

# Damen Schelde Naval Shipbuilding

## External adhesively bonded FRP ventilation ducts

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DAMEN SCHELDE NAVAL SHIPBUILDING



KVE COMPOSITES GROUP

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HEINEN & HOPMAN

25-11-2015

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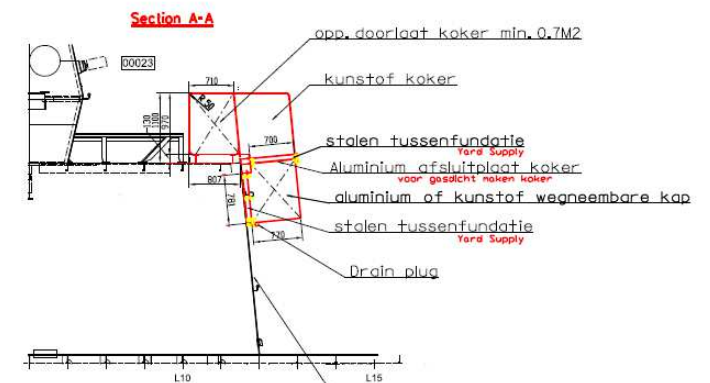
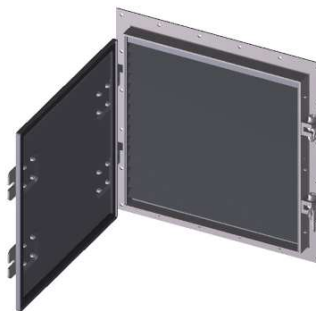
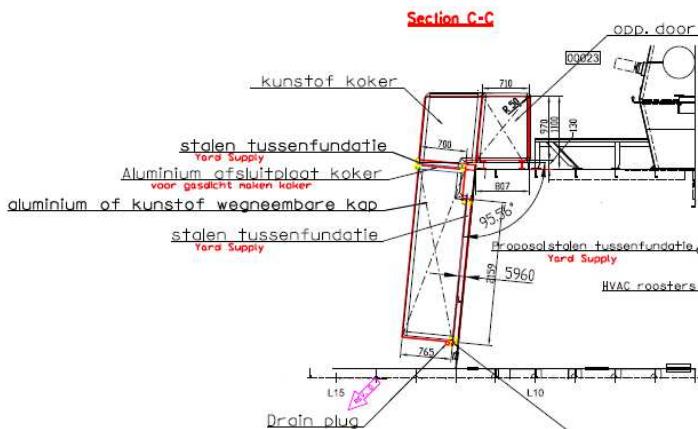
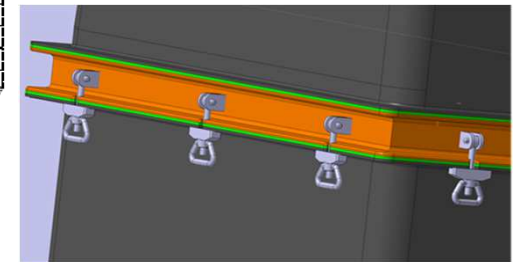
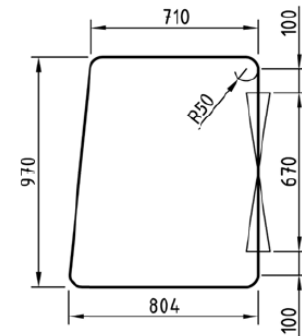
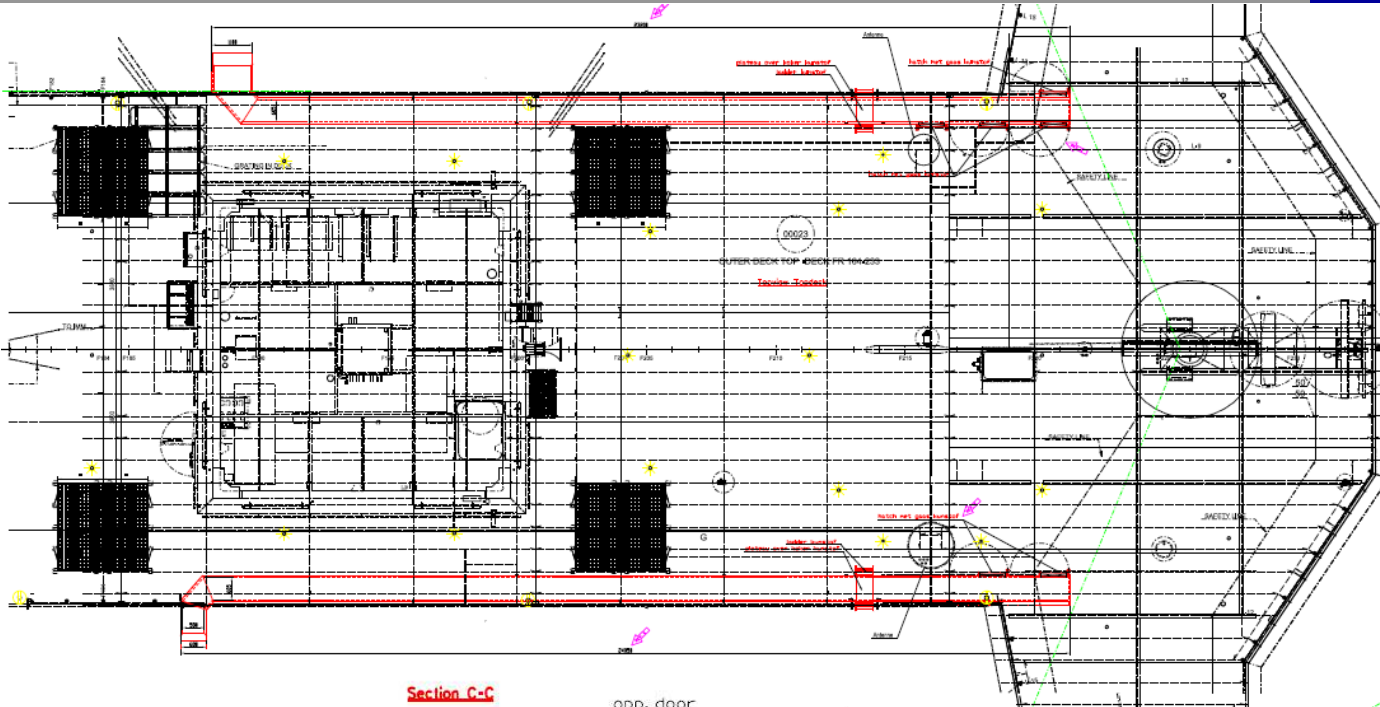
### Problem definition:

- During sea trials, it was noticed that in a number of circumstances (speed, heading) exhaust gases find their way into 2 accommodation ventilation air inlets, placed on both sides of the ship's superstructure.
- Customer requests DSNS to solve the problem (*more work*).
- DSNS envisages various solutions, both inside & outside the ship, and finally opts for a composite solution mounted externally onto the ship.
  - Ship is prepping up for operations: minimum disturbance for the crew
  - Required duct geometry is large → large internal modification
  - Very short planning → ship is leaving at the end of the year
  - Preferably no hot work in this phase
  - External solution is most cost-effective
  - Aesthetics are also of importance to the customer

## Solution in principle

### Solution in principle:

- Solution concept is defined in close dissertation with the Customer.
  - Move the air inlet positions maximally in longitudinal direction (> 25 m)
  - Warrant radar transparency (on antenna deck!) & radar cross section
  - Smooth inside & outside finish: NBCD-requirements (wash down / pre-wetting)
  - Air inlets with a removable mesh/grillage: prohibit the entrance to rats, birds, bugs, etc
  - Removable ducts segments are required to go into “pre-closed”.
  - Ducts should be gas-tight, when closing plates are placed.
  - Going into pre-closed on both sides should take maximally 5 minutes.
  - HSEQ-requirements: proper access, safety, ...
  - Replace partially the bulwark with ventilation ducts
  - Adhesively bonded connection, as to avoid hot work
  - Respect ship’s technical specification



### Technical requirements:

- Undisturbed air flow: smooth inside surface, de-watering, cleaning
- Dimensions: approx. 25m in length, 0.7m<sup>2</sup> cross-sectional area
- Use of GFRP to maximize the radar transparency
- Environmental: temperature, salt, hail, dust, UV, radiation, wind, ...
- Structural:
  - Wind load: 120 knots max. wind speed
  - Natural frequencies 7.5 – 12 Hz not allowed
  - Crew servicing load: 100 kg point load
  - Allowable deflection requirements
- Robustness requirements & min. 25 years life span
- Ship motions
- Wash down requirements: smooth outside surface, no dead pockets
- Gas tight when sailing in a NBCD Environment
- Hot work not allowed
- Adequate drainage

#### Scope of supply:

**Ducts**

**Platform, ladders, hand rails**

**Removable canopies**

**Closing plates**

**Drains**

**Adhesive deck connections**

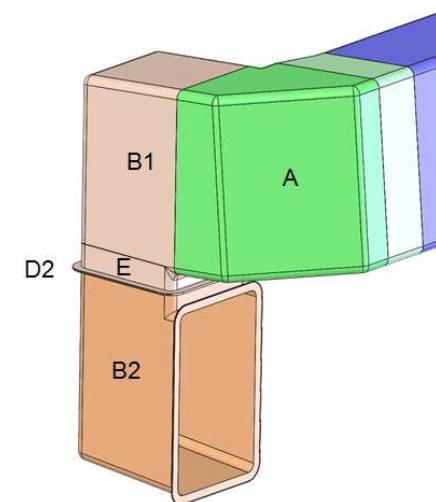
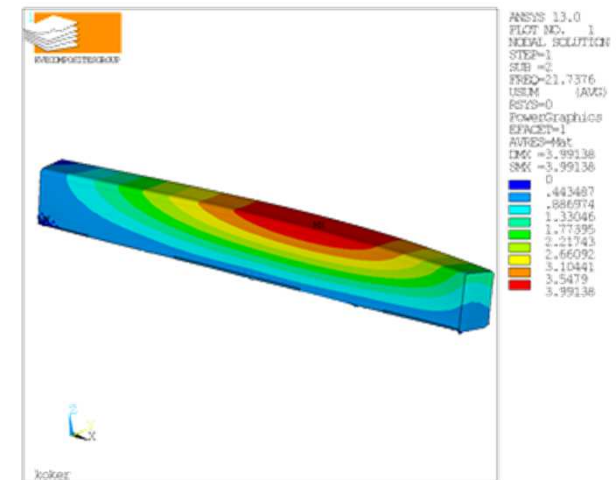
**Louvre grids**



### Project planning:

- RFQ sent medio June
- Response to RfQ:
  - Preliminary design for natural frequencies, basic 3D CAD design
  - Detailed project plan with planning, milestones and deliverables
- Contract honoured medio July
- Project outline:
  - Detailed design: 4 weeks
  - Tooling manufacturing: 4 weeks
  - Product manufacturing: 4 weeks
  - Installation: 2 weeks
  - Ship leaves harbour on 16 November 2015

**Very tight planning: no margin!**



### Design approach:

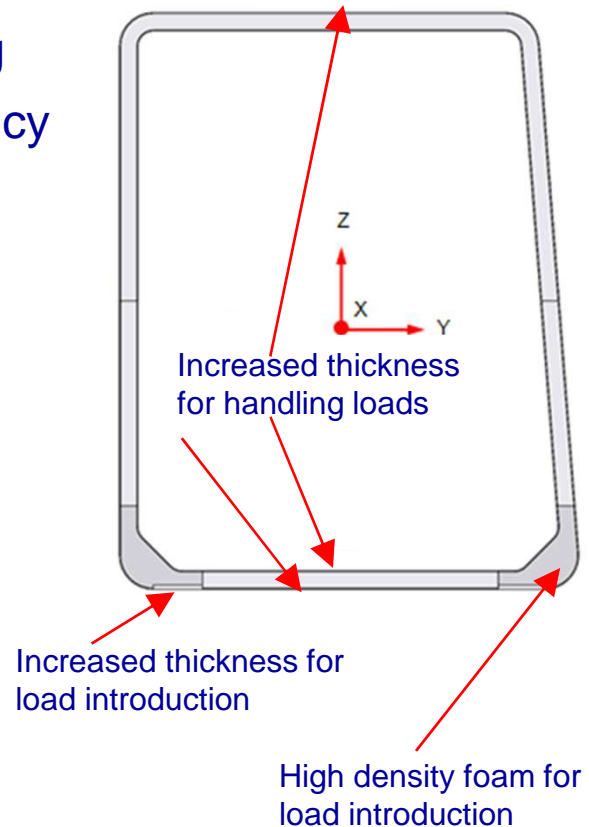
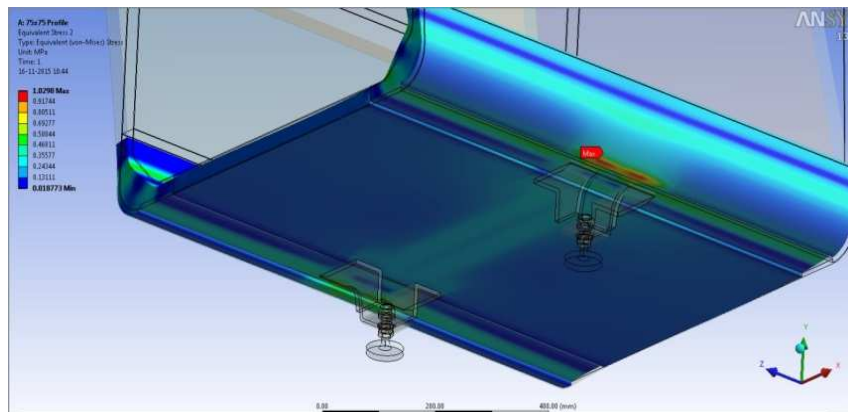
- Planning: Freeze outer geometry in first week  
**start manufacturing of tooling**
- The ducts are fabricated in 6m long sections, for process and handling considerations.
- Maximized in-house manufacturing of components and tooling (minimize dependency of suppliers).
- Relevant experience, similar materials and processes from radome manufacturing for Thales Netherlands are applied in this project.





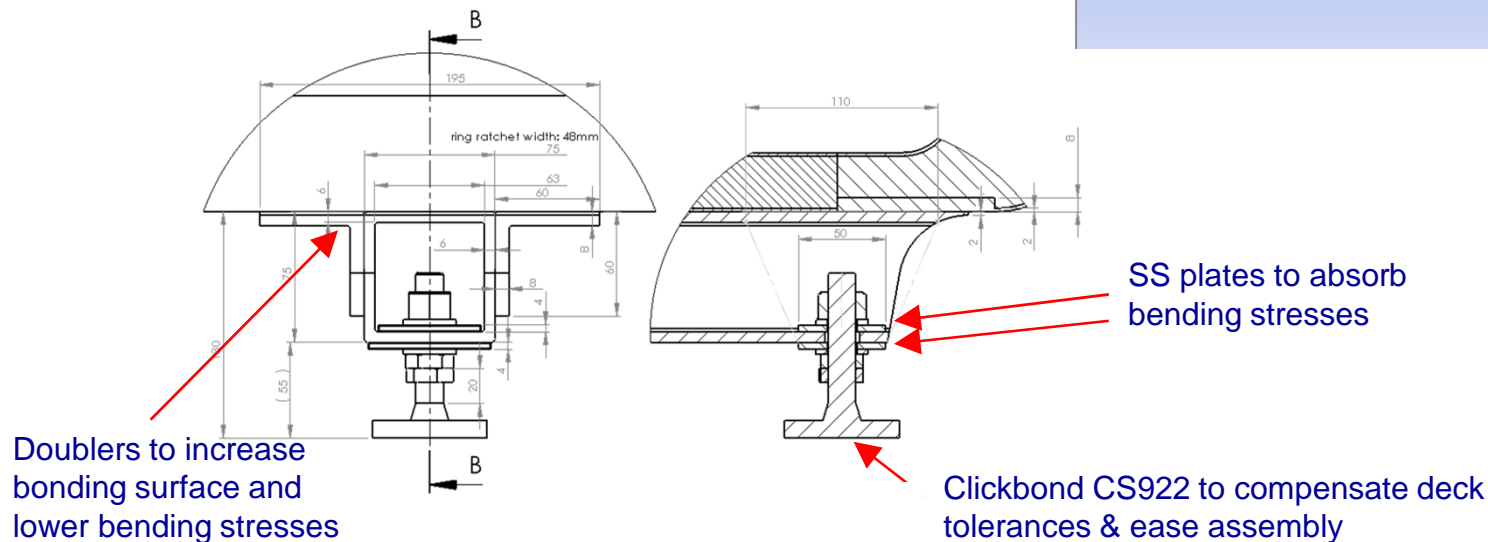
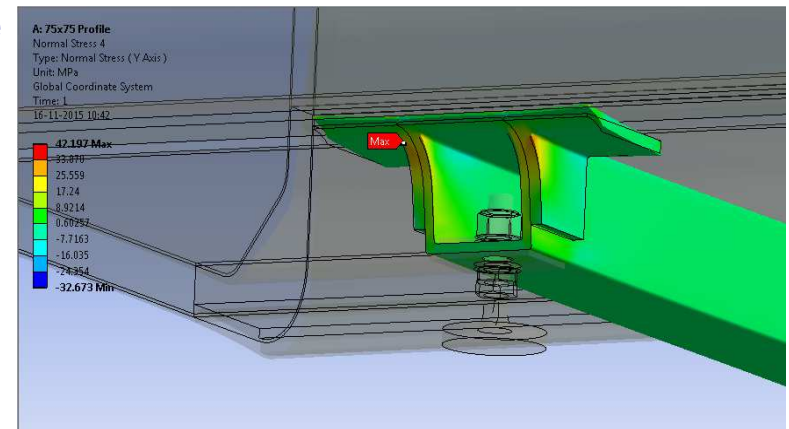
### Design highlights: duct section

- Full sandwich in corners, to increase lateral bending stiffness/strength for wind loads and natural frequency
- Laminate thickness optimized
- Load introductions in sandwich:
  - Increased density foam
  - Additional reinforcement layers
  - GFRP load introduction strips on bottom

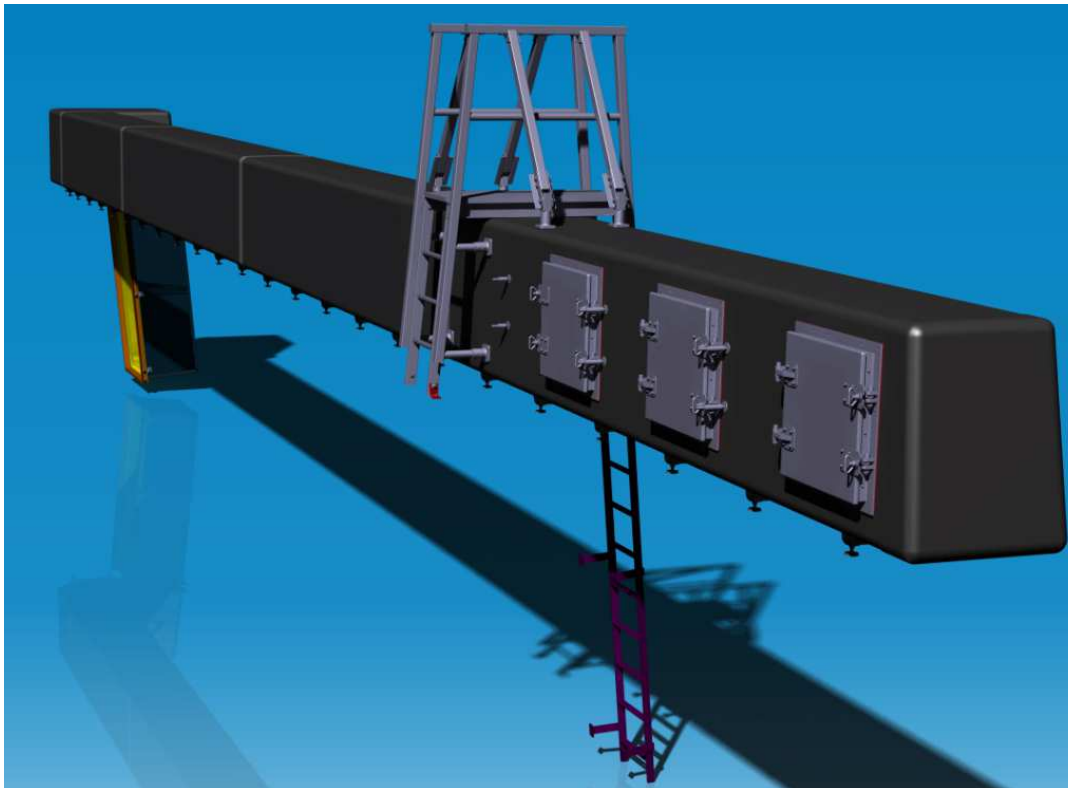


### Design highlights: deck connection

- Click bond CS922 M16 Deck stud
- GFRP pulltruded profile with pulltruded L- profile doublers
- stainless steel plates for load introduction
- GFRP load introduction on bottom



### Design highlights: CAD design



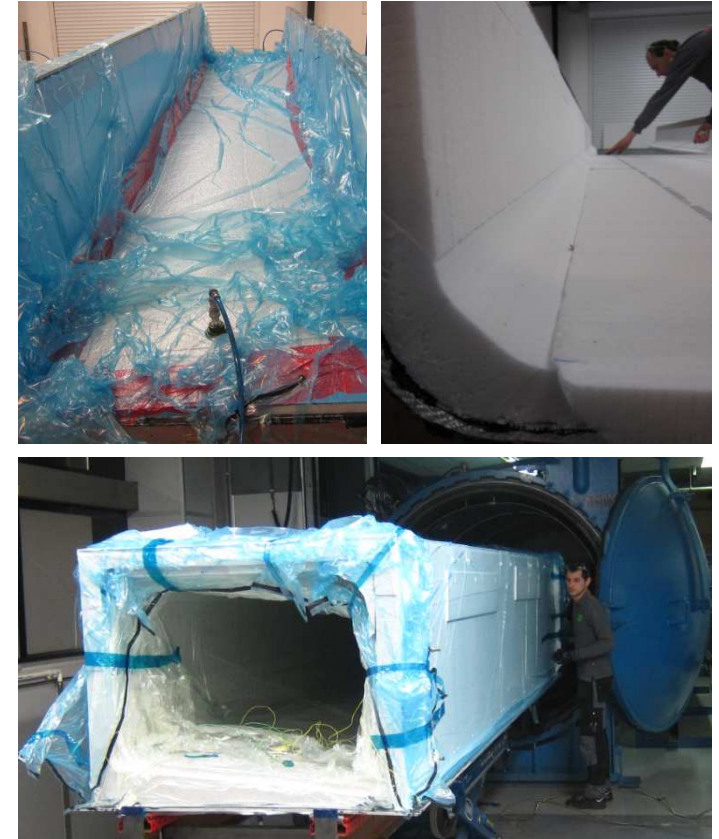
### Tooling manufacturing

- One time use of tooling
- 11 different mould cavities necessary
- Use of tooling board moulds
- All tooling machined in house on 5-axis milling machine (4.8x1.8x1.2m)
- Mould form building blocks: enable quick release from tool after cure (thermal expansion product larger than tool)



### Duct manufacturing

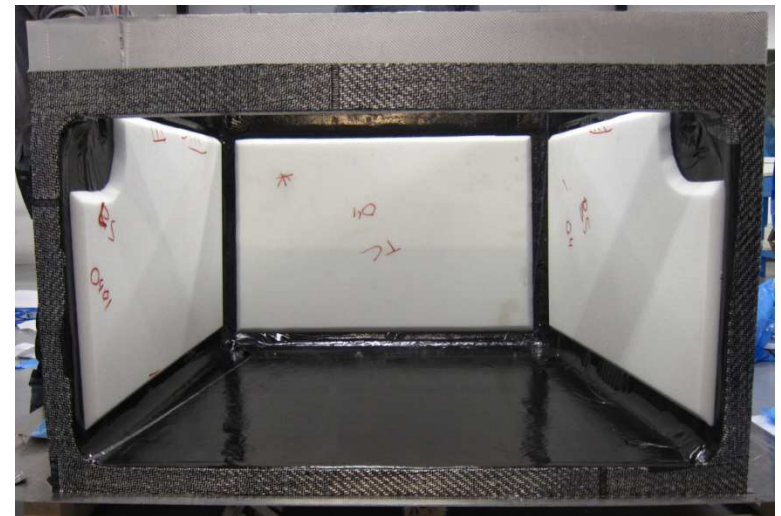
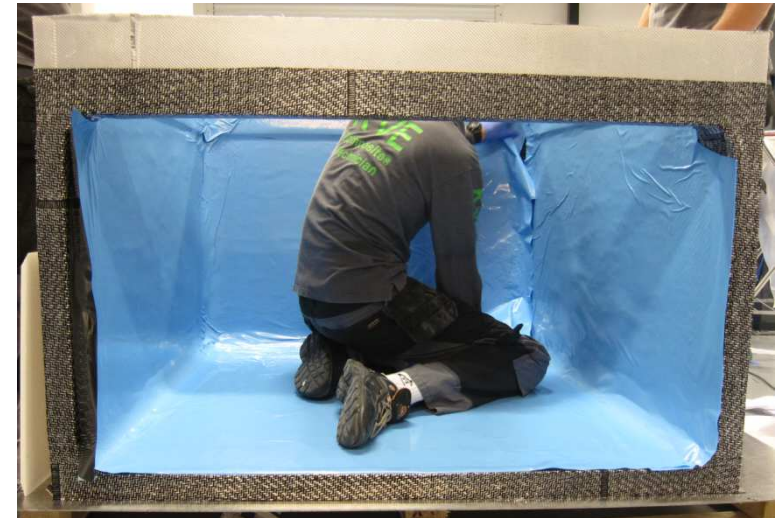
- Complete section of 6m in one shot
- Out of autoclave prepegs (proven for 25 years)
  - Glass fibre
  - Fire retardent
  - Tg: 120°C
- PET Foam core
- Paint spray system applied:
  - Akzo Aerodur primer
  - Akzo polyurethane topcoat





### Corner section manufacturing

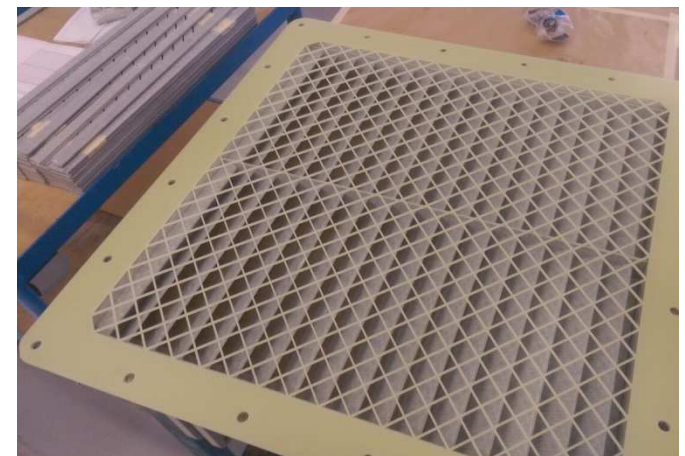
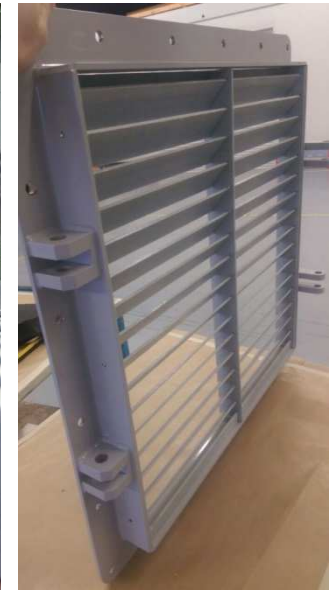
- 6 different corners
- Lay-up optimized
  - Flat surfaces stiffened
  - Increased thickness of flanges
- Removable corners light enough to lift with 2-3 people (~ HSEQ-requirement)





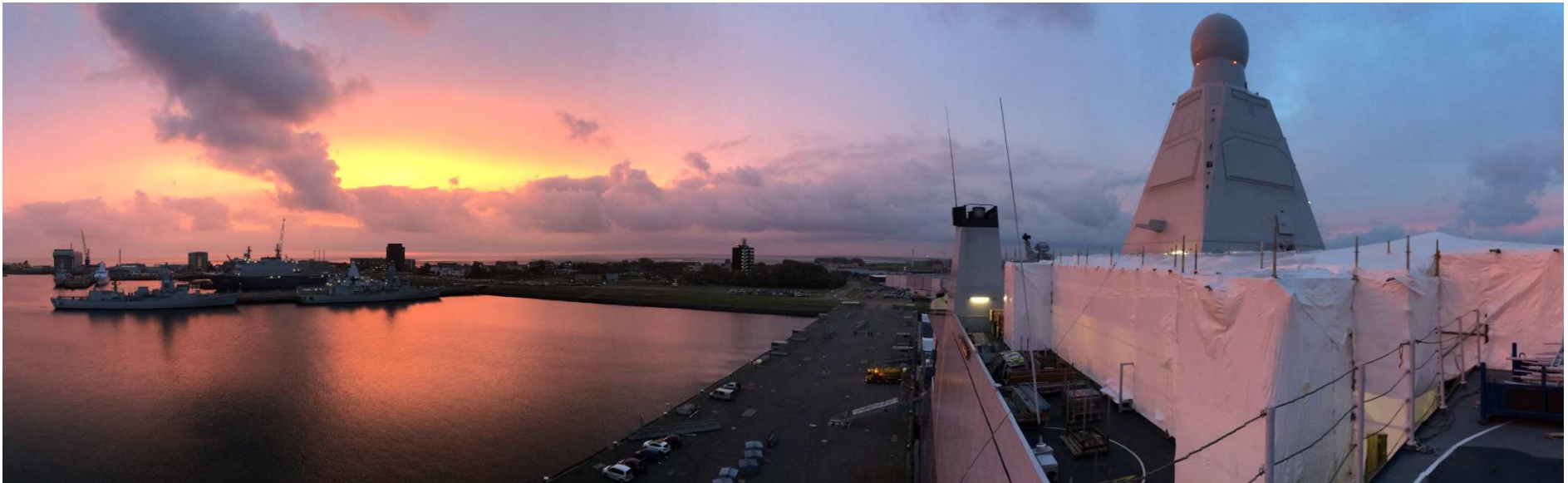
### Product highlights: Others

- Bonding of load introduction profiles
- Hatch assembly
  - Composite rat mesh
  - Composite hatches
  - Composite louvres
- GFRP drain connections
- GFRP stairs from pulltruded profiles



### Onboard assembly

Covered scaffolding built for installation...



### Onboard assembly

- Hoisting of components
- Alignment of duct sections
  - Relative to side of deck
  - Height adjustment with Click Bond





### Adhesively bonded deck connection:

- Large GFRP ventilation ducts are bonded onto the antenna deck of Karel Doorman.
- Each duct is installed with:
  - 60 x CS922 deck studs.
  - CB420 adhesive.
- Procedure is simple: position, mark, grind, clean, bond, press (Viba @ work)



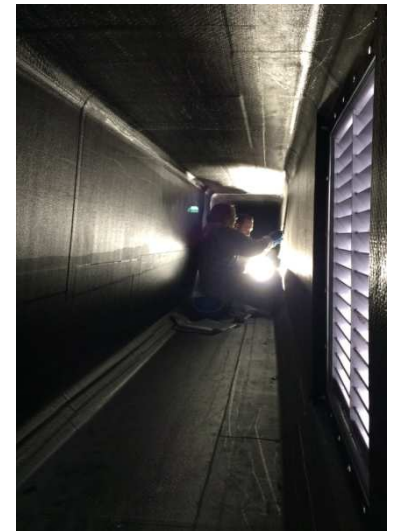
### Adhesively bonded deck connection:

- Studs are made out of stainless steel
- Foot of stud is filled with Araldite 2028 to prevent water ingress
- Deck conservation is applied on top as a fail safe concept
- Certified shock resistant connection



### On board assembly

- Bonding of duct segments
- Outside: bonding of painted strip with flexible adhesive
- Inside: laminating
- Laminating of drain channels
- Alignment and bonding of drain connection





### Onboard assembly

- Hatch assembly
- GFRP stairs
- Removable corners



# Karel Doorman – FRP ventilation ducts

Finished & approved product

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