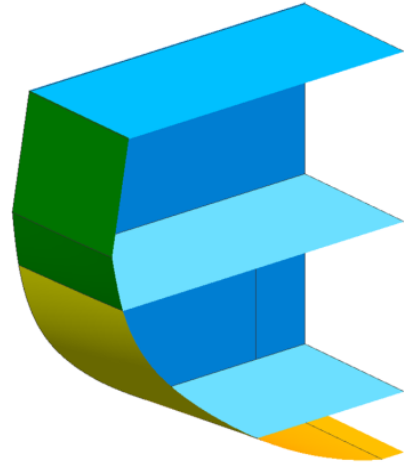


RAMSSES - Realisation and Demonstration of Advanced Material Solutions for Sustainable and Efficient Ships

E-Lass September 16th, 2020 Scaling up Composites Technology

Work Package 17
Custom Made Hull for Offshore Vessel
Marcel Elenbaas
Damen Schelde Naval Shipbuilding



Scaling up Composites Technology

Coming from Damen Shipyards Antalya standard in composites up to 25 meter...



11 meter



25 meter



...Up to 85 meter within RAMSSES

Why would we go for composites?

Key Performance Indicators: Weight reduction, less fuel, less CO2 and....



Offshore Patrol Vessels
Advanced functions



Crew Supplier/Offshore Patrol
Reduced engine capacity



Offshore Supply
Improved Stability



Expedition Cruises
No Emissions



Yachts
Advanced Aesthetics



Yacht Support
No fairing



Fishery
Integrated cargo holds



Fast Ferries
Client's Business Case

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Advanced functions



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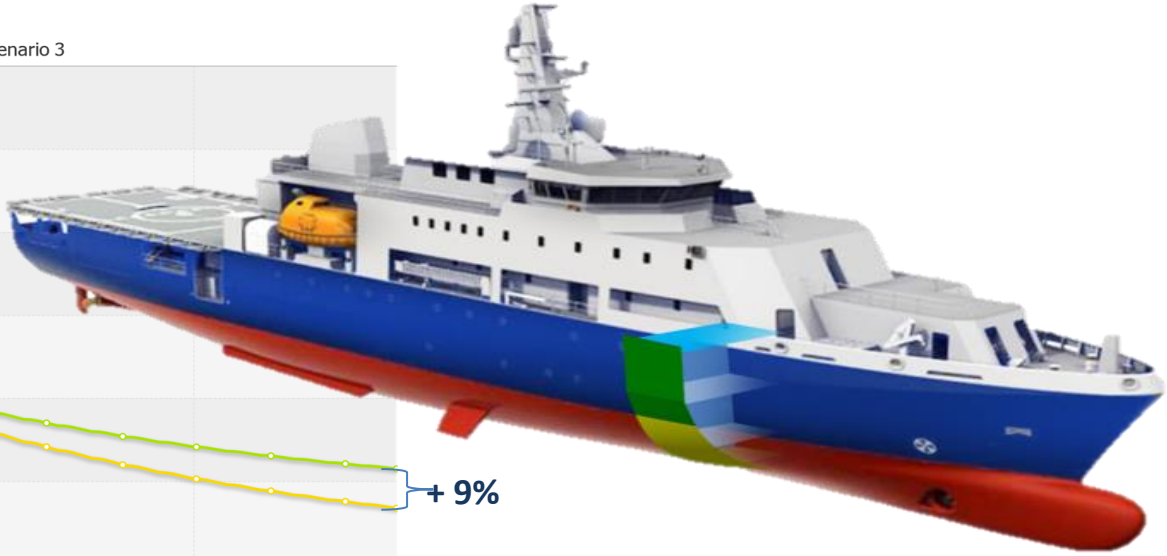
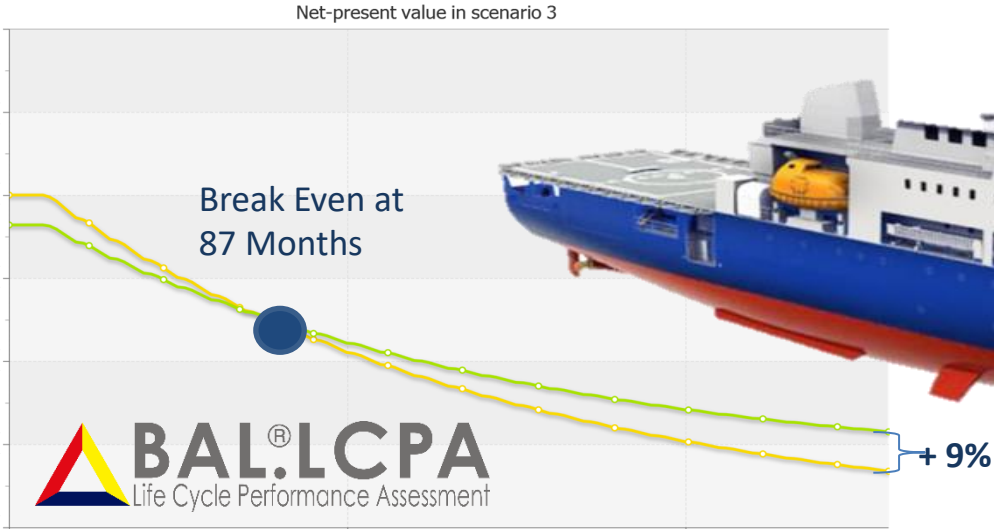
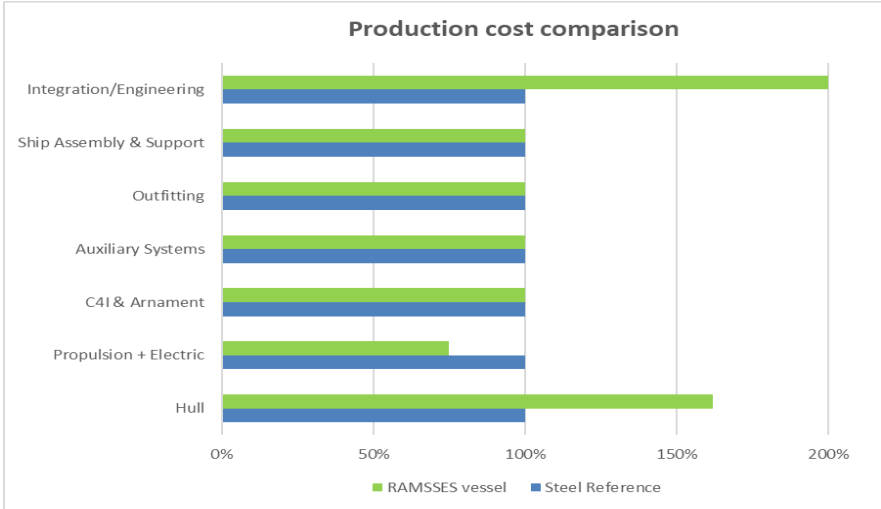
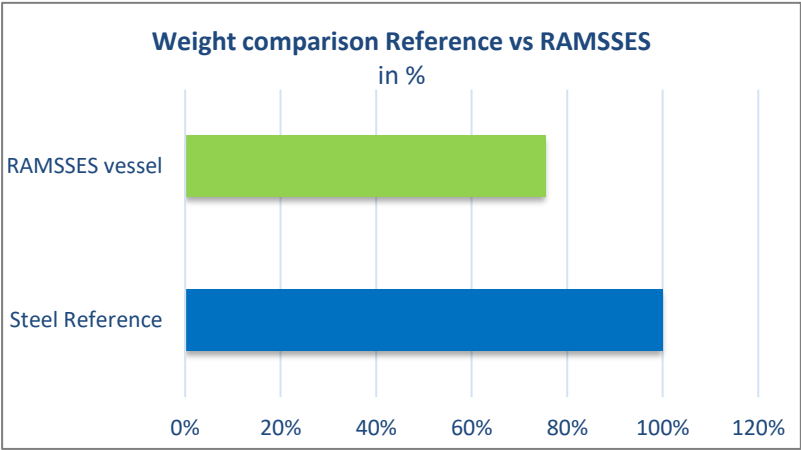
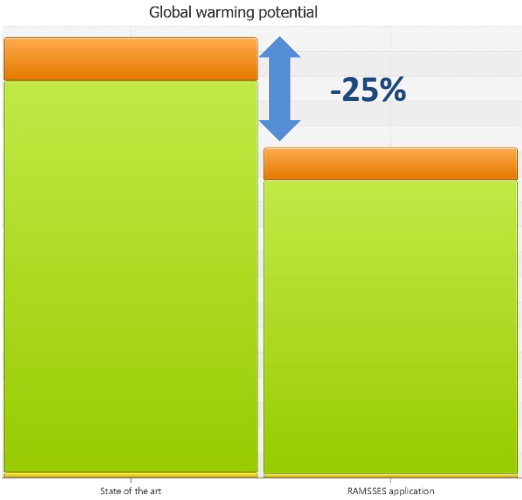
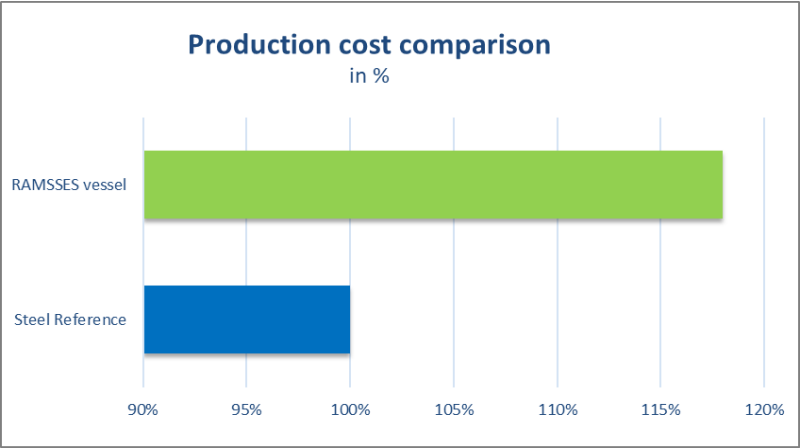


Fishery
Integrated cargo holds

Fast Ferries
Client's Business Case

Based on public available figures, in collaboration with, Balance LCPA

To be confirmed by production...



Just Imagine, one hull serving multiple functions and markets...

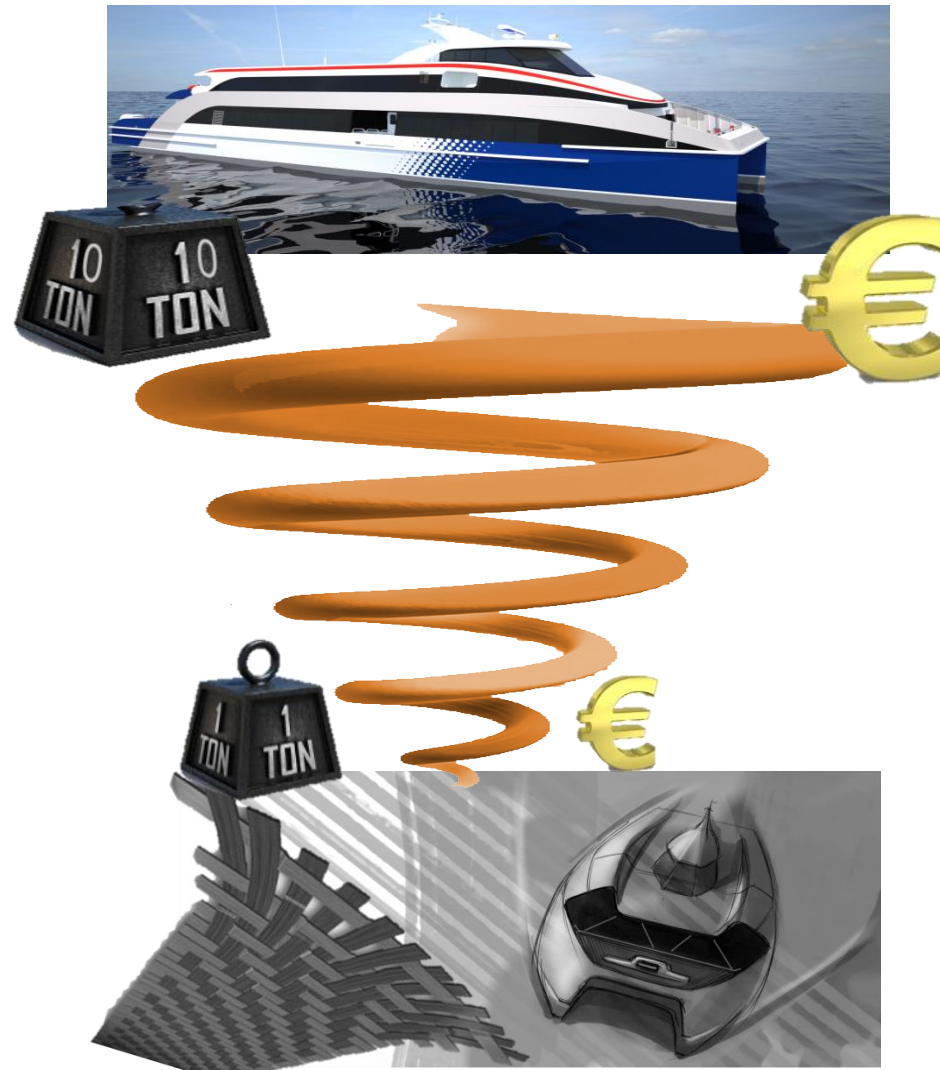


From naval ship to yacht in a single hull



Reaching the next level of standardization!

Just Imagine, how composites can effect the Design Spiral...



12 tons structural weight reduction

10 tons propulsion reduction

5 tons systems reduction

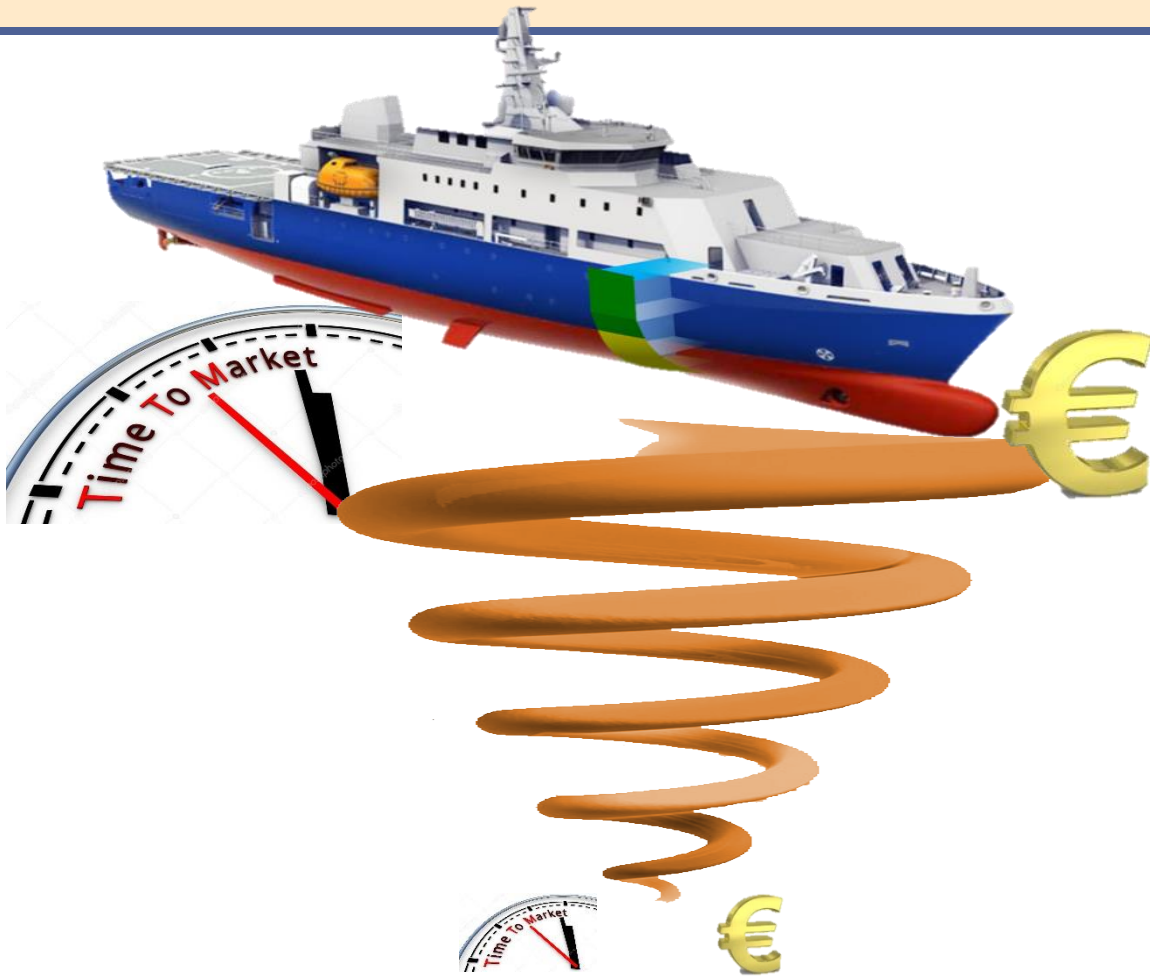
40 cm more slender hulls

27 tons total reduction

20% fuel reduction

3-5 years to break even

Just Imagine, the effect of leadtime reduction...



Reduced Production time

Reduced Costs of facilities

Reduced Insurance Costs

Reduced Manpower

Reduced Overhead

Shorter time to market

More ships sold per year

If Smart Track to Approval

Hence:



RAMSSES: Scaling up the technology for SOLAS Classed vessels

- Capability of development;
- Affordability by industrialization;
- Validation and acceptance;

building up trust for yard and clients
production at steel yard conditions
by testing and risk based design



IMO
SOLAS

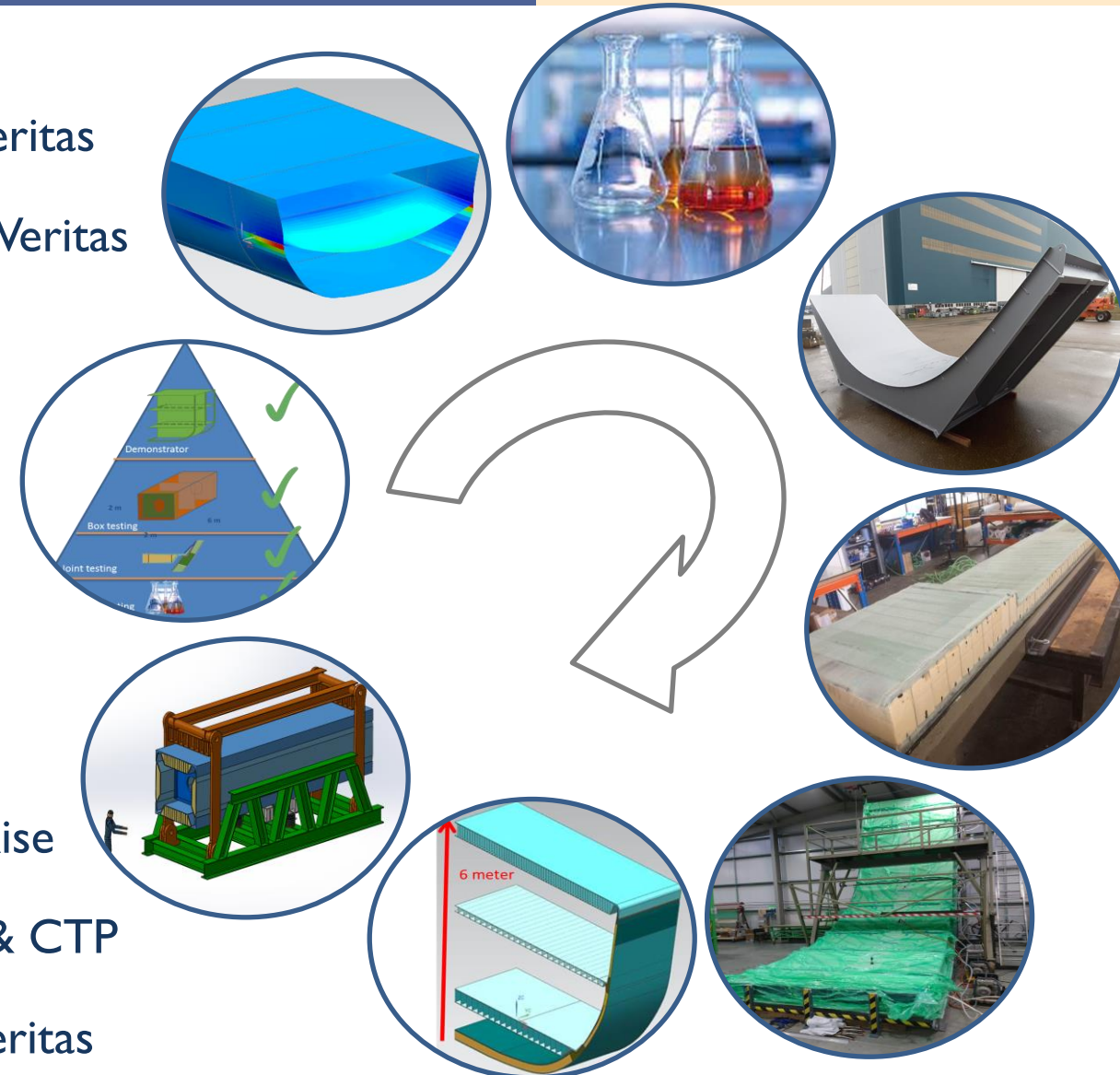


Move Forward with Confidence

RAMSSES: Featuring the whole development cycle in a single project!



1. **Requirements** for 85 meters by DSNS & Bureau Veritas
2. **Design** performed by DSGo & evaluated by Bureau Veritas
3. **Novel resin** developed by Evonik
4. **Infusion** process by Airborne and Infracore
5. **6 meter** hull shell infused by Airborne,
6. **6 meter** infusion achieved by Infracore
7. **Joints** developed by Infracore and tested by TNO
8. **HazId** performed by DSNS, NMTF, Bureau Veritas, Rise
9. **Assembly at steel yard** by Infracore, DSNS, BNS & CTP
10. **Validation testing** by TNO witnessed by Bureau Veritas



NEW:

- Introduce Hogging and Sagging loads
- Assembly at Steel Shipyard conditions
- Flooding loads on joints
- Comfortable safety margins
- Risk Based Design for Fire Safety
- Helideck with emergency landing loads

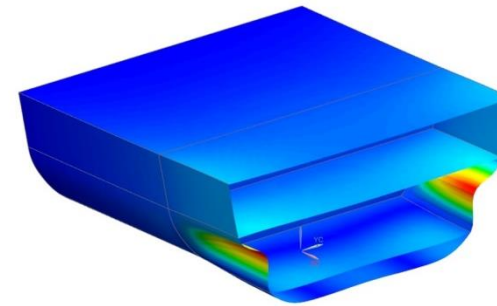


Basic Design by DAMEN Gorinchem

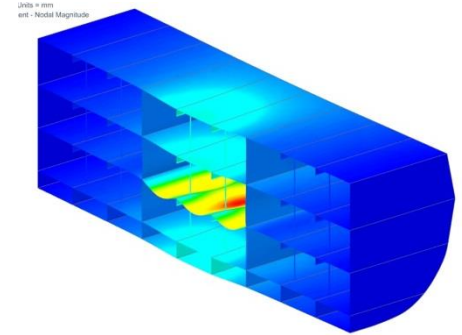
- Prepared for Production by Airborne and Infracore
- Joints Design Developed by Infracore

Featuring:

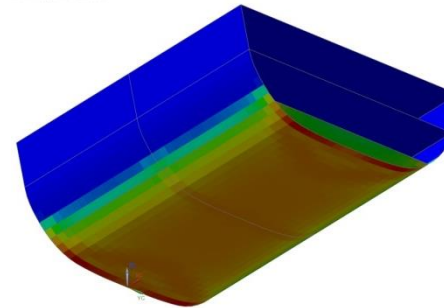
- 240 mm thick monolithic co-infused keel section
- 200 mm recyclable PET core sandwich bottom
- Prefab monolithic inserts around joints
- Shear ties around joints
- All for one shot infusion



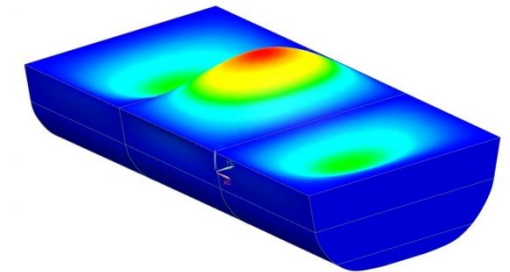
Hull Deflection



Deck Deflection



Sagging bending moment



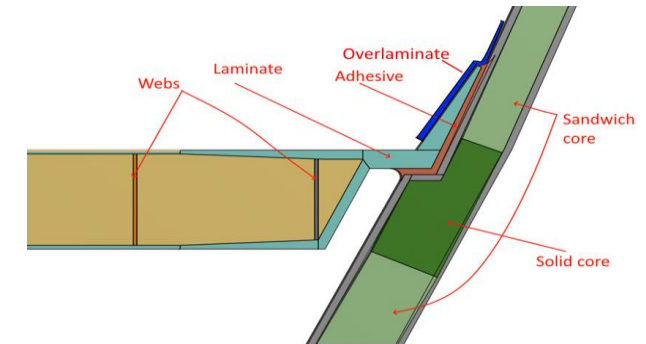
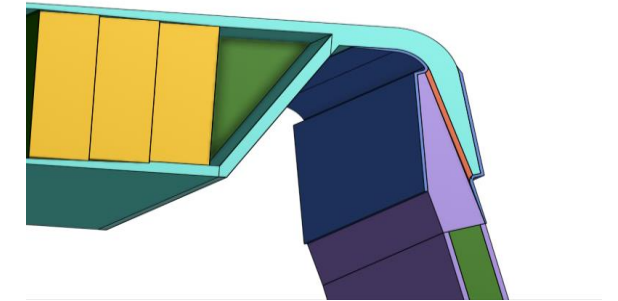
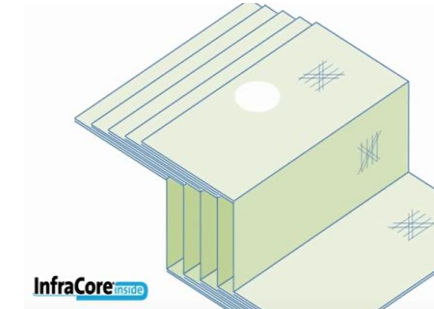
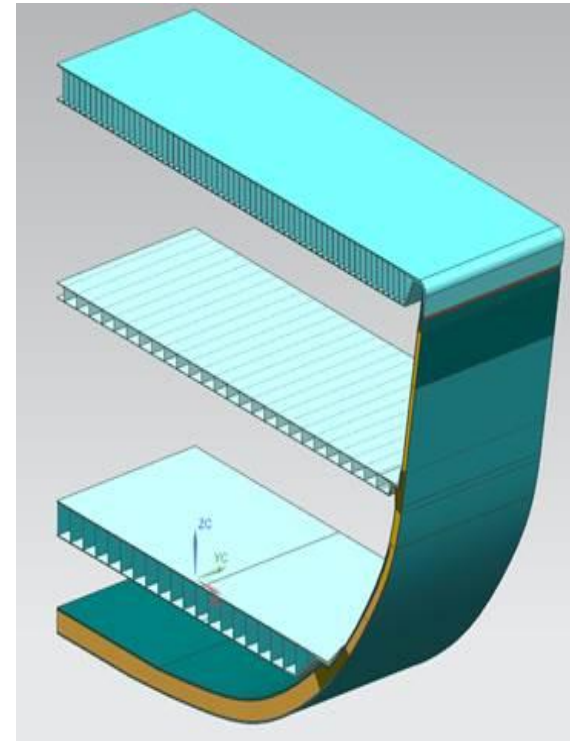
Natural Frequencies

Allowing for production at steel yard

- Comfortable safety margin on joints,
- No need for extensive fatigue assessment

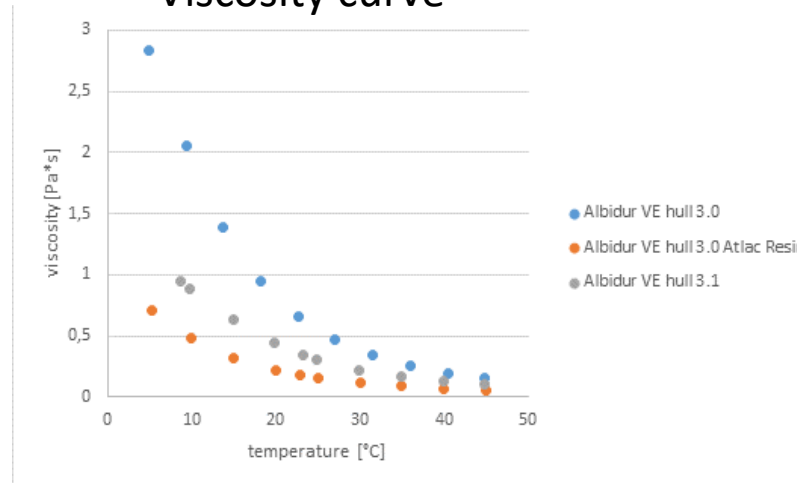
Featuring:

- Pillar less
- Optimising space
- Dealing with tolerances
- Low cost and/or fire retardant core
- With optional systems inside panels
- Vertical flooding loads on joints
- Fit for assembly at steel yard
- Shape-locked joints
- Etc..





Viscosity curve



Core shell particle representation



ALBIDUR®VE hull 3.2 developed by Evonik featuring:

- Low viscosity for large scale infusion
- No toughener particles lagging behind in infusion
- 7% elongation at break for fracture toughness
- 8 hours infusion
- 6 meter height hull shell infusion
- 240 mm monolithic keel section without exothermic burn

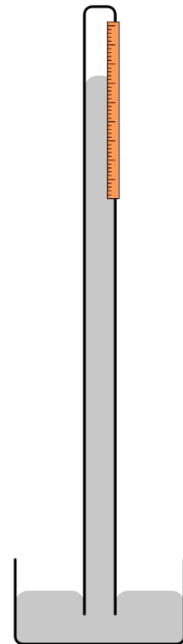
Vertical infusion; challenge of vertical infusion

Simple physics shows 10% pressure drop at every meter infusion height

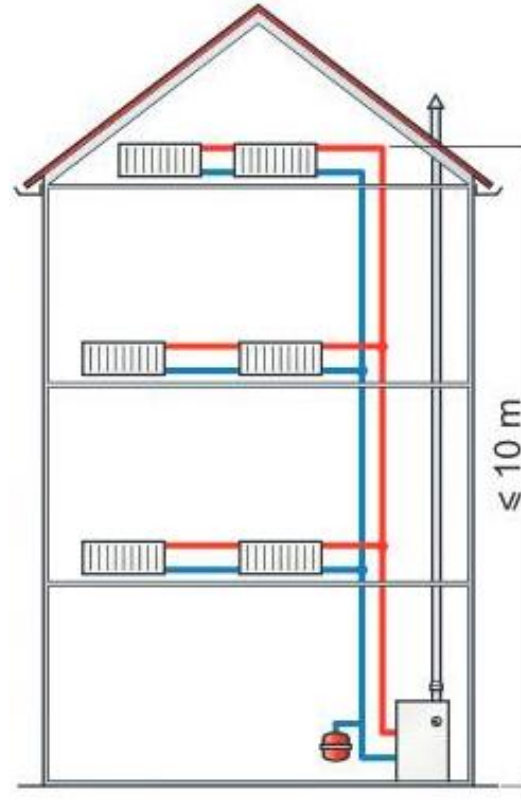
- 6 meter height results in resin infusion at 40 % vacuum.



Damen Waterbus 2.3 meter



Mercury 800 mm



Water 10 meter



RAMSSES WP 17 hull 6 meter

Vertical infusion; the challenge overcome by Airborne

6 meter vertical infusion achieved by Airborne

Realising hull shell in single shot with novel Evonik's resin

Featuring:

- Recyclable PET core by Armacell
- 240 mm co-infused monolithic keel section
- Monolithic prefab insert parts
- Shear ties



https://www.youtube.com/watch?v=_a9B8zpgbY0&feature=youtu.be

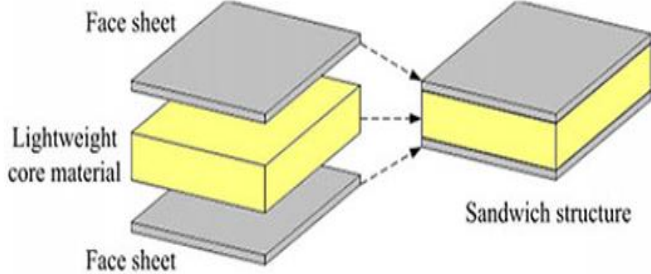
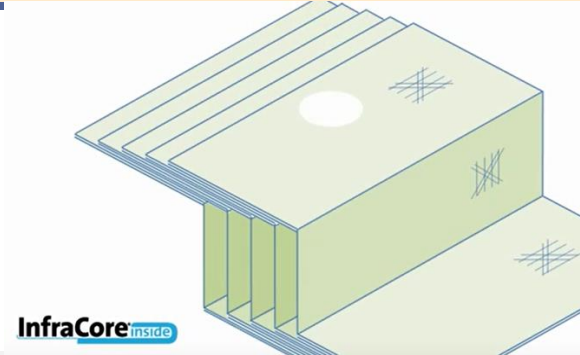
Vertical infusion; the challenge overcome by Infracore

6 meter vertical infusion also achieved by Infracore

- Demonstrated even up to 9.8 meter
- Also realised with new Evonik's resin
- Deck and bulkhead sections produced by Infracore



Trade off Traditional Sandwich vs. Infracore technology, theory

CONCEPT		
PROVIDER	AIRBORNE	INFRACORE
WEIGHT <i>based on flat panel with equivalent strength</i>	<ul style="list-style-type: none"> • higher density foam • foam resin uptake slightly smaller 	<ul style="list-style-type: none"> • lower density foam • foam resin uptake slightly larger • monolithic webs
MATERIAL COST <i>based on flat panel with equivalent strength</i>	<ul style="list-style-type: none"> • expensive core materials, specially for higher densities and mechanical properties 	<ul style="list-style-type: none"> • low density PU foam + monolithic webs is up to 80% cheaper than sandwich foam core
LABOR COST <i>based on qualitative assessment</i>	<ul style="list-style-type: none"> • Appears simple, but much effort in proper placement of layers, especially in vertical mould 	<ul style="list-style-type: none"> • more foam block assembly • more fibre reinforcement cutting • simple block laying process
FAMILIAR TO CLIENT & TRACK RECORD	<ul style="list-style-type: none"> • Sandwich technology is well-know to the maritime industry 	<ul style="list-style-type: none"> • Track record in the infrastructure industry (Bridges and lock gates) • Helideck on ship, rudder flap...



Building block approach
Applicability at steel yard conditions

Integration of shear ties

Integrated fire safety

Low Scrap rate

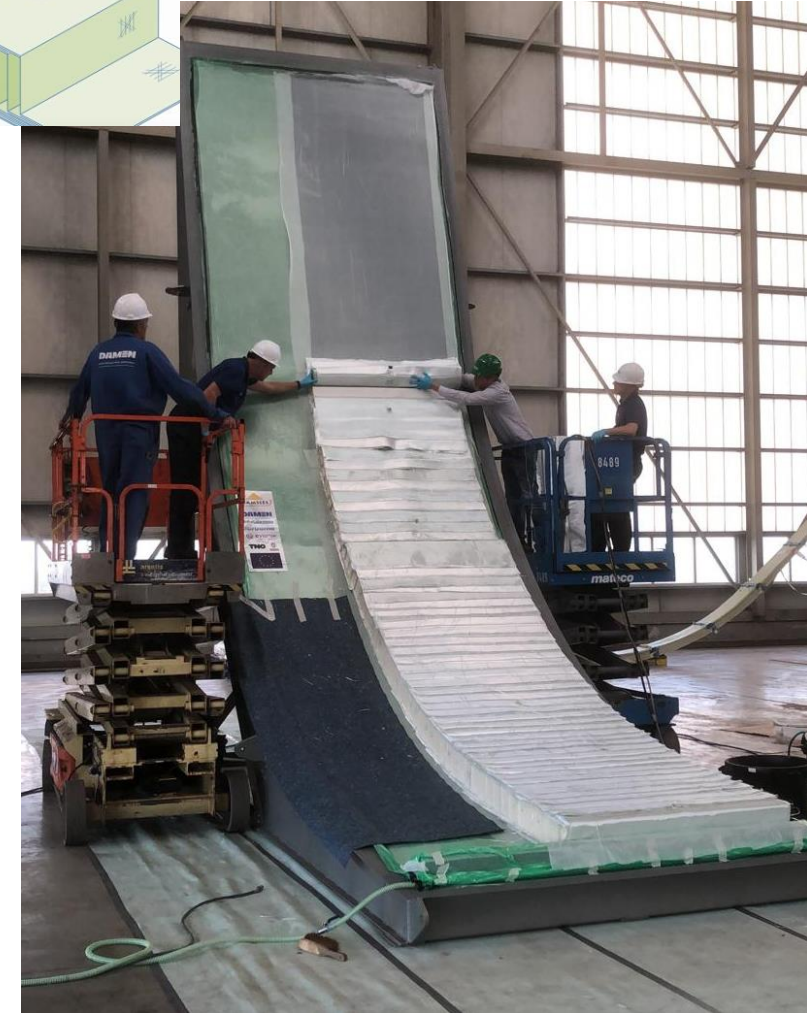
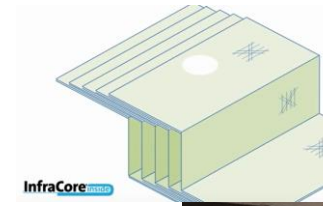
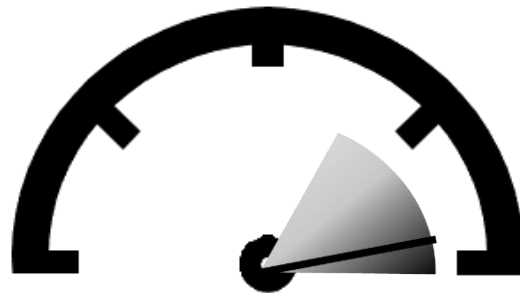
Non structural foam

Optional fire retardant foam

Integrated infusion channels

Short Leadtime

Short Infusion time



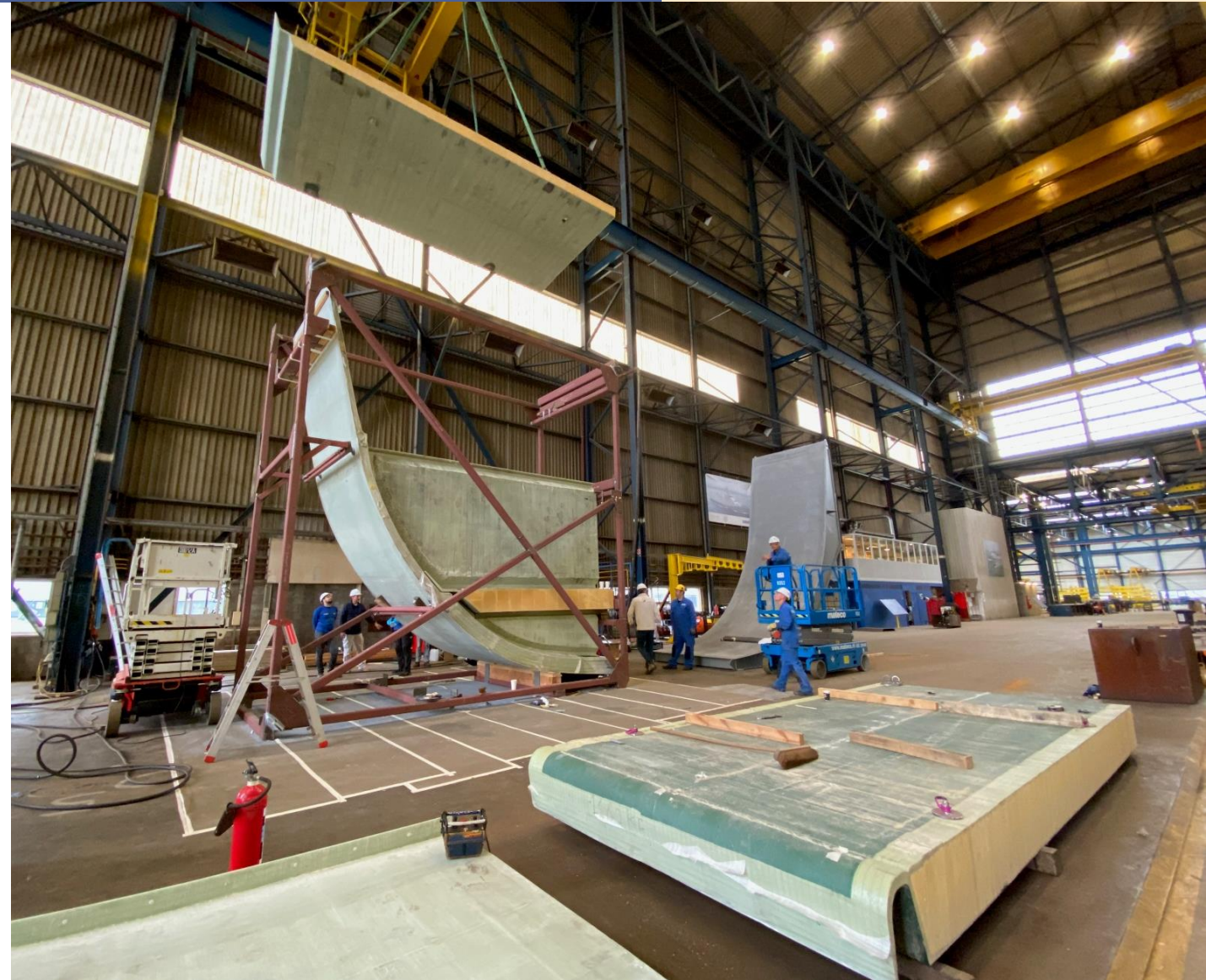
Assembly of demonstrator at DSNS Steel yard

Steel yard conditions; it's no clean room

Featuring:

- Limited temperature control
- Dealing with tolerances
- Fitting parts from two suppliers
- No lamination at the yard
- Only three Infracore experts needed

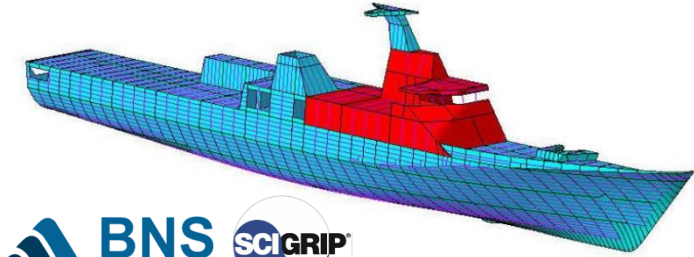
Approved procedure by Bureau Veritas



Assembly of demonstrator at DSNS Steel yard

Selected adhesive from EU PROJECT Qualify

- Qualification procedure under control by Bureau Veritas and Lloyd's Register
- Validated for application at steel yard conditions
- Demonstrating expected lifetime of 25 years service
- Extensive testing by a.o. Cambridge, TU Gent, TU Delft



Scigrip methacrylate adhesive introduced by DAMEN and BNS

Featuring:

- Ability for injection, instead of applying uncontrolled putty
- Low sensitivity to voids; no cracking as epoxies
- Toughness tested for extreme conditions including shock
- Gap filling allowing for building tolerances
- Class approved system



Well-controlled adhesive application proces

In collaboration with Infracore, DSNS, BNS industrial and CT Platon

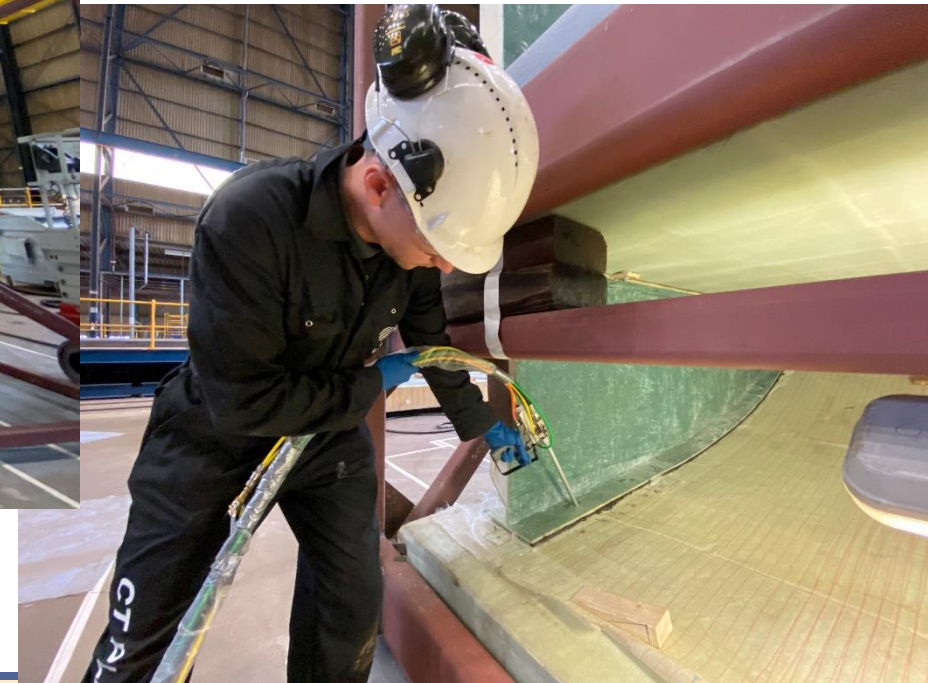


Sealing with Scigrip by BNS& ICC



Customised adhesive injection system
by CT Platon

Injecting Scigrip by CT Platon



- Video Assembly



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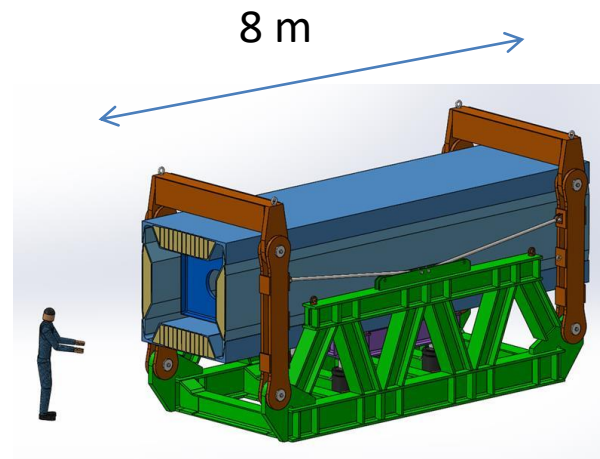
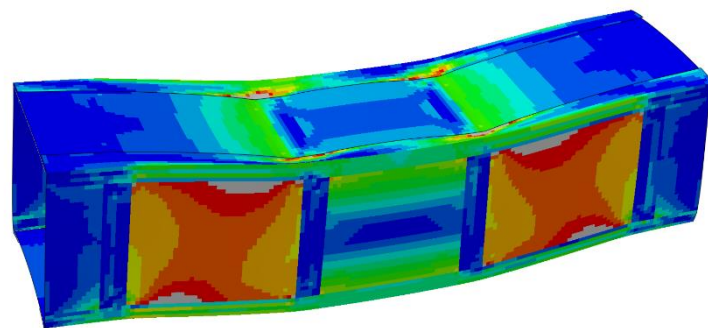
Custom Made Hull for Offshore Vessel, M.C.Elenbaas, DSNS

Full scale testing up beyond actual ship bending loads

Representing hogging and sagging loads on actual ship
For validation of design and production

Featuring

- Full scale helideck panels by Infracore
- Full scale bottom panels by Airborne
- Full scale joints designed for large safety margin
- Assessment performed by TNO and Bureau Veritas
- 4x 500 tons hydraulic cylinders



Full scale testing up beyond actual ship bending loads

Dedicated Testrig developed by TNO

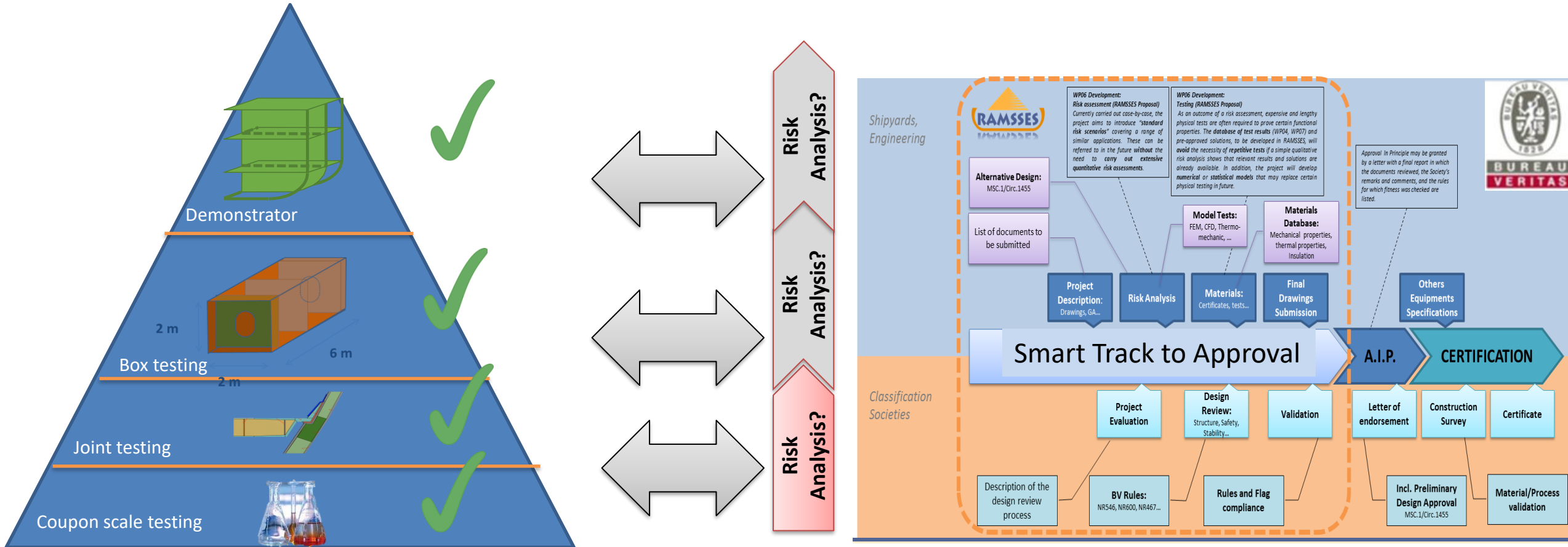
- Produced by DSNS with 100 m high grade steel
- Box panels produced by Airborne and Infracore
- Assembled at Infracore with same procedure as demonstrator.
- All ready for testing at TNO



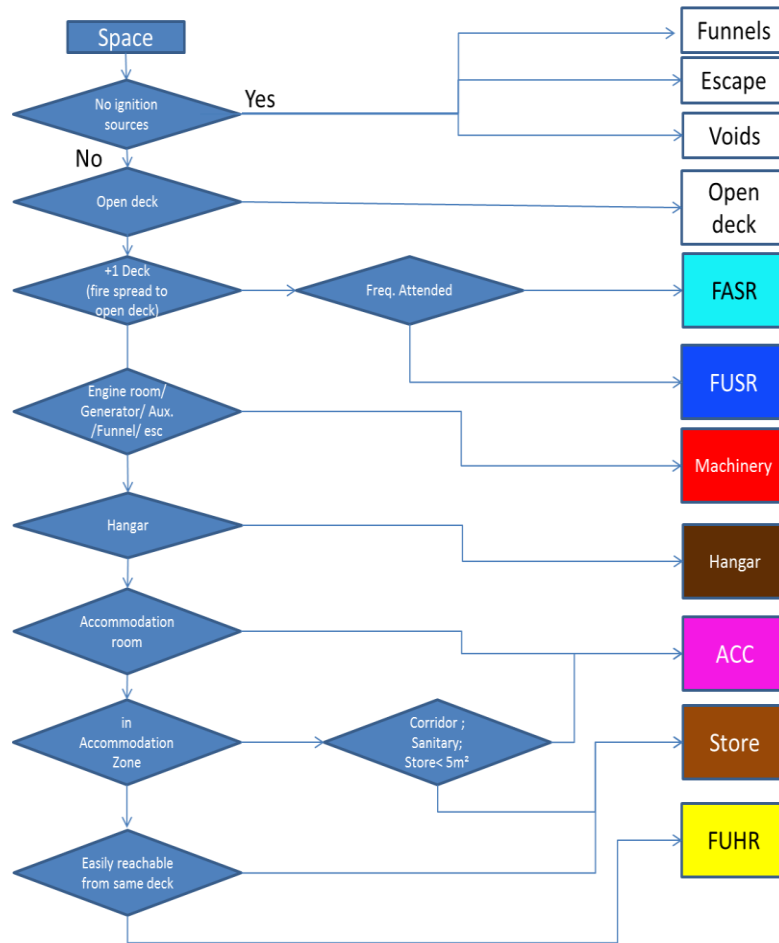
Completing the development cycle up to approval in principle

Risk based design full building block approach from coupon to full production scale

In collaboration with Smart Track to Approval, WP 6 with NMTF, RISE, and Bureau Veritas



Challenging Risk Based Design, beyond SOLAS guideline for 'non structural elements' of 85 meter hull with BV, RISE, NMTF and DSNS



	Control Stations	Corridors	Accommodation spaces	Stairways	Service Spaces (low risk)	Machinery spaces (A)	Other machinery spaces	Cargo spaces	Service Spaces (High risk)	Open decks	RoRO
BHD Insulation											
Control Stations	10	10	10	60***	10	H60	60	10	60	30 *	10
Corridors		10	10	60***	10	H60	60	10	60	30 *	10
Accommodation spaces			10	60***	10	H60	60	10	60	30 *	10
Stairways				60***	60	H60	60	60***	60	60***	10
Service Spaces (low risk)					10	H60	60	10	60	30 *	10
Machinery spaces (A)						H60	60	H60	60	H60	10
Other machinery spaces							60	60	60	60 *	10
Cargo spaces								10	60	30 *	10
Service Spaces (High risk)									60	60 *	10
Open decks										*	30
RoRO											10

- * Low flame spread surface in areas with direct risk of fire ignition or fire spread
- ** If no ignition sources: No protection required, otherwise FRD -10
- *** Either non loadbearing A-class or FRD-60 insulation

Qualitative design, HazID, and actual fire scenario's based on generic spaces and risk control options enabling 'Go Ahead' before contract



Generic space distribution for illustration purposes

Qualitative design
Pre Contract

Quantitative design
After Contract

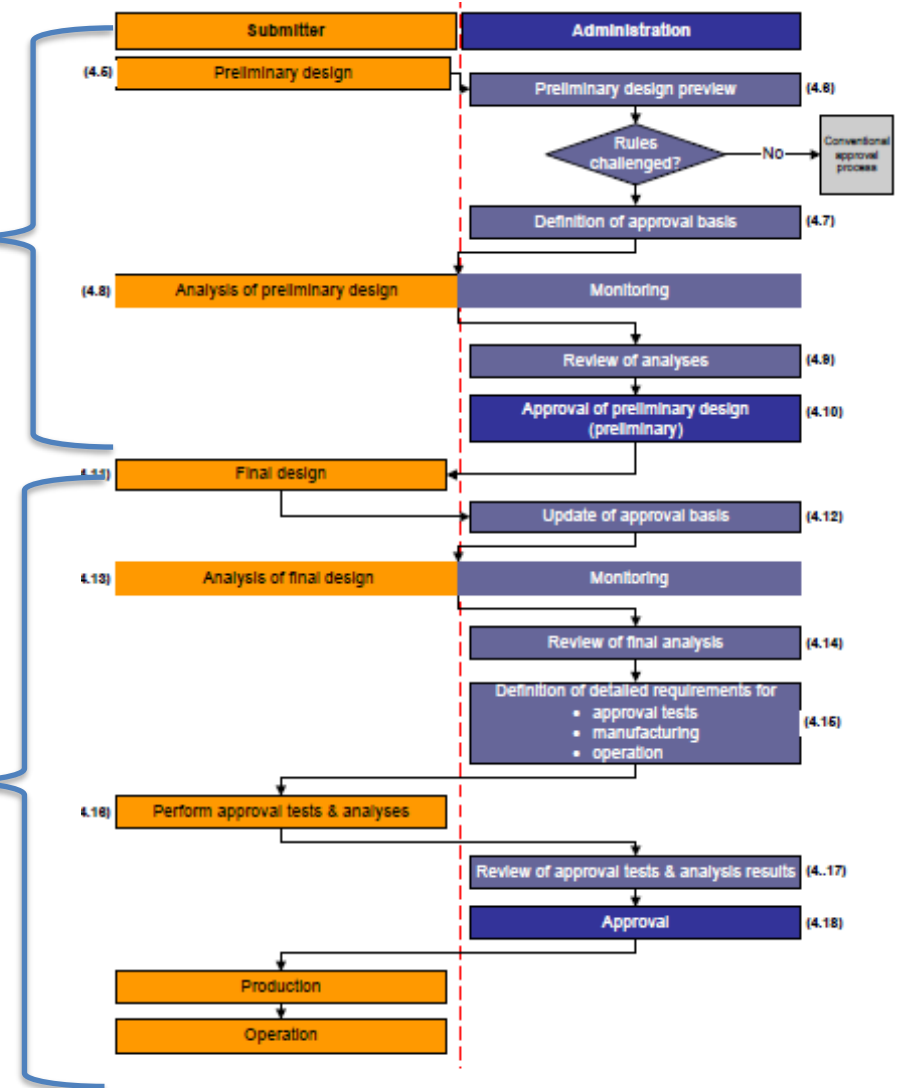


Figure 2: Design and Approval Process

Created in Collaboration, Thank you all!



Move Forward with Confidence

DAMEN

DAMEN SCHELDE NAVAL SHIPBUILDING



Airborne



E-Lass September 16th, 2020
RAMSSES Work Package 17
Custom Made Hull for Offshore Vessel, M.C.Elenbaas, DSNS



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