

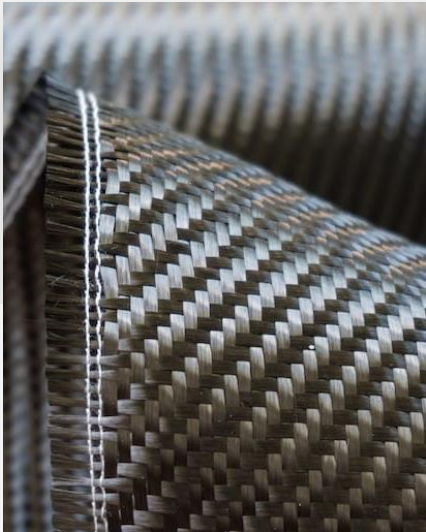


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COMPOSITE MARINE PROPELLER: OVERVIEW OF THE EUROPEAN RESEARCH PROJECT COPROPEL

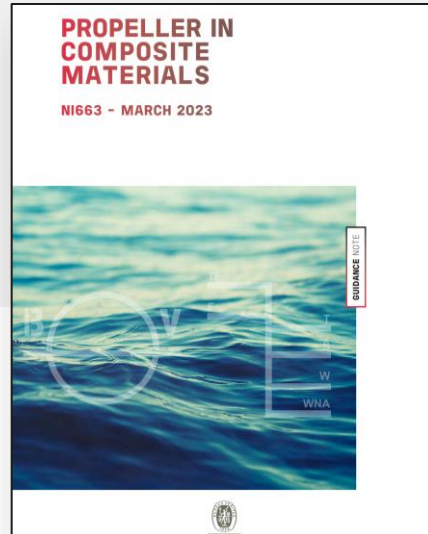
28th January 2026 – TKMS Kiel, Germany

SUMMARY



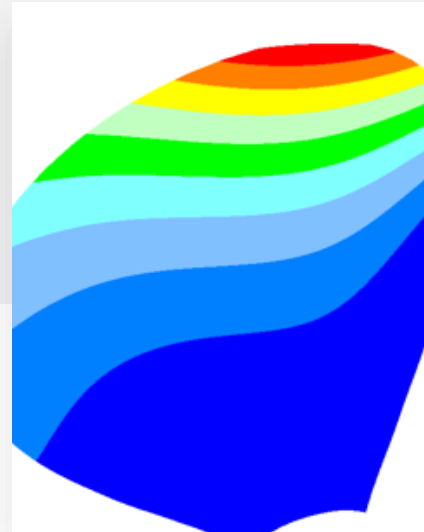
01

Introduction



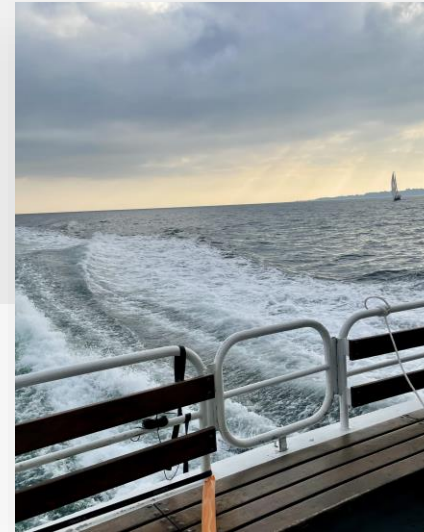
02

Certification



03

**Design &
Manufacturing**



04

Testing



05

Conclusion



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INTRODUCTION

COPROPEL PROJECT

The CoPropel project brings together **4 research institutes**, **6 industrial partners** and **1 class society** to develop, mature and optimize technologies for **marine propellers** made from **advanced composite materials**.



This project has received funding from Horizon Europe grant agreement 101056911 and from Innovate UK under grant agreement 10037872.



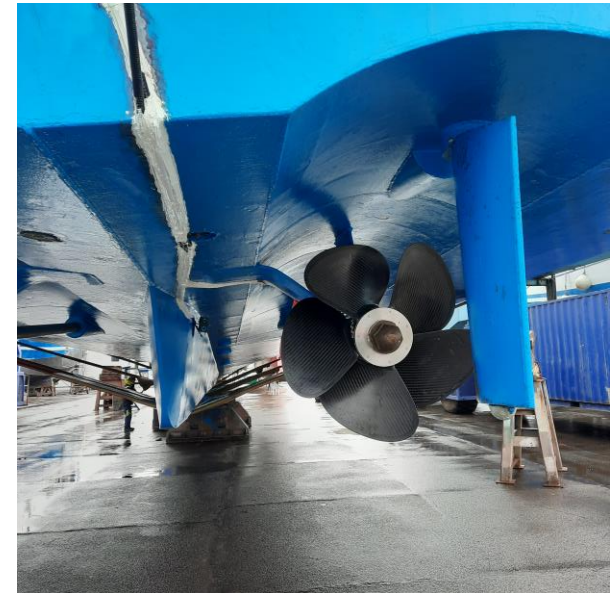
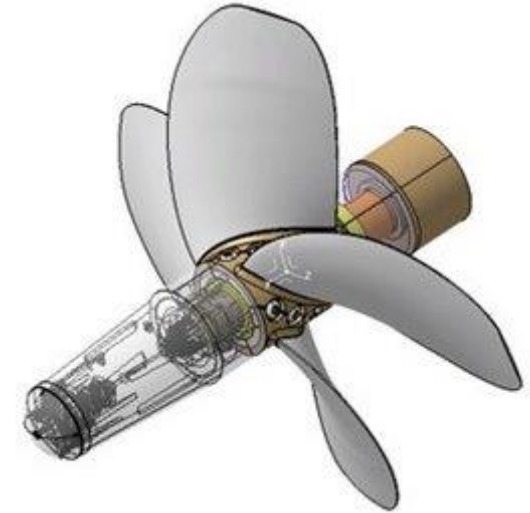
- 1) **Project Coordinator** - University of Ioannina - Panepistimio Ioanninon (UII)
- 2) Danaos Shipping Company Limited (DAN)
- 3) Bureau Veritas Marine & Offshore (BV)
- 4) Meca (MECA)
- 5) **Technical Coordinator** - Loiretech ingenierie (LRT)
- 6) Institute of Metal Science Equipment and Technologies with Hydroaerodynamics Centre Acad a Balevski (BSHC)
- 7) Glafcos Marine EPE (GME)
- 8) ErFlow Engineering (ERF)
- 9) Bureau Veritas Solutions Marine & Offshore (BVS)

Associated partners

- TWI Limited (TWI)
- Brunel University London (BUL)

OBJECTIVES

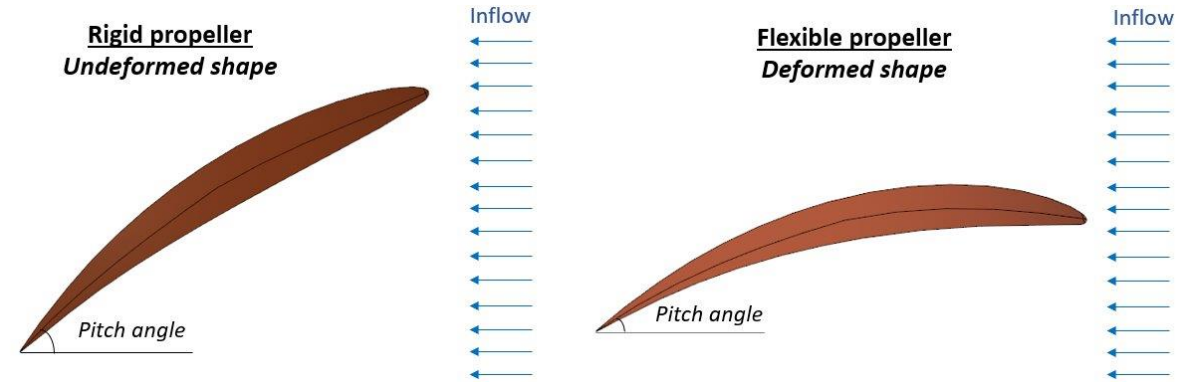
- **Design a composite propeller** to achieve optimum propulsive efficiency
- **Design and manufacture of innovative tooling** for the RTM process
- **Optimize the manufacturing process** based on closed mold resin infusion techniques (RTM)
- **Develop a condition and structural health monitoring system** that will be embedded within the propeller
- **Validate the composite propeller** with small-scale and full-scale trials
- **Assist in the formulation** of new guidelines for certification
- **Define roll out strategy** and **develop a business plan**



CONCEPT

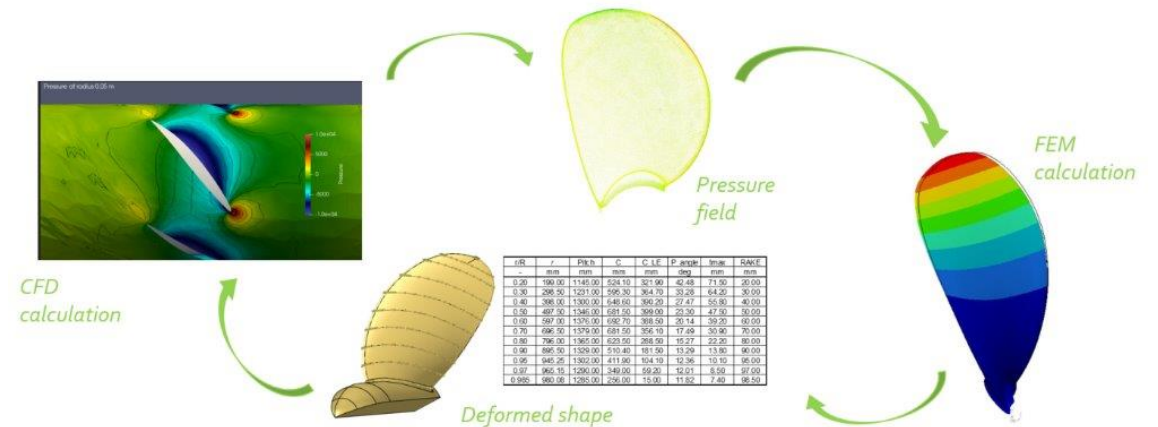
Why make propellers with deformable blades?

- › To adapt with the flow
- › To increase efficiency over a larger range of operating conditions



How to optimise?

- › Numerical simulations, coupling hydrodynamical and structural
- › Play with fibre orientations to increase deformation
- › Adjust pitch deformation between 2 design points



PROPELLER CHARACTERISTICS

Le Palais

Length: 29.6 m

Breadth: 7.82 m

Speed: 20 knot (10,3 m/s)

2 motors and shaft lines

Power: 969 kW, 1800 rpm

Propeller shaft 731.1 rpm
(gearbox reduction rate of 2.462)

Propeller diameter: 1.1m

Propeller 5 blades



Advance ratios:

- › **J=0.88** (SM0), which is the reference state for which the metallic propeller was design
- › **J=0.69** (SM30), a realistic off-design point where the optimization will be performed



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CERTIFICATION


BUREAU VERITAS NI663



PROPELLER IN
COMPOSITE
MATERIALS

NI663 - MARCH 2023

GUIDANCE NOTE

-  Sabella D10 (2011-2015)
-  ComProp (2014-2016)
-  ViComTe (2015-2018)
-  FabHeli (2016-2018)
-  ComProp2 (2017-2020)
-  RealTide (2018-2021)
-  MEVEF (2018-2021)
-  ORCA (2020-2024)
-  ECoProp (2020-2026)
-  CoPropel (2022-2025)
-  Certify (2025-2027)

BV Guidance Note for propellers made in Composite Materials covering:

Process of certification

- Design Phase
- Production Phase

Design assessment

- Analytical
- Numerical

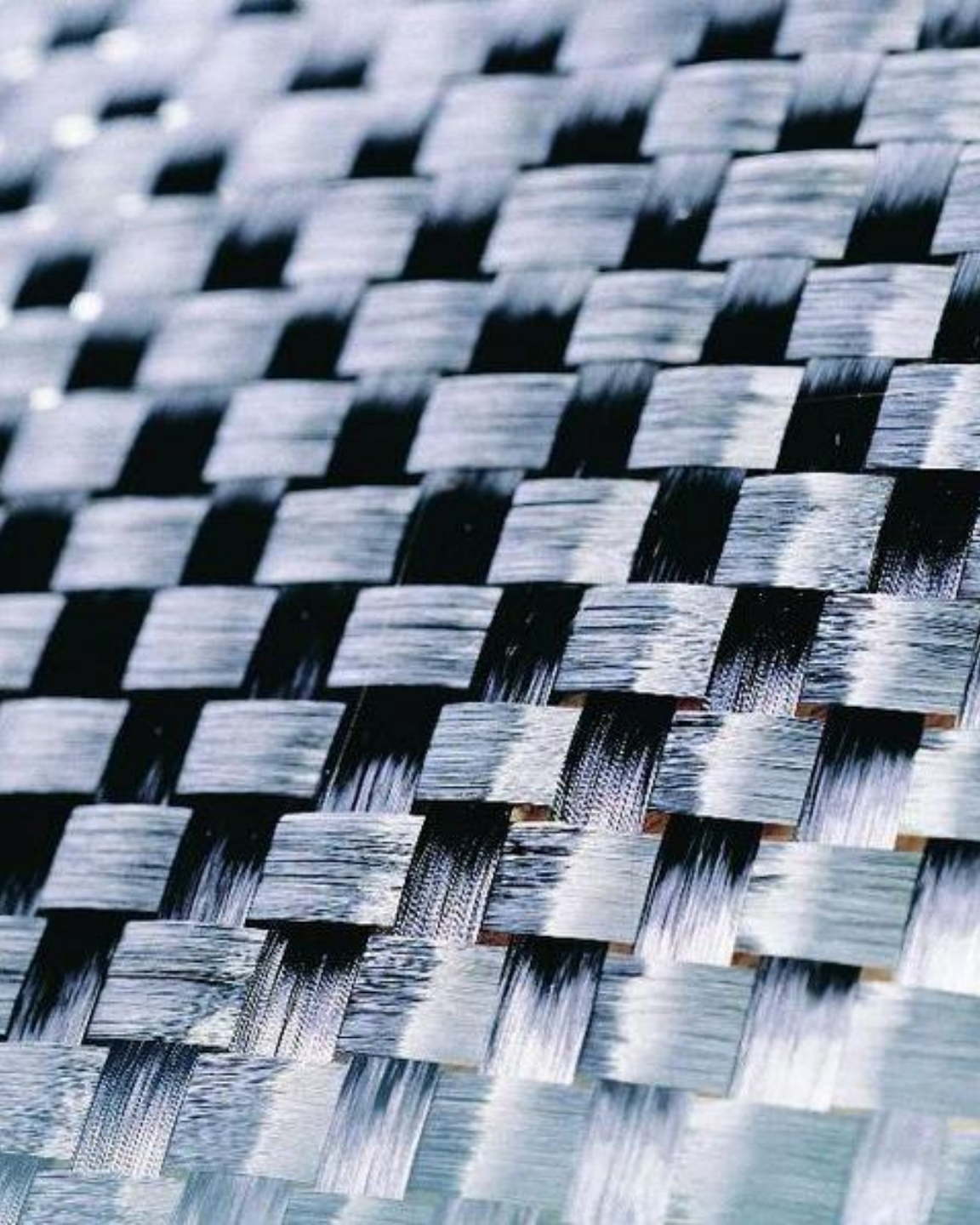
Testing

- Coupons
- Prototype

Manufacturing

In-service surveys

- Periodic survey
- NDT



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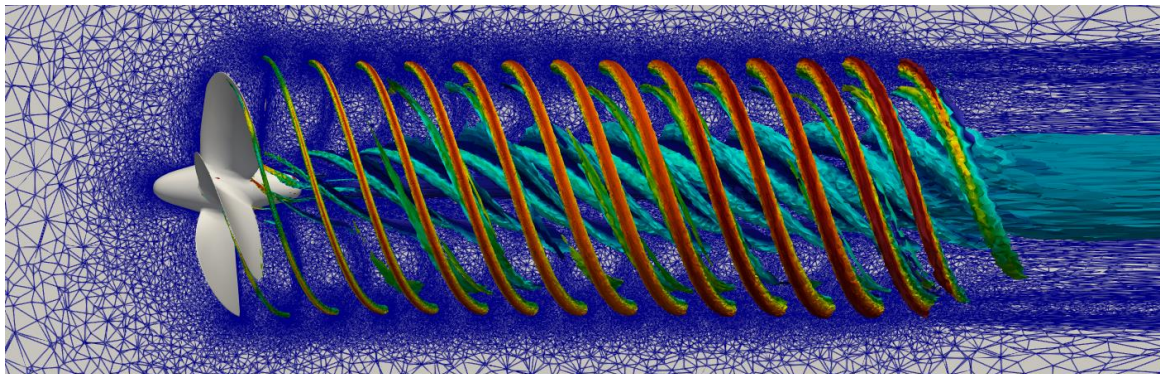
DESIGN & MANUFACTURING

FROM THE METALLIC PROPELLER GEOMETRY...

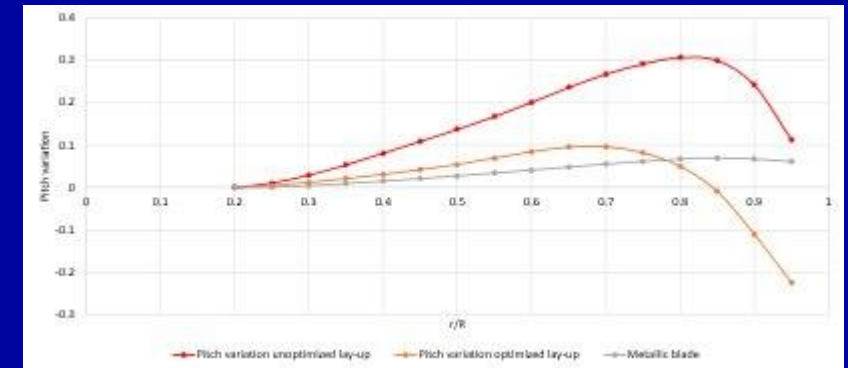
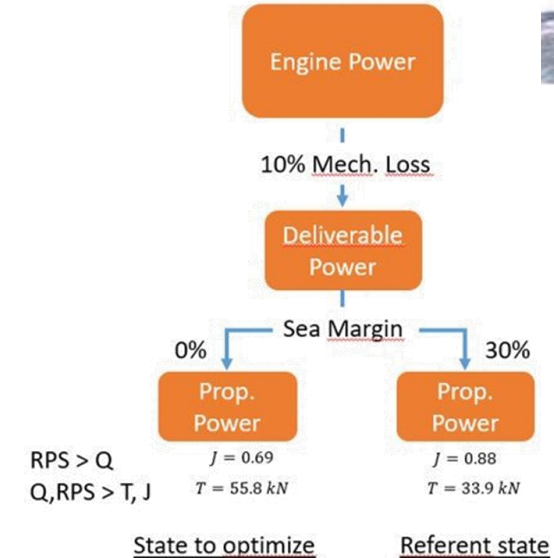


Hydrodynamic analysis

- › Definition of operating conditions and loadings, and limitations for the geometry of the composite propeller
- › **CFD simulations** to obtain pressure loads and efficiency curves
- › Analytical estimation of the **optimal shape of the blade** for the selected operational points.
- › **Structural calculation** and optimization of the orientation of the composite layers to **maximize the pitch variation** from a reference shape.
- › Hydrodynamic calculations to evaluate the **impact of the deformation on the performance**.



Operating point definition



Optimization of the pitch variation of the composite propeller thanks to blade deflection

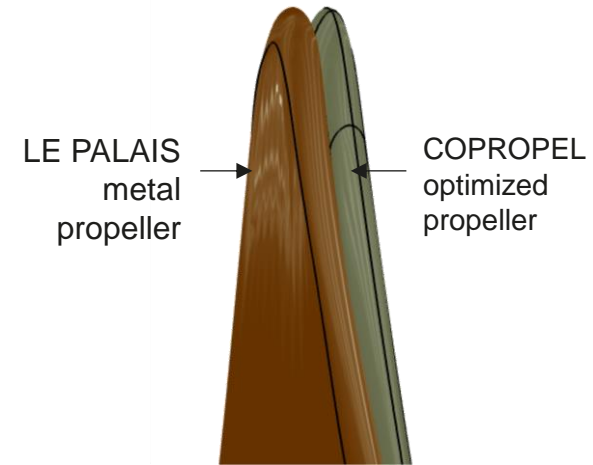
... TO THE COMPOSITE PROPELLER

Fluid-Structure Interaction

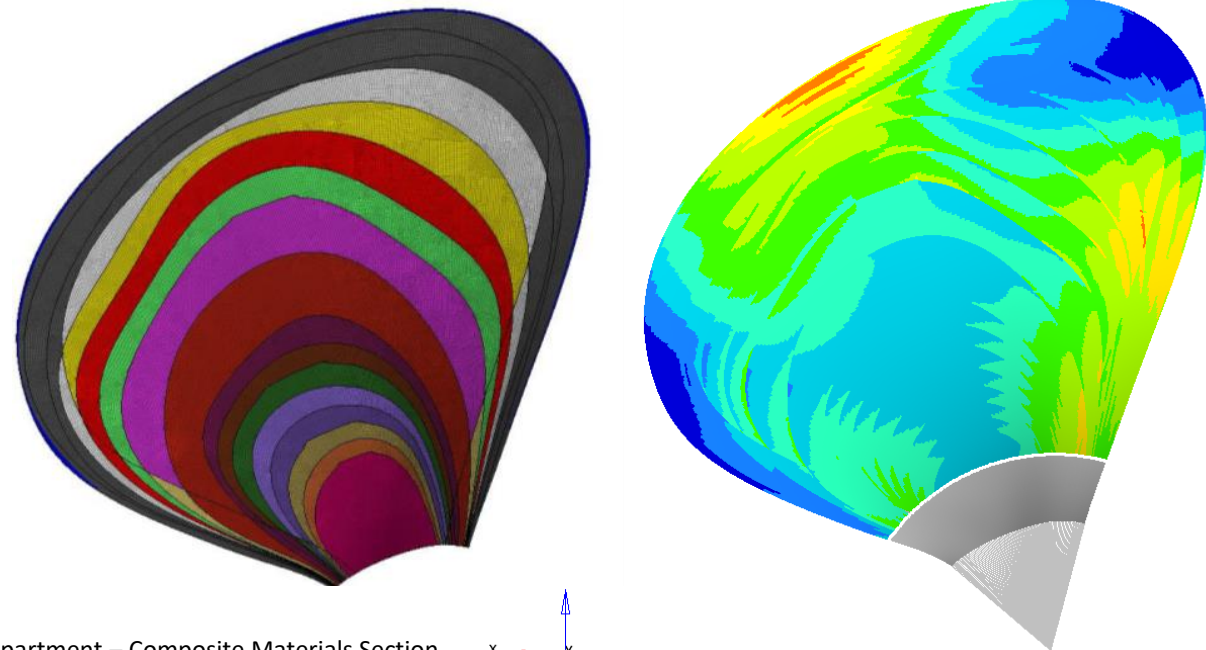
- › **One-way coupling** of fluid and structural simulations
- › Calculation of the **unloaded shape** to be manufactured, that will deform and match the shape of the reference metallic propeller at the design point for comparison
- › Verification of **strains and stress criteria** with 2D finite element model in accordance with BV rules
- › Maximum displacement: 12mm

Blade materials selection

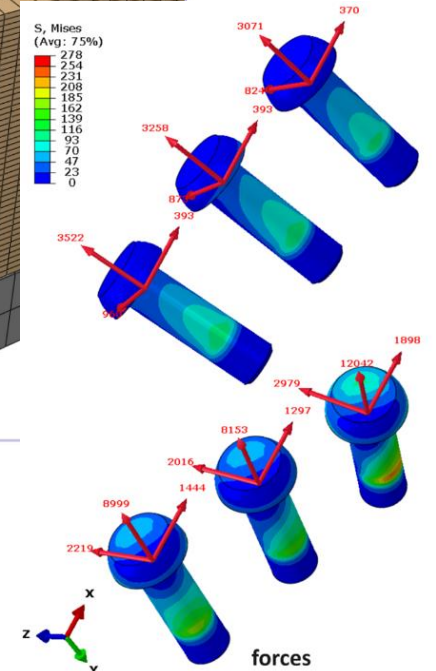
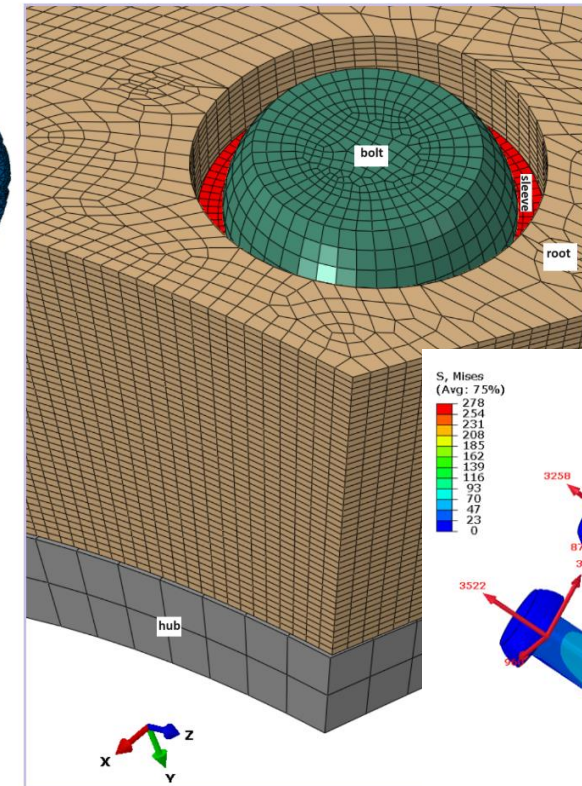
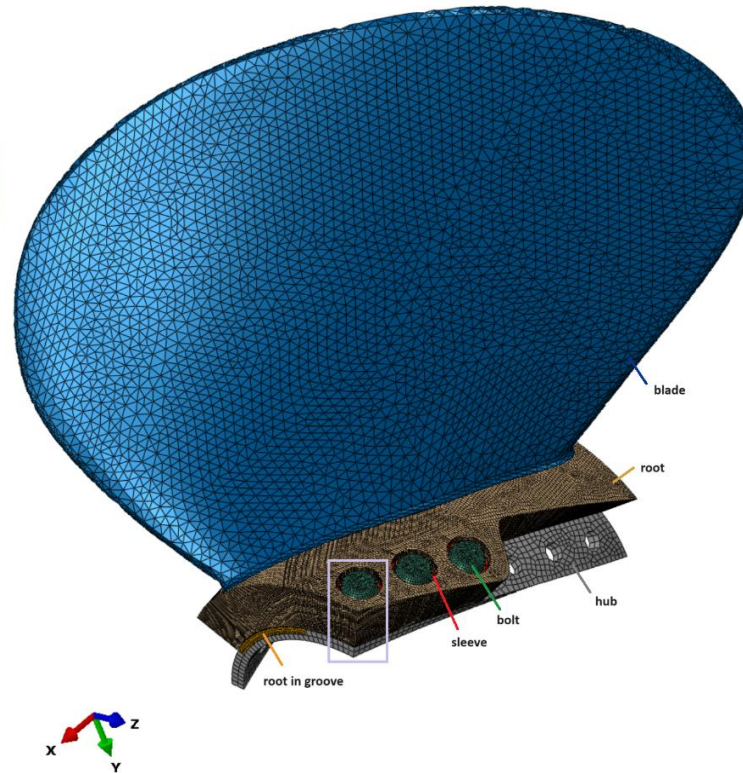
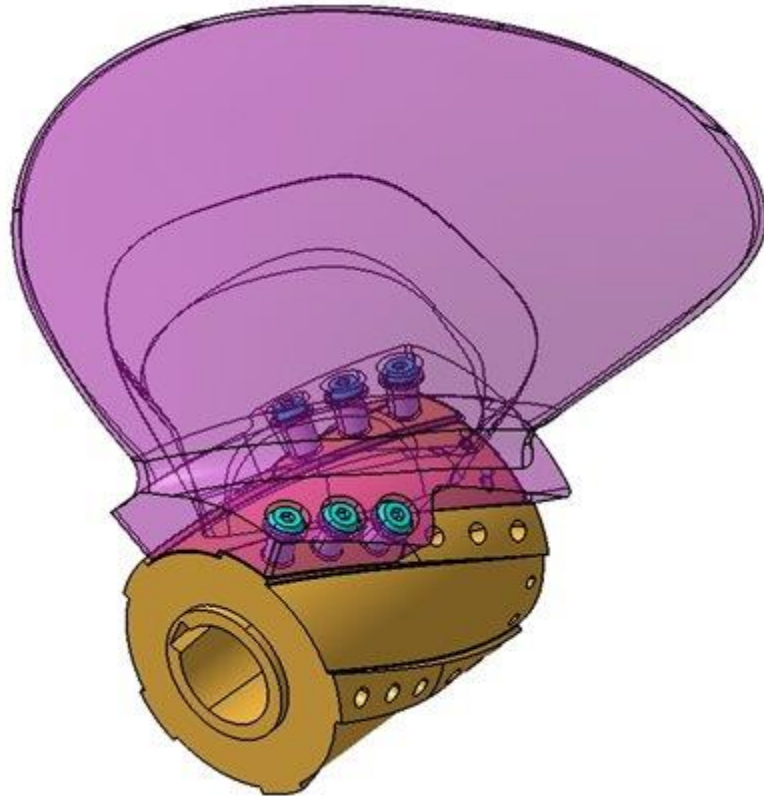
- › UD carbon
- › Carbon twill 2/2
- › Epoxy resin
- › Core in silaxyl



Contour Plot
Composite Strains(P1 (major) Strain, pli-1)



HUB ASSEMBLY DESIGN



› Design to be validated by testing as required by NI663

DESIGN VALIDATION

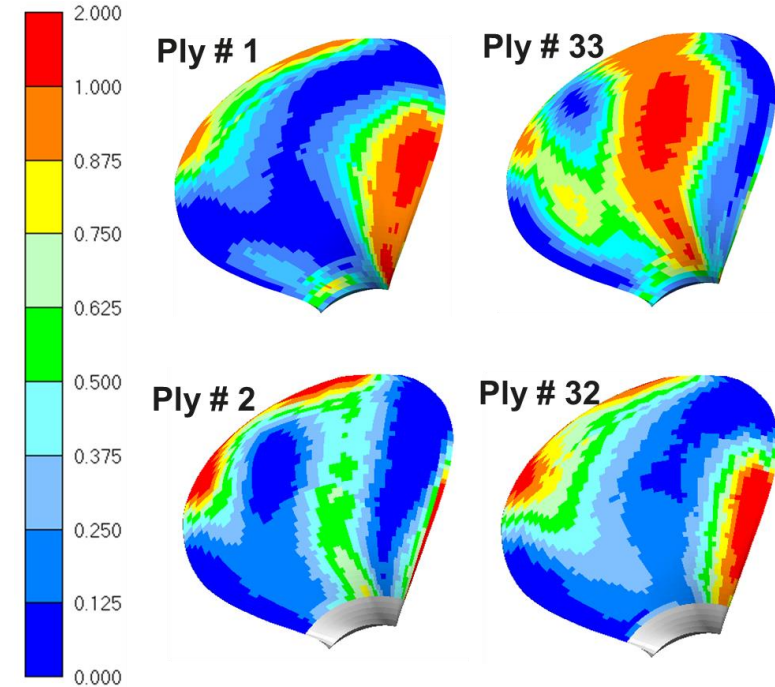
BEM-FEM coupling with ComPropApp, a Fluid-Structure Interaction in-house tool for flexible propeller

Safety factors taken from BV NI 663 considering no fatigue analysis is performed

- › Hoffman Failure Criteria used
- › Stress parallel to fiber, perpendicular to fiber and in-plane shear
- › Failure stress divided by SF for each stress
- › Similar results for BV and MECA for all plies

Fatigue analysis

- › BV methodology
- › Fibre and matrix damage
- › 400M of cycles
- › Fatigue factor max=0.45



Safety factor for		UD	Woven Roving
Accuracy of calculation	α	1.1	1.1
Ageing effect	C_v	1.2	1.2
Fabrication process	C_F	1.15	1.15
Type and direction of stress	C_R	1.7	2.1
Fatigue analysis	C_i	2.2	2.2
Total Safety Factor			
With fatigue analysis		2.58	3.19
Without fatigue analysis		5.68	7.01

MANUFACTURING

Resin Transfer Moulding (RTM) process

- › Design and manufacturing of the mold by LoireTech



- › Preform mold



MANUFACTURING

› Draping and integration of SHM system

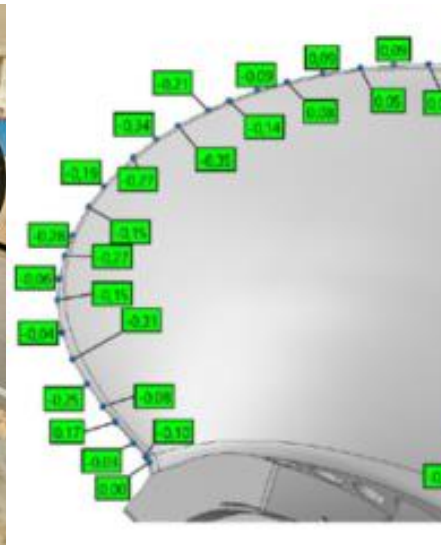
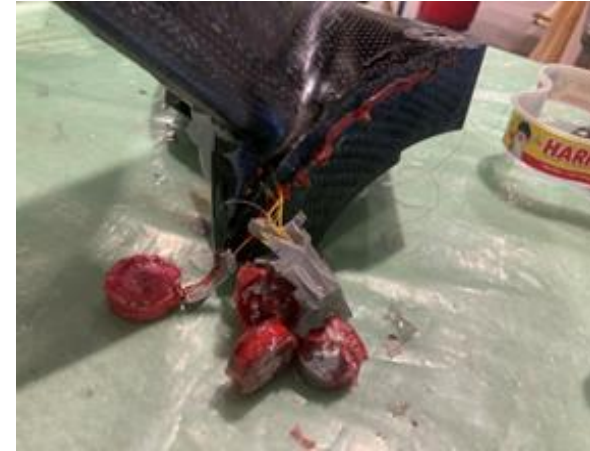
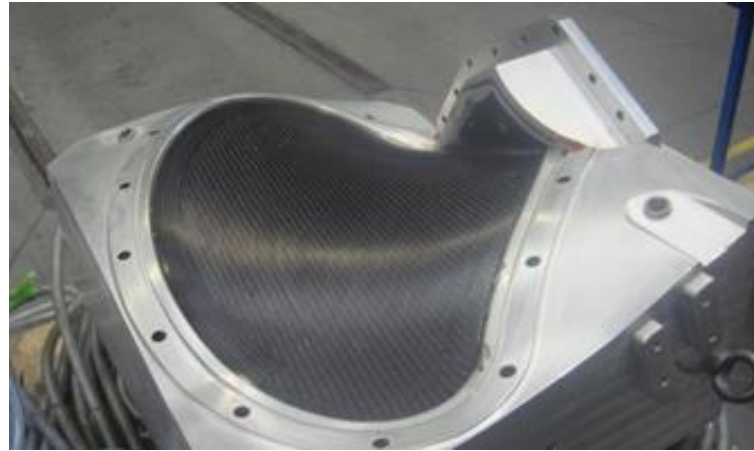


› Assembly and mold closing



MANUFACTURING

- › Injection, curing, demoulding, control and coating





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TESTING

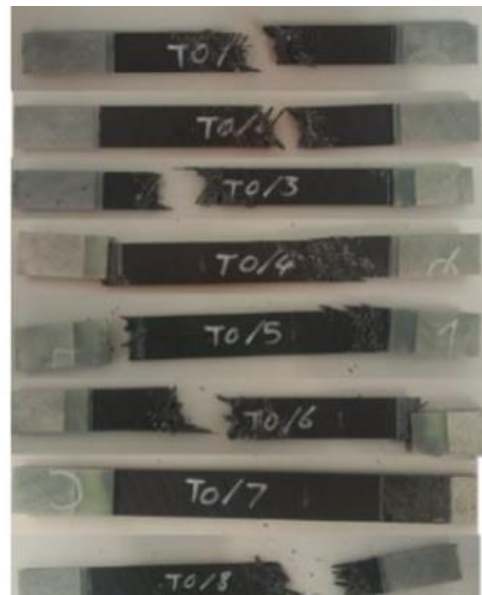
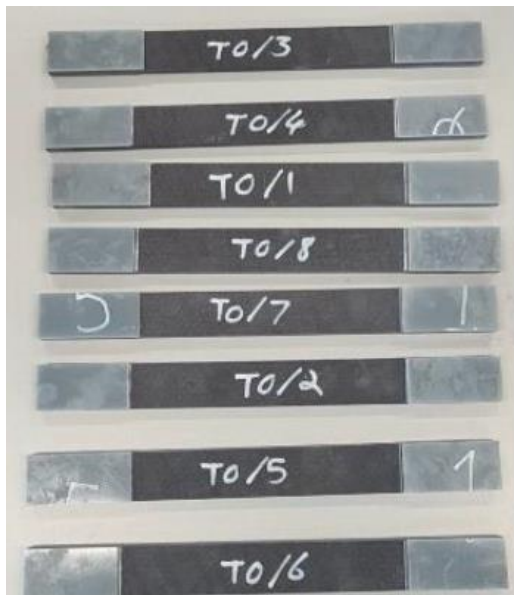
TESTING APPROACH



CHARACTERISATION TESTS

Coupons tests

- › Materials characterisation
 - › Tensile tests
 - › 3-points bending test
 - › Inter-laminar shear strength test
 - › Density
 - › Fibre content



Test	Direction	Specimens
Tensile ISO527	Longitudinal	8
	Transverse	8
	Long. with optical fibre	3
3-Point bending ISO14125	Longitudinal	6
	Transverse	6
	Long. with optical fibre	5
ILSS ASTM D2344	Longitudinal	6
	Transverse	6
Density ISO1183	/	8
Fiber content ASTM D3171	/	3

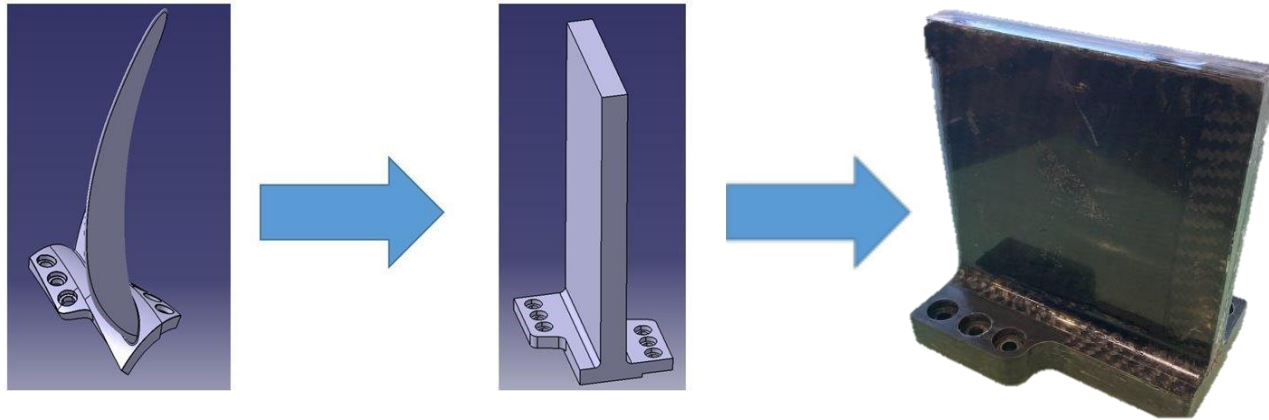
Objectives:

- Confirm mechanical properties used during design including the process
- Evaluate the influence of the SHM system

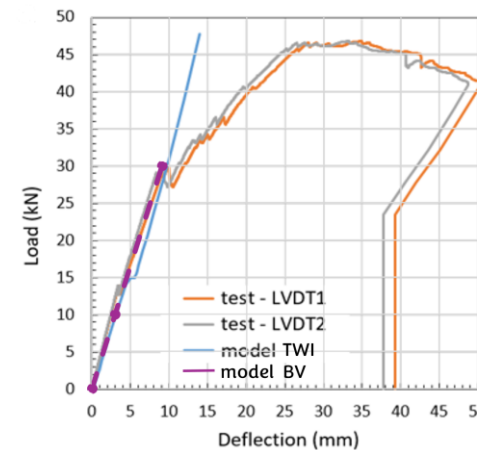
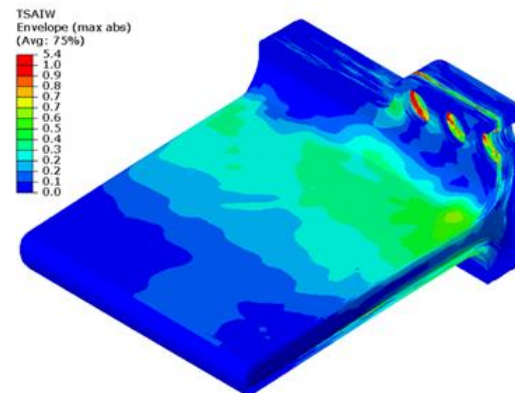
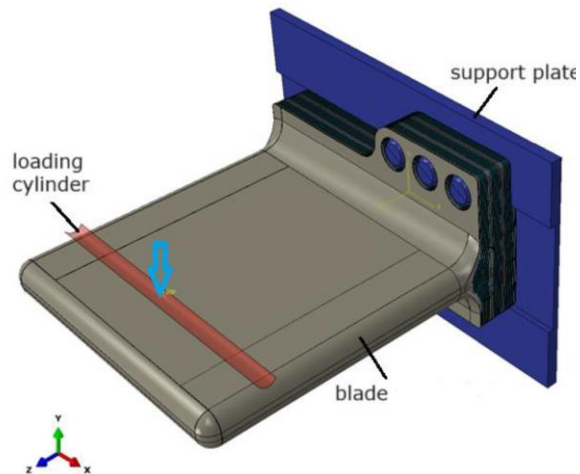
PROTOTYPE TESTS

Blade-Hub connection to be validated by test, required by NI663

- › Full-scale blade or representative prototype

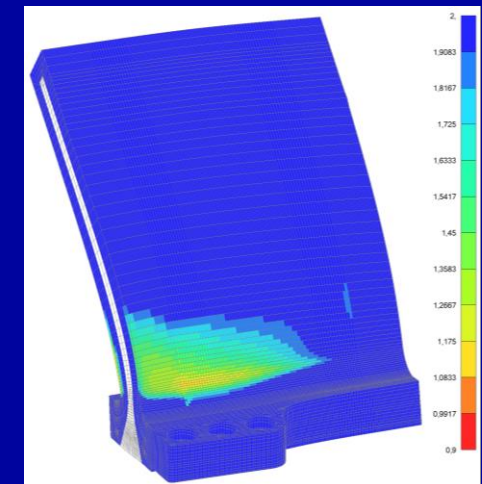


- › Mechanical test and Finite Element Analysis



BV review:

- Testing procedure
- Independant calculations
 - Ply-by-ply approach
 - Hoffman criteria
- Validation of models and safety factors



SHM SYSTEM

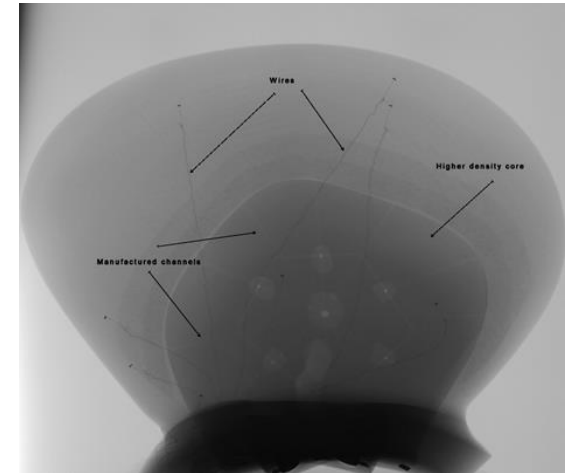
Small-scale propeller...

- › Tunnel tests
 - › Metallic propeller
 - › Composite propeller
- › Integration of SHM system
 - › Distributed Fibre Optic System (FOS)
 - › Fibre Optic Rotary Joint
 - › Wireless Strain Gauge System (SG)



... to full-scale

- › FOS with rotary joint and cable acquisition system on the ship's bridge
- › Wireless strain gauges and SD card recording



SEA TRIALS

4 days in March, Atlantic Ocean off Brittany coast

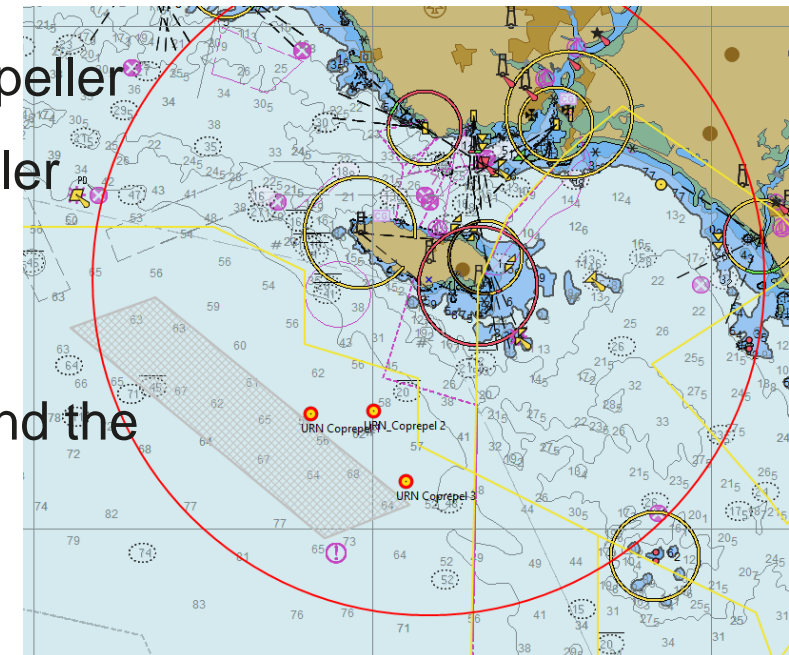
Two configurations tested:

- › 2 metallic propellers
- › 1 metallic propeller & 1 composite propeller



Objectives:

- › Obtain the **speed-power curves** of the ship with composite propeller
- › **Test the manoeuvrability** of the ship with the composite propeller
- › Measure **Underwater Radiated Noise** produced by composite propeller
- › **Compare the performance** between the composite propeller and the metallic propeller
- › Compare to numerical results to **validate models**



TESTS PERFORMED

Speed & Power tests

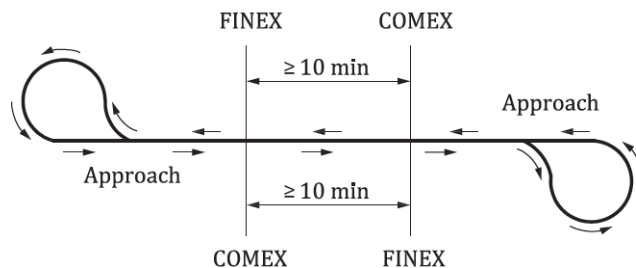
3 configurations

- › 2 engines functioning
- › Only starboard propeller engine powered (other rotating freely)
- › Only portside propeller engine powered (other rotating freely)

2 design points

- › 1600 rpm
- › 1300 rpm

Multiple runs for repeatability

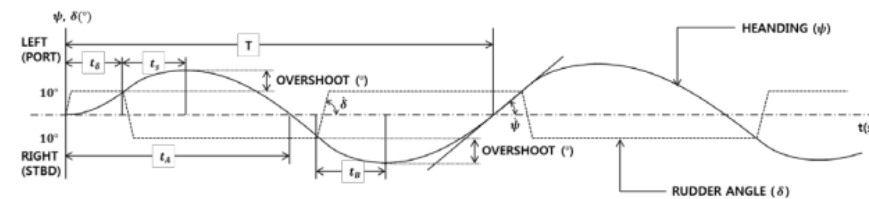
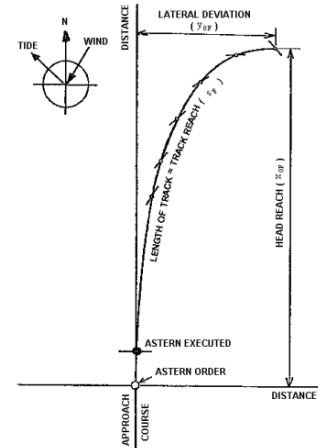
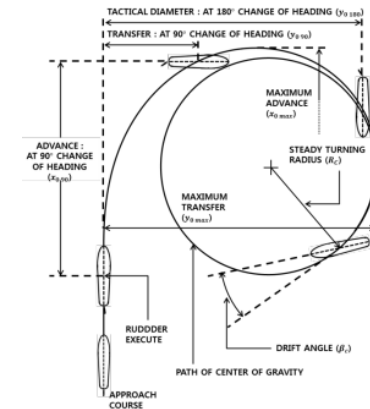


Path of ship during Double Run

Manoeuvrability tests

Based on IMO MSC.137

- › Turning circle
- › Stopping test
- › Zig zag manoeuvre test



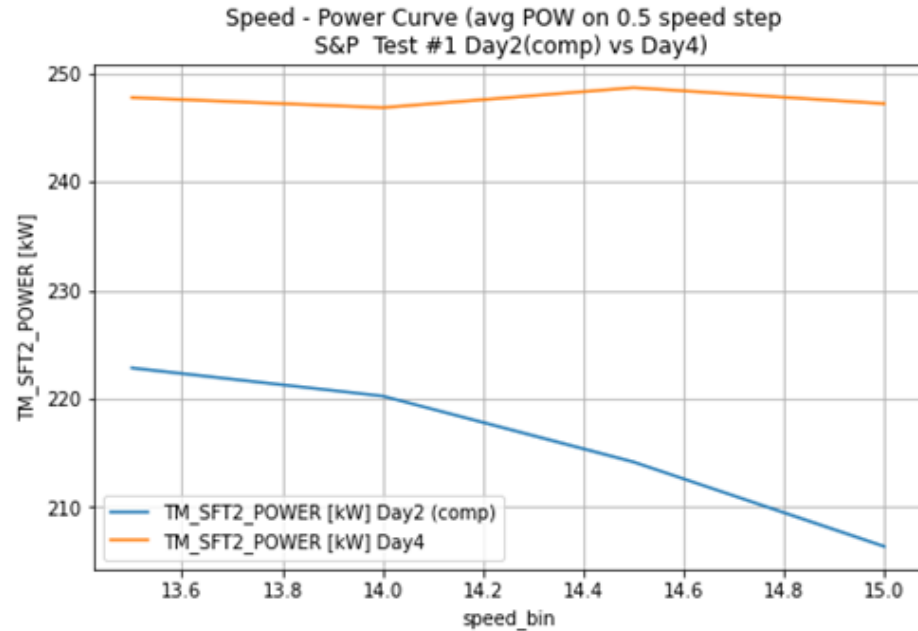
Underwater Radiated noise

Based on BV NR614

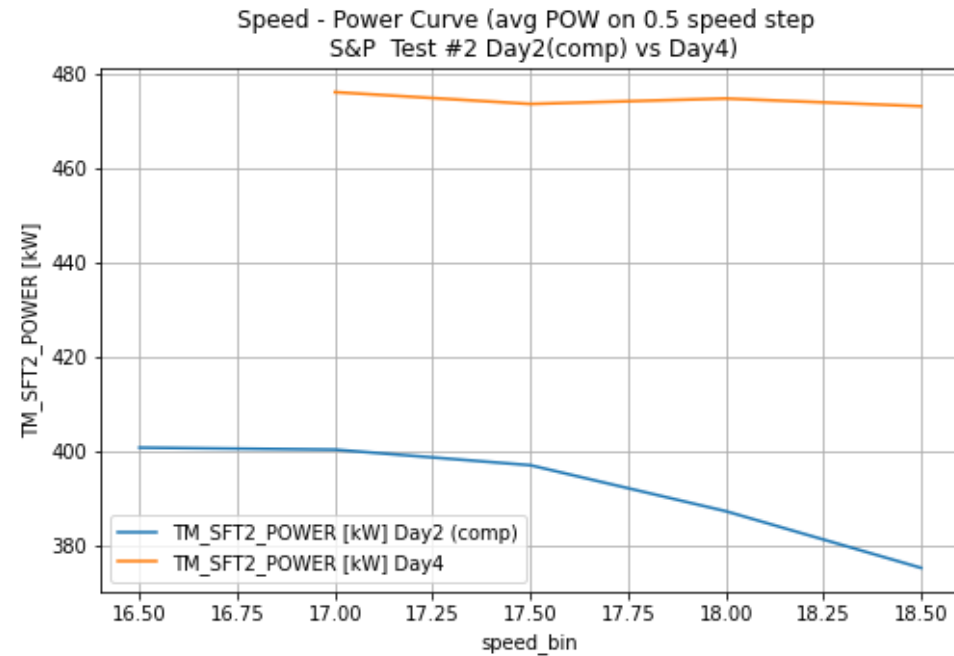
- › Test with starboard propeller only (composite)
- › Test with portside propeller only (metallic)

Measurement with hydrophones

SPEED & POWER RESULTS



Both engine - 1300 rpm

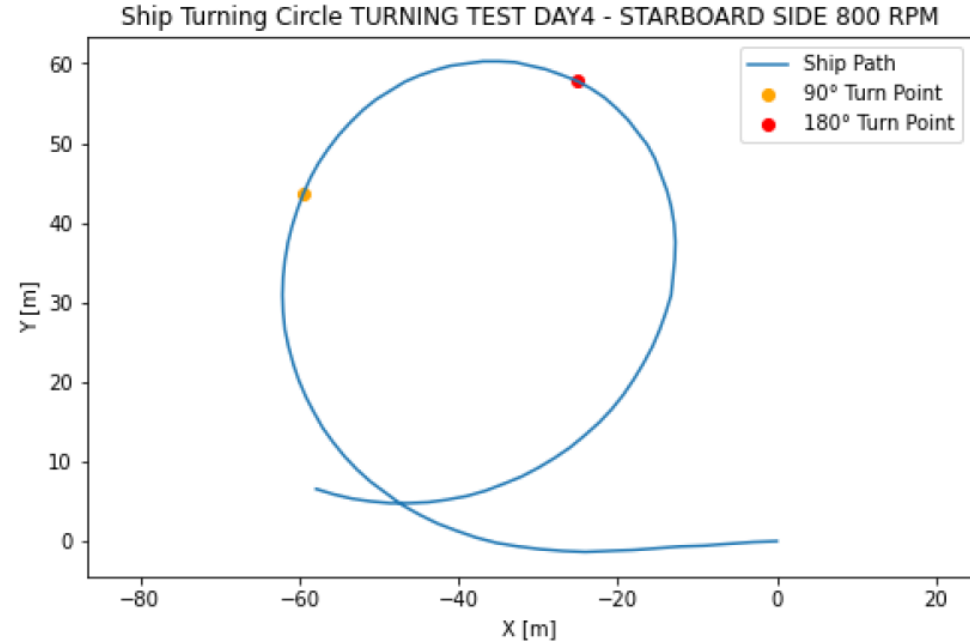
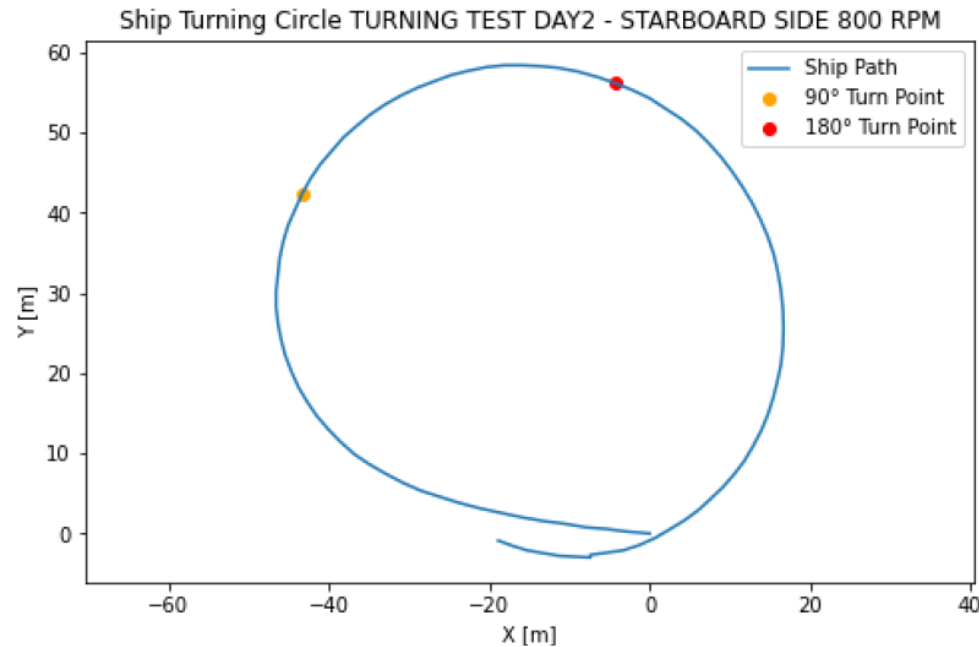


Both engine -1600 rpm

Less power (26%) required for the composite propeller
Approximatively 4% fuel consumption reduction

MANOEUVRABILITY

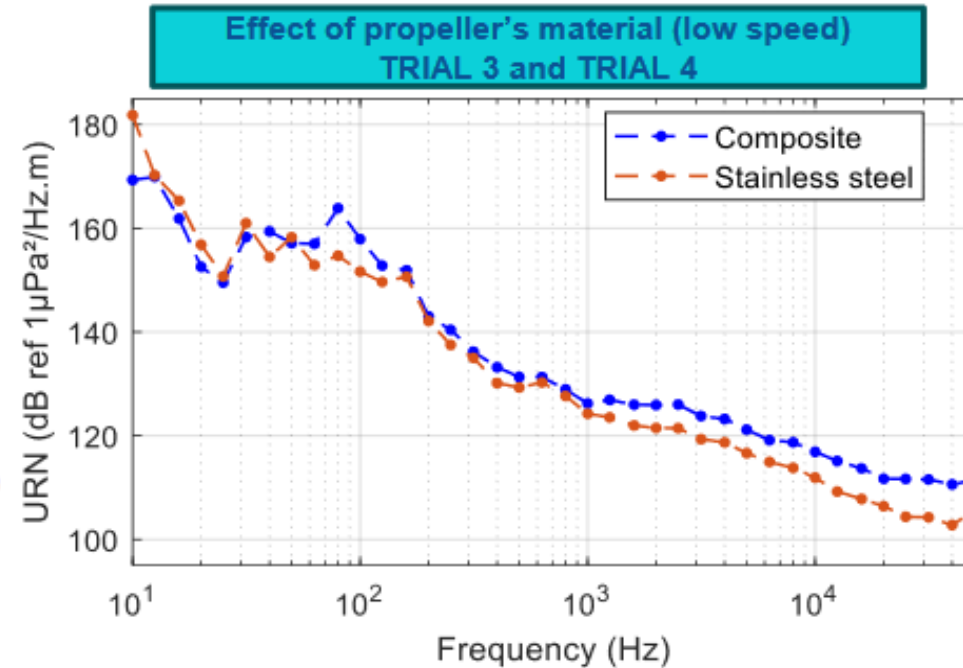
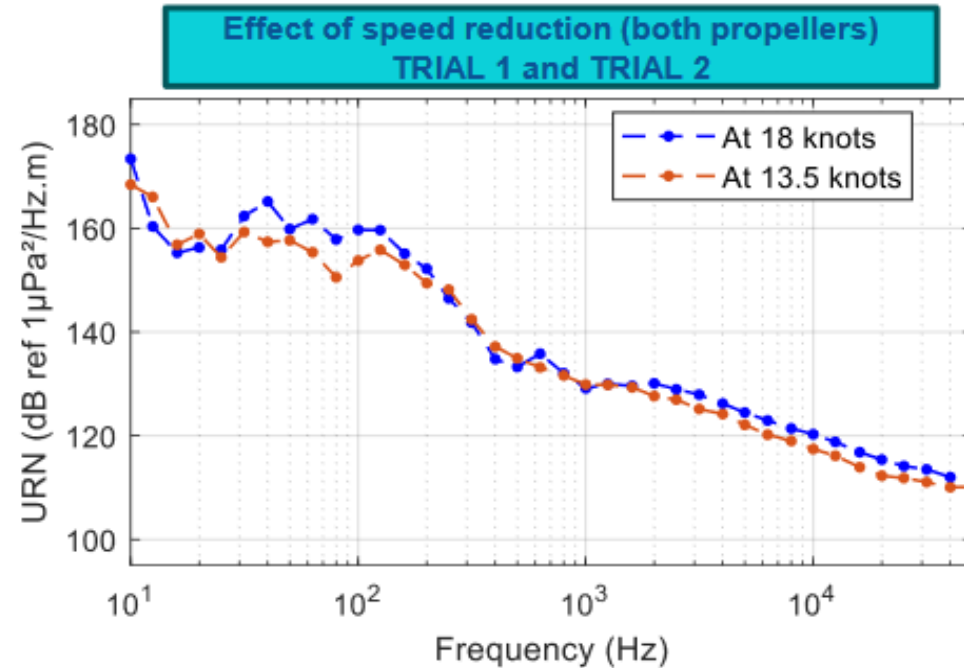
Turning circle



Portside worse condition than starboard → 70 m vs 120m

Starboard same tactical diameter → ≈ 56 m

URN RESULTS



Significant decreases of noise when reducing speed from 18.0 to 13.5 knots
Slightly higher noise levels at higher frequencies compared to the metallic propeller



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CONCLUSION

CONCLUSION

Design successfully validated in accordance with BV NI663

- › Numerical simulations
- › Multi-scale testing: coupons, prototype, full-scale sea trials

Integrated manufacturing with SHM system

- › Optical fibres and wireless strain gauges

Key technical outcomes

- › 50% weight reduction
- › Fuel consumption reduction under specific operating conditions
- › Noise reduction was not a primary design objective and remains unconfirmed

Future works:

- › **Update of the NI663** incorporating research projects findings and emerging technologies (thrusters)
- › **CRS Certify project** - Development and certification of a 1 m diameter propeller
- › **JIP PRINCE** - Gathering consortium to advance propeller development for large-scale applications (diameter >3 meters)





CRS CERTIFY



Within CRS programme
Started in January 2025

RNLN will provide a Diving Support Vessel:

Nautilus

History	
	Netherlands
Name	HNLMS <i>Nautilus</i>
Operator	 Royal Netherlands Navy
Builder	Scheepswerf Visser, Den Helder
Laid down	16 March 1992
Launched	10 June 1992
Commissioned	18 September 1992
Identification	IMO number: 9021758 MMSI number: 245989000 Callsign: PD2263 Hull number: A853
Status	In active service
Badge	

General characteristics ^{[1][2][3]}	
Type	<i>Cerberus</i> -class diving support vessel
Displacement	340 t (335 long tons) full load
Length	37.8 m (124 ft 0 in)
Beam	8.76 m (28 ft 9 in)
Height	13.2 m (43 ft 4 in)
Draft	1.50 m (4 ft 11 in)
Propulsion	2× Volvo Penta TADM 122A
Speed	10.5 knots (19.4 km/h; 12.1 mph)
Crew	6

Propeller diameter: 1.0 m
Carbon fibres

JIP PRINCE

PRINCE



New Joint Industry Project Propeller IN Composite

- › Coordinated by BV in collaboration with LoireTech
- › Expected to start in 2026



3.5 years



M€ 1.8

Objectives: Produce and Test a 3m diameter Composite Propeller

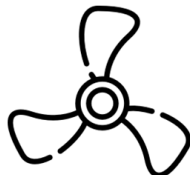
- › To confirm energy savings and noise reduction
- › To confirm manufacturing quality and reliability

PHASE 0



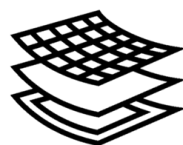
**Vessel
identification &
selection**
M0

PHASE 1



**Propeller
design and
validation**
M1-M24

PHASE 2



**Propeller
manufacturing
and control**
M25-M36

PHASE 3



**Installation &
sea trials**
M37-M42

The tentative participation fees:

Shipowners and shipyards:
€50,000 per year (for 3.5 years)

Other companies: €30,000 per
year (for 3.5 years)

**THANK YOU
FOR YOUR
ATTENTION**



**BUREAU
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Shaping a World of Trust



STEPHANE PABOEUF

Head of Composite Materials Section,
Research Department

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BUREAU VERITAS MARINE & OFFSHORE