

Heavy-lifting:
Coupled Stability
& Structural
Analysis in a
Load-out
Operation



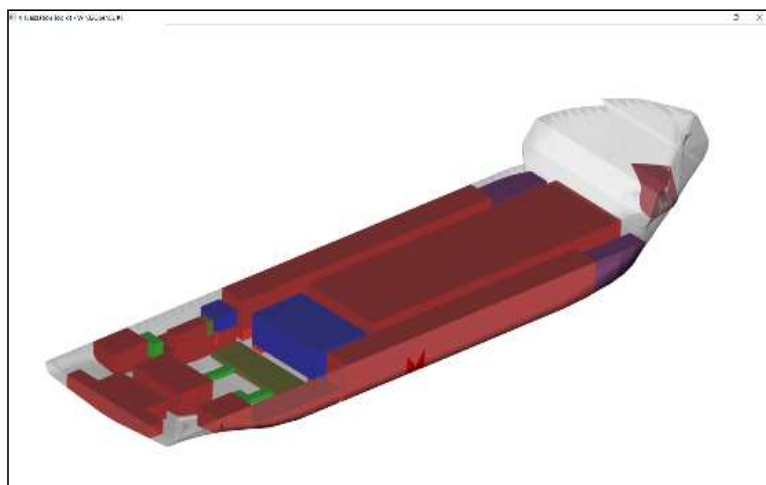
Stéphane DARDEL
NICK DANESE APPLIED RESEARCH
sd@ndar.com

Paper by:

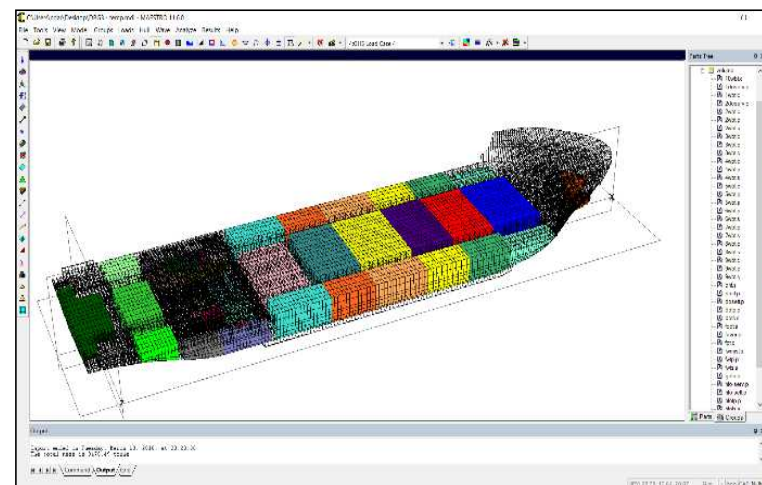
- Stéphane DARDEL & Nick DANESE, Nick Danese Applied Research Sarl
- Jean-Luc MORBELLI & Sylvain FLOURET, Terra Navtica A/S

2 DIGITAL MODELS:

HYDROSTATIC MODEL (GHS)

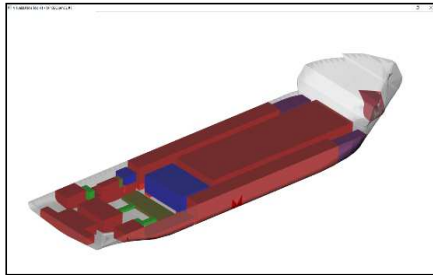


STRUCTURAL MODEL (MAESTRO Marine)



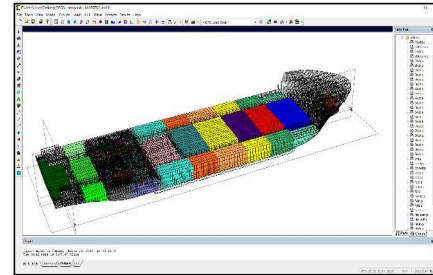
Working in synchrony !

Heavy-lifting: coupled stability & structural analysis in a load-out operation



HYDROSTATIC MODEL:

- Drafts & trim & hydrostatics
- Stability
- Tank status
- Ballast sequence
- Ballast pump capacity check
- Longitudinal strength & girder deflection (beam theory)
- Torque



STRUCTURAL MODEL:

- Finite Element model
- Automatic transfer of tank loads from GHS to MAESTRO
- Hydrostatic balance
- --> Synchrony with GHS
- Global strength & deflection, along 3 axis
- Torque
- Local structural strength: Limit State Analysis

Cargo control in GHS:

TRAILER A lines loads ✕

Tick to disconnect line	Define line load
<input type="checkbox"/> Line 1	Load <input type="text" value="12"/> tons
<input type="checkbox"/> Line 2	Load <input type="text" value="14"/> tons
<input type="checkbox"/> Line 3	Load <input type="text" value="14"/> tons
<input checked="" type="checkbox"/> Line 4	Load <input type="text" value="0"/> tons
<input type="checkbox"/> Line 5	Load <input type="text" value="12"/> tons



Noble Denton Ballast Capacity Check

Step No 1 - TIMING = 10 min
Aircraft AFT = 3.405 - Aircraft FWD = 3.738

Ballast Check	
Total Ballast	0.0 T
Required Capacity Condition A	0.0 T
Available Step Ballast Capacity	1281.3 T
UF Ballast Condition A	0.00
Required Capacity Condition C	0.0 T
Av. Step Damage Ballast Capacity	854.2 T
UF Ballast Condition C	0.00
UF Ballast Max	0.00

Deballast Check	
Total Deballast	0.1 T
Required Capacity Condition A	0.1 T
Available Step Deballast Capacity	1281.3 T
UF Deballast Condition A	0.00
Required Capacity Condition C	0.1 T
Av. Step Damage Deballast Capacity	854.2 T
UF Deballast Condition C	0.00
UF Deballast Max	0.00



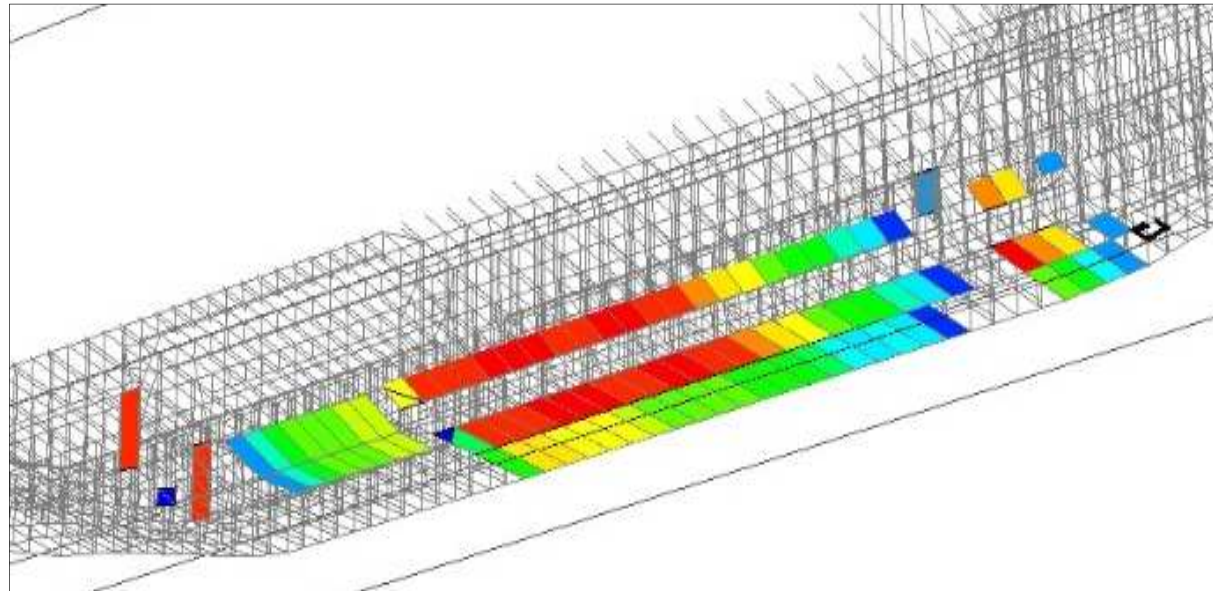
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MAESTRO Marine's Limit State analysis:

Beyond customary stress maps.

Load bearing capability of a structural assembly as a whole. 14 failure modes.

« Evaluation patches » are rated with an adequacy parameter, always lying within the normalized limits of **-1 to +1**



Heavy-lifting: coupled stability & structural analysis in a load-out operation

Engineering:

Hydrostatic model:

- Prepared in a few hours,
- Early feasibility checks: payload capacity vs drafts, longitudinal strength limits, ballast capacity, etc.

Structural model:

- 3 man-weeks. acceptable even in an initial study
- Invaluable gains in predicting structural behaviour: identifying weak zones, planning eventual reinforcing very early in the process, etc.

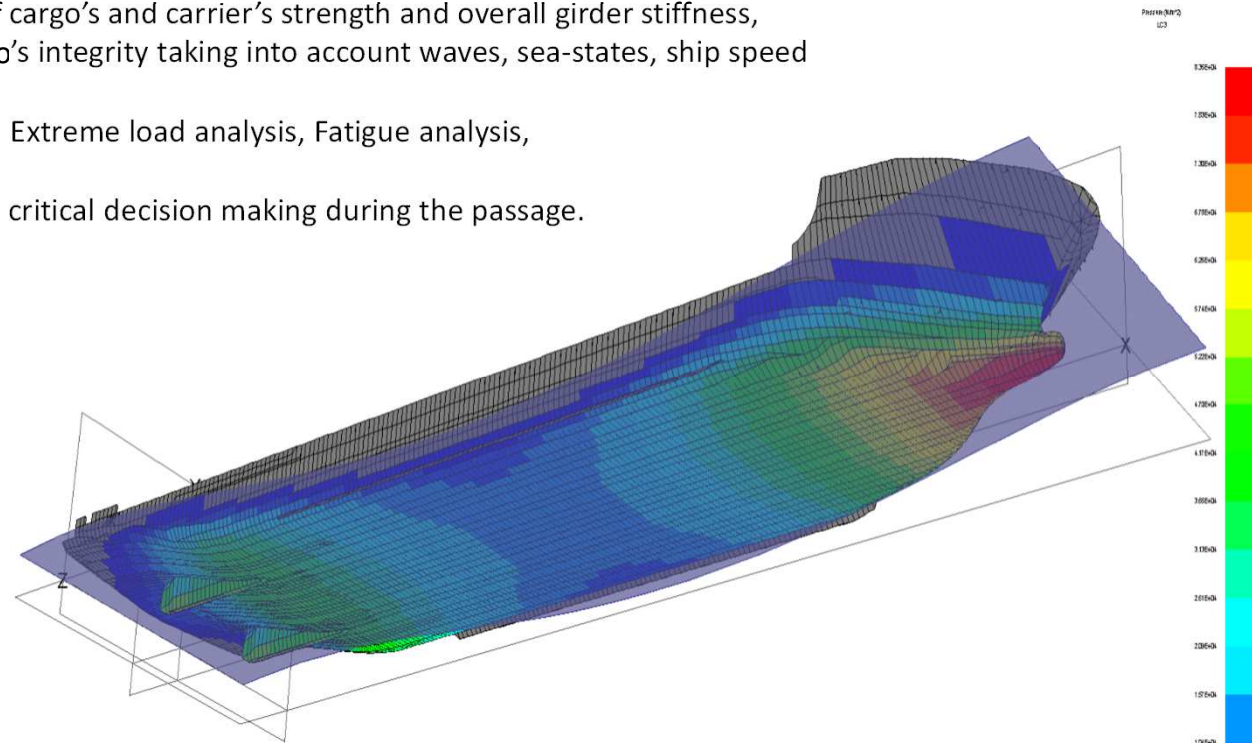
Model creation = one-time job, directly re-usable for future operations

Next?

Integrated « Hydro + structural » model supports at-sea operations too, opening new areas of engineering analysis and behavioural prediction:

- Combination and interaction of cargo's and carrier's strength and overall girder stiffness,
- Assessment of risks to the cargo's integrity taking into account waves, sea-states, ship speed and duration of the voyage,
- Integrated Seakeeping analysis: Extreme load analysis, Fatigue analysis,

→ Voyage prediction, planning and critical decision making during the passage.



Thank you!