RAMSSES final conference
2021-11-17

Similar objectives, different challenges and solutions

RAMSSES lightweight solutions by Naval Group

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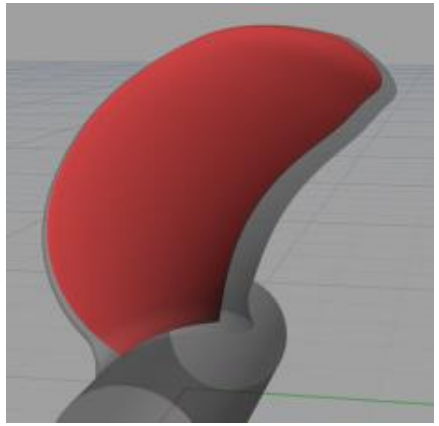
Naval Group

Content

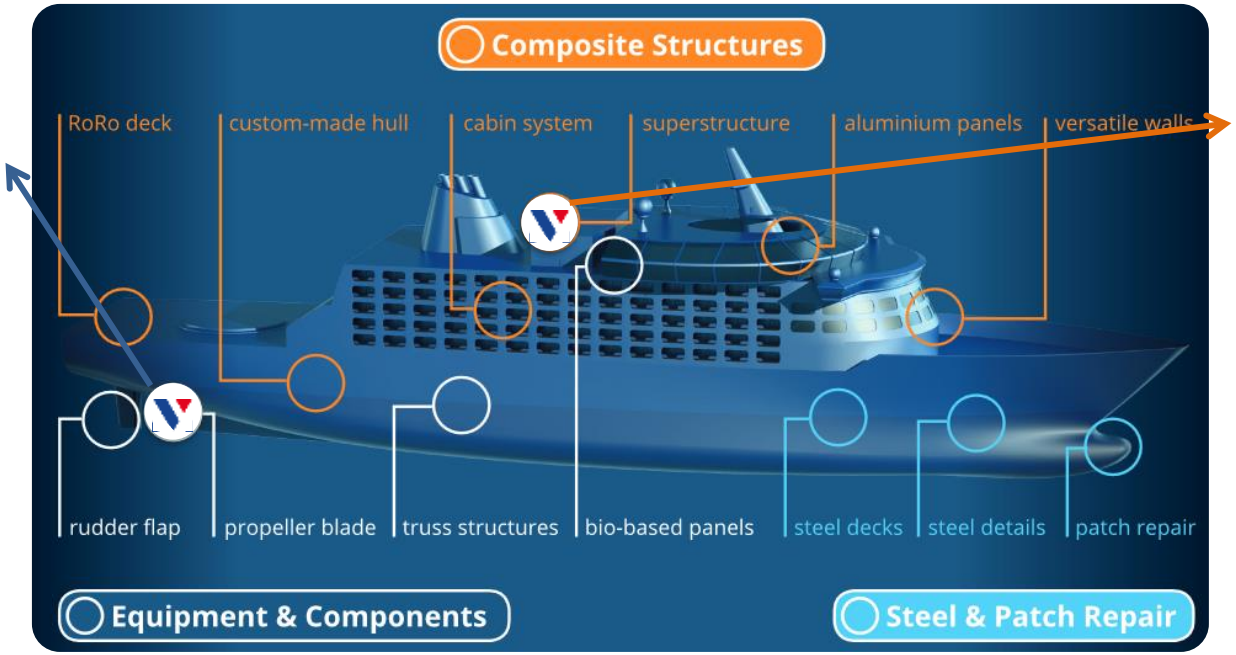
Introduction to Naval Group Use cases

Similar objectives, different challenges and solutions
RAMSSES lightweight solutions by Naval Group

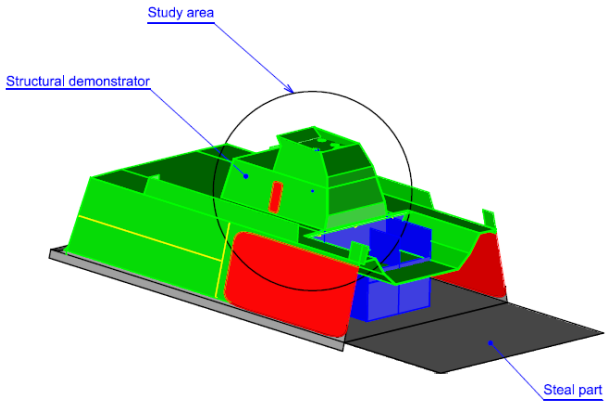
WP11 - Hollow propeller blade by additive manufacturing



NAVAL GROUP
CENTRALE NANTES
ENSTA Bretagne
SIREHNA NAVAL GROUP



WP16 - Composite superstructure module



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Main objectives of both use cases linked to RAMSSES aims

Weight reduction

- Lightweight composite materials
- Hollow blade

Maintenance cost reduction

- Corrosion resistance of composite materials
- Reparability of metallic blades

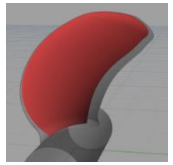
Production cost reduction

- Product cycles shortened

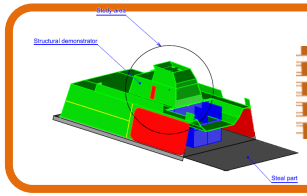
Legend: Hollow blade | Composite superstructure

Objectives linked to Naval Group products and use cases

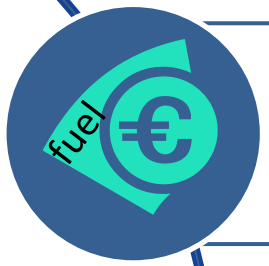
Hollow blade by AM



Composite superstructure

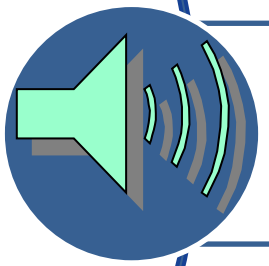


Propeller performance



Multifunctional structures (SHM, HF functions)

Control of radiated noise



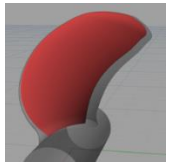
Fire Safety

Vibration reduction

Multi-material assemblies

Development methodology from requirements to site testing

Hollow blade by AM



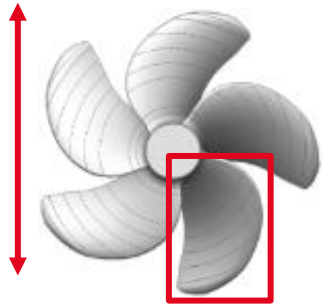
Ship in these categories with open data:

KCS (KRISO Container Ship)

- Length between perpendiculars: 230.0 m
- Breath: 32.2 m / Draught: 10.8 m
- Displacement volume: 52030 m3
- Service speed VS: 24.0 knots

Propeller:

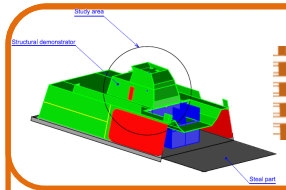
- 5 blades
- Diameter: 7.9 m
- Delivered power: 27.6 MW

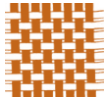


Technical specification:

- Dimensional tolerances → ISO 484-1 "class 1"
- Mechanical characteristics and tests
  → BV Rules NR467 / NR216

- **Requirements**
- Design
- Numerical analysis
- Material characterization
- Process engineering
- Process optimization
- Full scale experiment





Composite superstructure

Vessel caracteristics:

- OPV
- Length > 65m
- Tonnage > 500UMS
- 80 passengers

Structural rules:

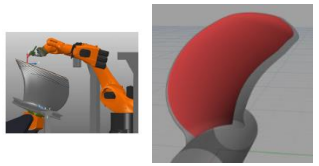
- Loadings → BV Rules NR467
- Composite calculations → BV Rules NR546
- Safety factors → BV Rules NR600

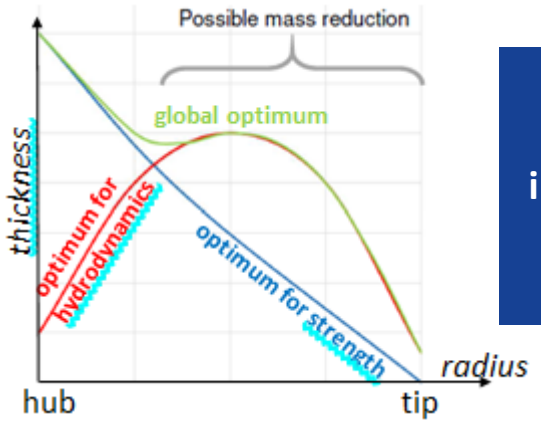
Fire rules:

- Alternative Design method → IMO – MSC/Circ.1002
- Guideline for AD approval → IMO – MSC.1/Circ.1455
- Use of composites → IMO – MSC.1/Circ.1574

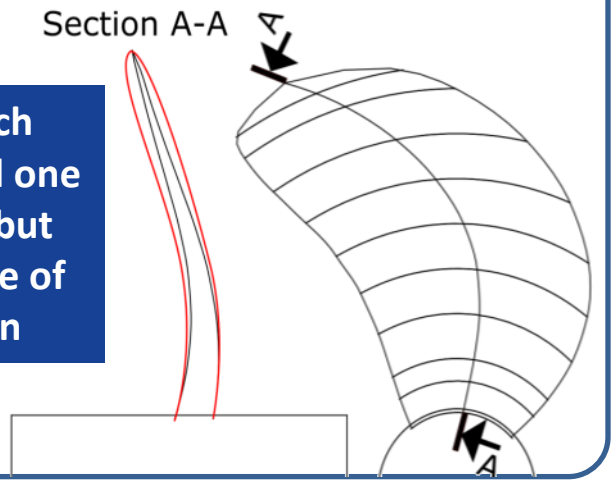
Development methodology from requirements to site testing

Hollow blade by AM





Blade strength is function of section inertia: hollow sections provide same strength for less mass



Final blade is much thicker than original one (+63% in volume) but not heavier because of the hollow design

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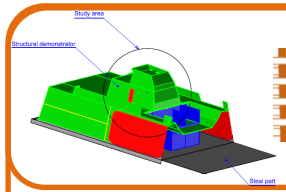
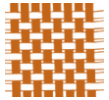


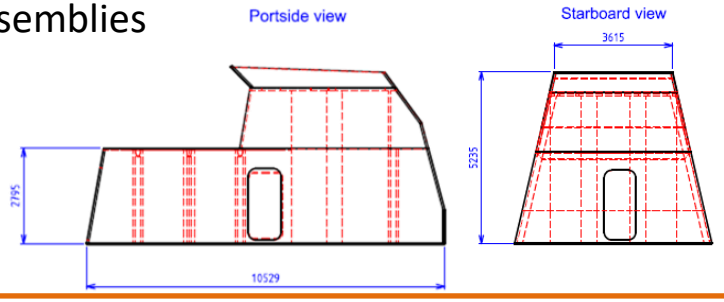


Composite superstructure

Use case:
Funnel bloc

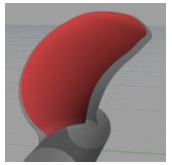
Analytic design of the overall bloc:

- Choice of materials
- Stacking sequences of sandwich bulkheads and stiffners
- Design of composite junctions and multi-material assemblies

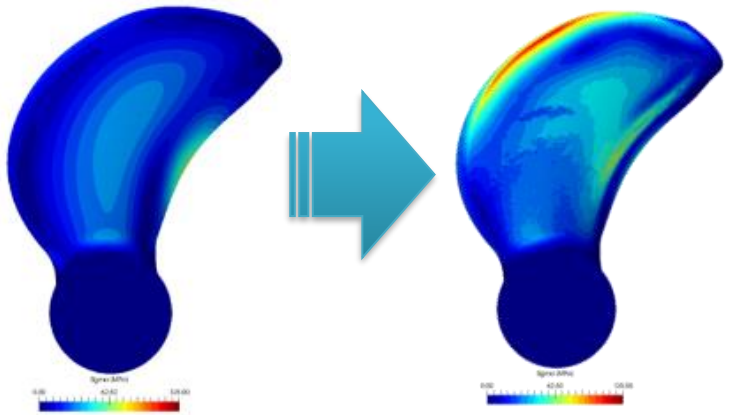


Development methodology from requirements to site testing

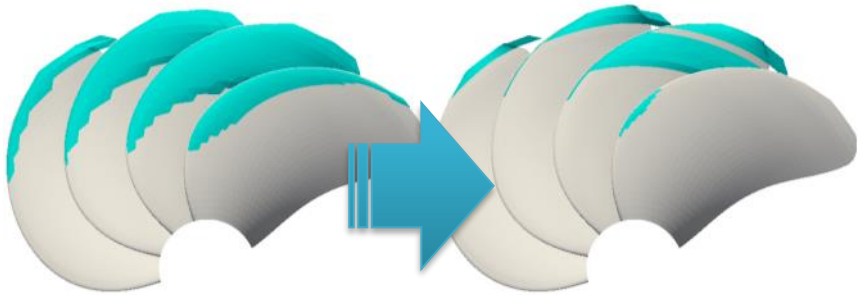
Hollow blade by AM



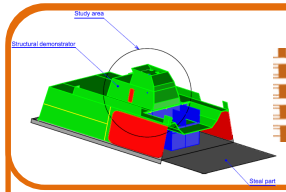
Mechanical design:

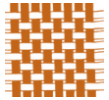


Cavitation simulation:



- Requirements
- Design
- **Numerical analysis**
- Material characterization
- Process engineering
- **Process optimization**
- **Full scale experiment**

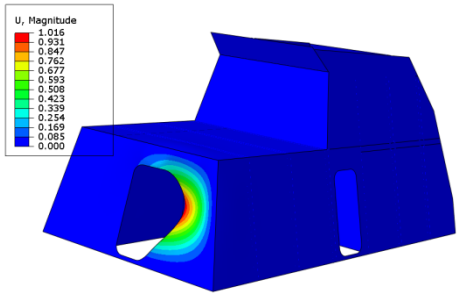




Composite superstructure

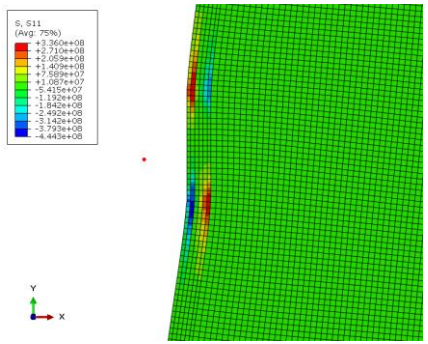
Global analysis to check the following criteria:

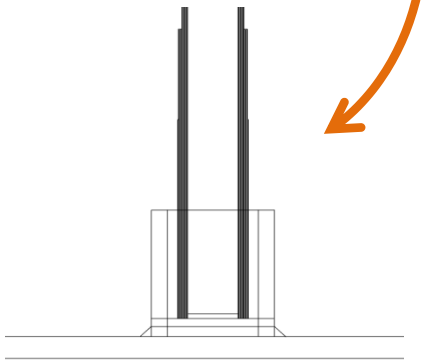
- Eigen values
- Overall buckling
- Local buckling
- Tsaï-wu criterion
- Core analysis



Local analysis on junctions:

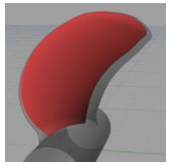
Serial approach

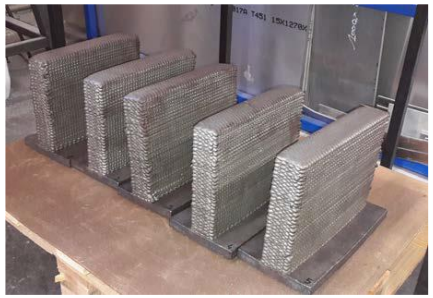




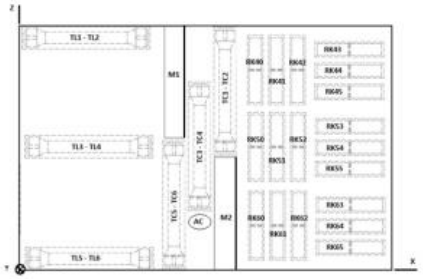
Development methodology from requirements to site testing

Hollow blade by AM

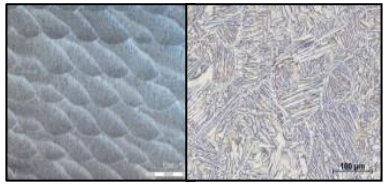




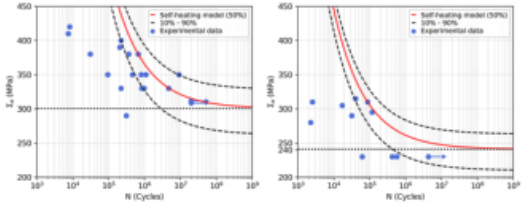
Blocks



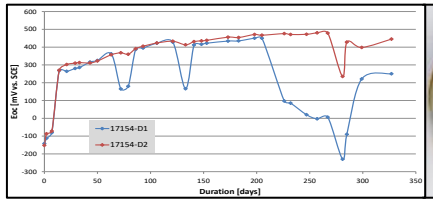
Coupons

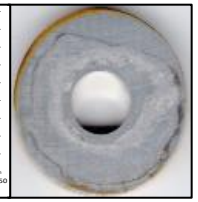


Macro & micrography



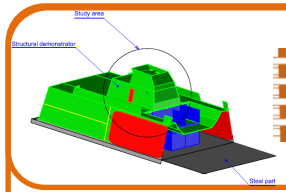
Static & dynamic characterisations

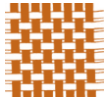




Corrosion

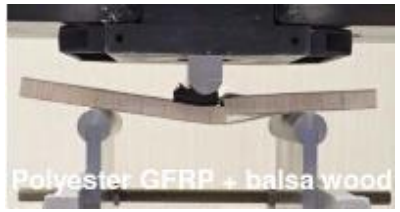
- Requirements
- Design
- Numerical analysis
- **Material characterization**
- Process engineering
- Process optimization
- Full scale experiment



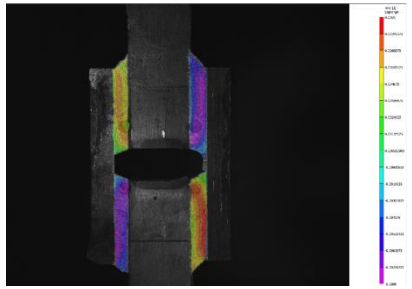


Composite superstructure

Coupon scale:

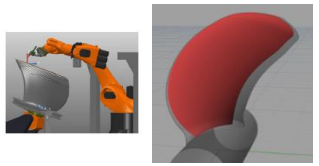


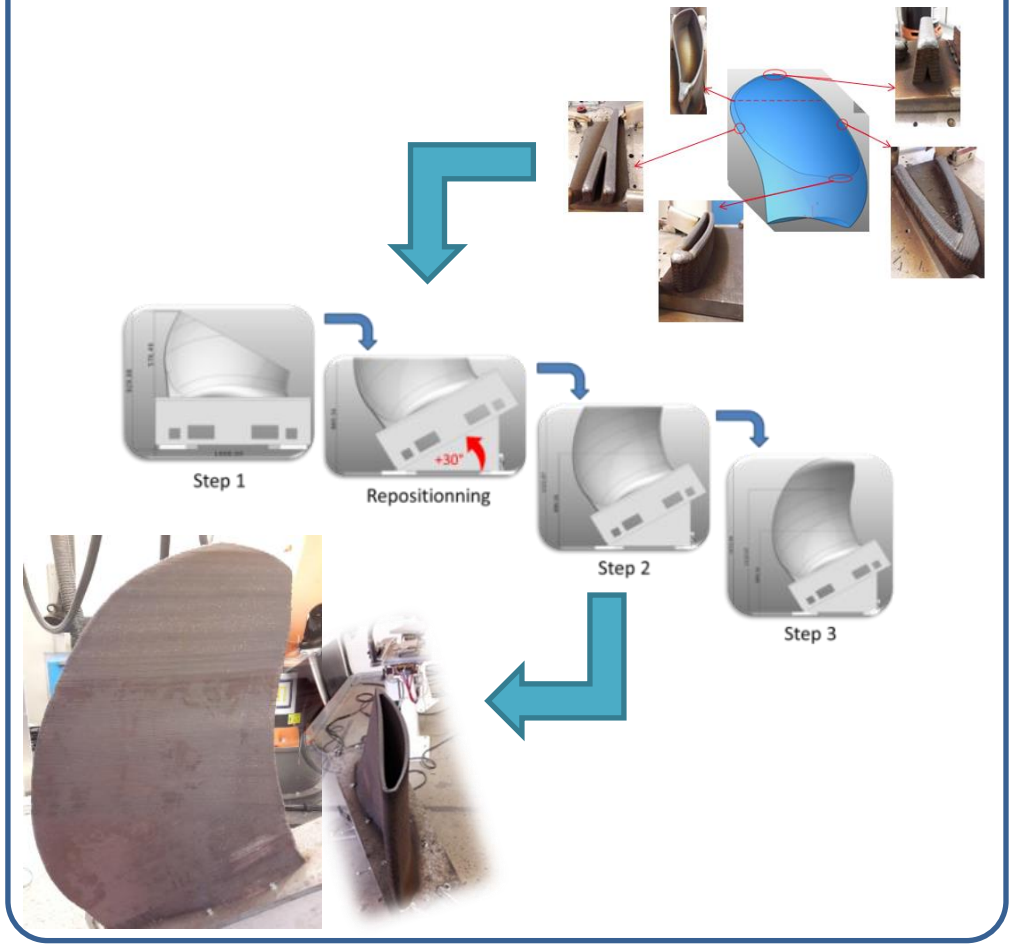
Intermediate scale:



Development methodology from requirements to site testing

Hollow blade by AM





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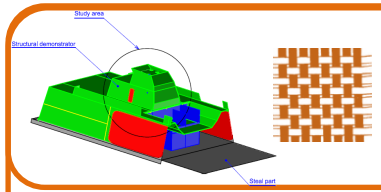
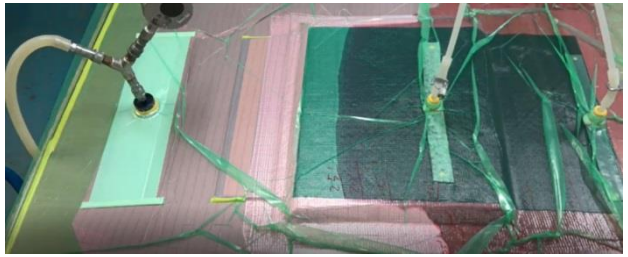


Composite superstructure

Infusion process of monolithic and sandwich parts with:

- GFRP skins + evaluation of bio-based materials
- Balsa wood and reinforced core
- Specific coatings



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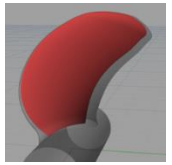

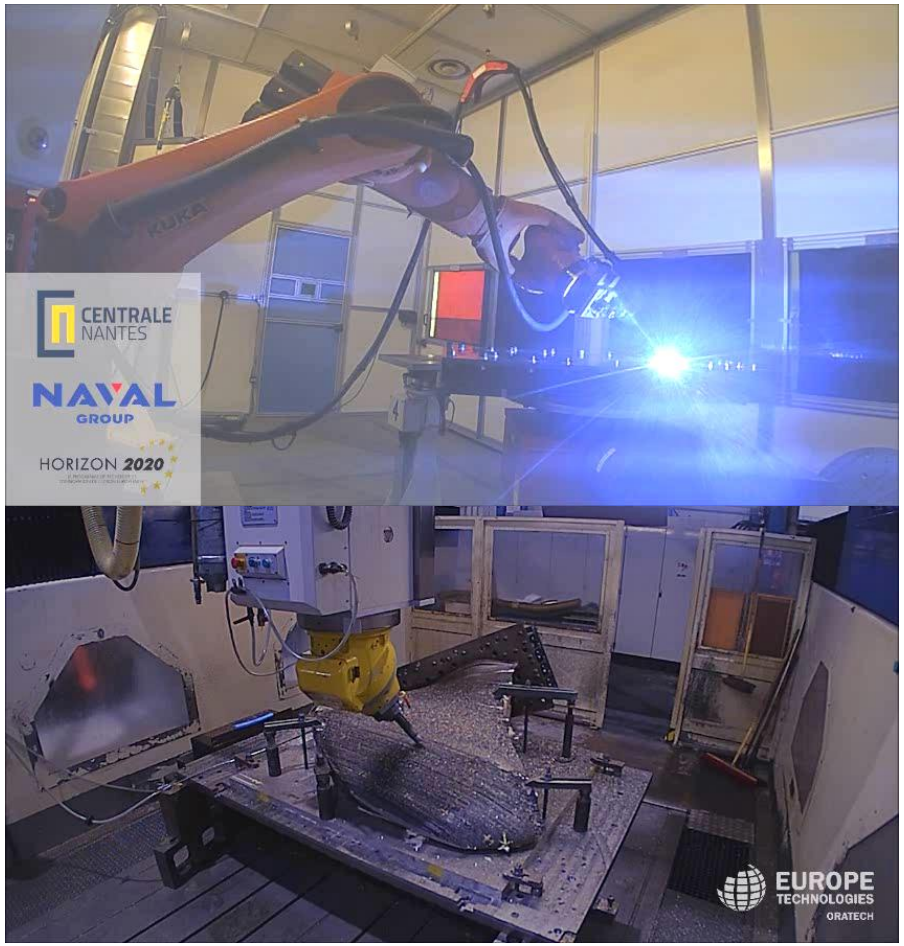

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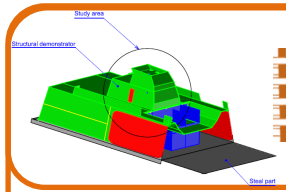
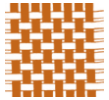
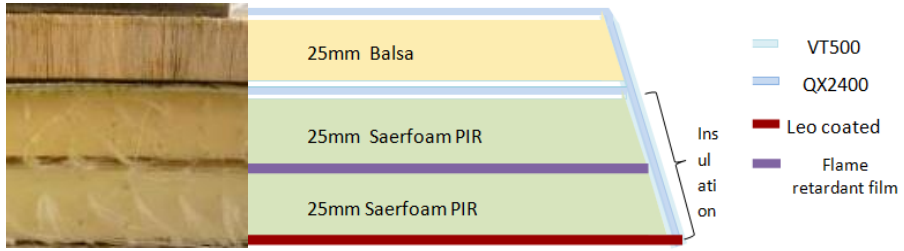




Composite superstructure

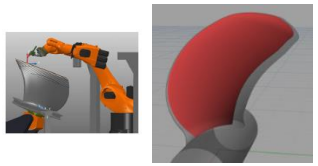
Optimization of the junction process with embedded sensors:

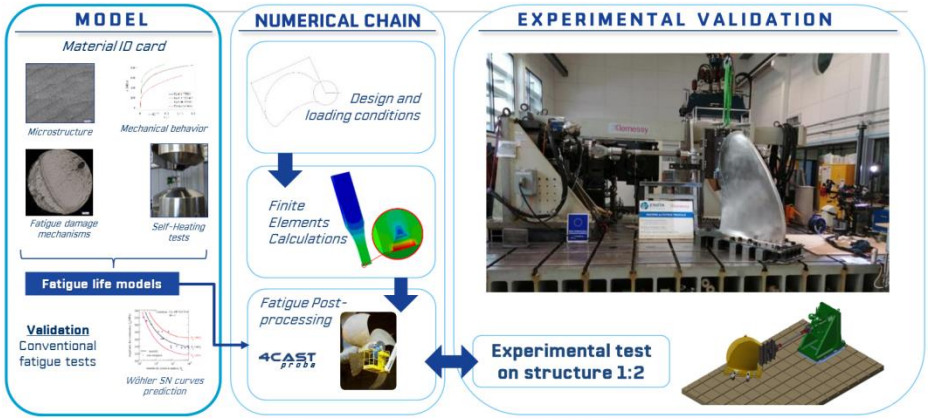
Production of fire proof composite bulkheads:

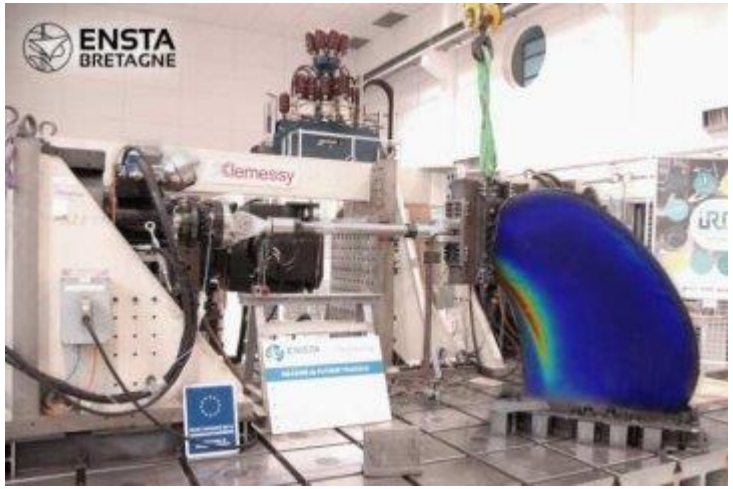


Development methodology from requirements to site testing

Hollow blade by AM







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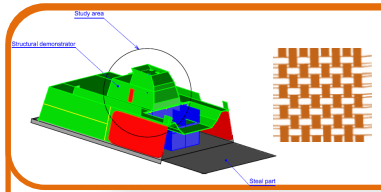
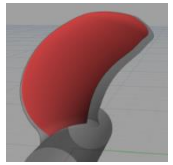
- **Full scale experiment**

Composite superstructure



Conclusions

Hollow blade by AM



Weight reduction 50%

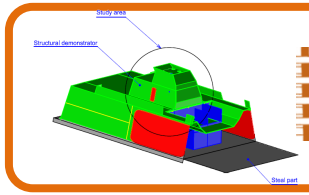
in sea water so … less material

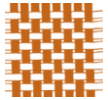
Improved efficiency of 5% and less erosion so … less repair

Radiated noise in correlation with directive for sea mamels

Reduce vibration → reduction of material to design the aft hull

Composite superstructure





Weight reduction 50%

nearly 6 tons for the funnel block

Qualif. of materials and assemblies → Structural approval

Improved fire behavior → fire approval

Validation of integrated sensors during full scale tests on junctions

Perspectives

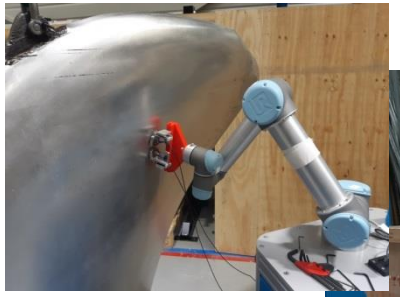
Composite superstructure

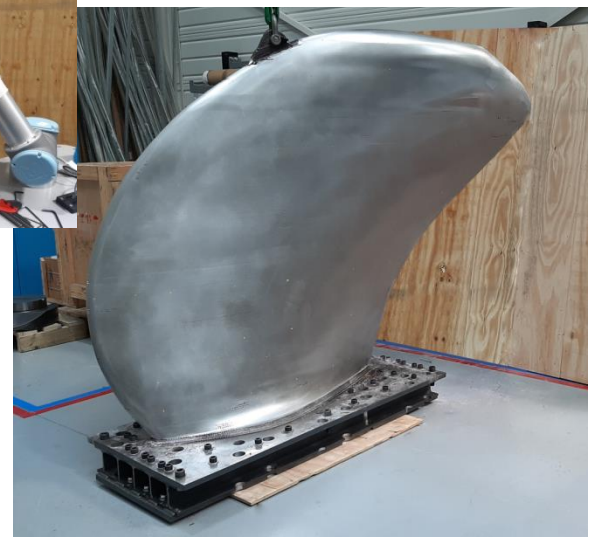
- Extend the use of composites on surface ships
- Functionalization:
  - Flat antennas in bulkheads
  - Signature reduction
  - Process and health monitoring with digital twin

Hollow blade by AM

- Residual way to qualification:
  - Capacity to validate NDT on rough internal surfaces

  … or improvement in monitoring for numerical validation
- Further optimization:
  - New design with chord variation for better efficiency
  - Use of the cavity for additional material or monitoring





Naval Group and its partners thank you for your attention

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