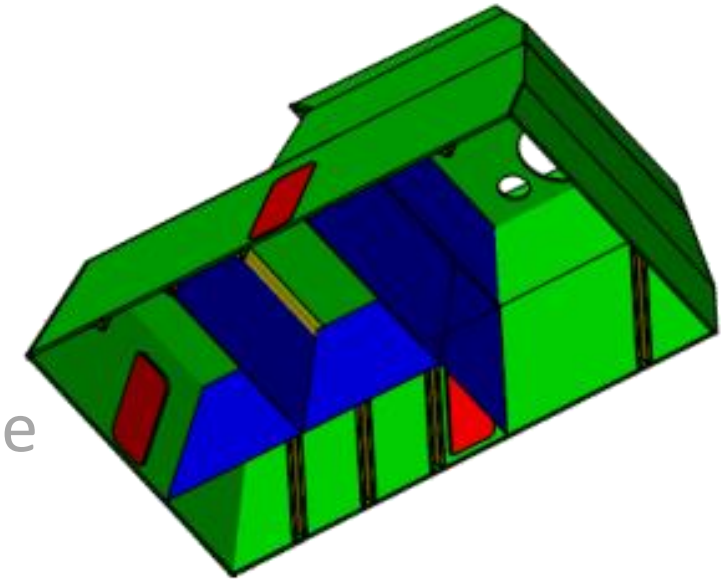
# RAMSSES - Realisation and Demonstration of Advanced Material Solutions for Sustainable and Efficient Ships

ELASS Seminar #13
January 27th, 2021



Work Package 16 - Composite superstructure module on a steel deck for multi purpose vessels

E. BILLAUDEAU (Naval Group)

NAVAL GROUP

RAMSSES

# WP16 Composite superstructure module on a steel deck for multi purpose vessels

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**Overwiew of the H2020 RAMSSES Project**

**Introduction to WP16**
- Objectives
- Description of the demonstrator case
- Work program

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- Design and structural analysis of the demonstrator case
- Experimental campaign: from screening tests on coupons to full scale tests

**Conclusions and next steps**

**Interview session**

# OVERVIEW OF THE H2020 RAMSSES PROJECT

## Realisation and Demonstration of Advanced Material Solutions for Sustainable and Efficient Ships


# Basic informations

01.06.2017
31.05.2021

Budget: €13.5 M
Funding: €10.8 M

36 partners
12 countries

www.ramsses-project.eu

**Call Topic:** MG-2.2-2016 Development and Use of High Performance and Lightweight Materials … (IA)

**Coordinator:** CETENA (Italy) – Financial and Administrative

CMT (Germany) – Technical and Dissemination

The project RAMSSES has received funding under the European Union's Horizon 2020 research and innovation programme under the grant agreement No 723246.
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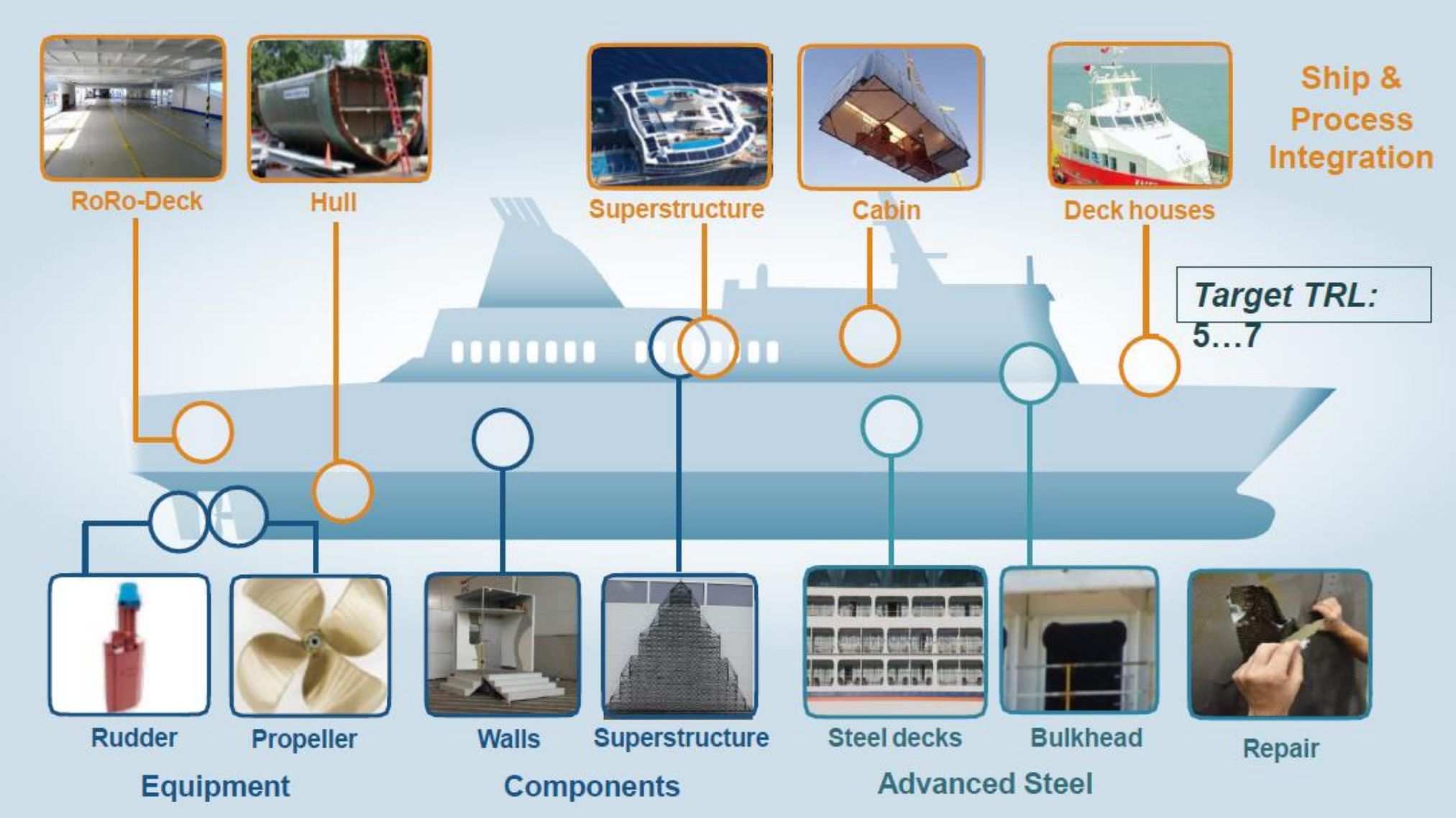
# RAMSSES – 13 Demo Cases

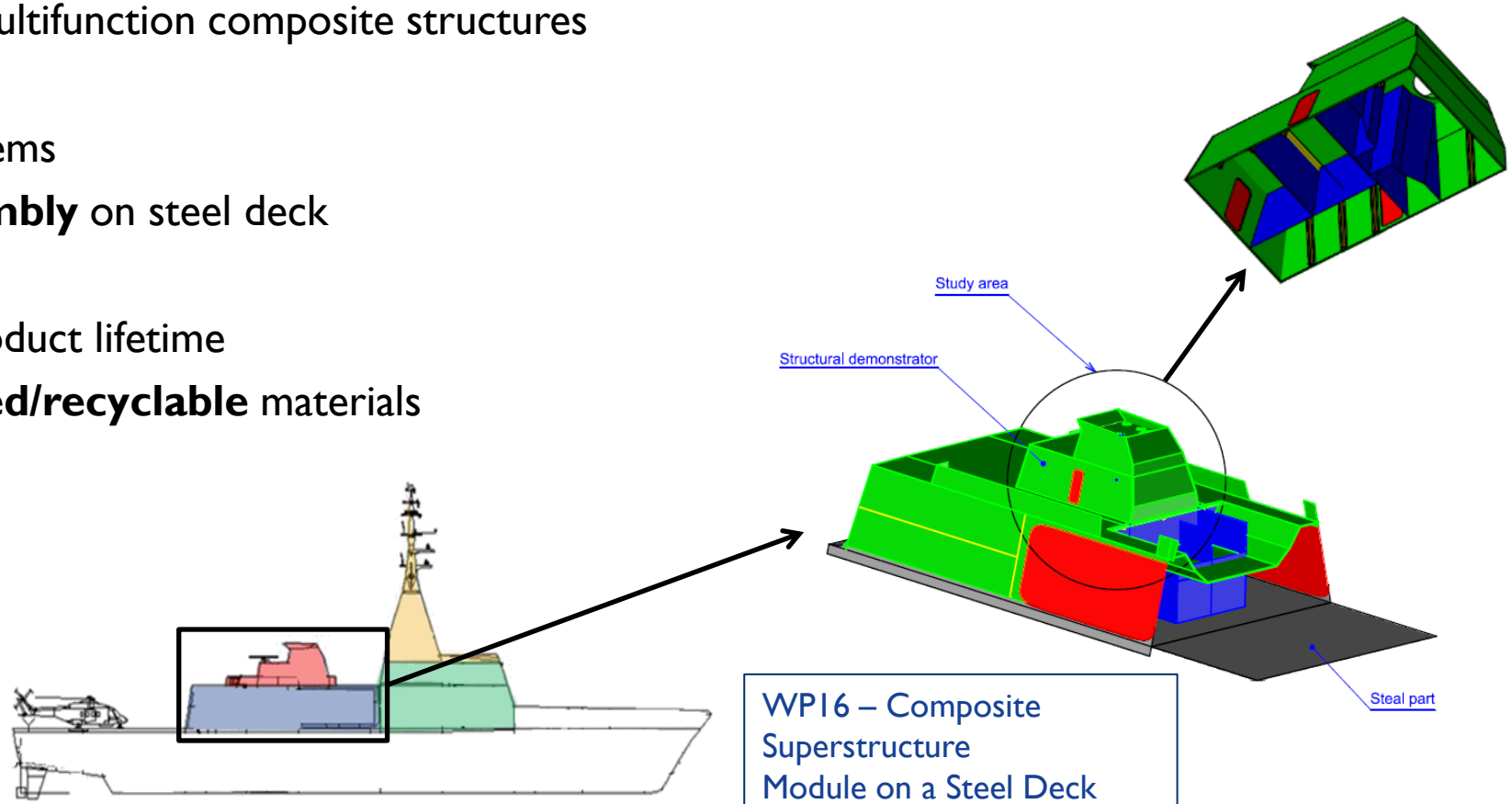


# RAMSSES – 13 Demo Cases

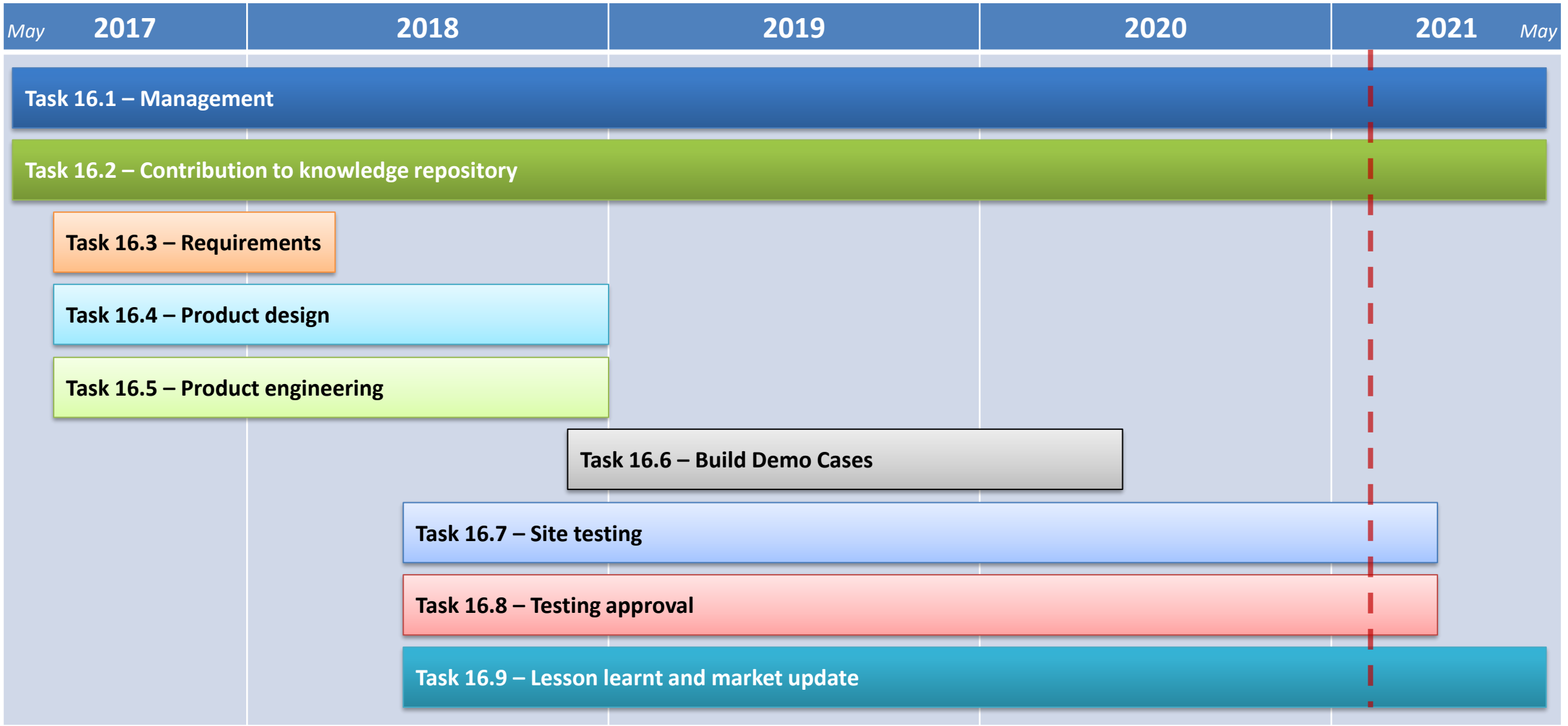
| WP No | Cluster Title / WP Title | Lead | Focus Material | Validation |
|---|---|---|---|---|
| | **Components & Equipment** | **NetComp** | | |
| WP09 | Modular Light System for Less Critical Internal Walls and superstructure | BALTICO | various | (pre)approval* |
| WP10 | Lightweight Components for High Loads and Fire Class | PODCOMP | composite | (pre)approval* |
| WP11 | Propeller blades by additive manufacturing | NG | metal | shore based |
| WP12 | Lightweight Rudder Flap | BMS | composite | onboard |
| | **Ship integration: Composite** | **DSNS** | | |
| WP13 | Integration of System for Internal Walls and Superstructure of Cruise Ships into shipyard processes | MW | composite | onboard |
| WP14 | Modular Decks for RoRo vessels | ULJ | composite | onboard |
| WP15 | Lightweight aluminium and composite walls for Work Boats | MEC | various | onboard |
| WP16 | Composite superstructure module on steel deck for multi purpose vessels | NG | composite | shore based |
| WP17 | Custom Made Hull for Offshore vessel | DSNS | various | shore based |
| WP18 | Multi material lightweight cabin for passenger ships | CdA | various | shore based |
| | **Ship integration: Steel&repair** | **CET** | | |
| WP19 | Highly Loaded structural details from high tensile steel in passenger and research vessels | FC | steel | shore based |
| WP20 | Lightweight Decks using High Tensile Steel in cruise ships | MT | steel | onboard |
| WP21 | Composite Overlay to repair and improve metallic and non-metallic structures | CARDA | various | (pre)approval* onboard |

# WP16 OF THE RAMSSES PROJECT

- **Objectives:** Conception, production, testing and validation of a demonstrator for composite superstructure meeting multi-criteria made up of a module on metallic deck:
  - Reduce **production costs**
  - **Reduce the weight** of multifunction composite structures
  - **Fire resistance**
  - **Health monitoring** systems
  - **Quick & easy (dis)assembly** on steel deck
  - **Noise insulation**
  - Mechanical resistance / product lifetime
  - Use of **recycled/bio-based/recyclable** materials



# RAMSSES WP16 - Schedule



Definition of succes criteria in collaboration with Bureau Veritas:

**Vessel's category studied:**

Offshore Patrol Vessel with lenght L>65m and Tonnage > 500 UMS (Universal Measurement System) ⇒ **BV Rules NR467**

**Structural design definitions:**

Based on BV rules for steel ship/naval ships **NR467 / NR 483** with use of **NR546** for composite approach (methodology)

safety factor based on **NR600**

**Fire assessment and test definition :**

Based on **IMO SOLAS**

| | |
|---|---|
| **MSC/Circ1002** | Guidelines on alternative design and arrangements for fire safety |
| **MSC/Circ.1552** | Amendments to the guidelines on alternative design and arrengements for fire safety |
| **MSC/Circ1574** | Interim guidelines for use of fibre reinforced plastics elements within ship structures: fire and safety issues |

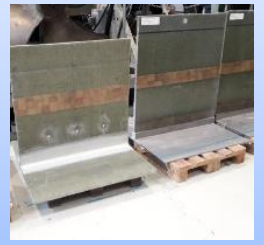
# Product design - General approach

- Serial approach:

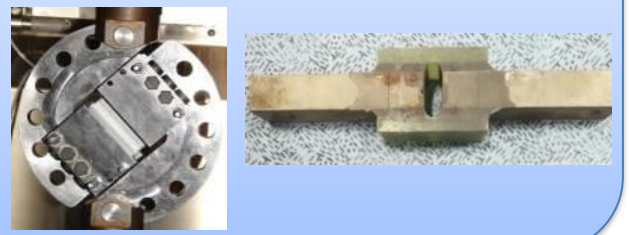
Global analysis first then transfer of boundary conditions to assemblies models

**Experimental tests on coupons**

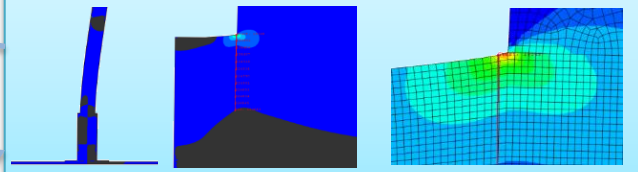

Experimental tests on **Structural Assemblies**



Experimental tests on adhesive lab **Specimens**



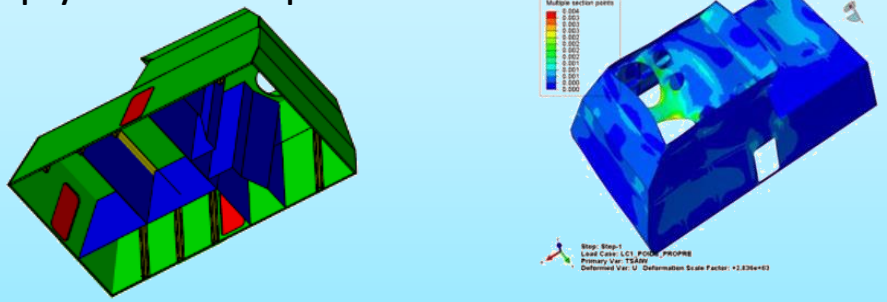
**Assemblies FEA**



**Assumptions note** related to the application case and BV rules

**Global Finite Element Analysis (FEA)**

Global model of the selected module in order to comply overall requirements



## FEA of the superstructure block

**Global model of the superstructur bloc:**

Multilayer shell elements for the bulkheads and the stiffners.

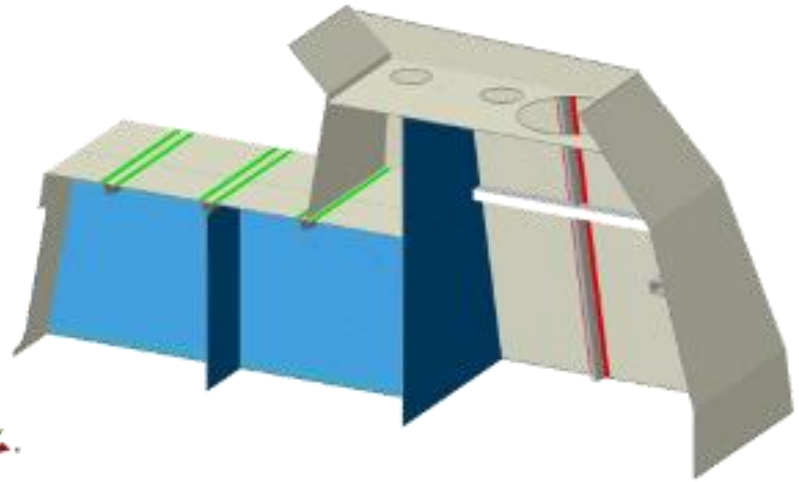
Static analysis / Buckling / Modal analyses

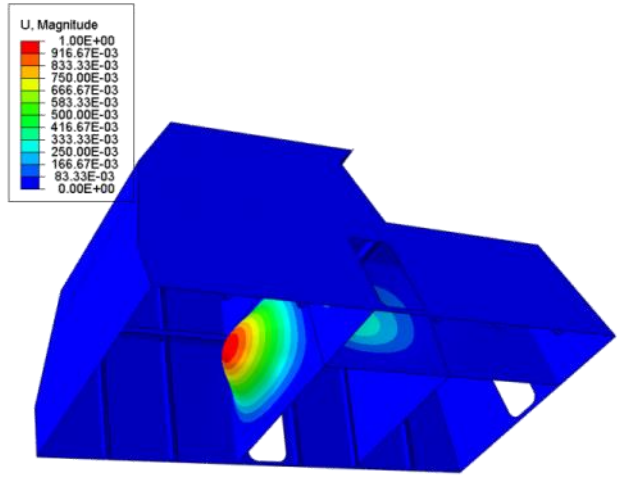
Solver Abaqus.

**Method:**

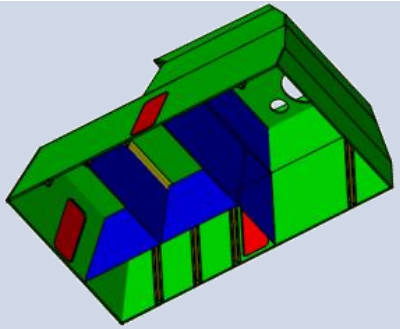
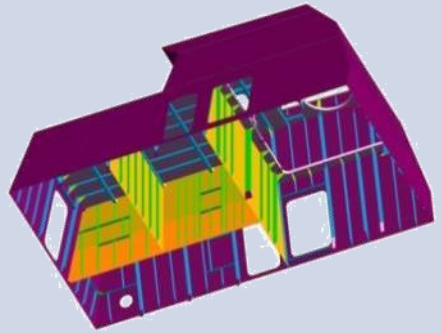
Structural analysis using Naval Group internal Rules

Structural assessment using BV rules





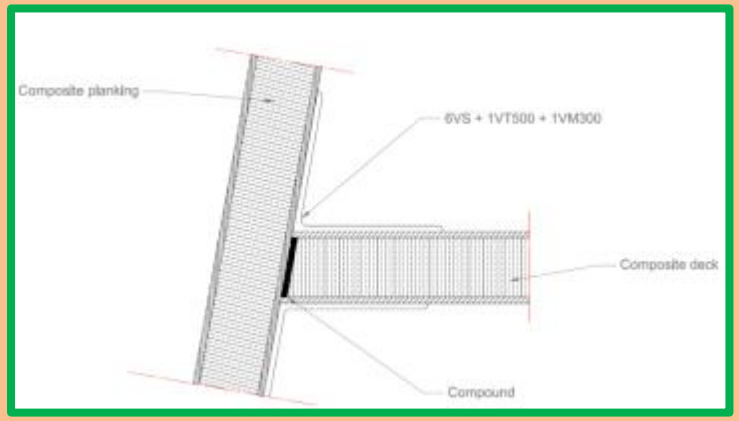

**Buckling stability**

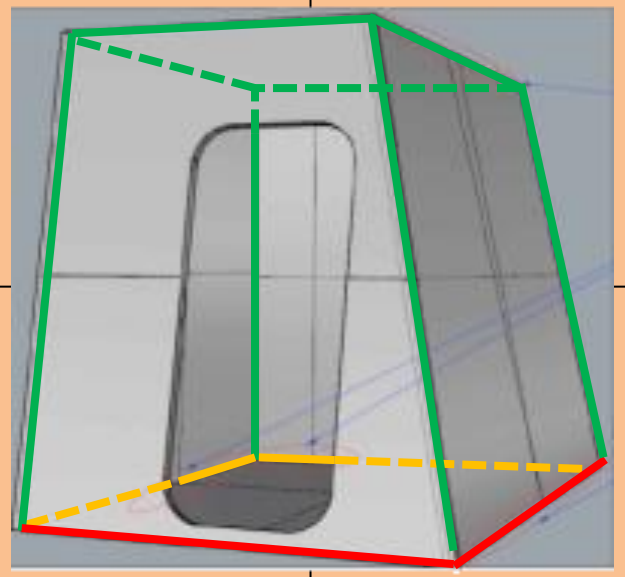
| | Composite superstructure block (WP16 design) | Metallic superstructure block (Original design) |
|---|---|---|
| **Structural calculation made by Naval Group Internal referential** |  **4 t** |  **11 t** |

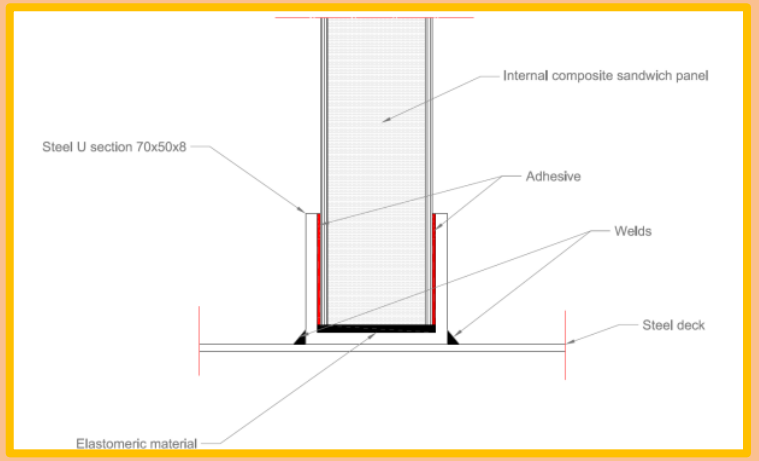
**Up to 60% of weight reduction**

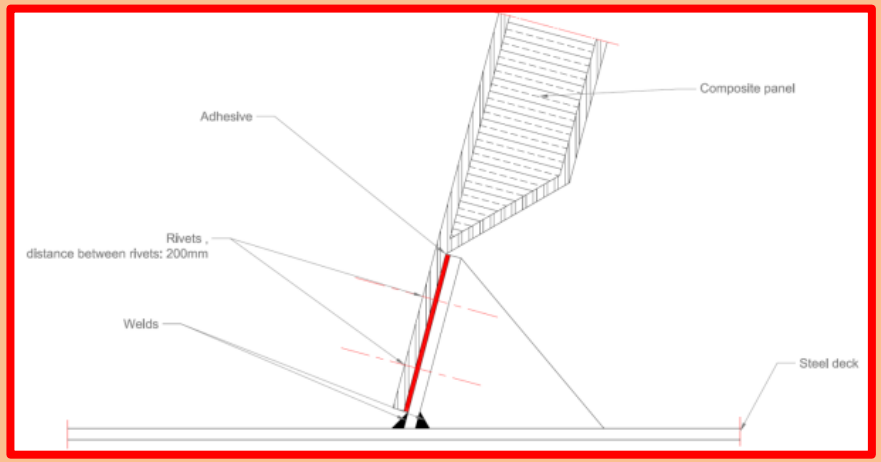
# Design principles of the junctions

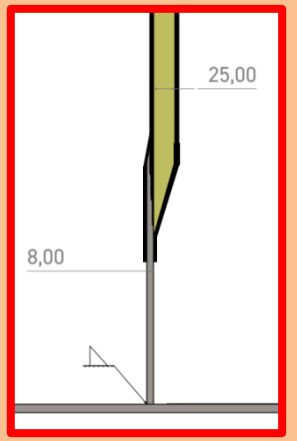
- Design of junctions of the demonstrator cases intended for full scale tests

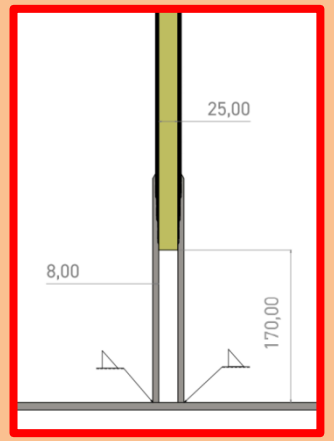


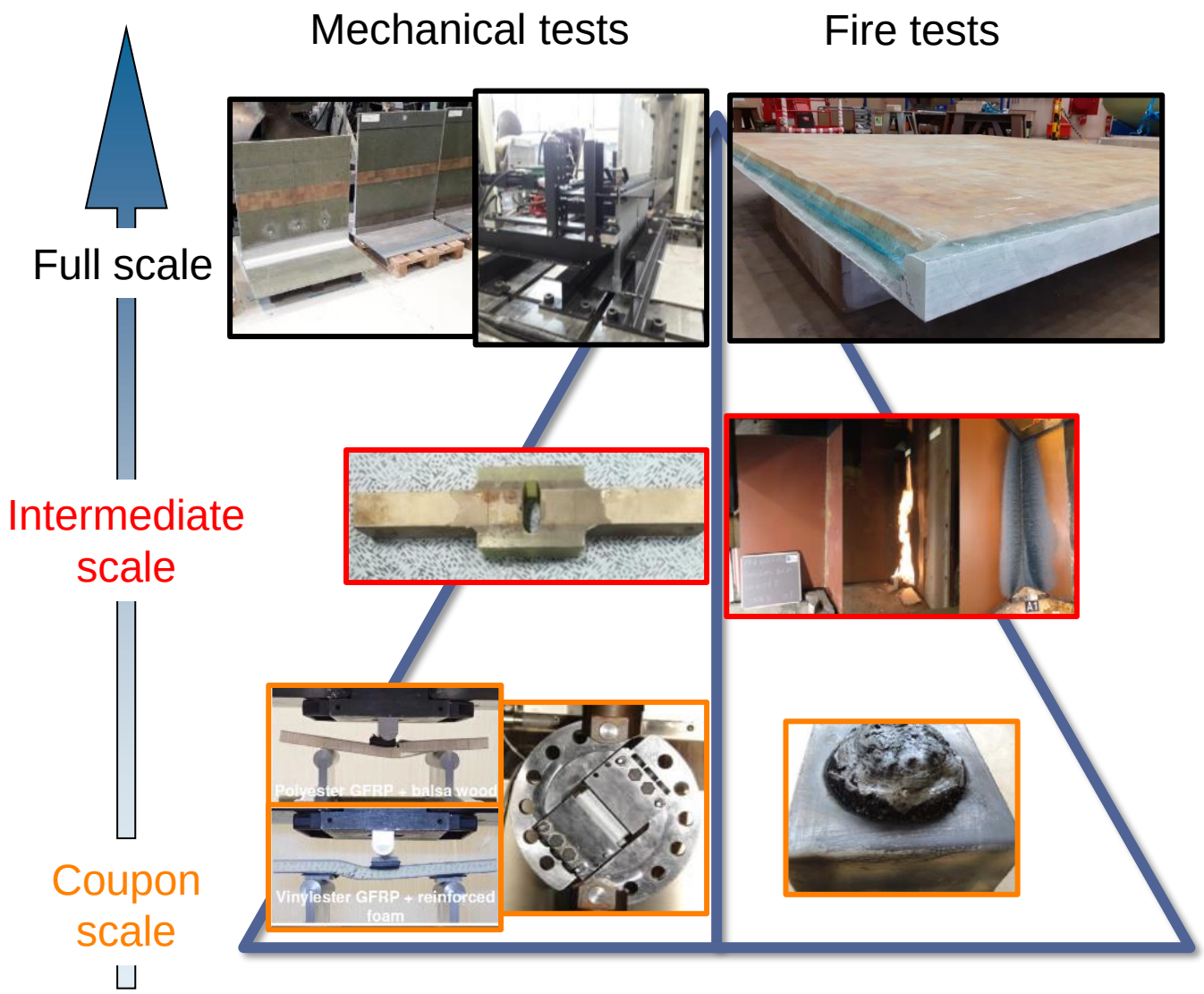


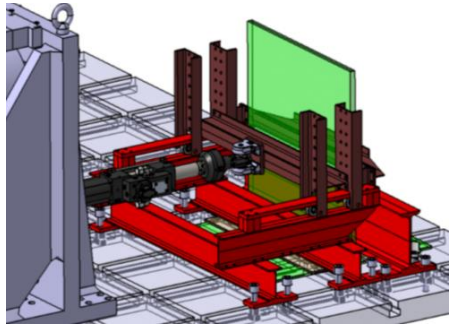



# Experimental approach – From screening tests to full scale tests




**Mechanical tests (ENSTA Bretagne):**

Static and cyclic tests on assemblies

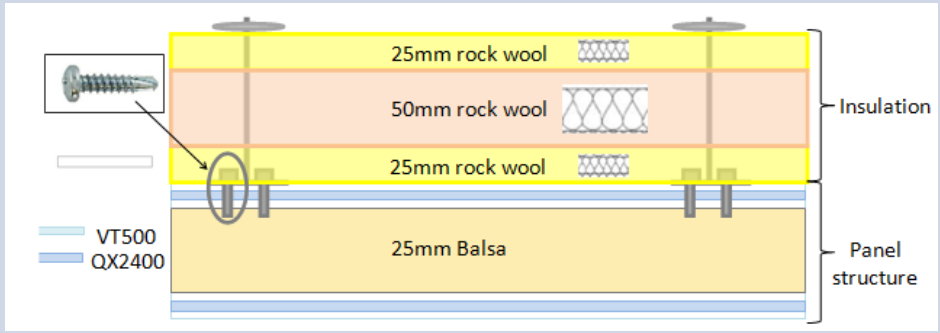
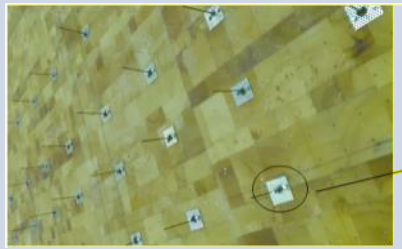
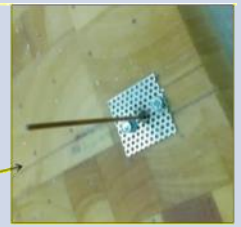
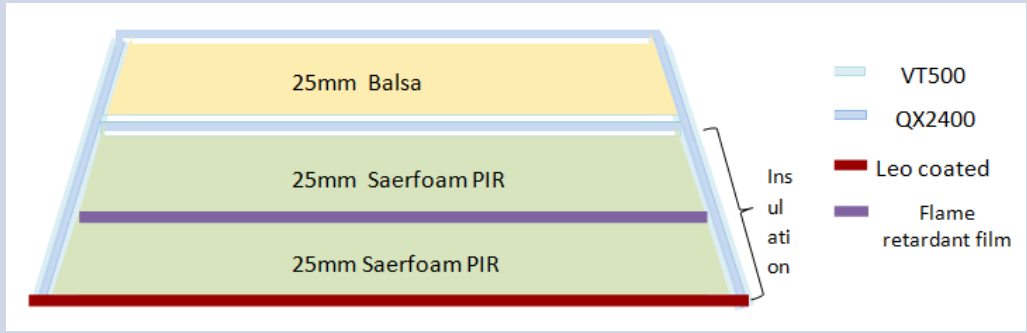


**Fire tests (RISE):**

Fire Resisting division tests

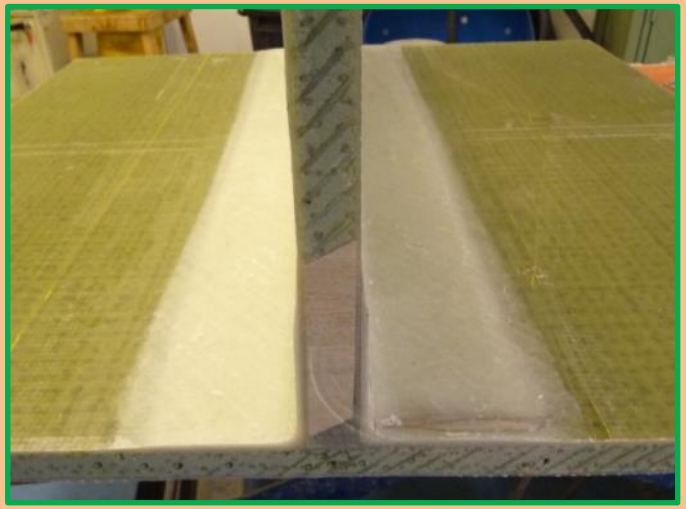
# DemoCases production – Fire tests specimens

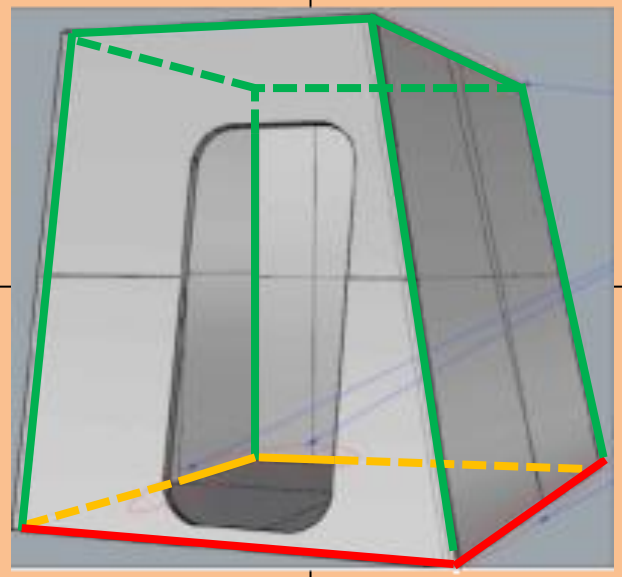
- Production of the demonstrator cases intended for Fire Resisitng Division (FRD) tests

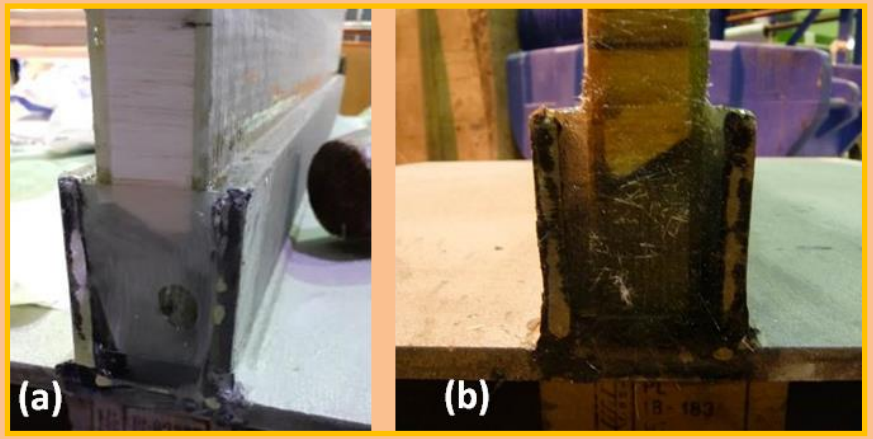
| Configuration | FRD 1 | FRD 2 |
|---|---|---|
| Panel dimensions | 3000*3070mm² | 3000*3070mm² |
| Description of the technology | Baseline: Insulated panel with mineral wool | Multifunctional panel: structural part + fire resisiting layer (LEO Coated + Insulation co-infused with the structural part) |
| Detail |     |    |

# DemoCases production – junction specimens

- Production of the demonstrator cases intended for full scale tests



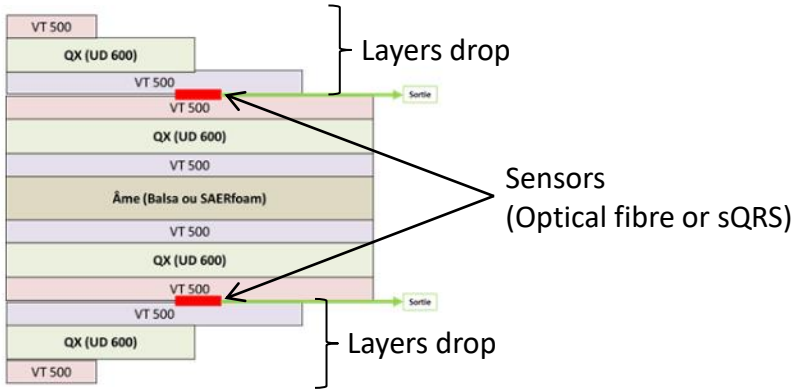




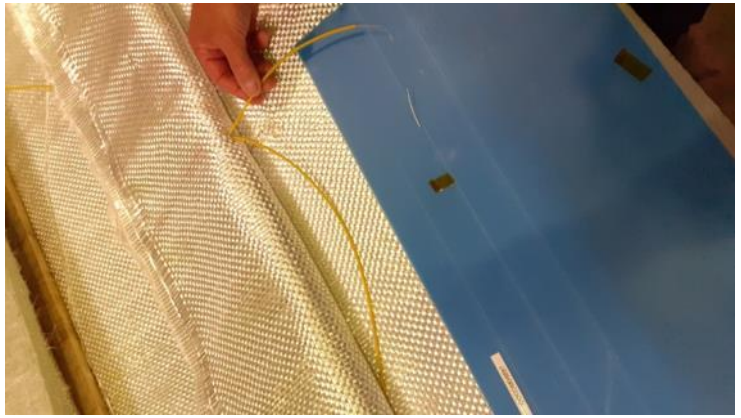

# DemoCases production – Multifunctional composite bukheads

- Structural Health Monitoring integration

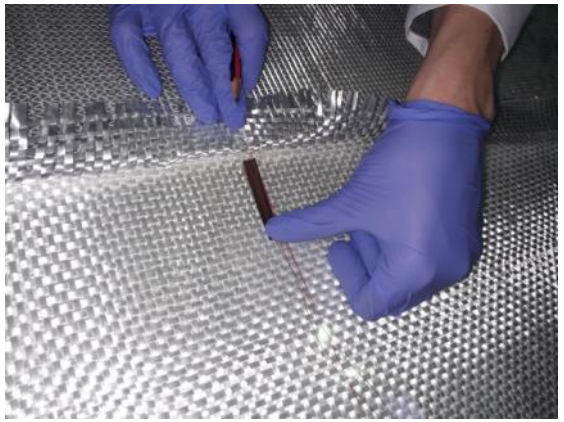
## Glass fibre/ Vinylester/ Saerfoam sandwich composite



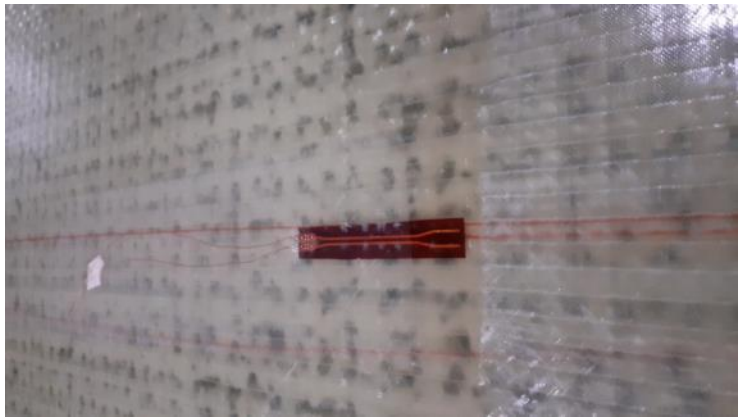

## Fiber Bragg Gratings integration (IDIL partnership)



## sQRS inegration (Sense-In partnership)

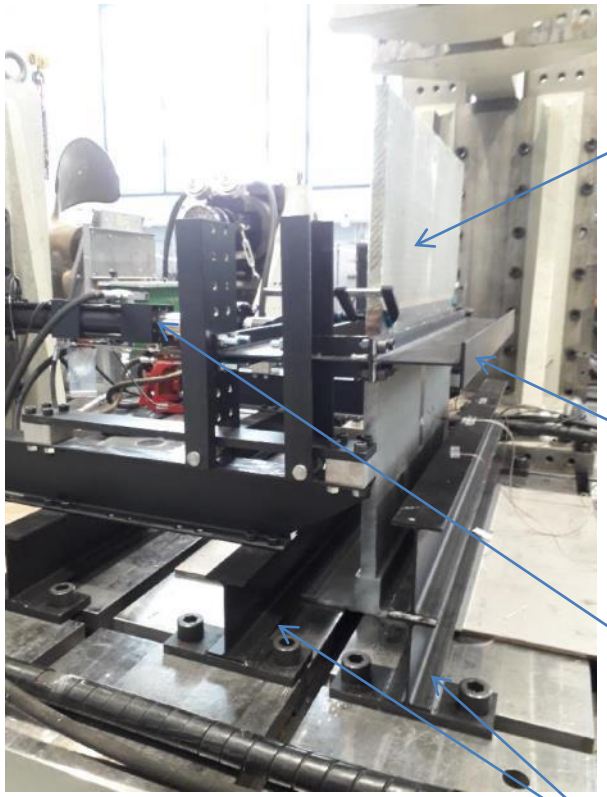


Sensor implementation in dry fibres



Embedded sensor after curing

- Production and installation of the bench test at ENSTA Bretagne

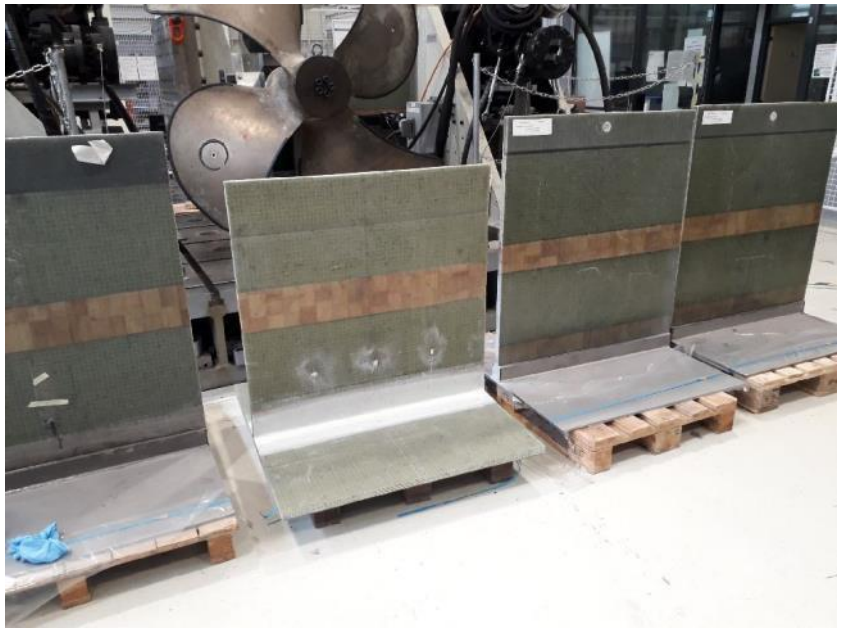


Assembly Demo case tested in bending

Loading area developed to apply a linear loading evenly distributed over the width of the specimen

Hydraulic actuator with its guide

Clamping device



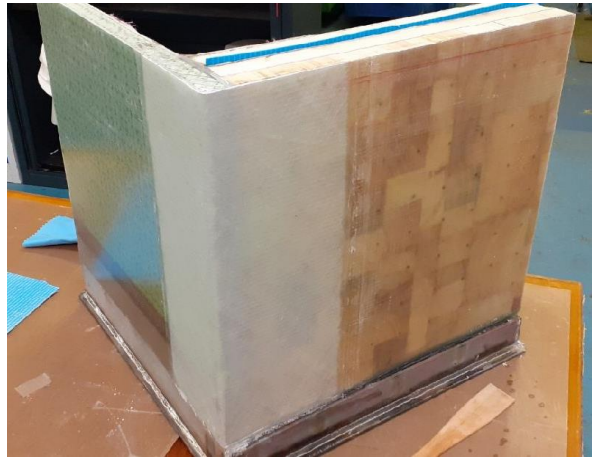
Full scale specimens produced at Naval Group composite facilities in Lorient (FR)

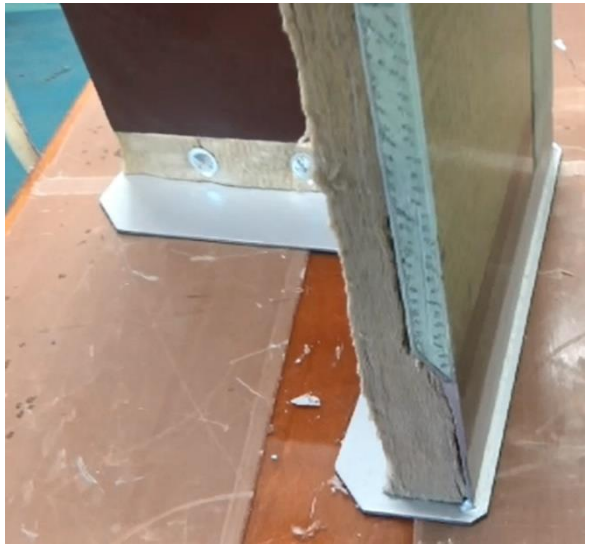
## Conclusions :

- Developpment of materials and processes and assemblies regarding structural and fire requirements

- Multiscale approach
  - Numerical simulations with a serial approach
  - Experimental campaign from coupon scale to full scale

- Multifunctionnal composite structures
  - Structural Health Monitoring systems
  - Thermal insulation and fire barrier system co-infused with the composite bulkheads





Node of composite superstructure bloc produced by Naval Group Lorient

## Next steps :

- Full scal tests on FAUSST assemblies at ENSTA Bretagne
- FRD tests at Rise in late february
- Testing approval - Structural and fire assessment of the demo case with Bureau Veritas
- Lesson learnt and market update
- Dissemination at ICCM-23 in Belfast (August 2021)

FRD test panel shipment from Naval Group Lorient to RISE (Sweden)

# The WP16 team thanks you for your attention

**Interview session of the WP16 partners :**

**Pierre BIDAUD (ENSTA Bretagne)**
**Cyril PRIEM (Naval Group)**
**Benjamin COLLIER (BV)**
**Yann LE GALL (Naval Group)**
**Anna SANDING (RISE – WP07)**

# Disclaimer

RAMSSES receives funding from the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme under grant agreement n° 723246.

# Interview 2

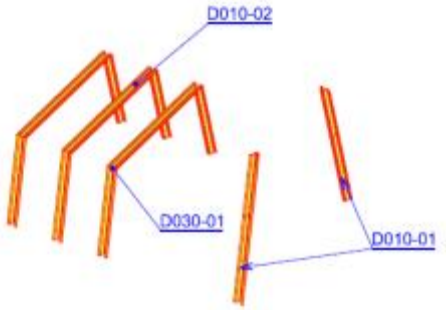
# Structural analysis & design phases of the democase

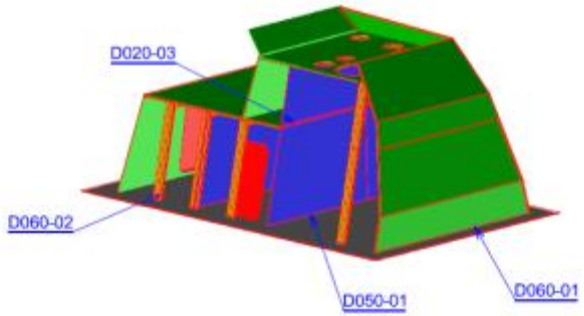
M. Cyril PRIEM
Calculation engineer of composite structures
Naval Group, Lorient

## Analytical calculation of the panels of the superstructure block based on Naval Group methods

First analytical calculation on elementary composite structure (sandwich and stiffener):

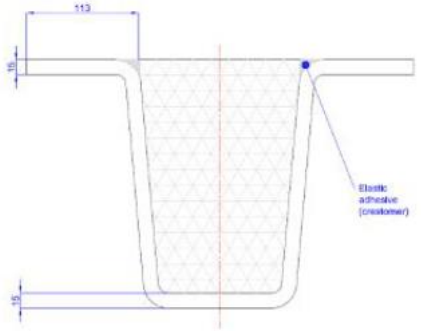
- A first approach allowing fast design choice
- Easy-to-use and robust-to-use

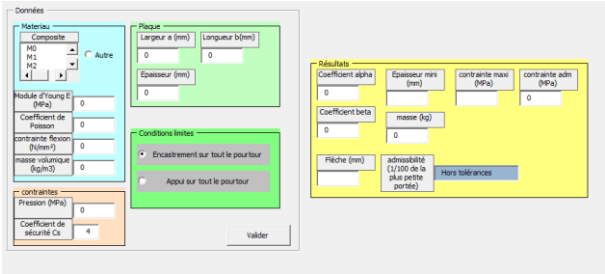



Results:

- First combination of composite materials
- Sandwich parameters (core material, skins)
- Number of stiffeners
- Distance between two stiffeners





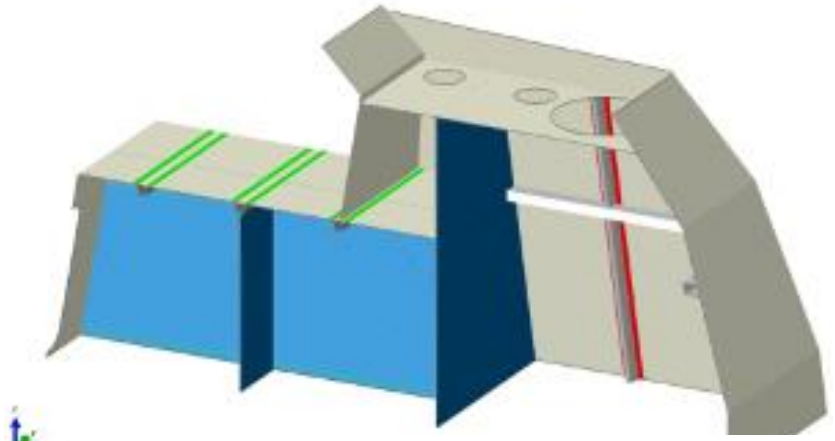
## Structural calculation of the superstructure block based on Naval Group methods

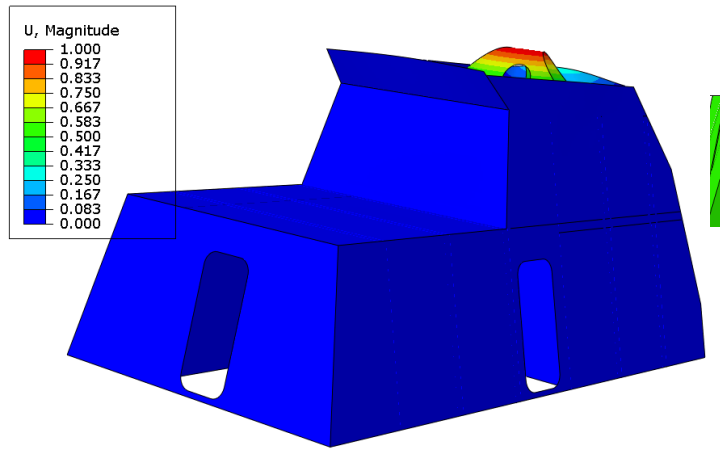
Material configurations calculated :

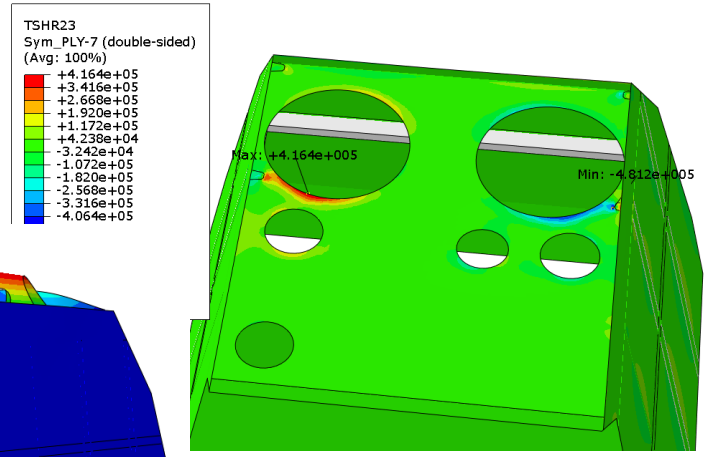
- From only glass fabric to a mix with unidirectional glass fibers with thermoset resin composite skins
- 3 core materials : two types of balsa and Saerfoam (fibre reinforced foam)
- 5 pressure loadcases, buckling and frequency analysis

Results :

- Balsa core configurations validated
- Higher thickness of saerfoam core required
- Up to 60% of mass reduction





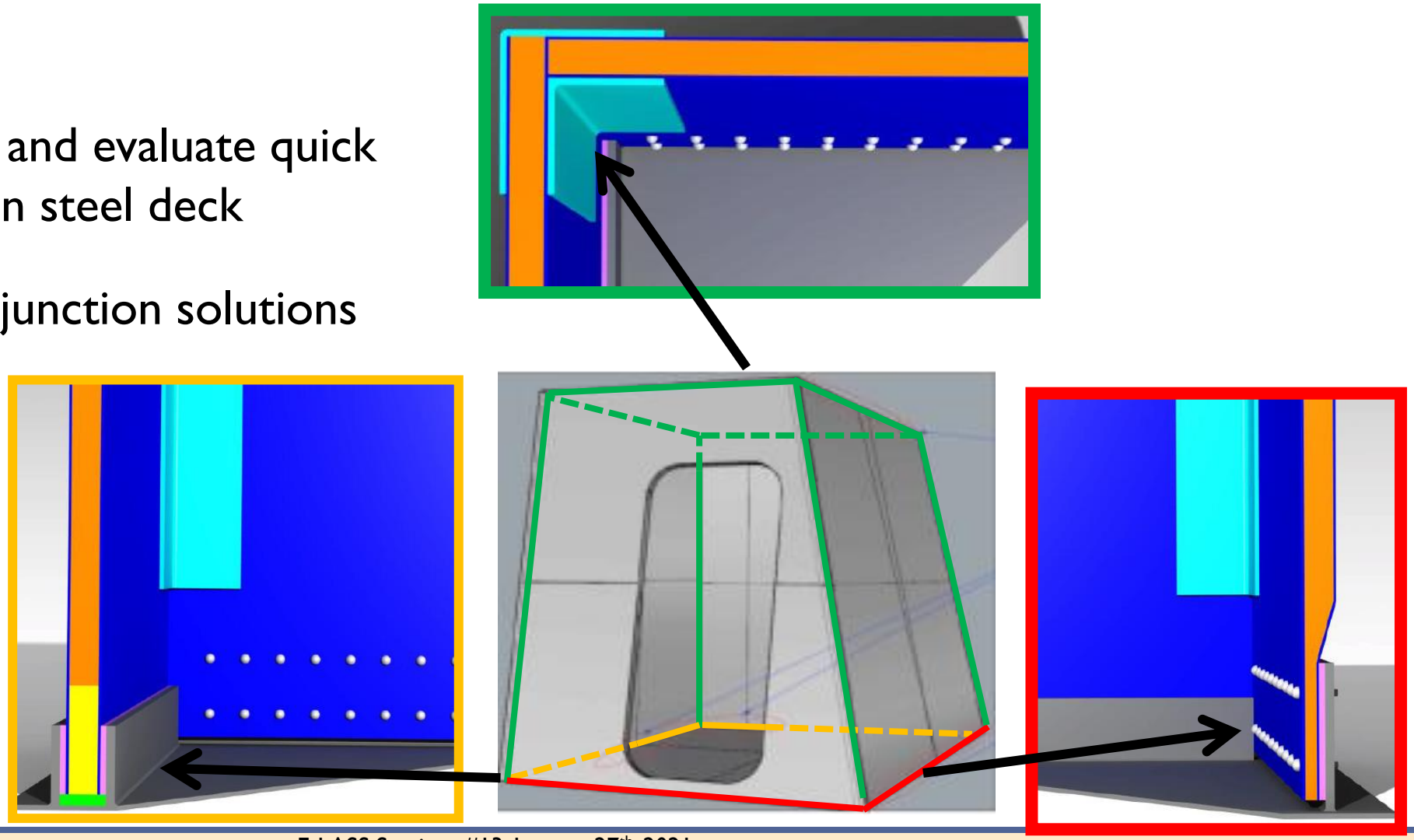



# Industrial strategy for module assembly:

- The aim is to propose and evaluate quick & easy (dis)assembly on steel deck

In this proposal different junction solutions have been proposed :

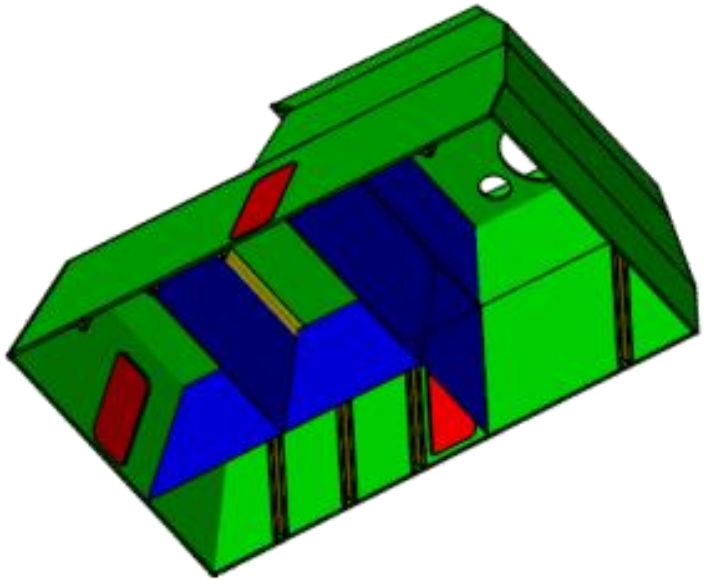
- Adhesive assembly
- Rivet solution
- Bolting assembly
- Composites cornering



# Interview 3

# RAMSSES - Realisation and Demonstration of Advanced Material Solutions for Sustainable and Efficient Ships

## ELASS Presentation
## January 27nd, 2021



Work Package 16 - Composite superstructure module on a steel deck for multi purpose vessels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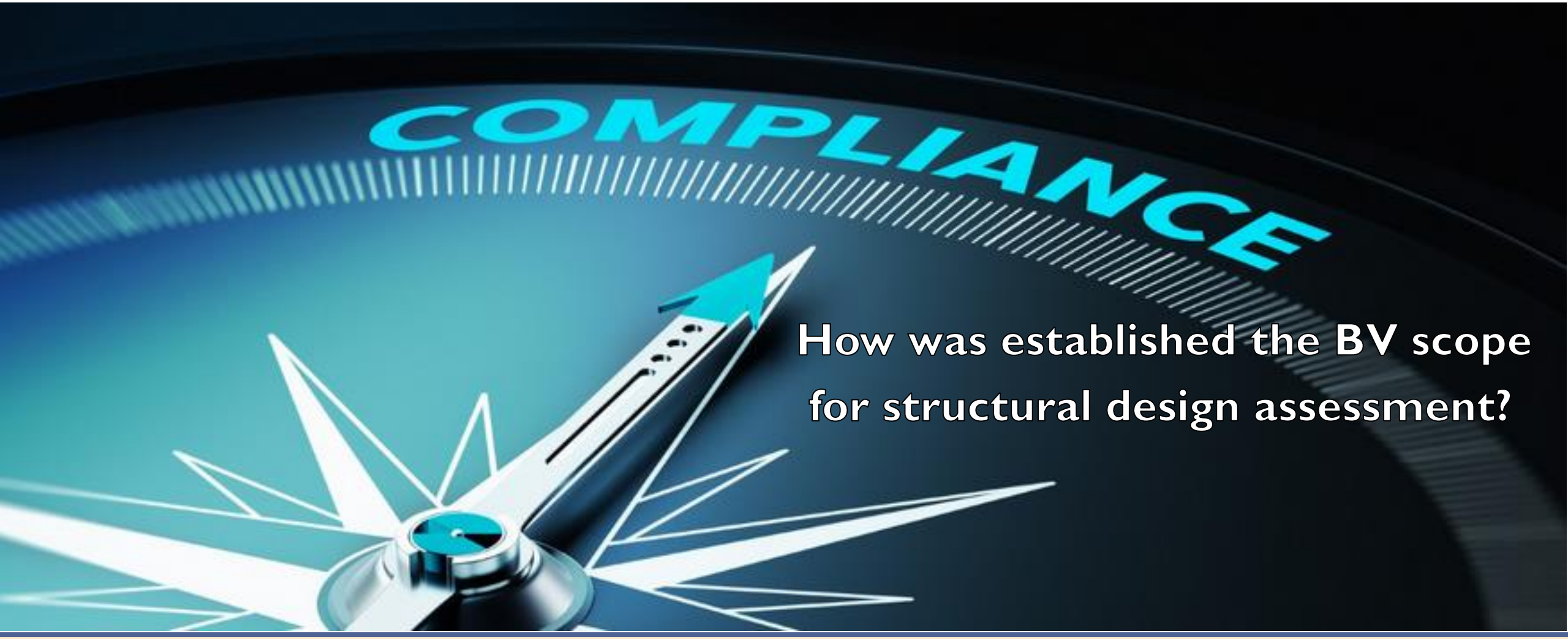
Specialist engineer @ DE-CMS (Composite Materials Section)

# WP16 Composite superstructure module on a steel deck for multi purpose vessels



- **Rule scope for the WP16 demonstrator structural review**

**Vessel's category studied:**

Offshore Patrol Vessel with

lenght L>90m and

Tonnage > 500 UMS

BV Marks and mentions: **I ✠ HULL ✠ MACH - OPV - Unrestricted**

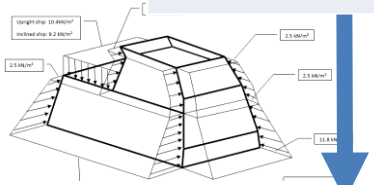
⇒ BV Rules NR467 scantling methodology dedicated to STEEL SHIP not to COMPOSITES STRUCTURE

| Item | | Greater than or equal to 500 GT | Less than 500 GT |
|---|---|---|---|
| Ship arrangement and hull integrity | L ≥ 90 m | • Part B<br>• Part C, Chapter 1 **(1)** | • NR566 **(2)** |
| | L < 90 m | • NR600<br>• Part C, Chapter 1 **(1)** | • NR566 **(2)** |
| Hull | L ≥ 90 m | • Part B<br>• NR396 **(3)** | • Part B<br>• NR396 **(3)** |
| | L < 90 m | • NR600 **(2)** | • NR600 **(2)** |

- **Rule scope for the WP16 demonstrator structural review**

**Rules matrix equivalencies**

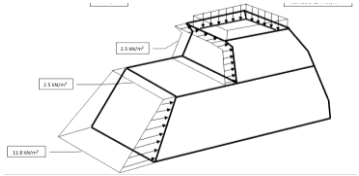
**NR467 / NR483**
Local Loads
Global Loads



Load Equivalency

Same structure
Same material

**NR600**
Local Loads
Global Loads



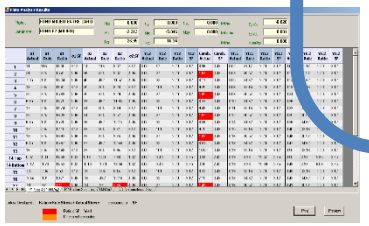
**NR600**
Safety coefficients for Steel Structure

Material Equivalency
Same structure
Same Load

**NR600**
Safety coefficients for composites

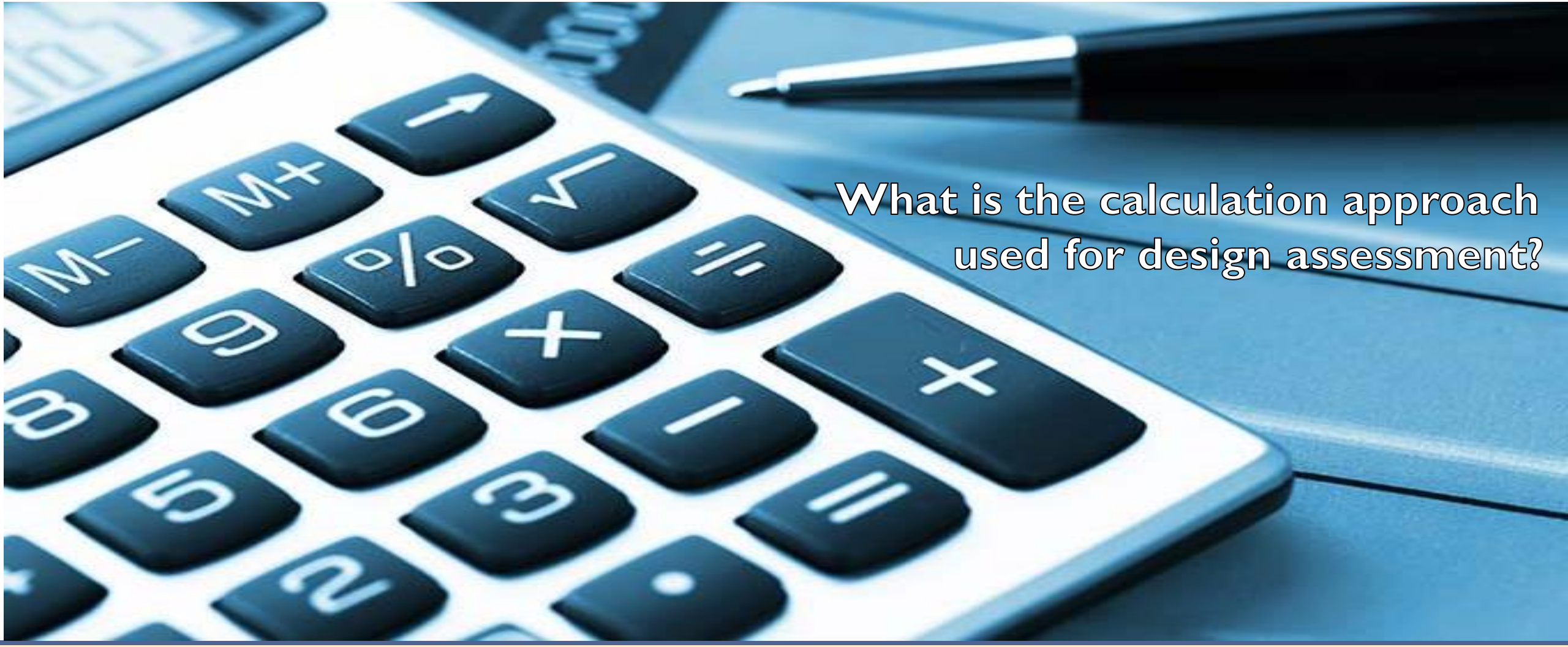
| Stress type Factors / Abbreviation | Stress | Orientation of stress with fibre | Reinforcement /core type | Partial safety Factor |
|---|---|---|---|---|
| $C_R$ for fibre and reinforcements | Tensile or compressive | parallel | Unidirectional, double bias, Multiaxial | 2.1 |
| | | | Woven roving | 2.4 |
| | | perpendicular | Unidirectional, double bias, Multiaxial | 1.0 |
| | | all | Mat | 2.0 |

**NR546**
Structural element calculation

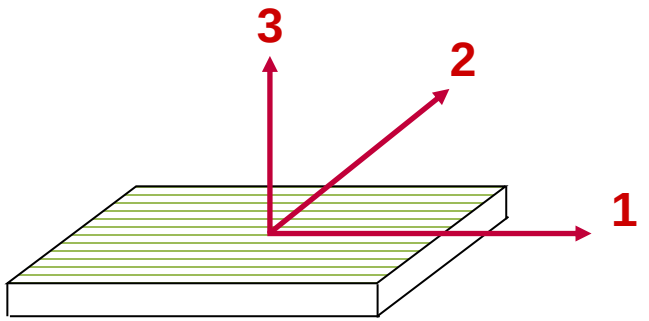


Validation of the composite design

# WP16 Composite superstructure module on a steel deck for multi purpose vessels



- **Presentation of the composite calculation methodology**



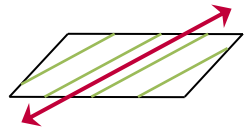

**Calculation approach:**

Based on ply by ply analysis:

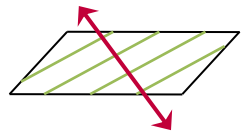
- Each ply of a laminate characterized by:
  - elastical coefficients: $E_1, E_2, G_{12}, G_{23}$
  - Breaking strains: $\varepsilon_{br1}, \varepsilon_{br2}, \gamma_{br12}, \gamma_{brIL}$
  - And breaking stresses $\sigma_{br1}, \sigma_{br2}, \tau_{br12}, \tau_{brIL}$

- Comparison for each plies realised Stresses breaking with actual stresses

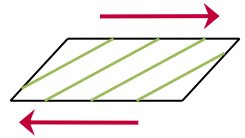
$$\frac{\sigma_1}{\sigma_{br1}} \geq SF$$



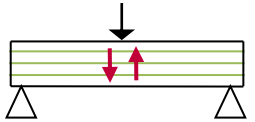
$$\frac{\sigma_2}{\sigma_{br2}} \geq SF$$



$$\frac{\tau_{12}}{\tau_{br12}} \geq SF$$



$$\frac{\tau_{IL}}{\tau_{br\,IL}} \geq SF$$



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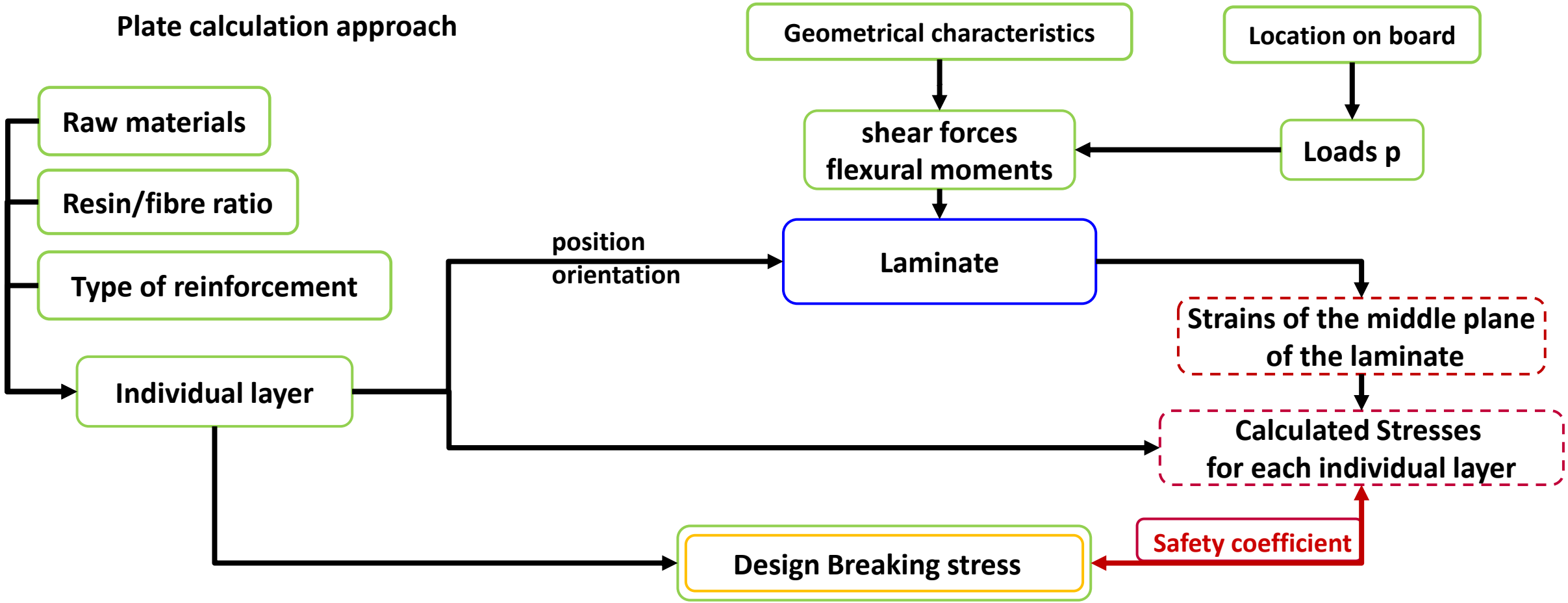

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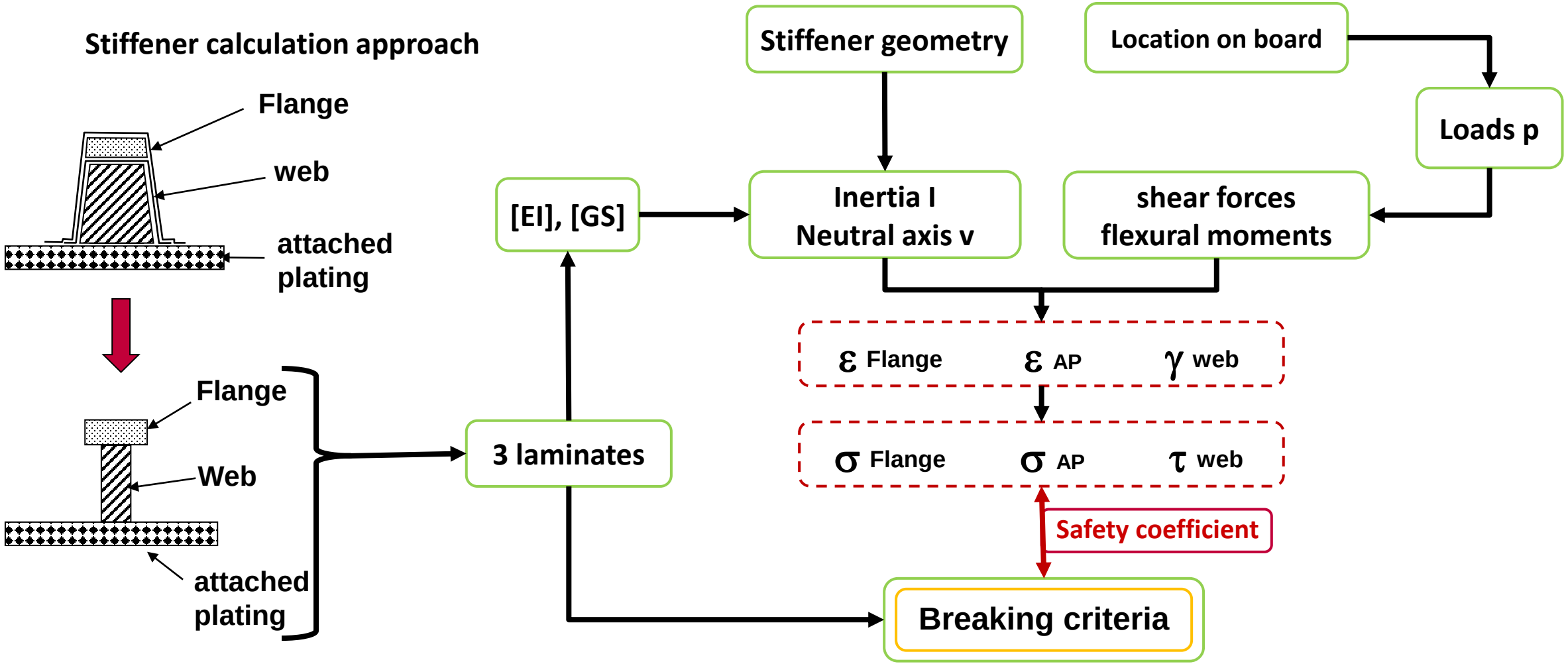
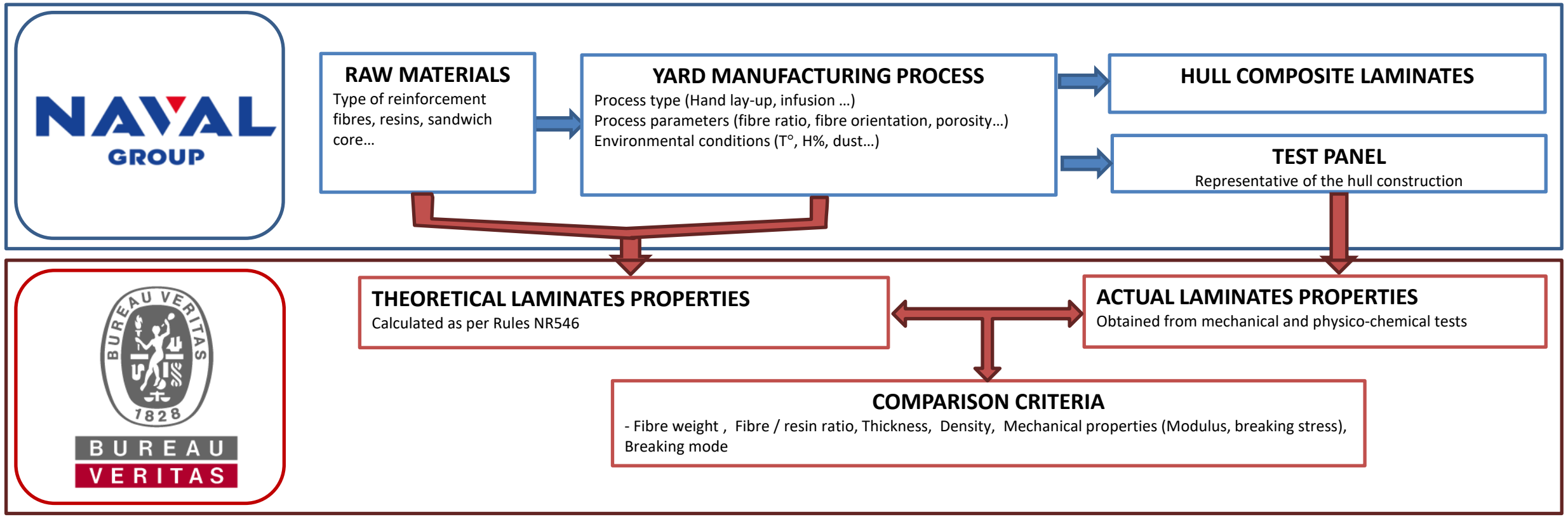


# WP16 Composite superstructure module on a steel deck for multi purpose vessels

- **Futur work for final assessment**

**perform correlation between theoretical properties (used design for BV review) and actual properties (as build by Naval Group)**



# The WP16 team thanks you for your attention

# Disclaimer

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# Interview 5

# Fire testing RAMSSES WP16

Anna Sandinge, RAMSSES WP07

RISE Fire Technology

# Screening with Cone Calorimeter ISO 5660-1

- Small-scale fire test
- Three configurations tested
- Duplicate tests
- The best performing configuration selected for further testing
  - → Configuration with LEO system protection

# Single Burning Item
# SBI
# EN 13823

- Intermediate scale fire test
- Single test conducted
- Promising result

  → Indicated fire class (EN 13501-1): **B-s2,d0**

# Next step

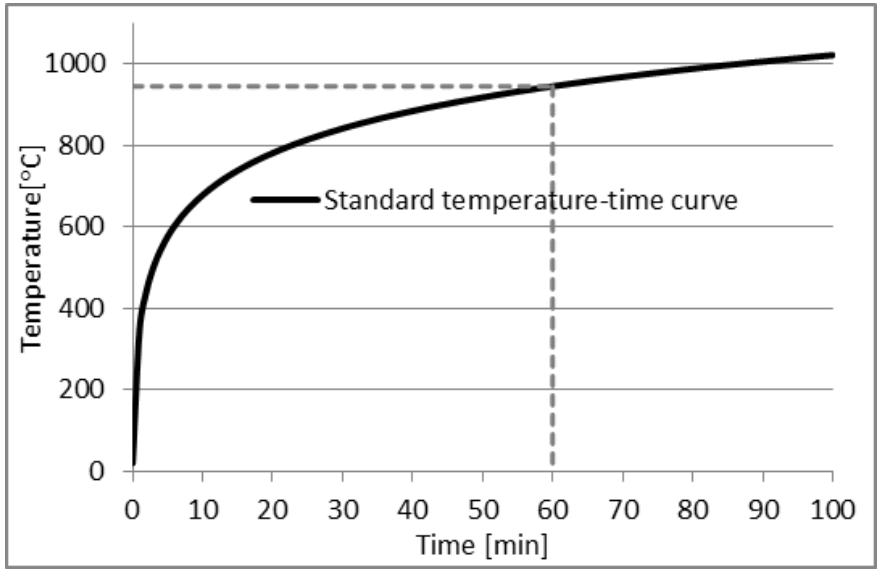
Large FRD furnace tests

Two tests scheduled for
week 7 at RISE in Borås, Sweden

# Fire safety engineering definitions

## Fire Resistance properties

- **Integrity** - Prevent passage of smoke and flames
- **Load bearing capacity**
- **Insulation** – Restrict the temperature rise on the unexposed side




# Large Vertical furnace for FRD test, IMO FTP Code Part 11

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