

Part IV:
MAAT Hydro's Advanced Data Management
Rev. 6.4

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1 Ship Model Components:

1.1 Solids:

B-Rep solids being MAAT Hydro's basic buoyant object, ship's hydrostatic analysis always starts by creating a virtual ship, i.e. ship's B-Rep solid equivalent.

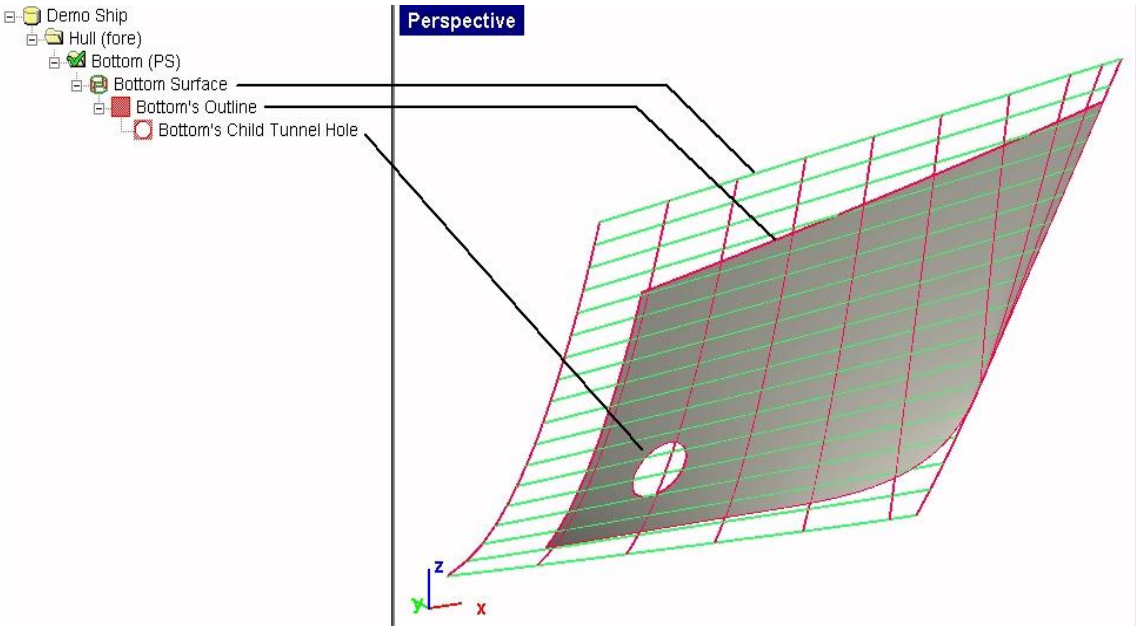
MAAT Hydro's B-Rep solid modelling therefore provides an intuitive, direct and accurate way to describe float's geometry without any limit of complexity and a closer link with ship's hull and surfaces design process.

Hundreds of solids can be used for defining this virtual ship if necessary, this amount being only limited by system's memory and response time.

1.1.1 Solid's Faces:

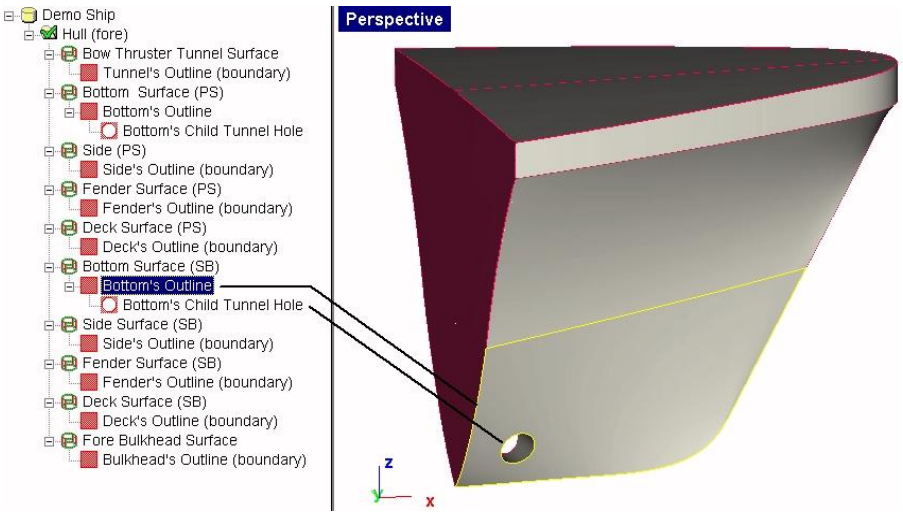
Basically, a B-Rep (Boundary Representation) solid is a closed / watertight set of oriented faces / boundaries delineating the inside and outside of a continuum.

Each of these faces / boundaries is a trimmed surface, that is a parent 3D surface including its trimming curve (Outline) restraining its «existing» part.



Note : The red / green isos shown above are fictitious, simply allowing to materialize outline's parent surface.

Face's outline properties are defined by its layer (see below and "Part I: MAAT Hydro's Quick Interface Tour").



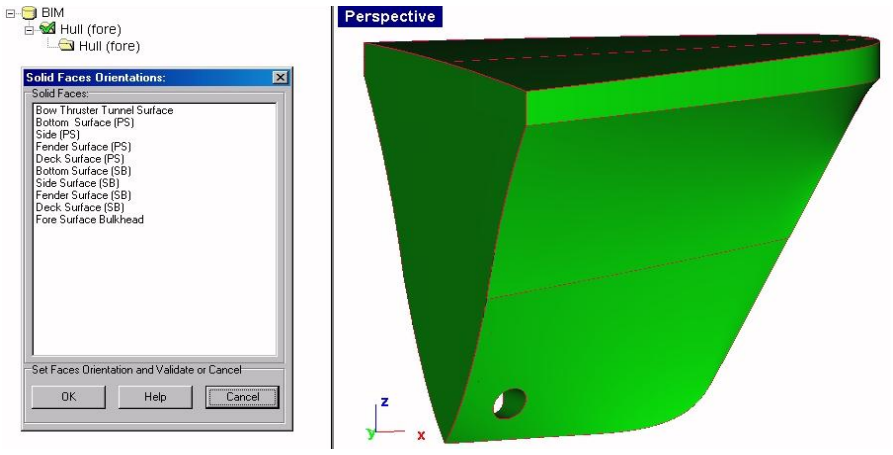
1.1.2 Solid's Faces Orientation:

Like play cards, each solid's face has two sides, the first one being displayed in green (wet side) and the second one in red (dry side).

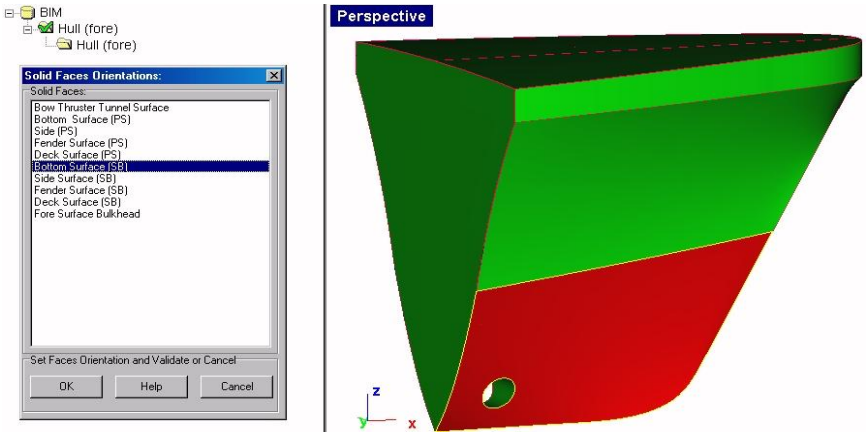
Water's pressure must then necessarily be only applied on the green (wet) sides, in order to be summed correctly for hydrostatic calculations.

Although MAAT Hydro automatically processes solid's face orientation in a transparent way, it is a good habit to control each solid before ship's analysis, orientation errors being, unfortunately, sometimes possible when complex, singular or too small faces are encountered.

When the faces are correctly oriented, only the green sides can be seen from an outer point of view (or, conversely, the red sides from an inner point of view):



When face singularities, leaks, data corruption… cause face orientation errors, red (dry) face side(s) may appear on the green (wet) side, causing potentially significant errors on water's reaction calculation. The orientation dialog box then allows correcting such orientation problems by double clicking on the face(s) to revert:

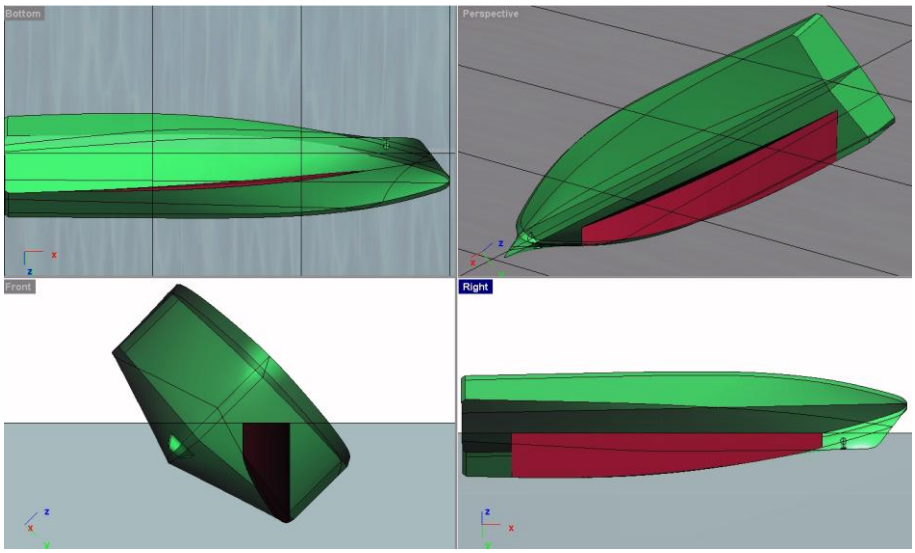


As MAAT Hydro's hydrostatic engine directly integrates water pressure on the immersed faces, it is therefore essential that no red side can be seen from any outer point of view.

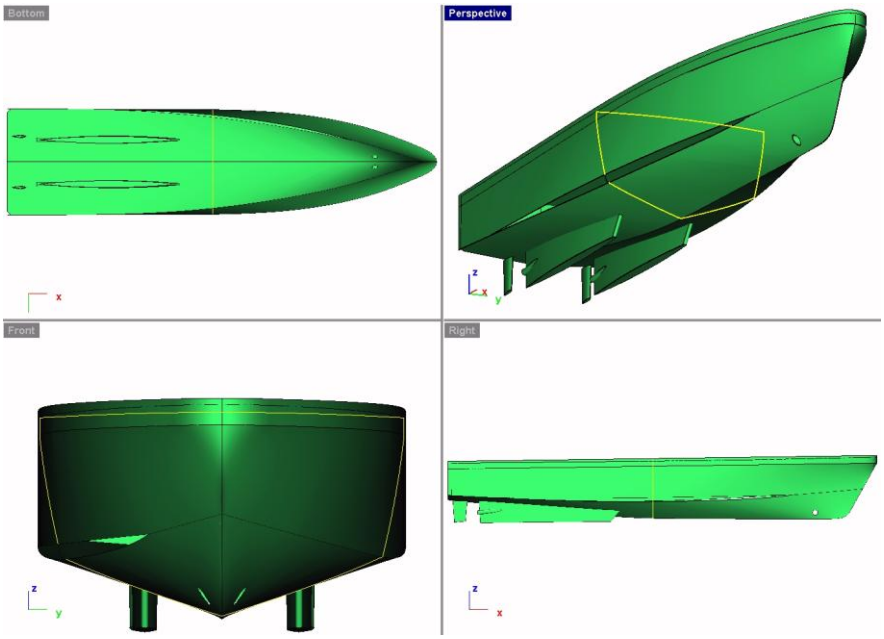
1.1.3 Solid's Faces Connexity:

Although solid's faces connexity has a limited incidence on its hydrostatic features, it is nevertheless important to check that boundary «leaks» between faces are as small as possible.

The incidence of such boundary "leaks" on solid's hydrostatic features can be evaluated by comparing the volume of extruded immersed leaks to the volume of extruded immersed faces:



Simultaneously, it must be kept in mind that a connexity problem may prevent from splitting / sectionning the solid into compartments / tanks when significant «leaks» are intercepted by splitting plane or surface (solid's intersection is not connex and splitting is aborted):



It is therefore a good habit to open the hydrostatic viewport during solid creation, in order to control solid's buoyancy changes simultaneously.

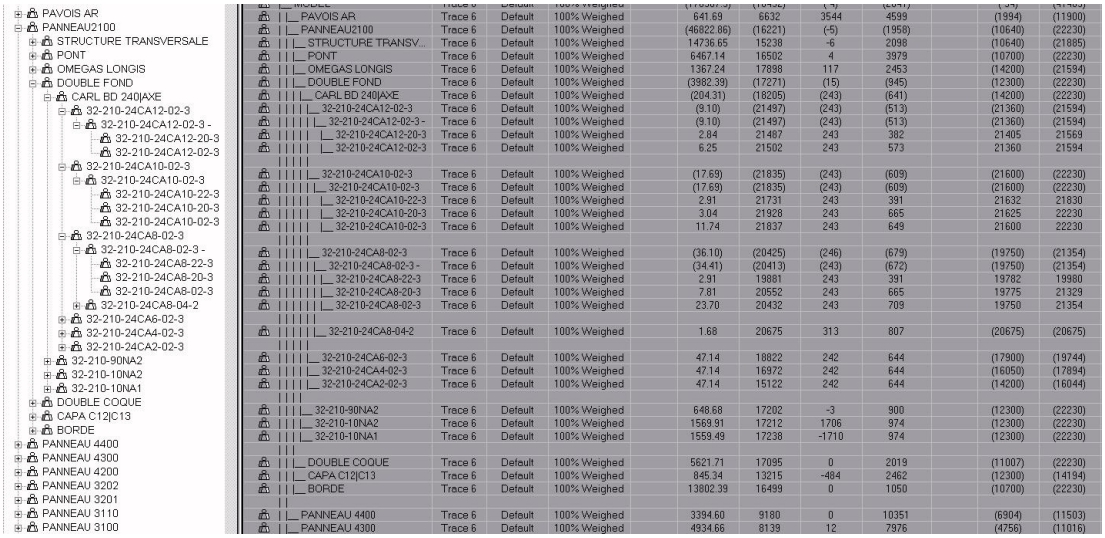
1.2 Masses:

Masses are the necessary counterpart of ship's buoyancy, being therefore necessary for calculating ship's balance.

In order to define ship's masses in a flexible, accurate and convenient way for ship designers, MAAT Hydro therefore also provides a totally recursive mass definition, allowing to combine and weigh any solid and liquid load in real time:

- «Totally recusive» means that you can encapsulate ship's weight estimate items, sub-items, etc… as children, sub-children, etc… of a parent weight estimate item.

- «Weighing solid and liquid loads in real time» means that any project's mass or tank can be weighed instantly by a «Quantity» setting on the [Data] page, interacting in real time with the overall weight estimate and distribution.



Moreover, mass's extension being also necessary for calculating the weight curve and longitudinal strength (see Part III), each mass is finally defined by its Weight, CGx, CGy, CGz, Xmin and Xmax, which can be set individually on project's [Data] page.

Masses describing ship's load can then be directly created and modified on project's [Data] page but, as mass estimates are often available in other software (MAAT 2000, EXCEL, …), they can be directly imported in the project :

- MAAT 2000 Masses and Loadings are directly converted into MAAT Hydro Masses.

- CSV files created by spreadsheets like EXCEL can be directly read in order to recover any previously defined estimate.

1.3 Lines:

Depending on the expected calculations, certain lines may be needed by MAAT Hydro: Ship's silhouette for windage calculations, sheer lines for freeboard calculations, opening lines for downflooding calculations…

These lines can be imported from your 3D modeller with ship's faces / solids, or directly created in MAAT Hydro (see "/Curve" functions in the menu bar).

MAAT Hydro's Line use highly depends on their layer, according to [Ship] tab's [Hydro] page settings.

2 Using Layers Efficiently

Qualifying MAAT Hydro objects by their layer is one of its key concepts. It is therefore important to understand how deeply layers allow controlling important aspects of ship model's features and behaviour.

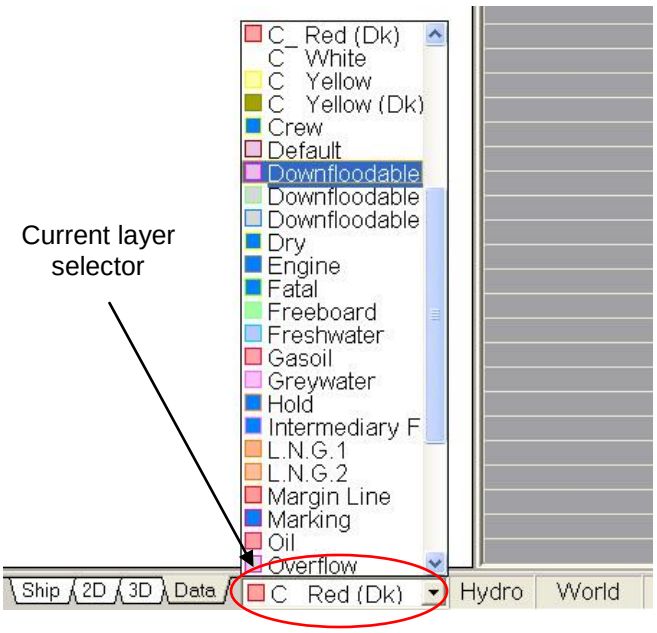
Basically, a layer allows assigning a group of properties to a MAAT object. These layer properties, which can be set on the [Layer] section of the [Ship] page, are the followings:

- Graphic properties.
- Rendering aspect.
- Density.
- Mechanical properties.
- Associated geometry (thickness, section).
- etc…

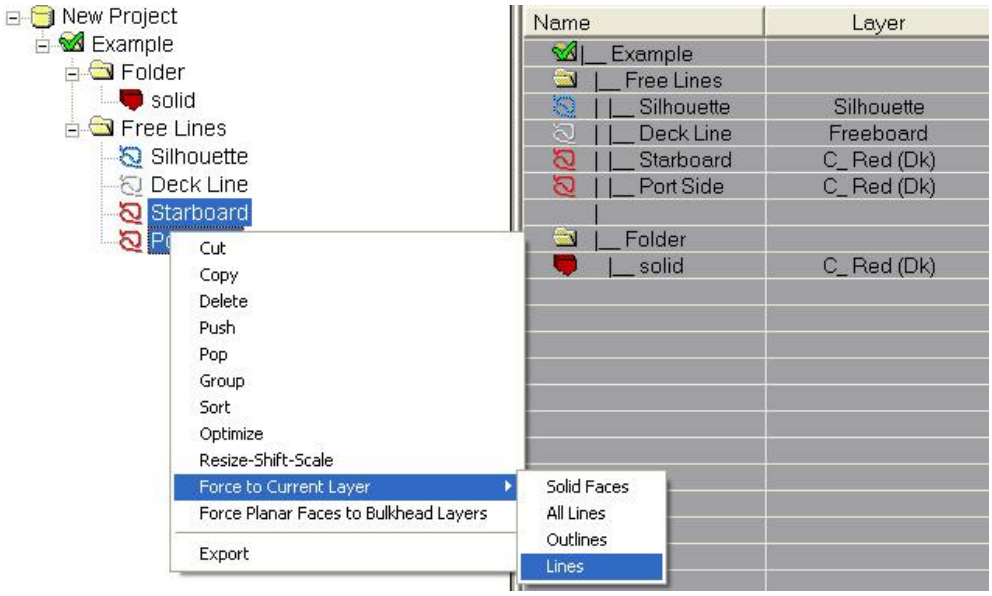
Object's layers can be set in the [Layer] column of the [Data] page.

Moreover, as soon as the items to convert are selected in the 3D browser and the target layer is selected in the current layer selector (at the bottom of the window), the right-click menu provides a set of "**Force to Current Layer**" functions allowing global layer transformations.

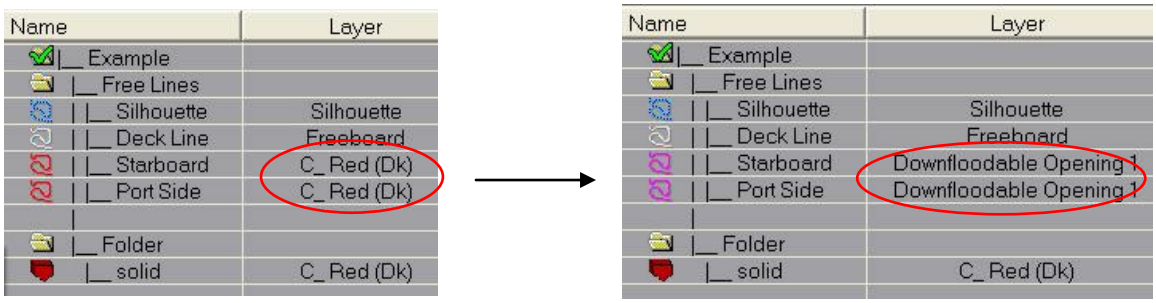
1- Select the target layer:



2- Select objects and then “**Force to Current Layer**” function in the right-click menu:



3- The layers are then converted:



Depending on [Ship] tab’s [Hydro] page current layer selections, object layers allow controlling their incidence on the hydrostatic results as follows:

2.1 Line Layers:

Layer Type	Description
Freeboard Layer	Allows identifying the lines used for freeboard calculations.
Downflooding Layer 1…3	Allows identifying the lines used for downflooding calculations. Different numbers are available, depending on the opening type, whose use depends on the selected stability script.
Overflow Layer	Allows identifying the overflow lines used for defining conditional buoyancies (see “Advanced Buoyancy Management” for more details).
Tank Gauge Layer	Allows identifying tank’s gauges (Not used yet).
Waterplane Trace Layer	Defines water plane’s layer and, therefore, trace’s color / rendering aspect.
Marking Line Layer	Allows identifying the marking lines whose freeboard must be calculated (script dependent, for distinct use of freeboard lines).
Unwettable Line Layer	Allows identifying the “unwettable lines”, whose immersion forces survivability to 0. Unwettable line’s immersion is always tested when it belongs to the current model, but only when its parent is flooded when it belongs to a compartment (immersion calculated according to compartment’s intermediary free surface in case of intermediary flooding, or to current floatation for standard damages).

2.2 Closed Line / Outline Layers:

Layer Type	Description
Silhouette Layer	Allows identifying closed areas for windage calculations.
Sail Layer	Allows identifying closed areas for sail area calculations.

2.3 Face Trimming / Outline Layers:

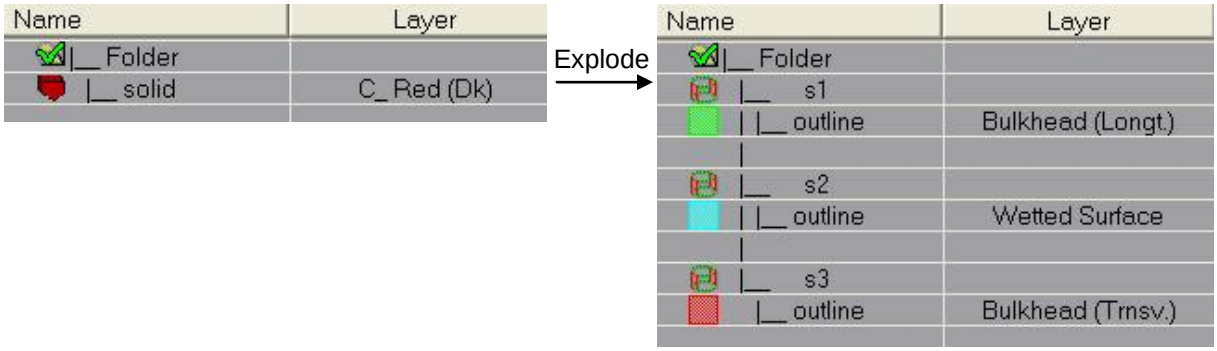
Layer’s Type	Description
Wetted Surface Layer	Allows sorting solid’s “wetted” faces from the others (transom, bulkheads, etc…) for an accurate wetted surface (and therefore plate thickness correction) calculation.
Transversal Bulkhead Layer	Allows identifying the transversal bulkhead faces in the probabilistic transversal subdivision scanning process (for damage stability only).
Longitudinal Bulkhead Layer	Allows identifying the longitudinal bulkhead faces in the probabilistic longitudinal subdivision scanning process (for damage stability only).
Horizontal Bulkhead Layer	Allows identifying the transversal bulkhead faces in the probabilistic horizontal subdivision scanning process (for damage stability only).

2.4 Solid Layers:

Layer's Type	Description
Fatal Compartment Layer	Allows identifying the compartments whose damage forces survivability to 0 (by example: compartments containing vital equipments).
Intermediary Flooding Layer	Allows identifying the damaged compartments in which intermediary floodings must be calculated.

⚠ It is important to stress that solid's layer is totally independent of its face's layers. Solid's layer controls solid's own properties, while face's layers control face properties, as the faces of a single solid can have different layers (for example for identifying wetted faces, transversal, longitudinal and horizontal bulkheads individually).

Exploding a compartment makes this distinction totally clear:



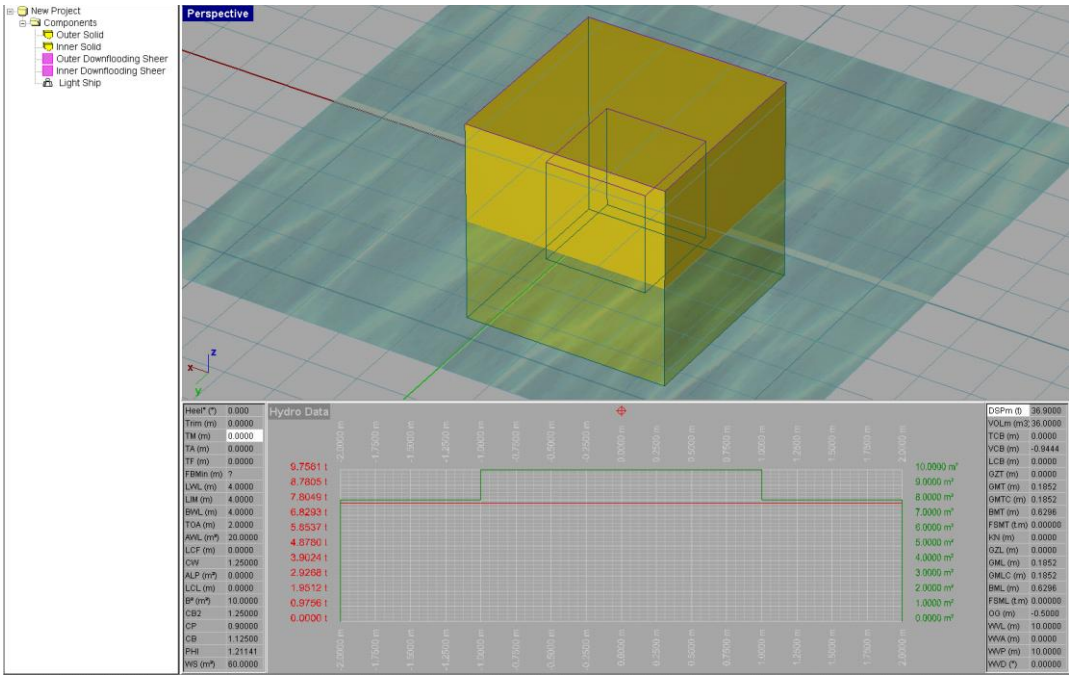
3 Advanced Buoyancy / Liquid Effect Management:

We saw how to modelize ship's mass and buoyancy in Part II, in order to simulate its hydrostatic behaviour in MAAT Hydro.

Now that you have become familiar with the main MAAT Hydro objects and the various ways to create and handle them, let us see how data structure and layer settings can modify their hydrostatic behaviour.

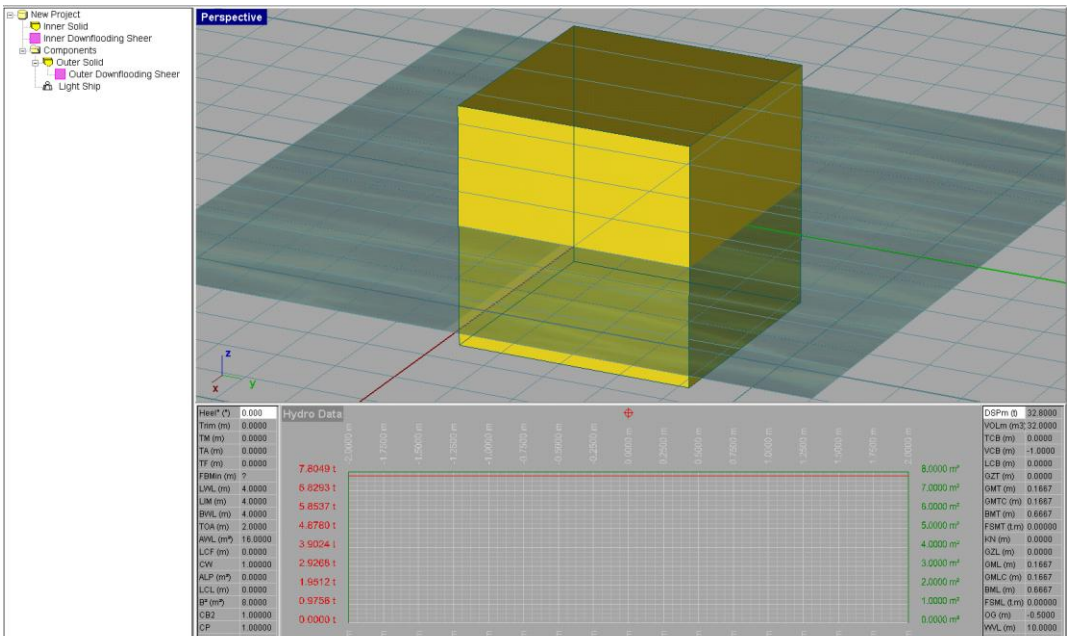
3.1 Incidence of Data Structure:

For this, open «\Demo Files\Float and Tanks.m2a»: This file simply contains a large (4x4x4) and a small (2x2x2) cube, with two purple associated «sheer» lines and a mass named «Light Ship»:



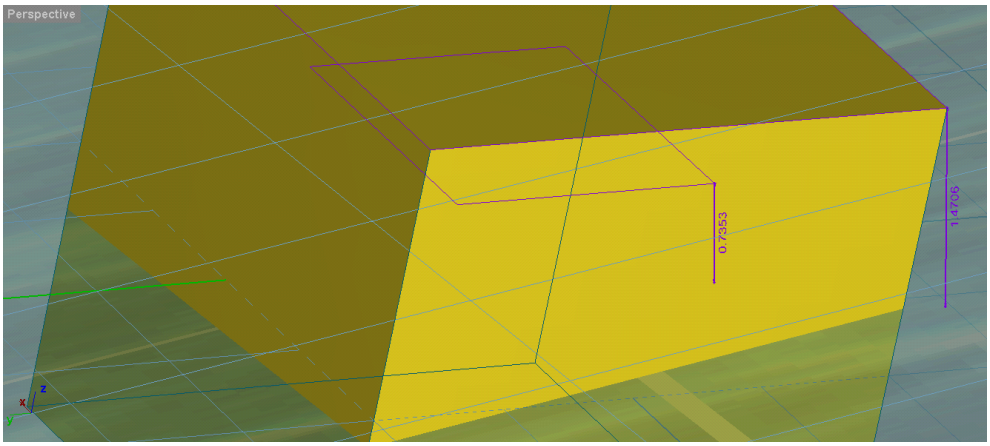
After opening the hydrostatic viewport by clicking on the [Hydro] pane, curve of area's bump shows that something is wrong with this data structure, the immersed volume of the small cube being obviously added to the outer one instead of being subtracted.

By dragging «Inner Solid» out of the «Components» folder, everything will return to normal, showing obviously that <u>solids describing ship's buoyancy must always be clearly disjointed in order to avoid integrating the stacked volumes twice:</u>



On the [Data] page, you will also notice that both purple sheer lines are located in the «Downfloodable Opening 1» layer. These lines have just been set in the «Ship/Hydro/Downfloodable Opening 1» layer in order to allow processing them as openings.

For example, if you select «Show Freeboards» in hydrostatic viewport's right-click menu, the [3D] viewports will now display the freeboards associated to these remarkable lines:

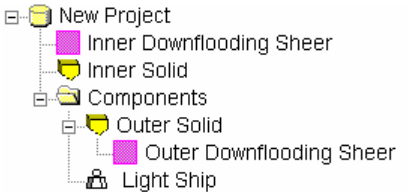


Moreover, you will also notice that setting heel, trim, immersion in the hydrostatic viewport instantly updates the displayed freeboards, immersed openings being automatically highlighted (this default display mode can be cancelled by selecting «Hide Downfloodings» in hydrostatic viewport's menu).

Current min. freeboards also depend on the swell data (WVL, WVA and WVP).

3.2 Compartment's Downflooding / Conditional Buoyancy:

We can now check that including a downflooding line in a compartment makes its buoyancy conditional. Just drag «Inner Downflooding Sheer» out of the «Components» folder and drag «Outer Downflooding Sheer» as child of «Outer Solid» compartment in order to get the following data structure:

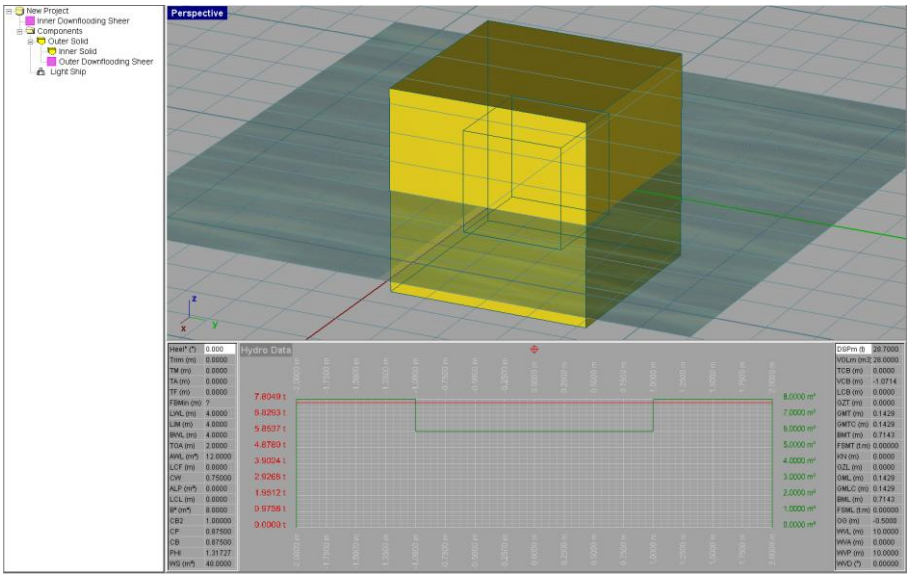


By setting various heels, trims and immersions in the hydrostatic viewport, you will notice that «Outer Solid» remains in the intact state as long as its child «Outer Downflooding Sheer» is not submerged… but «Outer Solid»'s buoyancy will start vanishing as soon as 'his' opening will be submerged, in order to progressively reach the flooded state defined by compartment's permeability.

A closer look to this buoyancy loss mechanism would show that compartment's downflooding is progressive, in order to avoid a too sudden buoyancy change which would disturb ship balance calculation. But this downflooding's «immersion range» can be controlled by setting the «Ship/Hydro/Downflooding Range» parameter: The defaut 0.100 m value means that compartment is considered as totally damaged when openings draft exceeds 0.100 m. Before modifying this value, keep in mind that a too large downflooding range may be unrealistic and a too sharp one may sometimes make ship balance unreachable.

3.3 Compartment's Hole Subtraction:

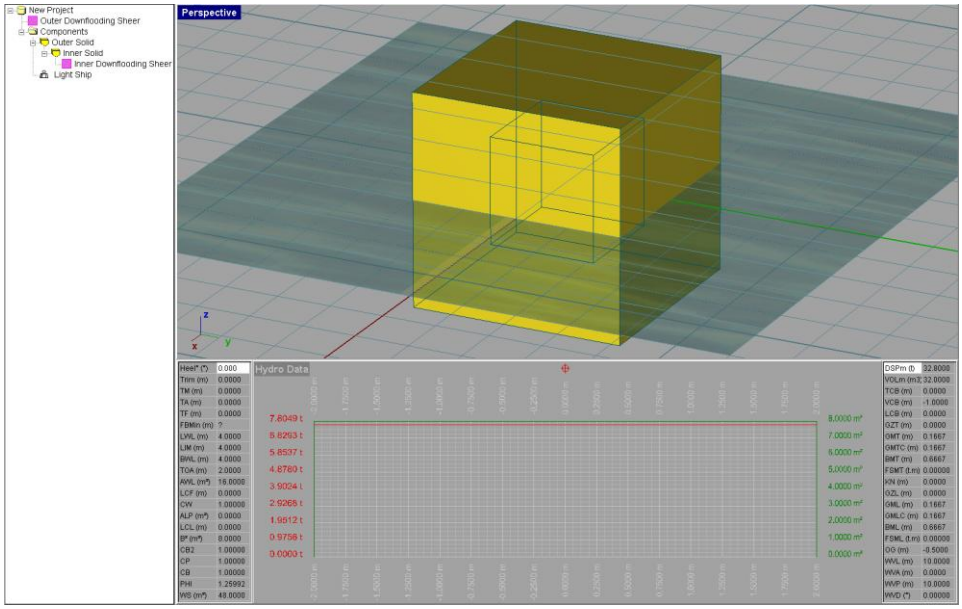
Let us now return to the upright position by resetting Heel°, Trim and TM to 0 (from hydrostatic viewport's right-click menu) and then drag the excluded «Inner Solid» as child of «Outer Solid»: The data displayed in the hydrostatic viewport now clearly show that the immersed volume of the child solid is subtracted from the outer one, which can be considered as the opposite of the initial situation. In other terms, the child compartments of a parent compartment are considered as holes:



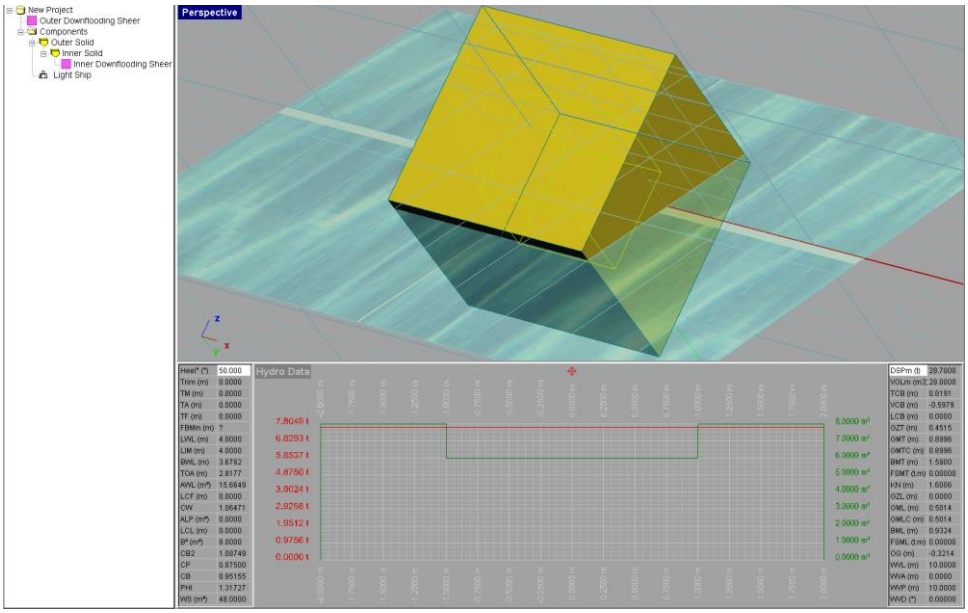
On the [Data] page, the overall buoyancy of such a hollow compartment can be controlled by setting its quantity, exactly like for an ordinary compartment. Moreover, as long as the opening «Outer Downflooding Sheer» will belong to the parent compartment, its overall buoyancy will depend on the immersion of this line.

3.4 Compartment's Conditional Hole Subtraction:

On the other hand, it is now interesting to drag «Outer Downflooding Sheer» out of «Components» and drag the previously excluded «Inner Downflooding Sheer» as child of «Inner Solid». The hydrostatic viewport now shows that the child compartment is no longer processed as a hole… as long as «Inner Downflooding Sheer» is not submerged…



… and begins to be processed as a hole when «Inner Downflooding Sheer» is submerged:



We can therefore conclude that <u>including a downflooding line in a child compartment makes its buoyancy «inversely» conditional.</u> For example, this mechanism allows modelling the conditional loss of buoyancy resulting from a cockpit downflooding.

Using both «Outer Downfloodable Sheer» and «Inner Downfloodable Sheer» in this model would be meaningless.

3.5 Tank's affiliation to a Compartment:

Let us now come back to the [Data] page in order to :

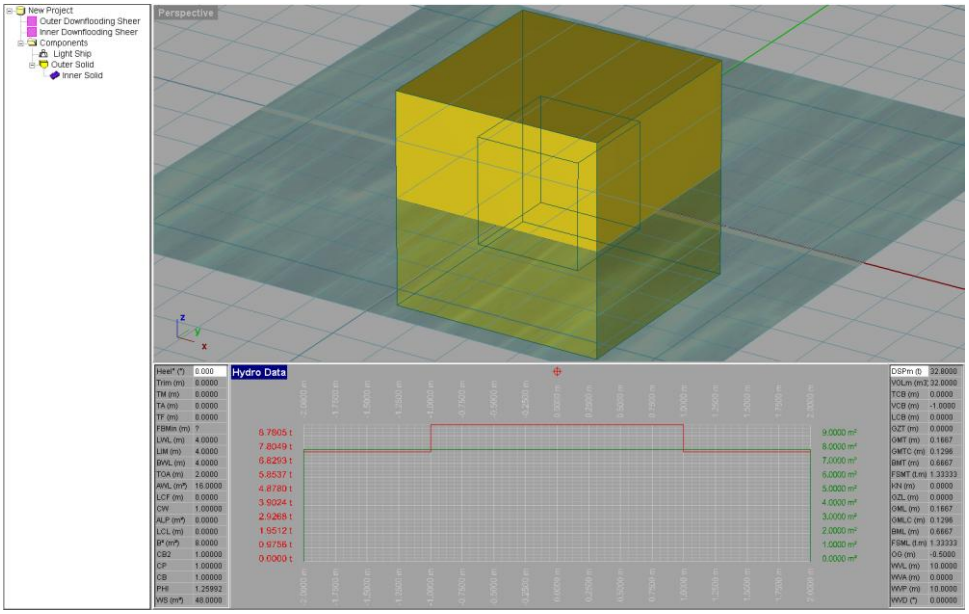
- Transform «Inner Solid» into a tank, remembering that this data structure corresponds to the on we used in Part II for affiliating tanks to parent compartments.

- Set tank's content to «Fresh Water» and its filling to 50%.

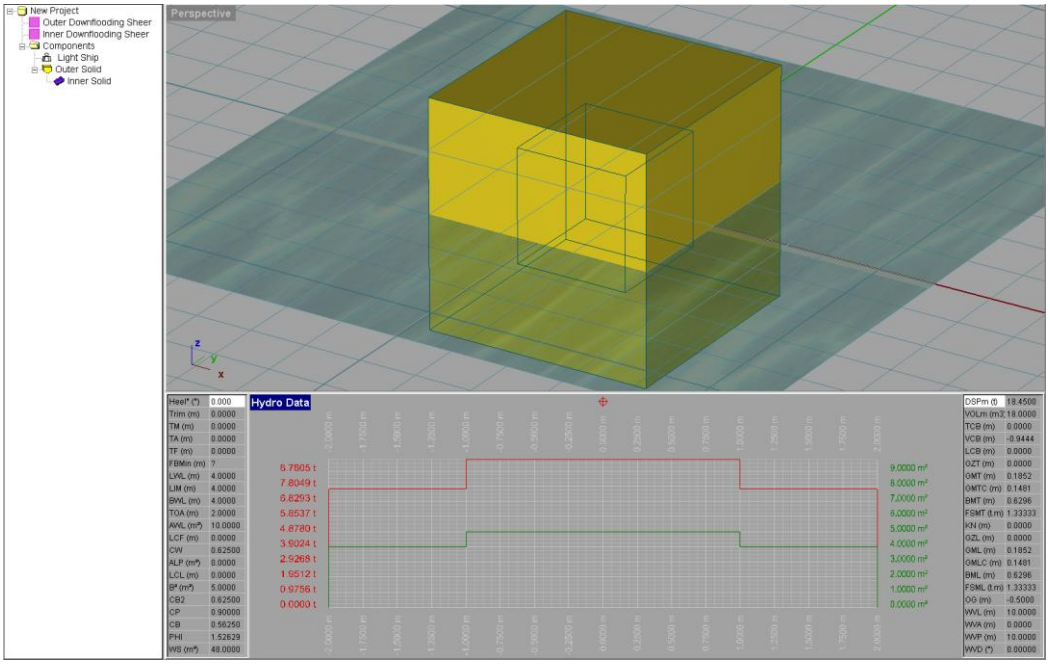
A tank being supposed to be watertight in order to be able to contain a liquid, the conditional buoyancy mechanism we have described above for compartments is meaningless for tanks.

We will therefore drag «Inner Downfloodable Sheer» out of the calculated data in order to return to the data structure used in previous example.

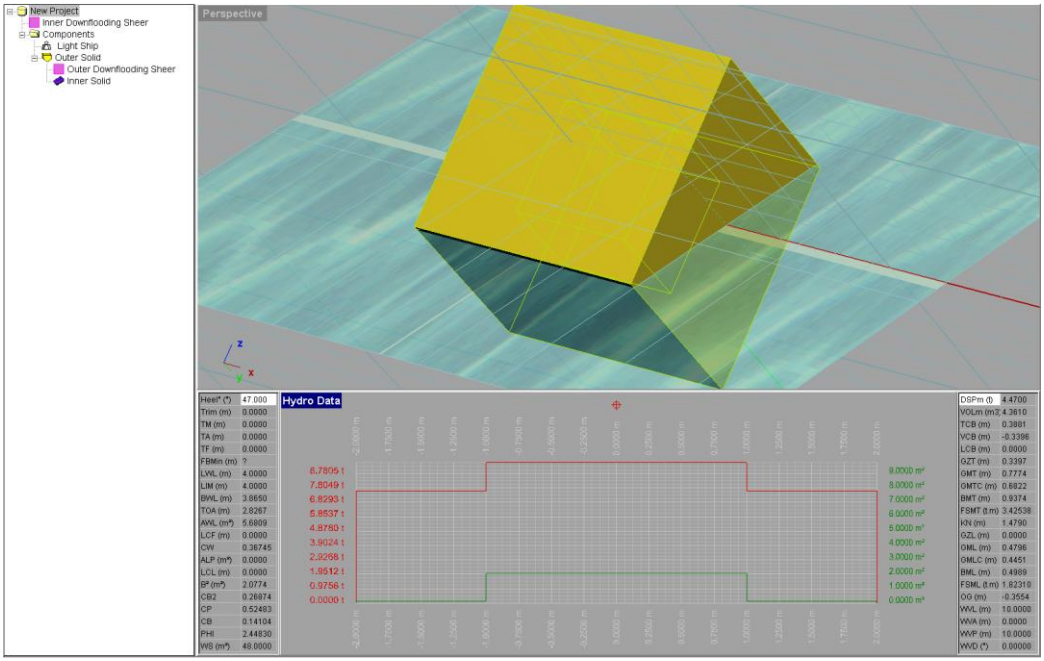
As seen previously, the hydrostatic viewport shows that, contrary to child compartment(s), the child tanks of an intact compartment have no incidence on its buoyancy, only increasing liquid effect / ship load , as shown by the (red) weight curve:



But when the parent compartment is damaged, the buoyancy of child tanks is taken into account, depending on compartment's flooding. To check this important feature, just reduce parent compartment's permeability to 50% on the [Data] page: The (green) curve of areas shows clearly that flooded compartment's 50% loss of buoyancy now lets appear 50% of tank's buoyancy:



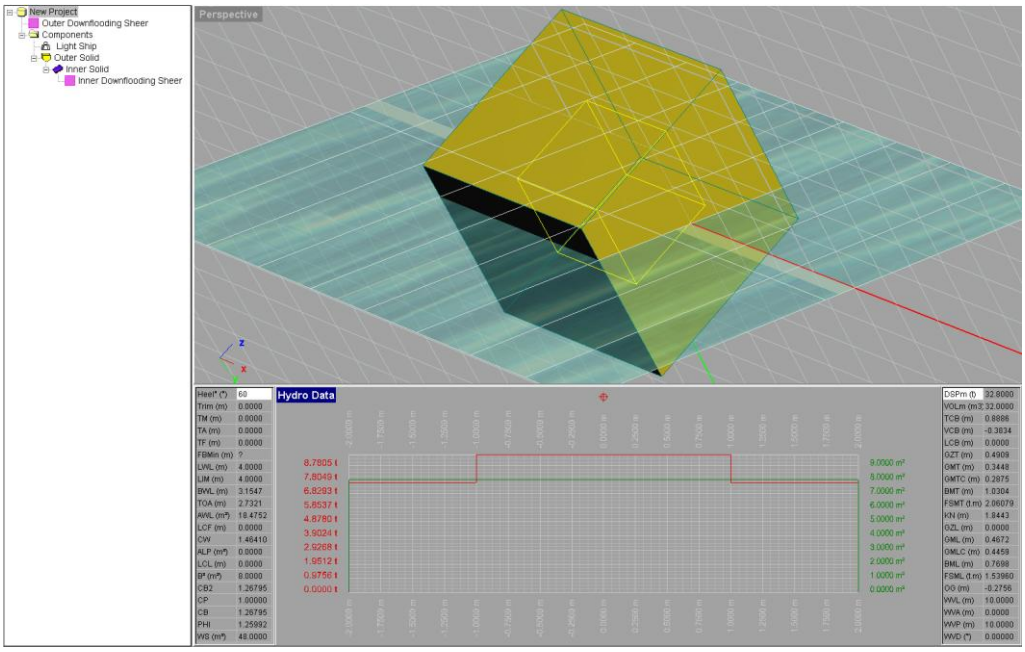
Like previously, dragging «Outer Downflooding Sheer» as child of the parent compartment will make its damage conditional, depending on line's immersion:



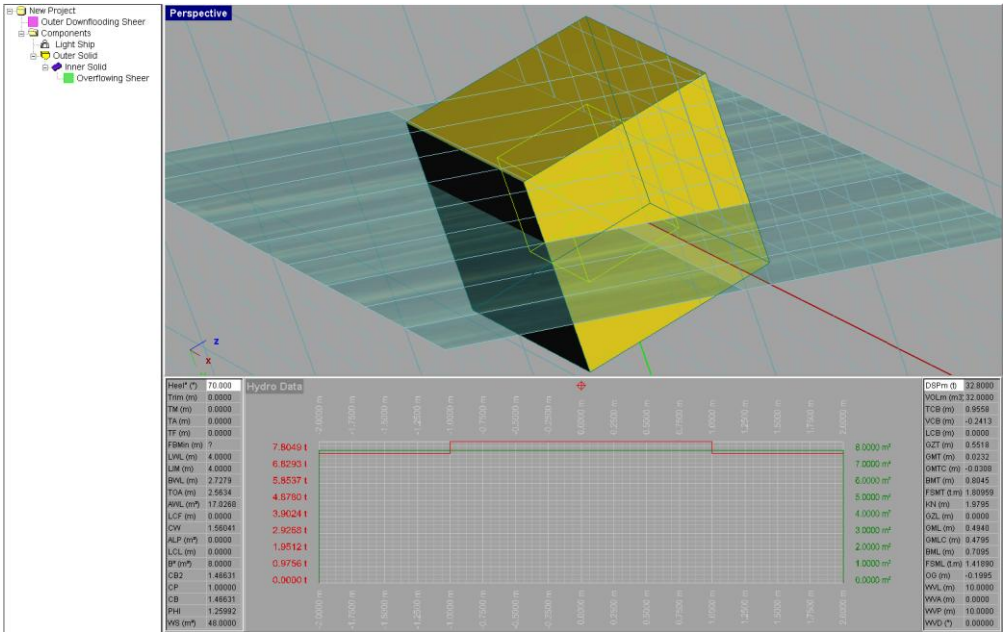
3.6 Tank's Overflow / Spilling:

Similarly, tank's content overflow / spilling can also be modellized:

On the [Data] page, return to the upright position by resetting hydrostatic viewport's Heel°, Trim and TM to 0, reset parent compartment to the intact state (permeability = 0), drag «Outer Downflooding Sheer» out of «Components», and drag the previously excluded «Inner Downflooding Sheer» as child of the «Inner Solid» tank: No change appears in the hydrostatic control window, even if you submerge «Inner Downflooding Sheer» by a significant heel:



But now, on the [Data] page, rename «Inner Downlooding Sheer» to «Overflowing Sheer» (for documentation only) and set its layer to «Overflow» instead of «Downflooding Opening 1». If tank's free surface submerges this «Overflowing Sheer» line (i.e., in this case, if heel exceeds 45° for a 50% filling), the liquid load will be automatically reduced in order to set the free surface on the lowest «Overflowing Sheer» point, which corresponds to tank's overflow:

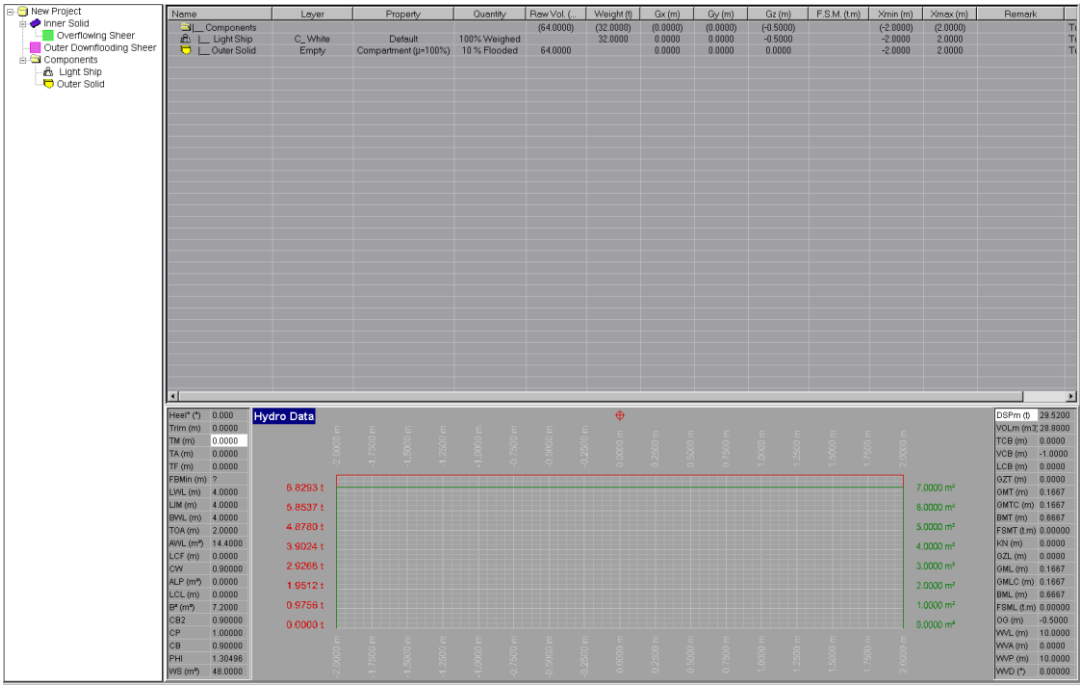


This spilling mechanism may be usefull for modelling the effect of water on deck, of cargo loss at heel (dredge…), of swimming pools (super yachts)...

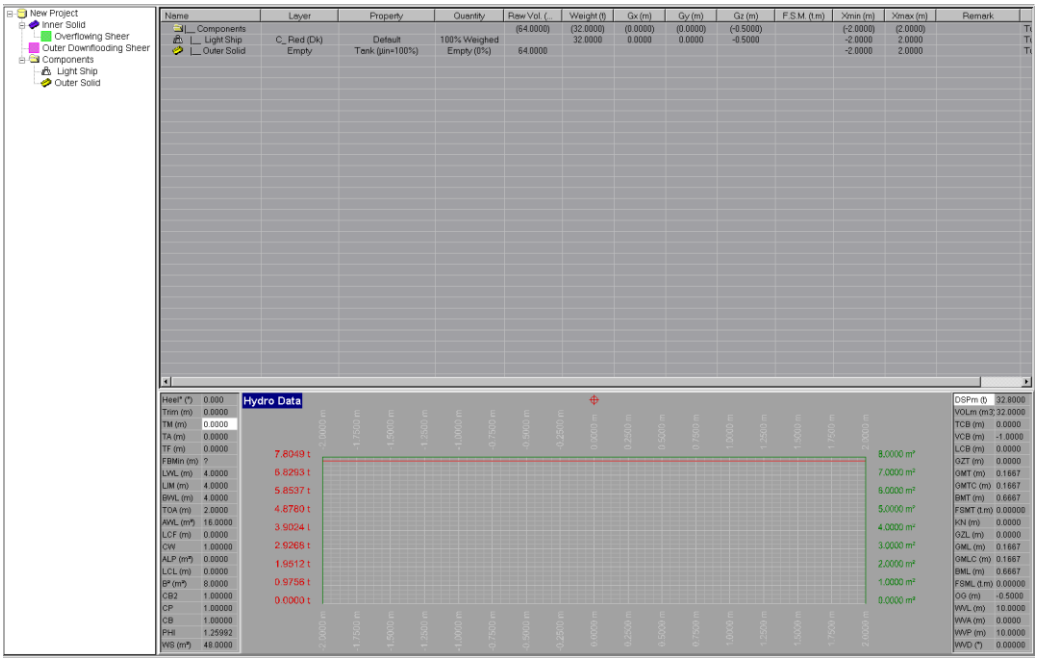
3.7 Tank's Unconditional Buoyancy:

Till now, tanks have always been depending on a parent compartment, as it is a convenient way to recover tank's buoyancy whenever the compartment is flooded.

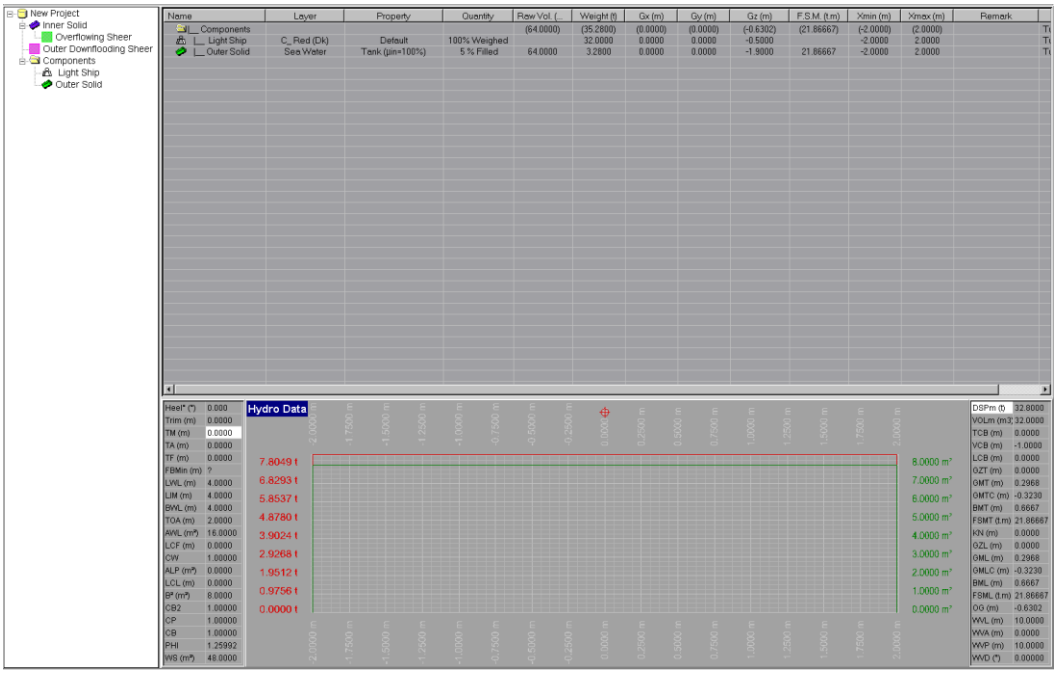
Nevertheless, tanks do not necessarily have to depend on a parent compartment, as transforming a compartment into a tank allows combining directly its intact buoyancy with a certain liquid effect. To illustrate this capability, let us drag «Inner Solid» and its child overflowing sheer out of «Components», in order to conserve only «Outer Solid» and its mass in the active workspace. On the [Data] page, compartment's flooding will also be set to 10%, immersed volume then falling to 28.8 m^3:



Let us now transform this compartment into a tank: The hydrostatic viewport shows that the buoyancy has now returned to its intact value (32 m^3), as tanks are necessarily watertight:



But, if tanks and compartments both have buoyancies when immersed, only tanks can contain a liquid load causing free surface effect. On the [Data] page, it is therefore interesting to set tank's layer to «Sea Water» and to fill it 5%: The previous 10% buoyancy loss is then replaced by the corresponding 5% liquid overload (in this case, 10% of immersed volume equals 5% of full volume). Although the hydrostatic viewport now shows that the (red) weight curve still exceeds the (green) curve of areas, like for the previous 10% flooded compartment, it is important to notice that we now have FSMt = 21.86667 t.m instead of 0 and GMTc = -0.323 m instead of 0.1667:

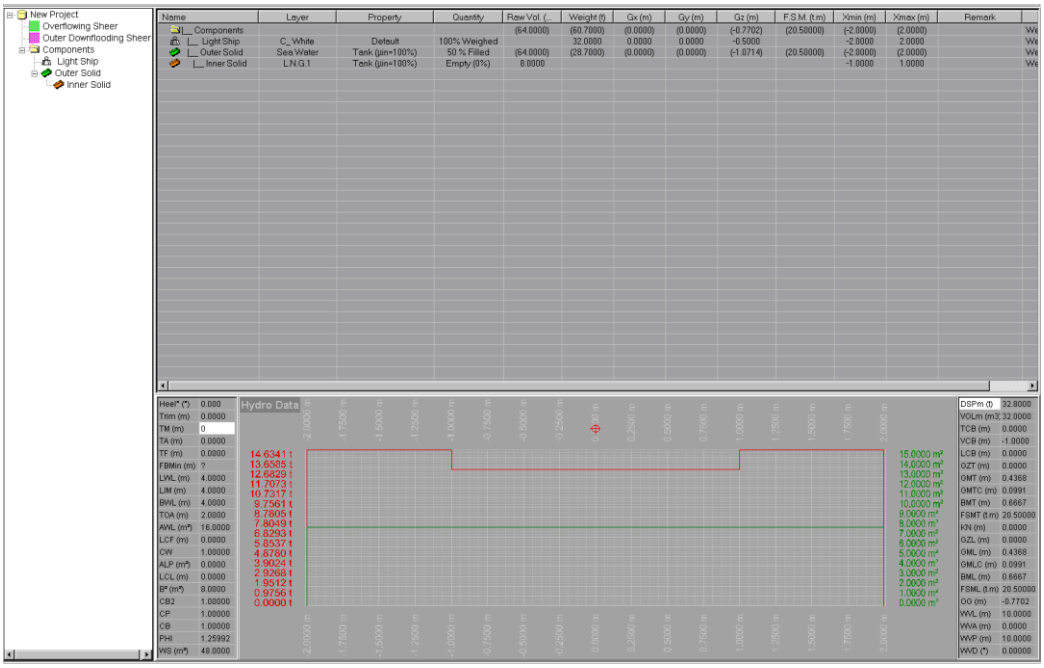


In other terms, although both compartment and tank's weight / buoyancy ratio are almost equivalent, tank's liquid effect avoids reaching any upright balance (GMTc < 0), contrarily to the equivalent flooded compartment.

Replacing a compartment by its equivalent tank is therefore usefull whenever the influence of liquid effect (added weight) on stability must be taken into account, a special attention having to be paid to the corresponding GM loss.

3.8 Tank's Child Tank:

Tanks therefore being able to replace compartments whenever liquid effect has to be taken into account, child tanks can therefore also depend on parent tanks. Let us drag «Inner Solid» again as child of «Outer Solid» and specify the following settings:



The (red) weight curve shows that the inner tank prevents the sea water contained in «Outer Solid" to spread in it and, more generally, as child compartments reduce parent compartment's buoyancy, child tanks reduce parent tank's content / free surface similarly.

The hydrostatic viewport also shows that the upright balance of this filled tank is reachable (GMTc > 0), due to «Inner Solid»'s buoyancy, but decreasing parent tank's filling to 10% would increase FSM, GMTc becoming negative as «Inner Solid»'s buoyancy would no longer reduce parent tank's free surface effect.

At last, child tanks can also be filled, allowing, for example, to combine easily internal tanks with external ballasts.

3.9 Float Modelling Rules:

In order to conclude these numerous examples showing how the data structure of a ship model can modify its hydrostatic behaviour, let us list the main rules to keep in mind:

- Parent compartment's buoyancy depends on its flooding state, except if a child opening is submerged, causing a partial or total flooding (buoyancy loss depending on compartment's permeability).

- When parent compartment contains child compartments, they are considered as holes, except if an affiliated opening is submerged. Such conditional holes are ignored as long as their openings are not submerged.

- When parent compartment contains child tanks, they generate a free surface effect depending on their filling. Their buoyancy can only results of parent compartment's flooding.

- Parent tank's buoyancy is always the intact one, tanks being necessarily watertight. Tanks can therefore not be flooded like compartments, but can contain a fixed amount of liquid, causing a GM loss due to the corresponding free surface effect.

- When tank contains a child overflowing sheer, its filling is automatically limited in order to keep this line emerged (overflowing mechanism). The selected amount of liquid is therefore the maximum possible, depending on current heel, trim and line's geometry.

- When parent tank contains a child tank, its content and free surface effect is automatically restrained by this inner volume, this inner tank remaing fillable like as its parent.