

Efficient carbon composite design for sailing boat structures

*To optimise is to minimise the structural
path length of forces in equilibrium*

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Fabio Bressan



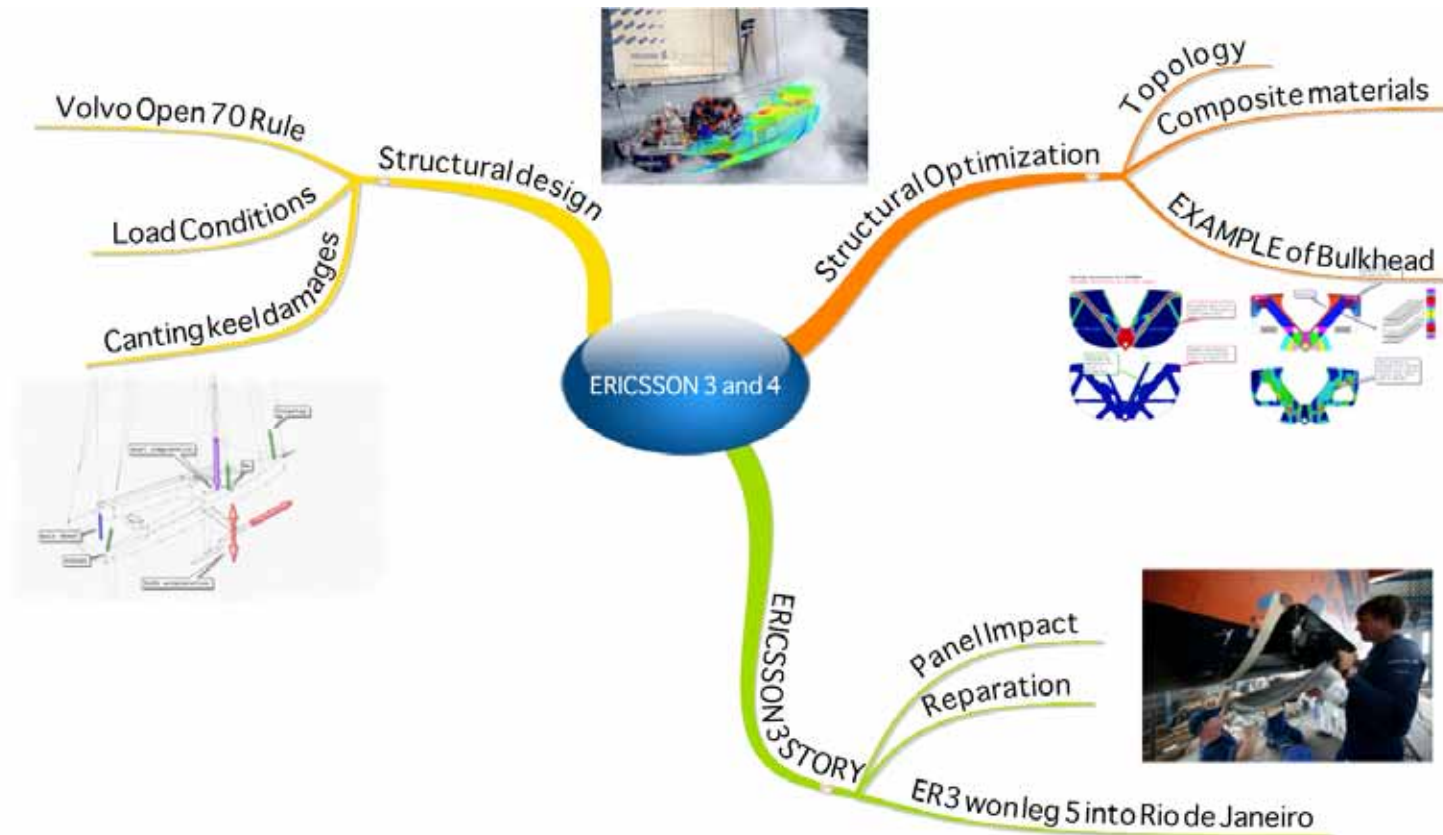
VOLVO
OCEAN
RACE

2008 - 2009

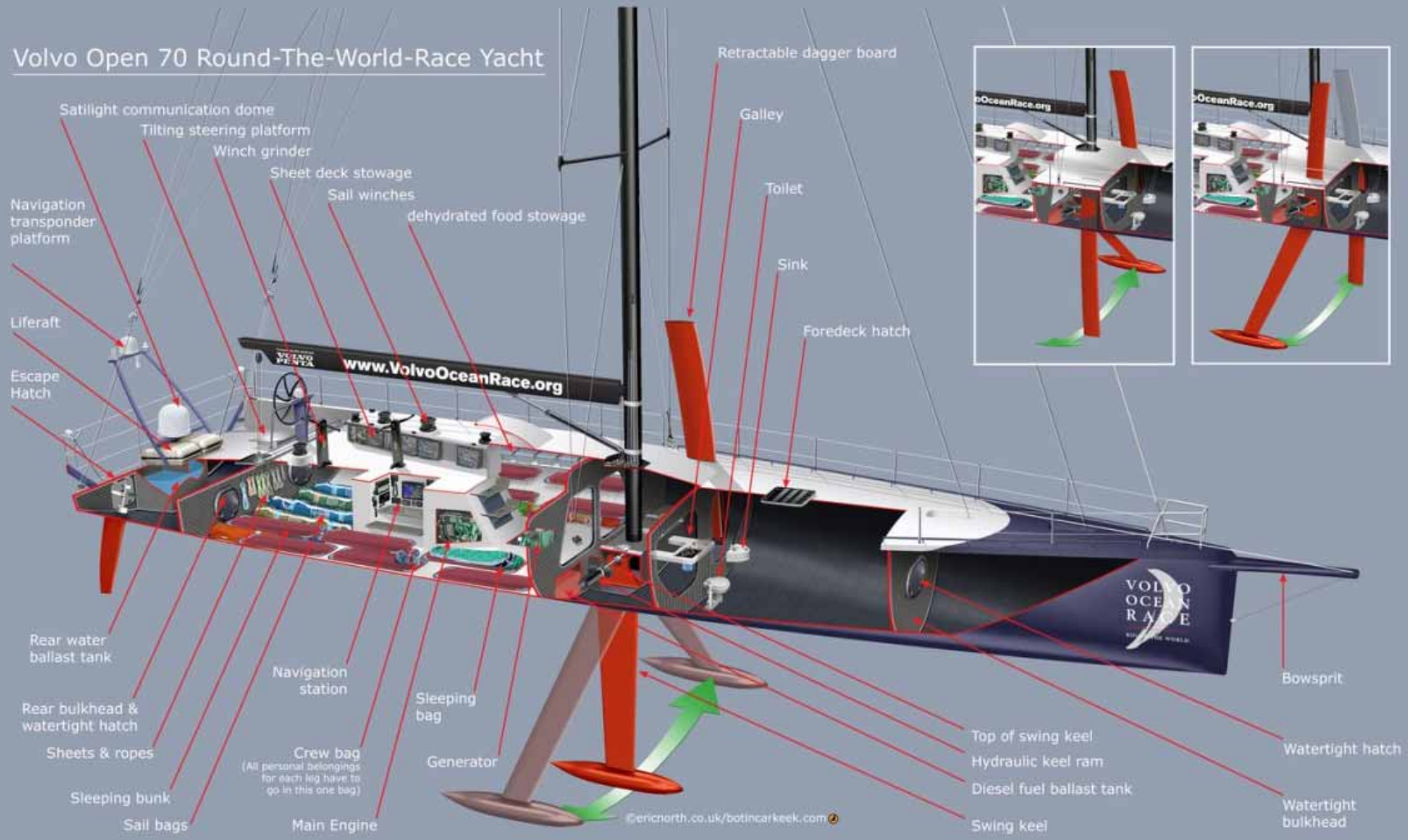
3^o EUROPEAN HYPERWORKS TECHNOLOGY CONFERENCE
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Content

1. Overview of structural loads and boundary conditions
2. Full multilayer HyperWorks optimization
3. A case of impact: Ericsson 3 in Taiwan

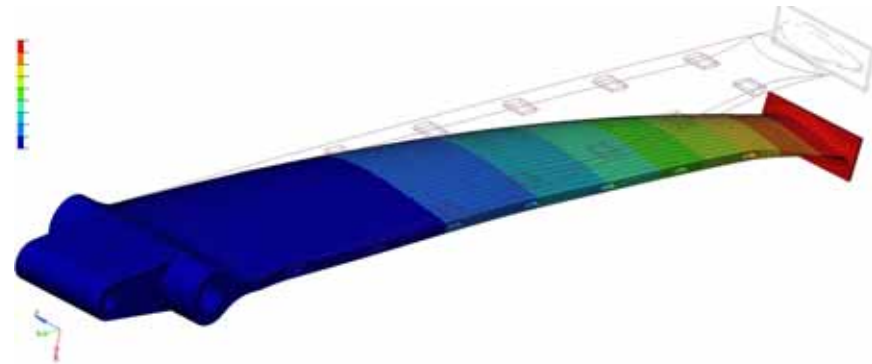
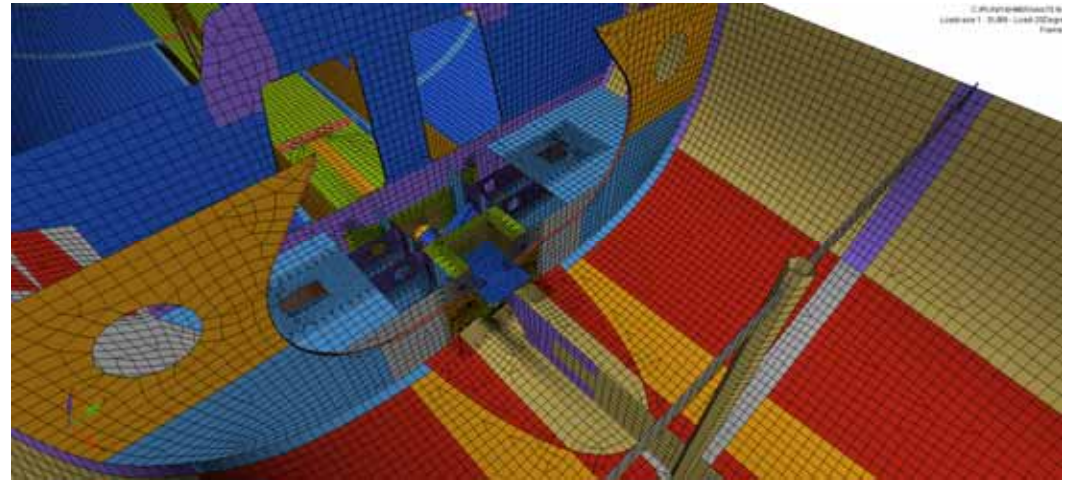
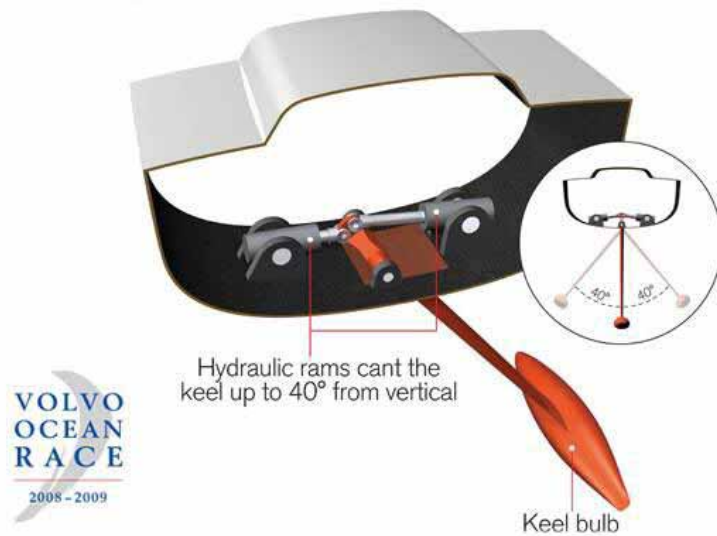


Volvo Open 70 Round-The-World-Race Yacht

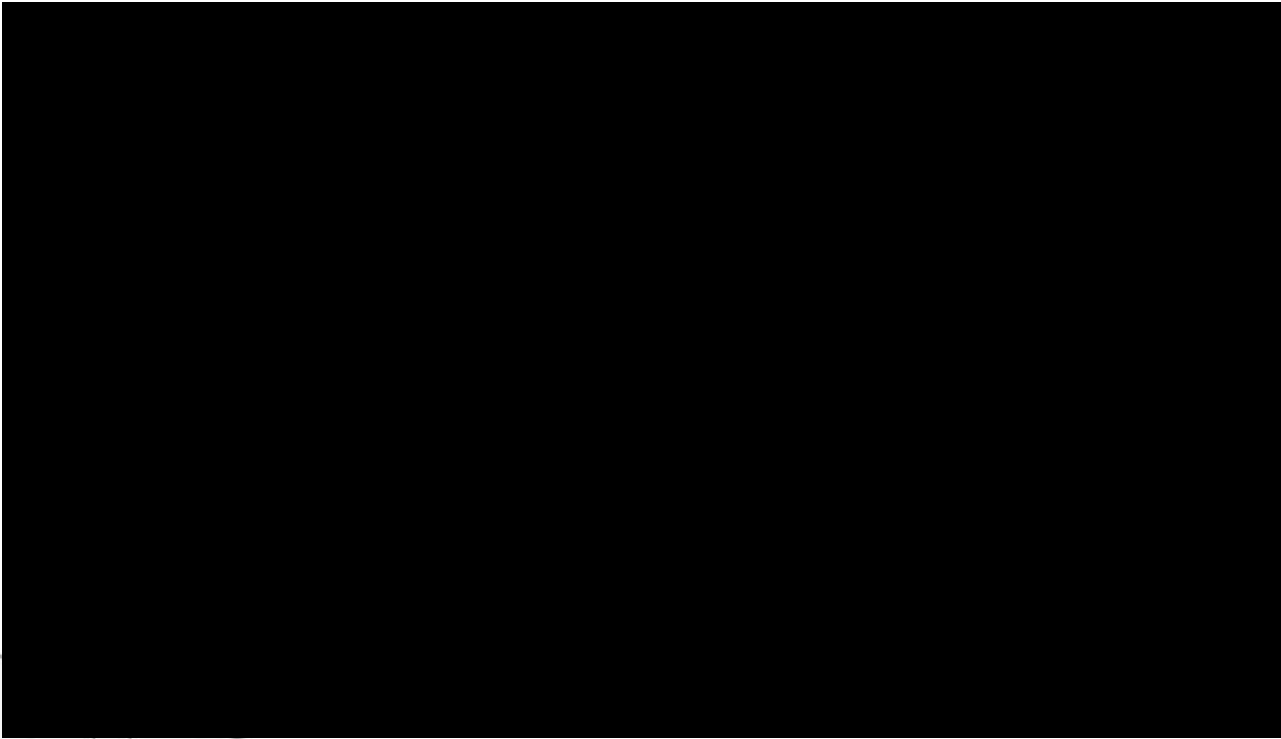
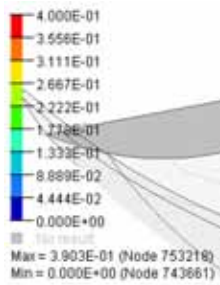


THE VOLVO OPEN 70 RULE

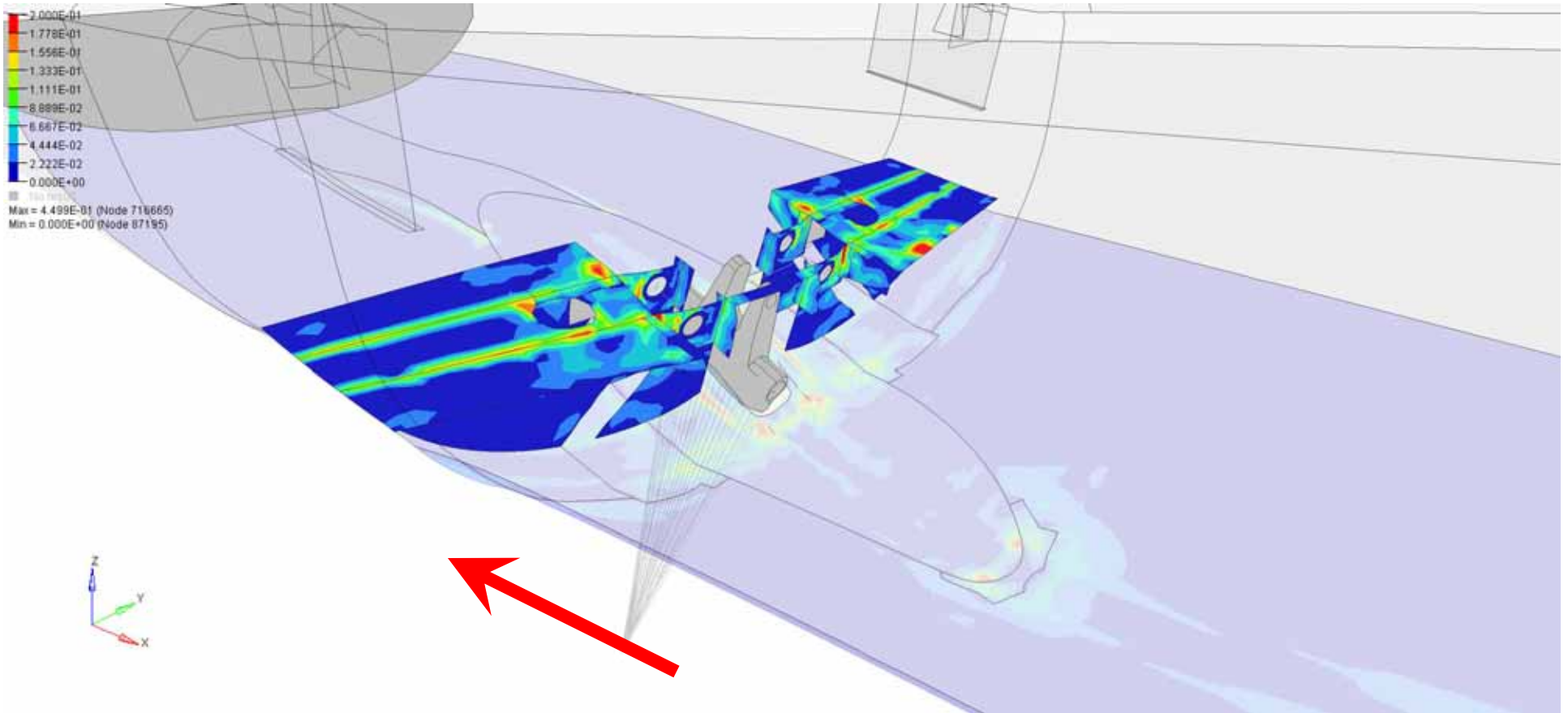
1. Stresses shall be calculated for the **keel fin sections**, each cant mechanism and the associated internal structure... The minimum **factor of safety** for the associated stresses shall be 3



Canting Keel structure

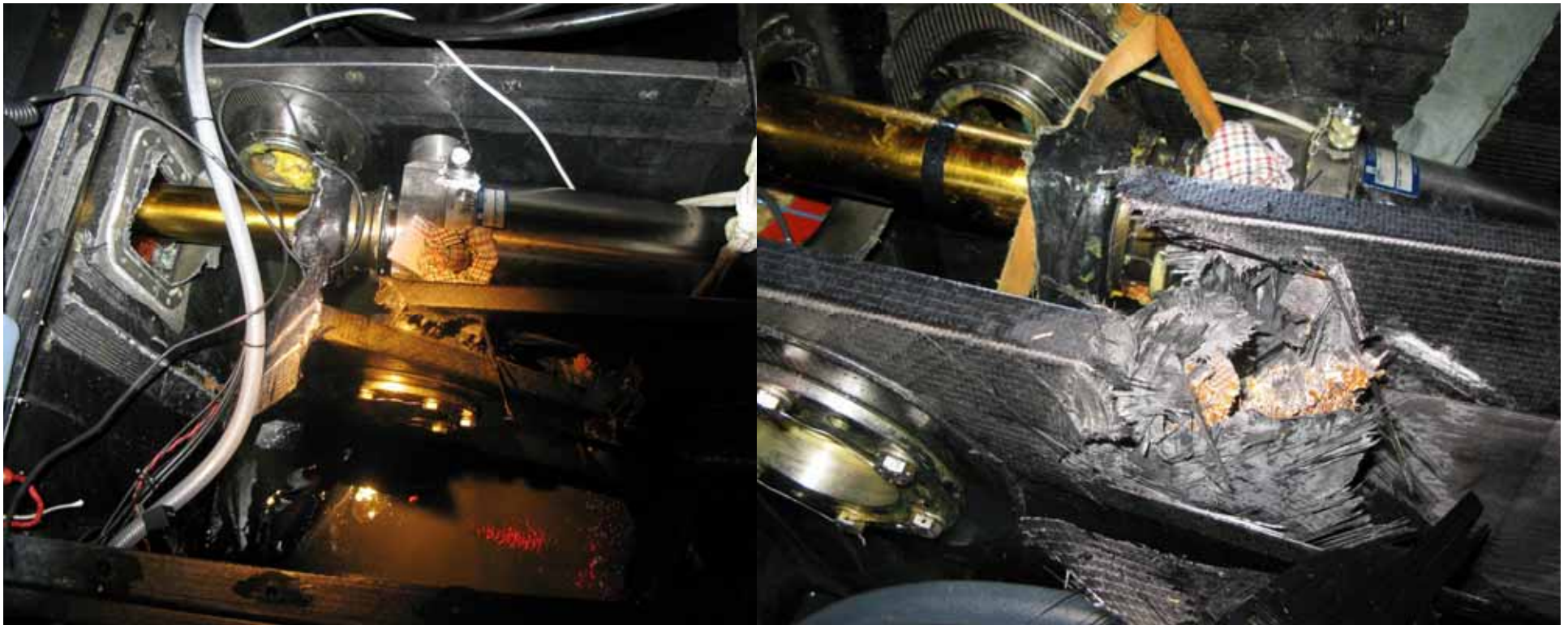


Canting Keel structure (grounding)



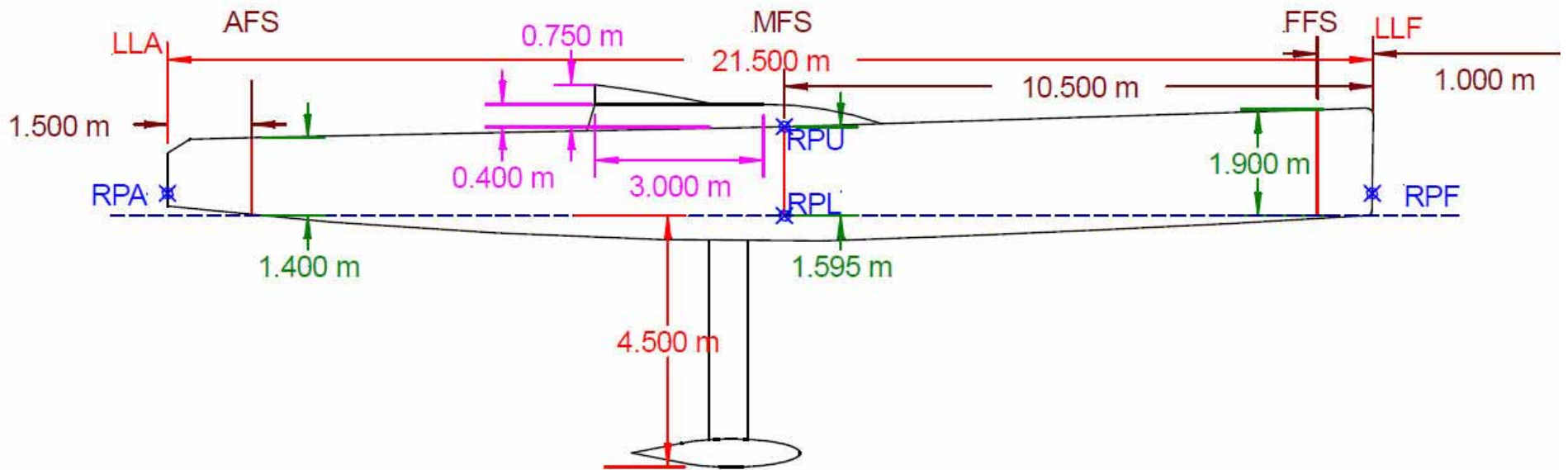
THE VOLVO OPEN 70 RULE

1. Stresses shall be calculated for the **keel fin sections**, each cant mechanism and the associated internal structure... The minimum **factor of safety** for the associated stresses shall be **3**



THE VOLVO OPEN 70 RULE (some parameters)

Minimum Panel Weights	5.7- 11	kg/m ²
Keel Weight (+bulb)	6000-7400	kg
Weight of Yacht	13860-14000	kg

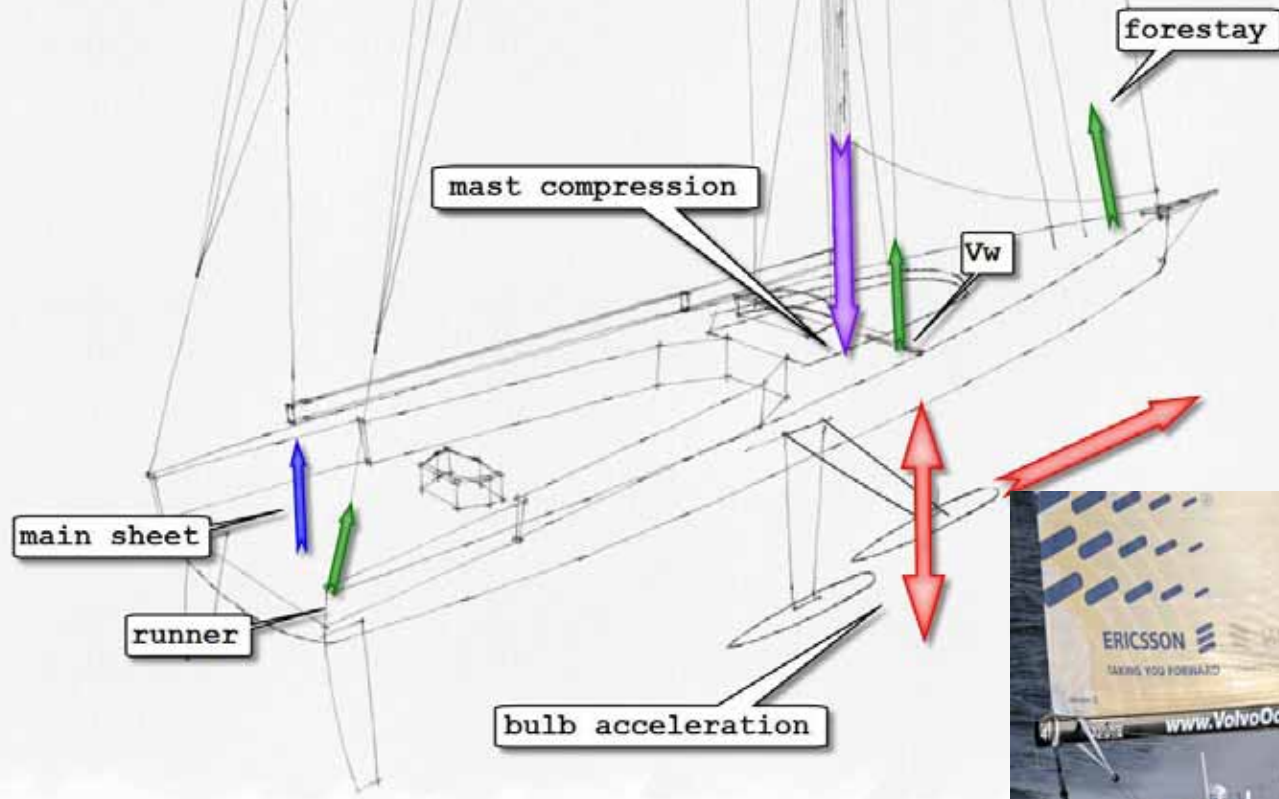


The real life (movie)

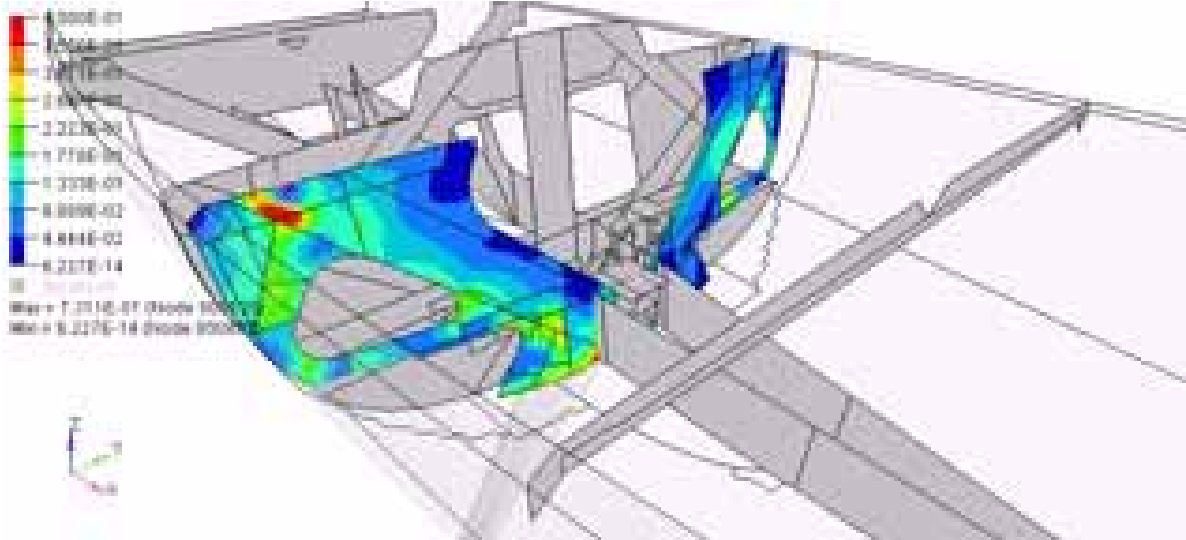
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The real life into the structural model

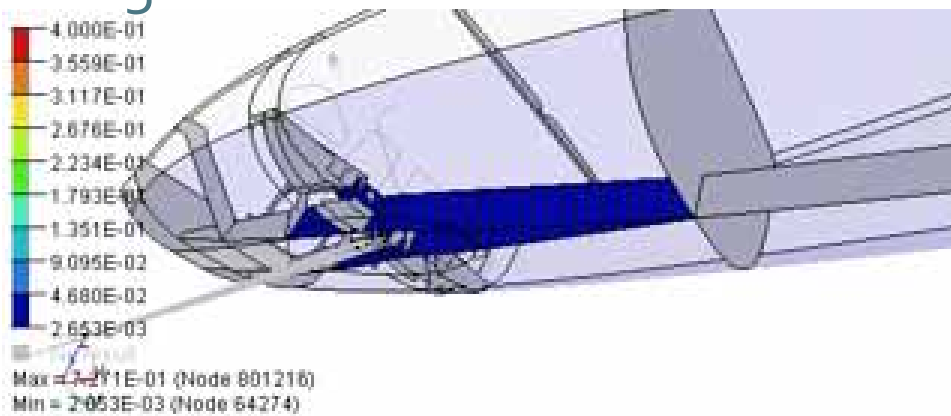


FEM animations

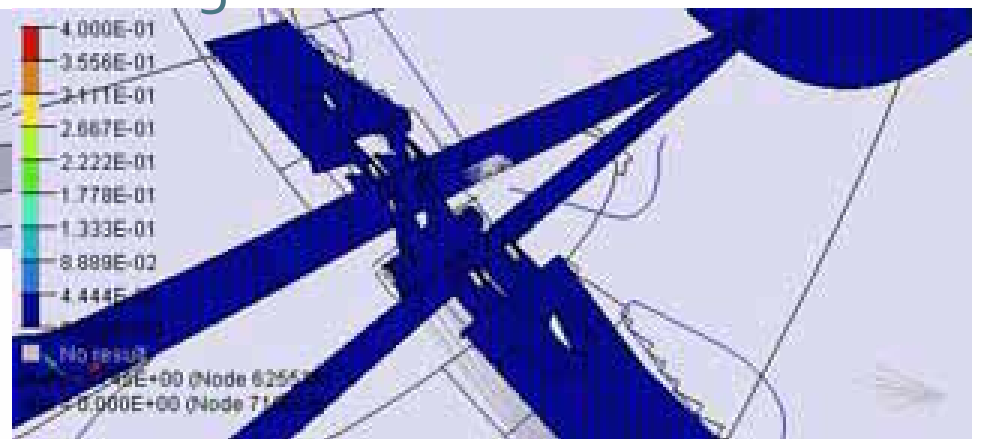


FWD
Mast Bulkhead

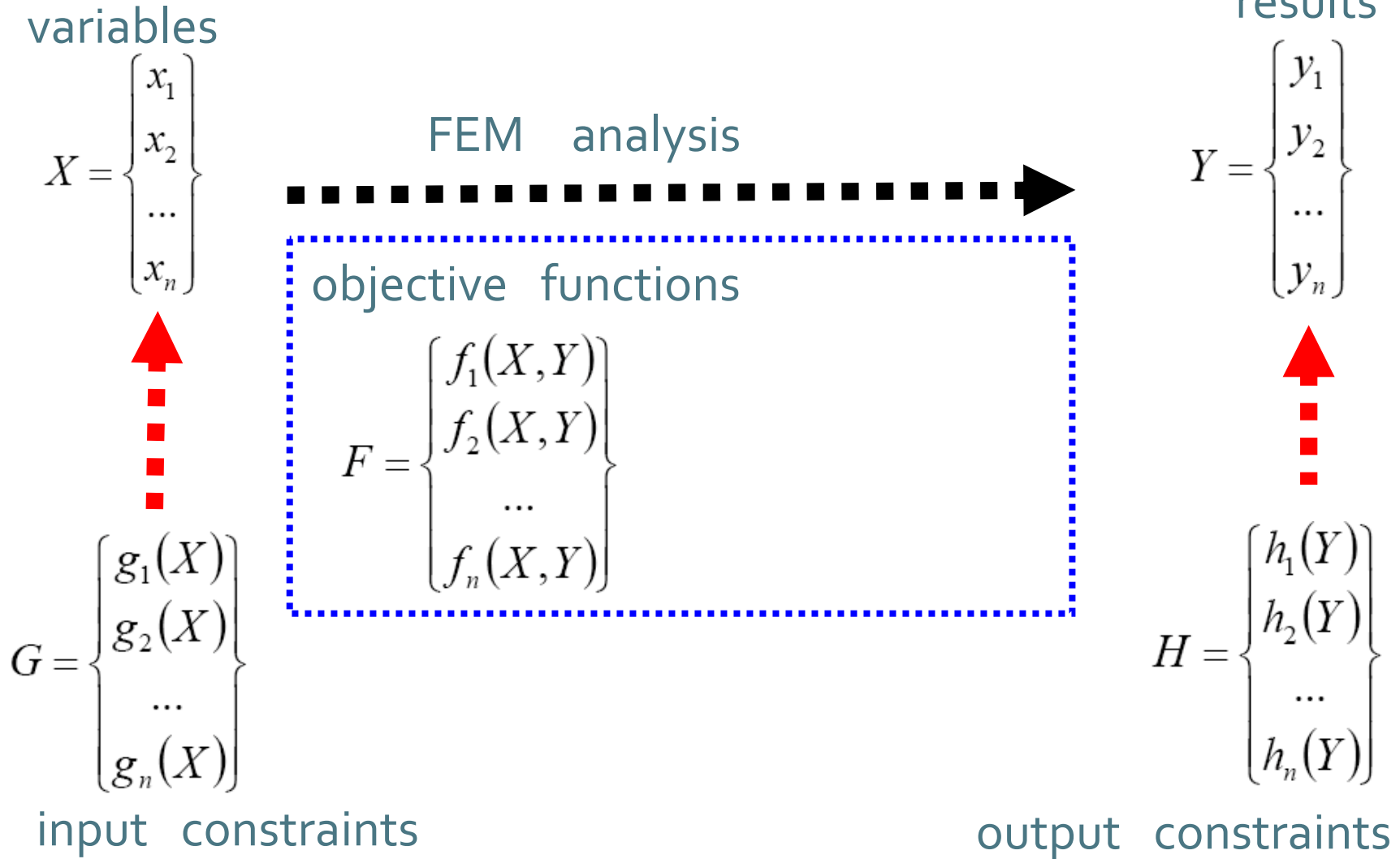
Longitudinal stiffeners



Canting mechanism

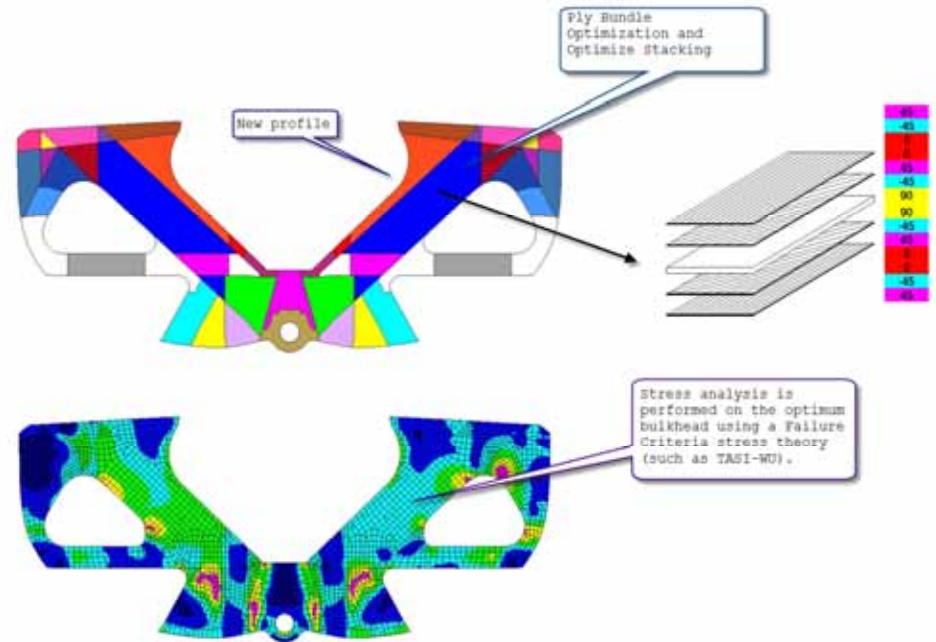
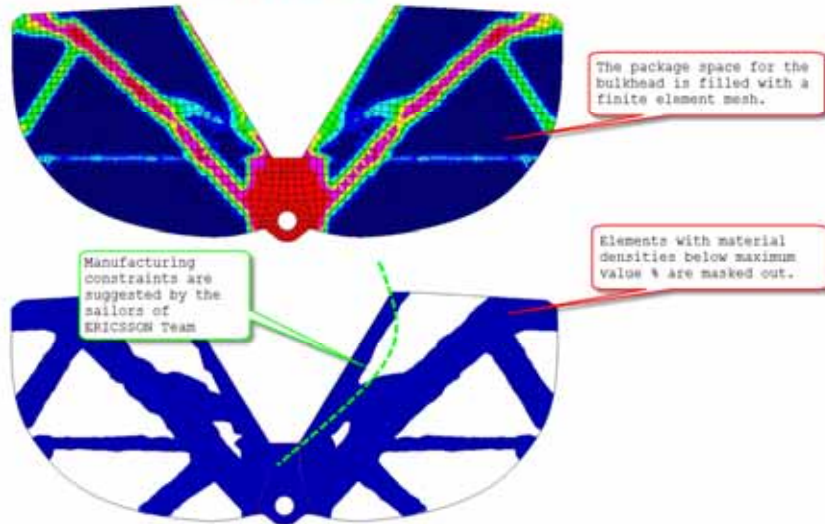


Full multilayer HyperWorks optimization:



Full multilayer HyperWorks optimization:

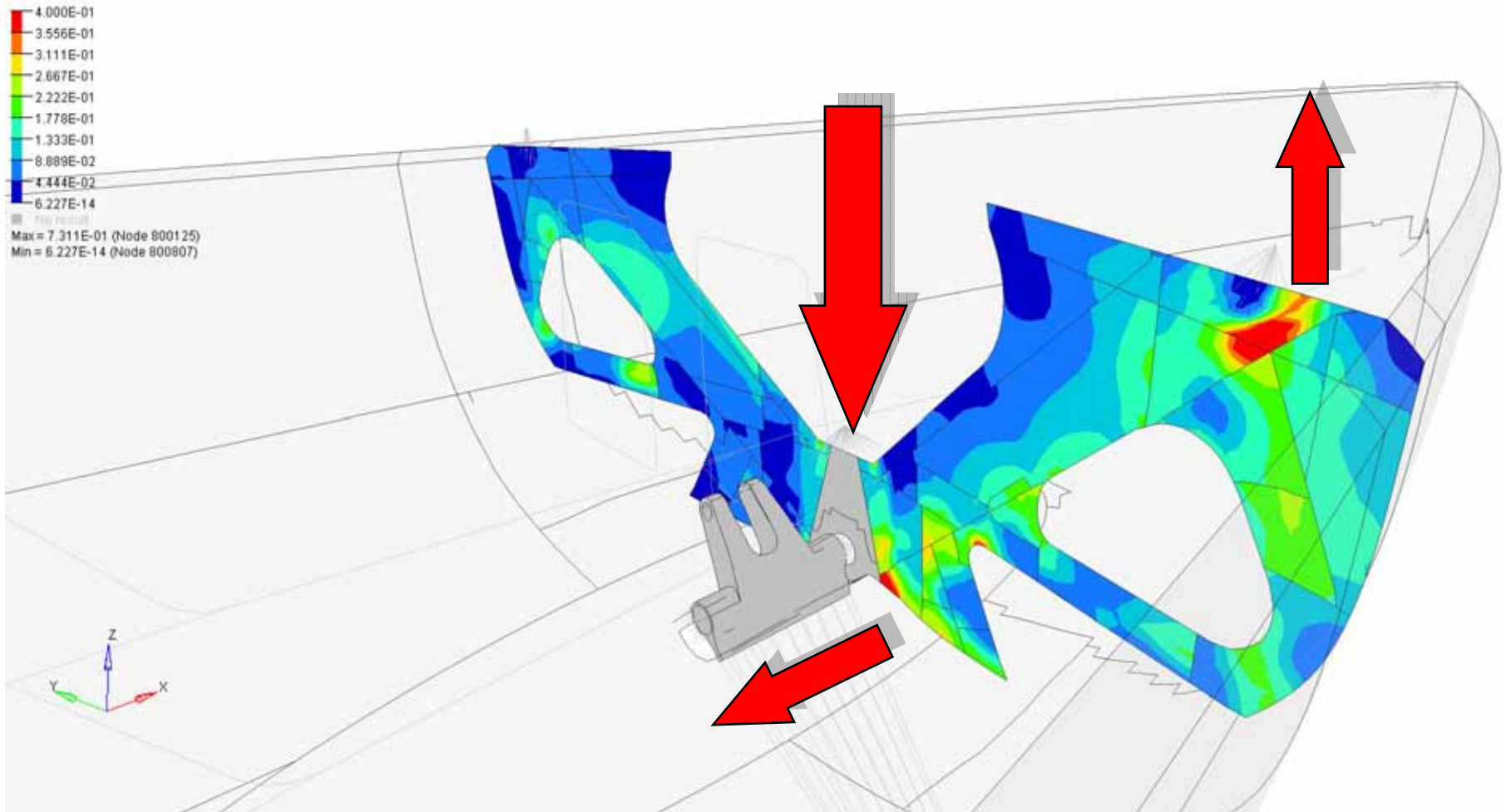
Topology optimization of a BULKHEAD
Thickness distribution per ply per element



The real bulkhead 100 kg



Full multilayer HyperWorks optimization:



A case of impact: Ericsson 3 (E3) in Taiwan

-Hualien, Taiwan, (Jan. 27, 2009) E3 is making way for Taiwan after discovering cracks in the forward port side of the hull.

-Hualien, Taiwan, (Feb. 1, 2009) Ericsson Racing Team plans to repair its damaged yacht, E3, in Taiwan before it returns here to the Leg 4 stopover port of the Volvo Ocean Race

-QINGDAO, China (Feb. 14, 2009) Ericsson Racing Team's Nordic crew finished Leg 4 of the Volvo Ocean Race a couple of weeks late and started Leg 5 a few hours late.

-Rio de Janeiro, Brazil (March 26, 2009) E3, skippered by Magnus Olsson (SWE) **finish first into Rio de Janeiro on leg 5** of the Volvo Ocean Race, crossing the line at 10:37:57 GMT 26/03/09, after 41 days at sea (**12070 miles**).



A case of impact: Ericsson 3 in Taiwan

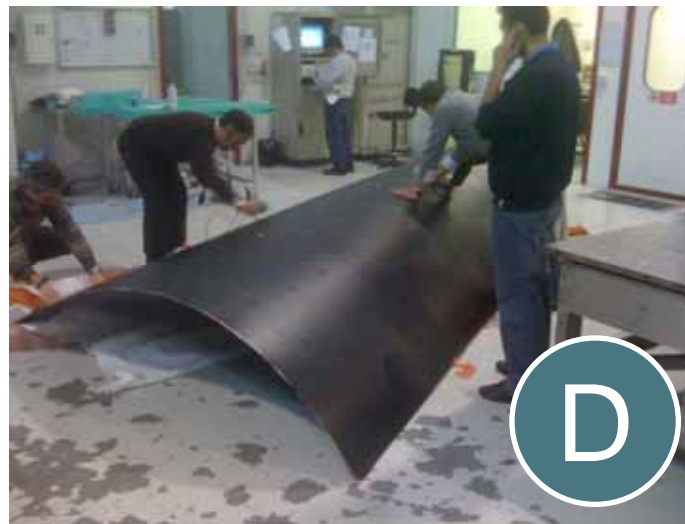


The boat was leaking through a crack in the hull (A). Coupled with the great water pressure from slamming into six-meter waves, the outer and inner carbon-fiber skins of the hull became delaminated.

A case of impact: Ericsson 3 in Taiwan

There's a delaminated area four meters long, and one and a half meter wide (C).

A replacement panel is planned to be crafted in Italy by ReFraschini (D).



A case of impact: Ericsson 3 in Taiwan



.Analysis of the repair options

.Scarfig and bonding the panel





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3



Thank you for your attention



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