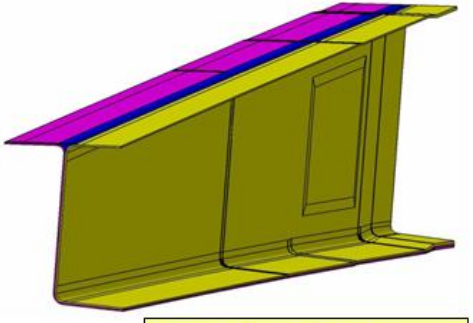
Integrated OOA part / SQRTM / thermoset

The sub-elements are assembled together by fasteners

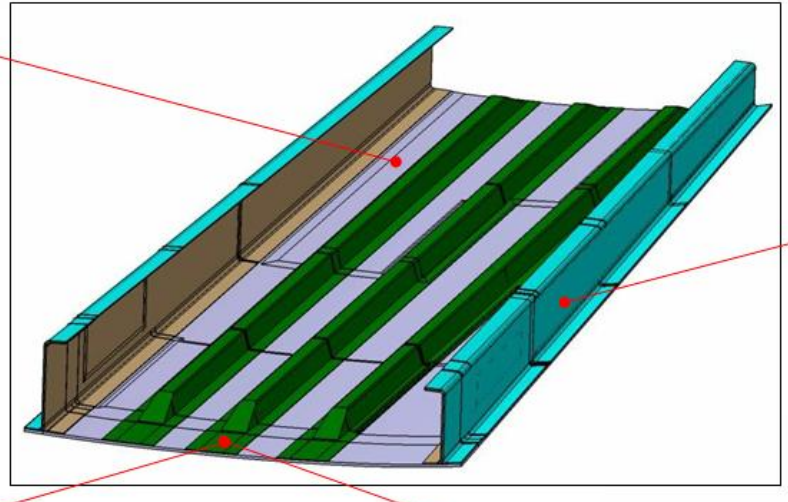
Demonstrator design



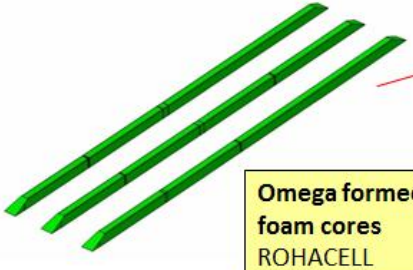
Integrated stiffened lower skin and spars



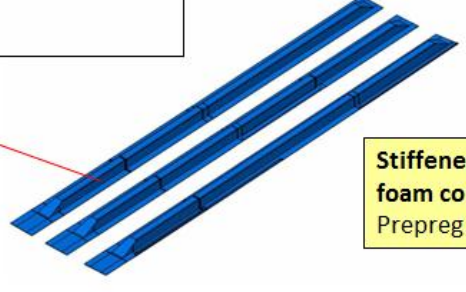
Skin laid up on tool
ATL prepreg



Longeron preforms :
C + Z preforms hot-formed
ATL prepreg

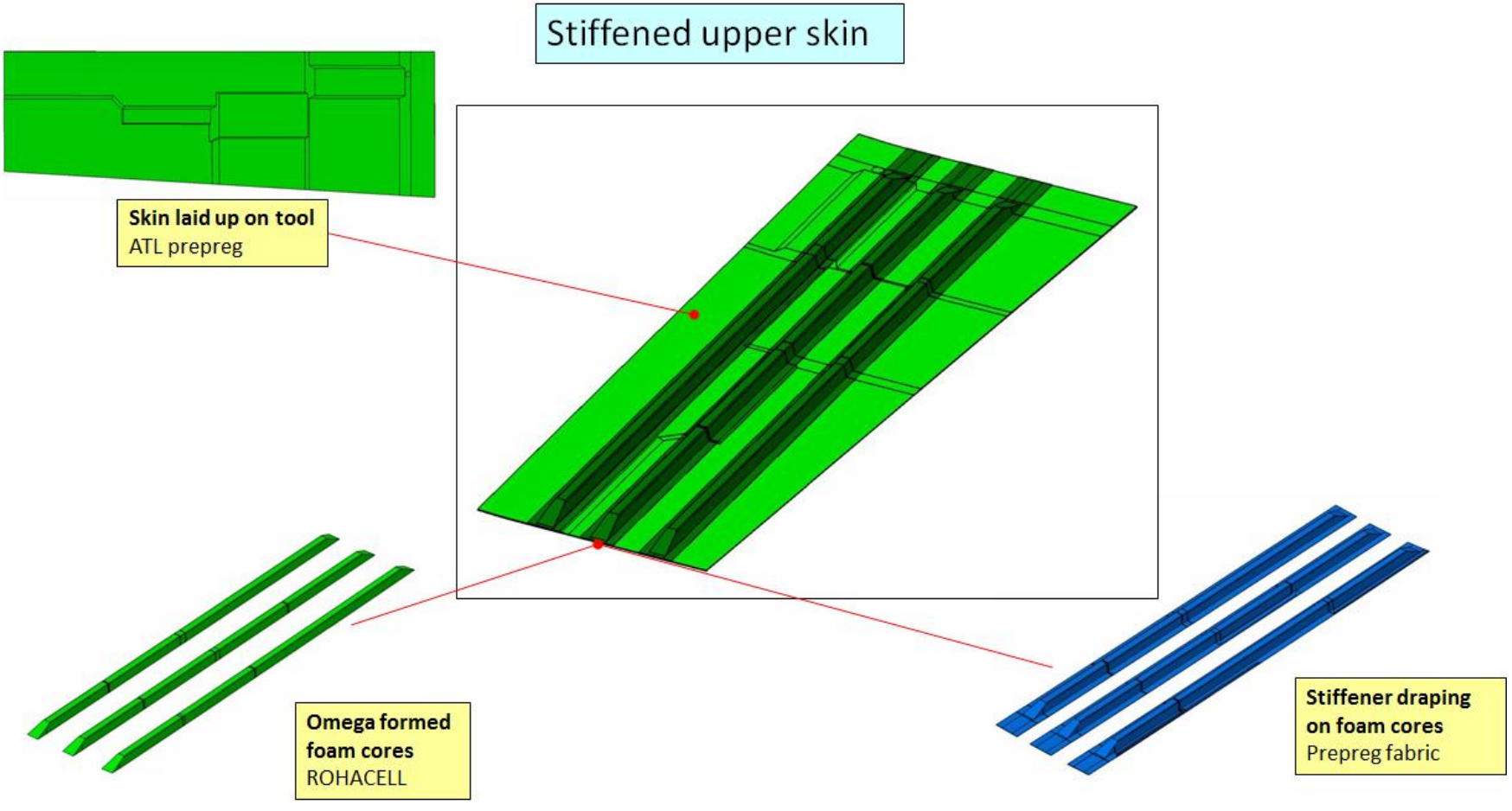


Omega formed foam cores
ROHACELL



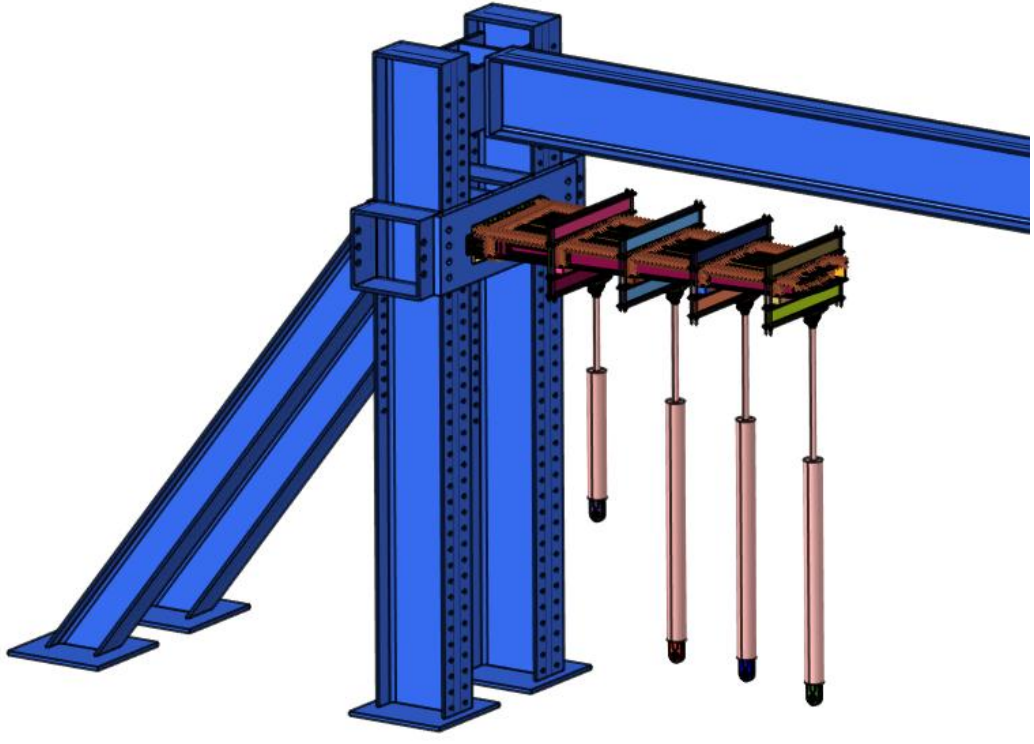
Stiffener draping on foam cores
Prepreg fabric

Demonstrator design



Test setup

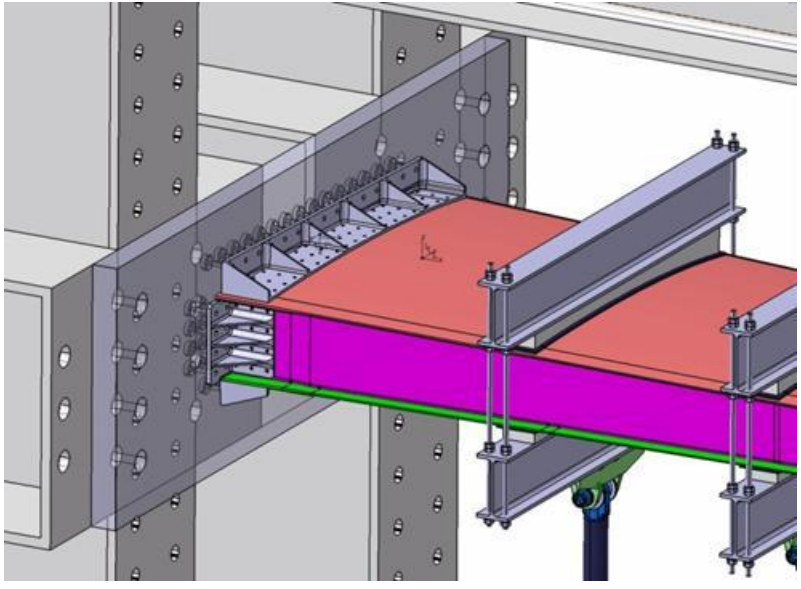
- Clamped interface on inboard side
- 4 hydraulic jacks for static and fatigue load introduction



Tests will be made at ULG M&S

Test setup

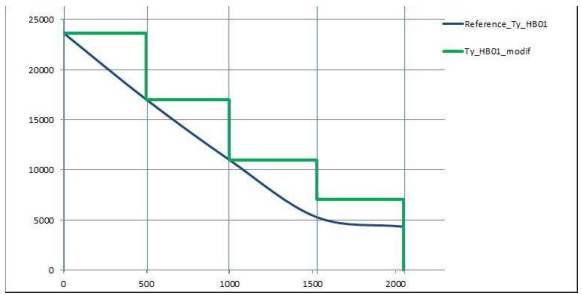
- Interface plate with test load portal
- Interface aluminium brackets designed to avoid fastener overload
- Standard steel profiles with steel rods for transmitting the jack loads
- Wooden blocks interface for matching skin profiles and rubber sheets to avoid excessive bearing load on composite



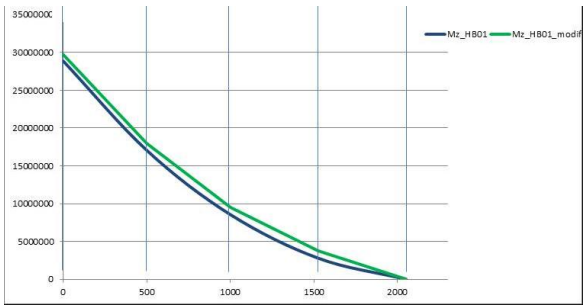
Test load derivation & test sequence

- Selection of a critical static load case from the real structure
- Upward approximation of the shear, bending and torsion loads with the 4 discrete loads
- Lengthwise and chordwise load positioning for best load fit

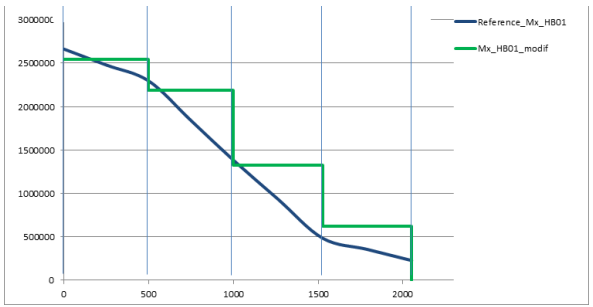
Shear



Bending

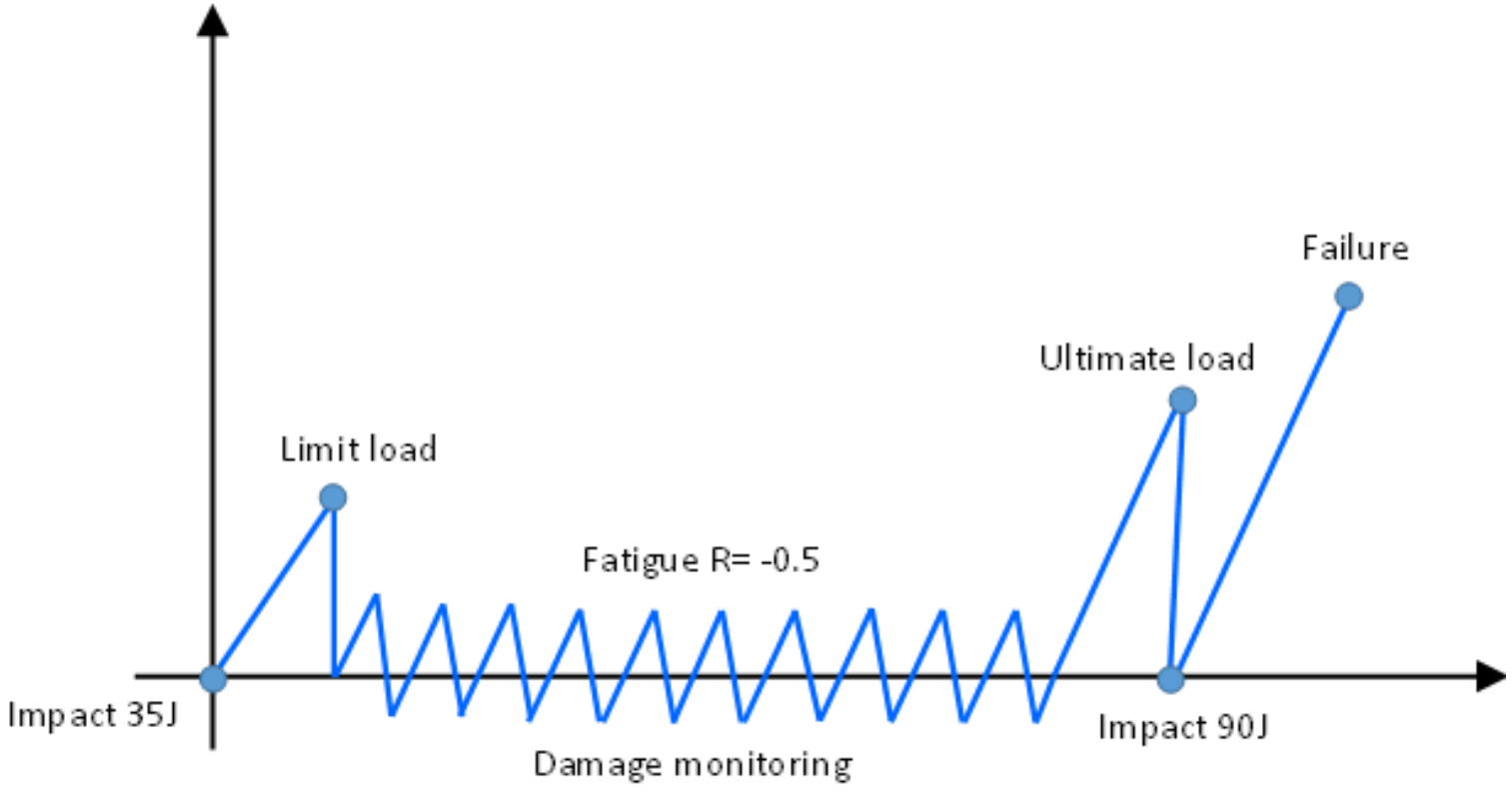


Torsion

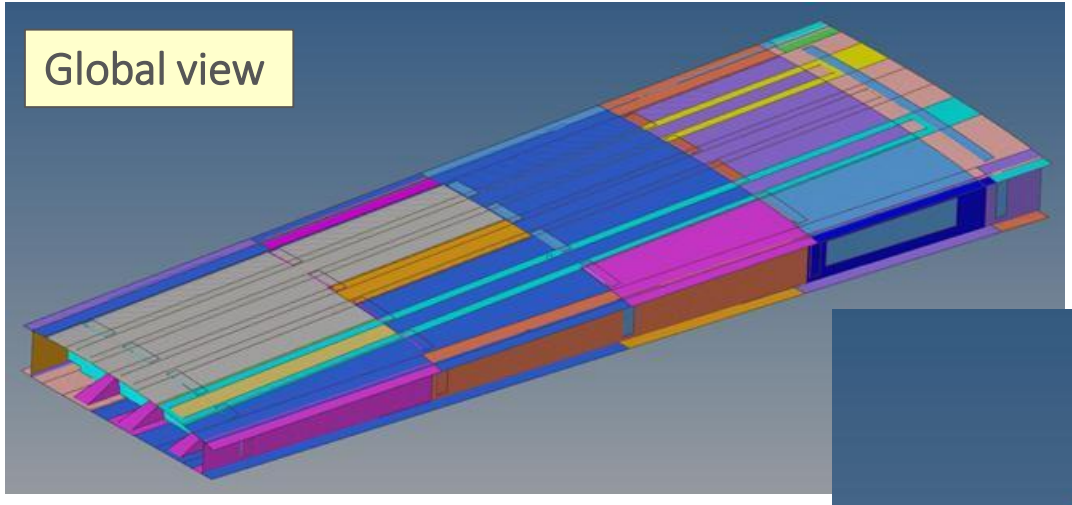


Test load derivation & test sequence

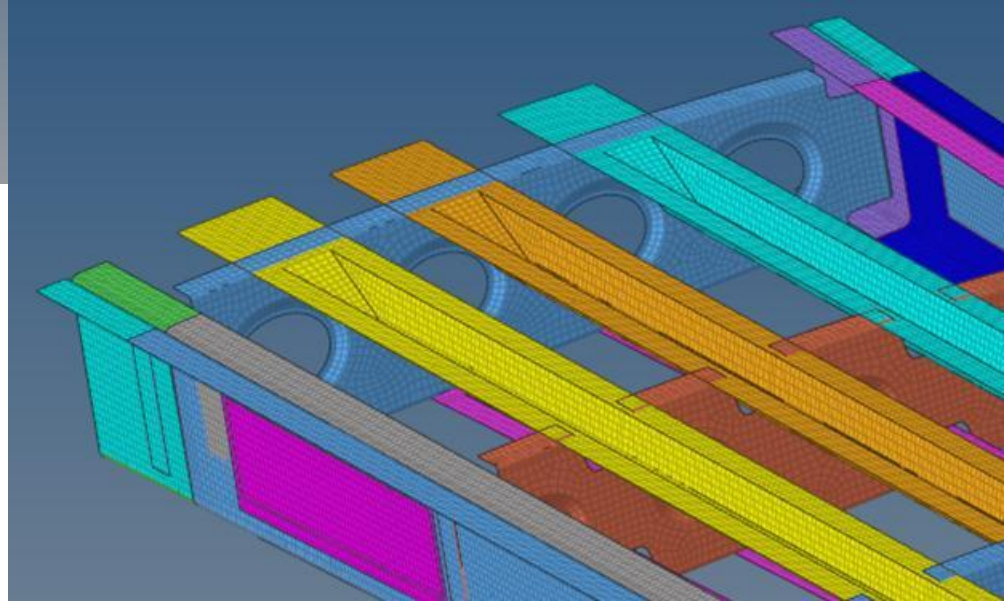
- Proposed test sequence



Detailed model



HTP:
- # Elements = 149628
- # Nodes = 154554
- Finite element size ≈ 7mm

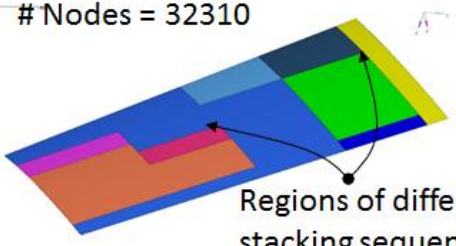


Components are modelled with shell FE elements

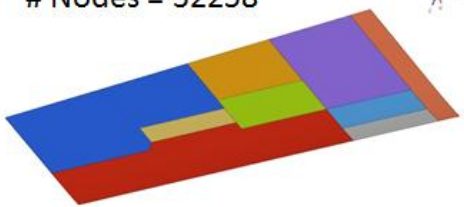
Detailed model

Sub-components view

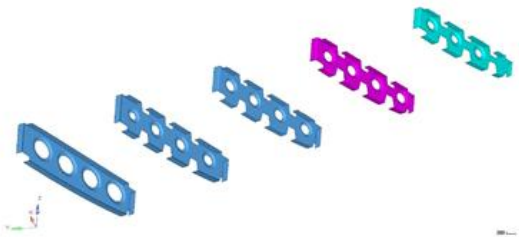
Lower skin:
- # Elements = 31893
- # Nodes = 32310



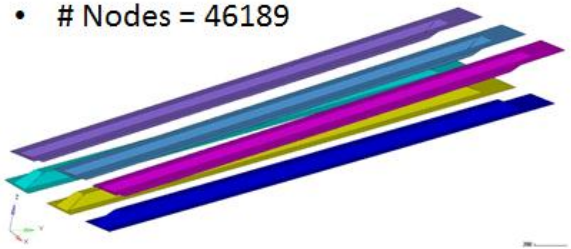
Upper skin:
- # Elements = 31843
- # Nodes = 32258



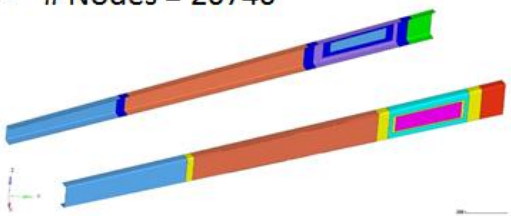
Ribs:
- # Elements = 21580
- # Nodes = 23173



Omega stiffeners:
- # Elements = 44223
- # Nodes = 46189



Front and rear spars:
- # Elements = 20089
- # Nodes = 20740



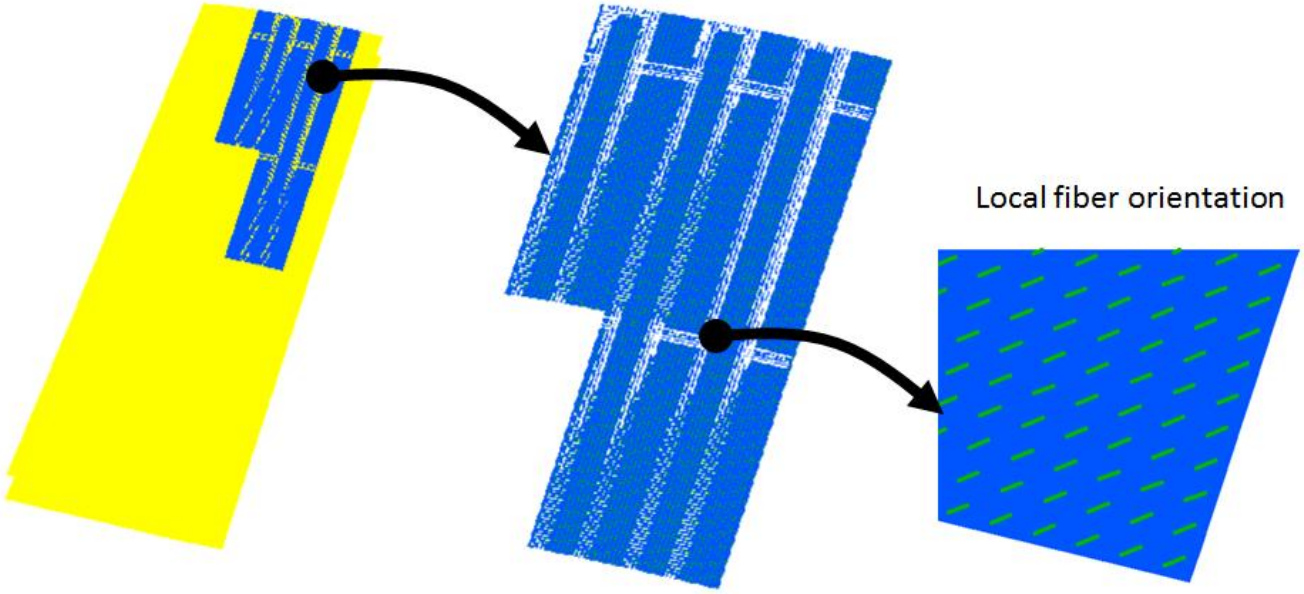
Modeling of the interfaces (gluing) between stiffeners and skins: to study possible separation during loading

Detailed model

- Each zone is characterized by:

  - its own stacking sequence (plies at 0°, 45°, -45° and 90°)

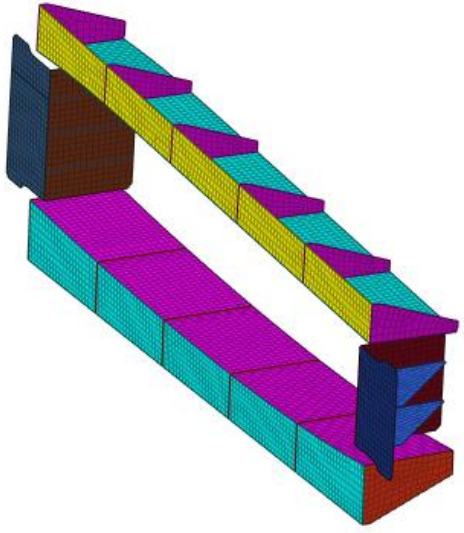
  - its own thickness

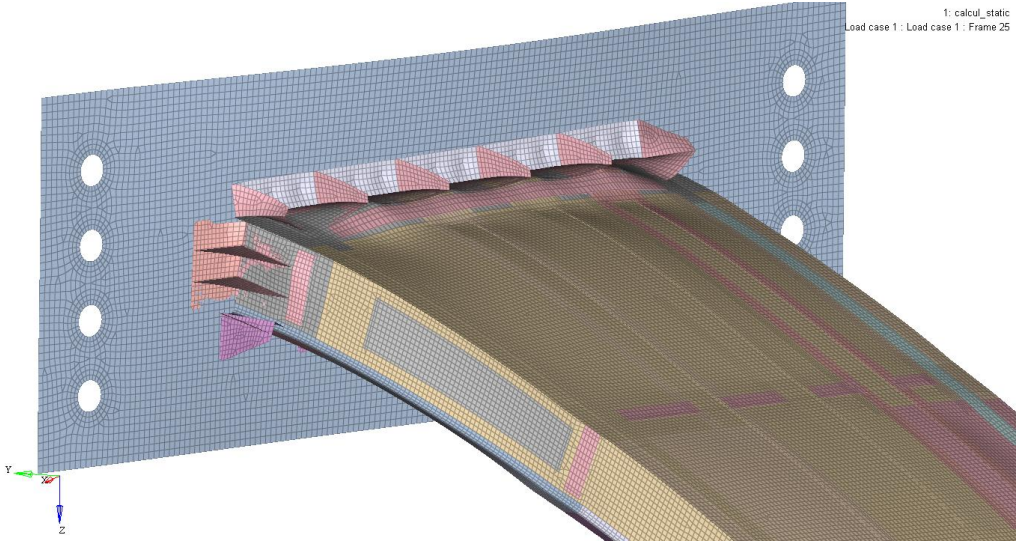


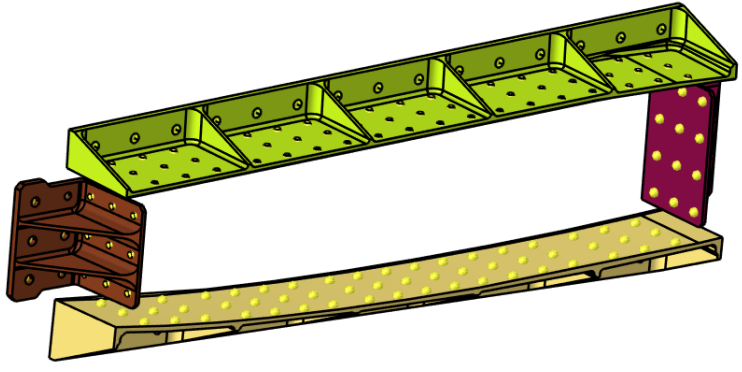
Sizing and interface validation

- Validation of interface parts with the demonstrator

- Stiffness and stress check of metallic plate and brackets
- Check of fastener strength and composite bearing

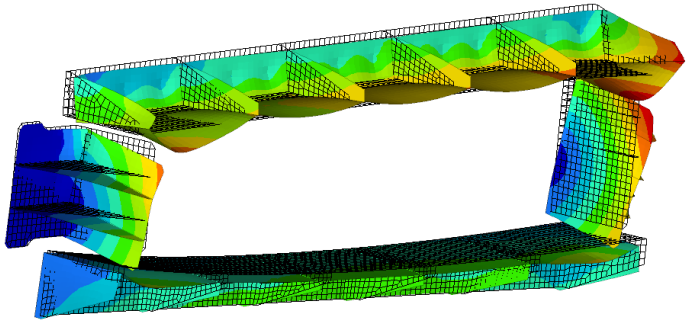


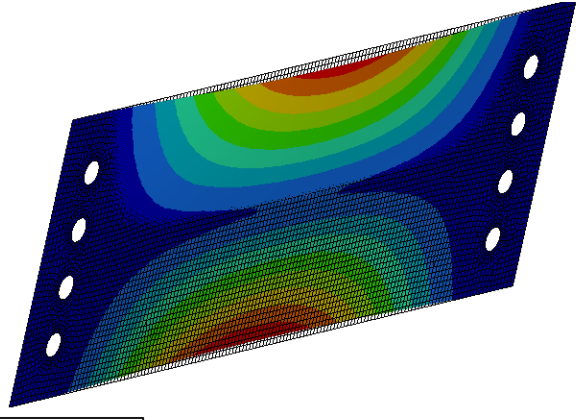




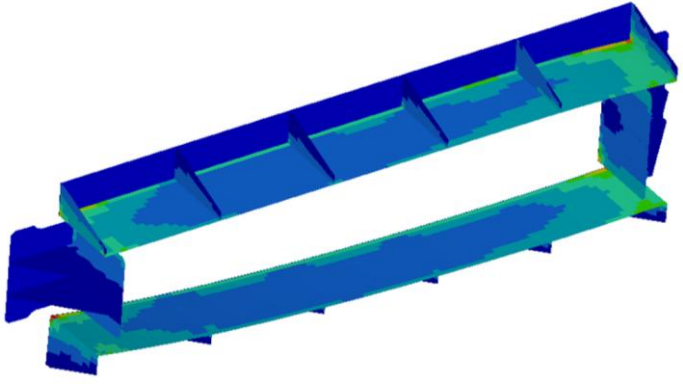
Sizing and interface validation

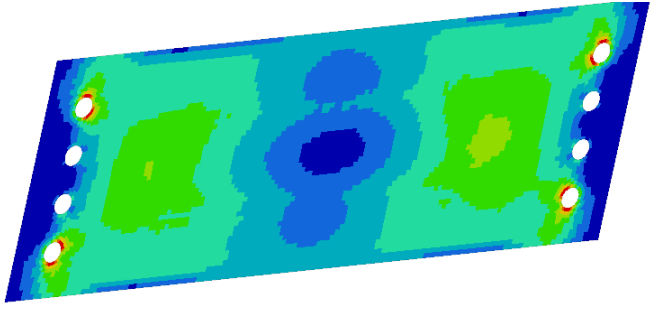
- Validation of interface parts with the demonstrator





- Stiffness check : max displacement ≈ 0,5mm
- Strength check : Von Mises stress < yield stress



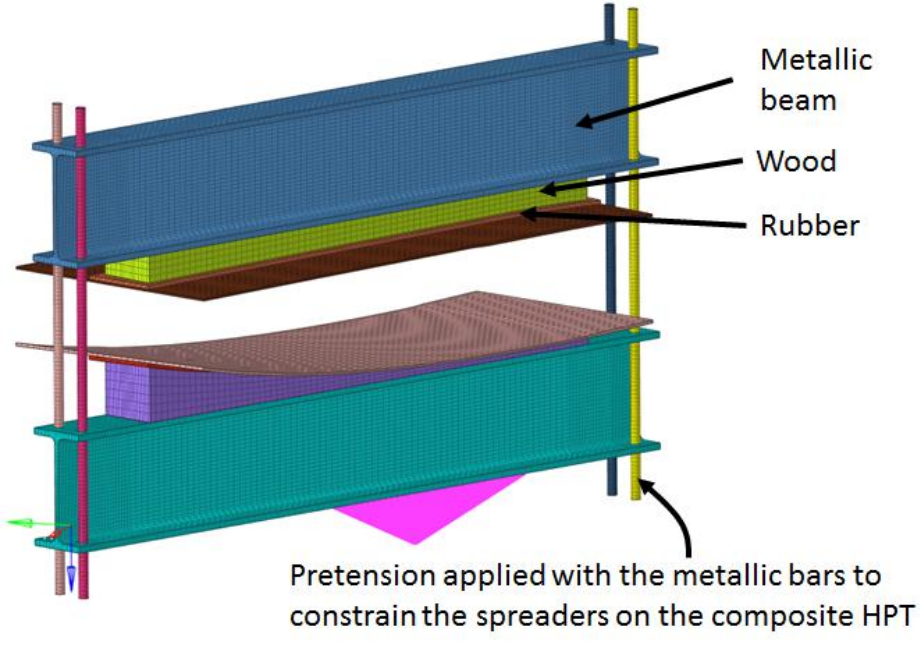


Sizing and interface validation

- Validation of the load introduction parts

Models of increasing difficulty are developed
- Contact between metallic frame and wood
- Contact between wood and rubber
- Contact between rubber and composite HTP

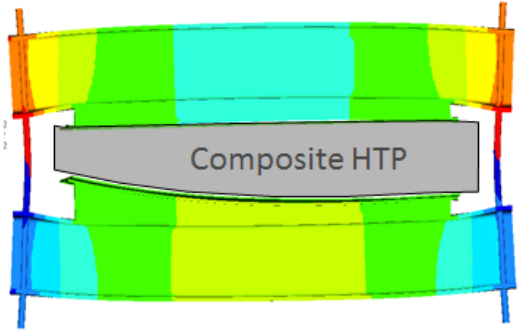
Pretension loads applied to the bar to model the behaviour under load
- Check for load transfer to demonstrator, should be as uniform as possible



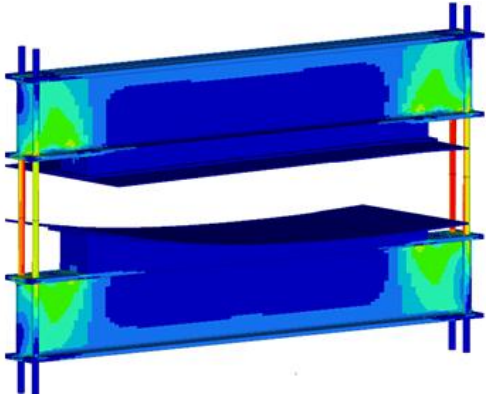
Sizing and interface validation

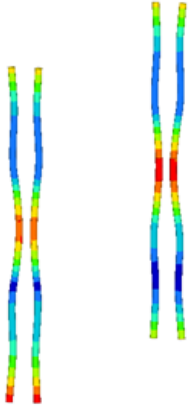
- Validation of the load introduction parts

Visualisation of the displacements (max displ ≈ 0,2mm)



Visualisation of the Von Mises stresses << yield stress

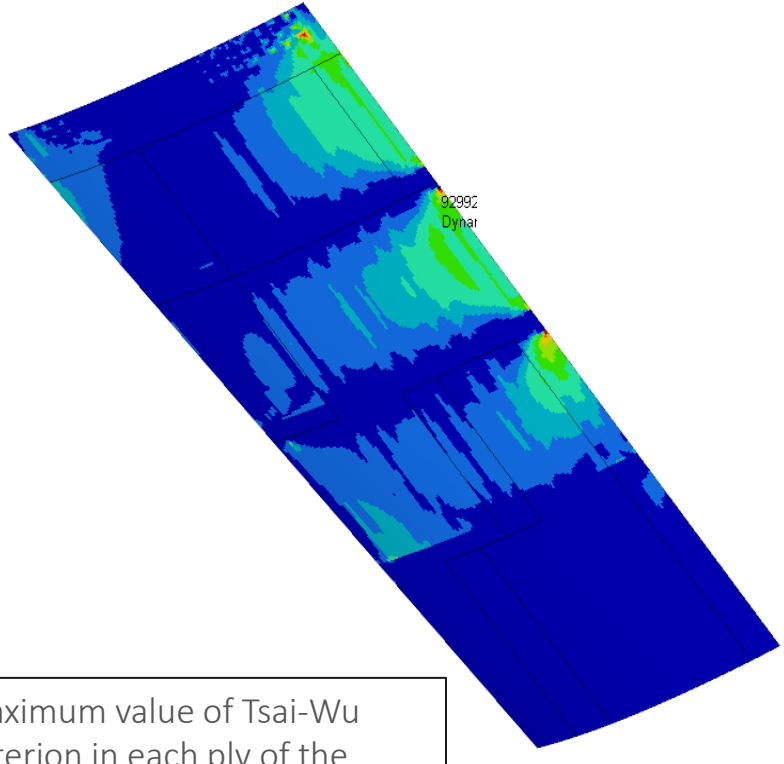




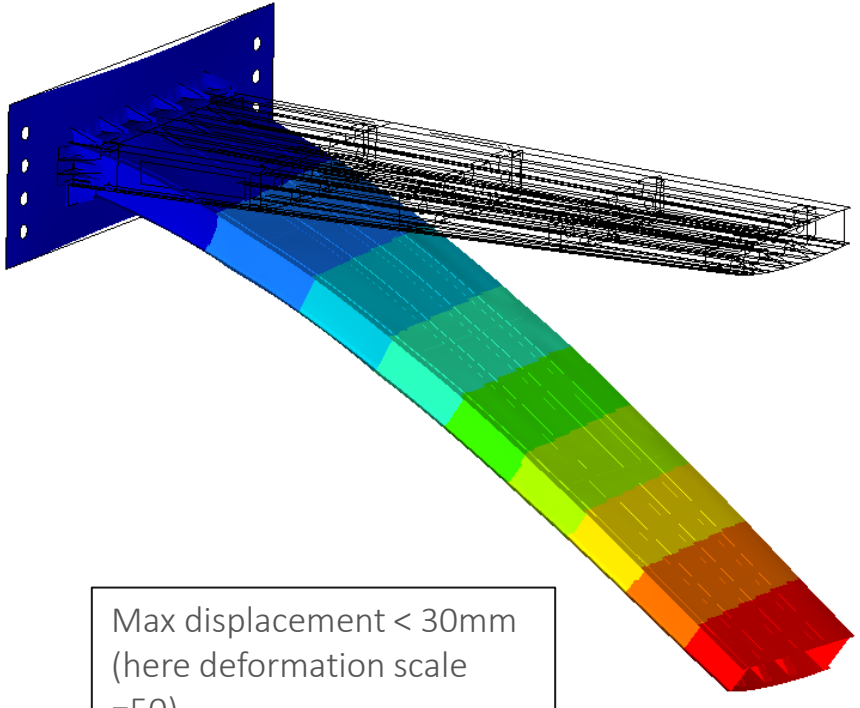
Check displacements and stresses in the metallic bars used for the pretension

Sizing and interface validation

- Validation of the composite parts: check of the structural integrity with a linear material model



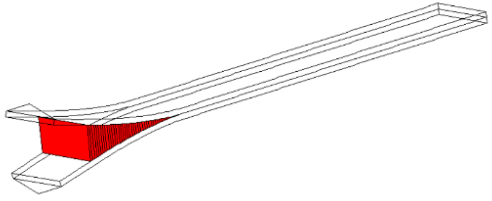
Maximum value of Tsai-Wu criterion in each ply of the lower skin < 1



Max displacement < 30mm (here deformation scale =50)

Next steps

- Manufacture,assembly and instrumentation of the demonstrator
- Positioning in the test bench
- Damage introduction
- Physical testing
- Correlation physical testing/virtual testing
  - Use of advanded non linear material models to simulate the progressive damage of the composite part (SAMCEF)
    - Specific material model for the plies
    - Specific material model for the interfaces between skins and stiffeners



Acknowledgement

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- The authors acknowledge the support of Wallonia (DGO6), Skywin and Innoviris

Thank you for your attention