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FIBRESHIP PROJECT: ENGINEERING, PRODUCTION AND LIFE CYCLE MANAGEMENT FOR THE COMPLETE CONSTRUCTION OF LARGE LENGTH FIBRE-BASED SHIPS

LATEST DEVELOPMENTS

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TSI INTRODUCTION

TÉCNICAS Y SERVICIOS DE INGENIERÍA, S. L. (TSI) is a Spanish SME established in 1983 specialised in Noise & Vibration Engineering solutions. Since its creation TSI has been continuously developing its specialised activities in the following fields:

- Marine, Power Generation, Nuclear, Wind, Defense, Oil & Gas, among others.

Since 2012, TSI is participating in several R&D projects related to marine industry. Through these projects, the company had increase its knowledge of noise and vibration, as well as developing solutions for new growing markets.

Main engineering services of TSI (more info on www.tsisl.es):

- Design of Silent Ships. N&V Prediction
- Noise & Vibrations and Urn Measurements in Vessels
- Static and Dynamic Structural Analysis
- Condition Based and Predictive Maintenance Assessment
- Sensor & Instrumentation Supplier

EUROPEAN R&D PROJECTS

- INCASS (http://www.aqua.eu/
- BEST (http://www.beest.it/BE3ST/index.xhtml)
- CDTI

FIBRESHIP PROJECT DESCRIPTION

FIBRESHIP Project

• FIBRESHIP project addresses the feasibility of composites for large-length vessels, trying to generate a regulatory framework that allows designing, building and operation of these vessels, and overcome the challenges identified. (technical and not technical)
• The project consists of:
  ✓ analyzing the possible impacts in the market of this technology
  ✓ evaluating innovative composite materials for marine applications
  ✓ developing numerical software tools capable to assess the structural performance of the vessel and validated through experimental testing
  ✓ performing new design guidelines
  ✓ generating production and monitoring methodologies

Main particulars of FIBRESHIP Project

• Grant Number: 723360
• Duration: 36 months (2 periods of 18 months)
  ✓ Start Date: 1st June 2017
  ✓ End Date: 31st May 2020
• 18 partners with broad skills and knowledge in different complementary disciplines
• Estimated Project Budget: 11,041,212.50 €
• Requested EU Contribution: 8,866,322.75 €
• TRL: 7-9
RESULTS ACCORDING TO FIBRESHIP OBJECTIVES (1/3)

• **Objective 1: EVALUATION AND SELECTION OF INNOVATIVE FIBRE-REINFORCED POLYMERS (FRP) FOR MARINE APPLICATIONS**
  - Several *experimental tests* have been performed, consisting of mechanical, fatigue and fire performance assessment of composite materials.
  - A *composite material selection methodology* for large vessels has been carried out as well as a set of joining techniques eligible to composite structures.
  - A *composite materials constitutive numerical model* has been developed and validated through experimental tests.

• **Objective 2: ELABORATION OF NEW DESIGN GUIDELINES AND PROCEDURES**
  - An analysis on the *current marine regulatory framework* focused on the use of composite materials has been conducted.
  - The *structural design* of 3 different vessel in composites has started and is progressing well: containership, ROPAX and fishing research vessel.
  - A set of *new design guidelines* is being developed based on structure performance criteria and fire resistance.
RESULTS ACCORDING TO FIBRESHIP OBJECTIVES (2/3)

**Objective 3: GENERATION OF EFFICIENT PRODUCTION, LIFE CYCLE MANAGEMENT AND INSPECTION METHODOLOGIES**

- It has been carried out a definition of **production methodologies** to reach a cost-efficient balance between design and production strategies for large-length composite vessels, considering **modular subdivision** and **production sequencing recommendations**.
- A **structural health monitoring strategy** has been developed according to the hydro-structural behavior of the vessel.
- Different strategies regarding **inspection** and **waste treatment** are being analysed.

**Objective 4: DEVELOPMENT OF VALIDATED SOFTWARE ANALYSIS TOOLS**

- It has been developed a **software suite** made up of different coupled numerical models able to simulate the structural behavior:
  - FRP mechanical and thermo-mechanical response in terms of constitutive elements, hull-girder long term hydro-structural behavior, local structural health monitoring assessment.
- **Calibration** and **validation** process of all developed numerical models is ongoing.
RESULTS ACCORDING TO FIBRESHIP OBJECTIVES (3/3)

• **Objective 5: VALIDATION AND DEMONSTRATION OF THE TECHNOLOGIES GENERATED IN FIBRESHIP**
  
  - **Vibro-acoustics tests** were performed in a small length vessel of composite material to:
    - ✓ (1) validate numerical models of URN
    - ✓ (2) assess potential benefits of using composite materials regarding on board vibration & noise.
  
  - A **full-scale testing campaign** in a 260m container ship has been performed in harsh sea states obtaining useful data to validate the coupled hydro-structural numerical model.
  
  - A ship block of a Fishing Research Vessel (FRV) has been selected as a full-scale **demonstration** of the **design** and **production solutions** proposed in FIBRESHIP project.

• **Objective 6: SHIPPING MARKET AND BUSINESS ANALYSIS**
  
  - It has been performed an **evaluation** of **impacts** and **potential benefits** of composites in large-length vessels.
  
  - A **SWOT analysis** (Strengths, Weaknesses, Opportunities, Threats) focused on all involved marine stakeholders (shipyards, suppliers, shipping principals) was carried out, including a possible roadmap of composite adoption in EU Shipping Market.
  
  - A **Cost-Benefit calculator tool** for composites large ships and an **economic support plan** for technical decision making is ongoing.
SOME SPECIFIC RESULTS OF THE PROJECT

Example of OBTAINED RESULTS

Example Case I: ZIM LUANDA testing campaign

Example Case II: DEMONSTRATOR
SOME SPECIFIC RESULTS OF THE PROJECT - Example Case I: ZIM LUANDA (1/6)

ZIM LUANDA testing campaign was carried out considering two aims:

1. Validate the developed hydro-structural numerical model
2. Assess the proposed Structural Health Monitoring strategy

ZIM LUANDA containership was monitored during navigation through a commercial route between Valencia (Spain) and Halifax (Canada).

Vessel main particulars:
- Length = 260 m
- Beam = 32 m
- Draft = 11 m
- Depth = 19 m
The proposed Structural Health Monitoring approach of the vessel during navigation is based on three steps:

**Measuring**
Measure local and global deformations of the ship during navigation.

**Analysing**
Analyse the tensional state and possible “hot spots” of the ship during navigation.

**Diagnosis**
Diagnose vessel structural integrity using maximum deformations theory (ULS / FLS).
**Measuring:** The local and global deformations of the containership as well as their motions and the environmental conditions were monitored in real time.

- Environmental tracker
- Inclinometers
- Strain gauges
- Inertial Measurement Unit (IMU)
Analysing:
The effect of the sea waves cyclic loads on the deformations of the ship hull is analysed.

- Height Wave = 7.5m
- Wind Speed = 30 kn
- Height Wave = 2.2m
- Wind Speed = 20.9 kn

**GLOBAL DEFORMATIONS**

**LOCAL DEFORMATIONS**

**ACCELERATIONS**
Diagnosis:
Real-time evaluation of the structural health state of ZIM LUANDA during route navigation.

- Wave Height = 2.2 m
- Wind Speed = 20.9 kns
- Wave Height = 7.5 m
- Wind Speed = 30 kns

Environment State:
- Height Wave
- Wind Speed
SOME SPECIFIC RESULTS OF THE PROJECT - Example Case I: ZIM LUANDA (6/6)

The main conclusions of this experimental campaign are the following ones:

- The system allowed to monitor the tensional state and motions of ZIM LUANDA during navigation.

- Local and global deformations of ZIM LUANDA were successfully measured during the navigation route.

- Detection of “hot spots” is possible through local and global deformations of the vessel.

- The existence of damage can be predicted using the maximum deformations theory.

- The environmental conditions (e.g. wave heights, wind speed, ....) can be predicted by means of GPS and reanalysis (NOAA database), making possible the correlation with vessel deformation.

- Data to validate the developed software has been obtained, which will allow to verify the finite element models of the designed vessels of the project.
Real-scale demonstrator of a Fishing Research Vessel (FRV) module is being built at iXblue facilities in La Ciotat (France).

**Fishing Research Vessel (FRV)**
- of 85m of length

**Demonstrator**: Engine room and other above accommodation spaces. 11m x 11m x 8.6m
**2ND PUBLIC WORKSHOP**

Engineering, production and life-cycle management for the complete construction of large-length FIBRE-based SHIPs

**2ND FIBRESHIP PUBLIC WORKSHOP – LA CIOTAT (FRANCE), 25TH JUNE 2019**

**Date & Time:** Tuesday, 25th June 2019, 09:00 – 17:00 Hrs

**Venue:** BEST WESTERN PREMIER Hôtel Vieux Port, 252 Quai François Mitterrand, 13600 La Ciotat, France

**About the event**

This 2\textsuperscript{nd} workshop is to engage with shipowners, ship operators, shipyards, regulatory bodies, transport policy-makers at EU and members states including research organizations/academia, ship design and engineering firms and transport organizations involved in different EU projects to not only raise awareness of the issues that the project is dealing with, but also to discuss ways to overcome the current market challenges and technology gaps to make feasible the building of large commercial vessels in FRP materials.
Any question?

THANK YOU

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BACK-UP SLIDES
FIBRESHIP PROJECT (2/3) – Vessels considered for the project

**CATEGORY I**
Light Commercial Vessels

- Vessel selected: Container Vessel
- Other options:
  - RORO vessel
  - Car Carrier vessel
  - Multi-purpose vessel
  - Freezer vessel
  - LNG vessel
  - …..

**CATEGORY II**
Passengers Transportation & Leisure Vessels

- Vessel selected: ROPAX
- Other options:
  - Ferry
  - Passenger vessel
  - Megayacht
  - …..

**CATEGORY III**
Special Services Vessels

- Vessel selected: Fishing Research Vessel
- Other options:
  - Fishing vessel
  - Seismic Vessel
  - Offshore Supply vessel
  - Rescue vessel
  - …..

THE CHALLENGES OF FIBRESHIP (2/2) – Potential benefits

Structural Weight reduction (30%-70%)

- Fuel Consumption Reduction
- Increase Payload Capacity
- Underwater Radiated Noise (URN) Reduction
- Lower Greenhouse Gas Emissions
- Higher Recycling Rate

- Reduced Maintenance & Life Cycle Costs
- Immune to Corrosion
- Continuous Structural Health Monitoring
- Possibility of Using Wireless Sensors
- Aesthetic Improvements

Aesthetic Improvements
MAIN OUTCOMES (1/4) – Expected Results

**Engineering**
- Design report for each vessel category.
- Project guidelines for design and certification of large-length vessels in FRP materials based on fire and structural performance criteria.
- Selection methodology of FRP materials.
- Catalogue of applicable materials & joining techniques.
- Development of numerical tools for FRP vessels design (structure and fire).
- Numerical tools validation.
- Decision Support Tool on life-cycle performance of FIBRESHIP approach.

**Shipping**
- End-users assessment and roadmap of composite adoption in EU shipping market.
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**Cost-benefit analysis & business plan**
- European and global business trends analysis.
- Cost-Benefit calculator and global business plan.
- Optimum building strategy & production techniques.
- Modular subdivision and production sequencing recommendations.
- Analysis of existing shipyard facilities adaptation.

**Fibre-based Materials**
- Development of numerical tools for FRP vessels design (structure and fire).
- Numerical tools validation.
- Design report for each vessel category.
- Project guidelines for design and certification of large-length vessels in FRP materials based on fire and structural performance criteria.
- Selection methodology of FRP materials.
- Catalogue of applicable materials & joining techniques.

**Validation and demonstration**
- Experimental test campaigns for validation:
  - Noise and vibration tests on board (URN measurement).
  - Full-scale vessel test for hydro-structural coupled numerical model validation.
  - Small-scale fire tests of FRP panels with and without insulation.
  - Modal tests of FRP panels for detection of changes in natural frequencies.
  - Engineering solutions for aesthetic improvements.
  - Demonstrator Building & Production Process Assessment.

**Production & Life Cycle/Dismantling**
- Guidelines on inspection, monitoring and maintenance applicable to FIBRESHIP approach.
- Guidelines on waste management in the implementation of FIBRESHIP approach.
- Structural health monitoring & long-term damage control (as part of the Engineering Guidelines).
- Decision Support Tool on life-cycle performance of FIBRESHIP approach.
Example: photos of the demonstrator construction process at the shipyard iXblue in La Ciotat (France)
Example: photos of the demonstrator construction process at the shipyard iXblue in La Ciotat (France)

“2nd Public Workshop”  25th of June 2019
MAIN OUTCOMES (2/5) – Expected Results

- **Short Term (0 Years)**
- **Medium Term (1/3 Years)**
- **Medium/Long Term (3/5 Years)**

### Relevant advance over the traditional methods, allowing the exploitation of the new solutions and procedures in the existing market

### Business Opportunity
- Massive application of FRP-materials
- Enhance competitiveness of the European Operators
- Enhance competitiveness of European shipbuilding industry

### Policies

#### Environmental
- Fuel safety / Gas Emissions
  - Directive 2012/33/EU
- Life cycle performance & reduced maintenance costs
  - Directive 2013/1257/EU
- Underwater Noise impact
  - Directive 2008/56/EU

#### Safety SOLAS / IMO / EMSA
- Structural resistance criteria
- Fire safety
- Stability
- etc...

### Classification Societies: Standards and Rules
- Owners: specifications & orders
- Shipyards: facilities adaptation
- Designers: design process

### Business Opportunity
- Classification Societies: Standards and Rules
- Owners: specifications & orders
- Shipyards: facilities adaptation
- Designers: design process