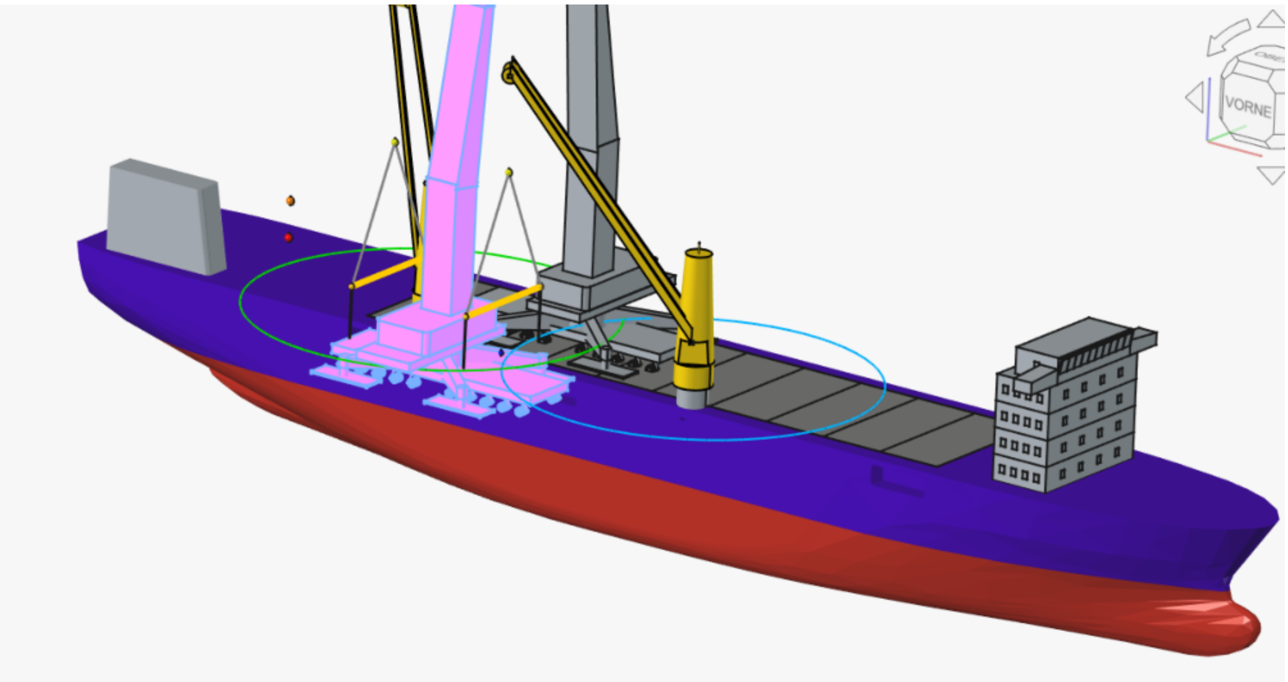
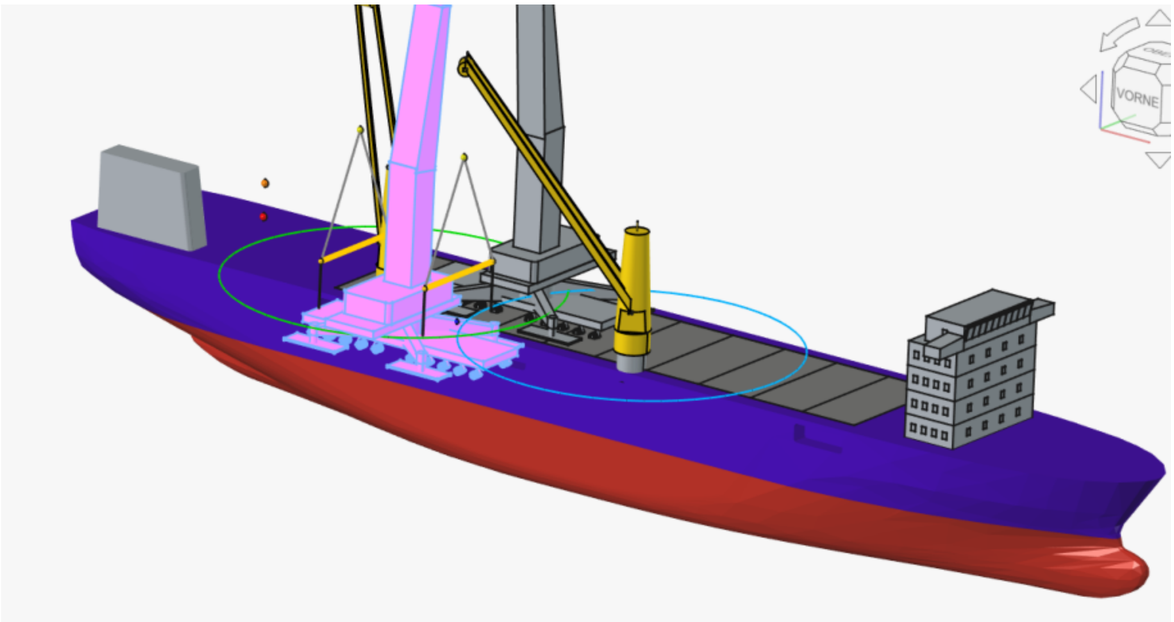

VORNE



1. Install FreeCAD 1.1

Table

System	Method	Command / Download
Windows	Installer	freecad.org → Windows 64-bit
Linux	AppImage (recommended)	GitHub Releases → Download .AppImage
Linux	Package Manager	sudo apt install freecad (Ubuntu/Debian)
macOS	DMG	freecad.org → macOS Intel or Apple Silicon

2. Install StowMind Workbench

Windows (with batch file)

batch

Copy

```
:: 1. Place installv1-1.bat and installv1-1.py in the same folder
:: 2. Double-click on installv1-1.bat
:: Or in CMD:
install.bat
```

Linux (System/Snap/Flatpak)

bash

Copy

```
# In the terminal:
cd /path/to/installv1-1.py
python3 installv1-1.py
```

Linux with AppImage

bash

Copy

```
# Option A: FreeCAD is already running
# Find Python in the mounted AppImage:
ls /tmp/.mount_FreeCAD*/usr/bin/python3
# Then:
python3 installv1-1.py -p /tmp/.mount_FreeCADXXXX/usr/bin/python3

# Option B: Extract the AppImage
chmod +x FreeCAD_1.0.AppImage
./FreeCAD_1.0.AppImage --appimage-extract
python3 installv1-1.py -p ./squashfs-root/usr/bin/python3
```

macOS

bash

Copy

```
# In the terminal:
cd /path/to/installv1-1.py
python3 installv1-1.py
# If not found:
python3 installv1-1.py -p
/Applications/FreeCAD.app/Contents/Resources/bin/python
```

3. Restart FreeCAD

The Workbench appears under **Tools** → **Workspaces** → **StowMind**

StowMind Workbench

Introduction

Ships are complex systems — technical objects that operate at the interface between two worlds, water and air, laden with cargo, bound by stability requirements and dependent on precise calculations. Anyone who designs, loads or analyses a ship navigates a complex interplay of physics, geometry, logistics and safety that no single tool from the traditional CAD world can fully capture.

StowMind is the answer to precisely this problem.

As a specialised workbench for FreeCAD, StowMind bridges a gap that has long existed in the maritime engineering landscape: the gap between the three-dimensional ship model and the calculations based on it. Traditional CAD environments generate geometry — they do not weigh, trim or lift. Traditional stability programmes calculate reliably, but are blind to the actual spatial situation on board. StowMind combines both. The workbench resides within the FreeCAD document, thinks in the same coordinates as the model and turns the ship into an active calculation object.

At the heart of this approach is the StowMind object — a parametric FreeCAD feature that permanently stores draught, trim, centres of gravity and all load-related state variables within the document. If the load changes, the hydrostatics, stability parameters and load verification calculations are updated accordingly. No manual transfer of figures between programmes, no version confusion between the CAD model and the stability booklet — the model is the calculation, and the calculation is the model.

For the cargo planner, this means a way of working that was previously impossible. Cargo units — containers, heavy-lift packages, monopiles, wind turbine components — are placed as true 3D objects within the ship's model. The stowage plan is not drawn up on paper or in separate software, but directly within the geometry. StowMind handles the tasks that, in practice, cost time and lead to errors: automatic calculation of the centre of gravity for the entire cargo, stability checks for the current loading condition, lashing verifications in accordance with applicable regulations, and the export of print-ready stowage and lashing documents — all from a single FreeCAD document.

StowMind goes even further in the area of lifting operations. Cargo planning does not end at the railing — often, the real engineering challenge only begins during loadout: when lifting heavy or bulky loads with one or more cranes, when verifying slings, and when dimensioning spreaders. StowMind maps this entire process in three dimensions. Crane geometries are anchored in the model as FreeCAD objects, whilst lifting gear — shackles, grommets, spreaders — is created and verified as parametric components. Tandem lifts, monopile slewing operations, and the verification of critical boom and load angles: all of this takes place within the same model space as the stowage planning itself. The result is a comprehensive digital verification process, from the stowage plan right through to the lifting report.

In its current form, StowMind comprises **99 modules**, organised into nine functional areas: hull geometry and hydrostatics, tanks and weights, cargo holds and deck configuration, stability calculations and GZ curves, visualisation and surface projections, as well as the full range of tools for lifting operations and rigging. Each module addresses a specific aspect of day-to-day maritime engineering — and all share the same geometric basis, the same FreeCAD coordinate system and the same database.

The following sections describe these modules in detail: their functions, their interfaces and how they interact. The result is more than just a technical reference — it is the documentation of a working environment that considers the ship as a whole, from design right through to the safe hoisting of the final cargo unit on board.

Chapter 1: Hull & Geometry — `StowMindCreateStowMind`

Overview

It all starts with the hull. Before StowMind can perform calculations, load cargo or lift it, the ship must be anchored in the FreeCAD document as a three-dimensional solid — a geometric object with volume, a bounding box, and one that recognises the StowMind internal coordinate system. This chapter describes how a file is transformed into a fully-fledged StowMind object.

The `StowMindCreateStowMind` module performs precisely this task: it imports hull geometry from various sources, converts it into a watertight solid where necessary, and uses this to generate the parametric StowMind feature that serves as the basis for all subsequent calculations.

Workflow

Step 1 — Start StowMind creation

Select the **Create StowMind** command from the FreeCAD menu or the StowMind toolbar. The TaskPanel opens — a guided dialogue that brings together all the necessary inputs in a single interface.

Step 2 — Select geometry source

The TaskPanel offers three options:

a) Import file (default setting) The most common option. Click the 📁 `Choose file…` button to select a hull file. Supported formats:

Format	Description
`.gf` / `.gf1`	Frame file (GF format, typically from shipbuilding CAD systems)
`.txt`	Frame points in GF format, automatically recognised
`.dxf`	DXF polylines as frames, including transom detection
`.stl`	Mesh file, automatically converted to a solid
`.iges` / `.igs` / `.step` / `.stp`	BREP geometry directly from design software
`.fcstd`	FreeCAD document — the solid with the greatest volume is used

b) Use an existing object If a solid already exists and is selected in the FreeCAD document, it can be imported directly as the hull. This is useful if the geometry is already in the document or has been created manually.

c) Load a sample vessel Four predefined hulls are available for testing and beginners: two Series 60 hulls (slim and full-form) and two Wigley hulls (canonical and a catamaran variant). These examples are fully prepared and require no external files.

Step 3 — Set units

StowMind automatically detects the unit of the imported file (`Auto (recommended)`): if coordinate values are in the range > 100, millimetres are assumed; smaller values are interpreted as metres and scaled accordingly. For GF files with foot coordinates (values > 50), the factor 304.8 (ft → mm) is automatically applied.

If required, the unit can also be manually set to millimetres or metres. The **'Auto-centre at X=0, Y=0'** option (enabled by default) centres the hull in the StowMind coordinate system during import: keel at Z=0, midship at X=0.

Step 4 — Enter ship dimensions

In the **'Ship Dimensions'** section, enter the actual ship dimensions in metres:

- **Length (L)** — ship's length
- **Breadth (B)** — Ship's breadth
- **Depth (D)** — side height
- **Draft (T)** — draught (default value: D × 0.5)

These values serve as metadata for the StowMind object and form the basis for all hydrostatic calculations.

Affine Scaling: Disabled by default. When enabled, the imported geometry is stretched so that its bounding box corresponds exactly to the entered L × B × 2T. Useful when a design geometry needs to be scaled to real ship dimensions. If the geometry is already to scale (e.g. STEP/IGES from the design programme), this option should remain disabled.

Step 5 — Confirm import

Once the file has been selected, a blue preview of the fuselage appears in the 3D viewport (60% transparency, blue tint). If the geometry looks correct, confirm the dialogue box by clicking **OK**.

StowMind then generates the following in the document:

- The `StowMind` feature based on the hull solid
- A **'Yard'** group containing a placeholder text document for shipyard hydrostatics (pantokarenes, stability booklet)
- A **'Superstructure'** group for superstructures and obstructions on the hatches (relevant for subsequent cargo planning)

Background: Geometry conversion

Not every source file immediately provides a usable solid. STL files in particular — as a mesh format — require conversion. The `GeometryConverter` operates in three stages, which are attempted in sequence:

1. **MeshPart.meshToShape** — the most robust method, directly generates a shell from the mesh
2. **Tolerance-based conversion** — for problematic meshes with gaps, using three tolerance levels (0.5 / 1.0 / 2.0 mm)
3. **Manual shell construction** — individual faces are checked for validity and assembled into a shell

Before each conversion, the converter checks whether the mesh is closed. Open meshes are automatically repaired (`fillupHoles`, `removeDuplicatedPoints`, `harmonizeNormals`). A shell that is less than 10% open is accepted as hydrostatically viable.

For frame files (GF, DXF), the `HullImporter` constructs the solid directly from the frame points: the half-frames are mirrored to form full frames, uniformly re-parameterised (arc-length resampling, 30 points per frame) and lofted by zone (stern / centre / bow). The three loft zones are then merged into a single solid.

Important notes

Coordinate system: StowMind operates in the nautical coordinate system: X = longitudinal direction (forward is positive), Y = transverse direction (starboard is positive), Z = vertical (up is positive), keel at Z = 0.

GF files: The GF format expects half-frames (starboard side). StowMind automatically mirrors these to full frames. The order of the points (from keel to deck) is automatically checked and reversed if necessary.

DXF files: Frames must be present as polylines in the DXF. A transom with a negative X-coordinate is recognised and treated as a separate closed wireframe.

Subsequent changes: The length, width and draught of the StowMind object can be adjusted directly in the FreeCAD properties after creation, without having to re-import the geometry.

Module reference

Module	Task
`TaskPanel`	GUI dialogue for guided StowMind creation
`Tools.createStowMind()`	Creates the parametric StowMind feature from one or more solids
`GeometryImporter`	Format router: recognises the file format and delegates to the appropriate importer
`StowMind_Hull_Importer`	Parses GF/GF1/DXF frame files and constructs the

Module	Task
`(HullImporter)`	hull solid using lofting
`GeometryConverter`	Converts STL meshes into watertight solids

StowMind design

Loading geometry
– in addition to the four familiar ship types, you can import your own ship or
geometry . The following options are available for this

* Use example ship: the length, beam and draught of the example ship are displayed; if a new length, beam and draught are entered, the example vessel is scaled to match the desired dimensions.
* Import a geometry as:
    STL file; the shape must be closed, i.e. including the deck and transom. If there is no closed shape, the STL file cannot be converted into a solid
    IGES or STEP files are usually solids
    GF / GF1 files; these point coordinates are grouped into frames and must converted manually into solids; it is recommended to create a closed mesh using lofts and then convert this into a solid in the Part Workbench
* Custom geometry: this must be a solid and can then be saved and edited as a StowMind instance.

You can choose a unit of measurement during import or opt for automatic conversion of dimensions. FreeCAD performs internal calculations in mm.

The structure is positioned so that the coordinate origin lies at L/2. This is rather unusual in shipbuilding; normally, the coordinate origin is at the stern in Europe and at the bow in the USA. This is just a note, as this coordinate origin is rather unusual. This must be taken into account, particularly for tank positions and weight positions.

Chapter 2: Hydrostatics — `StowMindHydrostatics`

Overview

Hydrostatics forms the basis of any stability assessment: How much displacement does the vessel have at a given draught? Where is the centre of buoyancy? How does the vessel behave when heeling? StowMind calculates these curves directly within the FreeCAD document — using the hull solid or existing frames — and saves the results as FreeCAD spreadsheets, which are immediately available for all subsequent calculations (stability monitor, GZ curves, cargo condition).

The module offers two calculation methods, which can be selected depending on the available source data:

- **Hydrostatics via Slice** (`hydrostatic_frames`): A fast method based on existing frame objects from the Frames group.
- **Frames + Hydrostatics + Pantocarenes** (`Spant_Tools`): A complete pipeline that first extracts frames from the hull solid and then calculates hydrostatics and heeling curves (KN values).

For a fresh installation — i.e. a newly imported hull without existing frames — **'Frames + Hydrostatics + Pantocarenes'** is the best place to start.

Workflow

Step 1 — Start Hydrostatics

Select the **Hydrostatics** command from the StowMind menu or the toolbar. The **TaskPanel** opens, acting as a launcher.

Step 2 — Select module

In the top section, **'Modules',** there are two options to choose from:

Hydrostatics via Slice Requires a Frames group to already exist in the document (generated by a previous run of *Frames + Hydrostatics + Pantocarenes*). Reads the saved frame polygons from the group and recalculates only the hydrostatics curves — significantly faster than a full run.

Frames + Hydrostatics + Pantocarenes ← recommended for initial calculation Independently extracts 50 evenly spaced frames from the hull solid (or mesh), calculates hydrostatic curves for three types of water and generates complete pantocarenes (KN curves) for 13 angles of heel. Automatically checks whether an existing `'Frames'` group can be reused.

Step 3 — Select hull object

In the **'Hull Object'** section, select the StowMind object (or another shape/mesh) from the document that is to serve as the basis for the calculation.

Step 4 — Define draught range

Under **'Parameters'**, enter the start draught, end draught and increment in metres:

Parameter	Default value	Recommendation
Start draught	0.50 m	At least 0.3 m above the keel line
Final draught	8.00 m	Below deck level
Step	0.25 m	0.25 m for standard resolution, 0.10 m for fine curves

Step 5 — Start calculation (OK)

StowMind performs the calculation. Depending on the method and draught range, this takes a few seconds to a few minutes. The FreeCAD console displays the progress.

Result structure in the document

After the calculation, the document contains a group **of frames** with the following structure:

```
Frames/
    Hydrostatic_Frames/   ← Frame objects with FramePoly, FrameArea, FrameX etc.
    HydrostaticCurves     ← Spreadsheet: hydrostatic table
    PantocarenesCurves    ← Spreadsheet: KN curves (only with Spant_Tools)
```

HydrostaticCurves — Contents

Each row corresponds to a draught value. The table contains:

Column	Description
Draft [m]	Draught
Displacement SW / BW / FW [t]	Displacement in salt water, brackish water and fresh water
LCB [m]	Longitudinal centre of buoyancy (from amidships)
KB [m]	Vertical centre of buoyancy (above the keel)
BM [m]	Transverse metacentre height
KM [m]	KM = KB + BM
BML [m]	Longitudinal metacentre height
KML [m]	KML = KB + BML
LCF [m]	Longitudinal centre of gravity of the waterline area
WPA [m²]	Waterline area
TPC [t/cm]	Tonnes per centimetre of immersion
MCT [tm/cm]	Moment to Change Trim by 1 cm

PantocarenesCurves — Contents

KN values (lever arm of buoyancy at heel) for heel angles from 0° to 90°, for salt, brackish and fresh water respectively. The calculation is performed on a constant-volume basis: for each draught and heel angle, the equilibrium waterline is determined iteratively.

Angles calculated by default: 0°, 5°, 10°, 15°, 20°, 25°, 30°, 40°, 50°, 60°, 70°, 80°, 90°.

Calculation method

Frame extraction

Fifty cross-sections are evenly distributed along the hull's length from the hull solid. Each cross-section is generated as a flat wire in the YZ plane and discretised into a polygon with 60 points. The points are stored as a FramePoly property within the FreeCAD object, so that they are directly available for subsequent calculations without the need to access the geometry again.

If the hull object is a mesh rather than a solid, the cross-section is generated using MeshPart methods.

Volume integration

The hydrostatic values are calculated by numerical integration across the frames (trapezoidal rule). For each draught, each frame cross-section is clipped at the waterline height (Sutherland-Hodgman clipping) and the area and centre of gravity of the clipped polygon are determined using the Gaussian area formula (Shoelace). This yields the volume, displacement, LCB, KB, waterline area, moments of inertia and all derived stability parameters.

Pantokarenes (KN curves)

For each draught and angle of heel, the hull is rotated about the current waterline. A bisection iteration (up to 60 steps) determines the waterline at which the displaced volume equals the upright initial volume. The KN value is derived from the position of the centre of buoyancy in the rotated coordinate system.

Important notes

Prerequisite: The StowMind object must be created correctly (Chapter 1). The keel is at Z = 0.

Reuse of frames: If a 'Frames' group with `'Hydrostatic_Frames'` already exists in the document, *'Frames + Hydrostatics + Pantocarenes'* automatically reuses it. There is no need to extract the frames again — this saves time when draught ranges or density values are changed.

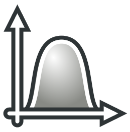
Waterline plots: If the FreeCAD Plot module is installed, StowMind automatically generates three plot windows: displacement curves (Volume), stability parameters (Stability) and form coefficients (Coefficients). The plots update automatically upon recalculation without opening new windows.

Saltwater standard: All stability parameters (KM, BM, TPC, etc.) are based on saltwater (ρ = 1.025 t/m^3). Brackish and freshwater values are also available in the spreadsheets.

Accuracy: The polygon-based calculation provides, for well-resolved frames (50 cross-sections, 60 polygon points), a level of accuracy that is sufficient for cargo planning and preliminary stability analyses. For official stability books, verification against shipyard-defined hydrostatic data is recommended — the Yard Group (Chapter 1) is intended for this purpose.

Module reference

Module	Task
`TaskPanel` (`TaskPanelLauncher`)	GUI dialogue for module selection and parameter input
`Spant_Tools`	Complete pipeline: frame extraction, hydrostatics, pantokarenes
`hydrostatic_frames`	Hydrostatic curves based on an existing group of frames
`hydrostatic_Tools`	Low-level calculation routines: Equilibrium waterline, GZ preparation, conversion tools
`pantokarenen`	KN curve calculation (integrated by Spant_Tools)
`PlotAux`	Generates and updates the three hydrostatic diagram windows




Constraints Hydrostatic

Ships' rea and Hydrostatic, as well as tank definitions and tank curves, are generated in the first part of the Constraints. The hydrostatic tables form the basis for further hydrostatic calculations depending on the loading condition. It is advisable to have a table ranging from minimum draught to the maximum permitted draught. This table is used to determine the approximate draught for a given weight under the respective loading condition, in order to reach the desired result more quickly in the sink/trim calculation.

Chapter 3: Tanks — `StowMindCreateTank`

Overview

Tanks are objects that affect stability: their fill level influences the ship's centre of gravity, whilst their free surface reduces the metacentric height. StowMind manages tanks as parametric FreeCAD objects that are directly assigned to the StowMind feature and are automatically taken into account by the stability monitor and the loading condition calculation.

A tank in StowMind is always a solid object with defined properties: fluid type, density and — via the fill level — a parameter affecting weight and centre of gravity in the loaded state.

Workflow

Step 1 — Modelling tank geometry

In FreeCAD, tanks are modelled as solid objects before being registered as StowMind tanks. Typical examples include simple box geometries (Workbench `Part::Cube`) or solids cut out of the hull solid using Boolean operations. The simplest method is to create a cuboid in the workbench at the location of the desired tank and define this as a common volume (cuboid/hull geometry) using the Boolean function (workbench `Part::Intersection`). The common volume is displayed as 'Common…'; this should then `be converted` into a solid (workbench `Part::Convert to Solid`). It makes sense to delete the first 'Common…' created whilst retaining the two components – the fuselage geometry and the cuboid; the latter can be reused for the next tank by moving it in the placement or by adjusting its dimensions, whilst the fuselage geometry should definitely be retained. It is simpler to copy the fuselage geometry once for tanks etc. The tank geometry must represent the actual internal volume of the tank — that is, the fillable volume excluding wall thicknesses.

Select the resulting solid in the FreeCAD viewport.

Step 2 — Open the Tank dialogue

Select **'Create Tank'** from the StowMind menu. The TaskPanel opens. Prerequisite: There must be at least one StowMind object in the document and at least one solid must be selected in the viewport.

Step 3 — Define tank properties

Set the following parameters in the dialogue:

Tank Name: A name of your choice, e.g. `FO_PS` (Fuel Oil Portside), `FW_AFT` or `BW_DB_1`. The name is used as a label in the document tree and in the loading condition calculation.

Fluid Type: Select a predefined fluid type from the drop-down list:

Fluid type	Density [kg/m³]
Fuel (Diesel)	850
Fresh Water	1000

Fluid type	Density [kg/m³]
Salt water	1025
Lubricating oil	900
Waste water	1000
Sludge	950

When a preset is selected, the density is set automatically and the density field is disabled. For user-defined fluids, a custom density can be entered.

StowMind Select the StowMind object to which the tank is to be assigned. In a document with a single vessel, this is usually already preselected.

Step 4 — Confirm (OK)

StowMind creates the tank in the document tree under a `'Tanks'` group assigned to the relevant `StowMind` object:

```
StowMind
└── StowMind_Tanks/
    ├── FO_PS
    ├── FO_SB
    └── FW_AFT
```

The source solid (the selected geometry) is removed from the document tree once the tank has been created — from then on, the geometry resides within the tank object itself.

Tank properties in the document

Each tank object has the following properties, which can be viewed and edited directly in the FreeCAD properties:

Property	Description
`Label`	Tank name
`FluidType`	Fluid name (e.g. "Fuel (Diesel)")
`Density`	Density in kg/m³
`FillLevel`	Fill level 0.0–1.0 (set in the load state)

The fill level is not set in the Tank dialogue, but in the Loading Status (Chapter 6) — there, each tank can be filled individually, which has a direct effect on displacement and centre of gravity.

Important notes

Coordinate system: The tank geometry must lie within the StowMind coordinate system — keel at Z = 0, midship at X = 0. Tanks that lie outside the hull geometry will be created, but will result in incorrect centres of gravity.

Multiple tanks at once: Multiple solids can be selected simultaneously and registered as tanks in a single step. Each solid creates its own tank object. The names must then be customised individually in the properties.

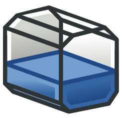
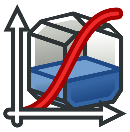
Tanks and stability: Tanks are automatically taken into account by the stability monitor (`StowMindSinkAndTrim`) and the GZ calculation as soon as they are placed in the `'Tanks'` group of the StowMind object. A tank outside this group has no influence on the stability calculation.

Double-bottom tanks: For double-bottom tanks, it is recommended to cut the geometry from the hull solid using a Boolean subtraction to obtain the correct internal volume. Select the resulting shape directly and create it as a tank.

Module reference

Module	Function
`TaskPanel`	GUI dialogue: Tank name, fluid type, density, StowMind assignment
`Tools.createTank()`	Creates the tank object, assigns it to the Tanks group, and cleans up source objects
`TankInstance`	Parametric FreeCAD class for tank objects, including ViewProvider

---

Constraints   Tanks

Tanks are created as Boolean elements. The process is straightforward: select a cuboid in the area where the tank is to be created and, using the Boolean functions in the Part Workbench, use the 'Intersection' function to create the common volume of the hull and the generated cuboid. This is repeated for each tank. Each of these elements should then be converted into a solid. The element resulting from the intersection can be deleted, thereby restoring the hull and the cuboid, which can then be used via 'Placement' and 'Properties' to create the next tank. Once all tanks have been defined, they are added as tanks via the ' ' tank icon in the StowMind  instance; it is recommended to use a suitable name such as BW_PS_1 or Fuel_Center_1 … etc. When creating these tanks, you will be prompted to specify the liquid and its density (e.g. 1.025 for seawater or 0.87 for diesel).

Chapter 4: Weights — `StowMindCreateWeight`

Overview

Whilst tanks represent liquid masses with variable fill levels, the weight module covers all fixed and other masses on board that affect stability: empty ship's fittings, crew and provisions, deck equipment, ballast loads, vehicles — in short, everything that has a defined mass at a defined location on the ship and is therefore included in the centre of gravity calculation for the loading condition.

StowMind manages these objects as parametric weight features, which are directly assigned to the StowMind object and are automatically included in the load condition calculation.

Weight types

The module supports a wide range of predefined weight types:

Type	Description	Typical use
Lightship	Light ship weight	Steel structure, engine, permanently installed equipment
Crew & Effects	Crew and personal luggage	
Provisions & Stores	Provisions and stores	
Hatch Covers	Hatch Covers	Relevant to trim weight
Stability Pontoon	Stability pontoons	
Ballast (solid)	Solid ballast	Keel ballast, cement ballast
Spare Parts	Spare parts	
Deck equipment	Deck cranes, bollards, anchor gear	

For cargo weights (containers, general cargo, bulk cargo, project cargo, vehicles), extended types are available, which are usually created in the cargo planning module (Chapter 6) via the stowage plan. The weight module is the direct route for all weights that do not require their own cargo geometry.

Workflow

Step 1 — Select geometry (optional, but recommended)

A solid, face, line or point selected in the FreeCAD viewport serves as the geometric basis for the weight. The geometry defines the spatial extent and enables the automatic calculation of the centre of gravity. It does not need to represent the exact volume — a simplified cuboid as a placeholder is sufficient for the stability calculation.

If no object is selected, the module also accepts point masses without any reference to geometry.

Step 2 — Open the Weight dialogue

Select **'Create Weight'** from the StowMind menu.

Step 3 — Define weight properties

Weight Identification: Name of the weight, e.g. `Crew_6pax`, `FW_Stores`, `AnchorGear_FWD`. The name appears in the document tree and in the load condition table.

StowMind Assignment: Select the StowMind object to which the weight is to be assigned.

Weight Type: Select the weight type from the drop-down list (see table above).

Mass Mass in any unit, specifying the unit, e.g. `1500 kg`, `2.5 t` or `5000 lbs`. StowMind automatically parses the unit and converts it internally to kilograms.

Centre of Gravity (COG) The centre of gravity can be defined in two ways:

- **Auto Calculate from Shape** — automatically calculates the volumetric centre of gravity of the selected geometry. This is generally sufficiently accurate for symmetrical objects (boxes, simple solids).
- **Manual** — X, Y, Z coordinates in metres, either relative to the centre of the shape (`Relative to shape centre`) or as absolute coordinates in the StowMind coordinate system.

For relative input, the following applies: X=0, Y=0, Z=0 places the centre of gravity exactly at the centre of the geometry's bounding box. Deviations from this, e.g. Z=+0.5 m, shift the centre of gravity upwards accordingly.

Step 4 — Confirm (OK)

The weight object is stored in the document tree within the `'weights_vessel'` group and assigned to the StowMind object under `'Weights'`:

weights_vessel/

Crew_6pax

FW_Stores

AnchorGear_FWD

HatchCovers_1-4

Weight properties in the document

Each Weight object has the following properties:

Property	Description
`Label`	Name of the weight
`WeightType`	Classification (e.g. 'Crew & Effects')
`Mass`	Mass in kg
`COG`	Centre of gravity vector (absolute, in mm)
`Dens`	Volume density (derived from mass / shape volume)
`Inertia`	4×4 inertia matrix (for dynamic calculations)

Important notes

Lightship: All fixed ship components that form part of the lightship should be created as `'Lightship'` type weights. They are included in every loading condition without needing to be re-entered.

COG accuracy: The vertical position of the centre of gravity (COG) is crucial for stability analyses. For flat or eccentric geometries, `Auto Calculate` provides a bounding box-based approximation — correct this manually if necessary, particularly if the actual mass distribution deviates from the geometric centre of gravity (e.g. heavy foundation plates in the underbody of a machine).

Free-surface moment: For filled tanks with a free surface, a simplified calculation of the free-surface moment is available (`calculate_free_surface_moment`), which is based on the bounding box width and the degree of filling. For official verifications, the shipyard hydrostatic data from the Yard group should be used.

Project `cargo`: The `'Project Cargo'` type additionally defines a critical tipping angle (`CriticalTippingAngle`, default 15°) as a property, which can be used as a warning limit during lifting operation planning (Chapter 9).

Vehicles: The `'Vehicle'` type automatically generates a box geometry based on length, width and height, and sets the centre of gravity to typical vehicle proportions (40% of the length, 50% of the width, 40% of the height). These values can be adjusted in the properties.

Module Reference

Module	Task
`TaskPanel (AdvancedTaskPanel)`	GUI dialogue: Name, type, mass, COG input and automatic COG calculation
`Tools.createWeight()`	Base weight with mass/density and inertia matrix
`Tools.createAdvancedWeight()`	Extended dispatcher for type-specific weight objects
`WeightInstance`	Parametric FreeCAD class for weight objects, including ViewProvider

---

Constraints Weights

Fixed weights are entered here, e.g. hatch covers, tweendeck covers; these are stored with the object as a property of the object. If the positioning changes, the positioning of the weight is also adjusted. For the ‘Ship’ object, two weights should be specified: the light ship weight and the weight of the crew, effects and provisions.

Chapter 5: Cargo Holds & Deck Configuration — `StowMindDecks`

Overview

Before a stowage plan can be drawn up, the ship's topology must be known: Where are the cargo holds? How high is the tank top? Where are the hatches, the tween decks and the crane supports located? StowMind solves this problem through an explicit deck definition, which is stored as a JSON structure directly within the StowMind object and serves as a common basis for all subsequent modules — stowage plan, lashing, stability calculation.

The `StowMindDecks` module has two operating modes: the **general cargo hold setup** for multi-purpose freighters, heavy-lift vessels and project cargo ships, and the **bulker mode** for bulk carriers with funnel-shaped cargo holds, hoppers and tapered fore and aft hold areas (monkey rocks).

Workflow

Step 1 — Start deck setup

Open the **'Deck Setup'** menu in StowMind. The system automatically reads the bounding box of the StowMind object and displays the vessel's length, breadth and keel position as information.

Step 2 — Select mode

Standard mode (general) For multi-purpose cargo ships, heavy-lift vessels, container ships and project cargo ships. The dialogue guides you through the configuration in two steps.

Bulker mode Select the **BULKER MODE** button. This opens a separate dialogue box offering advanced control over hold geometry, transverse decks (tank tops) and trapezoidal layouts for the fore and aft holds.

Standard mode — Step 1: Global parameters

Parameter	Description
Number of holds	1–8 cargo holds
Number of hatches	Number of TD pontoon covers per hold (default for all)
TD pontoon deck thickness	Geometric thickness of the intermediate deck pontoons in metres
Hatch cover thickness	Geometric thickness of the hatch covers
Mass per TD pontoon cover	Weight of a single TD deck cover in kg
Mass per hatch cover	Weight of a single hatch cover in kg

These values are the defaults for all cargo holds. They can be overridden individually for each cargo hold in the next step.

Standard mode — Step 2: Per cargo hold

A separate dialogue box is opened for each hold:

Length (X-coordinates) of the forward and aft bulkheads of the hold in metres, relative to the StowMind coordinate system (amidships = 0).

Width: Half hatch width `ymax` in metres. The hold is always symmetrical about Y=0. Side projections (tanks, hoppers) lie outside this range.

Heights (Z absolute)

- **Tank top Z** — Upper edge of the double-bottom tanks, reference height for the cargo hold level
- **Total clear height** — From tank top to upper edge of closed hatch cover
- **Height of TD pontoons** — Lower edge of the tween-deck pontoons above the tank top
- **Tank top plate thickness** — Notional plate thickness (standard 20 mm)

Taper **—** Taper of the cargo hold at the bow and/or stern. Relevant for container ships and bulk carriers. Specified in container widths (indentation) and zone length in metres.

Override per cargo hold — Different number, thickness and masses of pontoons for this cargo hold if it deviates from the global default.

Bulker mode

For bulk carriers with 3–9 holds. The dialogue controls all holds in a single interface:

Global parameters: total longitudinal extent (X bow / X stern), tank top height, deck height, crane clearances (gaps) between holds.

Forward and aft holds (trapezoidal): Hold and hatch dimensions plus taper width (0 = pointed, > 0 = truncated trapezoidal shape) and hatch centre offset (Hatch Offset).

Midships (identical or individual): Either a template for all identical midship compartments or individual dimensions for each compartment.

Result structure in the document

Once set up, the document contains:

StowMind

└── CargoHoldDefinitions ← JSON string with complete cargo hold topology

weights_vessel/

Tanktop_H1_fwd ← Tank top surface as Part::Feature

Coaming_H1_fwd ← Hatch coaming geometry

Cover_H1_fwd ← Hatch cover (with Mass property)

...

The CargoHoldDefinitions property in the StowMind object contains all cargo hold information in JSON format and serves as the common data source for the stowage plan, placement and lashing.

Module reference

Module	Task
`deck_setup`	General cargo hold setup dialogue (2-stage: global + per hold)
`deck_setup_2`	Extended version with additional options
`bulker_deck_setup`	Specialised bulker mode with trapezoidal geometry and crane spacing
`HoldGeometrySetup`	Low-level geometry generation: tank tops, coamings, covers

Constraints Deck

This tool is designed to define the relevant decks and cargo holds on board. On On deck, areas occupied by cranes, funnels or other superstructures can be defined as obstacles. Obstacles are left clear during automatic loading. As bulk carriers have slightly different hatches – considerably smaller hatches compared to the cargo holds, with stowage space available below the main deck and between the hatches – there is a separate tool for bulk carriers. In areas where the hull tapers sharply and no longer retains a box-shaped form, the narrowings can be defined using the corresponding container widths. Defining the decks as accurately as possible is essential for the automated stowage of cargo.

Chapter 6: Cargo Planning & Stowage Plan

Overview

Cargo planning is the core process of StowMind — and the area where the close integration with FreeCAD demonstrates its greatest added value. Cargo units are not managed in separate software, but are placed directly as three-dimensional objects within the ship model. The stowage plan is the model. Collisions are detected geometrically, obstacles (cranes, superstructures) are taken into account, and each cargo unit carries its mass and centre of gravity as a FreeCAD property — available for the stability calculation in the next step.

Workflow

Phase 1 — Import cargo manifest

Via Excel import (`CargoStowagePlan`) The most common method in practice. An Excel spreadsheet containing the cargo manifest is imported. StowMind expects the following column structure (configurable):

Column	Content
A	Designation/name of the cargo unit
B	Description (optional)
C	Mass (kg or t, unit detected automatically)
D	Length (m)
E	Width (m)
F	Height (m)
G	Cargo type (container / general / heavy / bulk / vehicle)

Each row creates a box object in the FreeCAD document with the corresponding dimensions and properties. Cargo groups (e.g. all items for Port X) are created as `App::DocumentObjectGroups`, with the 'Stackable' property for stackable goods.

Via 3D model import (`import_3Dcargo`) For project cargo, special cargo or vehicles available as STEP/IGES/STL files: direct import as a 3D object, which is then treated in the stowage plan like any other cargo unit.

Manual creation Individual cargo units can also be created manually as Part::Box in FreeCAD and assigned the required properties (Mass, Length, Width, Height, WeightType).

Phase 2 — Automatic placement

The **placement dialogue** reads all unplaced cargo units from the document and sorts them by priority:

- Large footprint (> 10 m²) — highest priority, placed first
- Heavy items (> 100 t)
- Standard items

Deck allocation Three levels are available for each hold:

Level	Description
Lower Hold	Lowest hold, from the top of the tank to the lower edge of the TD pontoons
Tweendeck	Between the top edge of the TD pontoons and the bottom edge of the hatch cover
On Deck	On the weather deck above the hatch covers

The placement algorithm systematically scans each level from bow to stern, searching for the first collision-free position. Obstacles are detected geometrically: all objects in the superstructure group (cranes, superstructures, foundations) and all cargo units already placed are included in the collision check.

Collision detection For each candidate position, an AABB (Axis-Aligned Bounding Box) overlap check is performed against all obstacles in the deck area. If a position is collision-free, the cargo unit is placed: the position is set as `'Placement'`, and `'StowageLocation'` is written as a property.

Manual placement Individual items can also be positioned manually by selecting them in the 3D viewport. The placement dialogue recognises the selection and suggests the next valid position on the selected level.

Phase 3 — Stackable cargo (`stackable_placer`)

A specialised stacking algorithm is available for block stowage — timber stacks, coils, steel bundles, sacks. It is automatically offered if at least two cargo units have the property `'Stackable = True'`.

The Stackable Placer:

- calculates the maximum stacking height based on the `MaxStackLoad` property
- distributes identical items into layers
- calculates underlay dunnage and records the layer heights as properties

---

Phase 4 — Stowage Plan Document (`CargoStowagePlan`)

After placement, StowMind generates a stowage plan overview: a table of all placed cargo units showing their position, mass, centre of gravity and stowage area — exportable as an Excel file.

Colour coding in the 3D viewport:

Colour	Cargo type
Blue	Container
Grey	General cargo
Red	Heavy cargo
Orange	Bulk cargo
Green	Vehicles

Phase 5 — `Discharge`

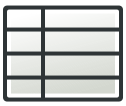
The **Smart Delete** dialogue box allows you to selectively remove individual cargo units or entire cargo groups. Three views:

- **Entire loads** — delete complete cargo groups (e.g. all items for Port X) in one go
- **Individual items** — remove individual cargo units from a group
- **Advanced** — selectively remove other objects in the document (not cargo)

When items are deleted, all references are automatically cleared from the Weights list of the StowMind object.

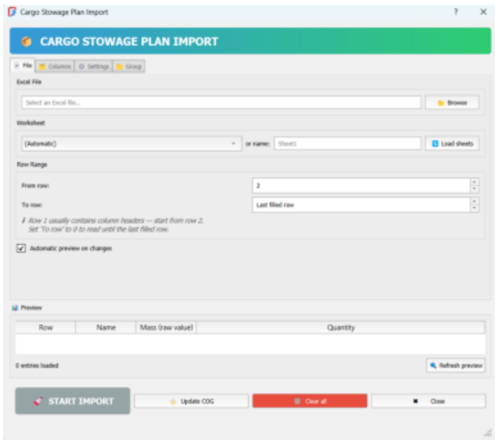
Module reference

Module	Function
`CargoStowagePlan`	Excel import, cargo unit generation, stowage plan export
`CargoStowagePlanGUI`	GUI wrapper for the import dialogue
`placement`	Automatic and manual placement with collision detection and obstacle avoidance
`stackable_placer`	Specialised stacking algorithm for block stowage
`import_3Dcargo`	3D model import for project cargo and special cargo
`integration`	Excel import extension for Stackable properties and group integration
`Discharge`	Smart Delete: targeted removal of cargo groups and individual items
`Stowage plan`	Stowage plan generation and export functions



Cargo Packing list / Excel sheet

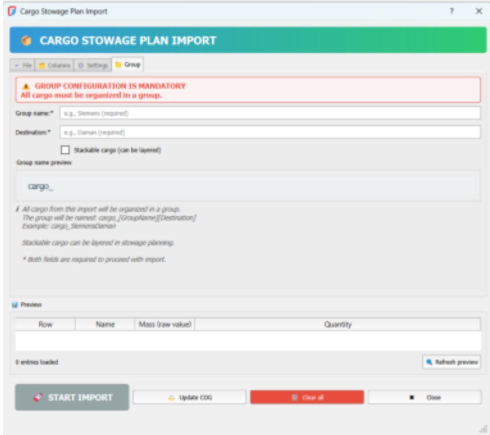
This function opens an input tool for importing Excel packing lists. The imported data, such as length, width and height, is converted into 3D cuboids. All cuboids are labelled, with the text protruding a few centimetres from the cuboid. It is very important that all four pages of the conversion tool ( ) are completed.

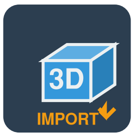


On page 1, select the relevant file:
On page 2, select the columns containing
the relevant information for the individual load
is located.
Page 3 specifies the conversion factors, i.e. whether the data
is given in m/cm/mm, inches or kg/t …. Internally, calculations are always
calculated in mm and kg.

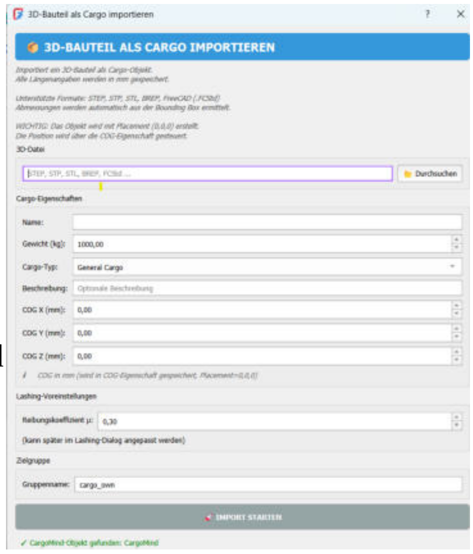
Page 4 is particularly important, as this is where the cargo is defined in more detail. Cargo is always prefixed with ‘cargo_’; it is recommended that the customer be entered next, followed by the port of destination.
This distinction is extremely important because, later on, individual cargoes can be accessed separately.
Another key point is
a tick to indicate whether the cargo is stackable
or not.

It is still possible later on to treat individual parts of the cargo as non-stackable.



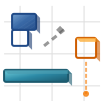


Cargo   3D Import



3D cargo parts can also be imported. Various formats are supported, including STEP, STL, IGES and FCStd files. The input screen is self-explanatory.

One issue with imported 3D parts should be noted: it is not always clear where the coordinate origin is, which can lead to incorrect placement; however, this can usually be rectified without major problems by adjusting the placement accordingly.



Cargo   Placement

Cargo Placement has two distinct modes: if the cargo parts have been marked as ‘stackable’ during import, the parts are sorted by size and stacked where possible. Before placement, it is still possible to remove individual cargo parts from the placement. The automatic system is designed to save space; it is up to the operator to decide whether the selection of stacked parts is acceptable.
The other option, without ‘stackable’ solutions, is based on a different priority: here, the priority is on being able to place the cargo using the crane(s).
Placed cargo is treated as an obstacle for subsequent loads.

Cargo Discharge

All load components are not merely objects in the drawing; they are linked within the instances of the main objects. For this reason, it is not advisable to simply delete parts, as this leaves data active which will sooner or later cause the model to crash. For this reason, load components (and other parts of the model, if necessary) must be deleted using this tool.

Chapter 7: Load Conditions & Stability Analysis

Overview

The Load Condition is StowMind's central tool for calculating a vessel's stability. It aggregates all masses, centres of gravity and moments from tanks, ballast, cargo and cranes into a single FreeCAD spreadsheet table and derives the hydrostatic parameters draught, trim, KMt and GMt from this data. The entire process is fully integrated into FreeCAD: the data sources are the 3D objects in the document, the calculation is performed using Python scripts, and the result is saved directly in the model. Changes to tank levels, cargo distribution or crane positions are recalculated with a single click.

Workflow

Phase 1 — Create Load Condition

The creation dialogue scans the active FreeCAD document and extracts all relevant objects from the StowMind object. Objects from groups (e.g. `cargo_`, `weights_`, `tanks_`) are automatically expanded to avoid double counting. The user can choose between two modes:

- **Complete rebuild (default)** — the existing LoadCondition spreadsheet is deleted and completely recreated with all sections: TANKS, WEIGHTS, CRANES, CARGO.
- **Update Cargo & Cranes only** — only the CARGO and CRANES sections are overwritten; TANKS and WEIGHTS remain unchanged. This is useful if only the cargo distribution or crane positions have changed, whilst tank levels and fixed weights remain constant.

Result of creation: A `Spreadsheet::`Sheet object named `LoadCondition`, which records all masses, densities, fill levels, centres of gravity and moments in tabular form.

Phase 2 — Perform calculation (Calculate Load Case)

The calculation takes place in four strictly sequential steps, the order of which is critical:

1. `calculate_all_items()` — iterates through all rows of the LoadCondition spreadsheet, calculates tank masses (including fill volume and free surface), weight moments and load moments, and writes the totals to **D4** (total mass), **E5/F5/G5** (LCG/TCG/VCG) and **H4** (FSM).
2. `doc.recompute()` — updates all spreadsheet formulas and ensures that dependent cells are refreshed.
3. `_run_sink_and_trim()` — calls `StowMindSinkAndTrim.Tools.compute()` and calculates draught, trim, KMt and GMt. These values are written to **E4, F4, G4, H5** and **D6**.
4. `switch_to_StowMind_workbench()` — automatically returns to the StowMind workbench.

Tank calculation

For each tank, the fill volume is calculated using `getVolume()` (preferred) or the BoundingBox fallback. The density is determined either from the tank's `'Density'` property, the `'Flu`idType' assignment (diesel 850, fresh water 1000, seawater 1025, lubricating oil 900) or the default value of 1025 kg/m³. The centre of gravity of the filled tank is calculated using `getCoG()` (input in mm³, output in mm). For partially filled tanks, the free-surface moment (FSM) is calculated using the formula $I = (L \times B^3) / 12$ and output in t·m².

Weights & Cargo

Objects with a ‘Mass’ property are classified as **‘Weight’** or **‘Cargo’** — depending on whether or not they are in a group with the prefix `‘cargo_’`. Missing masses or centres of gravity are automatically supplemented from the FreeCAD object properties (`Mass`, `COG`, `Shape.BoundBox.Center`). Cranes are recorded as separate lines with their components — **the crane boom (Boom)** and **load on the hook (Hook load)** — with the positions derived from `Placement.Base`, `BoomCGPosition` and `SheavePosition`.

Phase 3 — Hydrostatics (SinkAndTrim)

After the weight calculation, SinkAndTrim reads the aggregated values (total mass D4, KG G5, FSM H4) and calculates:

- **Draft** — from the hydrostatics table via interpolation
- **Trim** — from the ratio of LCG to LCB
- **KMt** — metacentric height above the keel
- **GMt = KMt − KG** — metacentric height (stability reserve)

The result is displayed in the FreeCAD console window and colour-coded:

Table

Stability assessment	GMt value	Meaning
✓ GOOD	> 0.5 m	Sufficient reserve
⚠ ACCEPTABLE	0.15–0.5 m	Critical, but permissible
⚠ CRITICAL	0–0.15 m	Very limited reserve
✗ UNSTABLE	≤ 0	The vessel is unstable!

Phase 4 — Manual editing & recalculation

The LoadCondition spreadsheet can be edited manually at any time: change tank levels, correct weights, enter new positions. After each change, simply click on *‘Calculate Load Case’* to run the entire chain through again. The calculation is idempotent — it only overwrites the calculated cells (D4–K6) and leaves manual entries in the data rows unchanged.

Spreadsheet structure

Table

Range	Cell(s)	Content
Header	A1:K1	Header row ‘StowMind LOAD CONDITION’
Meta	A2:B3	StowMind label, date
Results	A4:D4	Total mass [kg] → D4 = Σ masses
	E4:G4	Draught [m], KM [m], GM' [m] (from SinkAndTrim)
	F4:H4	Free surface [t·m] → H4 = Σ FSM
	E5:G5	COG X/Y/Z [m] (LCG/TCG/VCG)
	I6:K6	Sum of moments X/Y/Z
TANKS	A12:K…	Name, Density, Fill%, Mass, LCG, TCG, VCG, MomX/Y/Z, FSM
WEIGHTS	…	Name, Type, -, Mass, LCG, TCG, VCG, MomX/Y/Z, Note
CRANES	…	Name, Component, -, Mass, LCG, TCG, VCG, MomX/Y/Z, Note
CARGO	…	Name, Type, Dims, Mass, LCG, TCG, VCG, MomX/Y/Z, Ports

Colour coding in the spreadsheet:

Table

Range	Background colour	Meaning
Title	Light blue (0.8, 0.8, 1.0)	Header
TANKS	Light blue and white (0.95, 0.95, 1.0)	
WEIGHTS	Grey (0.95, 0.95, 0.95)	
CRANES	Beige (0.95, 0.90, 0.80)	
CARGO	Light green (0.95, 1.0, 0.95)	
Results	Light green (0.9, 1.0, 0.9)	Total rows

Module reference

Table

Module	Task
Tools.py	Creation and management of the LoadCondition spreadsheet; group identification; object type determination (Tank/Weight/Cargo/Crane); Cargo-&-Cranes-Only update; deletion of all LoadConditions; status display
CalculateLoadCondition.py	Calculation of all rows: tank volume, weight moments, overall centre of gravity; calling SinkAndTrim; Workbench switch; state tracking for incremental calculations
integration.py	Excel import extension for stackable properties; group integration; button extension for placement.py to switch to the stackable placer

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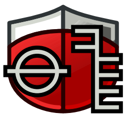


Cargo   Create Loading Condition

Once the load has been set, weights defined and tanks installed, the Create Loading Condition. A worksheet named ‘LoadCondition’ is generated. It is divided into the results at the top in the first few rows, followed by the ‘tanks’ section (which is set to 50% fill by default), the ‘Weights’ section, and the ‘Cranes’ section showing the load on the hook and the crane boom; the weight on the hook is specified in the crane boom column at the top according to the rotation angle and boom angle, and the COG of the crane boom is specified in the same way. Next comes the ‘Load’ section, where all load components are listed with their position and weight.

Cargo   Calculate Loading Condition

To save unnecessary processing time, the LoadCondition is recalculated. GM, GM`, KG and KM displacement are calculated. The current stability is calculated and displayed using Sink&Trim and the GZ curve.

Chapter 8: Lashing & Verification — `Lashcalc` / `lashing_pdf_export`

Overview

Every cargo unit on deck or in the hold must be secured against sea state. The verification follows internationally binding rules — StowMind implements the **IMO CSS Code Annex 13 (2021 Amendments), Advanced Calculation Method**. The result is a complete, print-ready lashing verification report in PDF format, which specifies the required lashing points, materials and forces for each piece of cargo.

Workflow

Step 1 — Launch Lashcalc

Select **'Lash Calculation'** from the StowMind menu. The dialogue box opens with several tabs.

Step 2 — Ship parameters

In the **'Ship Parameters'** tab, enter the ship's dimensions relevant to stability and acceleration:

Parameter	Description
Ship Length (Lpp)	Length between perpendiculars in metres
GM (metacentric height)	Metacentric height in metres
Hs (significant wave height)	Significant wave height in metres (affects reduction factor fR)
Stowage position	Cargo location: Deck-high / Deck-low / Tweendeck / Lower Hold
x/L ratio	Longitudinal position of the cargo as a ratio to the ship's length (0 = amidships, 1 = bow/stern)

Step 3 — Cargo parameters

In the **Cargo Parameters** tab:

Parameter	Description
Mass [t]	Total mass of the cargo unit
Length / Width / Height [m]	Dimensions of the cargo unit
KG Cargo [m]	Height of the cargo's centre of gravity above the keel
Coefficient of friction μ	Depends on the surface and type of load (typically 0.3 for steel/steel)

Step 4 — Define lashing equipment

The lashing concept is defined in the **Lashing Setup** tab. Up to four lashing groups can be entered for each of the four sides (SB, PS, FWD, AFT):

Parameter	Description
Material	Chain, Wire (new/used), Fibre rope, Web lashing, Steel band
MSL [kN]	Maximum Securing Load of the individual lashing device
Angle α [°]	Vertical angle of the lashing
Angle β [°]	Horizontal angle of the lashing
Number	Number of lashing devices in this group

The MSL factor is automatically suggested from the materials catalogue (e.g. chain: 0.50, new wire rope: 0.80).

Step 5 — Calculate

Acceleration values are interpolated from the IMO tables:

- Longitudinal acceleration ax (constant for each stowage area: Deck-high 3.8 m/s^2, Lower Hold 1.5 m/s^2)
- Transverse acceleration ay (interpolated from Table 2 based on the x/L ratio and stowage area)
- Vertical acceleration az (interpolated from a separate table based on the x/L ratio)

The **length factor** from Table 3 (based on ship's length and x/L) and the **GM factor** from Table 4 are also taken into account.

Force balance in each direction:

- Sliding force: $F = m \times a - \mu \times m \times g$ (minus frictional resistance)
- Tipping moment verification: Verification of the stabilising moment of the lashing against the tipping moment
- Tie-down limit: Vertical lashing force limited to 10 kN per metre of cargo length

The **utilisation rate** of the lashing equipment is shown (ratio of requirement to available MSL × factor). Green marking for utilisation ≤ 100 per cent, red marking if exceeded.

PDF export (`lashing_pdf_export`)

Once the calculation is complete, a print-ready lashing verification report can be exported with a single click. The report contains:

- Vessel data and voyage information (vessel name, voyage number, date, port)
- Cargo description with dimensions and mass
- Tabular presentation of acceleration values from the IMO tables
- Lashing plan showing all angles, MSL values and utilisation factors
- Force balance in each direction (SB, PS, FWD, AFT)
- Results page with PASS/FAIL assessment

The PDF file can be generated and saved directly from FreeCAD.

IMO table values (reference)

StowMind implements the complete tables from CSS Code Annex 13 (2021):

- Table 1: Transverse acceleration ay by stowage area and x/L
- Table 2: Vertical acceleration az by x/L
- Table 3: Length factor by ship's length and x/L
- Table 4: GM factor by stowage area and GM value

All values are linearly interpolated. Extrapolation beyond the limits of the tables is prevented by clipping to the last table value.

Important notes

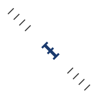
Stability input: The GM value must be entered for the current loading condition. It can be taken from the stability monitor (Chapter 8) — StowMind does not automatically read the current GM from the loading condition.

Coefficient of friction: The standard provides guide values, but the actual μ value depends on the underlay material and surface condition. StowMind does not set a default — the value must be deliberately selected by the user.

Multiple verification: For ships with many cargo units, it is advisable to first verify the most critical items (greatest mass, most unfavourable position). Lashcalc can be run separately for each unit and saved as a separate PDF.

Module reference

Module	Task
`Lashcalc`	Complete lashing verification calculation in accordance with IMO CSS Annex 13 (2021)
`lashing_pdf_export`	Generation of a PDF lashing verification report



Cargo Lashing Calculation

The lashing calculation complies with the requirements of the ADVANCED CALCULATION METHOD, in accordance with the 2021 Amendments to the Code of Safe Practice for Cargo Stowage and Securing – IMO

The start window asks for the ship's speed and any restrictions on the significant wave height Hs. It is possible to reduce the loads on the cargo by specifying a significant wave height of less than 12 m for a restricted voyage; for example, it is generally accepted in the Baltic Sea that the significant wave height is a maximum of 6 m, rather than 12 m for an unrestricted voyage worldwide. If a restricted voyage is selected, this is specifically highlighted in the lashing calculation.
It is possible to restrict the stowage calculation to cargo weighing a certain amount or more.

In the next window, you can select the cargo you wish to examine.

On the home page of the individual object, if stoppers are being used, the BL of the stopper must be entered; otherwise, chain or wire is assumed. For each side, fore and aft, the lashing materials are specified individually. Here, the calculation is restricted exclusively to vertical angles, with a safety factor of 1.5 applied to the calculated strength. Furthermore, stoppers are used exclusively for horizontal loads, whilst additional wire/chain lashings are used solely to prevent tipping in conjunction with a stopper.

For particularly large and heavy cargo, the additional tipping moment is taken into account in accordance with Appendix 3.

Chapter 9: GZ Curve & Projected Areas — `StowMindGZ / ProjectedAreas`

Overview

The GZ curve is the central tool for stability assessment: it shows the ship's righting lever arm for every angle of heel. A positive GZ value means the ship rights itself — a negative value means it heels further. The shape of the curve — its area, its maximum, the angle at which the maximum occurs, and the zero-crossing point at capsizing — forms the basis of all international stability regulations.

StowMind calculates the GZ curve directly from the hull geometry, without the need for external programmes. The calculation is geometrically accurate and volume-constant — the reference volume at upright draught is maintained for every angle of heel. In addition, the `ProjectedAreas` module calculates the projected wind and cross-sectional areas of the loaded ship, which are required for wind pressure analyses and IMO weather criteria.

Workflow: GZ curve calculation

Step 1 — Start GZ curve

Select **'GZ Curve'** from the StowMind menu. The module automatically reads the current loading condition from the LoadCondition sheet:

Source	Value
Cell E4 / D6	Draught [m]
Cell G5	KG (vertical centre of gravity above the keel) [m]
Cell H5	Free-surface moment FSM [tm]

If no LoadCondition sheet is available, draught and KG can be entered manually in the dialogue box.

Step 2 — Check parameters

The TaskPanel displays the values that have been read and these can be overwritten before the calculation. Of particular relevance:

KG (height of the overall centre of gravity): Crucial for the entire GZ curve. Setting the centre of gravity too low results in overly optimistic values, whilst setting it too high results in more conservative values. StowMind automatically estimates the centre of gravity from the geometry (KB + BM) if no value is available from the LoadCondition sheet — this estimate is suitable for early-stage design, not for official verification.

FSM (free surface moment): The free surface correction factor is subtracted from the effective KG: KG_eff = KG + FSM/displacement. The greater the FSM (full tanks with a free surface), the smaller the effective GMt.

Step 3 — Calculation

StowMind calculates GZ for 13 angles of heel: 0°, 5°, 10°, 15°, 20°, 25°, 30°, 40°, 50°, 60°, 70°, 80°, 90°.

Physical model for each angle φ:

1. The hull is rotated by φ about the waterline (pivot at z = draught)

2. The equilibrium waterline is determined using bisection iteration (max. 60 steps, tolerance 5×10^{-5}) such that the submerged volume corresponds to the reference volume
3. The centre of buoyancy B is calculated in the rotated coordinate system
4. Back transformation of B into the upright ship's coordinate system
5. $GZ = hl(\varphi) - KG \times \sin(\varphi)$, where $hl = B\_ship\_y \times \cos(\varphi) + B\_ship\_z \times \sin(\varphi)$

Each bisection step performs a Boolean operation (Part.common) on the hull solid. If the Boolean operation fails (numerical boundary case), StowMind automatically attempts a slightly shifted z_cut value.

Step 4 — Displaying the results

The result is displayed as **an** interactive **Qt plot** directly in the FreeCAD window — no external Matplotlib or TkAgg required.

The plot shows:

- The GZ curve in metres versus heeling angle in degrees
- **SOLAS minimum areas** as reference lines (0°–30° and 0°–40° or 30°–40°)
- Key values in the legend: GZ maximum, angle at which the maximum occurs, GMt, draught

SOLAS criteria (IS Code 2008, shown as a reference):

Criterion	Minimum requirement
Area 0°–30°	≥ 0.055 m·rad
Area 0°–40°	≥ 0.090 m·rad
Area 30°–40°	≥ 0.030 m·rad
GZ maximum	≥ 0.20 m for φ ≥ 25°
GM	≥ 0.15 m

The areas are determined by numerical integration (trapezoidal rule) over the calculated GZ points.

Projected areas — `ProjectedAreas`

Overview

For wind pressure analysis (IMO weather criteria, heeling simulations), the projected areas of the vessel, including superstructures and cargo, are required. `ProjectedAreas` calculates these areas directly from the 3D geometry of all visible objects in the document.

Calculation

The module collects all visible shapes (hull, superstructure group, cargo objects) and forms a geometric union from them. This is projected in two directions:

Lateral (side view, projection onto the XZ plane): View from starboard. Yields the longitudinal profile area, separated into above-water (z ≥ draught) and below-water (z < draught) sections, each with its centre of area.

Fore/Aft (front view, projection onto the YZ plane): View from the bow. This yields the transverse profile area, also separated into above-water and below-water sections.

Results

The calculated areas are entered into the LoadCondition spreadsheet and are thus available for subsequent calculations:

Value	Description
A_lat_above [m²]	Lateral area above the waterline
A_lat_below [m²]	Lateral area below the waterline
z_lat_above [m]	Centre of gravity height of the lateral area above the waterline
A_fa_above [m²]	Fore/aft area above the waterline
A_fa_below [m²]	Frontal area below the waterline

Trim treatment

The calculation assumes a horizontal waterline at z = draught. The effect of trim on the projected area is of second order and is neglected — sufficient for the estimation within the framework of the IMO weather criteria.

Important notes

Computation time: The GZ calculation performs several Boolean operations on the hull solid for each of the 13 angles. Depending on the complexity of the hull geometry, a complete GZ calculation takes 1–15 minutes. FreeCAD remains responsive during the calculation; progress is displayed in the console.

Pantocarenes vs. direct GZ: The KN curves from Chapter 2 (`PantocarenesCurves`) and the direct GZ calculation in this module operate independently of one another. The pantocarenes are faster (polygon-based), whilst the direct method is geometrically more accurate. With well-resolved frames (50 cross-sections, 60 points), both methods yield comparable results.

KG estimate: If no KG is available from the LoadCondition sheet, StowMind estimates KG ≈ KB + BM. This value corresponds to a GMt = 0 — the ship is right on the stability limit. For meaningful GZ curves, KG must be derived from the actual loading condition (Chapters 4–6).

SOLAS display: The SOLAS criteria lines in the plot are reference values for cargo ships. Different requirements apply to specialised vessels (cable-laying vessels, floating cranes, offshore units) — in such cases, the relevant classification societies should be consulted.

Module reference

Module	Task
`Tools (gz())`	GZ calculation: volume-constant bisection iteration over all angles of heel
`Tools (placeStowMindShapeEquilibrium)`	Equilibrium stowage with conservation of displacement
`Tools (findEquilibriumWaterline)`	Bisection solver for equilibrium waterline
`TaskPanel (GZPlotWidget)`	Qt-based interactive GZ plot with SOLAS reference lines
`PlotAux`	Additional plotting routines for GZ visualisation
`ProjectedAreas`	Calculation of projected wind and cross-sectional

Module	Task
	areas
`Spant_Tools`	Frame data for GZ preliminary calculations

Chapter 10: Sink and Trim & Hydrostatic Equilibrium Calculation

Overview

SinkAndTrim is the core hydrostatic module of StowMind. It calculates the ship's state of equilibrium – mean draught, trim, metacentric height and stability margin – based on the LoadCondition (total mass, centre of gravity) and a pre-calculated hydrostatic table. The calculation is fully integrated into FreeCAD — input data comes from the LoadCondition spreadsheet, the hydrostatics from a spreadsheet also stored within the document, and the results are written back to the LoadCondition and visualised in the 3D viewport. The module supports both an interactive calculation via the TaskPanel and an automatic background calculation, which is called directly from within the LoadCondition calculation. All Qt5/Qt6 compatibility issues have been resolved internally.

Workflow

Phase 1 — Preparation: LoadCondition & Hydrostatics

A prerequisite for any SinkAndTrim calculation is a fully calculated LoadCondition spreadsheet containing valid values in cells D4 (total mass in kg), E5 (LCG), F5 (TCG) and G5 (VCG). In addition, the document must contain a hydrostatics table generated by the StowMindHydrostatics module. The spreadsheet contains multilingual headers in row 1, which are automatically recognised:

Hydrostatics header mapping (automatic):

Table

Internal key	Recognised headers (German / English)
draft	Draft, draught, T, Tfg
disp_sw	DispSW, DisplacementSW, SW, Saltwater, Salzwasser, Salzw
disp_fw	DispFW, DisplacementFW, FW, Freshwater, Freshwater, Freshw
disp_bs	DispBS, DisplacementBS, BS, Baltic Sea, Brackish water
wet	Wet, Wetted Surface, wetted area, WSA
tmc	TMC, TPC, TonnesPerCm, Tonnescm, TonsPerCm
farea	FArea, WPA, WaterplaneArea, waterline area, Aw
kbl	KBL, LCB, LongitudinalCB, longitudinal centre of gravity
kbt	KBT, KB, VerticalCB, VCB, vertical centre of gravity
bmt	BMT, BM, BMTransverse
cb	CB, Block Coefficient, block coefficient
cf	CF, Prismatic Coefficient, Prismatic, CP, Prismatic Coefficient
cm	CM, Midship Coefficient, midship coefficient

If automatic header detection fails, a fallback to the fixed column assignment A–M is used. The hydrostatic points are read from row 2 onwards and sorted by displacement.

Hydrostatic spreadsheet priorities (automatic search):

Table

Priority	Source	Condition
1	Hydrostatics	Exact label 'Hydrostatics'
2	HydrostaticCurve (Frames)	Label 'HydrostaticCurve' in the 'Frames' or 'Frame' group
3	HydrostaticYard	Label exactly 'HydrostaticYard'
4	StowMindHydrostatics	Legacy name

Phase 2 — TaskPanel: Interactive calculation

The TaskPanel provides a complete GUI for manual equilibrium calculation:

StowMind selection

- **Find StowMind —** automatic detection by the 'StowMind' label or geometric fallback (longest shape)
- **Select from Tree —** manual selection from the tree

Load Condition selection

- **Find Load Condition —** automatic search using scoring: D4>0 (+3), E5/F5/G5 present (+1 per cell), A1 header 'LOAD CONDITION' (+2). At least 3 points required.
- **Select from Tree —** manual selection of a spreadsheet
- **Test LC Format —** diagnostic check of cells A1, D4, E5, F5, G5, K4

Hydrostatic Data Source

- **Refresh List —** loads all available hydrostatic spreadsheets into the combo box (with group path, e.g. "Frames/HydrostaticCurve")
- **Select from Tree —** manual selection
- **Analyse —** opens a header diagnostic with column mapping, mandatory field check and data row preview

Calculation options

- **Waterplane Reference:** At zero trim (horizontal) or At actual trim
- **Water density:** 900–1100 kg/m³ (standard 1025)

Phase 3 — Calculation (Compute)
The calculation is carried out in several steps:
1. Data extraction — The LoadCondition spreadsheet is read: D4 (mass), E5/F5/G5 (COG). The water type is determined from C3 (FW = Freshwater, BS = Baltic Sea, SW = Saltwater) and determines which displacement column of the hydrostatics table is used.
2. Load hydrostatics — The hydrostatics data points are extracted from the selected spreadsheet. Each point contains: displacement, draught, wetted area, TMC (tonnes per centimetre), waterline area, LCB, KBt, BMt, KMt (= KBt + BMt), block, prismatic and midship coefficients. Units are automatically converted (mm → m, kg → t).
3. Interpolation — For the current total displacement (in t), the corresponding draught and all hydrostatic parameters are linearly interpolated. If the displacement lies outside the table range, the nearest boundary value is used (with a warning).
4. Iterative trim solution (sinkingtool.py) — The trim is not calculated in a single step, but converges iteratively:

- Initial draught from displacement interpolation
- Retrieve LCB at current draught from the table
- Trim moment = $\Delta \cdot (LCG - LCB)$
- New trim = trim moment / TMC
- Re-interpolate LCB at the same draught (the mean draught does not change as a first approximation due to trim)
- Repeat until convergence (typically 3–5 iterations; terminate when δtrim < 1e-5°)

A warning is issued for trim values > 3°, as the TMC approximation then becomes questionable.
5. Saving results — The results are written back to the LoadCondition spreadsheet:
Table

Cell	Content
E4 / D6	Draught [m]
F4	KMt [m]

Cell	Content
G4	GMt corrected [m] (= KMt − VCG − FSM lever)
H5	FSM lever [m] (= ΣFSM / Δ)

Phase 4 — Results & Stability Assessment

The TaskPanel displays the results in a text box:

- Displacement, Draft, Trim (with units)
- LCB, VCB, KBt, BMt, KMt
- GMt with colour-coded stability assessment

Stability assessment (in the TaskPanel and console):

Table

Rating	GMt value	Display
✓ GOOD	> 0.5 m	Green
⚠ ACCEPTABLE	0.15–0.5 m	Yellow
⚠ CRITICAL	0–0.15 m	Orange
✗ UNSTABLE	≤ 0	Red

Before each new calculation, old visualisation objects are automatically deleted (objects named SinkAndTrim, Waterplane, StowMind_Equilibrium, COG, Buoyancy).

Phase 5 — Real-time monitoring (StabilityMonitor)

The StabilityMonitor is a frameless, translucent, always-on-top widget that hovers above the FreeCAD window and updates automatically every 4 seconds:

Table

Display area	Content
Heel Angle	Heel angle from TCG/GMt (asin(TCG/GMt) in degrees). Colour: green (OK), red (≥ 3° warning, ≥ 5° n/a). Direction indicator: → STB (starboard) or ← BB (port).
Mean Draft	Mean draught based on LoadCondition E4/D6
Trim	Trim in cm, colour-coded: green (< 50 cm), red (> 50 cm)
Aft / Fwd Draft	Aft and forward draught from hydrostatic interpolation
GMt	Metacentric height with colour coding
LCB / LCG	Longitudinal centres of gravity for comparison
Status	Total mass in tonnes and timestamp

The widget is drag-to-move (left-click and drag) and can be closed using the ✕ icon. The refresh button ⟳ updates the display manually.

Hydrostatic spreadsheet structure (example)

Row 1: Header (multilingual, see mapping above) Rows 2+: Data points, sorted in ascending order by draught or displacement

Table

Column	Example header	Unit	Content
A	Displacement SW	t	Displacement in salt water
B	Draft	m	Draught
C	Wetted surface	m²	Wetted surface
D	TMC	t·m/cm	Tonnes per centimetre
E	Waterplane area	m²	Waterplane area
F	LCB	m	Longitudinal centre of buoyancy

Column	Example header	Unit	Content
G	KB	m	Vertical centre of buoyancy
H	BM	m	Metacentric width
I	CB	—	Block coefficient
J	CP	—	Prismatic coefficient
K	CM	—	Midship coefficient

Module reference

Table

Module	Task
sinkingtool.py	Iterative hydrostatic equilibrium calculation; LoadCondition data extraction; hydrostatic interpolation; trim iteration; saving results to LoadCondition; StowMind object recognition
Tools(1).py	Non-iterative SinkAndTrim calculation (legacy); multilingual header recognition; hydrostatic spreadsheet search with priorities; header analysis diagnostics; water type recognition (freshwater/brackish water/seawater); result storage
TaskPanel.py	Interactive GUI TaskPanel for SinkAndTrim; StowMind/LoadCondition/hydrostatic selection; calculation options (waterplane reference, density); result display; delete old visualisations; Qt5/Qt6-compatible
StabilityMonitor.py	Real-time monitoring widget (frameless, always-on-top); Heel angle, draught, trim, GMt display; Auto-refresh (4 s); Coloured warning levels; Drag-to-move; Hydrostatic reload for aft/forward draught; Qt5/Qt6-compatible

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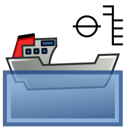
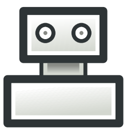
 

Constraints Sink&Trim and GZ-curve

Both tools are only available if a LoadCondition, i.e. a weight calculation, is present. If this is the case, Sink&Trim calculates the vessel's current floating condition, whilst the GZ-curve tool generates the stability curve along with the area under the stability curve, a comparison against the IMO/SOLAS criteria, and a PDF printout of the current stability situation.



Constraints Flying Monitor

opens a movable window in which the current trim and draught are displayed.

Chapter 10: Lifting Operations & Rigging — `StowMindCraneLoadout`

Overview

Cargo planning does not end once the last cargo unit has been placed in the stowage plan. The real challenge often only begins during loadout: when lifting heavy, bulky or long loads with one or two cranes, when verifying the slings, when sizing spreaders, and when ensuring that jib tips do not collide and that the vessel remains stable during the lift. StowMind maps this entire process in three dimensions — within the same model space as the stowage plan, using the same coordinates and the same crane geometries.

The result is a seamless digital verification process, from the crane right through to the load certificate.

Workflow

Phase 1 — Create crane (`TaskCreateCrane`)

Before a lift can be planned, the crane must be anchored in the ship's model as a parametric FreeCAD object.

Crane parameters:

Group	Parameter	Description
Geometry	BoomLength	Boom length [mm]
	BoomPivotHeight	Height of the boom pivot point above the crane base [mm]
	TowerHeight	Tower height [mm]
	BaseDiameter	Base diameter [mm]
	SheaveWidth / SheaveDiameter	Sheave geometry at the tip of the boom
Motion	SlewAngle	Rotation angle [°]
	LuffingAngle	Boom tilt angle [°]
Weights	BoomWeight	Boom weight [t]
Coupling	ParentStowMind	Link to the StowMind object
LoadCapacity	UseLoadStages	Load stage mode or automatic curve

Load capacity configuration — two modes:

Load stage mode: Three discrete load stages (Stage 1/2/3), each with a maximum load [t] and permissible radius range (min/max) [mm]. For cranes with tabulated load diagrams.

Automatic mode: Linear interpolation between the maximum radius (at minimum load) and the minimum radius (at maximum load). For simplified load capacity curves.

The crane is displayed as a complete 3D geometry in the viewport: tower body, jib geometry, sheave. The position is set relative to the StowMind coordinate system and automatically follows the ship when changes are made.

Phase 2 — Simple lift (`TaskLiftOperation`)

The **Single Hook Lift** calculates the optimal jib configuration for a given load.

Workflow:

1. Select the crane from the document
2. Enter load mass in tonnes
3. StowMind calculates the maximum permissible radius based on the load configuration
4. The boom is set to the optimum radius (maximum possible reach for the given load)
5. The hook height (sheave position) is visualised in the 3D viewport

Stability chain: The Single Hook Lift can optionally trigger the automatic stability chain: following the radius calculation, the crane mass – including the boom mass and load mass – is transferred to the LoadCondition sheet, and Sink & Trim (Chapter 8) is recalculated. This makes the influence of the lift on draught and heel directly visible.

Phase 3 — Tandem Lift (`TandemLift`)

For loads that exceed the capacity of a single crane or where the geometry requires two lifting points, the full **Tandem Lift solver** is available.

Inputs:

- Crane 1 (aft) and Crane 2 (bow) from the document
- Total load mass [t] or broken down into aft and forward
- Load position: Longitudinal position vector (LP1/LP2) as attachment points

Calculation (`TandemGeometrySolver`): The solver determines the hook positions of both cranes for every combination of slew angle and outreach, distributes the load according to the lever arm (static load distribution) and checks:

- Whether the load capacity of both cranes is adhered to
- Whether the permissible maximum slew angle (default: 10°) is not exceeded
- Whether the tilt angle (Kapp angle) remains below 15°

The result is a table of all valid positions, from which the optimal configuration is selected.

Swing simulation (`InteractiveSwing`): For load transfer from land to ship (or vice versa), StowMind simulates the entire swing process as a step-by-step animation in the 3D viewport. Each step shows:

- Current hook position (LP1, LP2 in the world coordinate system)
- Slew angles of both cranes
- Load height above deck
- Distances to obstacles

Phase 4 — Monopile swing (`MonopileSwing`)

For long loads — monopile foundations, wind turbine towers, long girders — there is a specialised swing simulation. This takes into account the geometry of long, rotationally symmetric bodies and calculates:

- Changes in load distribution during the swinging motion (mass displacement along the pipe)
- Ground clearance of the pile end during the erection movement
- Minimum clearances to the hull (`HULL_CL_MIN = 500 mm`) and to superstructures (`TOWER_CL_MIN = 1000 mm`)
- Optimal swing path, taking both load curves into account

Colour coding in the viewport: Green (OK) → Yellow (Warning) → Red (Critical).

Phase 5 — Boom collision check (`BoomCollisionChecker`)

In tandem lifts, there is a risk that the boom tips may collide with each other or with the load. The `BoomCollisionChecker` monitors three distances for each simulation step:

Check	Description	Safety distance
Boom 1 → Load	Distance from boom 1 to the load geometry	2000 mm
Boom 2 → Load	Distance from boom 2 to the load geometry	2000 mm
Boom 1 → Boom 2	Distance between the booms	2000 mm

If the minimum distance falls below half the safety distance, `a WARN` is issued; in the event of a genuine overlap, `FAIL`.

Phase 6 — Rigging verification (`lifting_arrangement`)

For each lift, StowMind generates a complete **rigging verification** in accordance with DNV standards.

Basis for calculation:

Factor	Value	Description
DAF	1.05–1.15	Dynamic Amplification Factor (depending on the environment)
Skew Factor	1.05	Load distribution inaccuracy for multi-point mounting
Safety factor	1.35	DNV Rigging Design Factor
Grummet SF	5.0	Breaking load = WLL × 5
Max. slinging angle	60°	Maximum slinging angle relative to the vertical
BFR minimum utilisation	2.5	Minimum ratio of breaking load to strand load

Sling classes:

StowMind dimensions and checks all components of the lifting gear:

Grummets (`grummet.py`*):* Endless wire ropes, dimensioned according to the WLL table (Green-Pin standard). The D/d ratio (rope diameter to bend diameter) is checked against minimum requirements.

Shackles (`shackle.py`*):* Green-Pin G-4163 series, 0.5 t to 600 t WLL. 22 size grades with complete geometry (shackle dimensions, pin diameter, internal dimensions). Each shackle is generated as a complete 3D model within the document — sweep geometry, pin, nut.

Hooks (`hook.py`*):* Ramshorn double hooks, generated parametrically for working loads from 50 t to 1000 t (9 size grades). Cross-section: trapezoidal profile, formed by arc sweep.

Traverses (`traverses.py /traverse_check.py`*):* Rigid traverse with multiple trunnions. Configurable as a single-lift or tandem traverse. Force distribution based on trunnion position (lever arm relative to the crane axis). D/d check of the grummets against trunnion diameters (always double-reeved at the top, 4 strands).

Rigging drawing (`rigging_drawing.py`): A rigging drawing is automatically generated as a PDF from the calculation results. It contains:

- A schematic representation of the lifting gear (crane → hook → shackle → grummets → crossbeam/load)
- BOM (Bill of Materials): all rigging components with designation, WLL and weight
- D/d check table for all bending members
- Force analysis for each strand, including utilisation factor
- Vessel and project data

Important notes

Load capacity curves: The load levels or automatic load capacity curves stored in StowMind are input data which the user must transfer from the ship's crane documentation. StowMind accepts no responsibility for the accuracy of the entered capacities — these must be taken from the current, valid load test certificate for the ship's crane.

Stability integration: During a lift, the lifted load rests on the hook — its centre of gravity shifts to hook height. With heavy loads and high crane positions, this can significantly reduce GMt. The automatic stability chain (Single Hook and Tandem Lift) transfers the hook position to the LoadCondition sheet and recalculates the stability status.

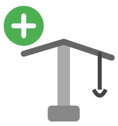
PDF documentation: All generated rigging PDFs and swing simulation reports are intended as working documents for the planning phase. For official approval of special transport operations or offshore lifting operations, additional documentation from certified rigging engineers and classification societies is required.

3D models of the lifting gear: Shackles, hooks and spreaders are generated as complete parametric 3D geometries within the FreeCAD document and can be placed directly in the stowage plan. This enables visual collision checks and a realistic representation of the entire lifting gear on the loaded vessel.

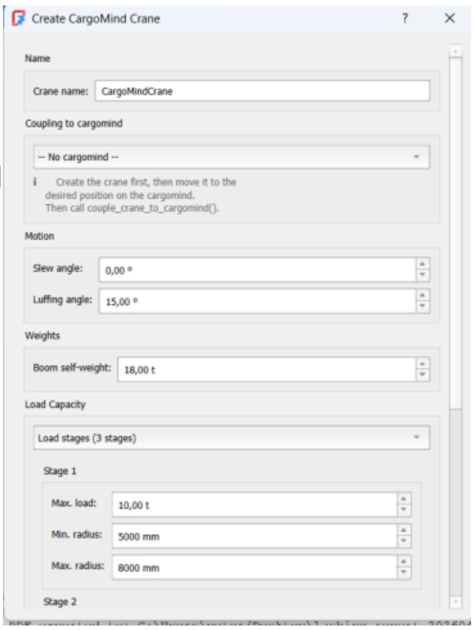
Module reference

Module	Task
`TaskCreateCrane`	Crane system: parametric FreeCAD feature with tower geometry and load configuration
`TaskLiftOperation` (`SingleHookLift`)	Single lift: optimal radius derived from load curve, optional stability chain
`TandemLift` (`TandemLiftCalculator`, `TandemGeometrySolver`)	Tandem Lift Solver: load distribution, radius optimisation, swing simulation
`InteractiveSwing`	Interactive step-by-step swing simulation in a 3D viewport
`MonopileSwing`	Swing simulation for long loads (monopiles, girders) with ground clearance and collision checks
`BoomCollisionChecker` / `boom_checker`	Boom collision prevention for tandem lifts (boom–load and boom–boom)
`lifting_arrangement`	Rigging Core: DNV verifications for slings, D/d

Module	Task
	check, force balance
`lifting_arrangement_ui`	GUI wrapper for the rigging verification dialogue
`lifting_wizard` / `lifting_wizard_p4p5`	Guided wizard for rigging configuration
`traverse_check`	Traverse integration: trunnion force distribution, D/d-Grummet check
`traverses`	Traverse database: geometries, trunion clearances, WLL values
`grummet`	Grummet sizing according to WLL table (Green-Pin standard)
`shackle`	Green-Pin G-4163 shackle: 22 size grades, 3D geometry generation
`hook`	Ramshorn double hook: parametric 3D geometry, 9 load-bearing classes
`rigging_drawing`	PDF export: rigging drawing with BOM and force analysis
`CraneSpreadsheetTools`	Data transfer from crane to LoadCondition sheet, stability integration
`pdf_to_3d_freecad`	Import of PDF crane drawings as 3D reference geometry

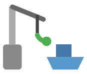
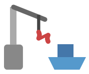


Crane Create Crane

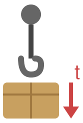


The module for creating cranes is essentially self-explanatory. Key features include the ability to either define load stages or use an automatic stage based on the maximum load for a defined slewing circle and the minimum load for the maximum slewing circle. The crane is created at the origin and must then be moved to the desired position using the ‘placement’ command.

The cranes are created parametrically and can be adjusted accordingly. Their appearance cannot be changed so easily; to do so, a new file would need to be created, but the focus here is essentially on the mechanical rather than the visual properties.

  ***Crane Couple / Decouple***

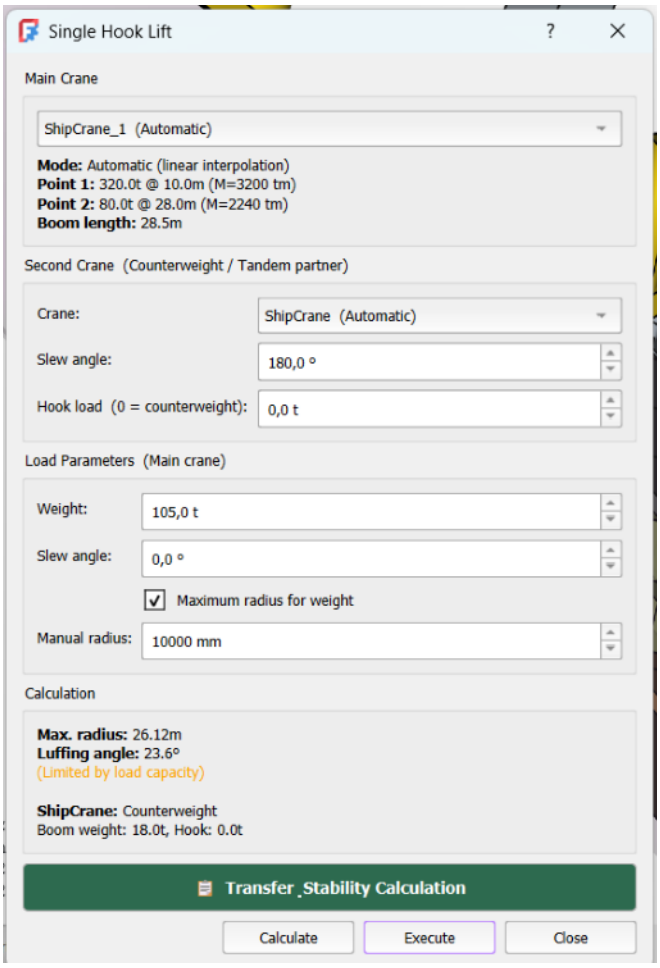
It is possible to couple or uncouple the cranes to the ship; the rationale behind this is to allow for potential further investigations using the model, although this is not currently relevant. When coupled, the crane follows the ship’s movements. This becomes particularly interesting when extending the analysis to include the movements of a cargo item during offshore lifting operations, taking sea state conditions into account. This module has not yet been implemented.



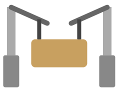
Crane Single-hook lift

A virtually self-explanatory task panel prompts the user for the relevant details. An interesting feature is the ability to rotate a second crane as a counterweight. The selected crane rotates in the desired direction, subject to the maximum rotation radius determined either by the geometry or by the load.

The procedure is as follows: first, press the ‘ ’ button ‘Calculate’; the corresponding swing circle is calculated; the ‘Execute’ button rotates the crane to the set number of degrees and positions the boom at an angle corresponding to the calculated swing circle. At this point, you can press the large green ‘Transfer Stability Calculation’ button; the load is transferred to the ‘LoadCondition’ according to the position of the deflection pulley at the top of the boom, the ‘LoadCondition’ is calculated, and the ‘Sink&Trim’ stability calculation is started, producing a corresponding report on the stability situation during the lift.



Crane Tandem Lift

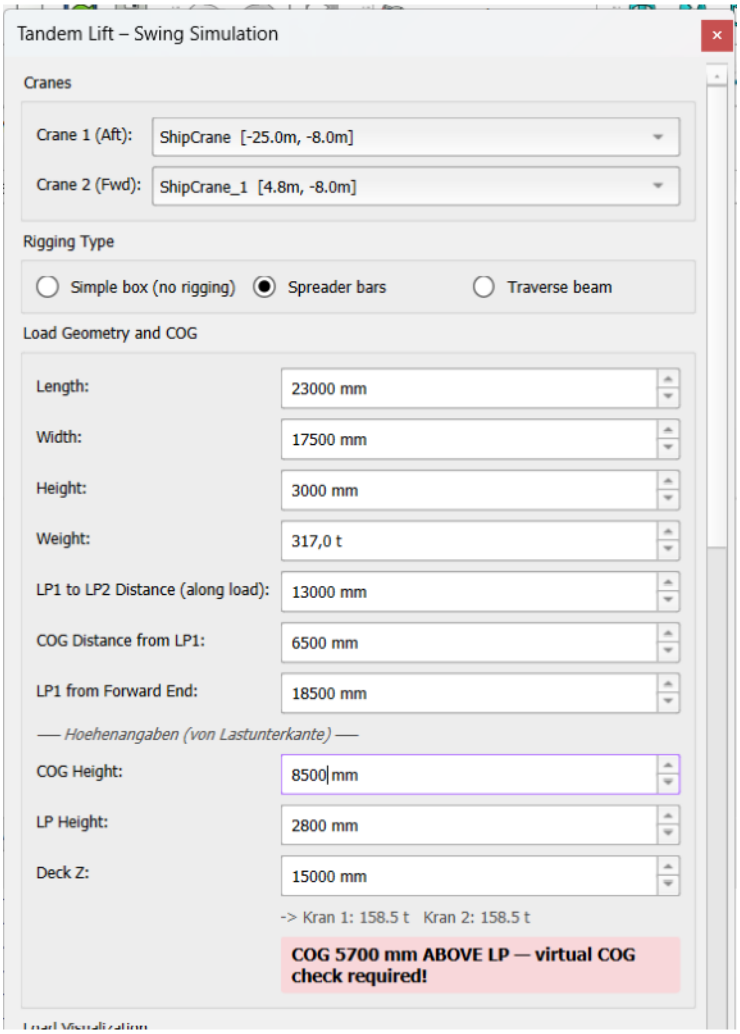


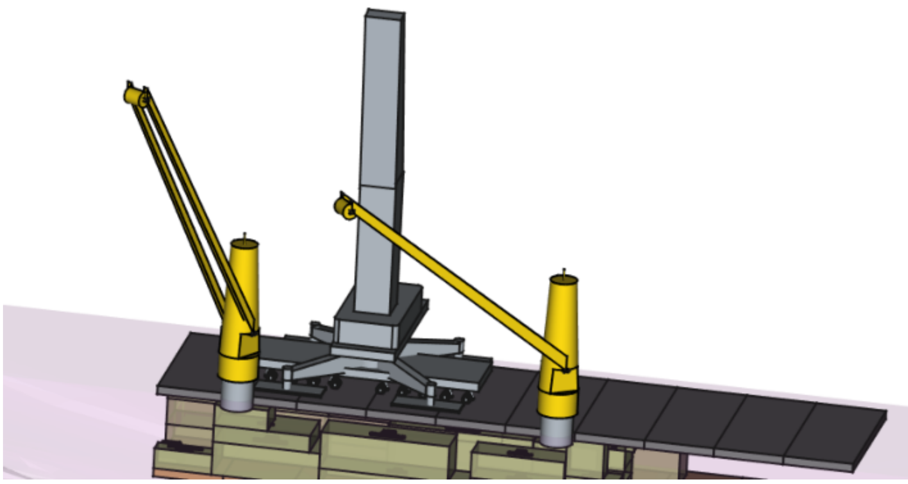
As with the single-hook lift, a tandem lift is also possible; this has, a very comprehensive TaskPanel, just like the single-hook lift. The procedure will now be demonstrated using a Liebherr LHM600 crane. First, the upper part of the TaskPanel:

Here, it has first been specified that the load is to be lifted using a spreader; the next items are the approximate geometric dimensions.

In this case, it seems somewhat odd that the distance LP1 from End is 18,500 mm; this is due to the slightly different zero-point definition of the 3D model, which has simply been imported here.

The key point here is that a warning appears stating that the COG is 5700mm above the lift points. In such a case, the lift is checked in accordance with DNV Stability of Lifts.



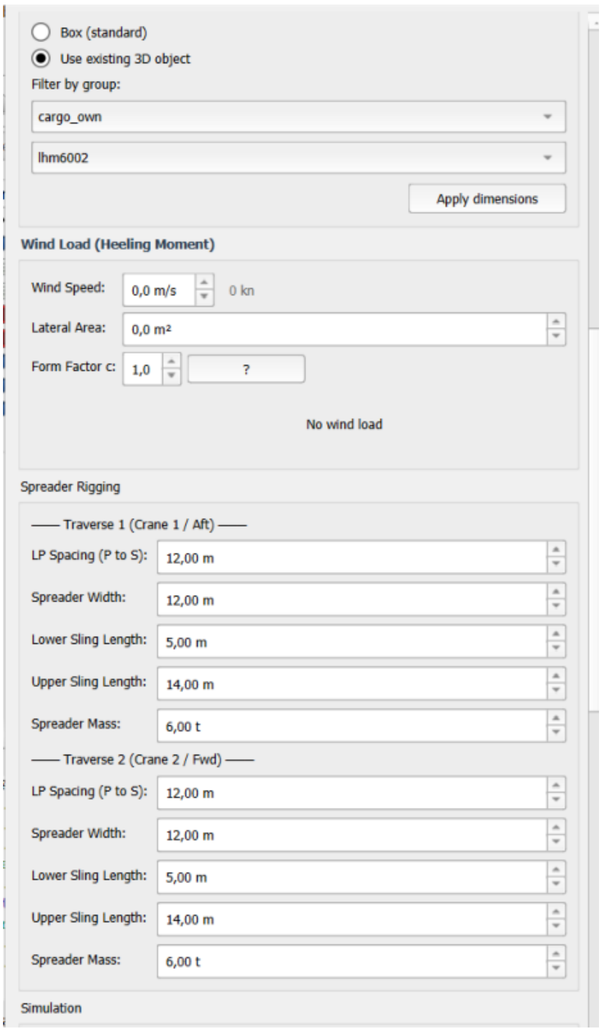


In the middle section of the Task Panel, you first specify whether you wish to use a simple cuboid as the simulation object or whether a 3D model is available; in this instance, a 3D model is available and should be used accordingly.

The wind load can be set; in this instance, calm conditions are assumed.

The spreader bars are then defined. A crossbeam would also be possible.

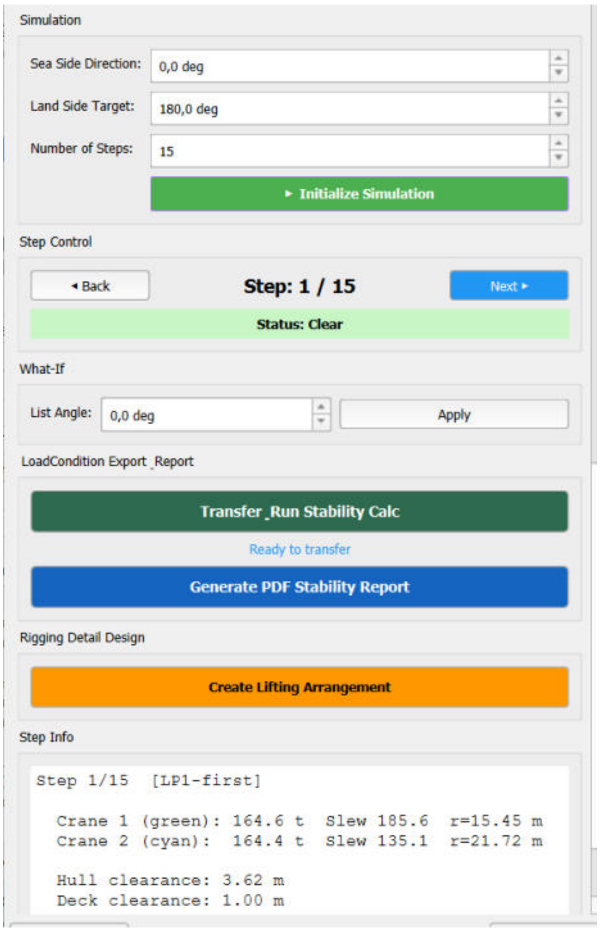
In the lower section, a simulation can be started; the crane is swung on board step by step.
There is no continuous collision detection with the mast structures, but even if a collision is visible there, it is very easy to decide whether this lift is feasible or not.

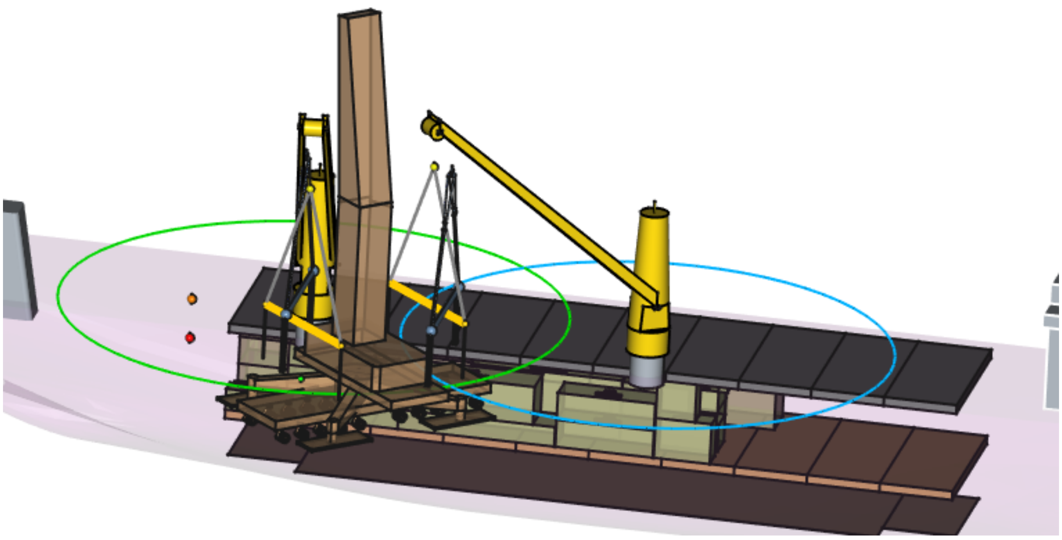


As with the single-hook lift, the current position of the cargo and the cranes can be transferred to the LoadCondition at each step ( ), and the ship's stability will be calculated automatically for this situation.

In this case, the 'Generate PDF Stability Report' function refers not to the ship's stability but to the stability of the lift in accordance with the DNV Stability of Lifts Guidance Paper 2024—

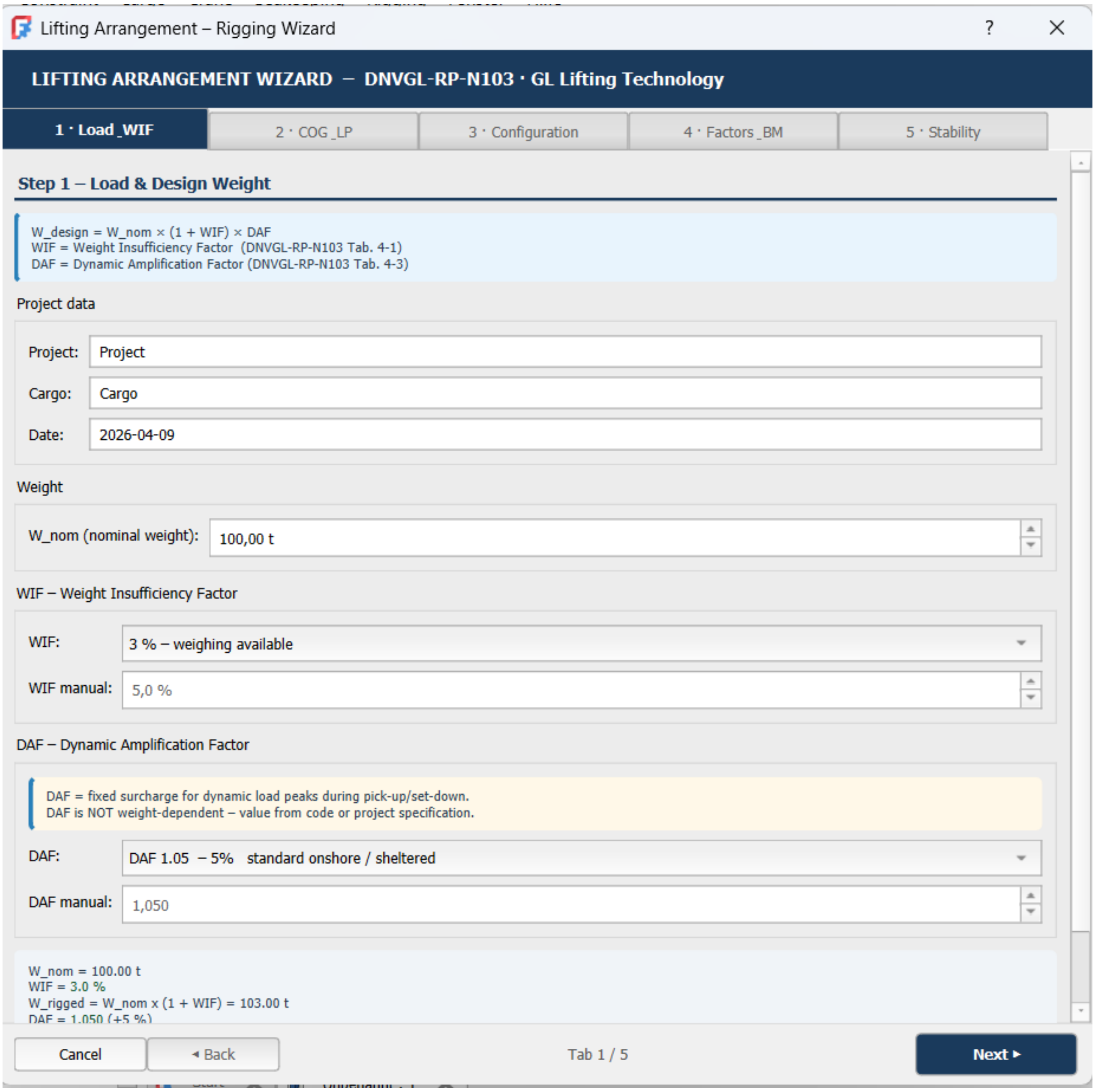
The final button generates a calculation of the lifting arrangement in accordance with Noble Denton / DNV, a drawing of the lifting arrangement and a bill of materials.





StowMind – Rigging

Even without a specific ship or crane, a lifting arrangement in accordance with DNV / Noble Denton can be designed using a rigging wizard. The lift is defined across five pages and can be calculated accordingly; as with the TandemLift, a 3D view of the lifting arrangement is provided, along with a bill of materials.



Furthermore, under ‘Rigging’, shackles, grommets and a crossbeam can be created as 3D objects for further use.

Chapter 11: Tools

Overview
This chapter describes two auxiliary tools that complement the workflow in StowMind: the **Cargo Editor** for direct editing of cargo objects and **SnipDecal** for enhancing the visual appearance of the 3D model using image textures. Both tools are fully integrated into FreeCAD, are Qt5/Qt6-compatible and operate directly on the objects in the active document.

Tool 1 — Cargo Editor (editor.py)
The Cargo Editor is a compact, two-part dialogue box for directly editing all relevant properties of a cargo unit. It replaces the need to manually click through the FreeCAD Properties window with a clear interface tailored to StowMind.
Tab 1: Main
Object Selection

- **Group** — Drop-down list of all groups with the prefix `cargo_`, `weights_` or `tanks_`. Display: "Cargo › PortX" instead of "cargo_PortX"
- **Object** — Drop-down list of all box-like objects in the selected group, with a preview of their dimensions (e.g. "Container_01 (6058×2438×2591)")
- **Refresh button** ↻ — refreshes groups and objects following document changes

Dimensions

- Unit: mm / cm / m (switching between units scales all values)
- Length, width, height — directly editable; volume is calculated in real time

Weight

- Mass in kg, t or g

COG Offset (editable)

- X/Y/Z offset — the VALUE in the FreeCAD expression (e.g. "Placement.Base.z + 1200 mm")
- **Absolute COG** — calculated and displayed in real time (e.g. "X:4520 Y:1219 Z:3897")
- **Expression info** — displays the current formula (e.g. "COG.z = Placement.Base.z + 1200")
- The offset remains dynamic via expressions: if the position changes, the centre of gravity follows automatically

Position & Rotation

- Unit: mm / cm / m
- Pos X/Y/Z and Rot X/Y/Z (Euler angles)

Tab 2: Visual

- Visibility (checkbox)
- Colour (colour picker with hex input)
- Transparency (0–100%)
- Label name (freely editable)

Actions

- **Apply** — saves all changes back to the object; COG is saved as an expression (e.g. `COG.z = Placement.Base.z + Height/2`) so that the centre of gravity moves with the object when its position changes
- **Dup** — duplicates the object with an offset of +500 mm in the X-axis; copies all properties, expressions and ViewObject settings; automatically adds the new object to the StowMind Weights list
- **Reset** — reloads the original values of the current object
- **Close** — closes the dialogue box

Live selection from the 3D viewport
The editor monitors the FreeCAD selection (`Gui.Selection.getSelection()`) every 300 ms. If another box-like object is clicked in the viewport, the editor loads it automatically — without closing or reopening the dialogue box. The timer is stopped cleanly when the dialogue box is closed.

Tool 2 — SnipDecal (tag.py)
SnipDecal is a texture placement tool that projects images (PNG with transparency, JPG, BMP) as decals onto the surfaces of cargo objects. Originally designed for screenshots (Snipping Tool), it is suitable for labels, logos, warning symbols or visual markings on cargo units.
How it works

1. **Load image** — via file browser or Snipping Tool (Win+Shift+S)
2. **Select cargo object** — drop-down list of all objects with Length/Width/Height
3. **Select surface** — Top, Bottom, Front, Back, Left, Right
4. **Scaling** — 0.1–1.0 (default 0.98, slightly smaller than the surface to avoid overlap)
5. **Apply** — creates a `Part::Plane` object with a Coin3D texture, which is linked to the cargo object

Technical implementation

- The decal is a `Part::Plane` whose placement is calculated relative to the cargo object (`Placement.multiply(local_pl)`)
- The texture is projected onto the surface via Coin3D (pivy) as `a SoTexture2` with `SoTextureCoordinatePlane`
- UV coordinates are automatically adjusted to the length and width of the decal
- A `DocumentObserver` monitors the Cargo object: whenever the placement changes, the decal is automatically updated
- All decals are grouped together in the “Decals” group
- The line width and point size of the plane are set to 0 so that only the texture is visible

Dialogue elements

- **Image preview** — scaled preview of the loaded image
- **Browse** — file selection (*.png *.jpg *.jpeg *.bmp)
- **Open Snipping Tool** — launches the Windows Snipping Tool for quick screenshots
- **Face & Scale** — area selection and scaling
- **Status bar** — success message or error
-

Limitations

- Requires pivy / Coin3D (otherwise texturing is disabled, but the dialogue box remains usable)
- The texture only follows the cargo object when its placement changes, not when its dimensions change

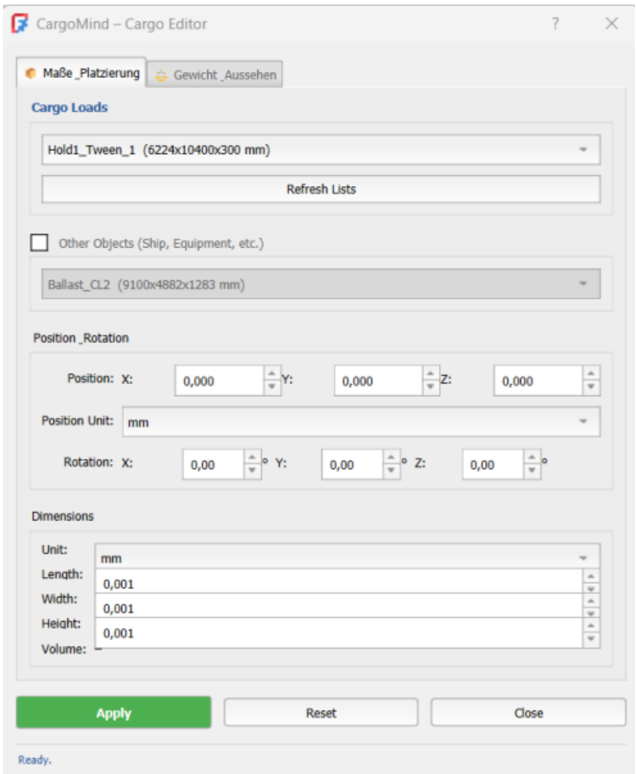
Module reference

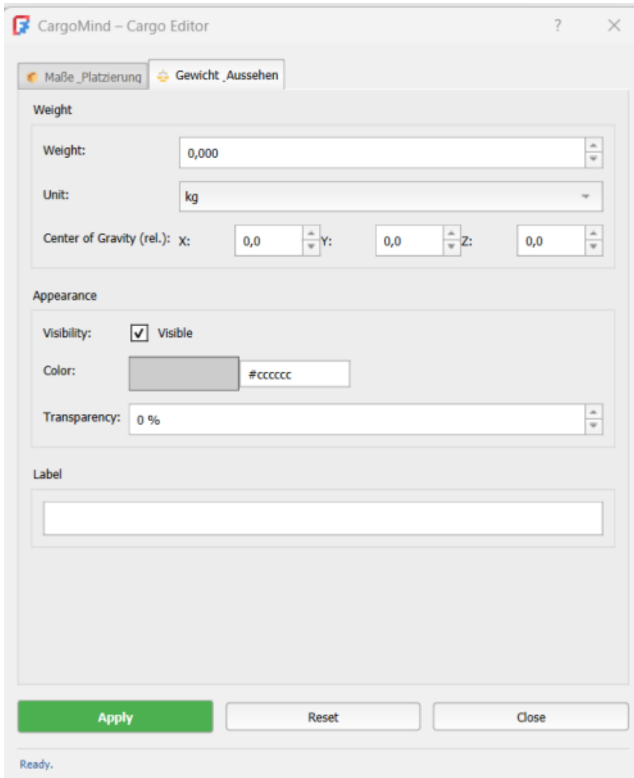
Table

Module	**Task**
editor.py	Cargo Editor: Direct editing of dimensions, mass, COG offset (using expressions), position, rotation, colour, transparency and label; duplication with automatic weights registration; live viewport selection
tag.py	SnipDecal: Image texture placement on cargo object surfaces; Coin3D texturing; DocumentObserver for automatic updating; group management; Qt5/Qt6-compatible

Tools Editor

The Editor can be used to edit cargo parts and properties can be modified. The most important feature is the ability to rotate the cargo part or move it to a different position. This editor brings together the usual manipulable data from FreeCAD

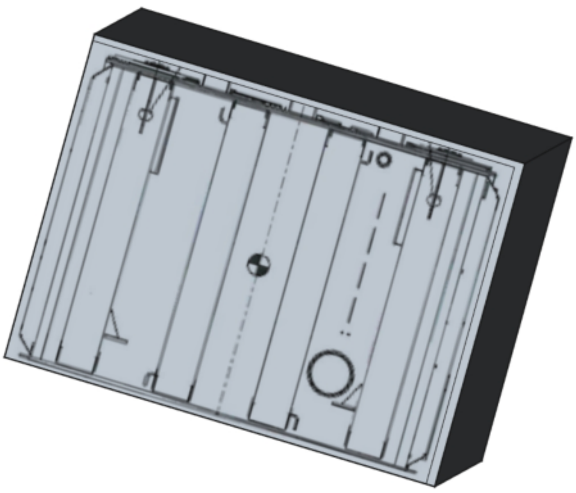




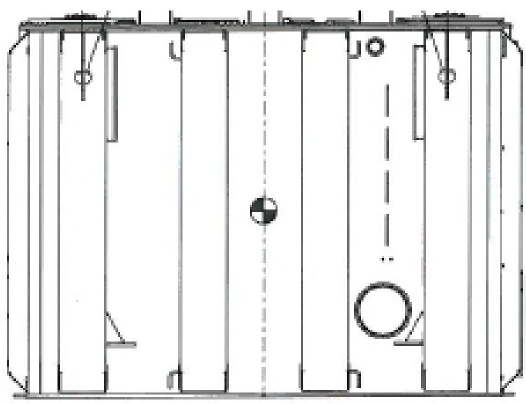
Tools Tag

The ‘Tag’ tool allows drawing elements to be projected onto a cuboid. The aim is to ‘stick’ the drawing details from a PDF onto a cuboid of the same spatial dimensions as the original drawing, in order to create the impression of a technical drawing. First, the desired section is selected using a snipping tool, such as the one provided by Windows, and saved as a *.png file. This *.png file can then be applied to the outer surface of the cuboid using this tool. The front, rear, left and right sides, as well as the base and top, can be selected. These graphics are saved under the ‘Decals’ group

Cube with ‘applied’ image



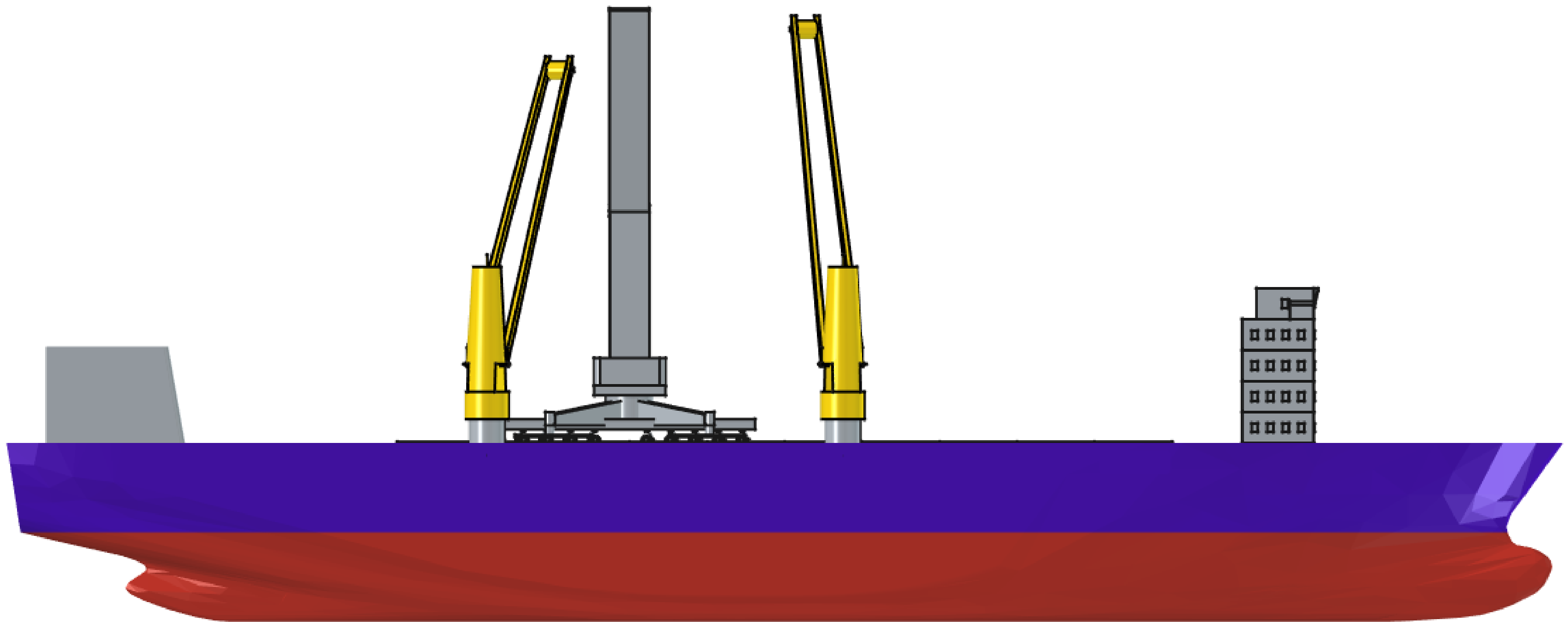
Original copy generated from the PDF and saved as a PNG:



Chapter 12: Sample printouts

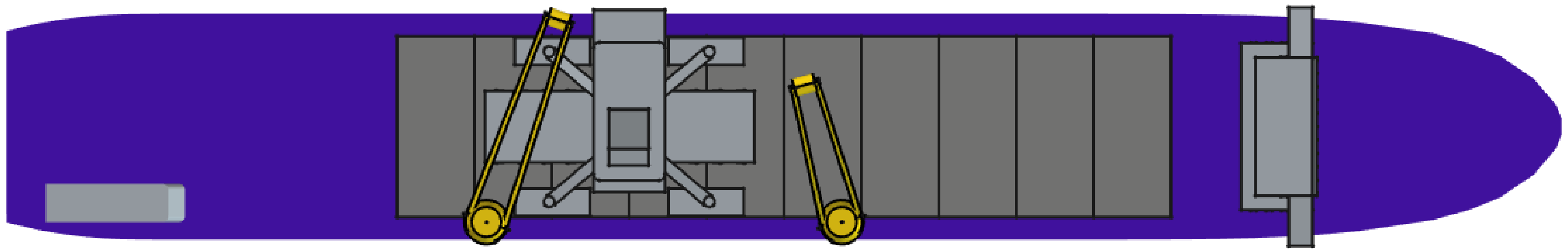
SIDE VIEW – PNG

viewFront · orthographisch



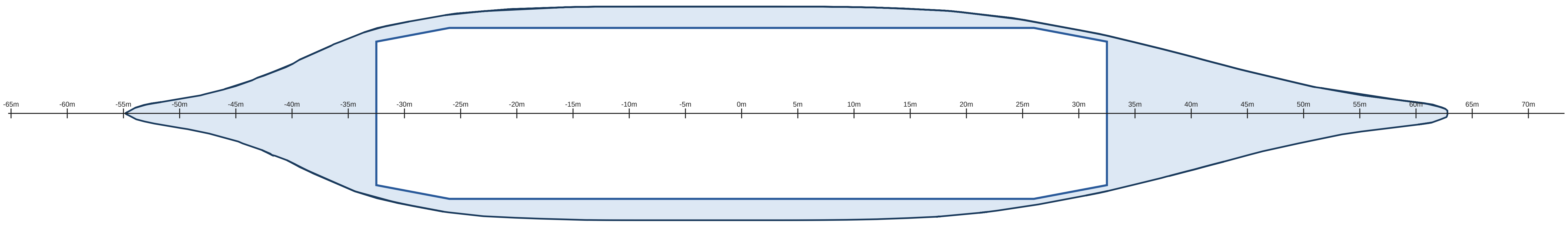
DECK TOP VIEW – PNG

viewTop · orthographisch



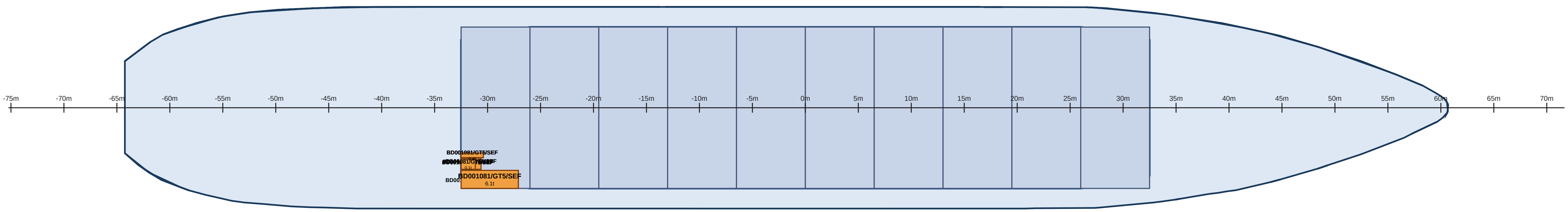
HOLD 1 – LOWER HOLD

Schnitt z=2.3m | Tanktop z=2.0m



HOLD 1 – TWEENDECK

Schnitt z=8.3m | Tweendeck z=8.0m



VESSEL	DOCUMENT	DATE	SOFTWARE	PAGE
StowMind001	STOWAGE PLAN	2026-07-05	StowMind	1 / 2

GZ CURVE DATA

Vessel: Ship | Load case: LoadCondition | Displacement: 10461.4 t | KG: 7.821 m | GM: 0.670 m

Roll [deg]	GZ [m]	Draft [m]	Trim [deg]	Cumul. Area [m*rad]
0.00	-0.10017	6.454	-	0.00000
5.71	-0.03030	7.131	-	-0.00651
11.43	0.05299	7.736	-	-0.00537
17.14	0.16193	8.298	-	0.00534
22.86	0.30920	8.775	-	0.02884
28.57	0.50252	9.171	-	0.06931
34.29	0.73320	9.446	-	0.13094
40.00	0.98381	9.558	-	0.21656

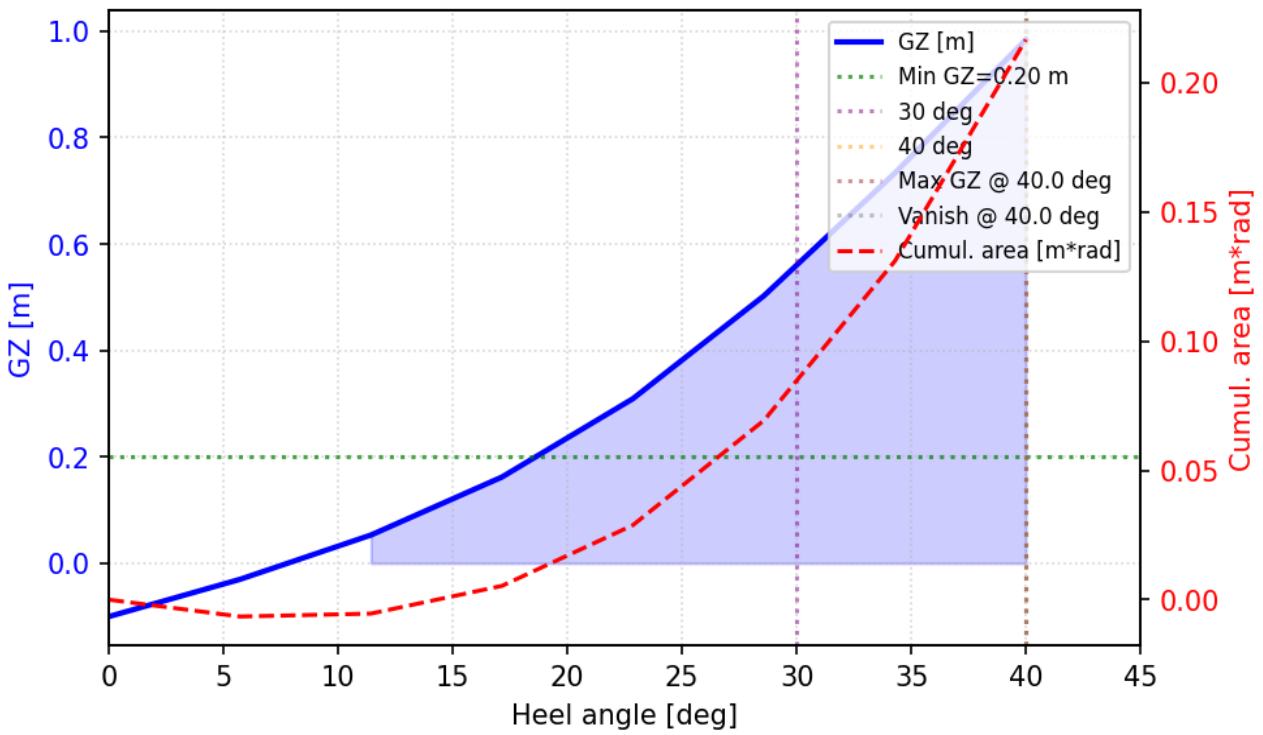
Generated: 2026-04-10 14:04

SOLAS / IMO STABILITY CRITERIA (IS Code 2008)

Criterion	Required	Actual	Status
Area 0-30 deg >= 0.055 m*rad	0.055 m*rad	0.0826 m*rad	PASS
Area 0-40 deg >= 0.090 m*rad	0.090 m*rad	0.2166 m*rad	PASS
Area 30-40 deg >= 0.030 m*rad	0.030 m*rad	0.1340 m*rad	PASS
GZ at 30 deg >= 0.200 m	0.200 m	0.5602 m	PASS
Max GZ angle >= 25 deg	25.000 deg	40.0000 deg	PASS
Initial GM >= 0.150 m	0.150 m	0.6697 m	PASS

6/6 criteria passed | Max GZ: 0.984 m @ 40.0 deg | Vanishing: 40.0 deg | GM: 0.670 m (spreadsheet)

GZ RIGHTING LEVER CURVE



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LOAD CONDITION SUMMARY - WEIGHT GROUPS

Vessel	Ship
Load case	LoadCondition
Displacement	10461.39 t
KG (VCG)	7.821 m
KM	8.497 m
GM (calc.)	0.670 m
Date	2026-04-10 14:04

Weight Groups

Group	Items	Mass [t]	LCG [m]	TCG [m]	VCG [m]
TANKS	12	2543.30	-0.810	-0.249	3.028
WEIGHTS	22	7181.00	-0.191	0.000	8.543
CRANES	2	36.00	-10.075	-8.000	22.930
CARGO	37	701.09	-3.280	-0.171	17.036
TOTAL	**-**	**10461.39**	**-0.582**	**-0.100**	**7.821**

Group total: 10461.39 t | Sheet displacement: 10461.39 t | Difference: 0.000 t (0.0 %)

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LASHING CALCULATION

Advanced Calculation Method · IMO CSS Annex 13 · 2021 Amendments

VESSEL		CARGO	lhm6002
Length LPP	**130.6 m**	Mass	**320.000 t**
Breadth	**19.00 m**	Stowage	**Deck-high**
GM	**1.500 m**	x / L	**0.000**
Speed	**17.0 kn**	Friction µ	**0.30**
Voyage	**unrestricted**	COG height	**8.900 m**
fR	**1.0000**	Footprint w×l	**17.290 × 22.600 m**

Forces (fR = 1.0000)

Direction	Accel×fR kN	Wind kN	Sea kN	Total kN	Tag
Transverse →PS	2084.0	270.6	45.2	**2399.8**	Fy_ps
Transverse →SB	2084.0	270.6	45.2	**2399.8**	Fy_sb
Longit. →Aft	1097.1	170.8	34.6	**1302.5**	Fx_aft
Longit. →Fwd	1097.1	170.8	34.6	**1302.5**	Fx_fwd
Vertical	2194.2	—	—	**2194.2**	Fz

fR = 1.0000 reduces acceleration forces only. Wind/sea areas in m²; force = area × 1 kN/m².

Appendix 3 applicable – additional transverse: 6567.4 kNm | additional longitudinal: 9484.0 kNm

Securing Materials (SF = 1.5)

Material	BL kN	MSL kN	CS (SF 1.5) kN	Count
Chain / D-Ring / Welded	200	100.0	**66.7**	**60**

Securing Arrangement

Side	n	Material	α °	Lever m	MSL kN	CS kN	f	Restr. kN	Mom. kNm
SB → resists PS	**22**	Chain / D-Ring / Welded	23	6.00	100.0	**66.7**	1.00	**1467.4**	8804.4
PS → resists SB	**22**	Chain / D-Ring / Welded	23	6.00	100.0	**66.7**	1.00	**1467.4**	8804.4
FWD → resists Aft	**8**	Chain / D-Ring / Welded	45	22.60	100.0	**66.7**	0.92	**490.9**	11094.6
AFT → resists Fwd	**8**	Chain / D-Ring / Welded	45	22.60	100.0	**66.7**	0.92	**490.9**	11094.6

Balance of Forces (Sliding) & Moments (Tipping)

Sliding [Lashings + Fr (941.8 kN)]	Req kN	App kN	Status	Tipping	Req kNm	App kNm	Status
→ PS (SB lashings)	2399.8	2408.4	**OK**	→ SB (PS lashings)	27925.6	35938.4	**OK**
→ SB (PS lashings)	2399.8	2408.4	**OK**	→ PS (SB lashings)	27925.6	35938.4	**OK**
→ Aft (FWD lashings)	1302.5	1432.0	**OK**	→ Aft (FWD lashings)	21075.8	46552.9	**OK**
→ Fwd (AFT lashings)	1302.5	1432.0	**OK**	→ Fwd (AFT lashings)	21075.8	46552.9	**OK**

Appendix 3: additional transverse moment +6567.4 kNm | additional longitudinal moment +9484.0 kNm

SF = 1.5 | Vertical lashing angles only (conservative approach). For SF = 1.35 horizontal angles must be measured and documented per IMO CSS Annex 13.

1. Project and Load Data

Total Lift Weight	332.00 t
Crane 1 (Aft) Share	166.00 t (50%)
Crane 2 (Fwd) Share	166.00 t (50%)
Load Dimensions L x B x H	23000 x 17000 x 3000 mm
COG Height above Baseplate	8500 mm
Lift Point Height above Baseplate	2800 mm
COG relative to Lift Points	5700 mm – ABOVE LP: stability check required
LP1 to LP2 Distance	13.00 m

2. Rigging Geometry

Lifting Arrangement: AFT / Crane 1	
LP Spacing BB to SB	12.00 m
Spreader Width	12.00 m
Lower Sling Length	5.00 m
Lower Sling Angle (from vertical)	0.0 deg
Lower Sling Vert. Component S	5.000 m
Upper Sling Length	14.00 m
Upper Sling Angle (from vertical)	25.4 deg
Upper Sling Vert. Component V	12.649 m
Phi – Vertical to Upper Sling	25.4 deg
Spreader Mass	6.00 t
Hook Height above LP (COS)	17.649 m

Lifting Arrangement: FWD / Crane 2	
LP Spacing BB to SB	12.00 m
Spreader Width	12.00 m
Lower Sling Length	5.00 m
Lower Sling Angle (from vertical)	0.0 deg
Lower Sling Vert. Component S	5.000 m
Upper Sling Length	14.00 m
Upper Sling Angle (from vertical)	25.4 deg
Upper Sling Vert. Component V	12.649 m
Phi – Vertical to Upper Sling	25.4 deg
Spreader Mass	6.00 t
Hook Height above LP (COS)	17.649 m

3. Virtual COG Stability Check (Kapp/Nikitin)

Result: AFT/Crane1	
Z – COG above LP	5.700 m
S – Lower sling vert.	5.000 m
V – Upper sling vert.	12.649 m
Phi	25.4 deg
R_rigging	3.598 m
R_wind	0.017 m
R_total	3.615 m
Virtual COG above LP (Z+R)	9.315 m
COS (S+V)	17.649 m
Margin M = COS - vCOG	8.334 m

STABLE

Result: FWD/Crane2	
Z – COG above LP	5.700 m
S – Lower sling vert.	5.000 m
V – Upper sling vert.	12.649 m
Phi	25.4 deg
R_rigging	3.598 m
R_wind	0.017 m
R_total	3.615 m
Virtual COG above LP (Z+R)	9.315 m
COS (S+V)	17.649 m
Margin M = COS - vCOG	8.334 m

STABLE

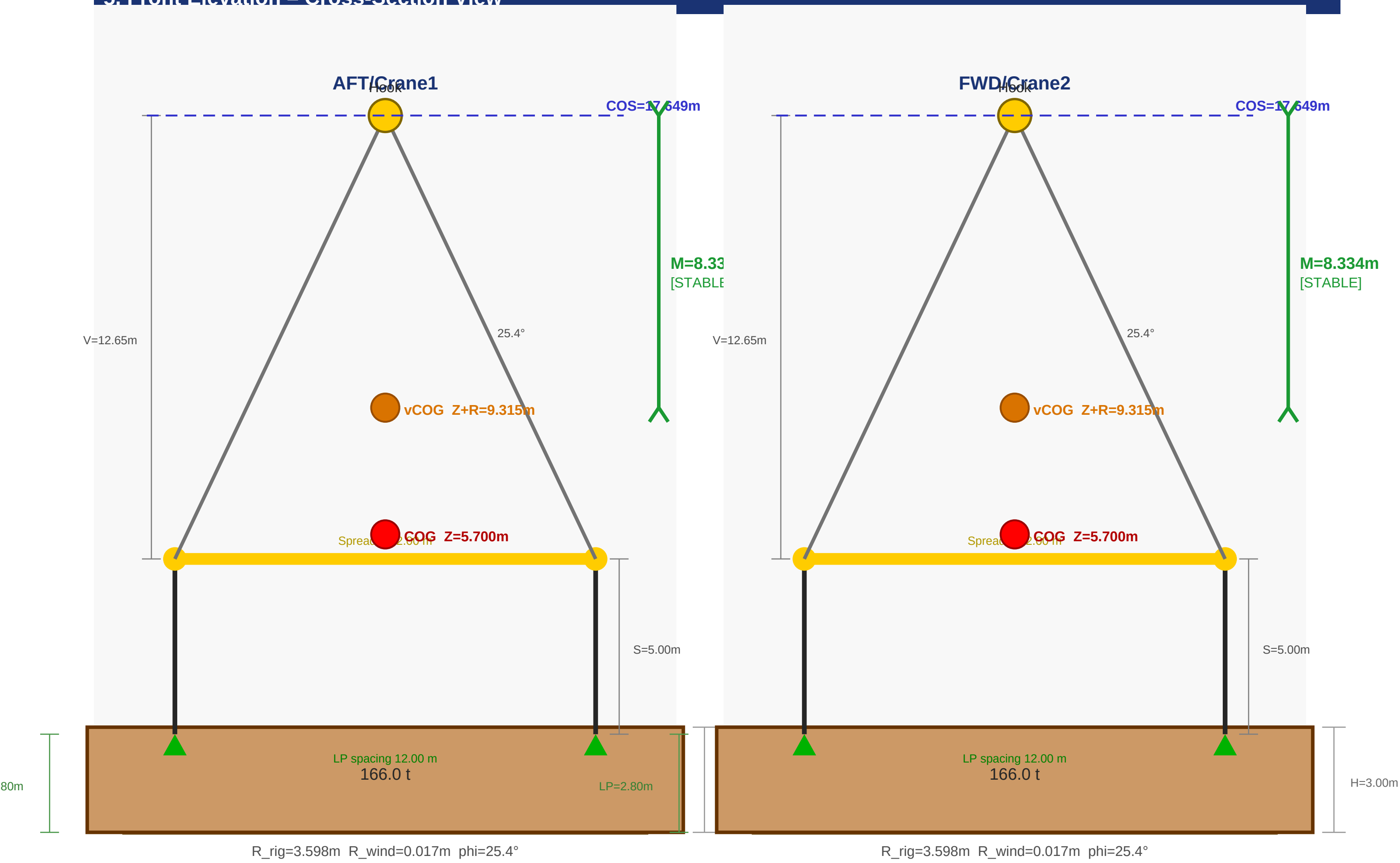
4. Overall Assessment

Overall: PASS (governing margin = 8.334 m)

Virtual COG is 8.334 m below COS. Governing margin exceeds 2.5 m minimum.

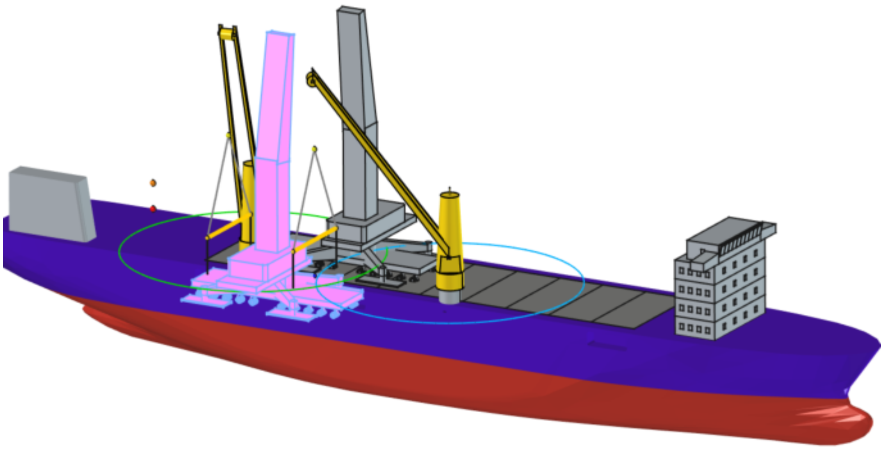
Acceptance: PASS >= 2.5 m | MARGINAL 0.5–2.5 m | FAIL < 0.5 m

5. Front Elevation – Cross-Section View

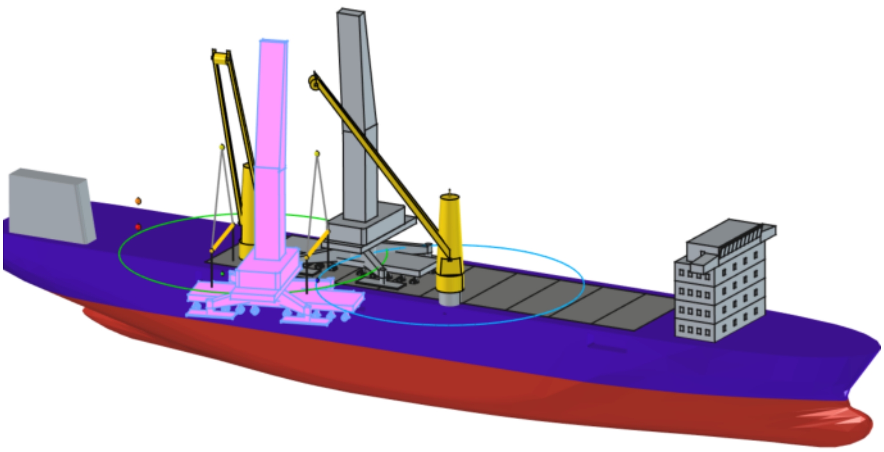


6. Simulation Steps 1–3 (of 14)

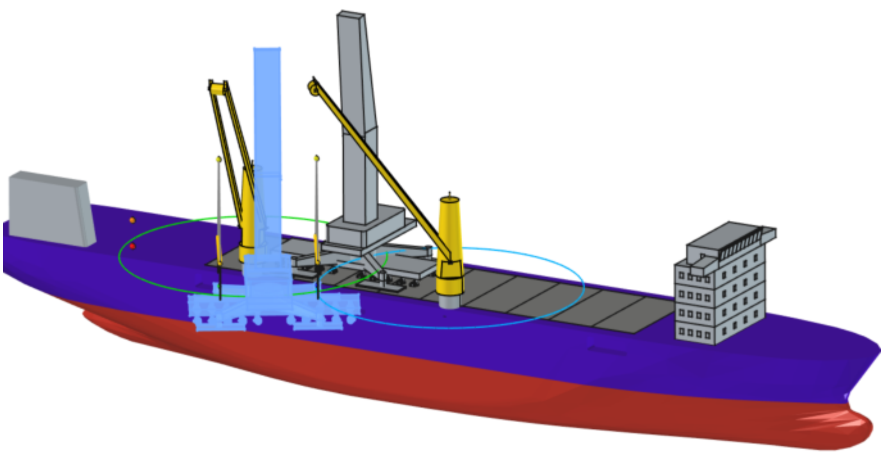
Step 1/14 [SWING] Status:FAIL K1: r=9.23m slew=188.4° K2: r=17.99m slew=120.5°



Step 2/14 [SWING] Status:WARN K1: r=13.60m slew=191.2° K2: r=17.71m slew=124.3°

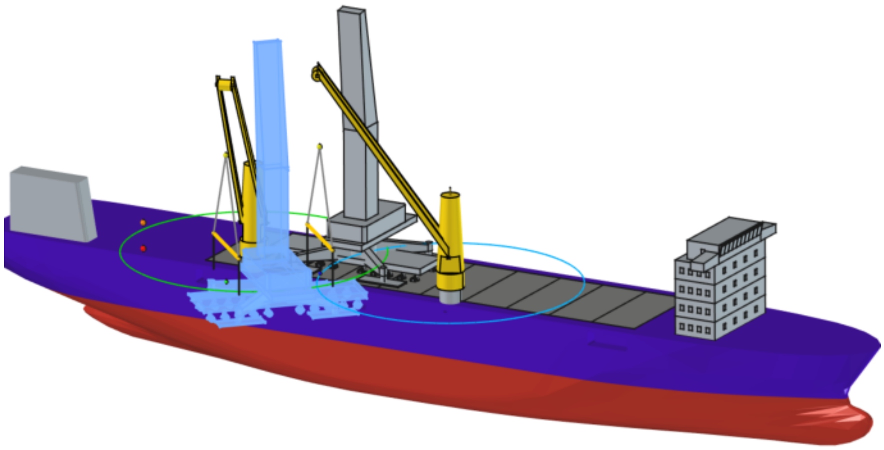


Step 3/14 [SWING] Status:OK K1: r=17.83m slew=194.1° K2: r=17.89m slew=127.1°

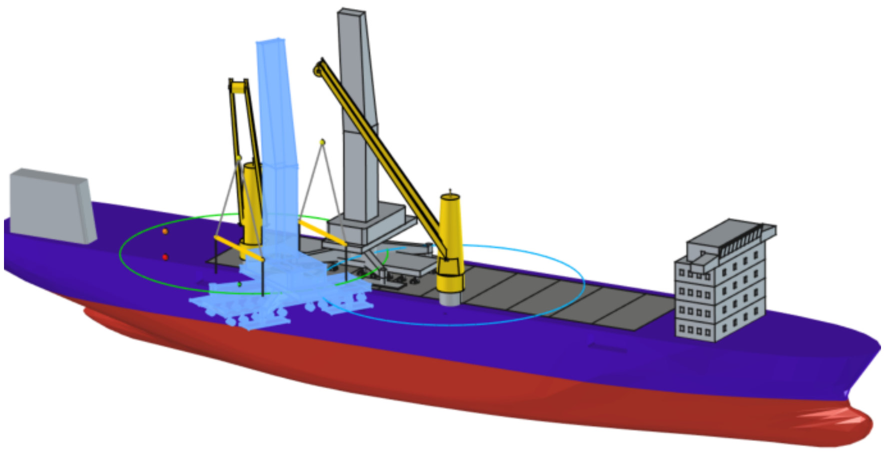


7. Simulation Steps 4–6 (of 14)

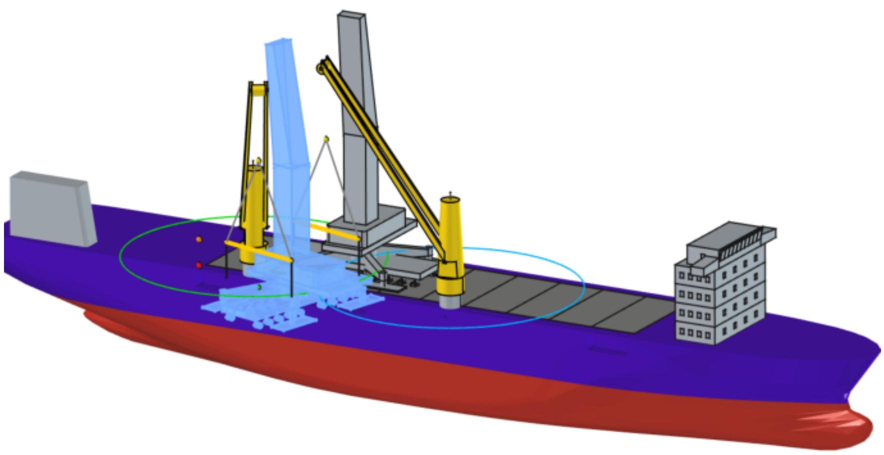
Step 4/14 [SWING] Status:OK K1: r=17.83m slew=196.9° K2: r=17.37m slew=117.0°



Step 5/14 [SWING] Status:OK K1: r=17.83m slew=202.5° K2: r=17.33m slew=107.5°

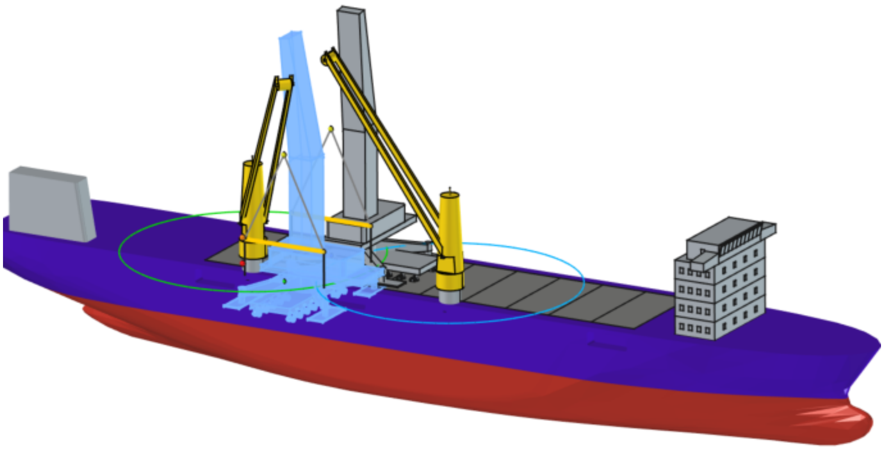


Step 6/14 [SWING] Status:OK K1: r=17.83m slew=210.9° K2: r=17.53m slew=99.0°

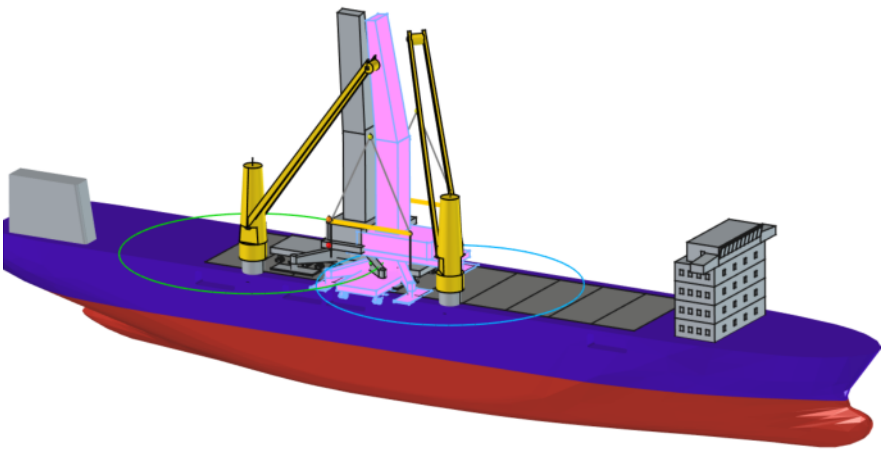


8. Simulation Steps 7–9 (of 14)

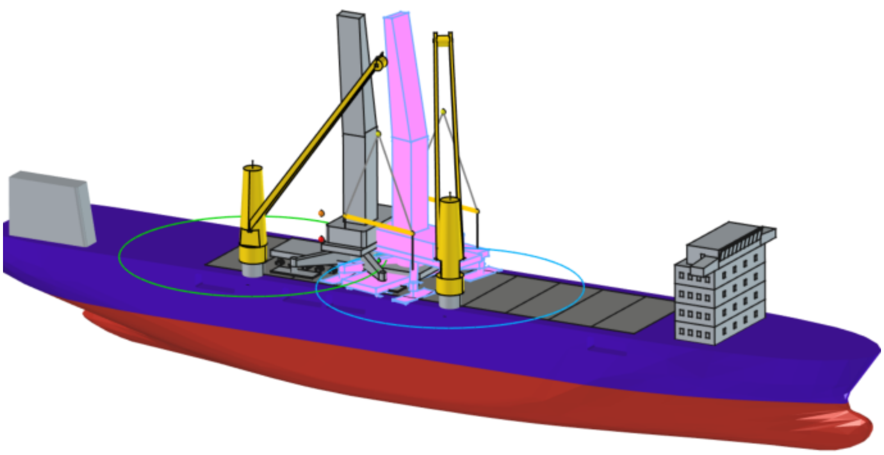
Step 7/14 [SWING] Status:OK K1: r=17.83m slew=222.2° K2: r=17.88m slew=90.7°



Step 8/14 [SWING] Status:FAIL K1: r=17.83m slew=270.0° K2: r=17.70m slew=42.7°

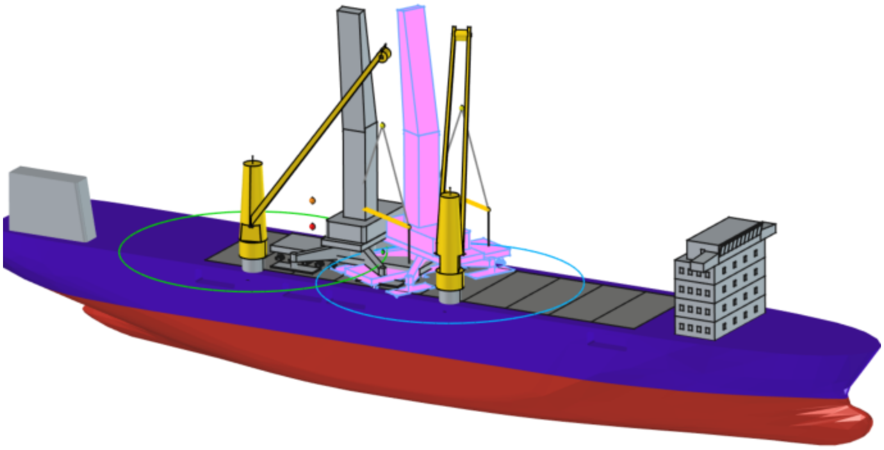


Step 9/14 [SWING] Status:FAIL K1: r=17.83m slew=278.4° K2: r=17.91m slew=31.4°

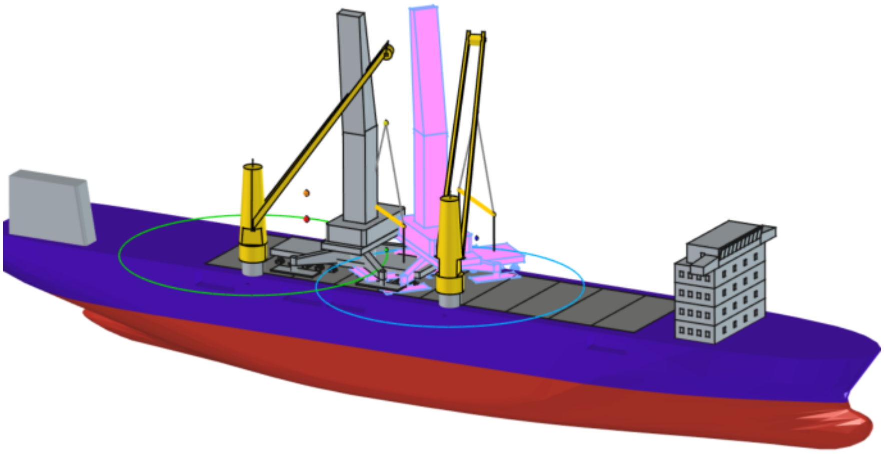


9. Simulation Steps 10–12 (of 14)

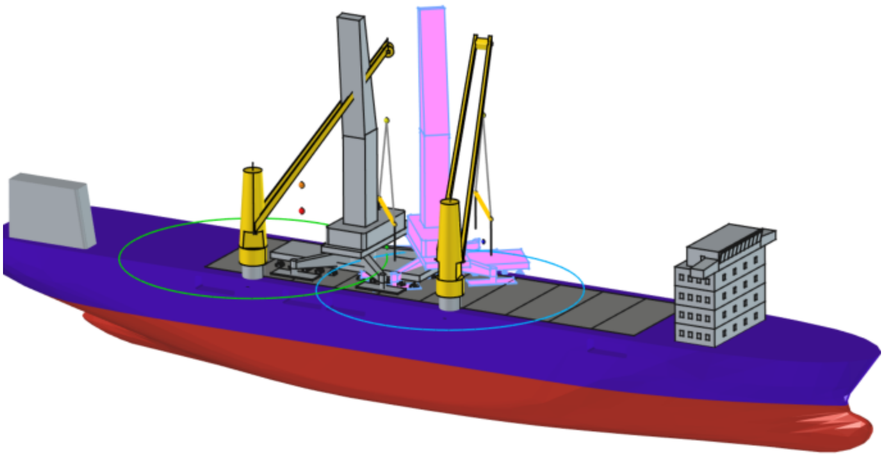
Step 10/14 [SWING] Status:FAIL K1: r=17.83m slew=284.1° K2: r=17.47m slew=23.3°



Step 11/14 [SWING] Status:FAIL K1: r=17.83m slew=292.5° K2: r=17.79m slew=17.2°

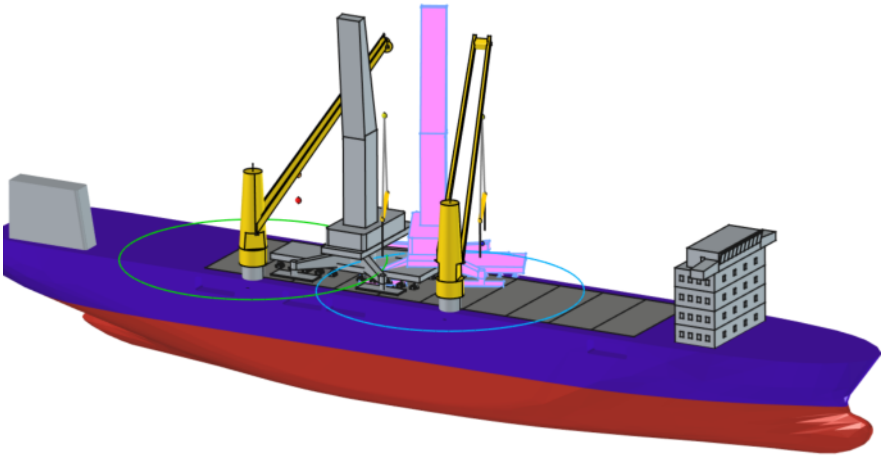


Step 12/14 [SWING] Status:FAIL K1: r=17.83m slew=300.9° K2: r=17.82m slew=14.3°

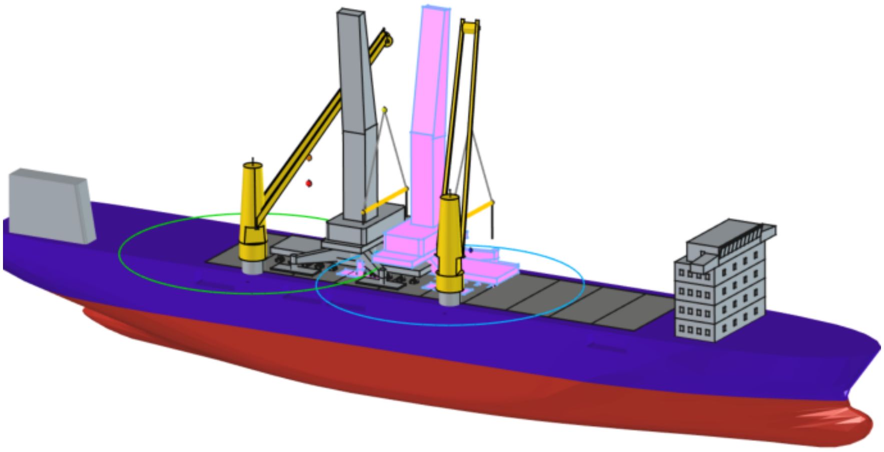


10. Simulation Steps 13–15 (of 14)

Step 13/14 [SWING] Status:FAIL K1: r=17.83m slew=309.4° K2: r=17.50m slew=14.4°



Step 15/14 [SWING] Status:FAIL K1: r=17.83m slew=309.4° K2: r=11.72m slew=15.2°



LIFTING ARRANGEMENT REPORT

Project: Tandem_Rigging | Date: 2026-07-05 15:20 | DNV-ST-N001 / Noble Denton

PASS

1. Project Data

Project	Tandem_Rigging
Crane 1 operating load	166.000 t
Crane 2 operating load	166.000 t
DAF sheltered / open_sea / offshore	1.05/1.1/1.15
Skew factor (Noble Denton)	1.05
Safety factor WLL	1.35
D/d min normal/reduced	5.0/4.0

2. Load Verification (DNV-ST-N001)

PASS

Crane	F0[t]	DAF	Skew	a_max[deg]	Ang.fac.	F_d[t]	WLL_req[t]
1	166.000	1.05	1.05	24.7 deg	1.133	183.015	135.941
2	166.000	1.05	1.05	24.7 deg	1.133	183.015	135.941

LIFTING ARRANGEMENT REPORT

Project: Tandem_Rigging | Date: 2026-07-05 15:20 | DNV-ST-N001 / Noble Denton

PASS

3. Geometry Verification (actual angles from segment lengths)

PASS

Crane	h_up target[m]	h_up act.[m]	Delta[mm]	a_up target	a_up act.	h_low target[m]	h_low act.[m]	Delta[mm]
1	12.649	12.649	+0	25.4 deg	24.7 deg	5.000	5.000	+0
2	12.649	12.649	+0	25.4 deg	24.7 deg	5.000	5.000	+0

4. D/d Verification (DNV-ST-N001 Tab. 9-7)

PASS

Crane	Position	WLL[t]	D shackle[mm]	d wire[mm]	D/d	BFR	Status
1	Coupling-1	150.0	105	90.0	1.17	0.537	OK

5. Bill of Material

No.	Description	Qty	Specification	Wt.[kg]
1	Crane 1 Grommet upper Seg.1	2	L=9.00m d=90mm WLL min 158.99t	–
2	Crane 1 Grommet upper Seg.2	2	L=5.00m d=90mm WLL min 158.99t	–
3	Crane 1 Coupling shackle #1	1	WLL 150.0t	160.0
4	Crane 1 Grommet lower Seg.1	2	L=5.00m d=90mm WLL min 158.99t	–
5	Crane 2 Grommet upper Seg.1	2	L=14.00m d=90mm WLL min 158.99t	–
6	Crane 2 Grommet lower Seg.1	2	L_geom=5.00m L_order=2×5.00m=10.00m d=45mm WLL min 34.55t ■ 4 strands	

6. Design Statement

Project: Tandem_Rigging Date: 2026-07-05 15:20

Basis: DNV-ST-N001 (Marine Operations) and Noble Denton General Guidelines.

Factors: DAF 1.05/1.1/1.15 (sheltered/open_sea/offshore), skew/slew factor 1.05 (Noble Denton tandem lift), angle factor 1/cos(a)*1.03, safety factor 1.35. D/d check: minimum 5.0 (normal) / 4.0 (reduced, WLL reduction 80%).

Geometry: effective sling angles are calculated geometrically from the configured grommet segment lengths and the ramshorn hook width.

Crane 1: F0=166.000t F_d=183.015t WLL_req=135.941t PASSED.

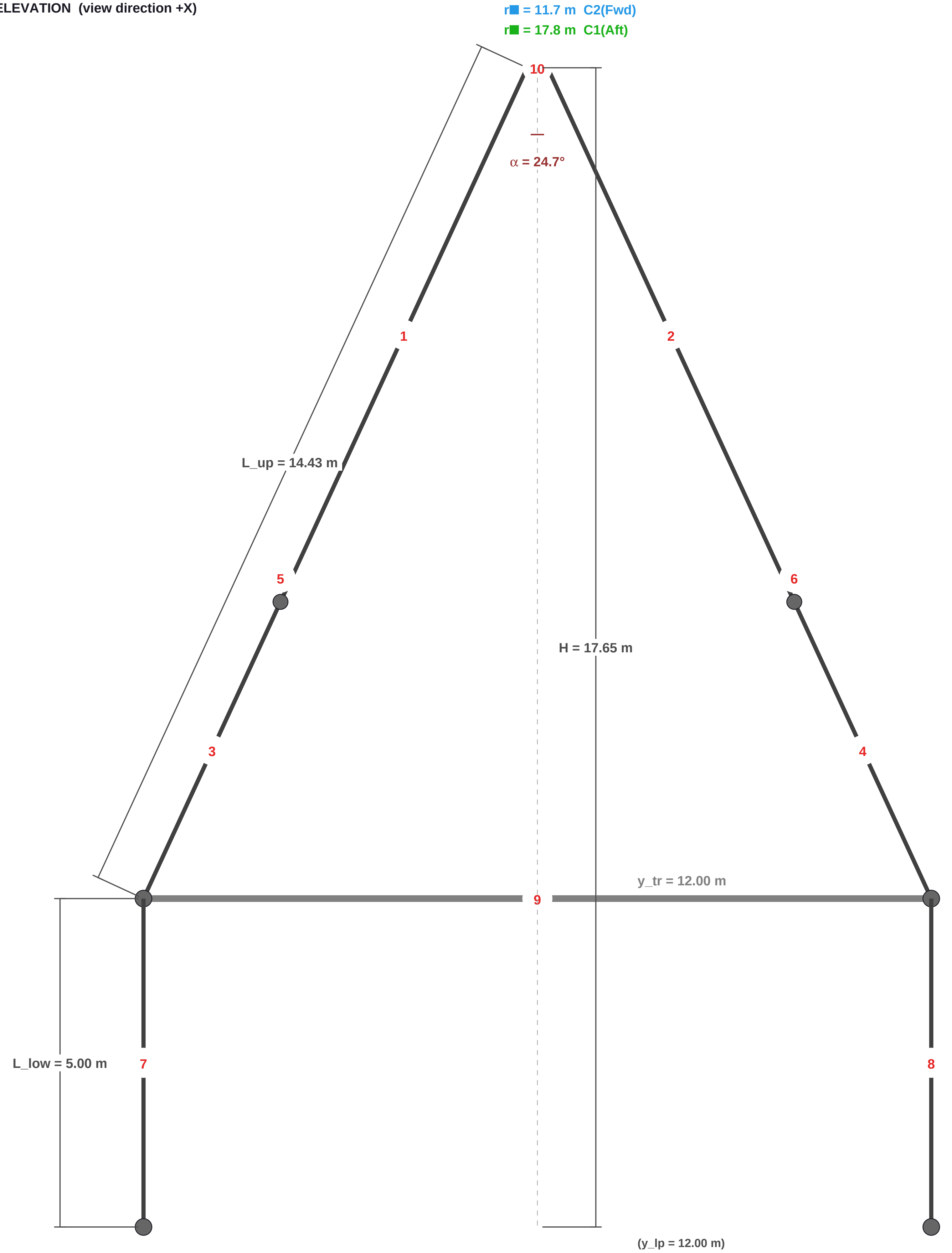
Crane 2: F0=166.000t F_d=183.015t WLL_req=135.941t PASSED.

Overall result: All verifications passed. Recommended for MWS approval.

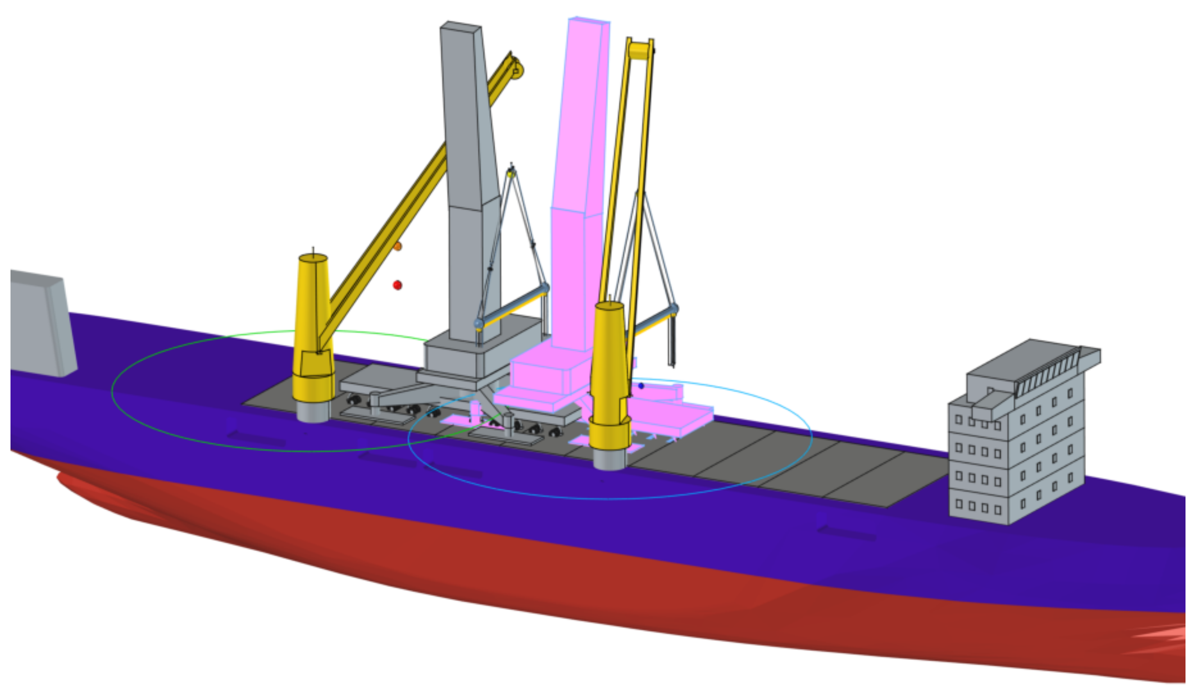
LIFTING ARRANGEMENT - RIGGING DRAWING (DNV-ST-N001)

Project: Tandem_Rigging | Strand 1 / 2 | Load: 166.00 t | Tandem: r1=17.8m / r2=11.7m | 2026-07-05 15:20

SIDE ELEVATION (view direction +X)



3D VIEW (FreeCAD axonometric)



Crane 1 (Aft): r = 17.8 m

Crane 2 (Fwd): r = 11.7 m

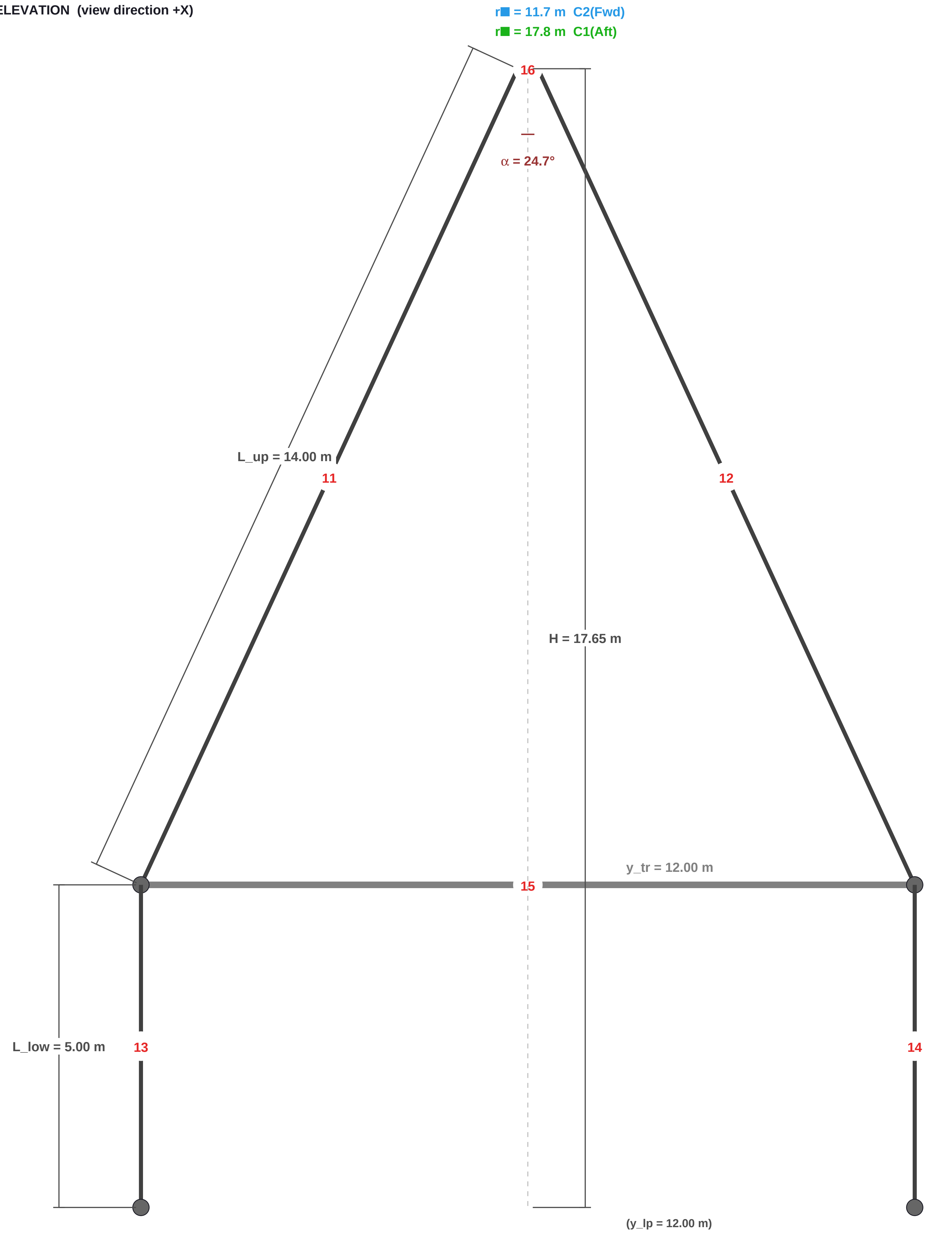
BILL OF MATERIALS – CRANE 1

Qty	Description	Pos.
2×	Grummet d=90 mm L=9.00 m	1. 2.
4×	Grummet d=90 mm L=5.00 m	3. 4. 7. 8.
2×	Shackle WLL 150 t	5. 6.
1×	Spreader beam L=12.00 m	9.
1×	Ramshorn hook 320 t	10.

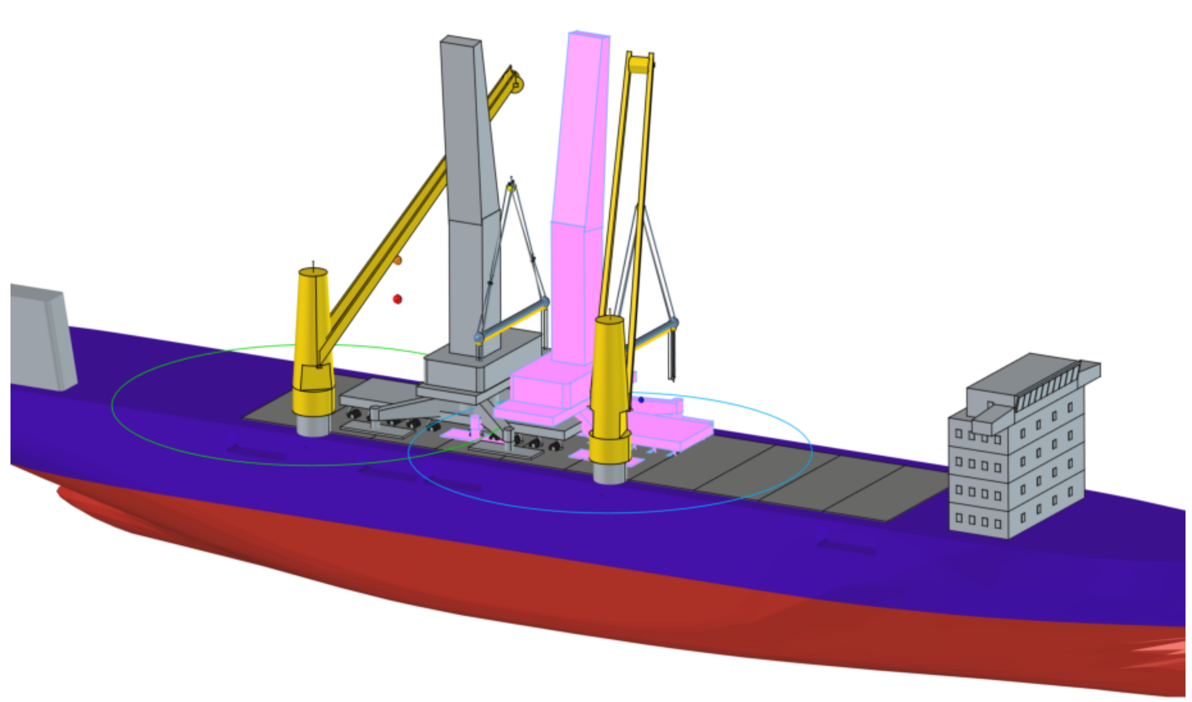
LIFTING ARRANGEMENT - RIGGING DRAWING (DNV-ST-N001)

Project: Tandem_Rigging | Strand 2 / 2 | Load: 166.00 t | Tandem: r1=17.8m / r2=11.7m | 2026-07-05 15:20

SIDE ELEVATION (view direction +X)



3D VIEW (FreeCAD axonometric)



Crane 1 (Aft): r = 17.8 m

Crane 2 (Fwd): r = 11.7 m

BILL OF MATERIALS – CRANE 2

Qty	Description	Pos.
2×	Grummet d=90 mm L=14.00 m	11. 12.
2×	Grummet ■ d=45 mm L geom=5.00 m → order 2×5.00=10.00…	13. 14.
1×	Spreader beam L=12.00 m	15.
1×	Ramshorn hook 320 t	16.