Towards Safety of Composite Ships

Date: Monday 3 February, lunchtime

Duration: 30 minutes

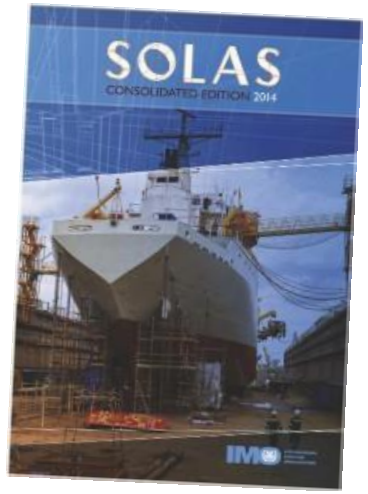
Presenters: Alfonso Jurado, Matthias Krause, Stéphane Paboeuf

Presentation outline

- Motivations for both projects
- FIBRESHIP
- RAMSSES
- Joint conclusions
- Q&A

Motivations Current regulatory regime

Very little number of FRP ships registered at IMO



SOLAS Ch.II-2 Regulation 2:

"The hull, superstructures, structural bulkheads, decks and deckhouses **shall be constructed of steel or other equivalent material**. " **= barrier**

SOLAS Ch.II-2 Regulation 17:
"Alternative design and arrangements"
On basis of Equivalent Safety **= opportunity**

Main issue to be addressed: **fire safety**

Motivations Current regulatory regime

Guidance available

- MSC.1/Circ.1455 Guidelines for the approval of alternatives and equivalents as provided for in various IMO instruments
  - **Uncertainty of getting approval in contract phase**
- MSC/Circ. 1002 Guidelines on alternative design and arrangement for fire safety
- MSC.1/Circ.1574 Interim guidelines for use of fibre reinforced plastic (FRP) elements within ship structures: Fire safety issues.
  - **Adopted June 2017, 4 years evaluation period**

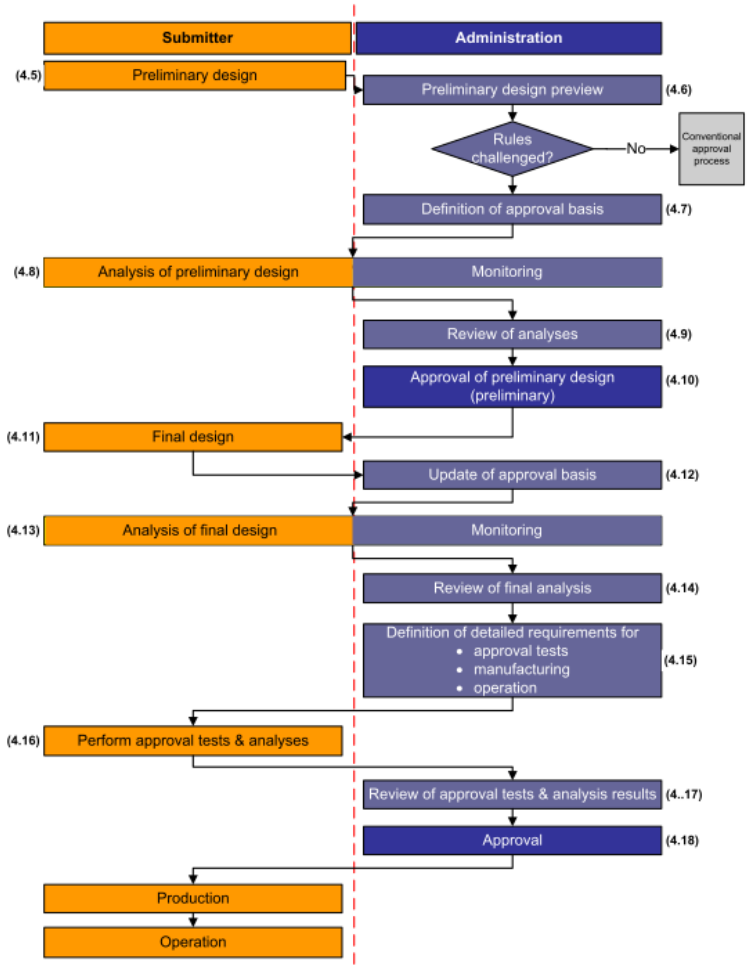


Figure 2: Design and Approval Process

Developed Approaches

Short term approach

- Based on existing rules and **a Smart Track to Approval**
  - Database of pre-approved solutions and materials test results
  - Fire risk scenarios
  - Analysis and modelling tools, including numerical or statistical models

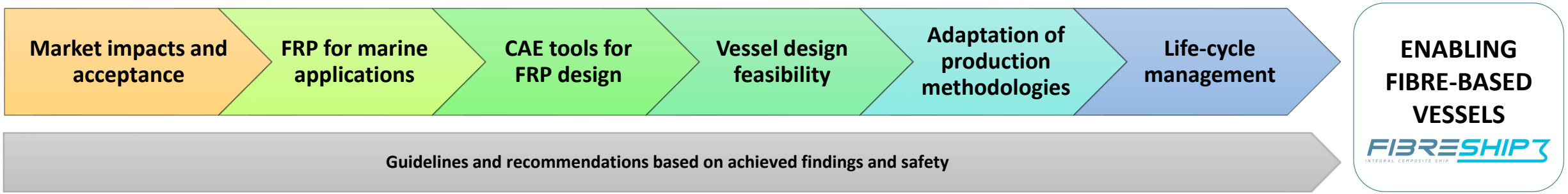
Long term approach

- Development of **new prescriptive rules** in:
  - Structure
  - Fire
  - Production
- Validation by simulations, tests and full-scale demonstrator

FIBRESHIP PROJECT DESCRIPTION

FIBRESHIP Project

- FIBRESHIP addresses the **feasibility** of using **FRP** technology for **large-length vessels**, trying to overcome the identified technical challenges and promote a change in the regulatory framework that enables their design, building, and operation.



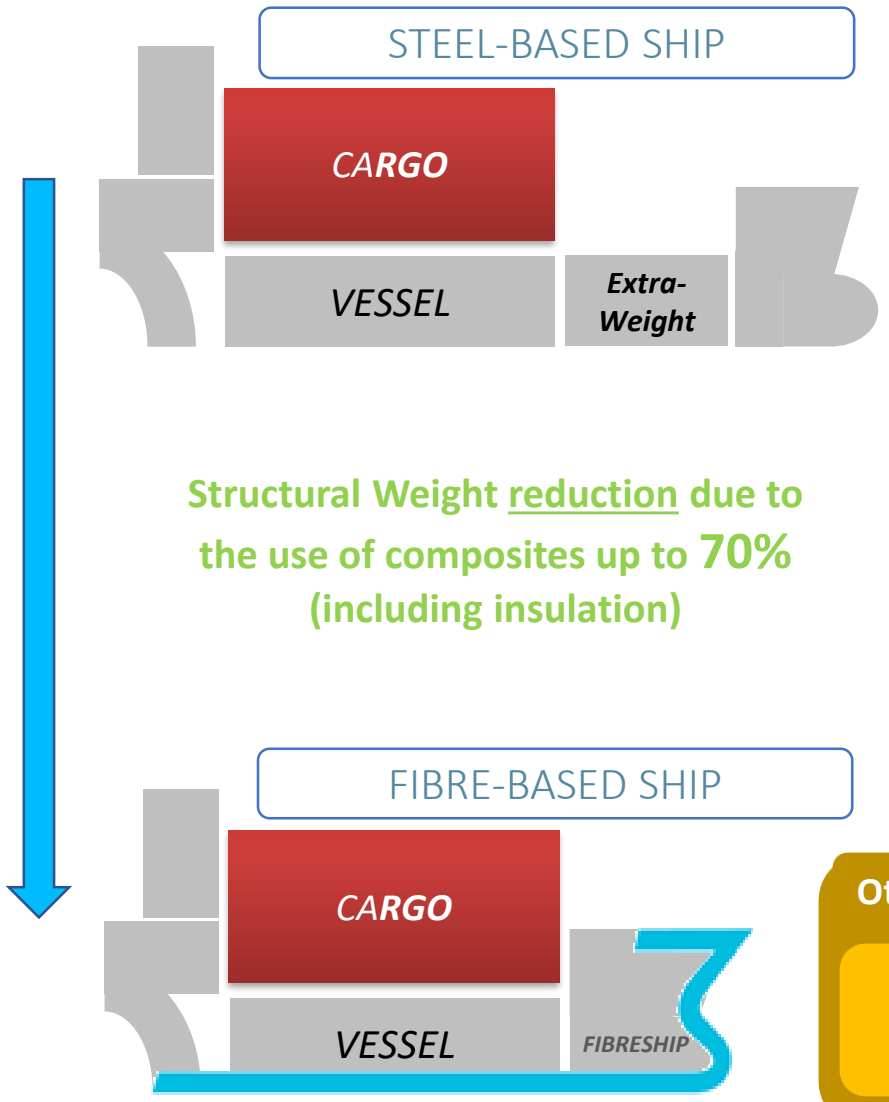
Main particulars of FIBRESHIP:

- Grant Number: 723360
- Duration: 36 months (June2017-May2020)
- Project Budget / EU Contribution: €11M / €8,7M
- TRL: 7-9
- Collaboration between 18 partners of 11 countries

H2020 Project Management

This project has recived funding from European Union's Horizon 2020 research and innovation programme under grant agreement Nº 723360

POTENTIAL BENEFITS IDENTIFIED



Benefits for shipowners due to the reduction of structural weight:

- **Reduction of Powering Needs & Wet Surface implying:**
  - Bunkering Consumption Reduction
  - Lower Greenhouse Gas Emissions
- Increasing of Payload Capacity

Other potential benefits for shipowners:

- Better Fairing Solutions for the Constructed Hull
- Aesthetic Improvements
- Corrosion Immunity
- Life Cycle Costs Reduction

Other potential benefits identified in the FIBRESHIP project:

- Continuous Structural Health Monitoring
- Possibility of Using Wireless Sensors
- Underwater Radiated Noise Reduction

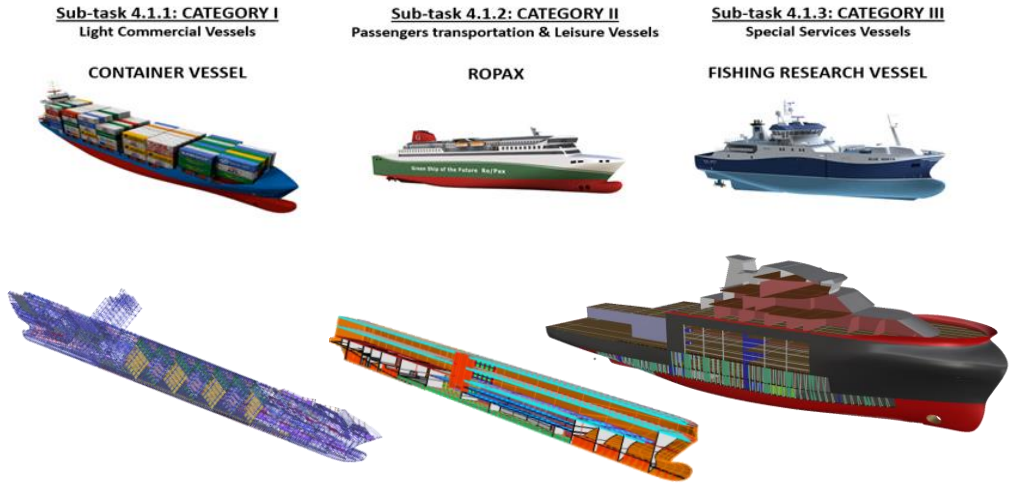
MAIN OUTCOMES (1/5) – SUMMARY OF RESULTS

FRP adoption roadmap in EU shipping market considering end-users satisfaction

Cost-Benefit calculator and Global Business Plan

FRP methodology selection

Designing of three fibre-based vessel structural



Containership 250m LOA

ROPAX 204m LOA

FRV 85m LOA

Results verification with experimental tests:

- Material mechanical properties and bondings.
- Small- & medium scale fire tests of FRP panels with and without insulation.
- Influence of environmental conditions on FRP panels.
- Onboard N&V tests and URN measurements.
- Structural full-scale vessel test.
- Modal analysis and NDT of FRP panels for detection of delamination failures.
- Engineering solutions for aesthetic improvements.

Coupled software capable to assess the vessel structural and fire performance

Building a FRV block fully in composites as a demonstrator

Definition of vessel inspection and SHM strategy

Guidance notes and recommendations:

- Applicable materials and joining techniques.
- Structural design based on structural and fire criteria.
- Adoption of new production strategies and building techniques.

Decision Support Tool on life-cycle assessment (LCA)

MAIN OUTCOMES (2/5) – FRV Structural design process

STANDARD SCANTLING FOR STRUCTURAL DESIGN

3D MODELLING

Classification Society Rules

Structural configuration definition

Materials and laminates definition

Midship and Web-frame Scantling

1st stage

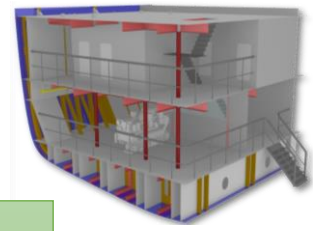
From Midship to a full 3D ship structure

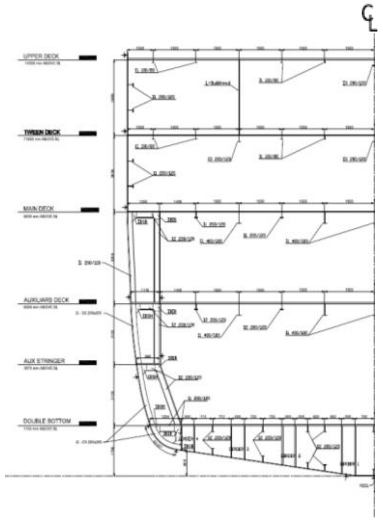
2nd stage

Demonstrator design for construction

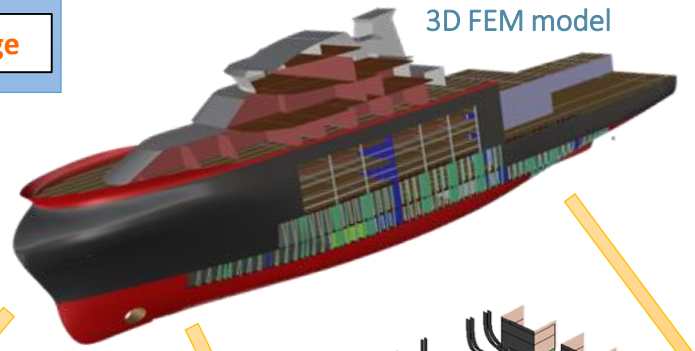
FEM Analysis

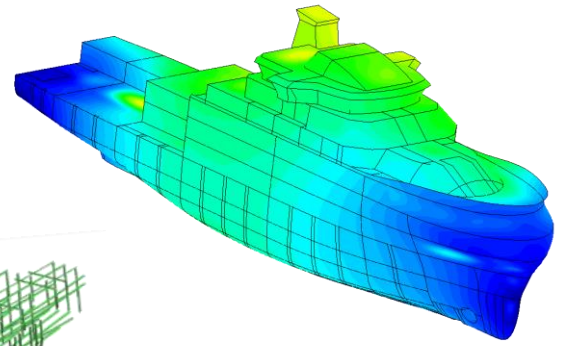
Optimization stage

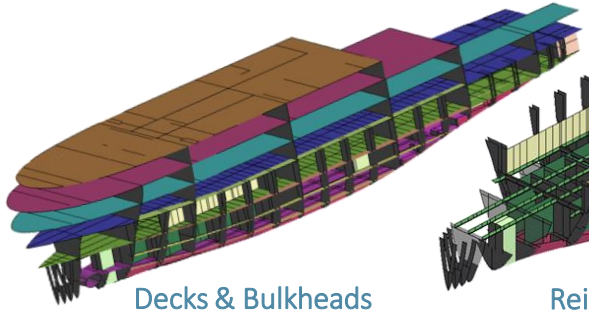




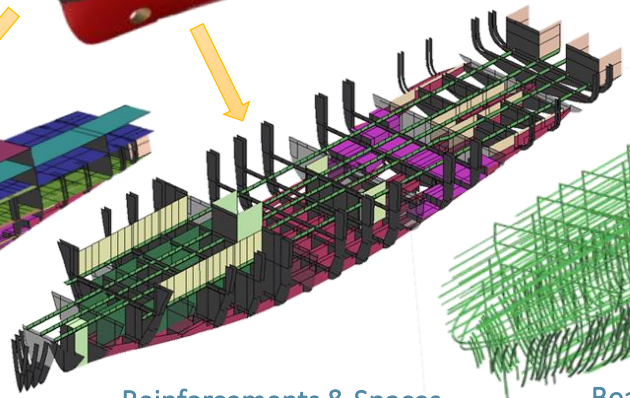
3D FEM model



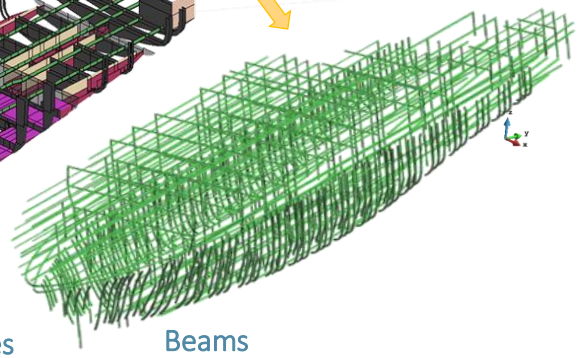




Decks & Bulkheads



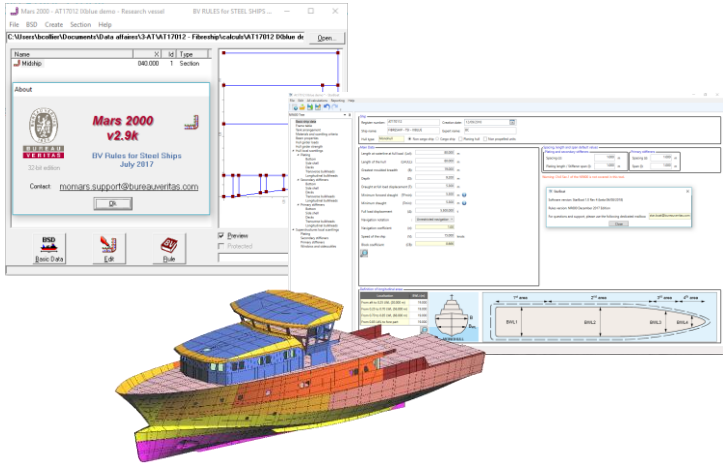
Reinforcements & Spaces



Beams

MAIN OUTCOMES (3/5) – Structural and Fire Performance Criteria

- **Structure Performance Criteria**
  - ✓ **Calculation Approach:** Loads - Rules Based / Numerical (FE) approach
  - ✓ **Loads combination:** Local / Global
  - ✓ **Fatigue assessment:** S-N Curves, cumulative damage
  - ✓ **Joining:** Adhesive bonding of composites and hybrid materials
  - ✓ **Structural continuity:** Between primary hull girder and structure / primary and secondary stiffener



- **Fire Performance Criteria: two complementary approaches**
  - ✓ **Local equivalence approach for composites:**
    - Based on **SOLAS** expectations for steel structures and deck/bulkheads fire ratings.
    - Proposal of **new fire division rating and spaces**: **REI**
      a. Resistance (R), Integrity (E), Insulation (I) (to avoid misunderstanding with A & B class fire divisions)
    - Proposal of **new fire tests and performance criteria** for FRP structures
  - ✓ **Global equivalence approach for composites:**
    - Based on **generic risk models** to be developed.
    - Considers fire risk in a **global approach** and all possible **fire safety systems**
    - Identification of **specific nodes** (from **local equivalence** approach) to reach an **equivalent safety level**

Adjacent space → / Space on fire ↓	A	B	C	D	E	F	G	H	I	J	K	L	M	N
A	60	60	60	60	30	30	30	30	30	60	60	60	60	60
B	60	60	60	60	30	30	30	30	30	60	60	60	60	60
C	60	60	60	60	30	30	30	30	30	60	60	60	60	60
D	60	60	60	60	30	30	30	30	30	60	60	60	60	60
E	60	60	60	60	FRM	FRM	FRM	30	30	60	60	60	60	60
F	60	60	60	60	30	30	30	30	30	60	60	60	60	60
G	60	60	60	60	FRM	FRM	30	30	30	60	60	60	60	60
H	60	60	60	60	FRM	FRM	30	30	30	60	60	60	60	60
I	60	60	60	60	FRM	FRM	30	30	30	60	60	60	60	60
J	60	60	60	60	30	30	30	30	30	60	60	60	60	60
K	60	60	60	60	30	30	30	30	30	60	60	60	60	60
L	60	60	60	60	30	30	30	60	60	60	60	60	60	60
M	60	60	60	60	30	30	30	60	60	60	60	60	60	60
N	60	60	60	60	30	30	30	60	60	60	60	60	60	60

Space classification	Description	Space classification	Description
A	Control stations	H	Areas of minor fire risk
B	Stairways	I	Areas of moderate fire risk
C	Corridors	J	Areas of high fire risk
D	Evacuation stations and external escape routes	K	Machinery spaces
E	Open decks	L	Auxiliary machinary spaces
F	Sanitary and similar spaces	M	Special category and ro-ro spaces
G	Tanks, voids with no or little fire risk	N	Cargo

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MAIN OUTCOMES (4/5) – FIBRESHIP Market Readiness

ACHIEVABLE IMPACTS FOR SHIPOWNERS

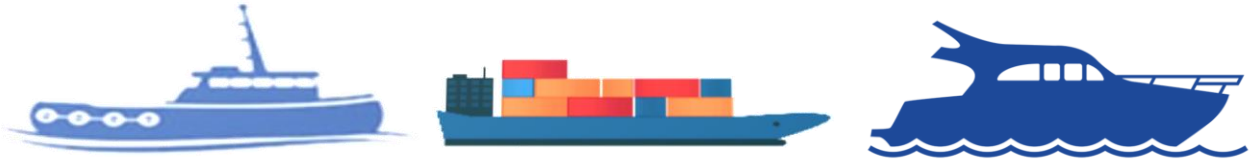
- **O&M cost savings**
- **Emissions reduction**
- **Economies of scale achievement by increasing cargo capacity**

Larger ships in FRP looks as a good idea to owners!

Smooth Scale Increasing

Vessel segments closest to market:

Inland Waterway Vessels / Superyachts / Small Feeders
Research Vessels / Small Offshore Supply Vessels



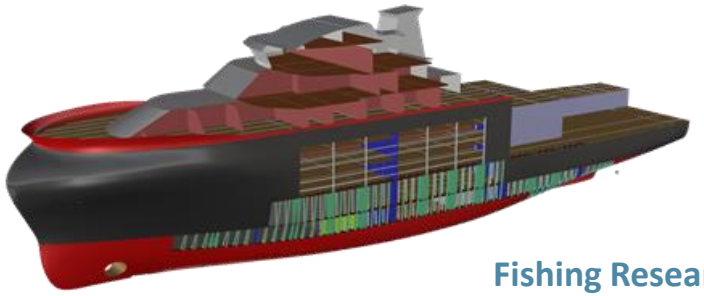
Good starting point for fully fibre-based vessels

FACTORS OF MARKET READINESS

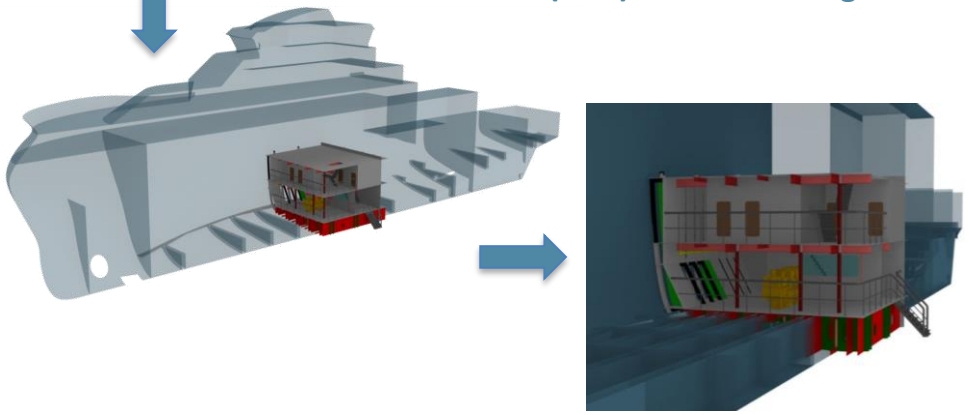
- ✓ Incentives to Short Sea Shipping market
- ✓ Construction Readiness
- ✓ Positive ROI

MAIN OUTCOMES (5/5) – FIBRESHIP Demonstrator

Full-scale demonstrator of a Fishing Research Vessel (FRV) module was built at iXblue facilities in La Ciotat (France):

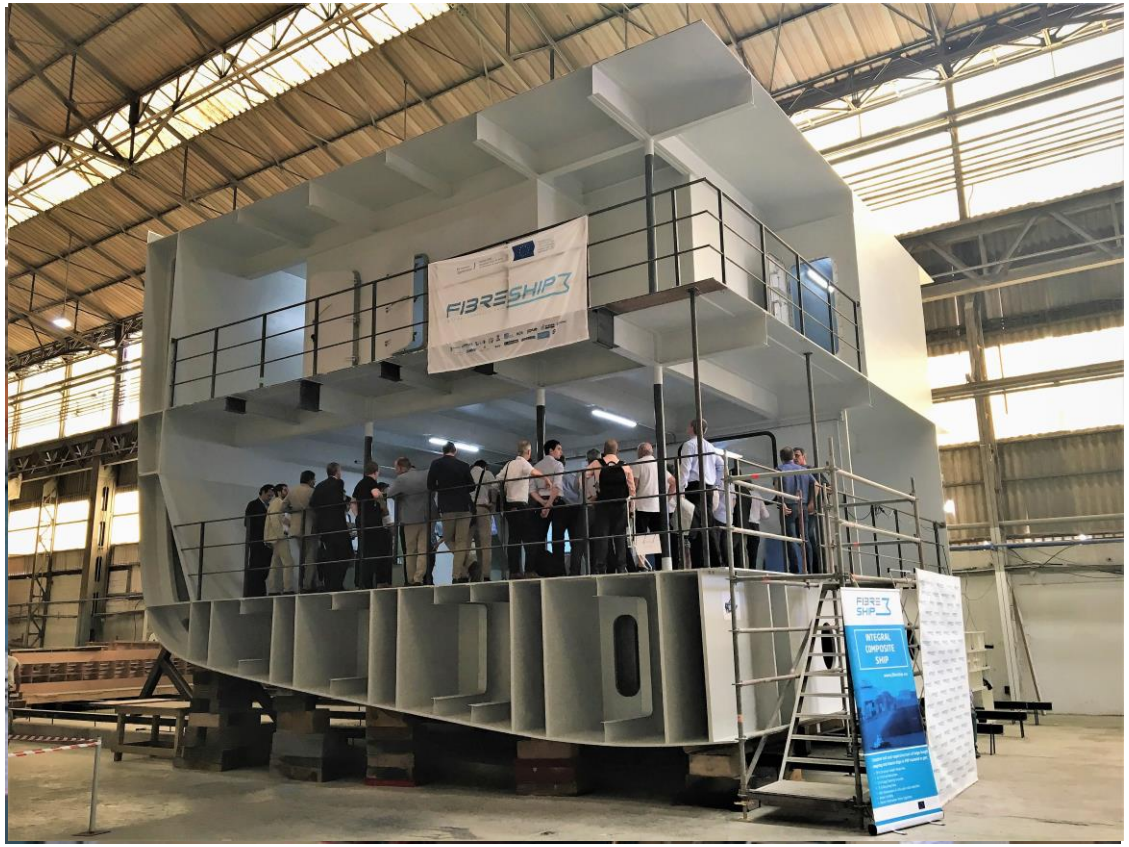


Fishing Research Vessel (FRV) of 85m of length



Ship block that considers two different spaces on board.

Approx.: 11m x 11m x 8.6m; 20 tons



The ship block considers:

- Bottom deck with a part of an engine room.
- Upper deck with a set of accommodation spaces.

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

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

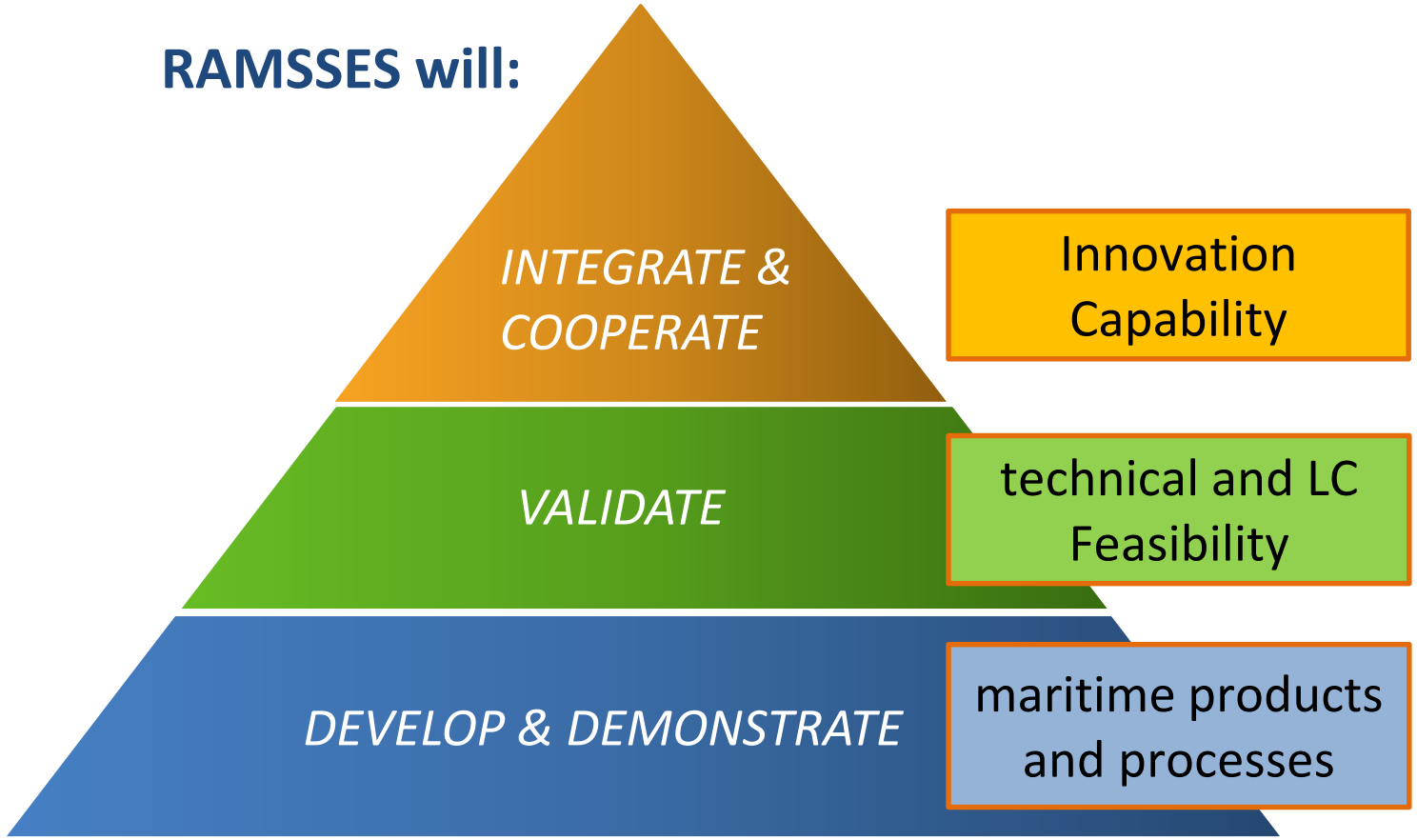
The project RAMSSES has received funding under the European Union's Horizon 2020 research and innovation programme under the grant agreement No 723246.
The information contained herein reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained herein.

Motivation and ambition

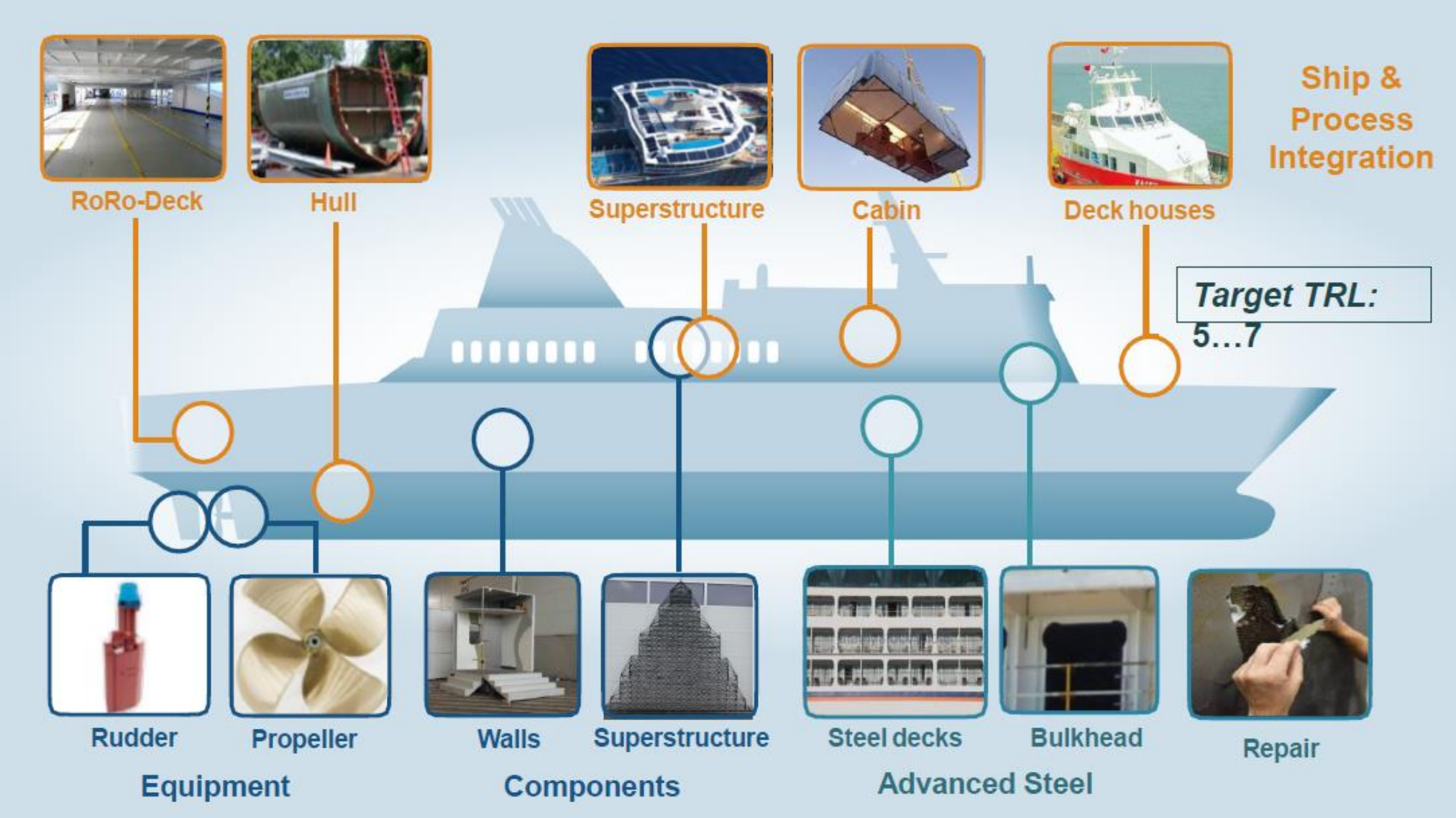
Innovative Materials for Ships:

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

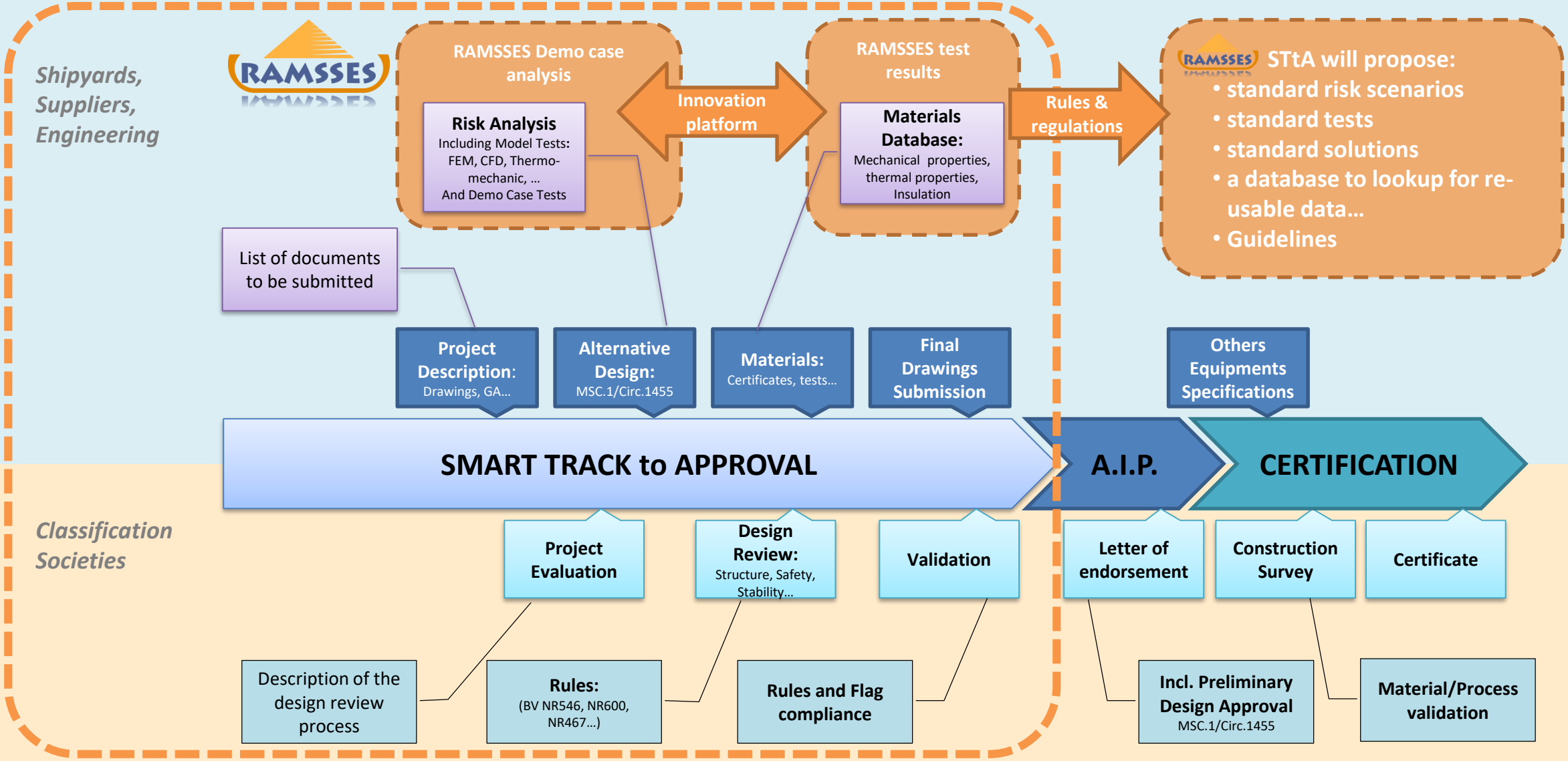
RAMSSES will:



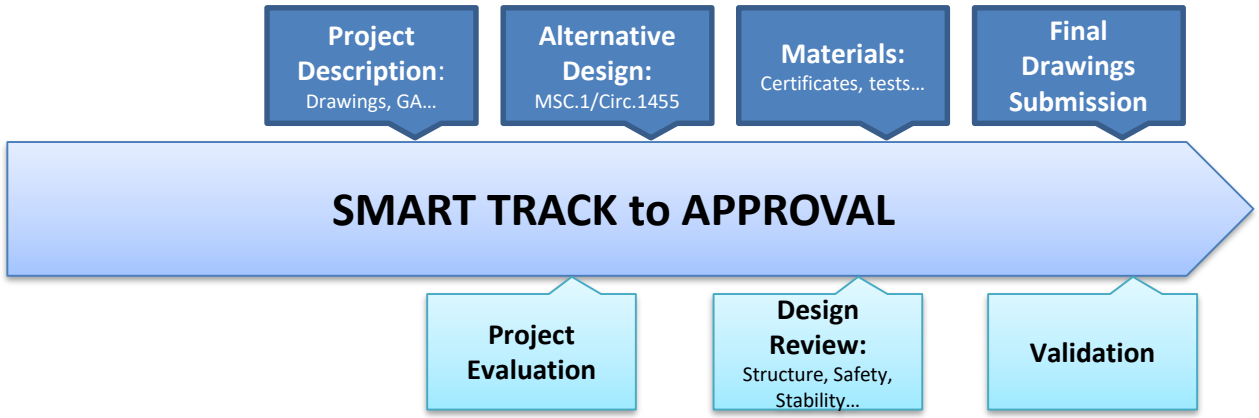
RAMSSES – Demo Cases



Smart Track to Approval



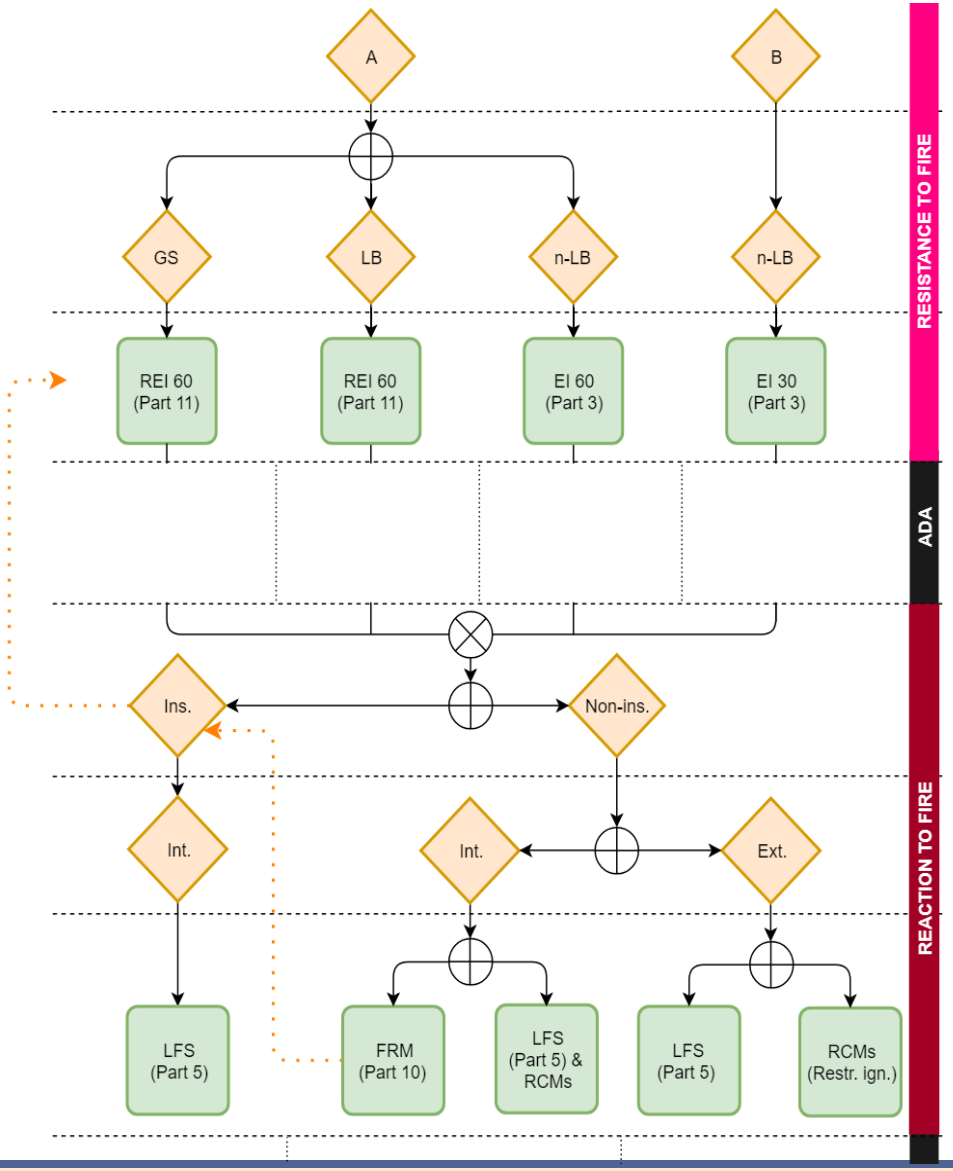
Standard Fire Risk Scenarios



Fire

- A and B Class Division
- Resistance Class Definition
  - REI or EI
- Insulation / No insulation
  - Fire-Restricting Materials
  - Low Flame-Spread
  - Restricting ignitability

In accordance with FTP Code



RAMSSES Innovation Platform

Project Description: Drawings, GA...

Alternative Design: MSC.1/Circ.1455

Materials: Certificates, tests...

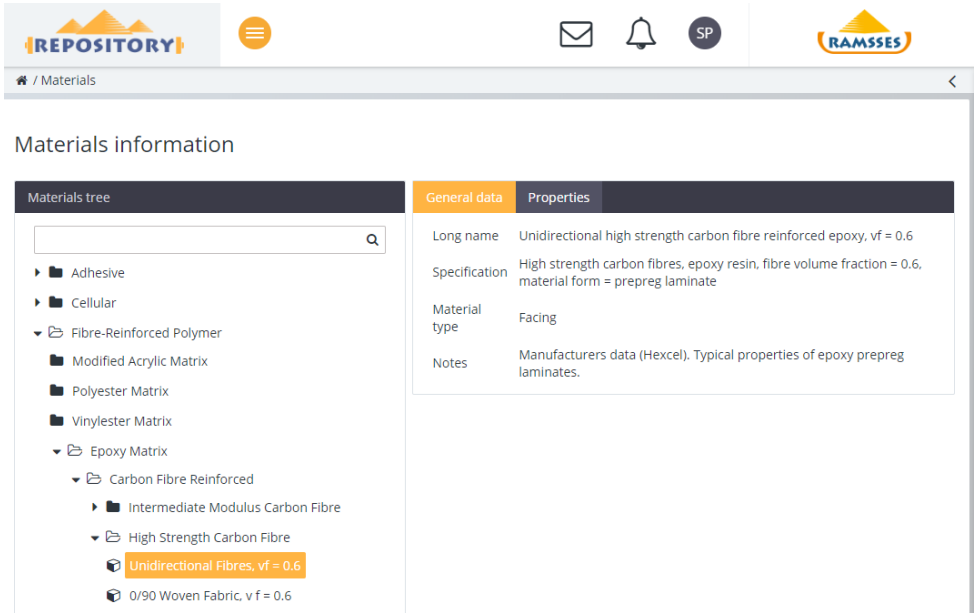
Final Drawings Submission

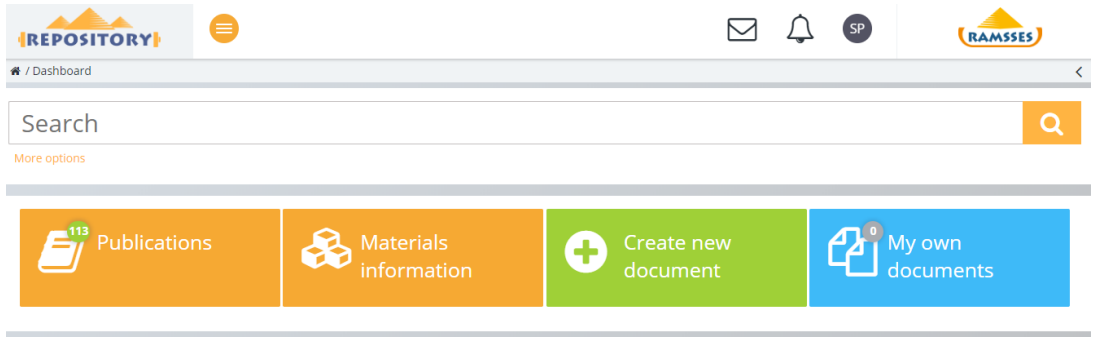
SMART TRACK to APPROVAL

Project Evaluation

Design Review: Structure, Safety, Stability...

Validation





General data | Properties

Property	Value	Unit	Value type	Reference
Compressive Stiffness 1	115.0	GPa	Typical	Hexcel (2005)
Compressive Stiffness 2	10.0	GPa	Typical	Hexcel (2005)
Compressive Strength 1	1300.0	MPa	Typical	Hexcel (2005)
Compressive Strength 2	250.0	MPa	Typical	Hexcel (2005)
Poisson's Ratio 12	0.25	no unit	Typical	Hexcel (2005)
Shear Stiffness 12	4.4	GPa	Typical	Hexcel (2005)
Shear Strength 12	95.0	MPa	Typical	Hexcel (2005)
Tensile Strength 1	2000.0	MPa	Typical	Hexcel (2005)
Tensile Strength 2	80.0	MPa	Typical	Hexcel (2005)
Young's Modulus 1	130.0	GPa	Typical	Hexcel (2005)
Young's Modulus 2	9.0	GPa	Typical	Hexcel (2005)
Thermal Conductivity	1.0	W/m.K	Typical	Hexcel (2005)
Thermal Expansion Coefficient	-0.1	µstrain/K	Typical	Hexcel (2005)

Finding pre-approved solutions

- Suggestion to use selection tables to find existing solutions

Material selection	Test Compliance			
	Test A	Test B	Test C	Test D
Material 1	✓	✓		
Material 2		✓	✓	✓
Material 3	✓		✓	
Material 4			✓	✓

Pre-approved solutions	Standard fire risk scenarios			
	Scenario A	Scenario B	Scenario C	Scenario D
Solution 1			✓	✓
Solution 2		✓	✓	
Solution 3	✓		✓	
Solution 4	✓	✓		

- Quickly known what is already possible, and what is not
- More time available to assess safety of new elements

Conclusion

FIBRESHIP & RAMSSES:

- Demonstrate **advantages** of composite materials in shipbuilding,
- Prove the **ability** to build large structure in composite,
- Propose **new approach** for fire division rating,
- Ask Member States to:
  - **support using our results in evaluation of MSC.1/Circ.1574** and,
  - **encourage them to submit their own experiences to IMO**

Q&A