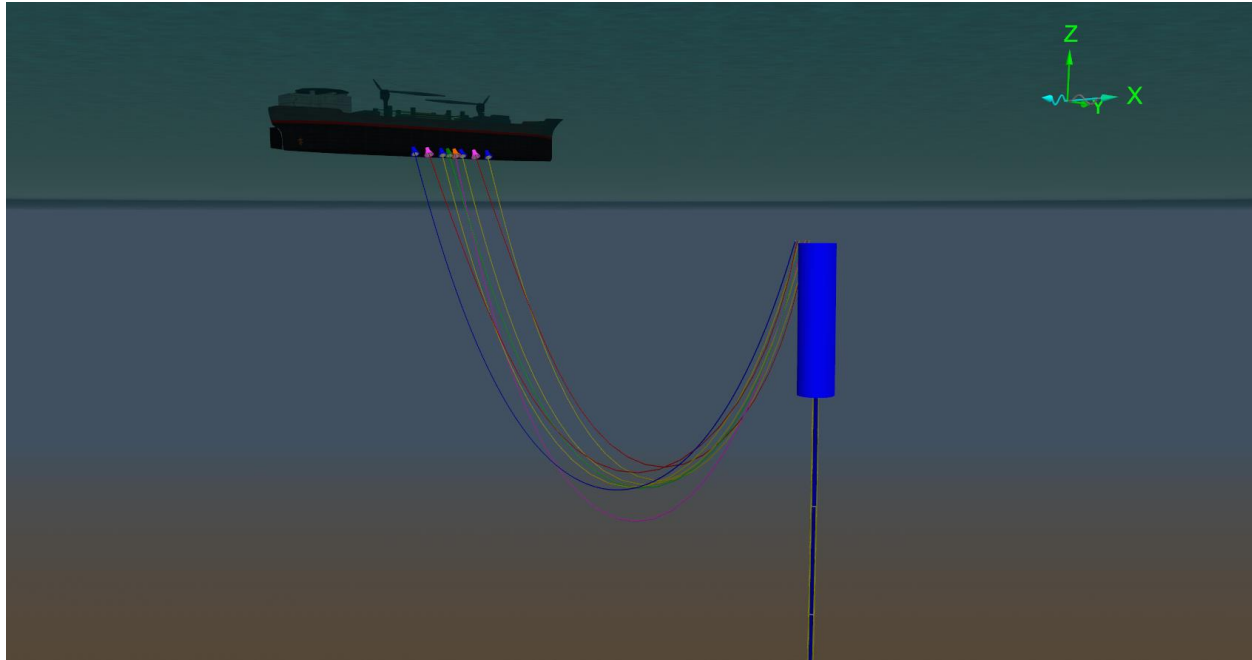


A03 Jumper to high tower

Introduction



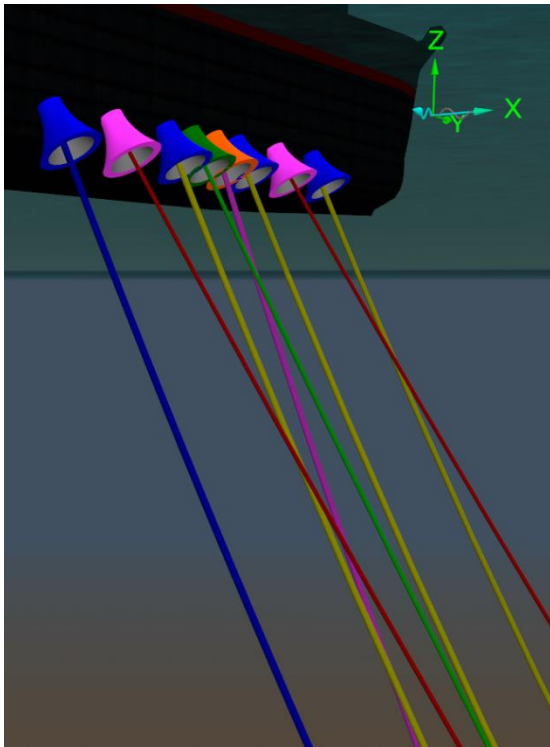
Flexible jumpers connect a spread moored FPSO to a high riser tower in deep water, i.e. the tower top is close to the surface. The lines descend to the seabed as rigid structures clamped around the tower. An installation of this type can be found in the Girassol field.

As this is a deep-water system, the tower top will flex under the weather and jumper loads. The tower has therefore been modelled as a very stiff line with one end fixed to the seabed, i.e. a vertical cantilever. Tower motion depends on loads from all the jumpers as well as the waves and current, so all the jumpers need to be included in the model.

If the tower motions are pre-defined, it could be modelled as a vessel with the motions specified as harmonic motions or time histories. This would mean that individual jumpers could be analysed, if required, as they would have no effect on the modelled motion of the tower.

The default workspace shows a shaded view of the tower top and the jumpers.

Building the model



Eight jumpers extend from the vessel side to the top of the tower. They leave the vessel through bellmouths inclined at 30° to vertical. The bellmouths are modelled explicitly using *curved plate* shape objects. Contact between the jumper and the bellmouth takes account of the jumper diameter.

Bellmouth thickness is artificially increased to reduce the risk of the jumper 'cutting through' the solid and escaping. Nodes push to the nearest face of the shape, so you want the outer surface to be well out of the way so that line nodes don't get pushed to the wrong surface. Some experimentation may be needed to find acceptable values of thickness and stiffness (very high stiffness is effective in constraining the jumper but may require a reduced integration timestep for stability).

Jumper segmentation is chosen so that up to 10 nodes can make contact with the bellmouth. Again, some experimentation is advisable here to ensure that the modelling is adequate.

Additional bellmouth shapes are superimposed on the hollow ones. These extra shapes fill in the hollow and have no stiffness. To fill the hollow of the bellmouth simply copy the original shape in the model browser and change the curved plate setting from hollow to solid. Then set the shape type to *trapped water* so it shields the jumper length within the bellmouth from direct wave and current loading. For further details, please see the [Theory | Shape theory](#) page of the OrcaFlex help.

The riser tower is a slender vertical cantilever supported by a float at the upper end. We model it as a line with a 6D buoy at the top to represent the float.

The line representing the tower core is built-in (encastré) at both ends, as are the four production risers. The risers are clamped to the outside of the tower using the *line contact* model. Open the *line contact data* form from the *model browser*. Two sets of relationships have been defined. Firstly, each riser is clamped to the tower core by means of an *around* relationship, which spaces clamps along the tower's length at locations defined on the *penetrator locations* page. This page also defines how far offset from the tower centreline the risers are held (1m in this case), as well as the *contact diameter* and *area* of each clamp. The second set of line contact relationships specifies that each riser's outer diameter can (if the environmental conditions are severe enough) contact the outer diameter of the tower core i.e. using *outside* relationships. For more details of the available line contact relationships, please see the [Modelling, data and results | Lines | Line contact | Modelling](#) page of the help.

Close this data form and open the workspace *A03 Jumper to high tower clamps.wrk* to see one set of clamps in the shaded graphics mode.

Press [Ctrl+T](#) to return to the default view. One of the production jumpers is modelled with slugs of gas flowing along the line.

Open the line data form for the [Product S Out](#) line and click on the [contents](#) page. Here, ten slugs of gas, each 80m long, have been set up to flow along the line from the tower towards the vessel. The flow velocity has been set up using a variable data item called [Start Up](#). Right-mouse click anywhere on the form and select [edit variable data](#) to open the data form for this. Start-up conditions are modelled with the flow velocity being 0m/s initially, increasing up to a constant 10m/s during the simulation (this is deliberately set to a high value so that the effects of the slugs moving through the line can be seen in the model). Note that the negative velocity indicates that the flow is moving from end B towards end A of the line; a positive velocity would indicate the flow is moving in the opposite direction.

Slug flow can also be visualised by ticking the [draw slug flow](#) option on the [drawing](#) page of the line data form. You also have the option to change the colour of the slugs.

Close any open data forms and run the simulation replay ([Ctrl+R](#)) to see the white slugs flowing along the blue [Product S Out](#) line.

Open the [environment](#) data form and take a look at the [current](#) page. In this example, the current profile (velocity variation with depth) is applied as a 7th power law rather than interpolating between specified depths.

Moving to the [waves](#) page, notice that the model contains both a swell and a wind wave. We have chosen to run the simulation for a minimum duration of swell period * wind wave period (16s * 9s=144s).

All the lines have their normal drag coefficient specified as a relationship with Reynolds number. Note this relationship is a generic form and you should check what relationship is appropriate for your lines.

The [FPSO](#) uses the default data for a 103m vessel. This has then been Froude scaled for a 130m long vessel. The original vessel length is specified on the [structure](#) page of the [vessel type](#) data form. The shaded drawing is also scaled by setting it to 103m draw size on the [shaded drawing](#) page. The required [length](#) of 130m is specified on the [FPSO](#) vessel data form.

Beware: Use Froude scaling with caution. The method has many limitations and is intended for use in research studies or pre-bid analysis. It should not be used on an actual project. Please see the [Modelling, data and results | Vessels | Vessel data](#) help page for further details.

Results

With the model in the default view (*Ctrl+T*), look at the animation through stage 1. Dynamic movements of the tower are small. The main dynamic loading occurs at the FPSO end of the jumpers, caused mainly by roll motion of the FPSO.

Load the *A03 Jumper to high tower bellmouth.wrk* workspace. This shows the balcony region in shaded graphics and an instantaneous range graph of *y-curvature* for one of the jumpers. It shows the section closest to the bellmouth (arc length 0m to 10m). Restart the replay and observe the reverse curvature through the wave cycle.

The bellmouth covers an arc length of about 3m and is designed to restrict curvature to about 0.2 rad/m (5m bend radius). Note in this model, the jumpers are pinned at the inner end of the bellmouth (arc length = 0) so the curvature here is zero.

Load the *A03 Jumper to high tower slug flow.wrk* workspace. The graph in the upper right of the screen shows the instantaneous range graph of the contents density for the *Product S Out* line, which includes slug flow. As the animation plays you can see the gas slugs (lower density) moving along the jumper. You can also see the effect of the slug movement on the response of the riser in the top left hand view. The blue line is the one that contains the slug flow; you can clearly see it move in response to the white coloured slugs of gas moving along the line.