APPLICATION OF TITANIUM IN THE NAVAL SECTOR

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MINISTERIO DE INDUSTRIA Y TURISMO
Plan de Recuperación, Transformación y Resiliencia
Financiado por la Unión Europea
NextGenerationEU

1. INTRODUCTION

- Titanium is widely used in aerospace and biomedical fields due to its excellent strength-to-weight ratio and corrosion resistance.
- However, its naval applications are limited to specialized equipment, submarines, and structural components.

2. HISTORICAL APPLICATIONS OF TITANIUM IN SHIPS

- **Propellers:** High resistance to cavitation and corrosion, reducing mass and improving efficiency.
  - In 1964 the U.S. Navy introduced titanium alloy propellers on the hydrofoil “Plainview” (AGEH–1), followed by the UK and Russia in "Alpha" and "Mike" class submarines.
  - In 1972 China developed titanium alloy propellers in 1972, producing around 800 by 2014.
  - Titanium propellers last three times longer than copper ones, but high costs limit widespread adoption.
  - Other naval components have also been manufactured from titanium.

- **Pumps, valves, and pipelines:** Extended service life in seawater.
  - Steel and copper pipes have a lifespan of 2-5 years.
  - Russian regulations are more demanding and use titanium alloy pipes, valves, pumps, and heat exchangers to extend system longevity.
  - This allows for a thinner, more compact design, reducing space and overall weight.

2. HISTORICAL APPLICATIONS OF TITANIUM IN SHIPS

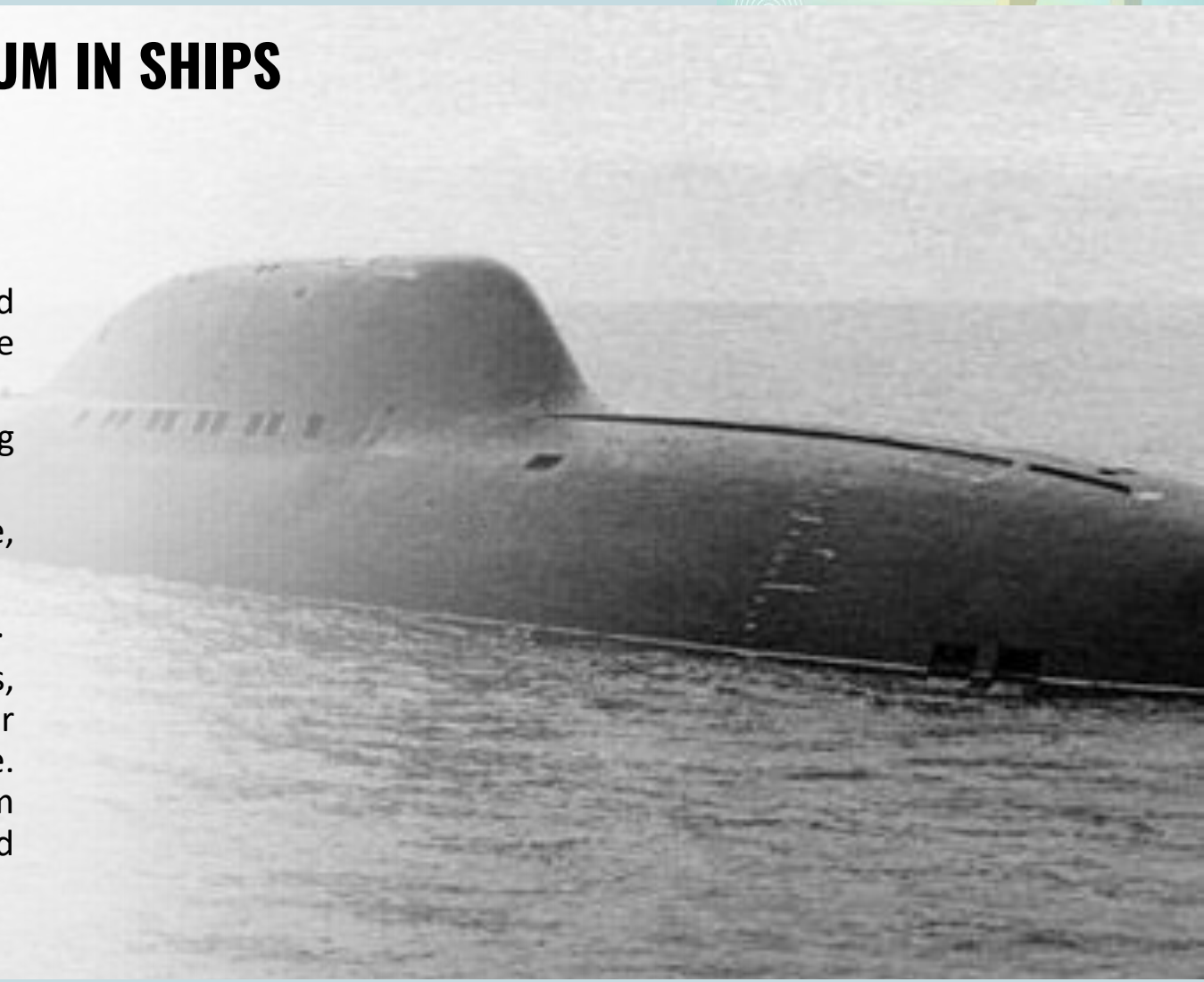
- **Sonar domes**: Improved acoustic properties.
  - Russian submarines like Kursk and aircraft carriers like Minsk and Kyiv installed titanium sonar domes.
  - Compared to stainless steel and reinforced plastic, titanium offers better sound transmission and collision resistance.
  - New titanium alloys are expected to be developed, expanding their applications.

- **Submersibles:** Experimental vessels demonstrating advantages.
  - Titanium alloy hulls are commonly used in deep-diving vehicles and submarines due to their high pressure resistance, corrosion resistance, and non-magnetic properties.
  - U.S. *Alvin* class
  - China's *Jiaolong* submersible

2. HISTORICAL APPLICATIONS OF TITANIUM IN SHIPS

- **Nuclear submarines**

  - The K-222, the first titanium double-hulled submarine, set a speed record and influenced future designs.
  - The "Alfa" class was fast and lightweight, using 3,000 tons of titanium.
  - The "Typhoon" class remains the largest submarine, with over 9,000 tons of titanium.
  - Sierra I and II classes were the last to have titanium.
  - Titanium hulls offer reduced magnetic fields, corrosion resistance, and longer lifespan, but their high cost makes construction more expensive. Despite this, titanium submarines provide long-term benefits like deeper immersion and reduced maintenance.



3. TITANIUM PROPERTIES

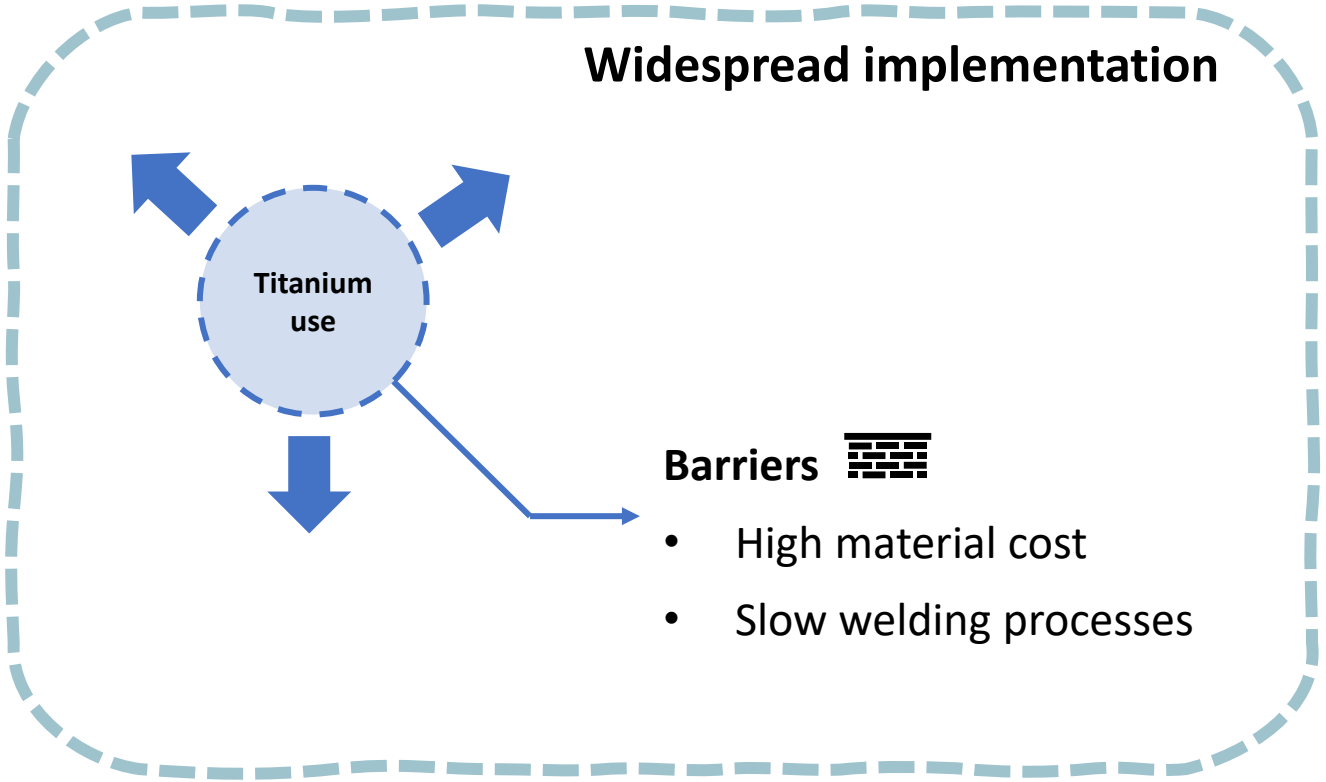
Low density (4.5 g/cm³), reducing vessel weight.

High mechanical strength and durability.

Exceptional corrosion resistance in seawater.

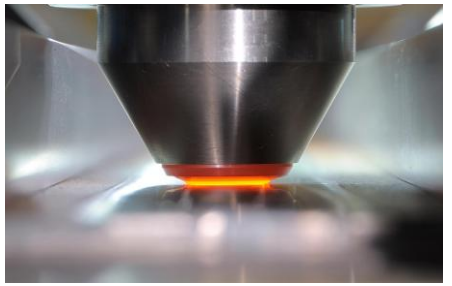
Non-magnetic properties, beneficial for military applications.

3. TITANIUM PROPERTIES – MARKET BARRIERS & CURRENT SITUATION



Falling barriers[1]

- Improved welding methods
  - Friction stir welding
  - High power laser welding
- Faster ships
- Higher scrap value
- Longevity



1. Lundquist E., U.S. Navy: The Business Case for a Titanium Ship, April 9, 2012, MarineLink

4. ANTI-FOULING SYSTEM - TiTech INNOVATION

Five months immersion

With TiTech

Five months immersion

Without TiTech

30 months immersion

With TiTech

4. ANTI-FOULING SYSTEM

TITANIUM SURFACE/COATING

Creates surface conditions that avoid biofouling.

ELECTRONIC SYSTEM

Manages the electrical signal applied to the titanium surfaces, ensuring biofouling prevention.

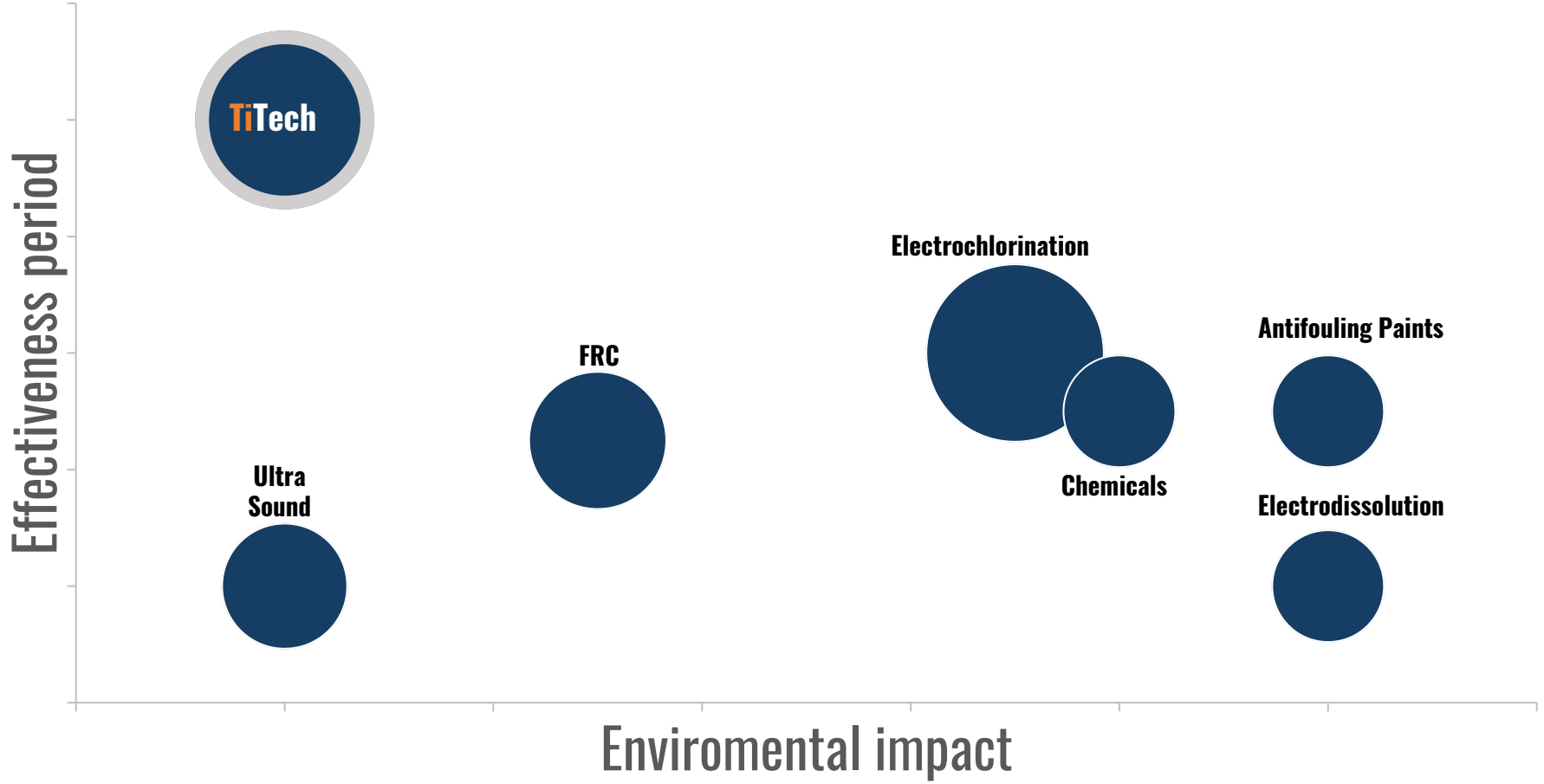
CLOUD PLATFORM

To remotely control and monitor the electronic systems of the submerged component or structure.

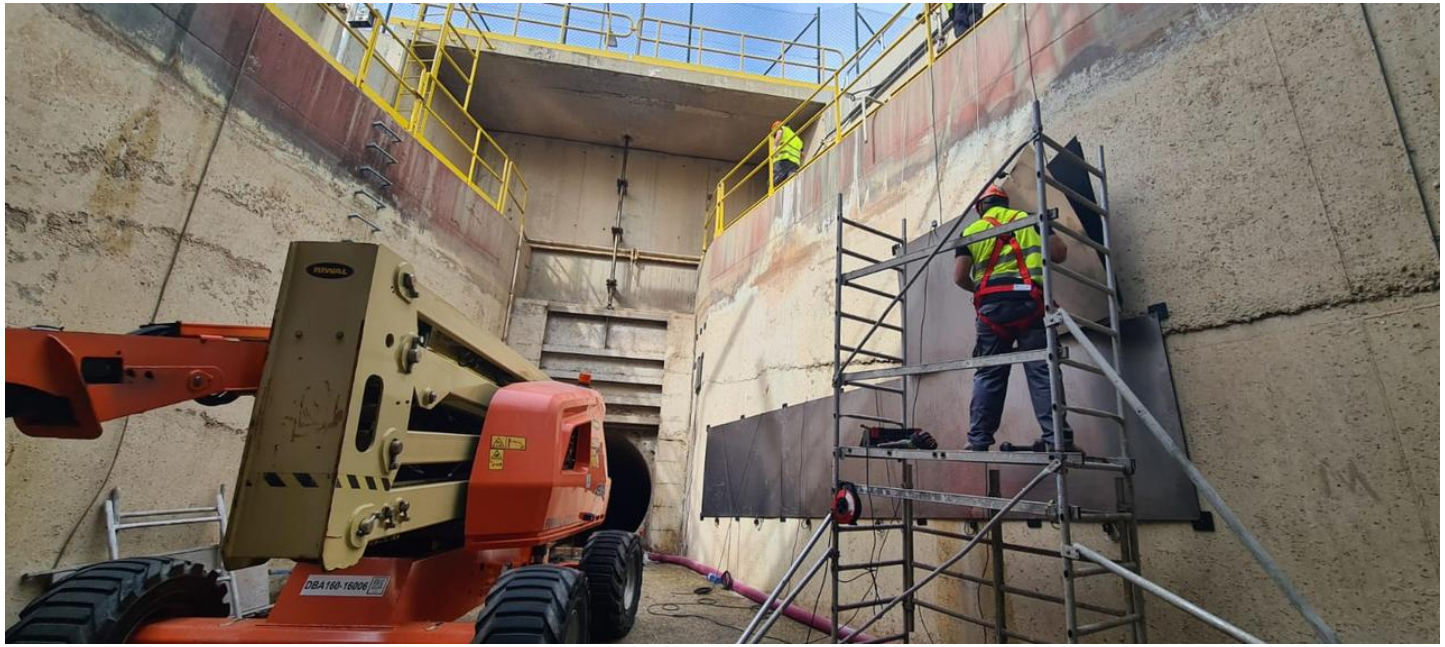
4. ANTI-FOULING SYSTEM – VALUE PROPOSITION

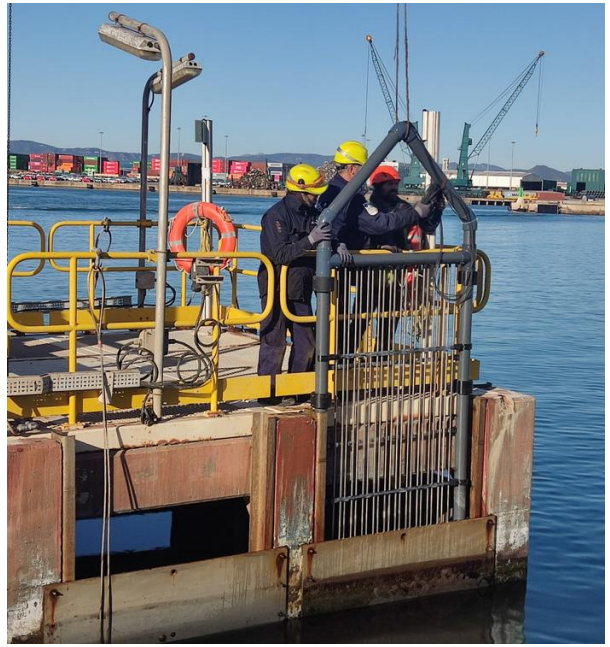
- Environmental Friendliness
- Permanent Solution
- Performance Improvement
- Pollution Reduction
- Improved Efficiency
- Reduced maintenance

4. ANTI-FOULING SYSTEM – COMPETITIVE ADVANTAGES



4. ANTI-FOULING SYSTEM – ENAGÁS PILOT





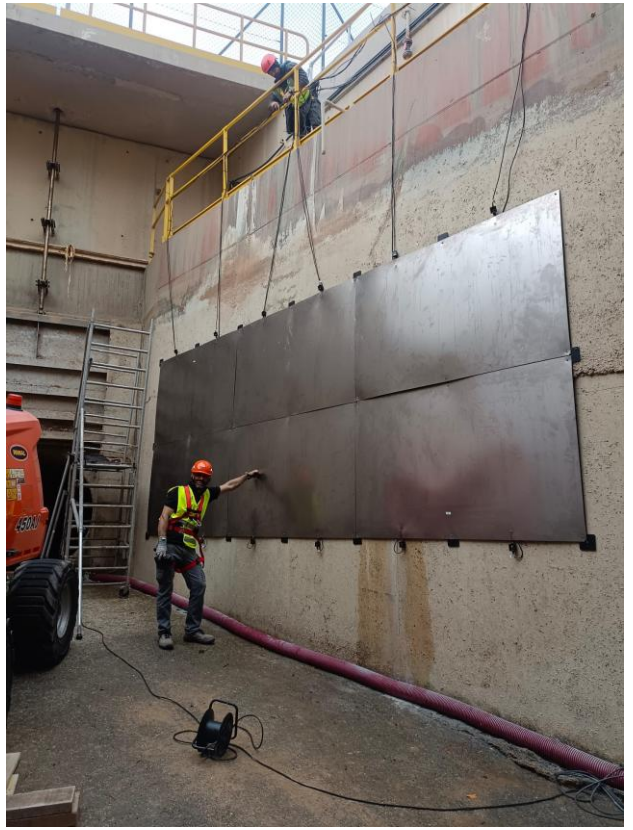
Annual electricity cost for the entire pool (400 m^2 -1 Wh/m^2) ~ 500€/year

Annual electricity cost for great (2,8 m^2 -1,5Wh/m^2) ~ 5€/year

4. ANTI-FOULING SYSTEM – ENAGÁS PILOT

4 months underwater

11 months underwater



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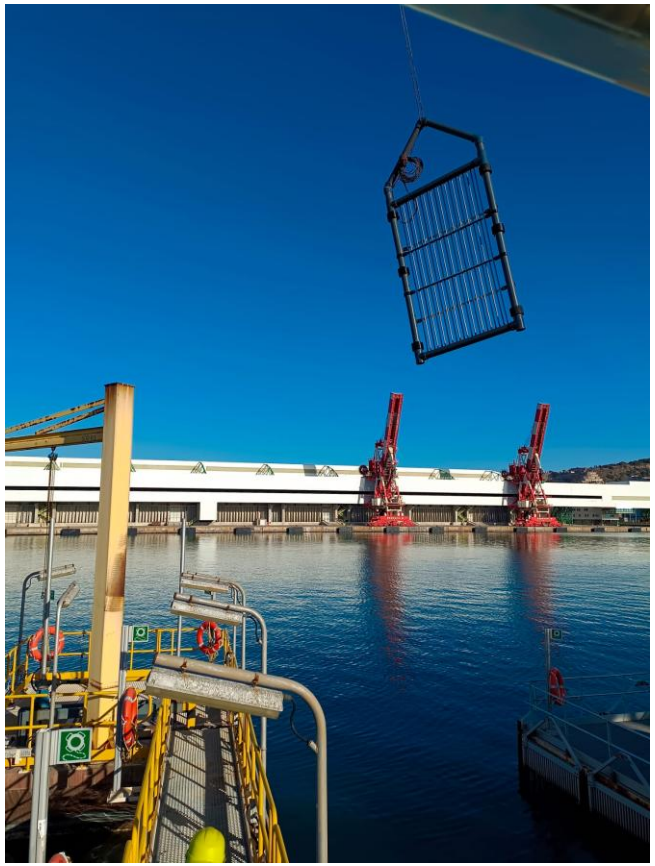
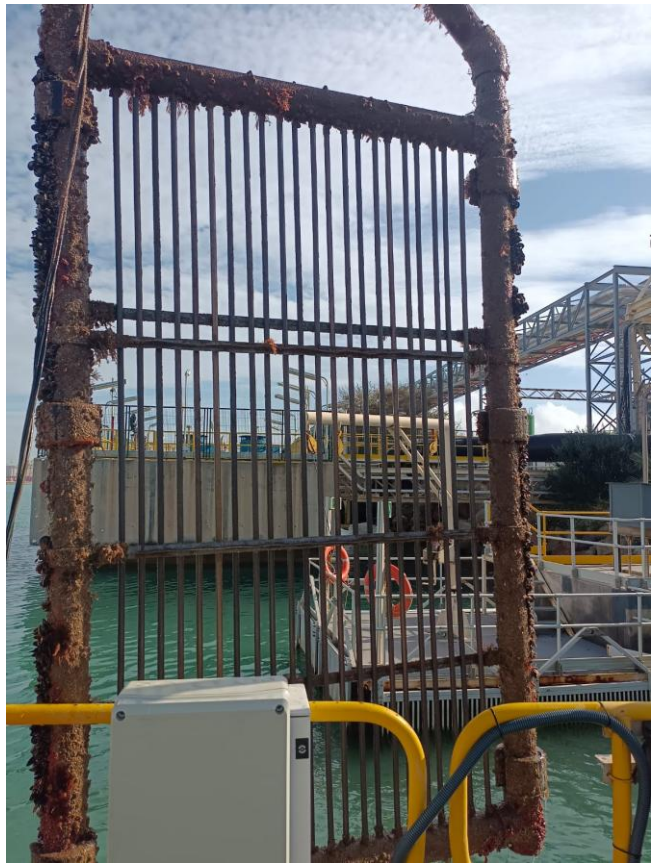




Intake grate with Titech technology in bars

Maintenance of conventional intake grates

4. ANTI-FOULING SYSTEM – ENAGÁS PILOT

4. ANTI-FOULING SYSTEM – COMPONENT FAMILIES

WATER INTAKE SYSTEMS & HEAT EXCHANGER

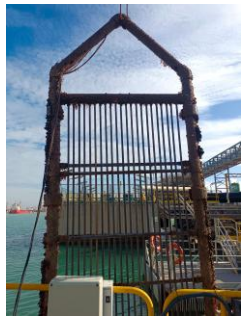
Seachest

Boxcooler

Boat Hulls

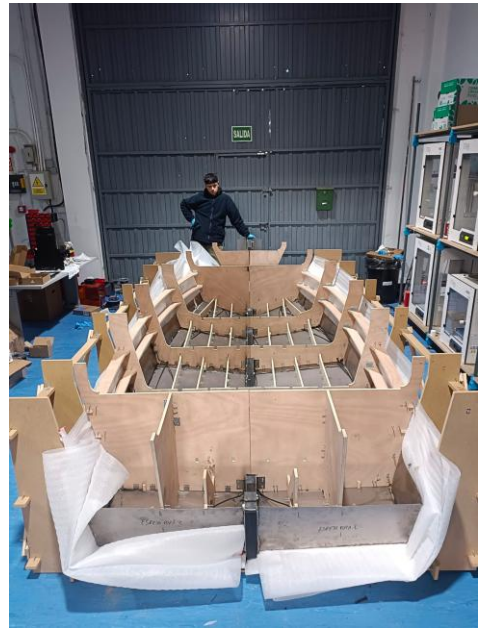
Pipes

Grates

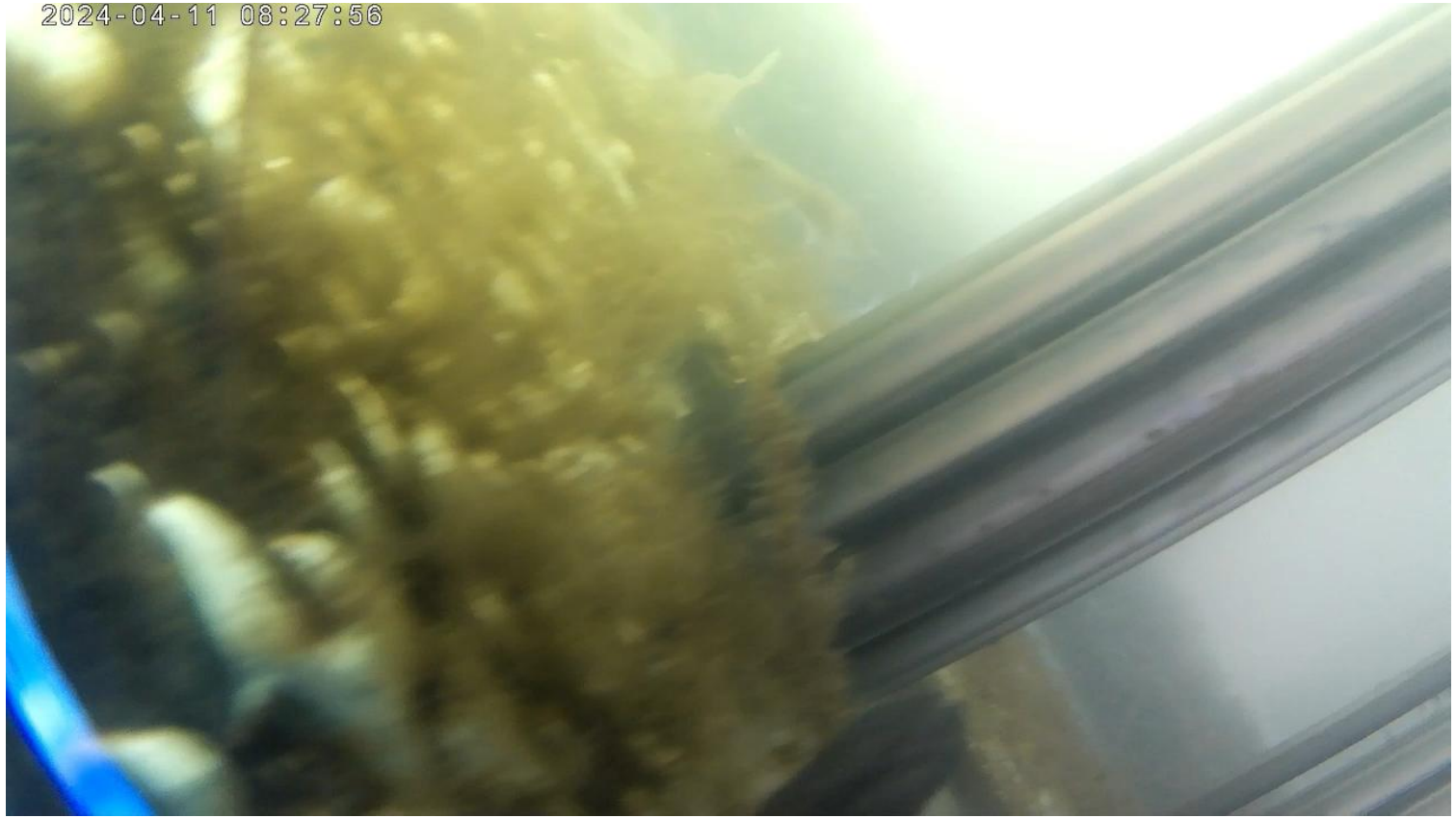


PROPELLERS

BOAT HULLS



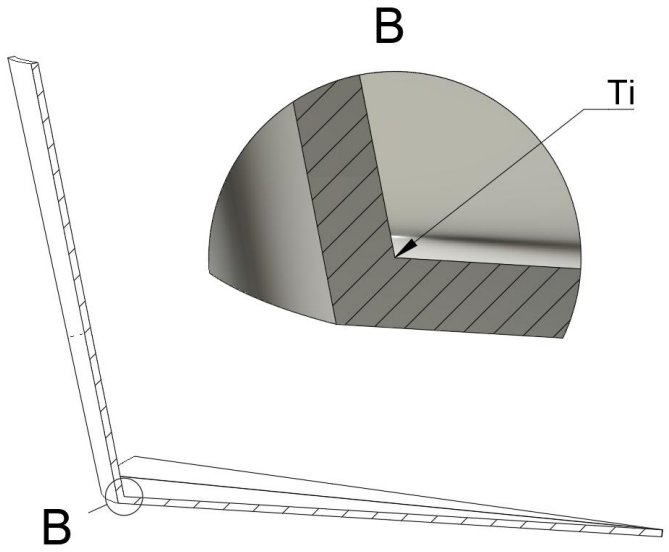
4. ANTI-FOULING SYSTEM – TUBES HEAT EXCHANGER



5. PROTOTYPE VESSEL

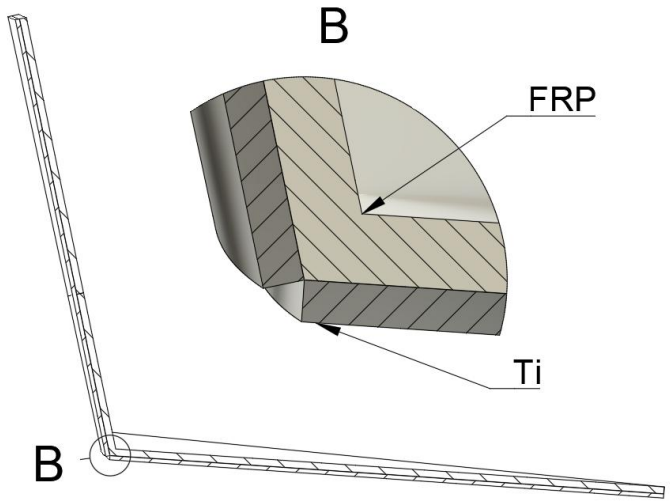
TWO ALTERNATIVES

Full body titanium vessel



Lightweight
More expensive

Titanium covered vessel



Reinforced resin hull
Cheaper

El presente proyecto ha sido financiado a través de las ayudas a actuaciones de integración y transformación de la cadena de valor industrial del sector naval, dentro del Proyecto Estratégico para la Recuperación y Transformación Económica para la modernización y diversificación del ecosistema naval español (PERTE NAVAL), en el marco del Plan de Recuperación, Transformación y Resiliencia, financiado por la Unión europea y gestionado por el Ministerio de Industria, Comercio y Turismo.

BLUEBOATS: INVESTIGACIÓN DE NUEVO SISTEMA PRODUCTIVO PARA LA FABRICACIÓN DE COMPONENTES CON PROPIEDADES ANTI-INCRUSTRANTES PARA LA INDUSTRIA NAVAL

PNA-020100-2023-49

Beneficiario: TITANIUM TECHNOLOGY S.L.U (B88331640)

Presupuesto Total: 883.993,14€

Importe de la Ayuda: 707.194,50€

Resolución: Orden ICT/1306/2022, de 21 de diciembre, se modificó la Orden ICT/739/2022, de 28 de julio, por la que se establecen las bases reguladoras para la concesión de ayudas a actuaciones de integración y transformación de la cadena de valor industrial del sector naval, dentro del Proyecto Estratégico para la Recuperación y Transformación Económica para la modernización y diversificación del ecosistema naval español, en el marco del Plan de Recuperación, Transformación y Resiliencia.

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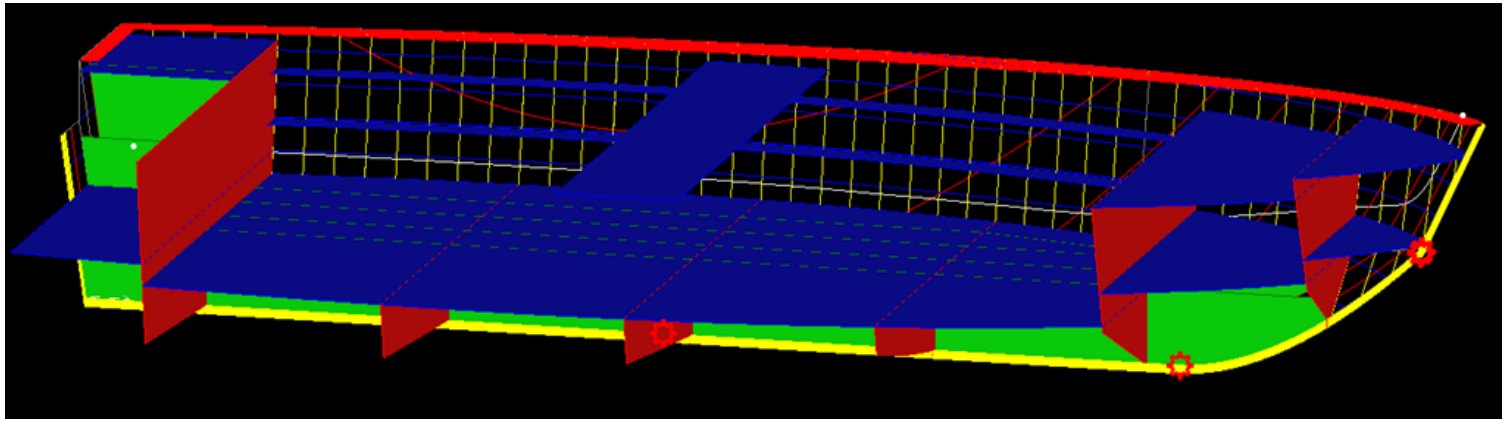
GOBIERNO DE ESPAÑA
MINISTERIO DE INDUSTRIA Y TURISMO

Plan de Recuperación, Transformación y Resiliencia

5. PROTOTYPE VESSEL

- Titanium-fiberglass hull.
- The vessel will stay in port for extended periods to demonstrate titanium's effectiveness as an antifouling system.
- It is not intended for regular navigation, except in special cases.
- It will always operate near the port area.

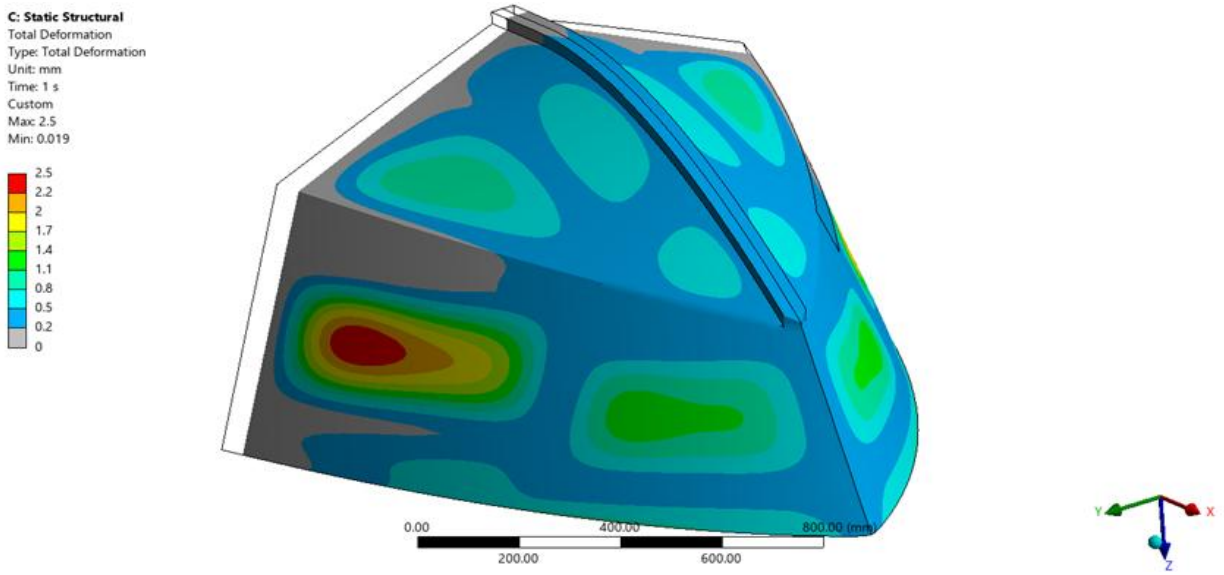


Total length	4.72 m
Waterline lenght	4.25 m
Beam	1.9 m
Design draught	0.205 m
Displacement	963.9 kg
Max. Speed	15.2 knots
Power	25 cv (18.7 kW)* – long shaft 20'' (508 mm) *Limited by ISO 11592 tests
Crew	4 persons
Design category	C
Navigation zone	Zone 6 (Daytime navigation)

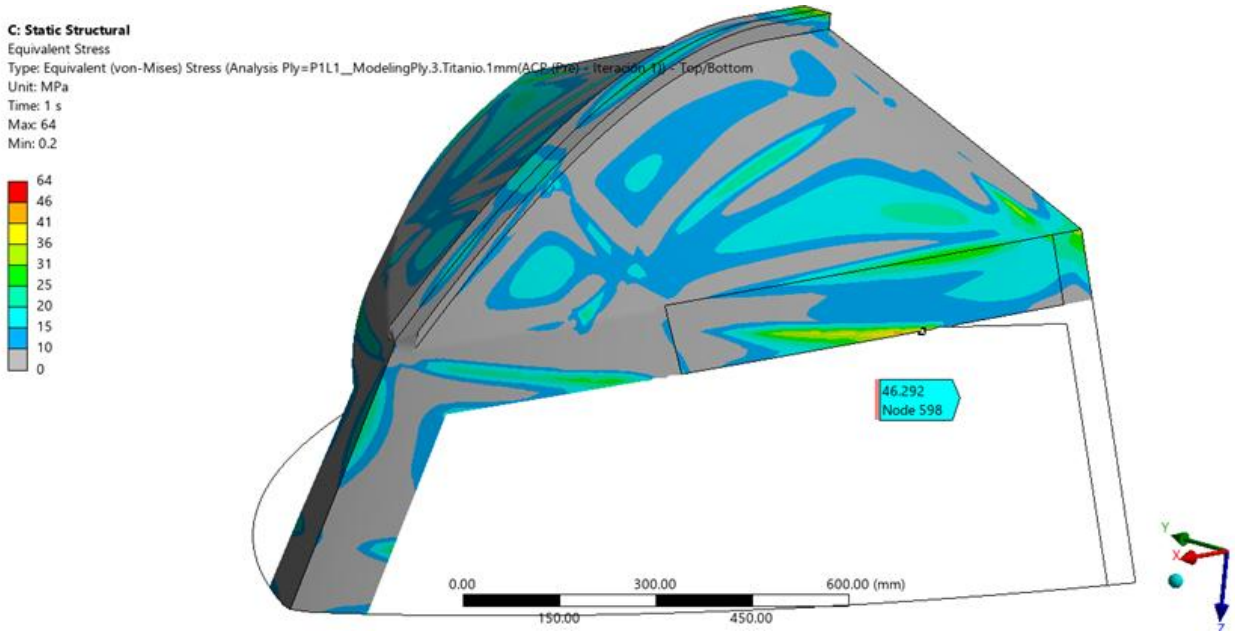
5. PROTOTYPE VESSEL

- UNE-EN ISO 12215-5
- Structural optimization using FEM analysis.

BOW ZONE	
TITANIUM ZONE	1.7 mm of FRP + 1 mm of titanium.
NO TITANIUM ZONE	3 mm of FRP



Deformations in the bow area.

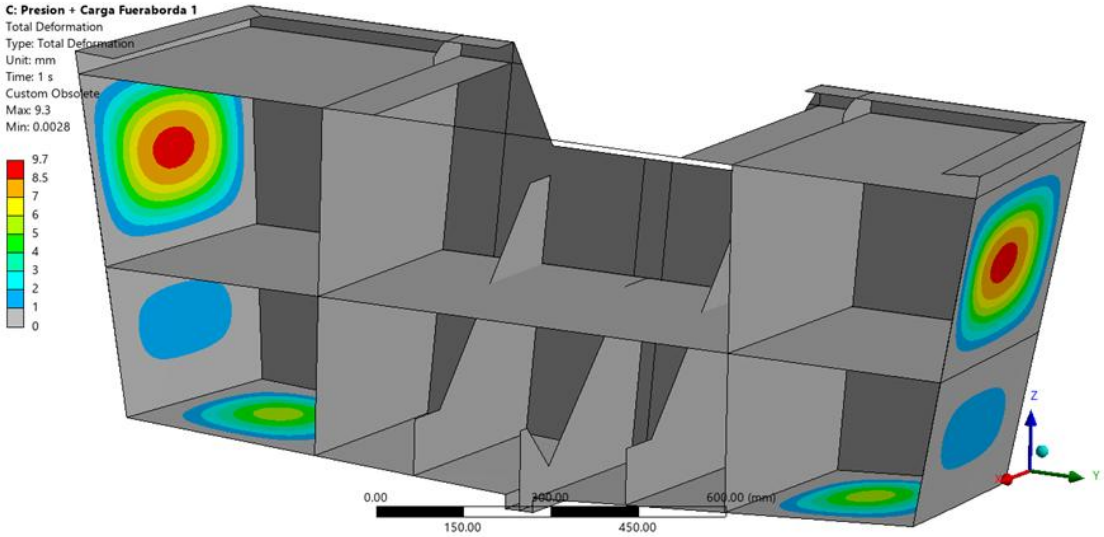


Von Mises stresses of the titanium plate

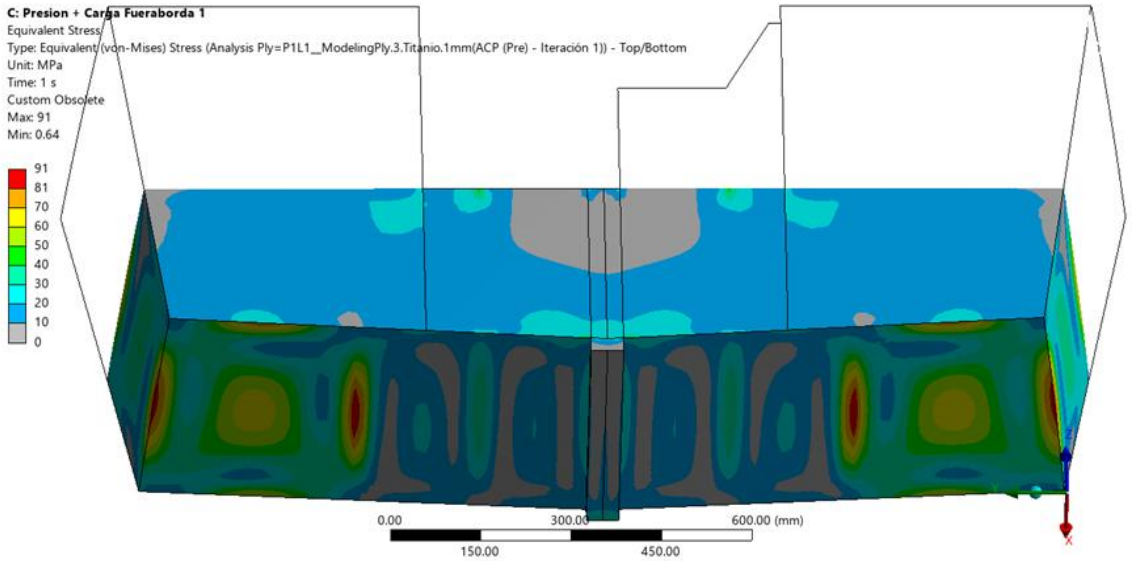
5. PROTOTYPE VESSEL

- UNE-EN ISO 12215-5
- Structural optimization using FEM analysis.

STERN ZONE	
TITANIUM ZONE	1.7 mm of FRP + 1 mm of titanium.
NO TITANIUM ZONE	3 mm of FRP



Deformations in the stern area.



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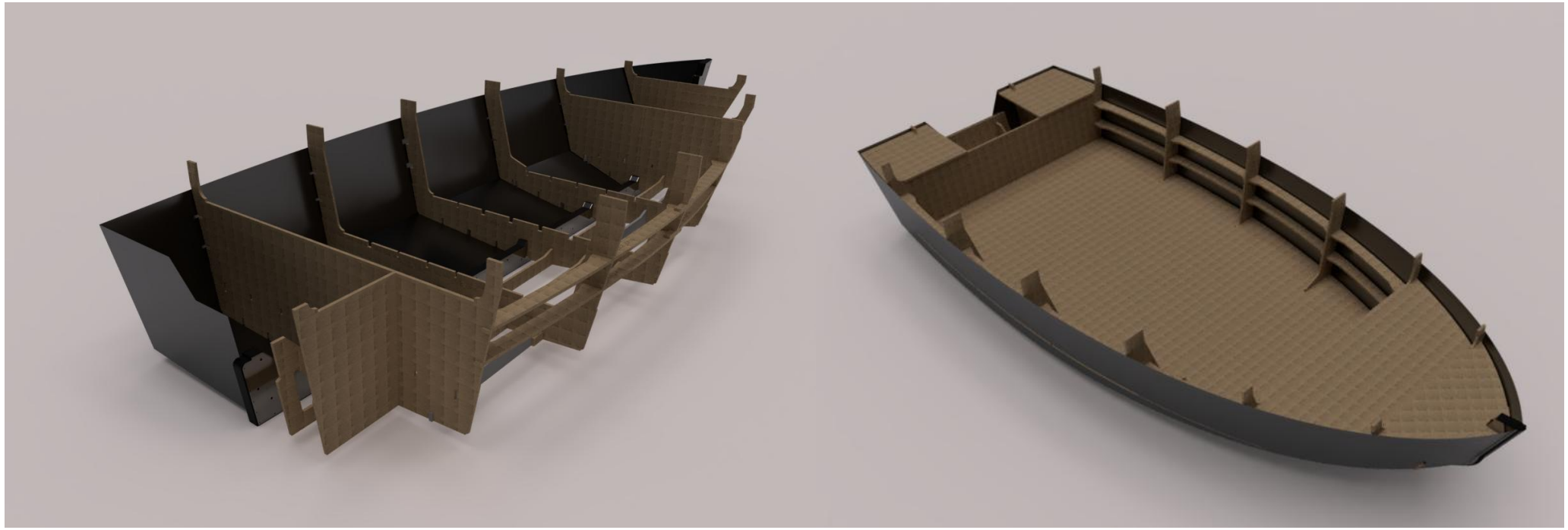


5. PROTOTYPE VESSEL

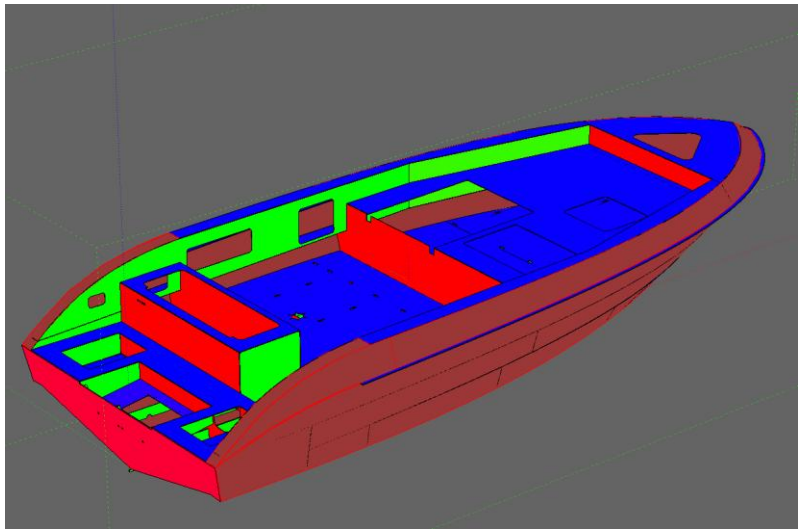
Construction

- CNC milled titanium hull
- Titanium laser welding
- FRP applied on the interior of the titanium surface

6. NEXT STEPS

Full titanium hull

Case study: Economic and technical comparative

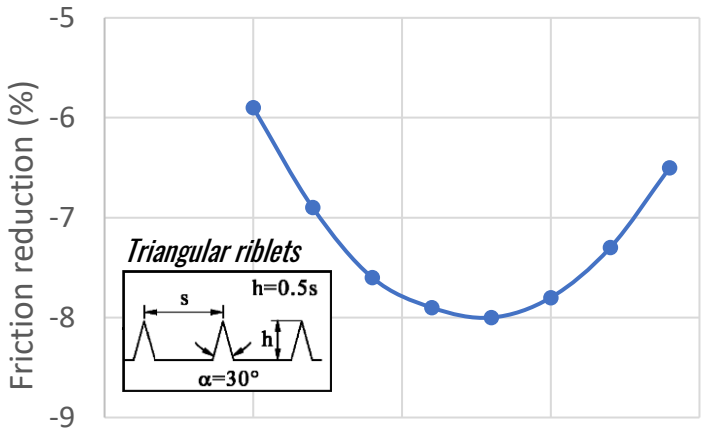


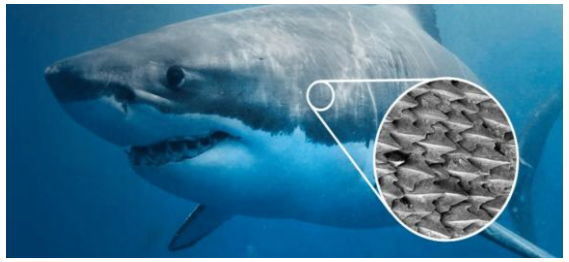
Texturizing titanium surface to improve hydrodynamic performance.

Riblets (biomimetic microstructures): reduces viscous friction (up to 10%)

Cannot be applied long term due to biofouling.

TiTech can make it possible.





Even faster and more efficient vessels

Thank you for your attention

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