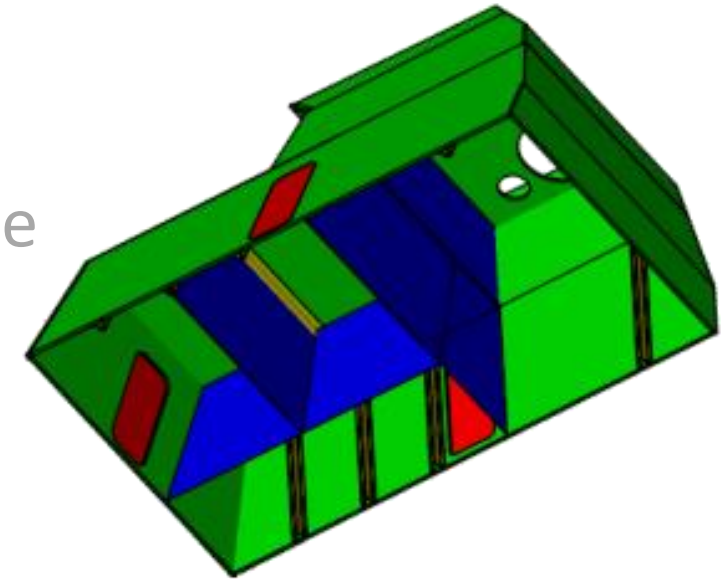
RAMSSES - Realisation and Demonstration of Advanced Material Solutions for Sustainable and Efficient Ships



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

WP leader: E. BILLAUDEAU
Naval Group

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

Content

Overwiew of the H2020 RAMSSES Project

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

Technical progress : Presentation of the work done so far
- Design and structural analysis of the demonstrator case
- Experimental campaign on coupons and assemblies

Work to be done
- Next steps and 1-year timeline

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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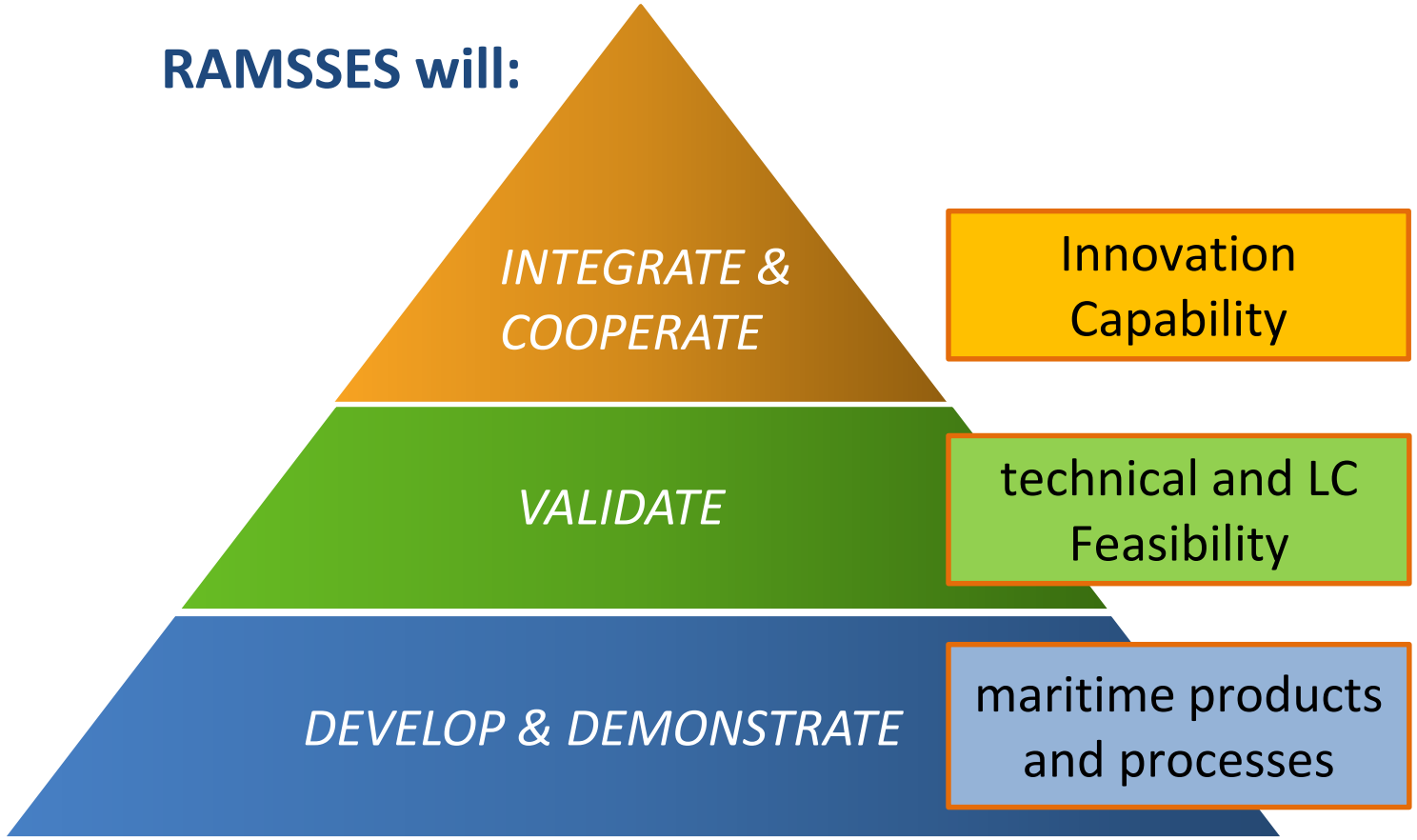
Motivation and ambition

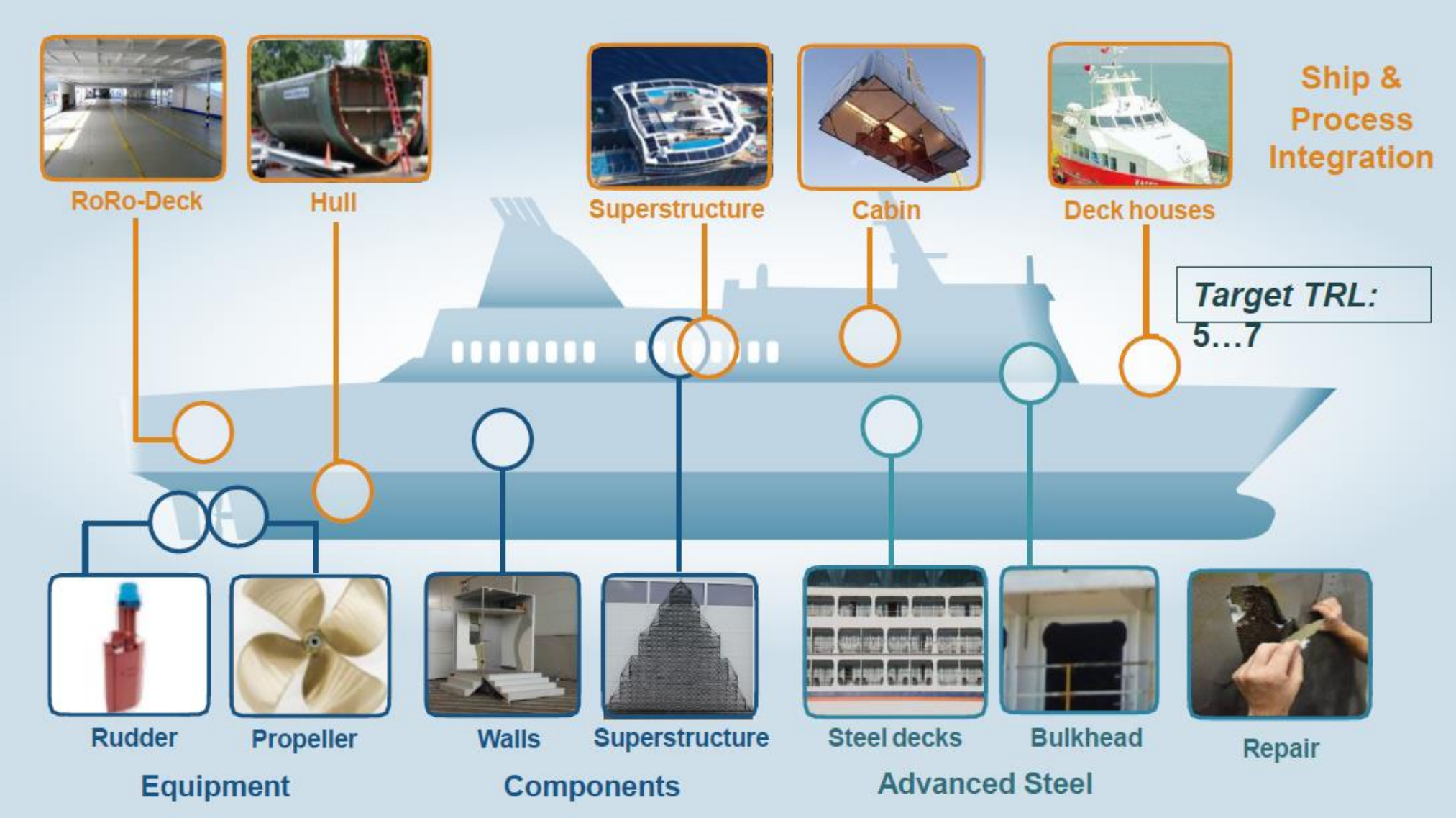
Innovative Materials for Ships:

- less fuel and emissions
- efficient and competitive
- safe and comfortable
- smart and functional

RAMSSES will:



RAMSSES – Demo Cases



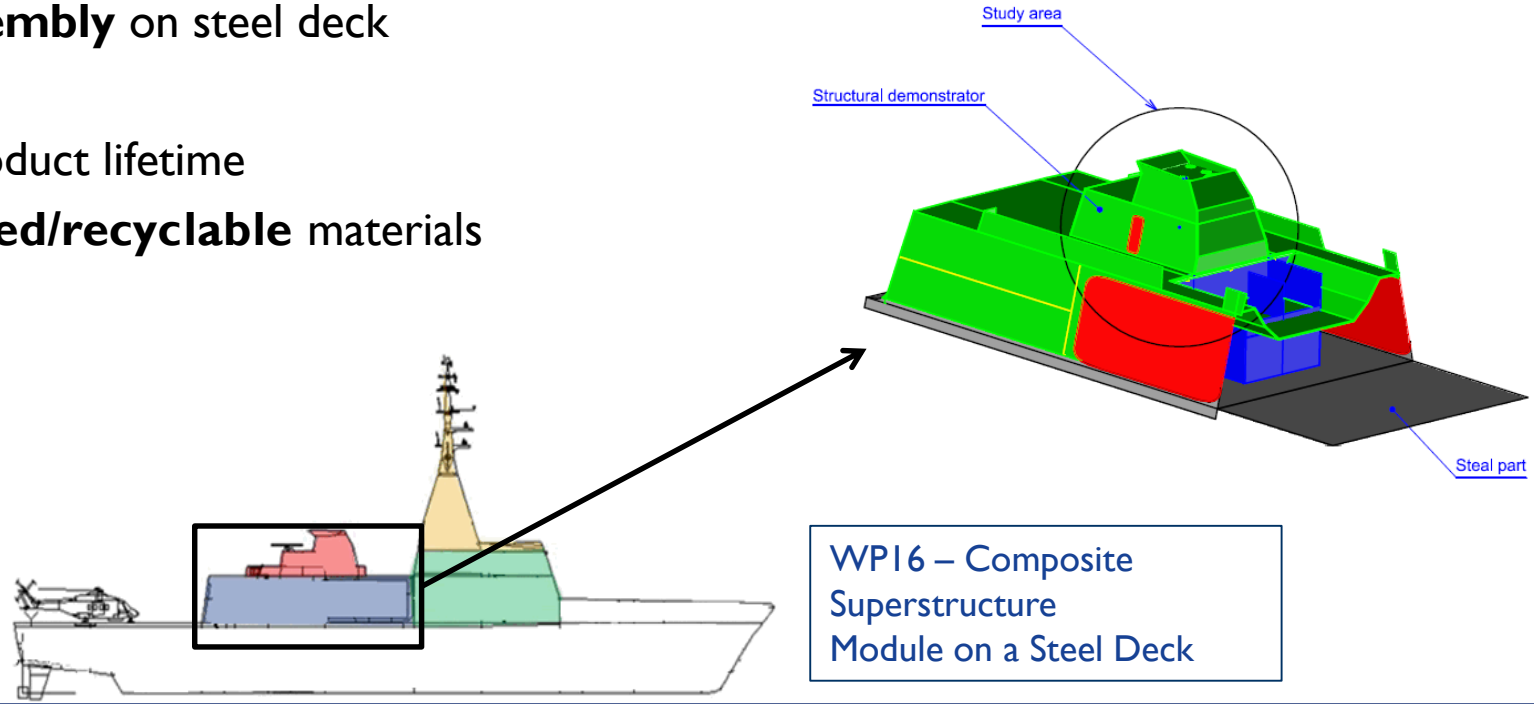
RAMSSES – Demo Cases

WP No	Cluster Title / WP Title	Lead	Focus Material	TRL Target	Validation
	Components & Equipment	**NetComp**			
WP09	Modular Light System for Less Critical Internal Walls and superstructure	BALTICO	various	6-7	(pre)approval*
WP10	Lightweight Components for High Loads and Fire Class	PODCOMP	composite	6-7	(pre)approval*
WP11	Propeller blades by additive manufacturing	NG	metal	4-5	shore based
WP12	Lightweight Rudder Flap	BMS	composite	6-7	onboard
	Ship integration: Composite	**DSNS**			
WP13	Integration of System for Internal Walls and Superstructure of Cruise Ships into shipyard processes	MW	composite	7	onboard
WP14	Modular Decks for RoRo vessels	ULJ	composite	7	onboard
WP15	Lightweight aluminium and composite walls for Work Boats	MEC	various	6	onboard
WP16	Composite superstructure module on steel deck for multi purpose vessels	NG	composite	6	shore based
WP17	Custom Made Hull for Offshore vessel	DSNS	various	6	shore based
WP18	Multi material lightweight cabin for passenger ships	CdA	various	6-7	shore based
	Ship integration: Steel&repair	**CET**			
WP19	Highly Loaded structural details from high tensile steel in passenger and research vessels	FC	steel	6	shore based
WP20	Lightweight Decks using High Tensile Steel in cruise ships	MT	steel	7	onboard
WP21	Composite Overlay to repair and improve metallic and non-metallic structures	CARDA	various	7	(pre)approval* onboard

** commercial approval to be done outside the project based on data elaborated in RAMSSES*

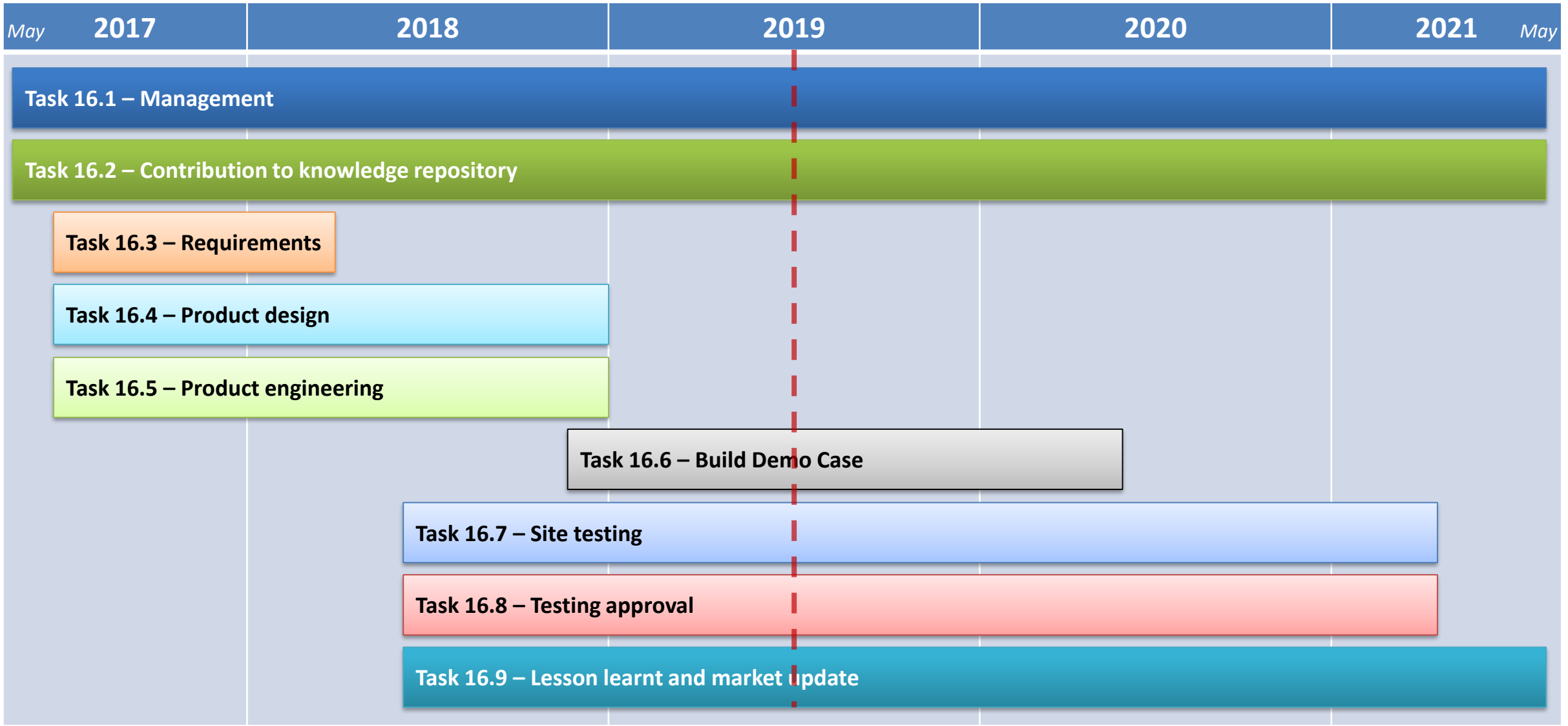
WP16 OF THE RAMSSES PROJECT

- **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 r**ecycled/bio-based/recyclable** materials



WP16 – Composite Superstructure Module on a Steel Deck

RAMSSES WP16 - Schedule



Technical Progress – Contribution of each partners

Assumptions
note related to the application case

Design assessment of the WP16 demonstrator case
Analysis based on BV rules:
- NR 467
- NR 546

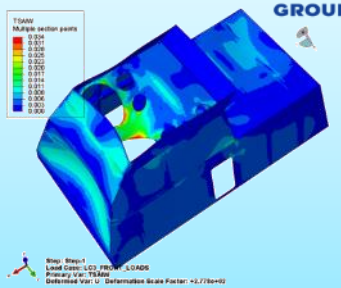
Task 16.3 – Requirements

Task 16.4 – Product design

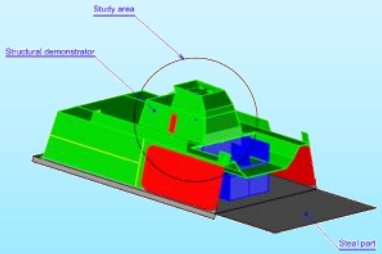
Task 16.5 – Product engineering

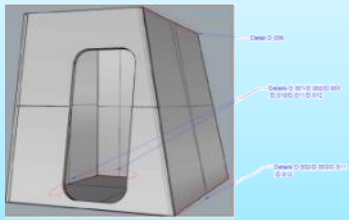
Task 16.7 – Site testing

Global Finite Element Analysis of the Demonstrator case

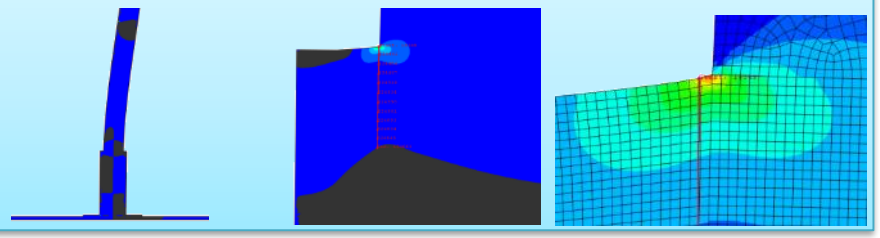


Design of the demonstrator case

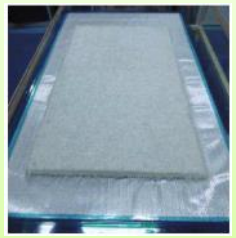


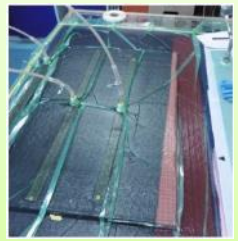


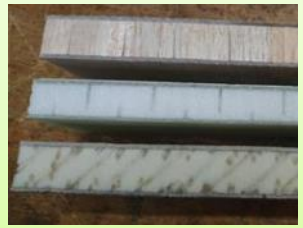
Finite Element Analysis of the junctions



Sandwich panels manufacturing



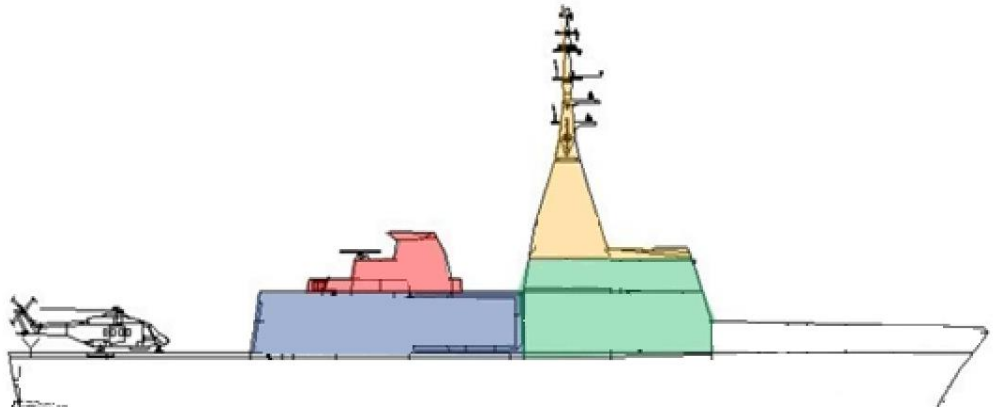




Mechanical evaluation

Assembly evaluation

- Ofshore Patrol Vessel



Ship particulars:

Full Load Displacement at delivery:	≈ 3000 tons
Draught:	≈ 3.9 m
Length between Perpendiculars:	105 m
Length Overall:	110 m
Breadth at the waterline:	14 m

- Classification requirements
  - NR467 Part D chapter 16 of BV rules gives applicable requirements for ship classed with OPV service notation.
  - Loadings from NR467
  - Calculation methodology, testing, surveys from NR546
  - Safety coefficients from NR600

- Serial approach:

Global analysis first then transfer of boundary conditions to assemblies models

Experimental results (tests on coupons)

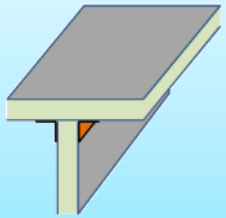
Mechanical properties

Assumptions note related to the application case

Experimental tests on **Structural Assemblies**

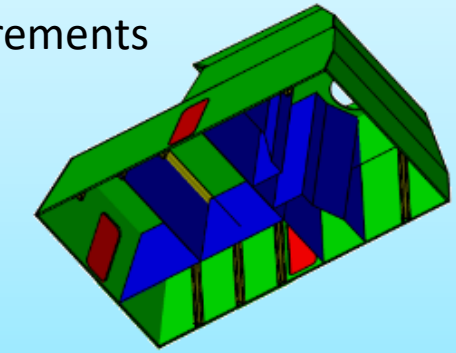
Experimental tests on adhesive lab **Specimens**

Assemblies FEA



Global Finite Element Analysis (FEA)

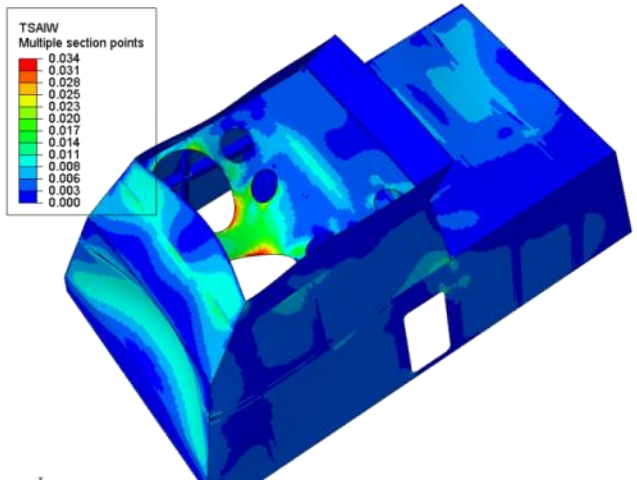
Global model of the selected module in order to comply overall requirements



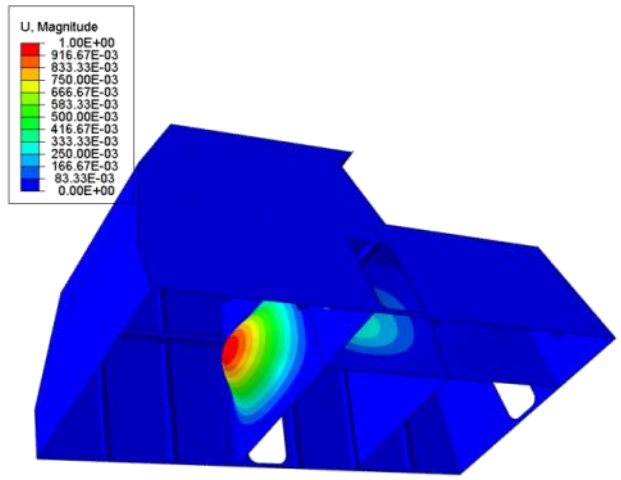
FEA of the superstructure block

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

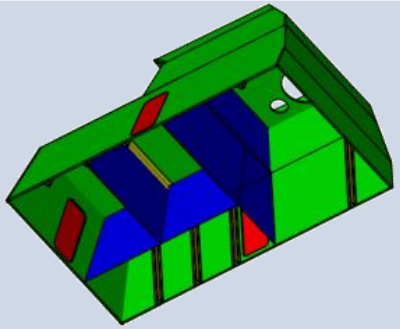
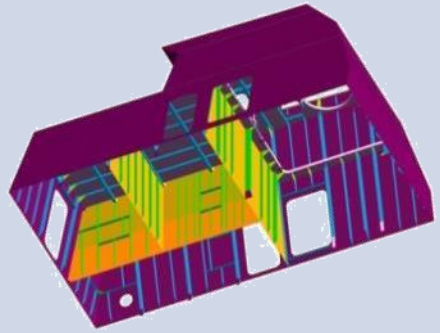
- Eigen values
- Deflection
- Buckling stability
- Tsaï-Wu failure criterion (GFRP)
- Core analysis



Tsaï-Wu failure criterion

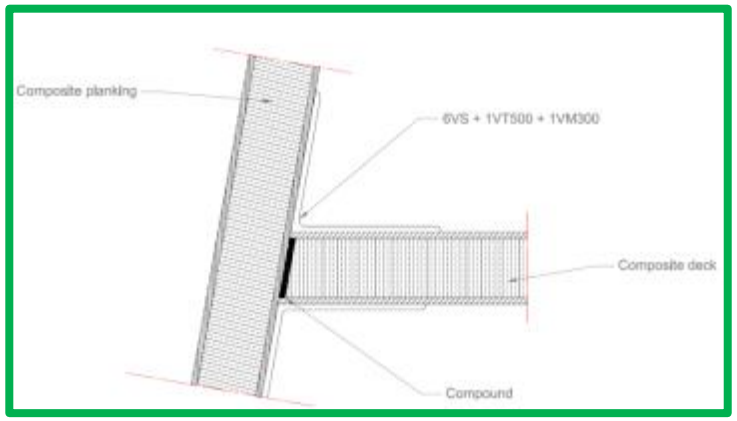


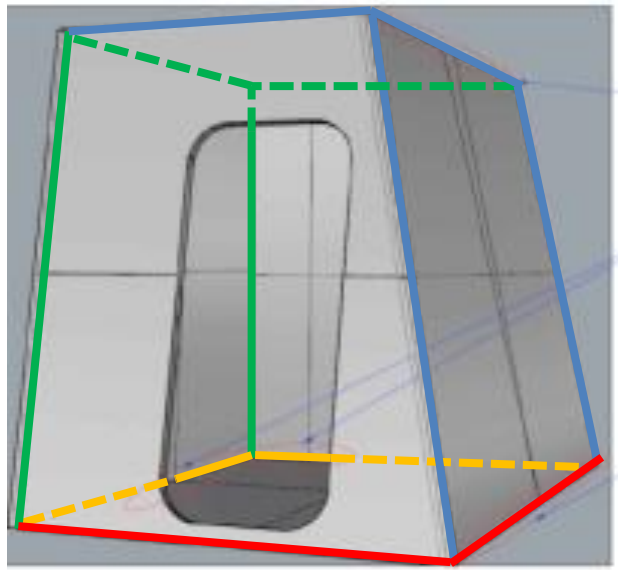
Buckling stability

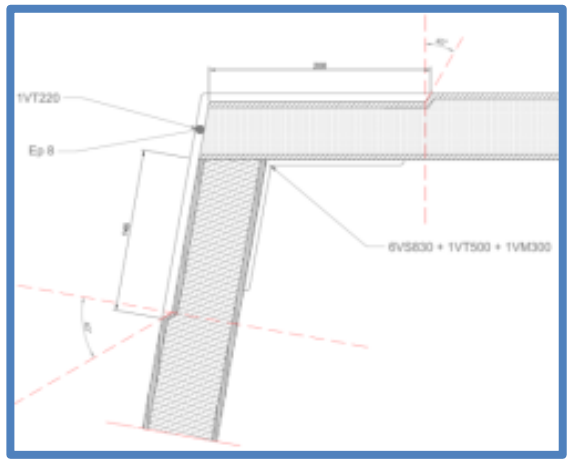
	Composite superstructure block (WP16 design)	Metallic superstructure block (Original design)
Structural calculation made by Naval Group Internal referential	 **4 t**	 **11 t**

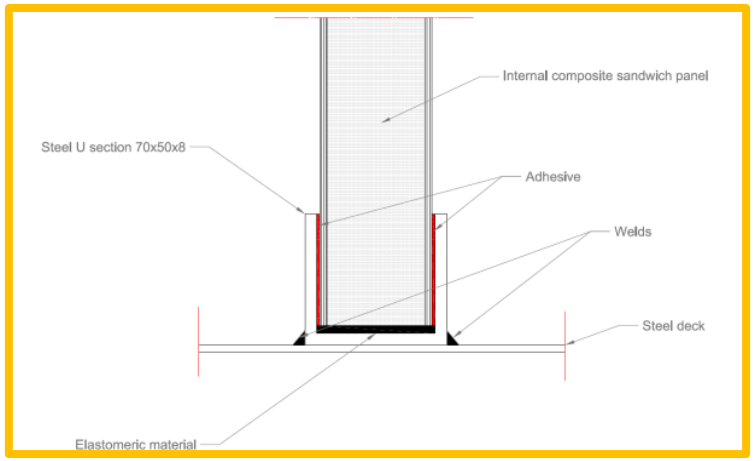
Up to 60% of weight reduction

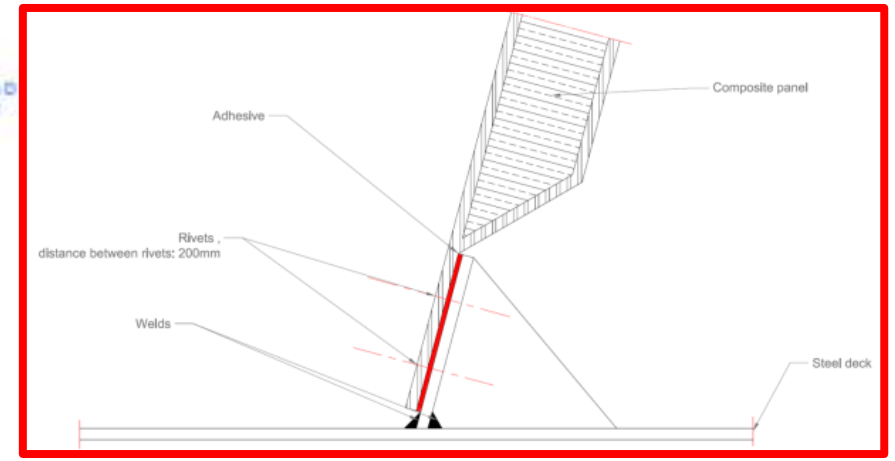
- Overall design of the demonstrator case and its junctions





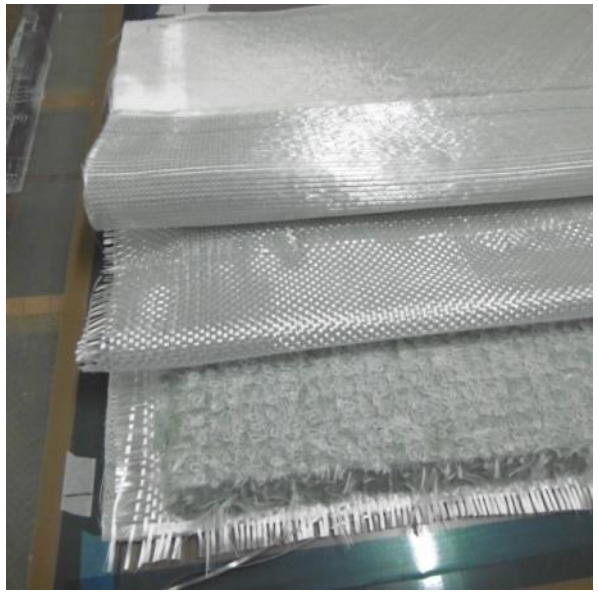




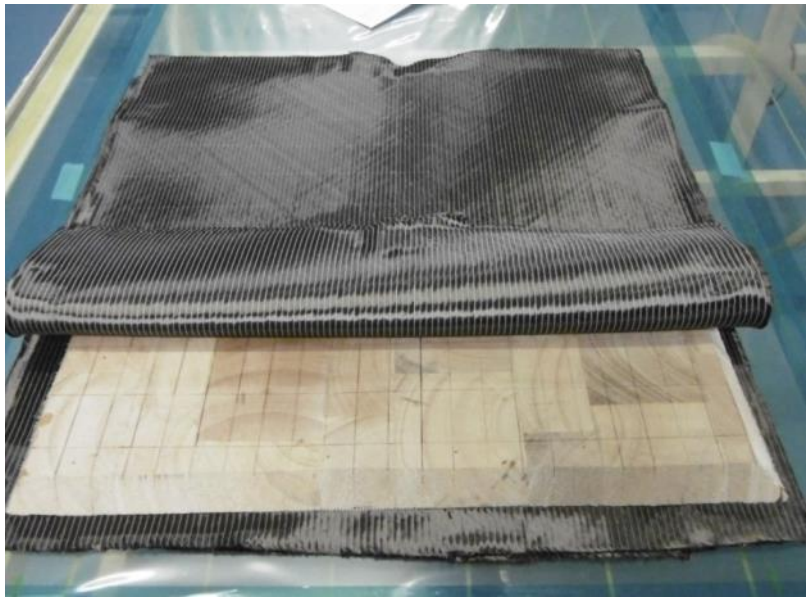


- Material selection for the sandwichs panels
  - Skins : Glass/Vinylester for external bulkheads (evaluation of Carbon/Epoxy)
    Glass/Polyester or Glass/Vinylester for internal bulkheads
  - Core : 3D reinforced foams or balsa wood
  - Protection against fire : LEO Coated and/or intumescent paint

3D reinforced foam



Sandwich lay-up (GFRP + reinforced foam) before vacuum infusion



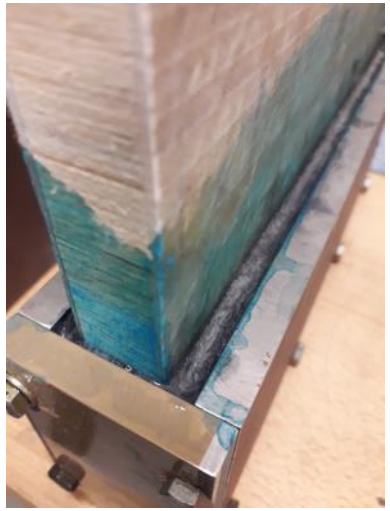
Sandwich lay-up (CFRP + Balsa) before vacuum infusion

Sandwich pannel with intumescent paint

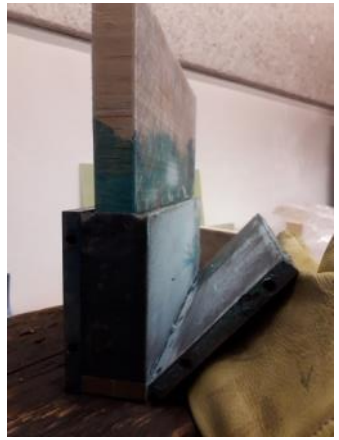
- Adhesive bonding with the disassembly function
  - Multi-material assembly
  - flexible resin (damping, tolerance, thermal expansion)
  - Disassembly function by heating the metallic part

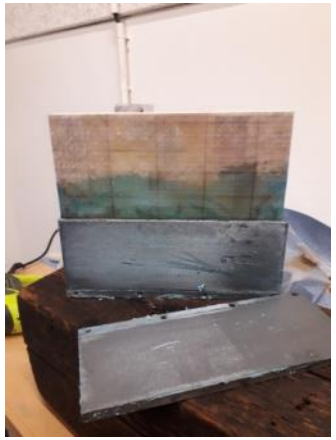
    Evaluation: Heating by a hot air device

    Industrial potential: Joule effect heater with addings in the adhesive or induction heating



Bonded junction





Bonded junction after heating

- Experimental approach

  General Campaign

Demonstrator scale tests

- Fire behaviour tests (WP07)
- Mechanical tests on assemblies

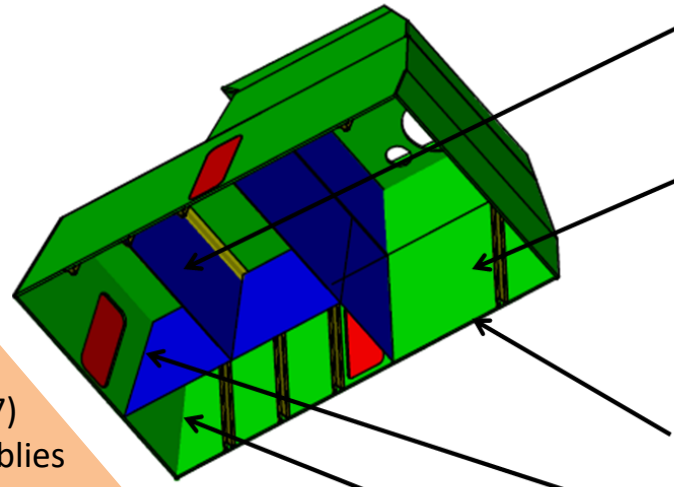
Intermediate level tests

Joints and composite panels

- Mechanical tests on joints (static and cyclic)
- Fire behaviour (WP07 - RISE)
- Resistance to marine environement evaluation

Material coupons tests

- Mechanical tests (WP16 and WP07 - Fraunhofer)
- Physico-chemical tests (WP16 and WP07 - Fraunhofer)
- Fire raction tests (WP07 - RISE)



Non-load bearing Bulkhead - Fire Resisting Division Test (FRD) according to FTP code part 11

Load bearing Bulkhead – FRD Test according to FTP code part 11

Assembly on the steel deck

T Assembly between nonload bearing and load bearing bulkhead

L Assembly of load-bearing bulkhead

- Experimental approach – Tests on coupons

WP07 - Fraunhofer | WP07 - RISE | WP16 - Naval Group

Mechanical

Monolithic And skins	*Sandwich*
3-point bending *ISO 14125*	**3-point bending** *NF T54-606*
Interlaminar Shear test *ISO 14130*	**4-point bending** *NF T54-606*
Tensile test *ISO 527*	**Interlaminar Shear test** *NF T54-606*

Physico-chemical

Monolithic, skins and core materials

- **Density** *ISO 1183*
- **Fiber content** *ISO 1172*
- **DSC** Differential Scanning Calorimetry *ISO 11357*
- **TGA** ThermoGravimetric Analysis *ISO 11358*

Fire

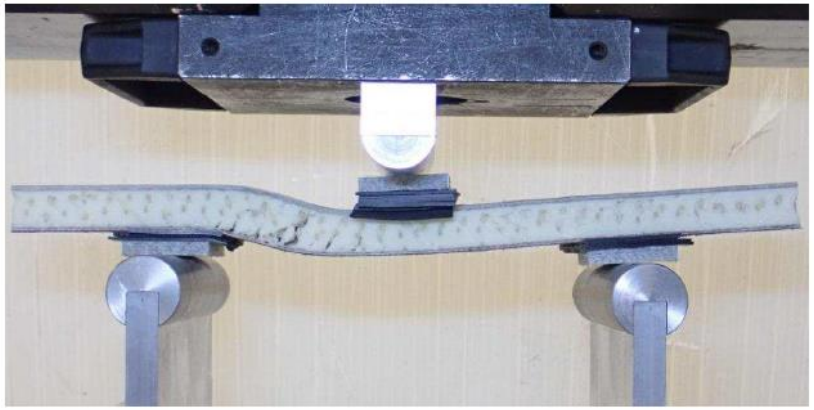
Sandwich samples

- **Cone calorimeter** *ISO 5660*

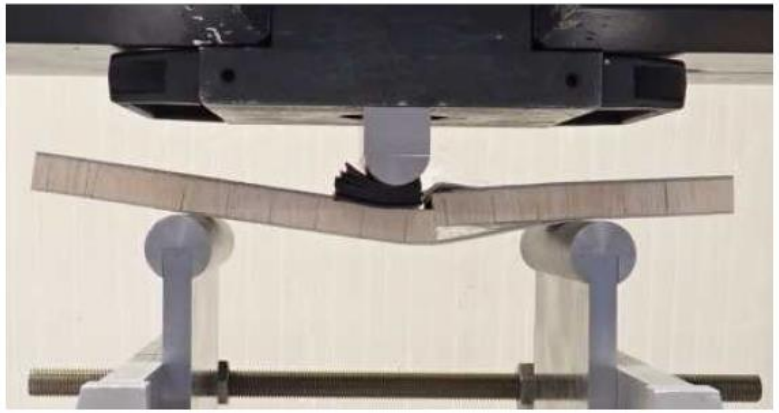
- NI546 based approach:
  - A first campaign has been performed by Naval Group to select the materials
  - Then 2 materials will be tested at Fraunhofer within WP07 framework

- Experimental approach – Tests on coupons
  - Experimental campaign on monolithic coupons to feed a decision matrix based on mechanical and physicochemical tests
    - Reinforcements: Glass, Carbon, Basalt, flax
    - Resins: Vinylester, polyester, epoxy
    - Fire retardant: FR infusion resin, coated fabric, intumescent gelcoat
  - 3-point bending on sandwich samples

Tensile test on woven flax/baslat monolithic coupons



Sandwich lay-up (vinylester GFRP + reinforced foam)
Shear strength : 1.9 MPa



Sandwich lay-up (polyester GFRP + balsa wood)
Shear strength : 4.0 MPa

Sandwich lay-up (epoxy GFRP + PET foam)
Shear strength : 0.9 MPa

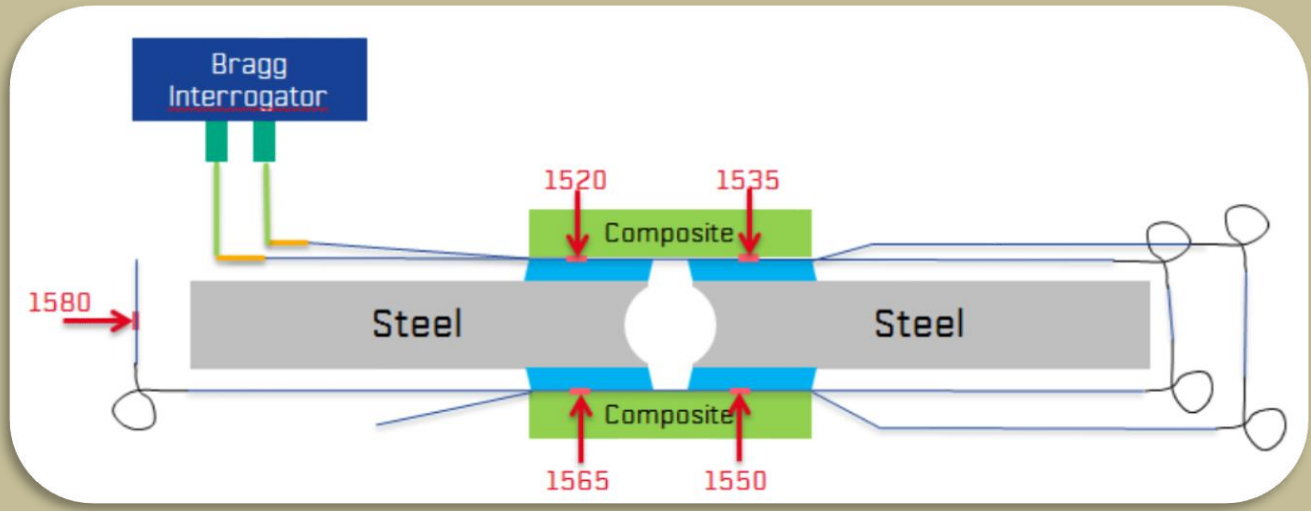
- Experimental approach – Intermediate level tests – Tests on adhesives

Modified Arcan test

Objectives of this campaign:

- Adhesive **multiaxial characterization** (static and fatigue)
- Definition of the **linear elastic material constants**
- Definition of a **failure stress** based criterion

Test on coupons



Objectives of this campaign:

- Evaluation of the **intrusivity of the fibre bragg gratting** sensors
- Behaviour of the assembly **with and without primary**
- **Durability** (unaged and aged samples)

- Experimental approach – Intermediate level tests – Tests on adhesives

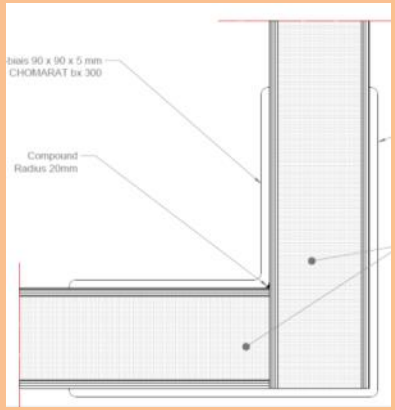
- Experimental approach – Demonstrator scale tests – Test on junctions

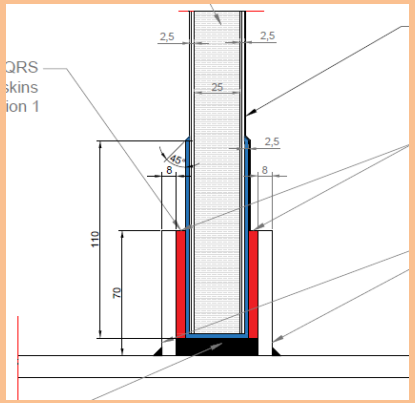
Mechanical tests on assemblies

Monotonous and cyclic loadings with SHM (sQRS and Bragg grattings)

Configuration 1

Bonding principle of 2 external bulkheads



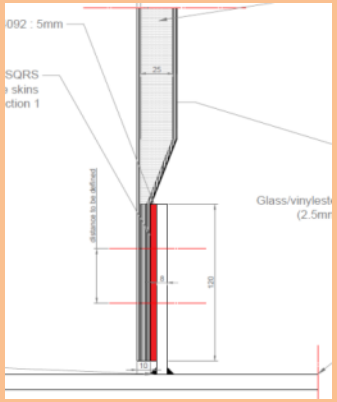


Configuration 2

Assembly detail of steel deck and internal composite bulkhead

Configuration 3

Assembly detail of steel deck and external composite bulkhead

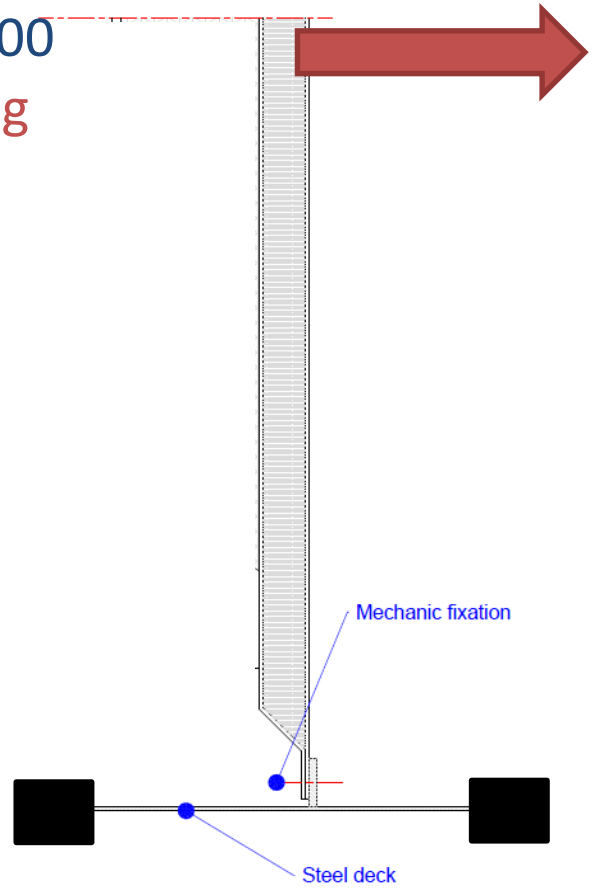


Configuration 4

FAUSST System
Assembly detail of steel deck and external composite bulkhead

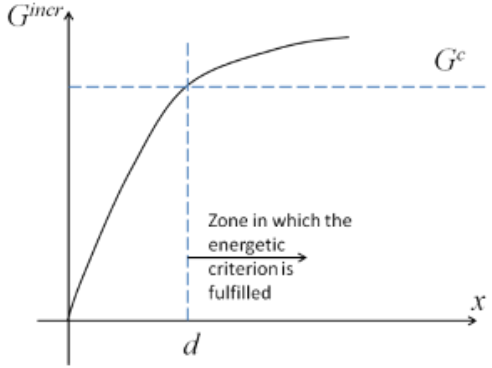
Multiaxial fatigue platform (ENSTA Bretagne) :

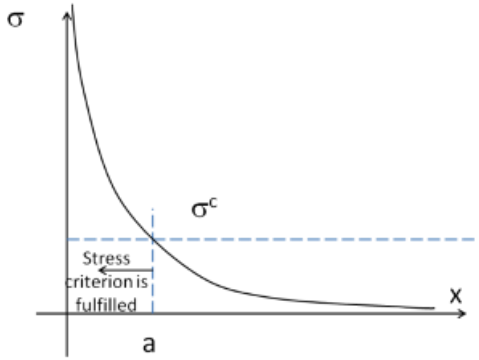
hydraulic actuators (400 kN): bending

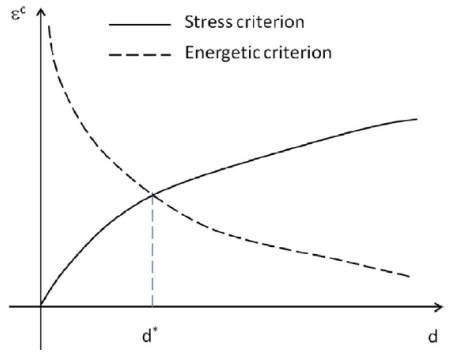


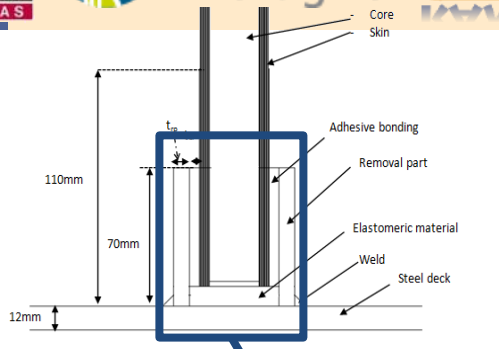
Design of specific clamping device

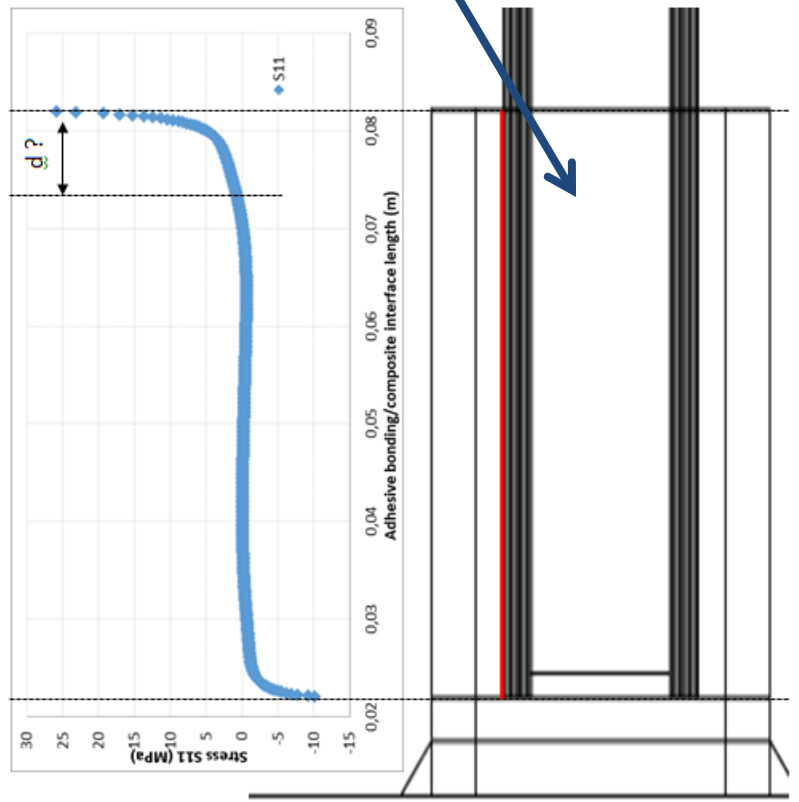
- Characterization of structural specimens of bulkhead junctions
  - Structural specimen test campaign :
    - Design of a **clamping device**
    - 1 loading case : Bending
    - Monotonic and **Fatigue** tests
  - Numerical approach :
    - **FEA linear elastic model** from Composite (Naval Group) and Adhesive (ENSTA B.) material parameters
    - Based on a **coupled approach** : Definition of the **process zone** for each loading case to evaluate the stress criterion











Next steps and timeline

Production of extra sandwich panels

- Fire and mechanical tests within WP07 framework

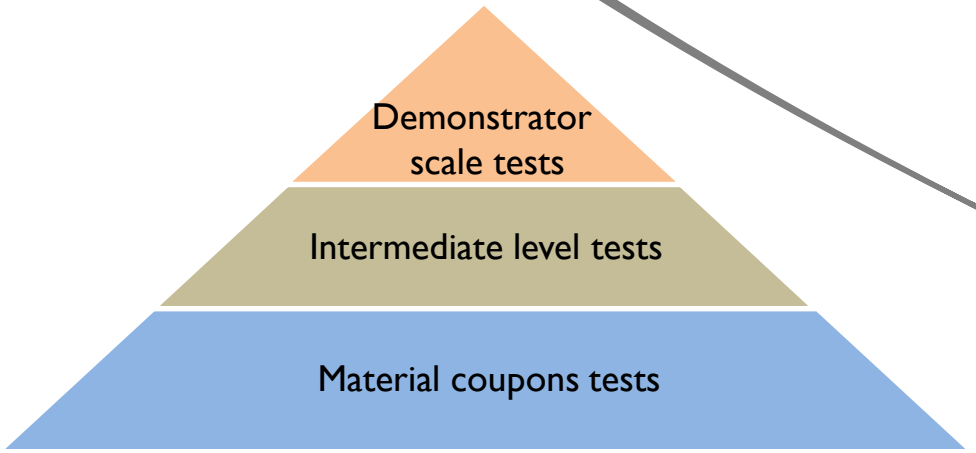
June 2019

Analysis and production of junction specimens

- Composite and multi-material junctions (rivets, adhesive and FAUSST)
- Integration of Structural Health Monitoring (SHM)

Test on junction specimens

- Monontonous loading
- Fatigue evaluation



Production of large panels for demonstrator case and fire tests

- Single Burning Items (SBI)
- Fire Resisting division Tests (FRD)

June 2020

Demonstrator case finalized

Thank you for your attention

Any question ?

Contact: emilien.billaudeau@naval-group.com

Disclaimer

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