SOFTWARE

Sesam user course

HydroD Hydrostatics & Stability

DNV GL

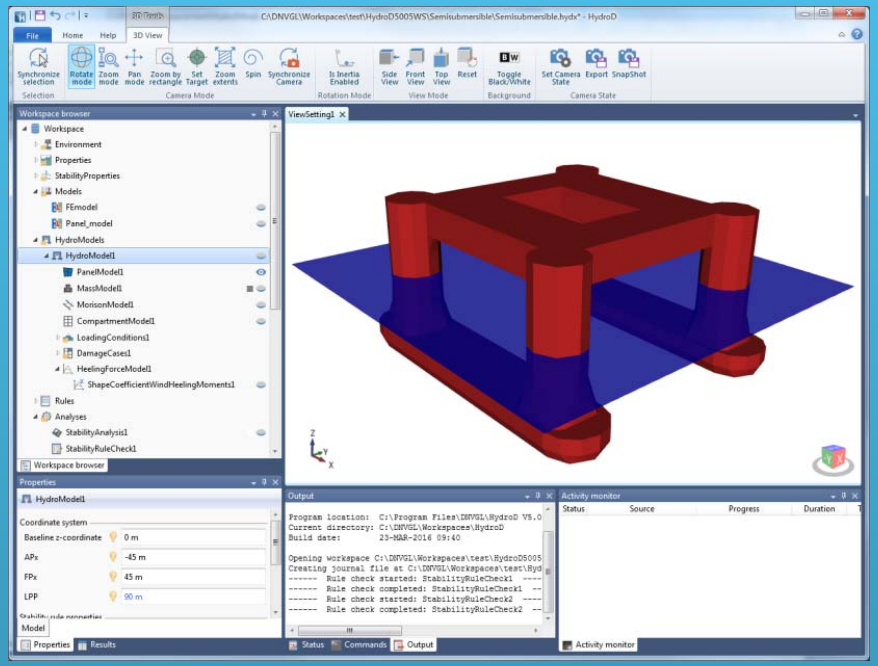
12 May 2016

Ungraded

Scope of presentation

Describe features & commands for performing a hydrostatic analysis, and their concepts

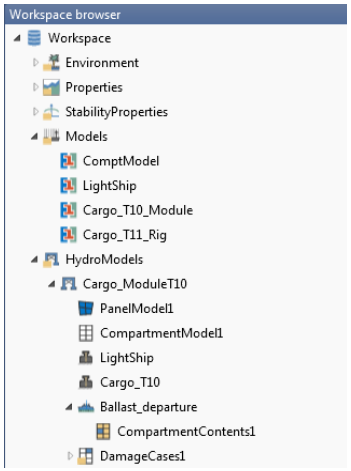
- Analysis setup
- Code-checking
- Reporting



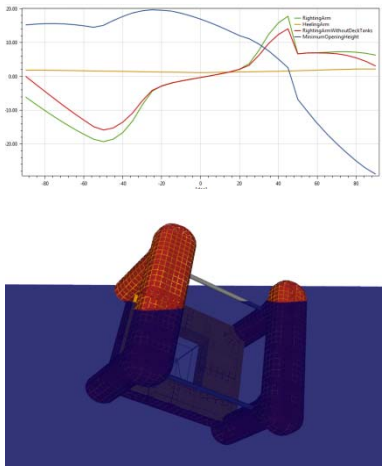
Why HydroD for Hydrostatics and Stability?

Function

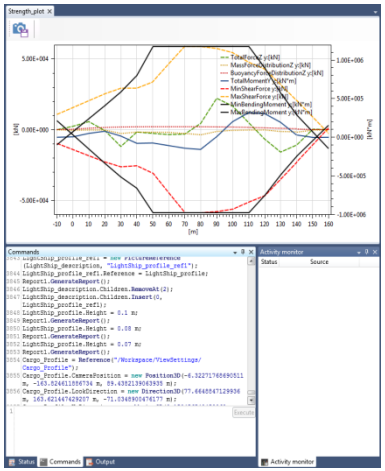
User friendly



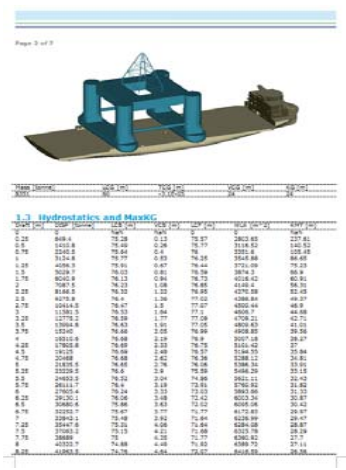
Robust



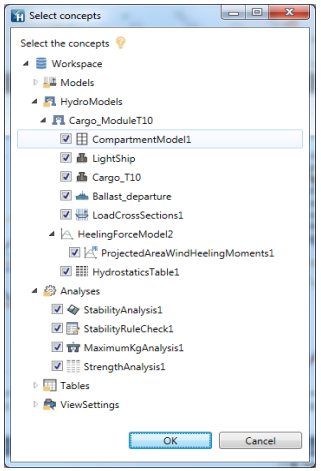
Flexible



Reportable

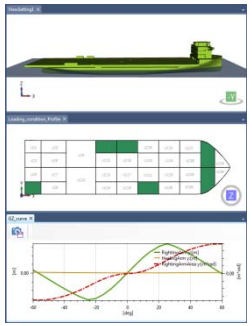


Reusable

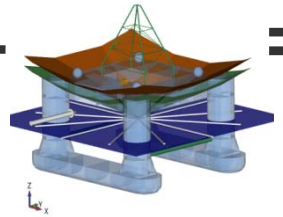


Application

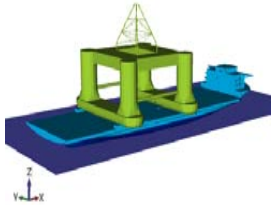
Ship



Offshore

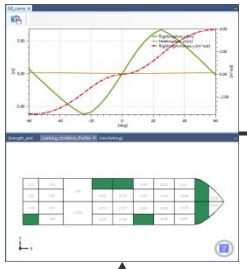


Temporary cond.

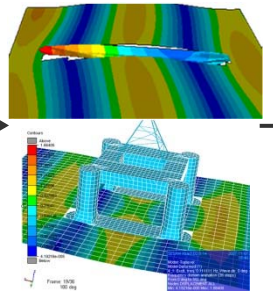


Integrated Engineering process

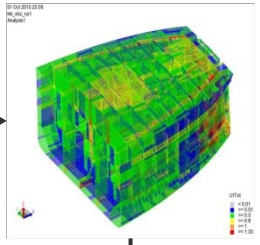
Stability



Motion&Acc.

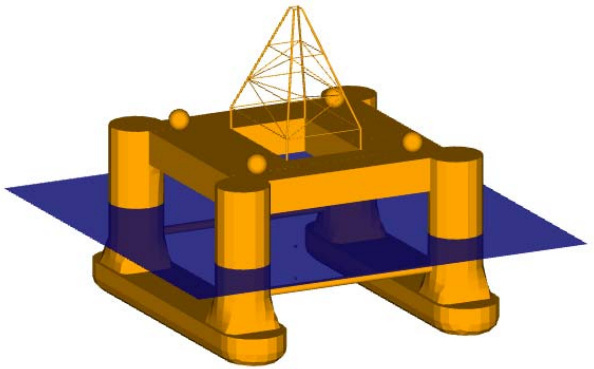


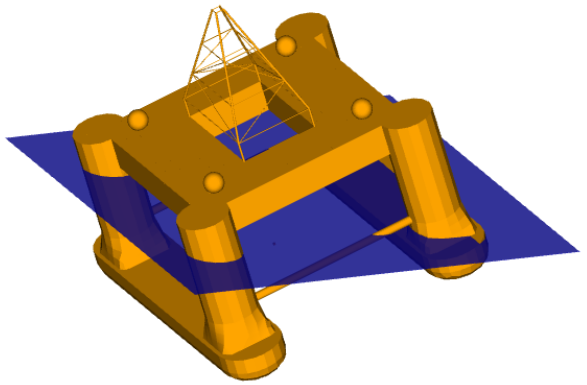
Structure



Some highlights

- Flexible and easy to do hydrostatic and stability computations in intact or damaged condition
- Variable filling or flooding of internal tanks (by specifying filling fraction)
- Automatic computation of trim, heel and draft to balance mass and buoyancy
  - No need for remodelling if non-zero trim and heel
- Automatic filling of tanks to balance mass and buoyancy in different loading conditions
  - No need to remodel with different fillings
- Stability codes for ships and mobile offshore structures



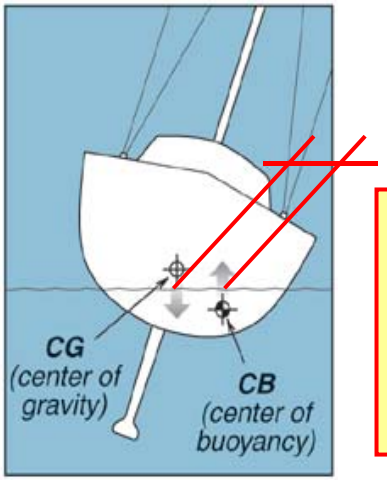


Main features

- Computation of draught, trim and heel
- Computation of GZ-curves and metacentric height
- Balancing vessel and maximizing GM by filling of n tanks
- Report, including tables and plots, of
  - buoyancy information (including block coefficient)
  - trim moment
  - flooding openings distance to waterline
  - righting and heeling moment curves, righting and heeling arm areas etc.
  - code check results
- Computation of calm sea sectional force and moment curves.
- Computation of wind heeling moment
- Max KG (AVCG) analysis
- Watertight/Weathertight integrity plan

Hydrostatic computations

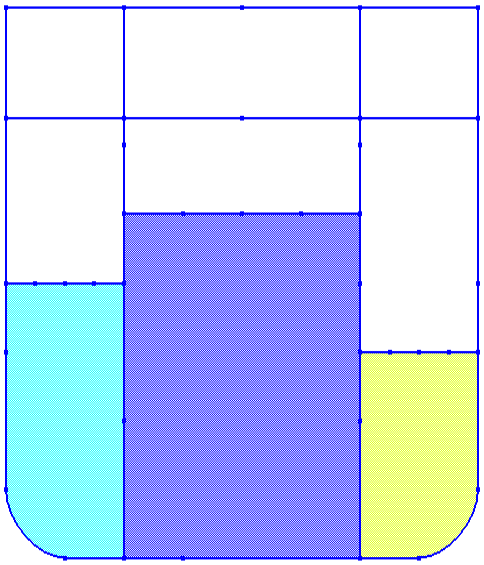
- Accurate computations (no interpolations or approximations)
  - Exact level of free surface in internal tanks computed at every heel angle
  - Exact draught of model computed at every heel angle (ensuring constant displacement during the heel motion)
  - Option to iterate on trim balancing out trim moments
  - Elements cut in the waterline/free surface level to give exact volume and mass computations
  - Mass and centre of gravity of tank fluid computed by an analytically exact method



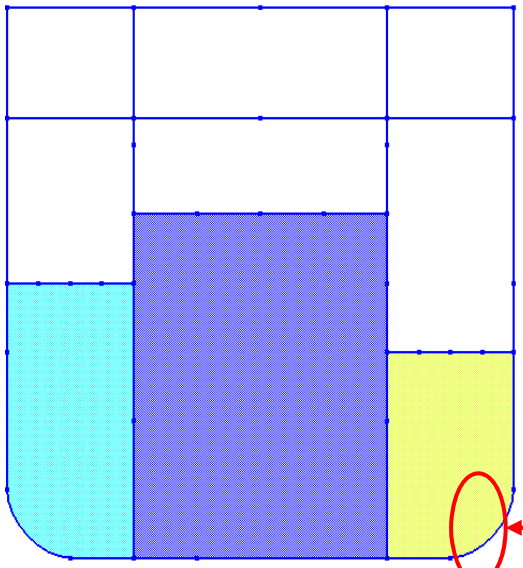
- **GZ** is the horizontal distance between CG and CB
- **GZ** provides an upward-acting torque called the righting moment (RM)
- **RM** is calculated by multiplying the GZ by the vessel's displacement

Flooded tanks

- HydroD will find new equilibrium position

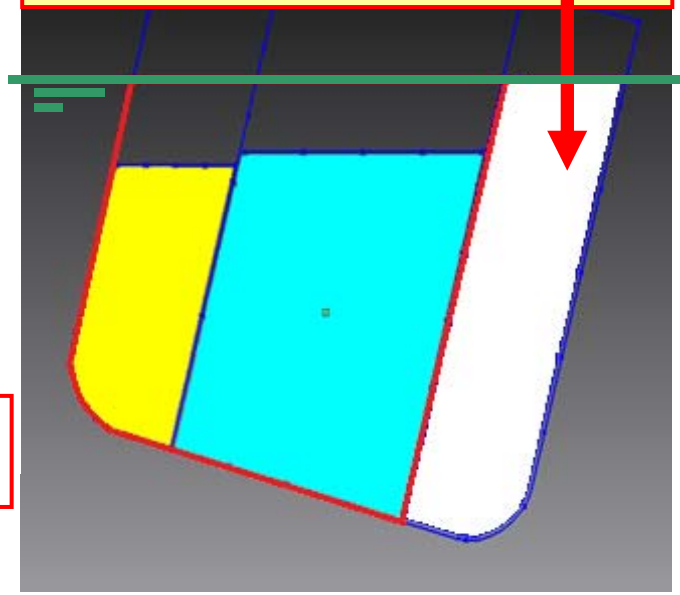


Equilibrium position (draught, trim, heel)



A flooding occurs in one of the tanks

Flooded tank automatically filled (or really emptied) until equilibrium is reached

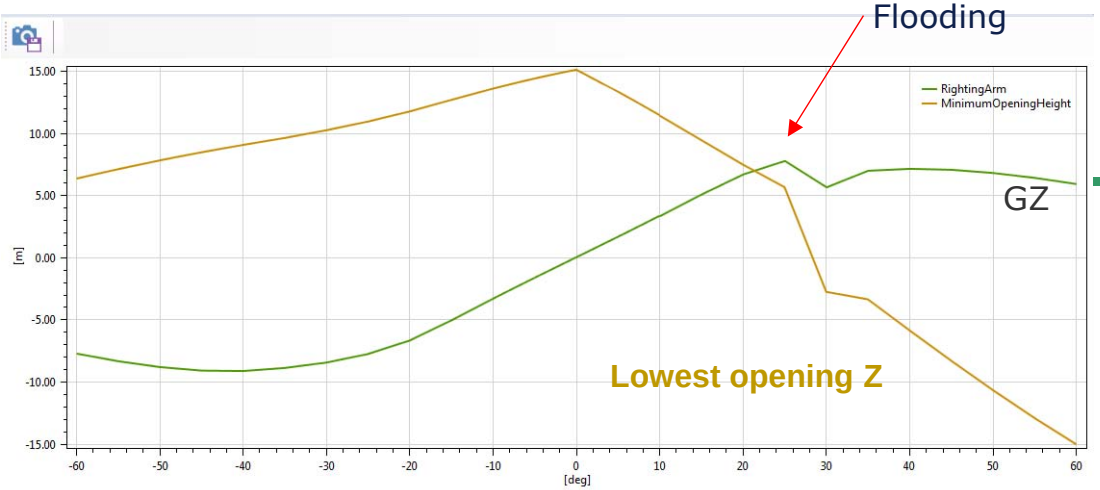


Closed tanks, same mass as before, but different top surface

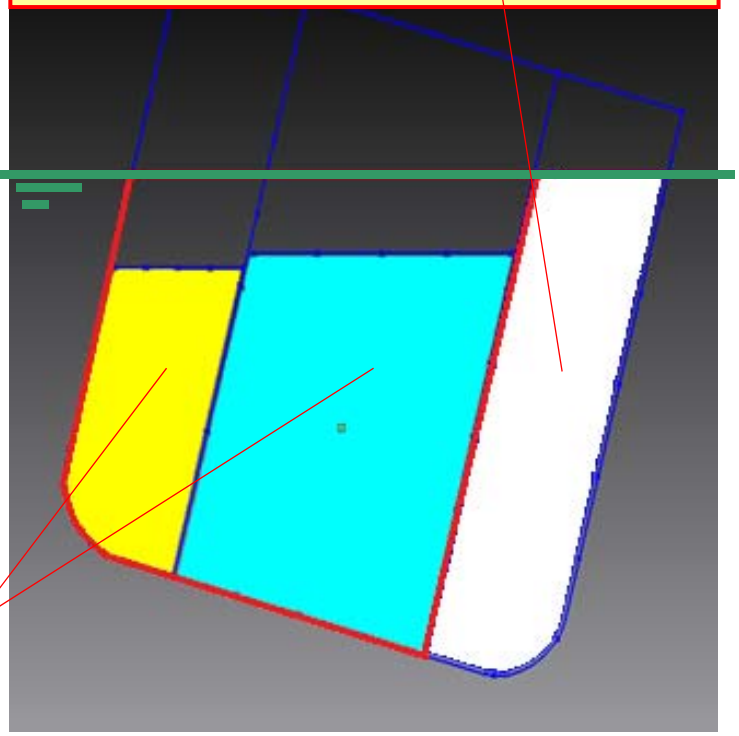
Using lost buoyancy method

Results – Righting arm (GZ) curve – Flooded tanks

- Computing GZ-curve with flooded tanks
  - For each angle in computation (here -60 deg -> 60 deg) the free surface in all tanks are computed

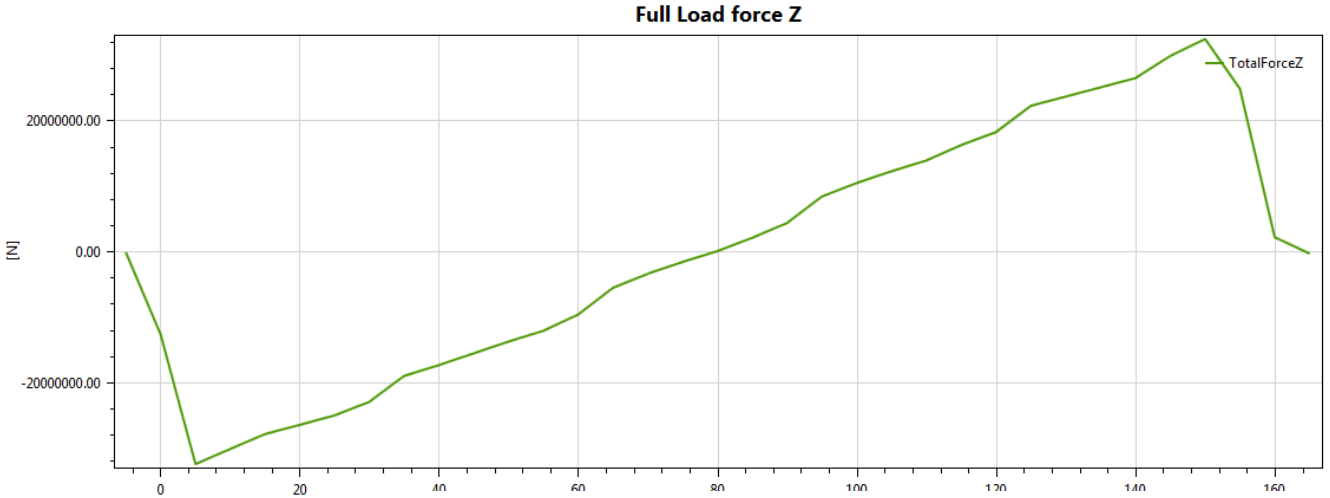


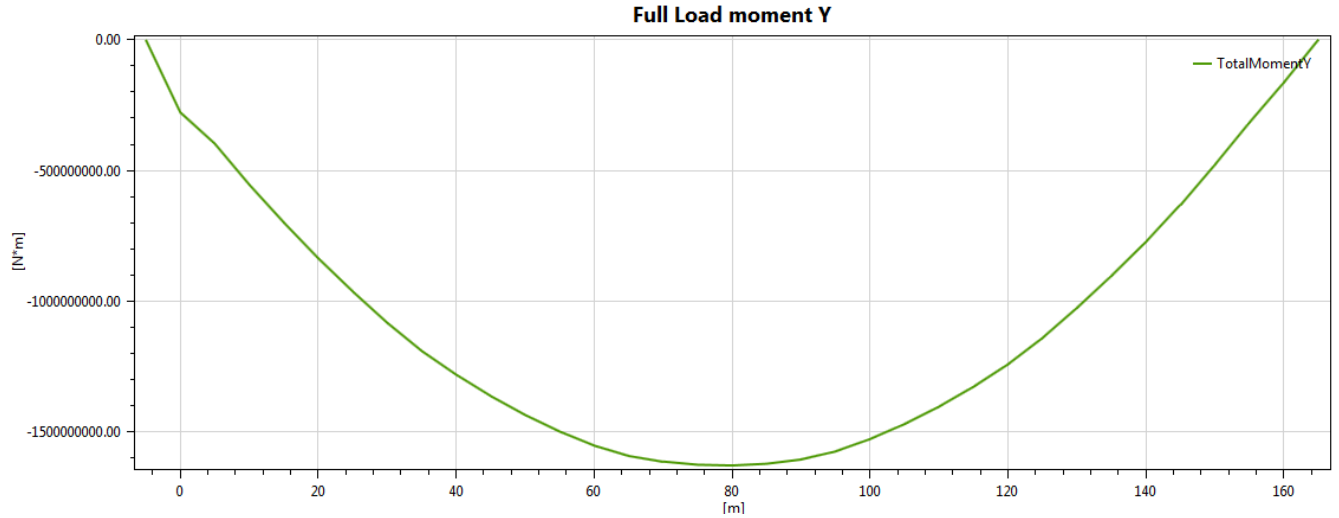
Flooded tank automatically changed by HydroD for each heeling angle



Closed tanks, different top surface for each heeling angle

Results – Strength Analysis – Still water sectional loads

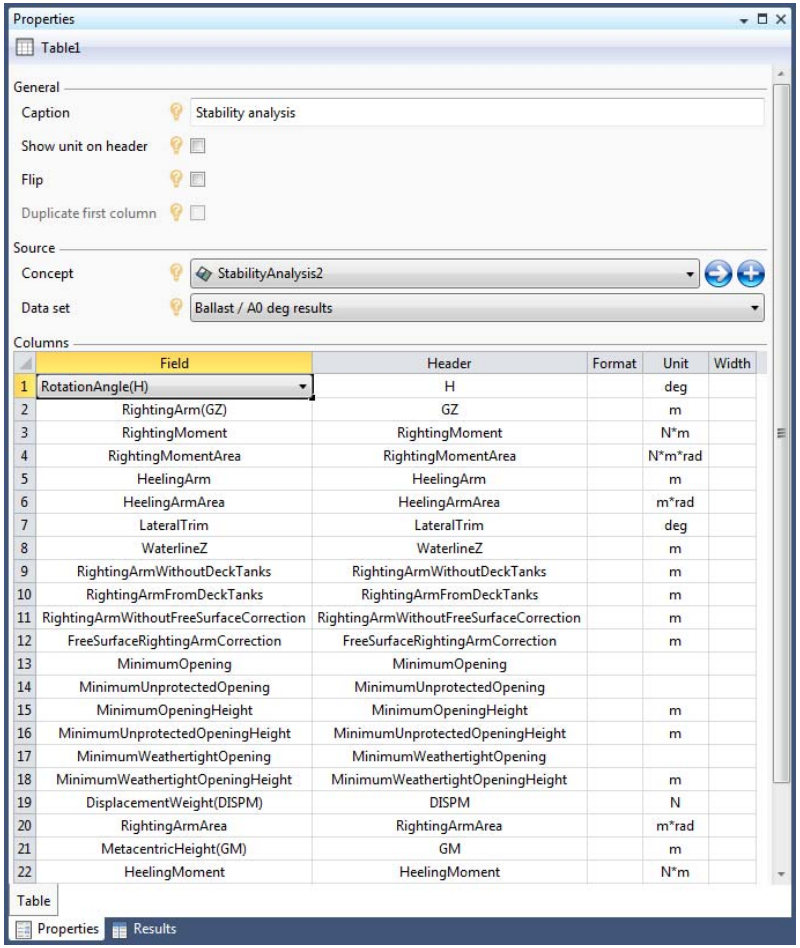


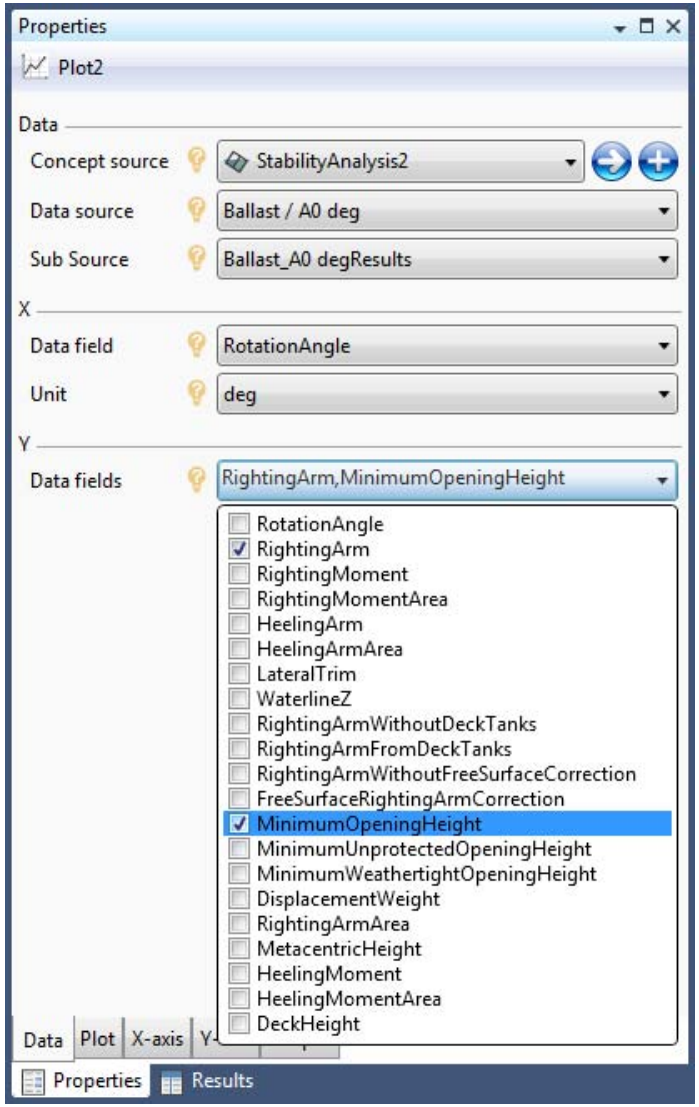


Ungraded

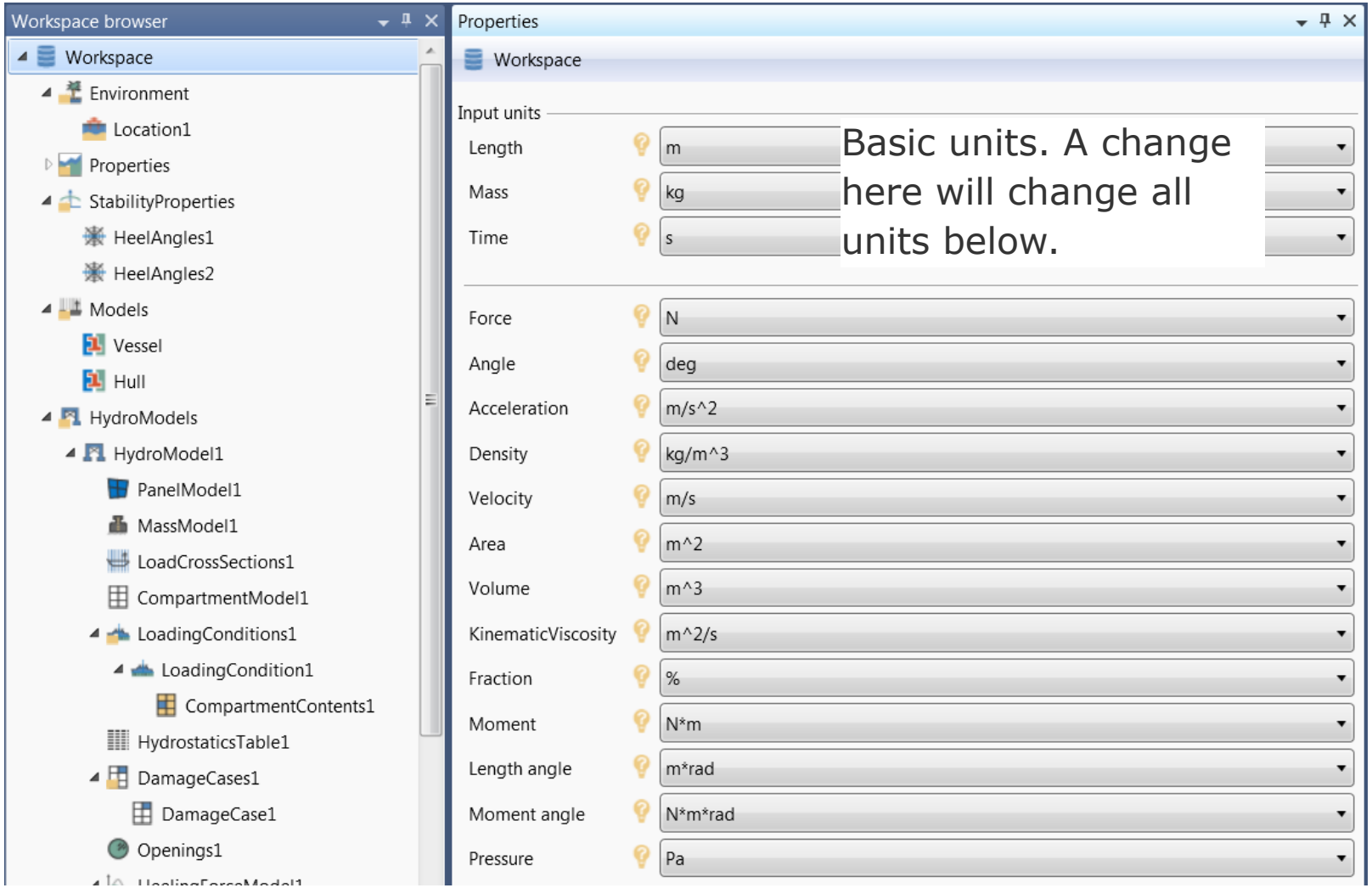
Results

- A high number of results from the strength and stability analyses may be plotted and tabulated

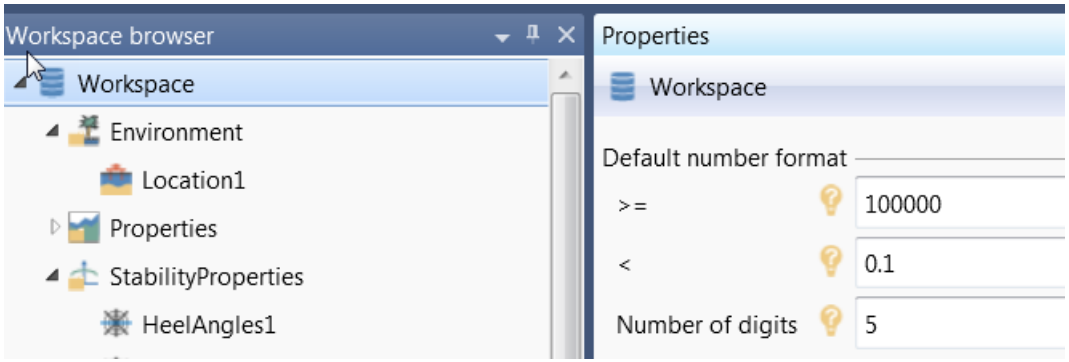


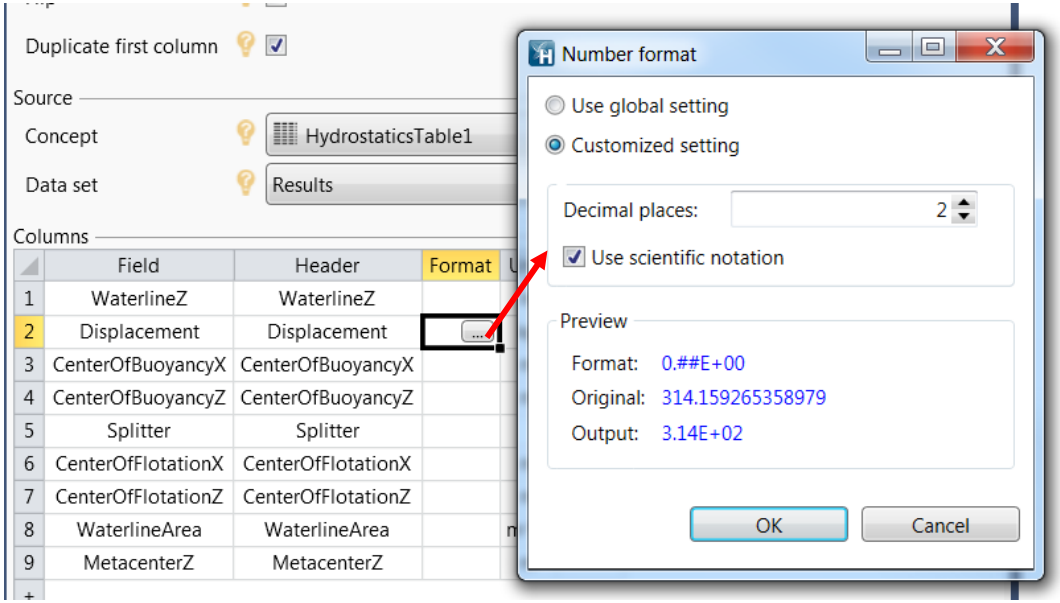


Units



Number accuracy





Number setting in Workspace.

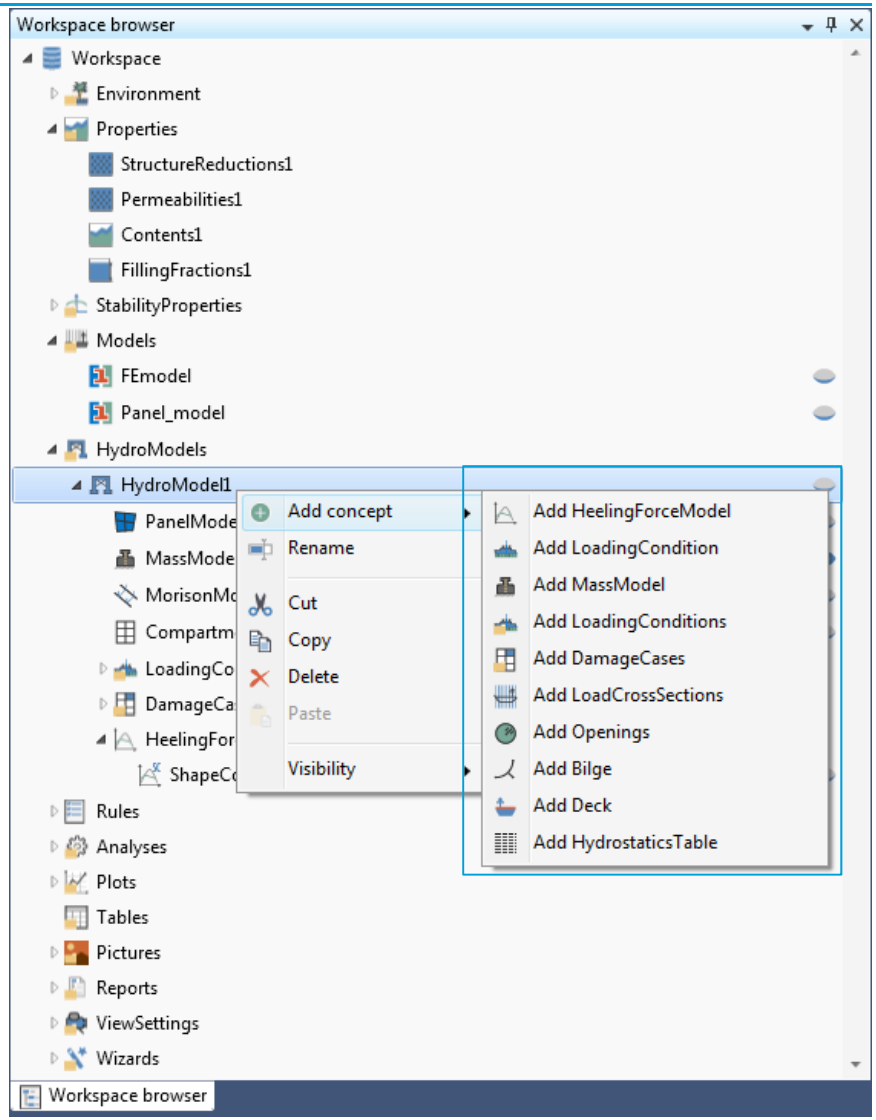
You can define your preferred default in File, Options.

Workspace setting may be modified for individual columns in a table

Set-up of wanted features

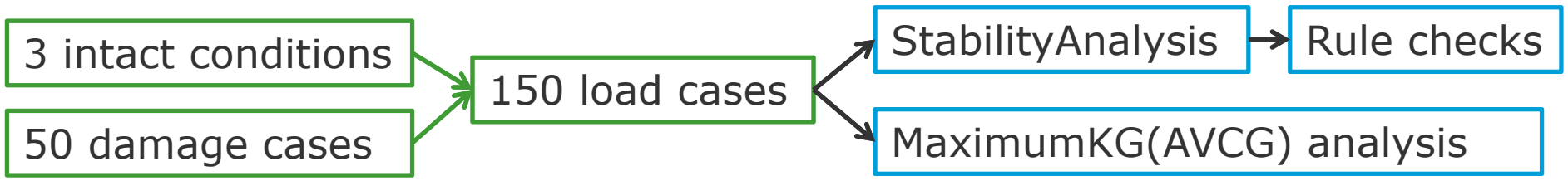
HydroModel Concepts

- A HydroModel will contain many concepts, depending on the wanted features and results for the analysis.
- Some concepts may be added directly from the Wizard
  - Wizard setup found at the bottom of the browser
- All concepts can be added from the browser, by RMB click



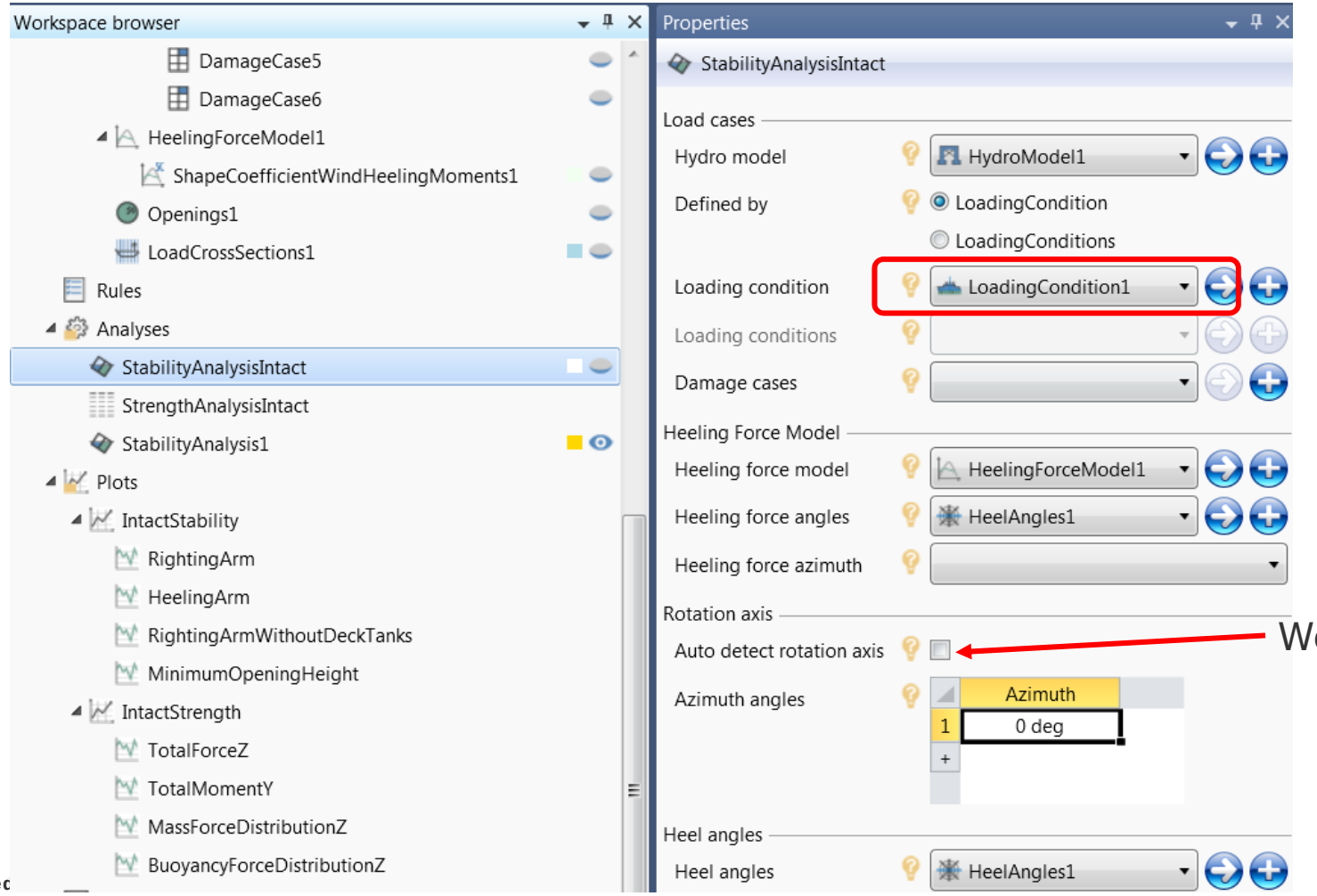
Efficient definitions of load cases

- Simplified user input for large damaged analyses – no need to generate 200 loading conditions and manually edit damages in each of those
- Define a set of intact loading conditions
- Define a set of damage cases
- HydroD will evaluate all combinations of intact conditions and damage cases
- This is implemented for stability analyses, rule checks and KG/AVCG



Stability of single loading condition

- The loading condition may contain damaged compartments



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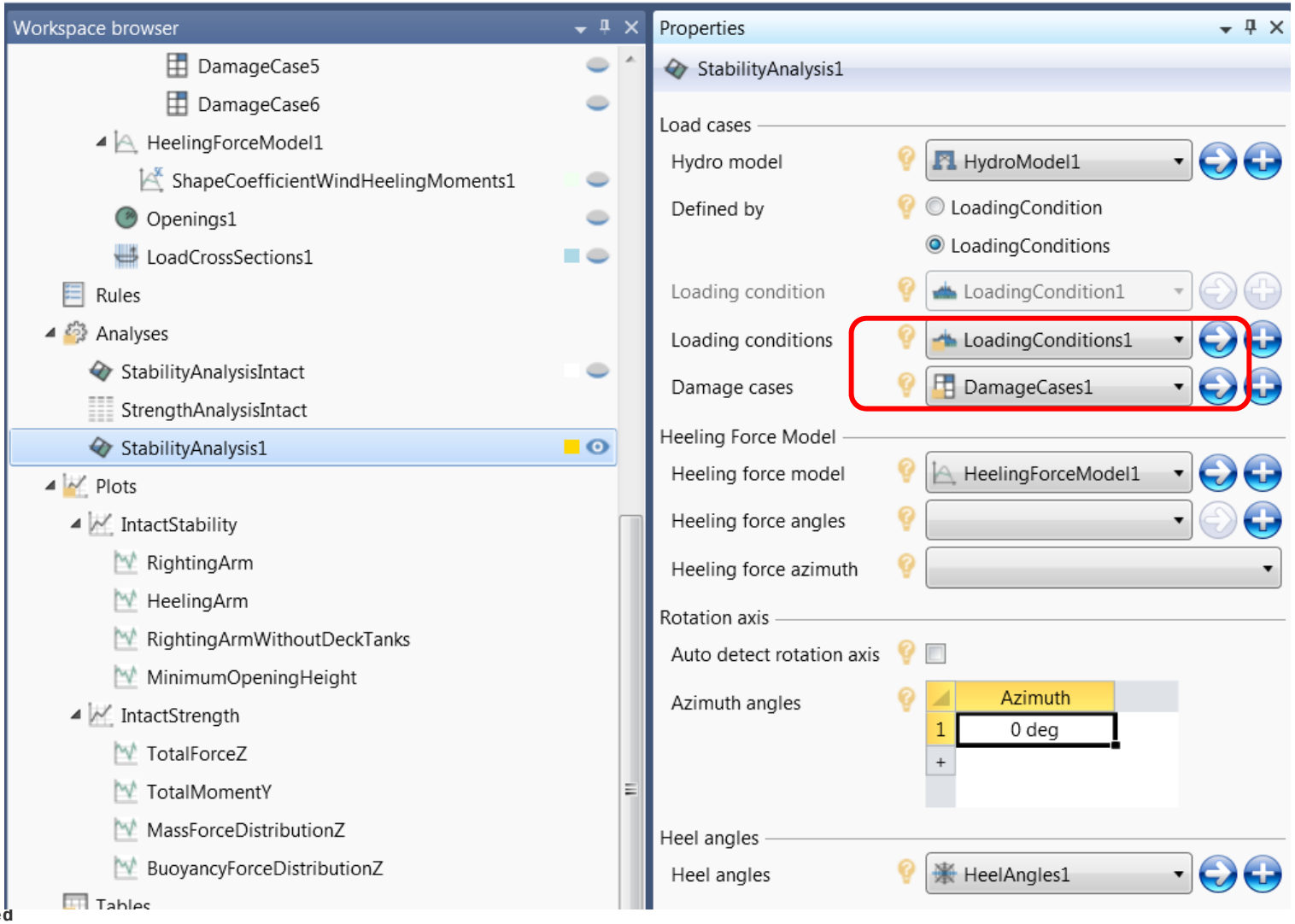
Stability analysis of multiple loading conditions and damages



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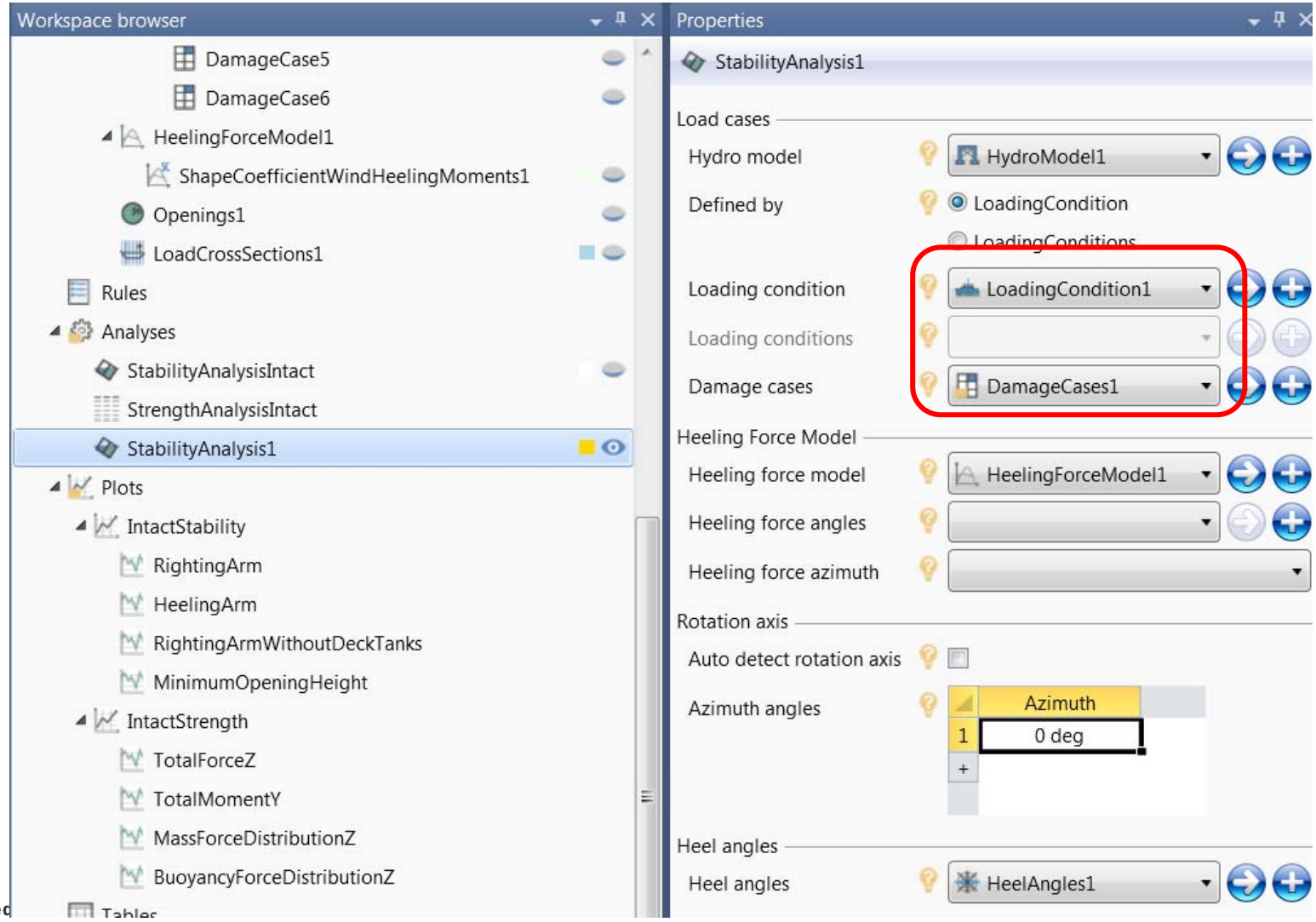
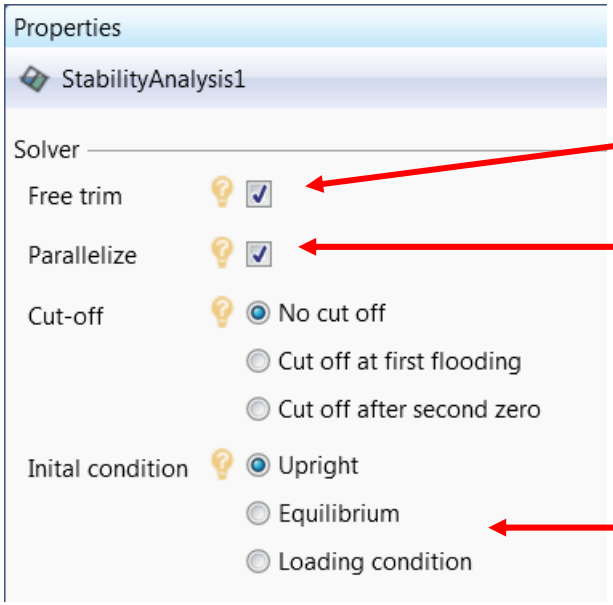
Or combine a single loading condition with a set of damages



Stability properties – Options tab



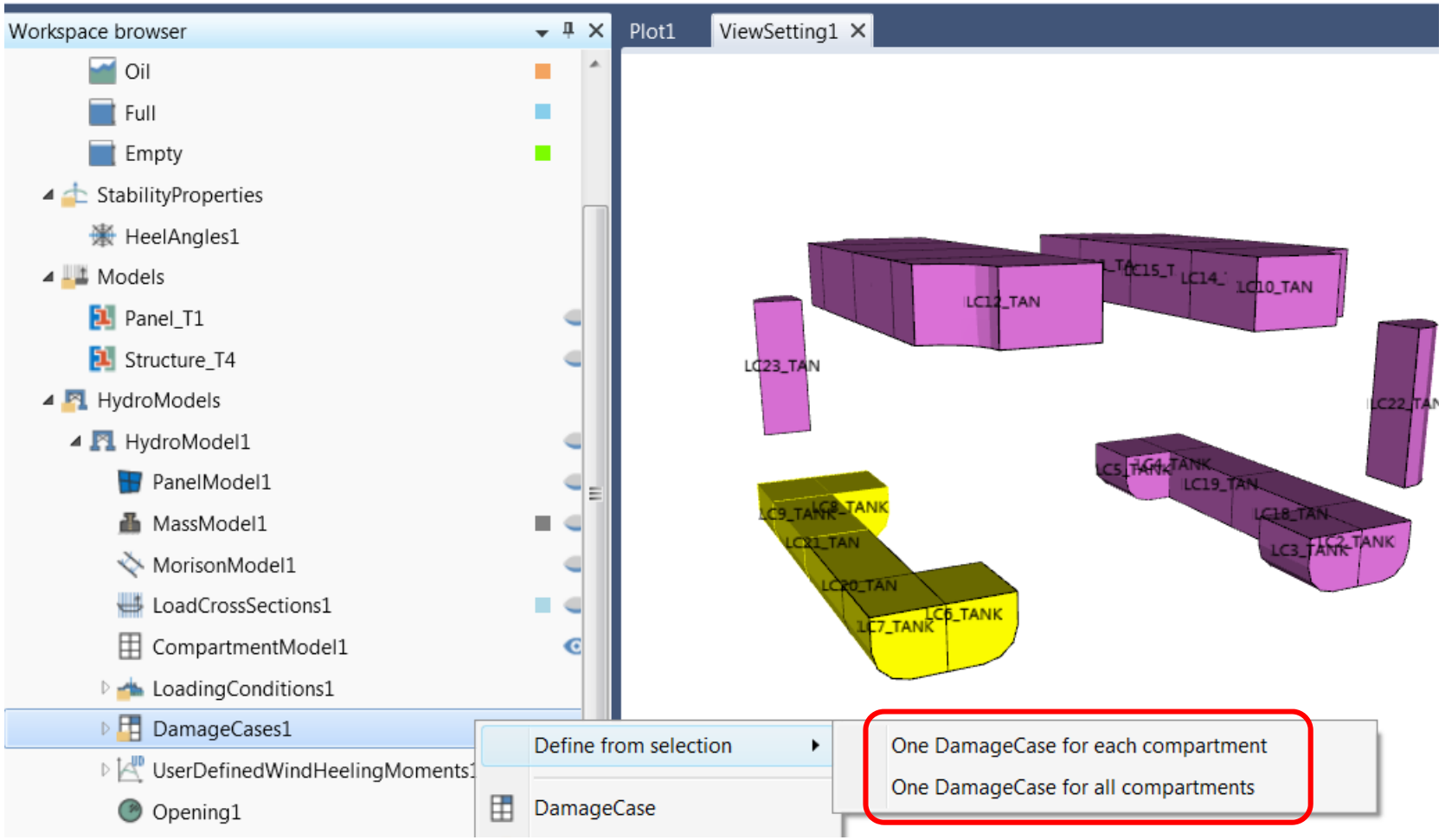
Expensive computation

Run several loading conditions in parallell

(max no given in File, Options)

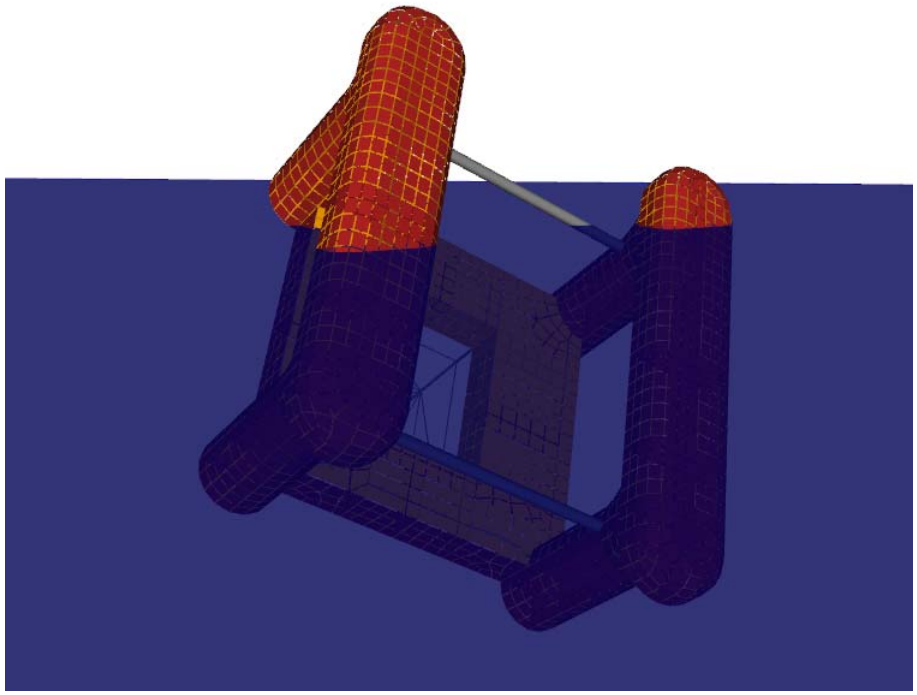
The condition corresponding to zero rotation angle

Quick and easy definition of damages



Robust hydrostatic equilibrium calculation

- Any orientation and damage condition will find equilibrium

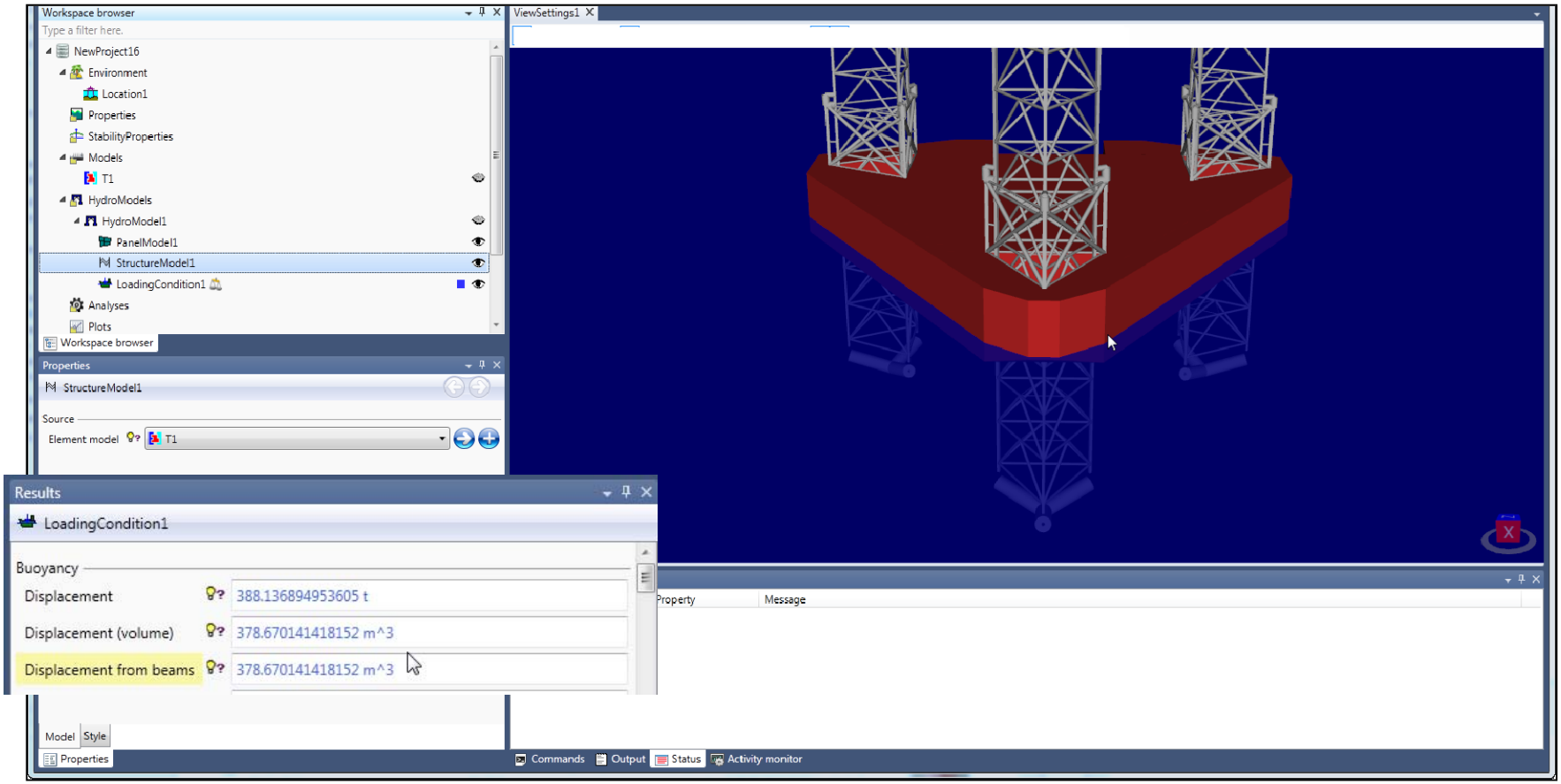


Mass	
Total mass	2.592E+07 kg
Centre of gravity X	1.281E-06 m
Centre of gravity Y	-1.1033E-08 m
Centre of gravity Z	7.6782 m
Dry mass	2.1259E+07 kg
Compartment contents	4.6615E+06 kg
LCG	1.281E-06 m
TCG	-1.1033E-08 m
VCG	7.6782 m
KG	7.6782 m

Balance	
The loading condition is in hydrostatic equilibrium.	
Mass error	1.8626E-08 kg
Relative mass error	7.186E-14 %
X alignment error	-1.281E-06 m
Relative X alignment error	9.8859E-07 %
Y alignment error	1.1033E-08 m
Relative Y alignment error	8.5149E-09 %

Beams contribute to buoyancy

- In hydro statics and stability analysis – the beams contribute to buoyancy



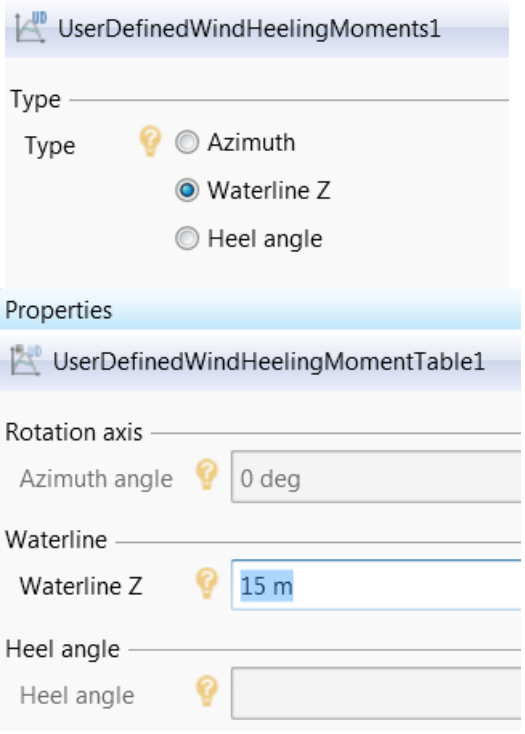
Wind heeling moment calculations

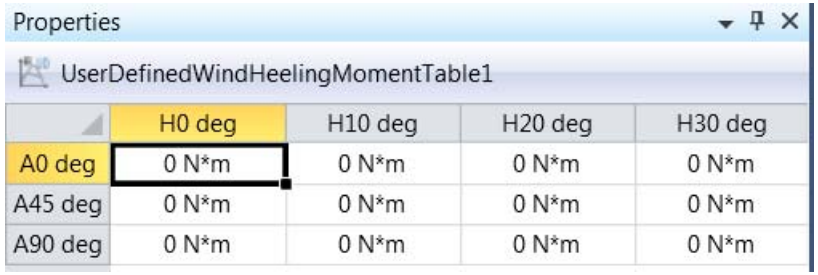
Method	Example	HydroD 4	HydroD 5
User defined	Results from wind tunnel tests	For **single** wind azimuth angle	For **multiple** wind azimuth angles and drafts
Projected area	Ship stability rules	N/A as curve	HydroD calculates projected area and heeling moment curve
Shape coefficients	Offshore stability rules	N/A*	Shape coefficients are specified by the user, HydroD calculates heeling moment curve

* HydroD 4 implements a method based on a blocked empiric grid and drag/block coefficients

User defined wind heeling moments

- The user will be able to input multiple wind directions for AVCG analyses (or KG)
- 3-dimensional input table (Waterline, azimuth, heel angle)
  - Select which parameter to keep fixed
  - Give table for each specified value of the "fixed" parameter
  - Example shows table for azimuth/heel for a given waterline
- Specify the heeling moments
- HydroD will interpolate (linear interpolation) needed
- Copy from Excel is supported

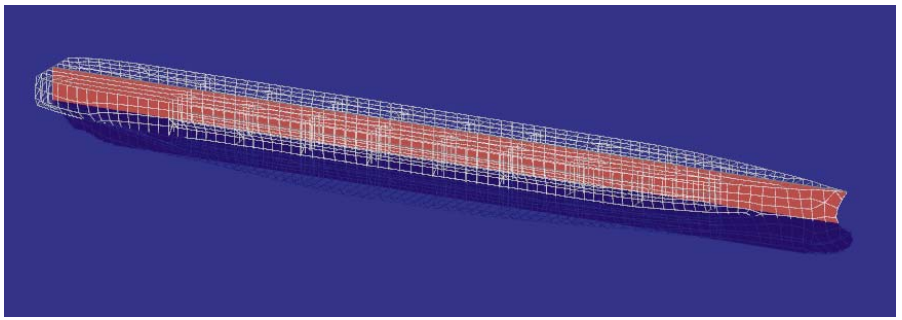




	H0 deg	H10 deg	H20 deg	H30 deg
A0 deg	0 N*m	0 N*m	0 N*m	0 N*m
A45 deg	0 N*m	0 N*m	0 N*m	0 N*m
A90 deg	0 N*m	0 N*m	0 N*m	0 N*m

Wind heeling moments by projected area

- Used by stability rules for ships
- The user must specify grid resolution for projected area calculation
- Wind heeling lever



Containership - projected area (red)

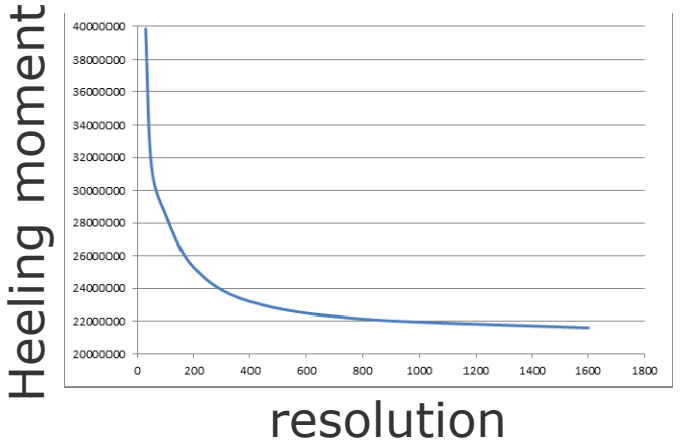
$$l_{w_1} = \frac{PAZ}{1000g\Delta}$$

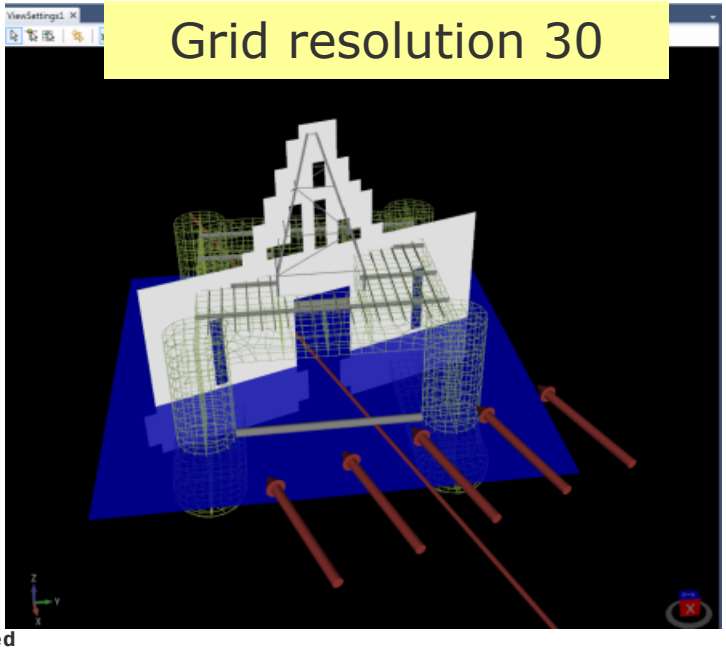
P	Wind pressure	Defined by the rules
A	Projected area	Calculated by HydroD
Z	Vertical distance*	Calculated by HydroD
g	Gravity	Defined by the rules
Δ	Displacement	Calculated by HydroD

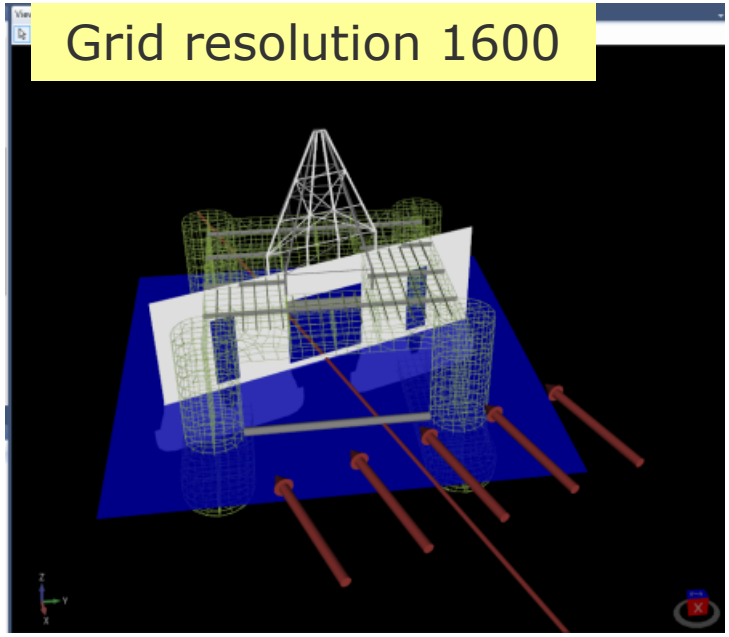
Ung

Projected area grid resolution

- Low grid resolution gives conservative heeling moment, but it is quick to run higher resolutions
  - Resolution 30: 10 sec
  - Resolution 400: 16 sec
  - Resolution 1600: 68 sec







Wind heeling moments by shape coefficients

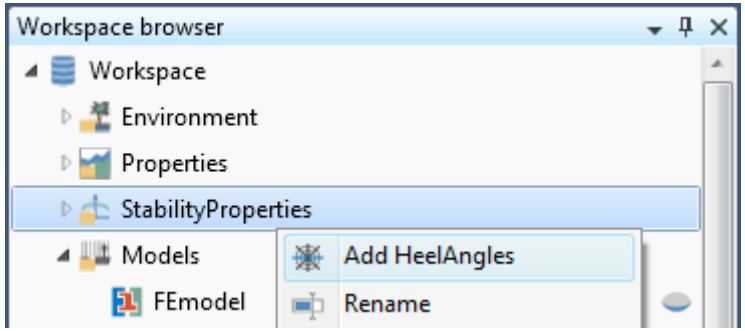
- Used by offshore stability rules
- Wind force (IMO MODU 3.2.3 / DNV OS C301 B101)

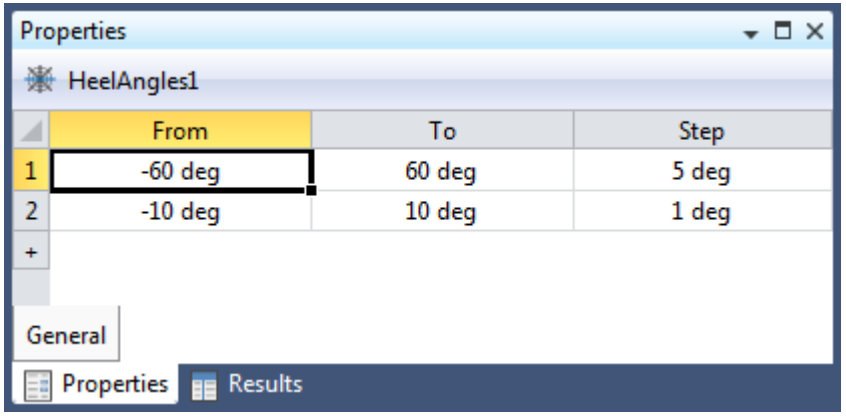
$$F = 0.5\, C_s \cdot C_h \cdot P \cdot V^2 \cdot A$$

C_s	Shape coefficient	Defined by the user
C_h	Height coefficient	Defined by the rules
P	Air mass density	Defined by the rules
V	Wind velocity	Defined by the rules
A	Projected area	Calculated by HydroD

Heel angle input

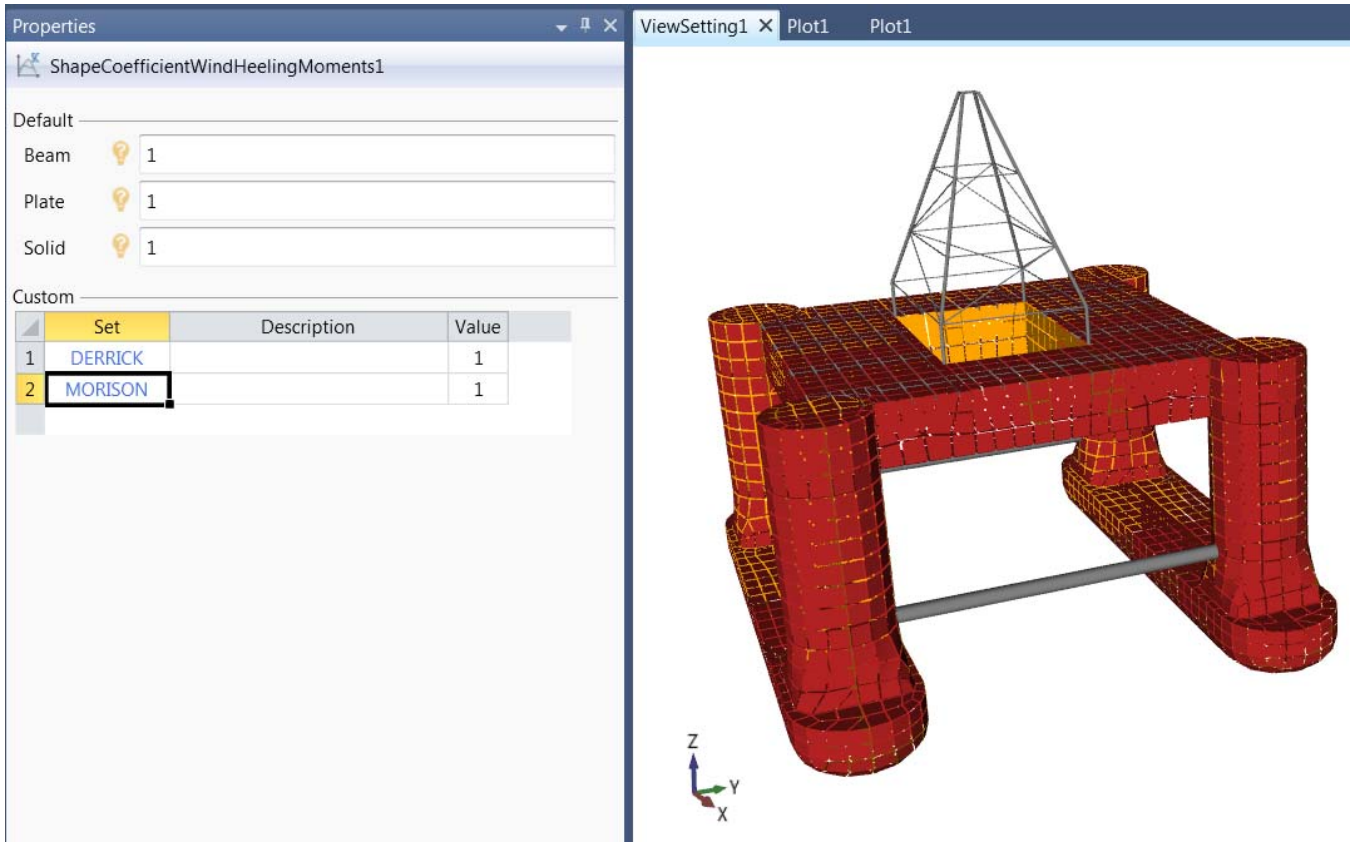
- Defined as a stability property
- Used in the stability analysis





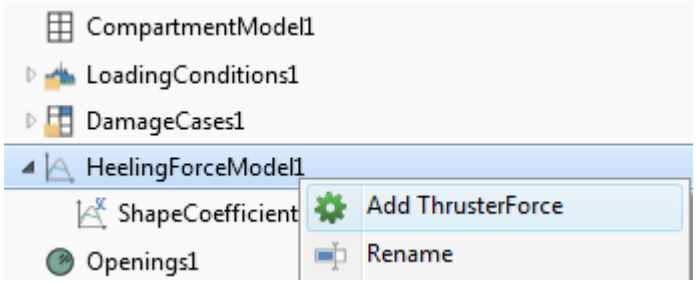
Shape coefficient input

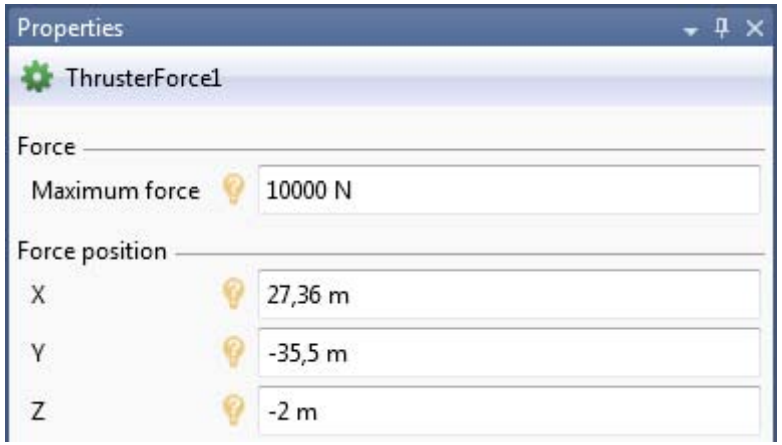
- Assign to set (as predefined in GeniE)
- Assign default to element type

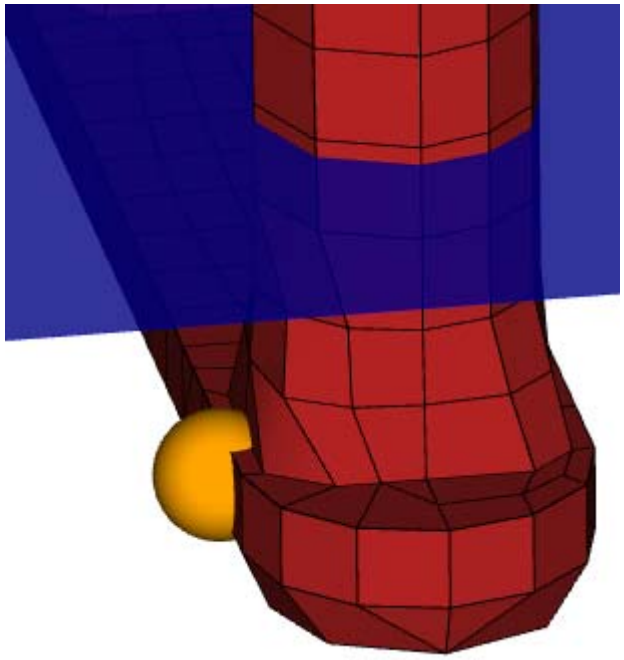


Thrusters

- Define thruster
  - Part of a Heeling force model
    - One resulting thruster in one model
  - Maximum force given
  - Give position

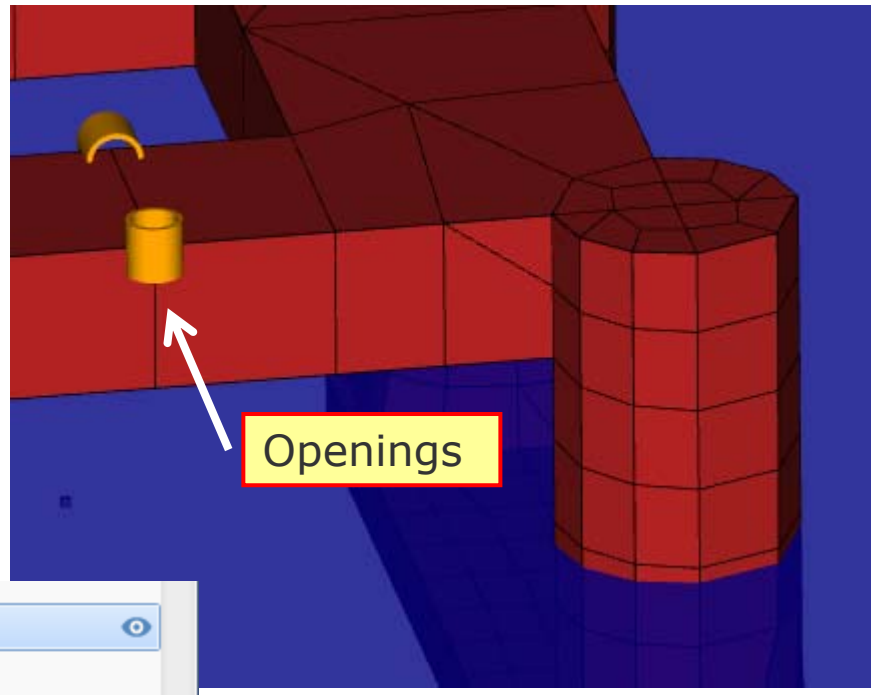


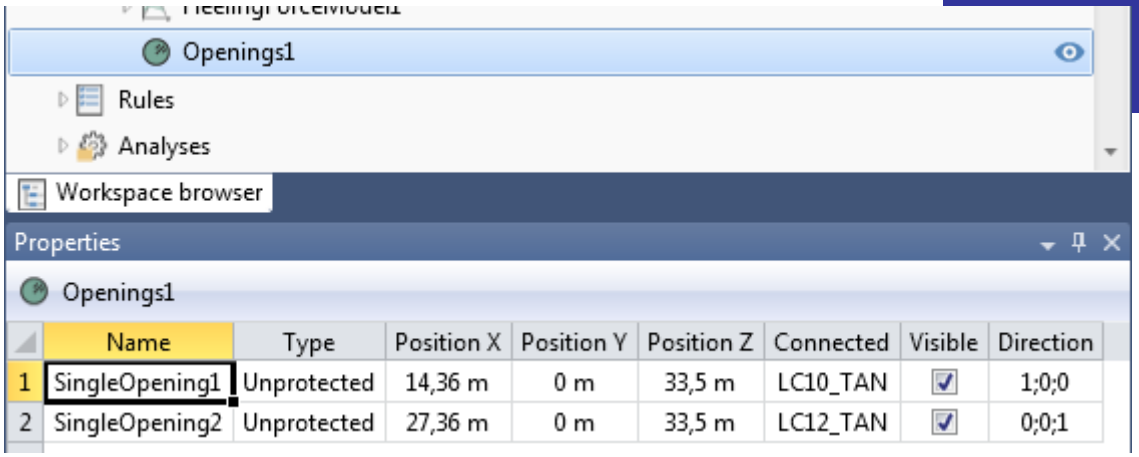




Opening Concept

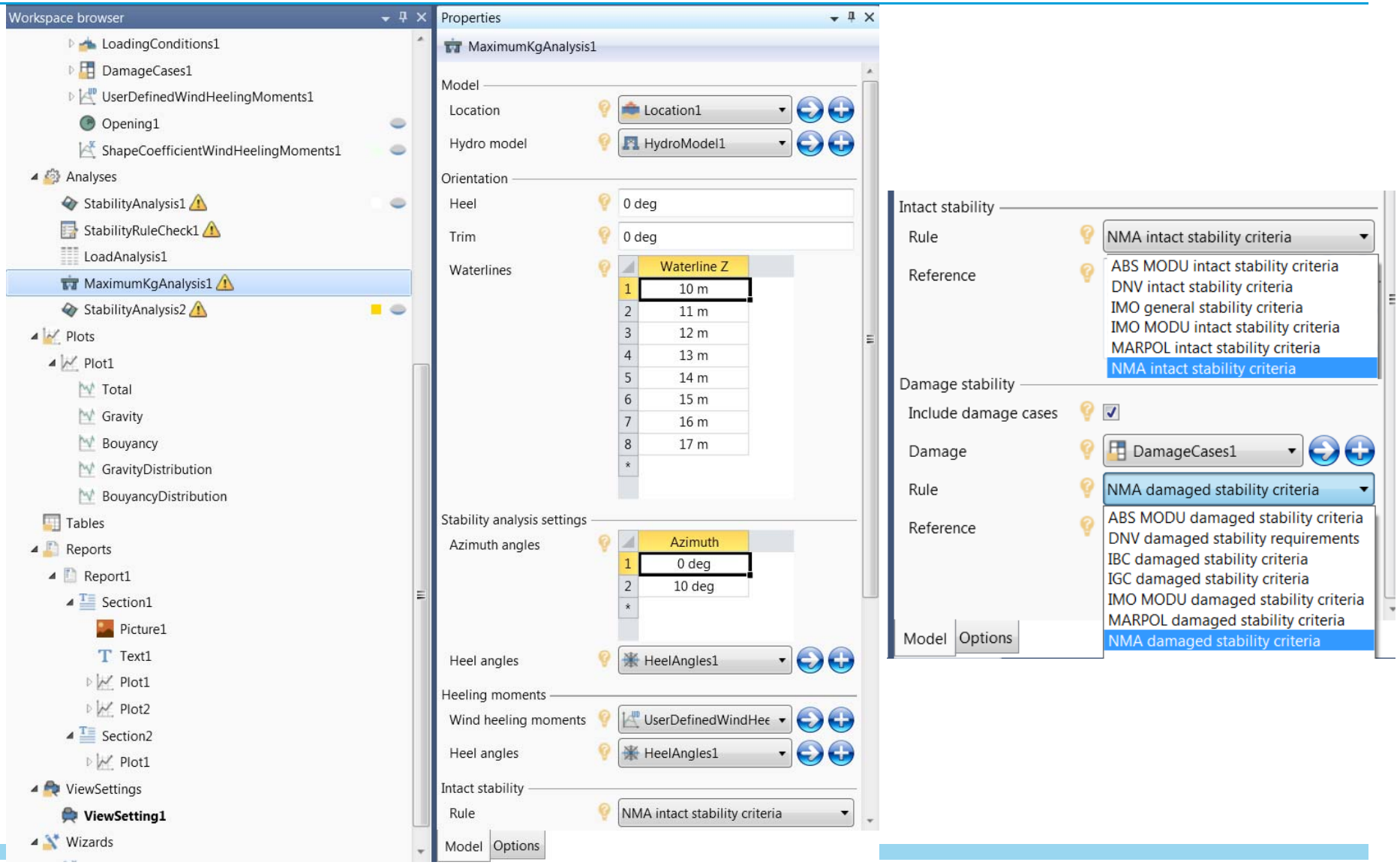
- One or more flooding openings may be defined.
- The distance between the waterline and the opening will be computed and displayed for different heel angles.
- An opening may be connected to a tank. The tank will be flooded when the opening is submerged





	Name	Type	Position X	Position Y	Position Z	Connected	Visible	Direction
1	SingleOpening1	Unprotected	14,36 m	0 m	33,5 m	LC10_TAN	☑	1;0;0
2	SingleOpening2	Unprotected	27,36 m	0 m	33,5 m	LC12_TAN	☑	0;0;1

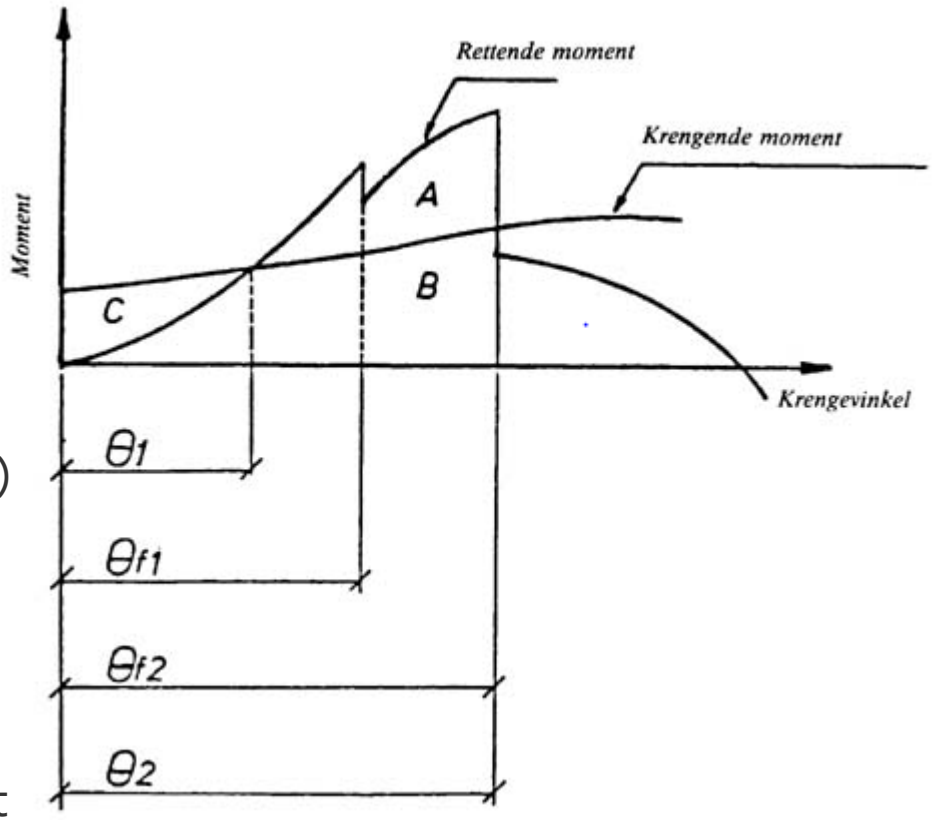
MaximumKG analysis (AVCG analysis in HydroD4)



Rule checks

Intact stability curves

- Criteria are typically related to:
  - Value of the angles
  - Area under righting moment curve vs. area under heeling moment curve
  - Distance from openings to free surface



First intercept (equilbrium with wind)

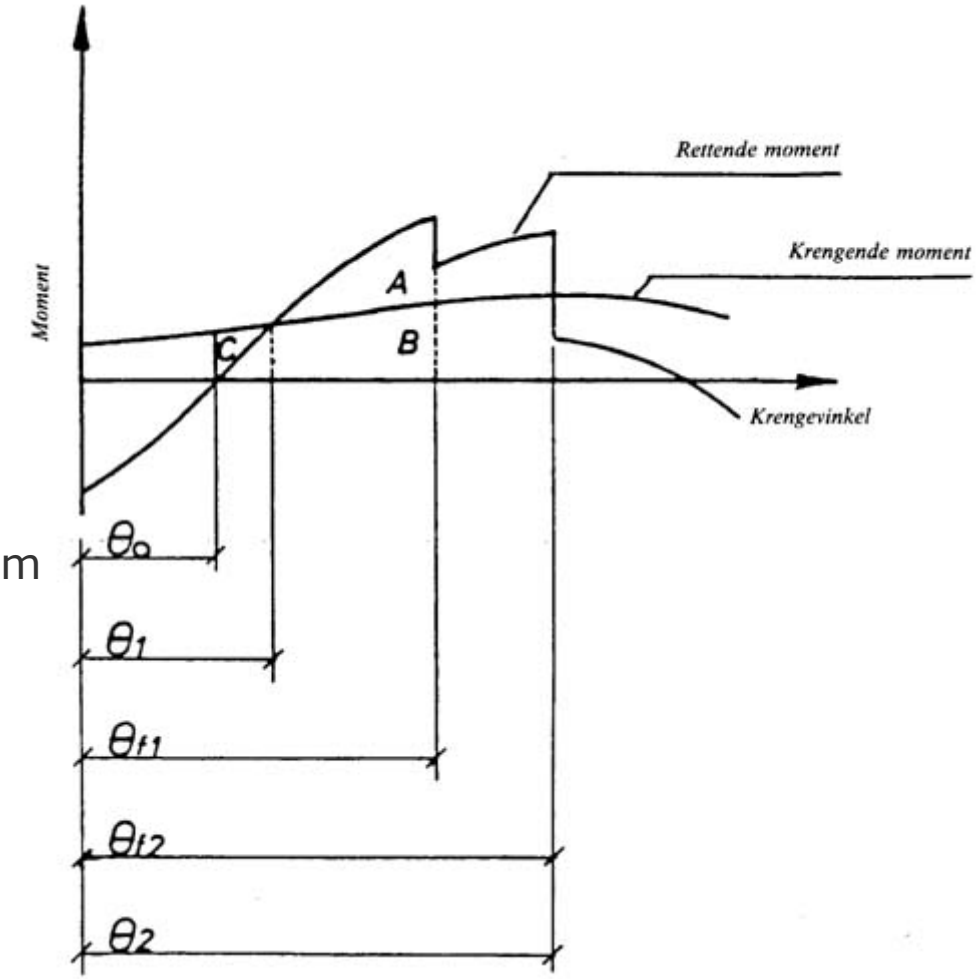
First flooding

Second flooding

Second intercept

Damaged stability diagram

Hydrostatic equilibrium



Typical criteria in the rules

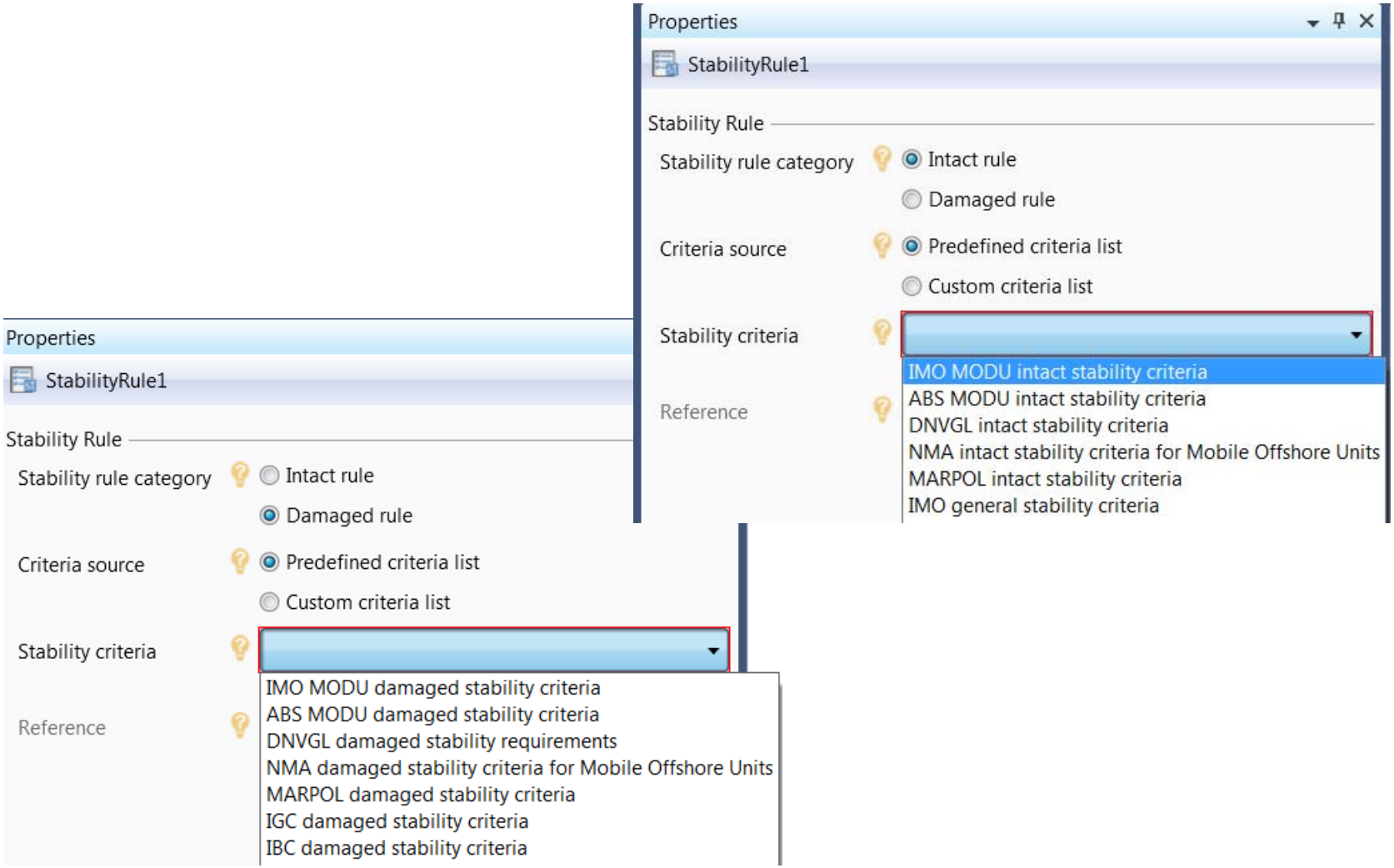
- Maximum or minimum value of angles
- Relation between righting and heeling arm/moment
  - Values
  - Area under curve (=work)

- Example (NMA rules):

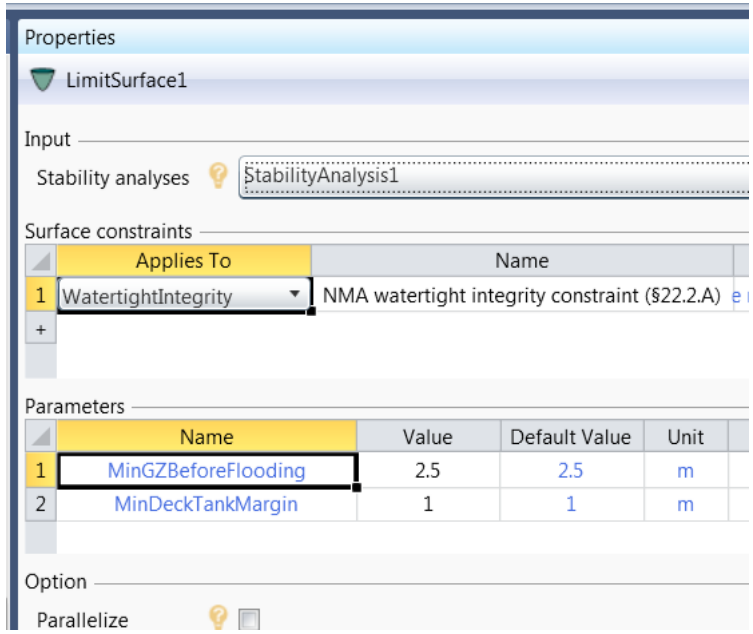
The static angle of heel due to wind shall not exceed 17 degrees in any condition.

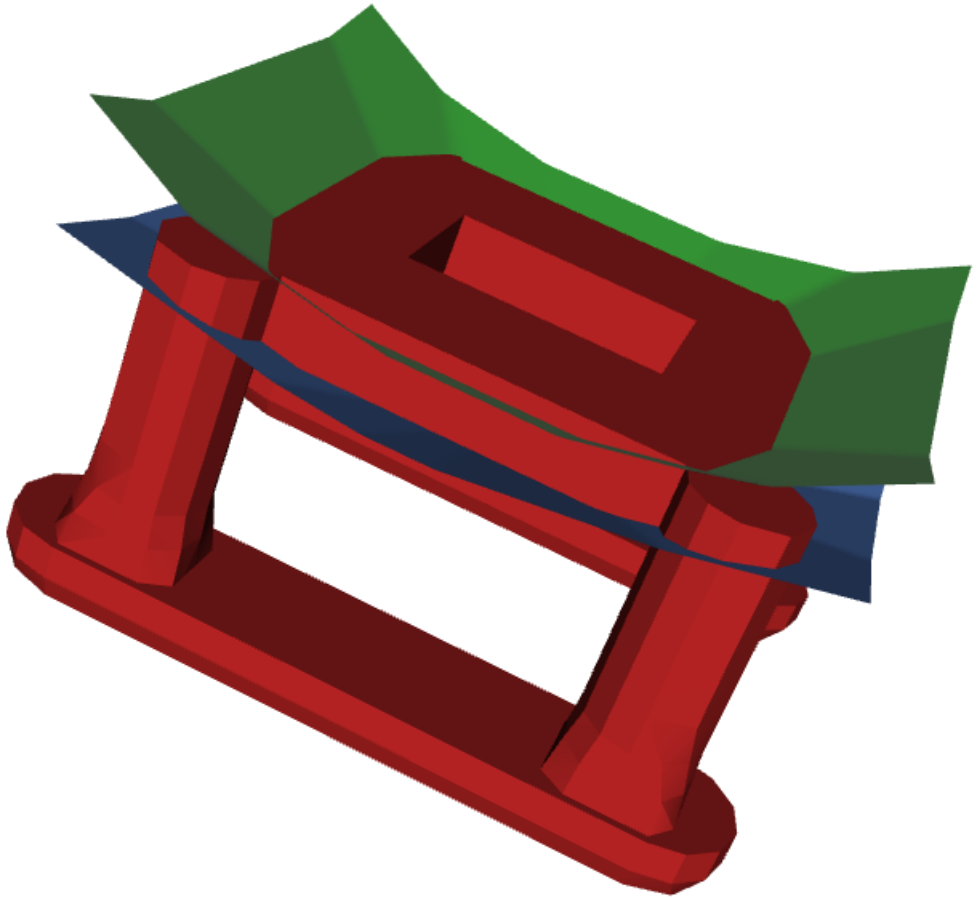
The area under the righting moment curve to the second intercept, or any lesser angle, is not to be less than 30 % in excess of the area under the wind heeling moment curve to the same limiting angle.

All main rule sets supported



Watertight and weathertight integrity surfaces



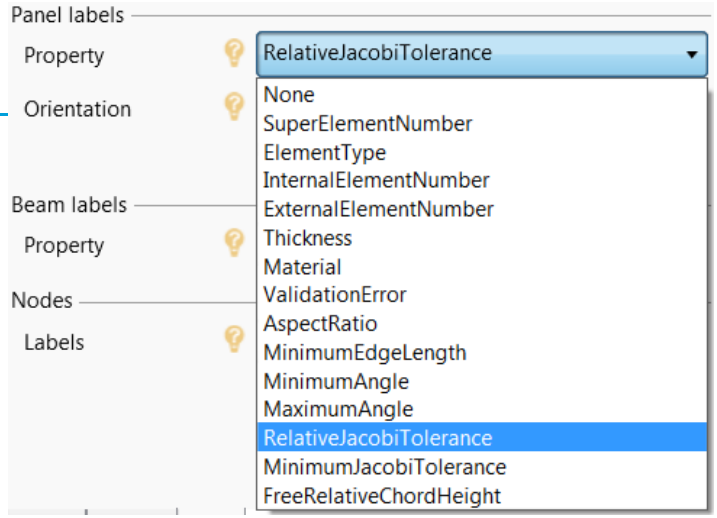


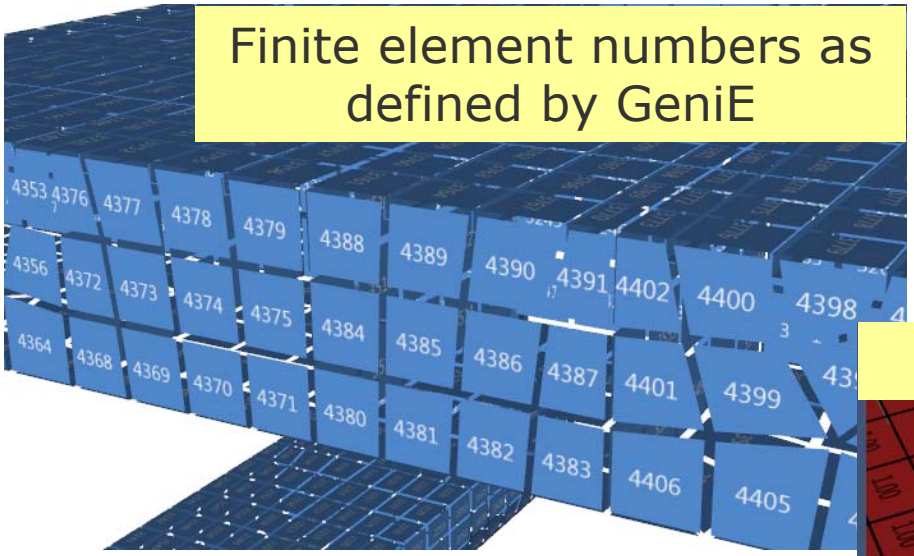
Verification and reporting

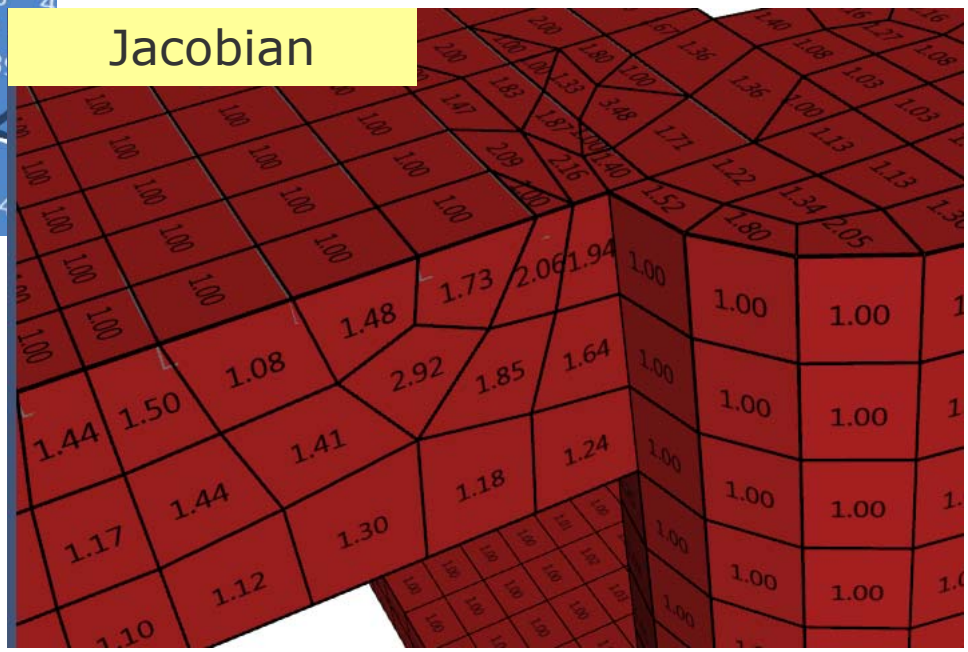
- Verify models and input
- Create reports including pictures, plots and tables
  - Automatically updated after reanalysis

Easier to verify the model inside HydroD

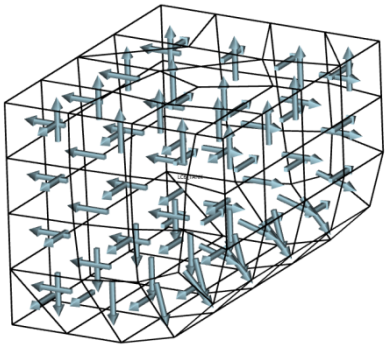
- No need for other tools to view details







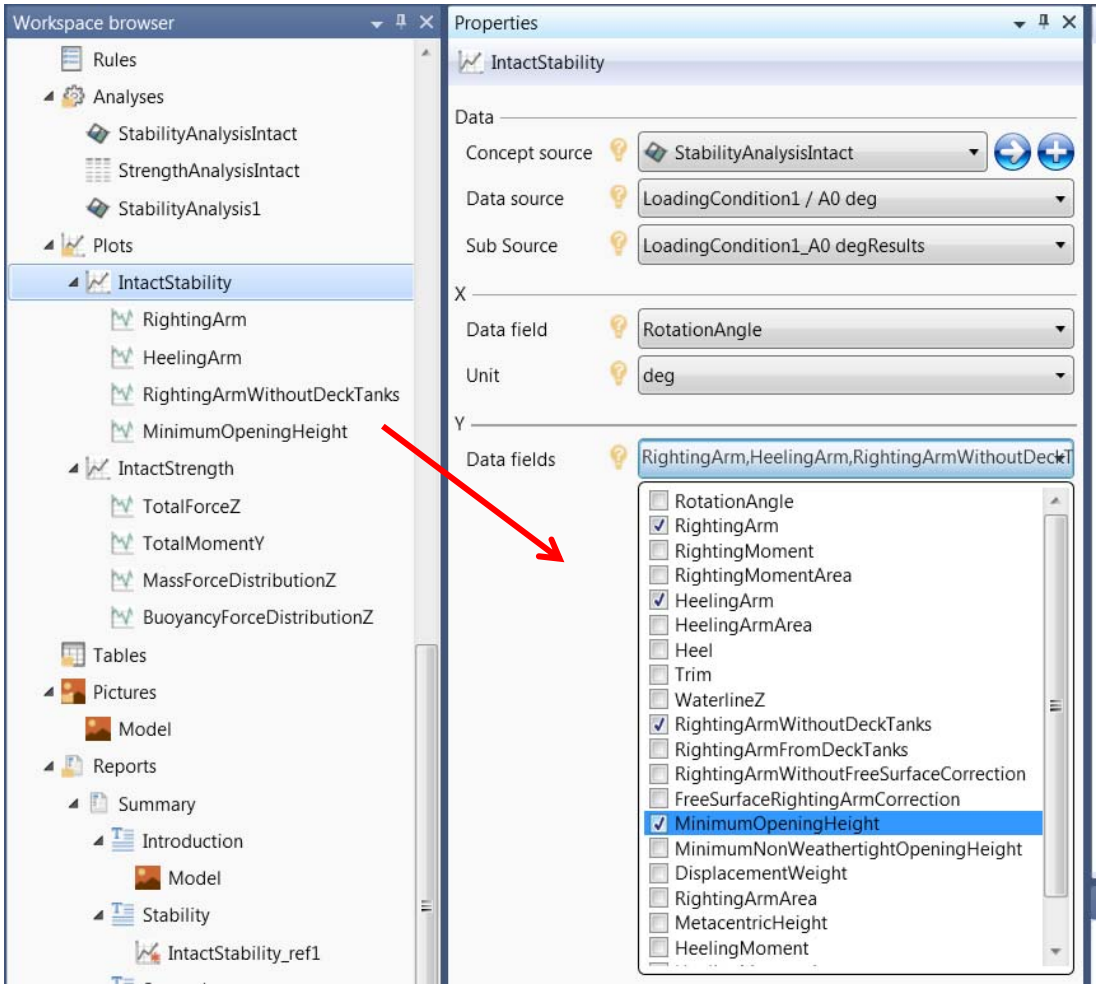
Verify compartments



Ungraded

Reporting engine

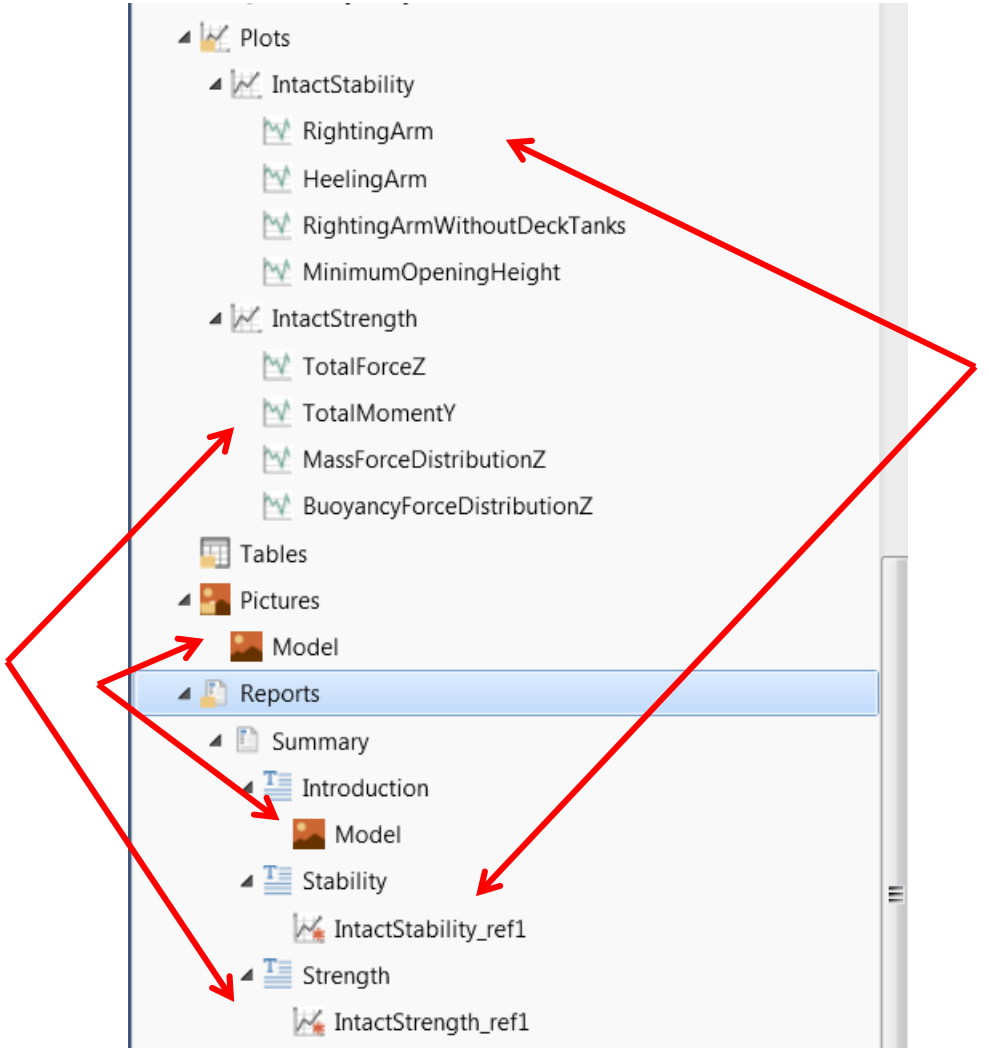
- Define templates for
  - Table
  - Plot
  - Report
- Report style
  - Created in Word format
  - Word templates can be used
- Customize report contents
- Copy/paste report structure
- Regenerate reports at any time
- Reports are part of the scriptable model
- Tables and plots are bound to analysis output



Automatic updating of reports

- Store plots, tables or pictures in separate folders
  - Reuse in many reports (by reference)
- Or store directly in the report

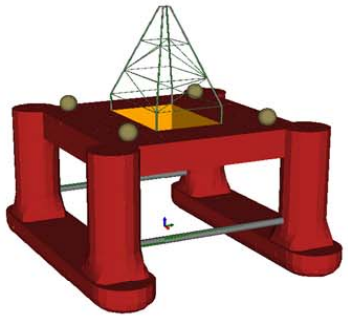
- Tables and plots are automatically updated when the analysis is run again
- Pictures may be static (a fixed picture) or dynamic (based on what is currently displayed in a defined ViewSetting)

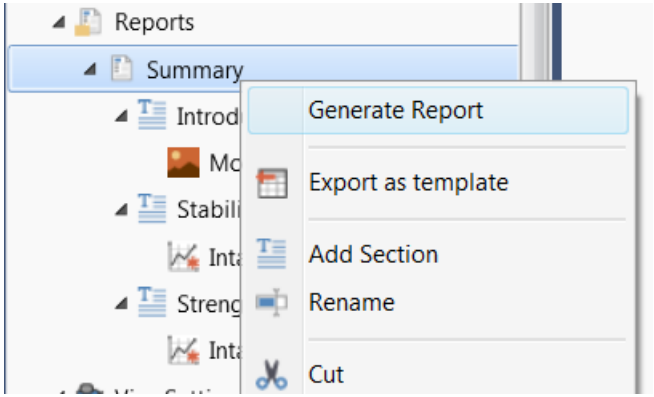


Create reports in Word format using company / project template

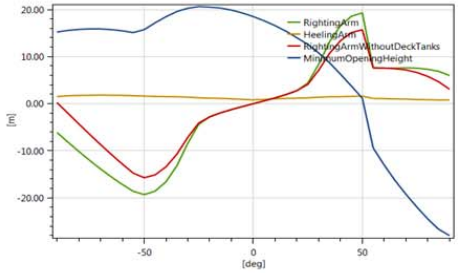
1 THE MODEL TO BE ANALYZED

The example semisubmersible

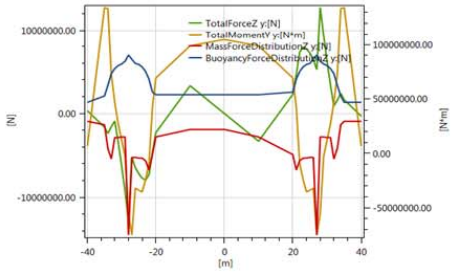




2 RESULTS FROM STABILITY ANALYSIS



3 RESULTS FROM STRENGTH ANALYSIS



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