Floating turbine modelling in Bladed

Recap, plus new features

07 November 2016

Floating turbine modelling in Bladed

- A floating module was released for the first time with Bladed v4.1 (2011)
- This allows fully coupled simulations which include
  - both wind and wave loading
  - structural dynamics
  - global support structure translations and rotations
- 'Advanced hydrodynamics' in Bladed v4.6 (2014)

Hydrodynamics modelling options in Bladed

Morison Model

- Semi-empirical
- Added mass radiation
- Froude Krylov excitation
- Instantaneous hydrostatics
- Viscous drag
- Wide range of sea state definition options
- Diffraction correction based on MacCamy Fuchs

BEM Model

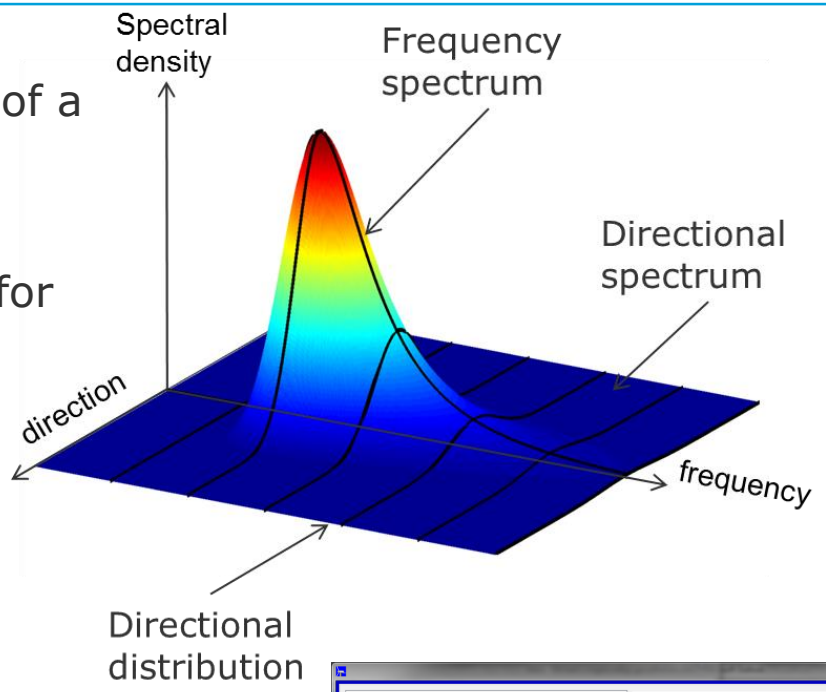
- Analytical, reliant on potential flow solver
- Added mass and damping radiation
- Froude Krylov and diffraction excitation
- Linear hydrostatics
- Viscous drag (from Morison)
- Linear, Airy waves only

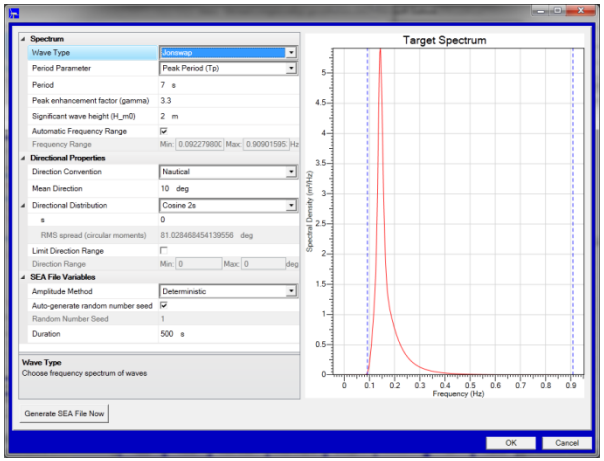
New and ongoing developments:

- Dynamic moorings
- Second order wave forcing

The SEA file

- Very versatile and complete description of a linear airy sea state
- Required during BEM hydrodynamic calculations and can optionally be used for Morison's hydrodynamics also
- Regular or JONSWAP spectra
  - Others available, currently as service
- Directional spreading
  - Wrapped normal
  - Cosine2s
  - Ewans
- Reproduction of time history of sea surface elevation possible currently as a service
- Random amplitudes to investigate sampling variation





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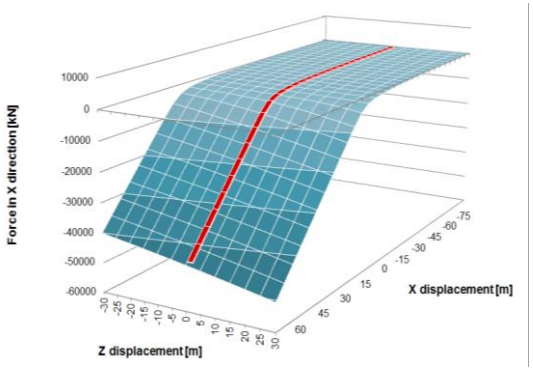
Different mooring models available in Bladed

- **Tension-leg model**
  - Very simple – just a linear spring with optional damping.
  - Able to apply pretension
- **Catenary (1D lookup) model**
  - Generally non-linear using lookup tables, therefore quite fast.
  - Full 6x6 matrices of stiffness, damping and inertia.
  - Stiffness lookups can be populated automatically from a simple mooring-line model.
  - Can be autopopulated
- **Catenary (2D lookup) model**
  - Lookup tables in 2D
  - Can be autopopulated



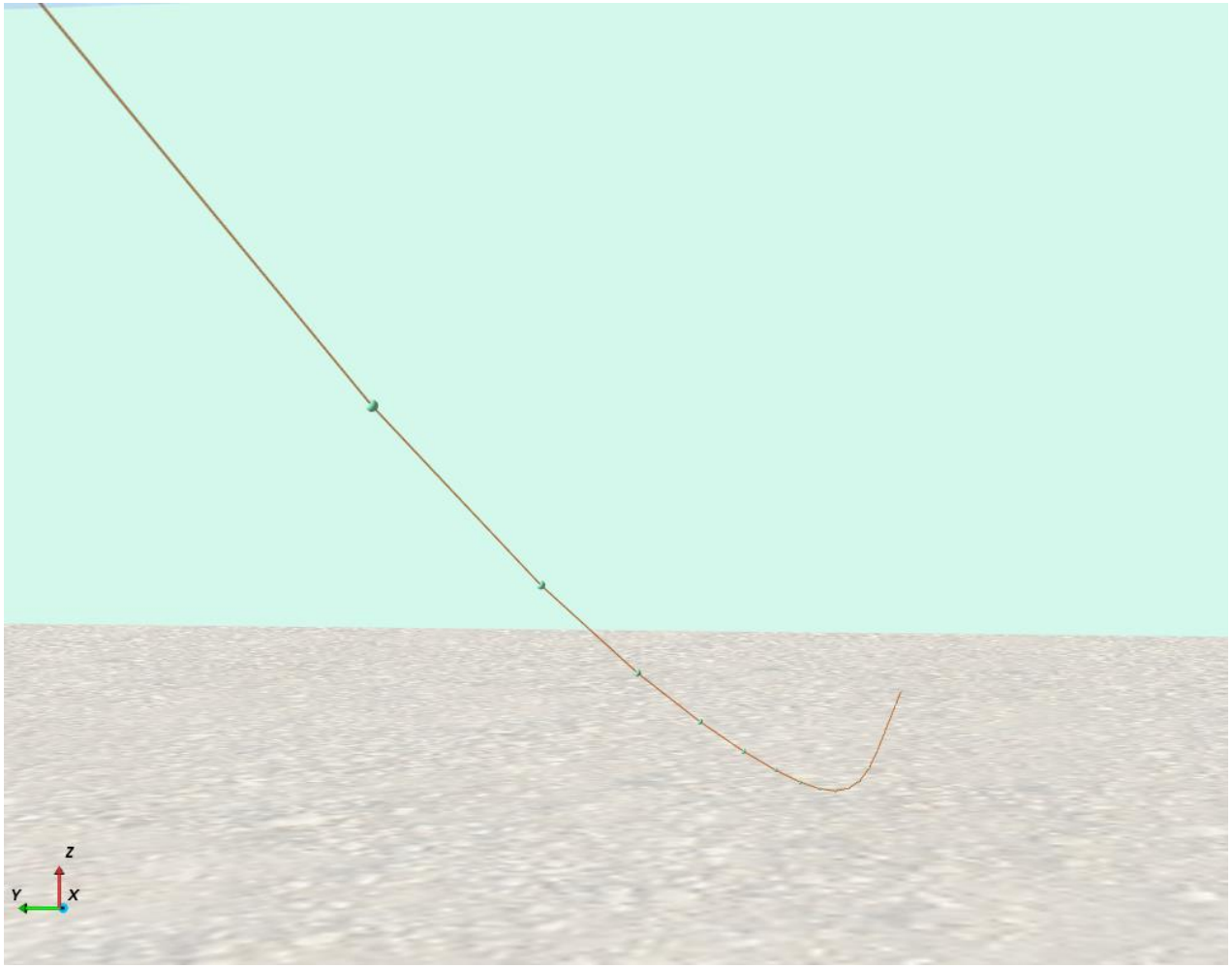
- **New Dynamic mooring line …**

New dynamic moorings: Motivation

- Improve modelling fidelity!
  - Can be important both for turbine loads and mooring loads
  - Some studies suggest inadequate mooring model can cause up to 30% error in turbine loads

- Represent complex or specialised moorings, as well as more common ones
  - E.g. inline weights or buoys, multiple sections with different properties, etc

Line is modelled as a jointed chain of segments



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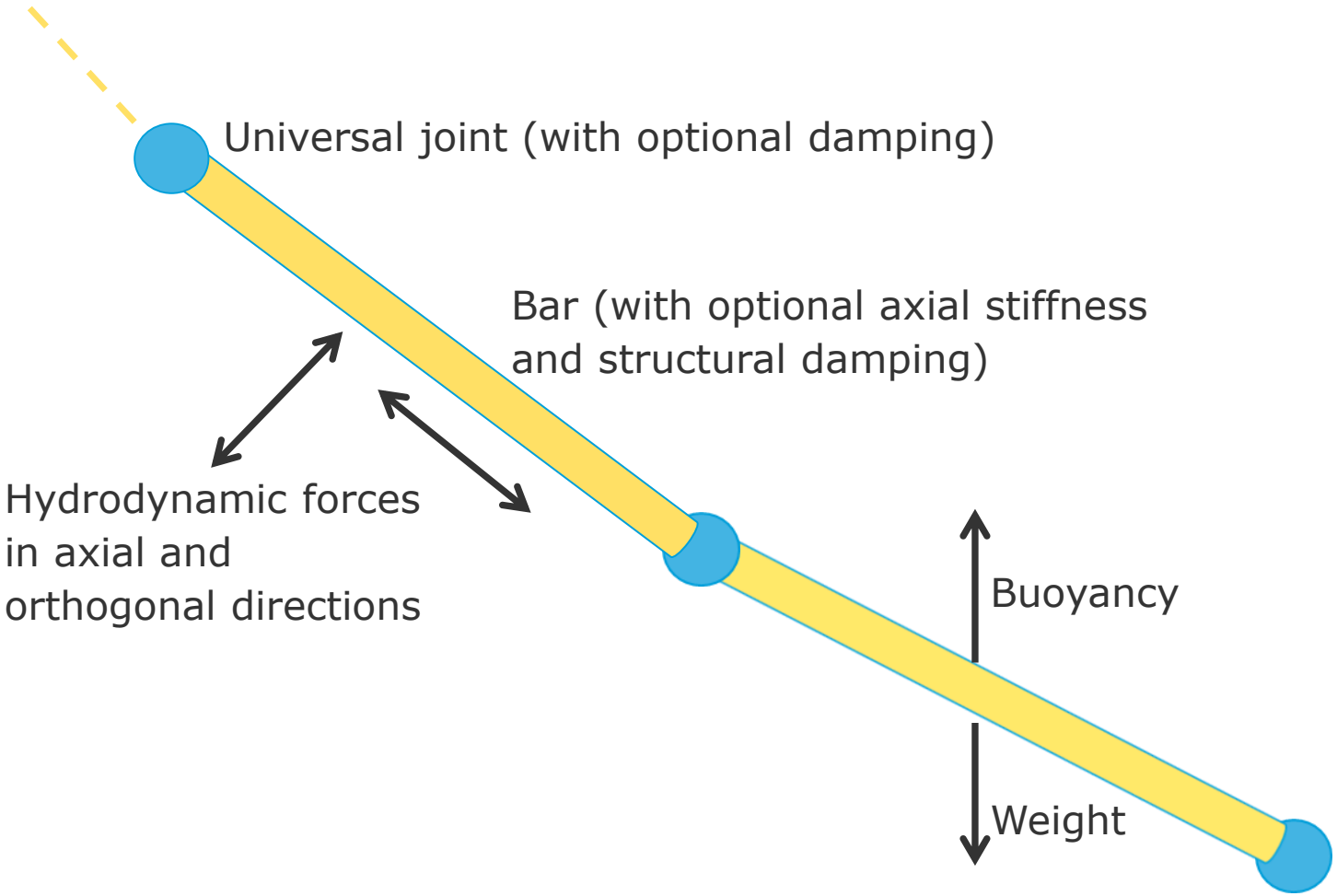
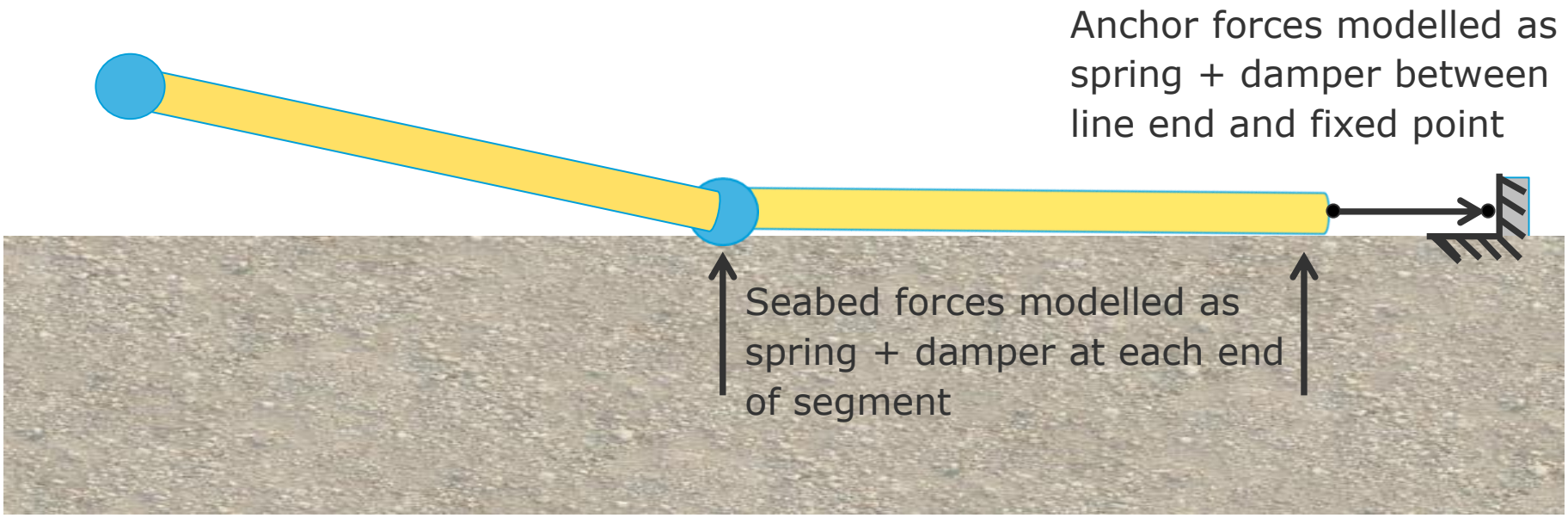
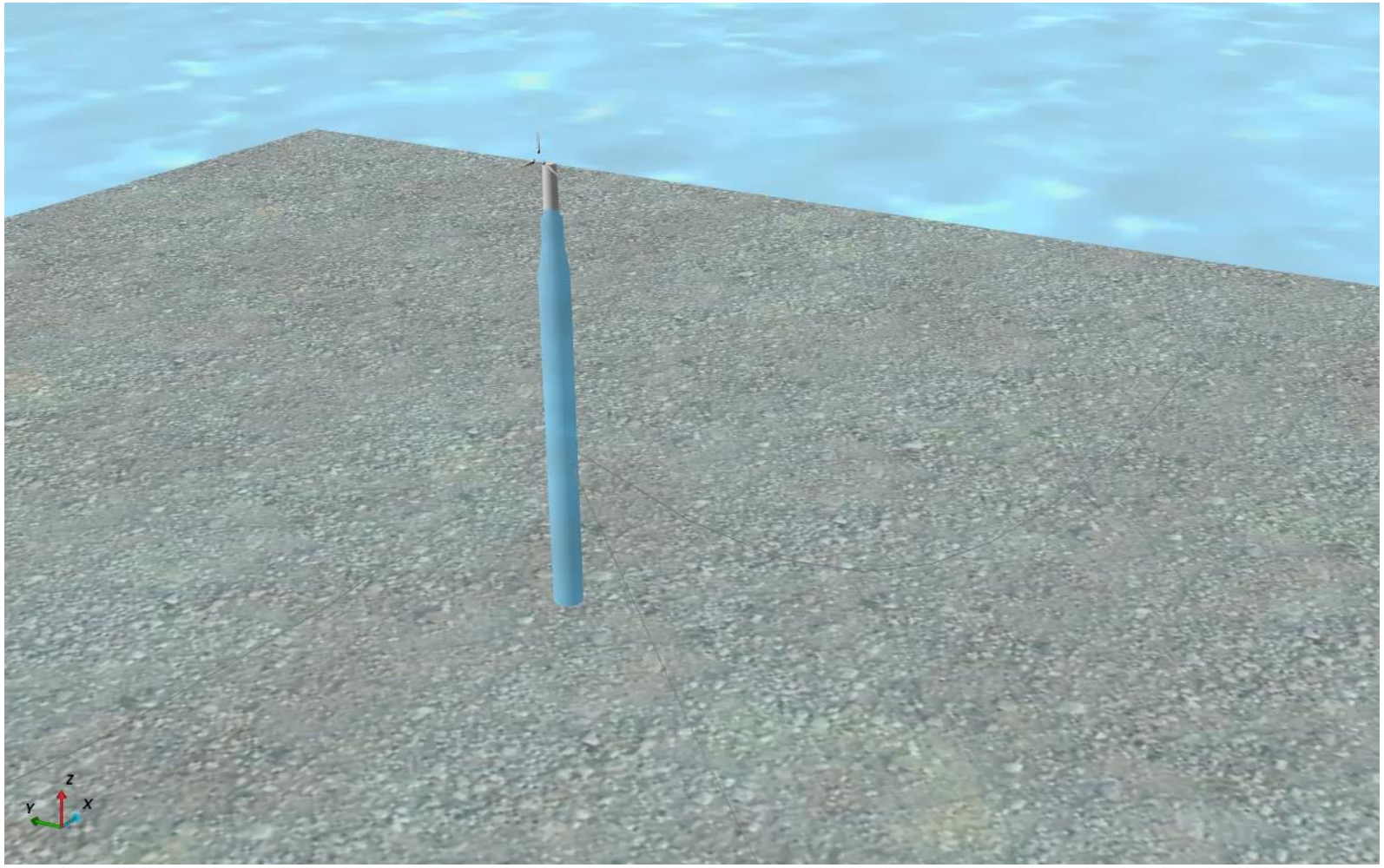
Segments and joints are modelled as follows



Other forces on a segment...



The model in operation (1)



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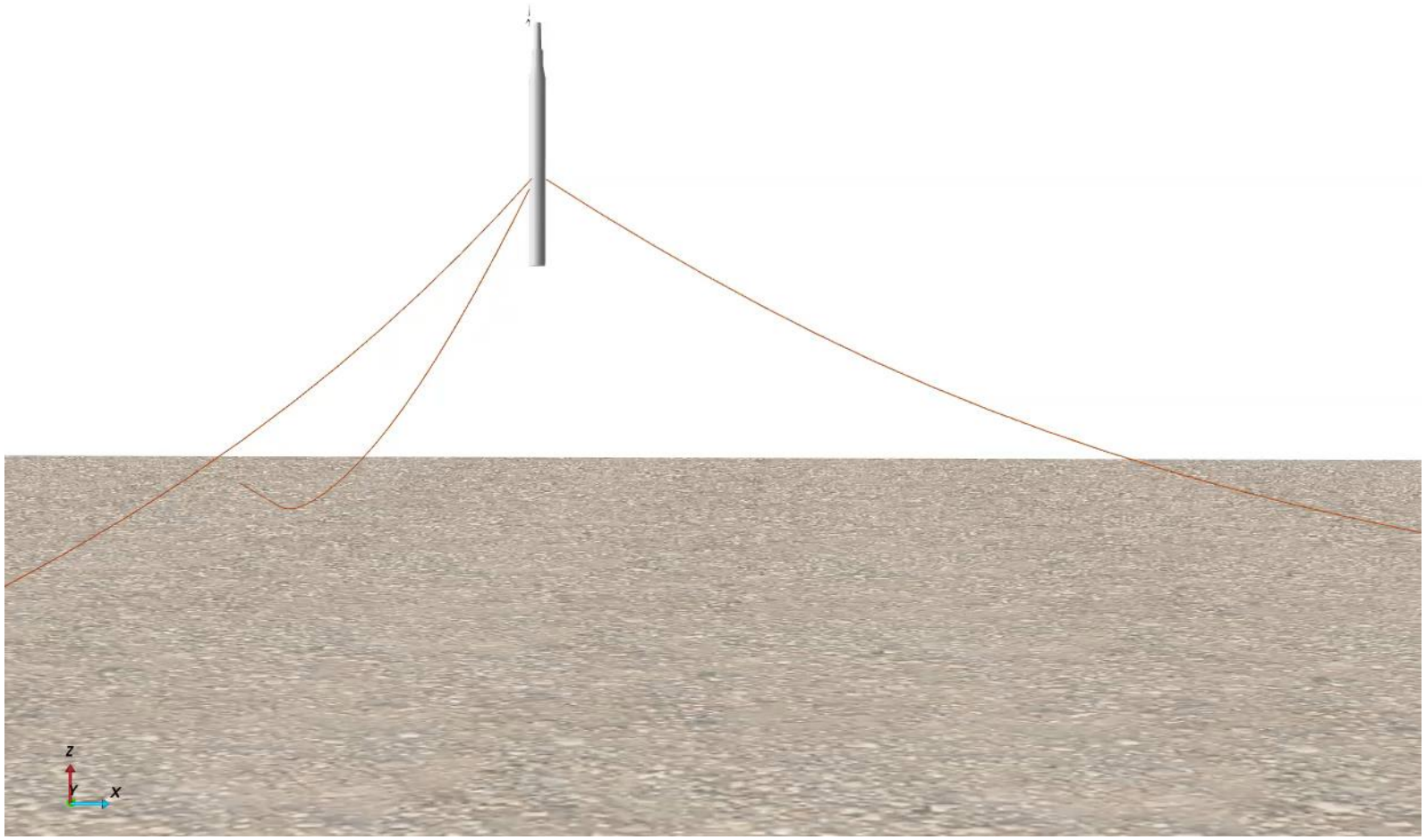
The model in operation (2)



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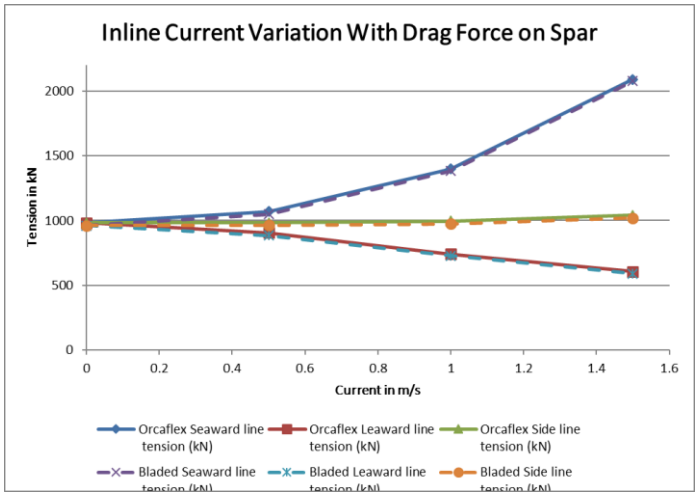
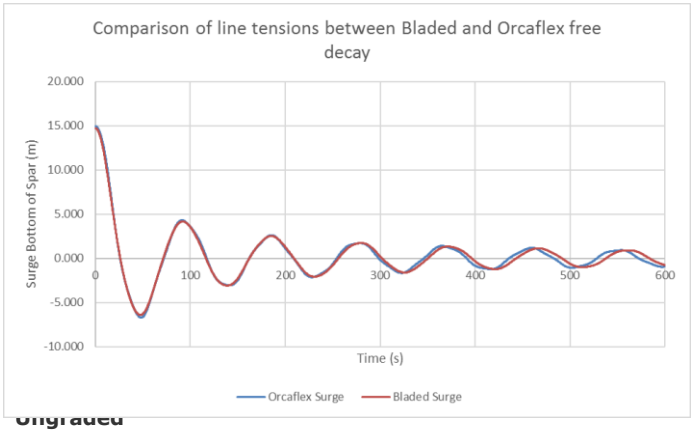
Verification against OrcaFlex (1)

Steady Uniform Current



Surge Free Decay

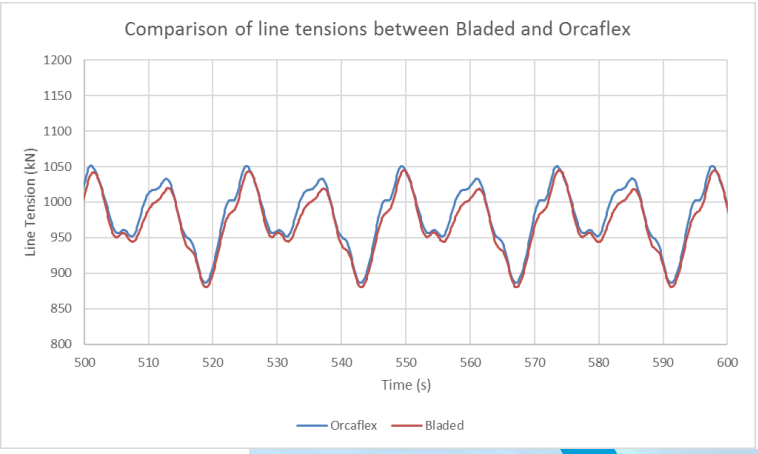


The Test Subject

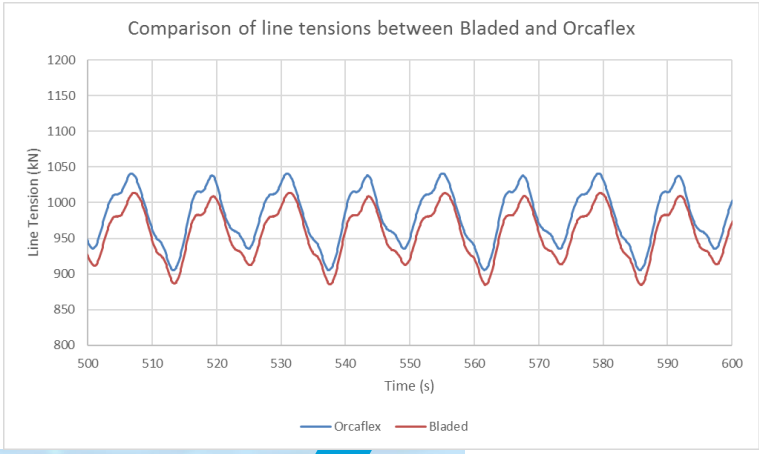
- OC3 inspired spar
- Spar & line Morison hydrodynamics
- Water depth = 264.6m
- Spar diameter = 9.4m
- Total mass ≈ 8500 tons
- Line length = 835.5m
- Line effective diameter ≈ 0.14m
- Verified response with no mooring
- Line drag from DNVGL-OS-E301
- Limited segments (10 segments)

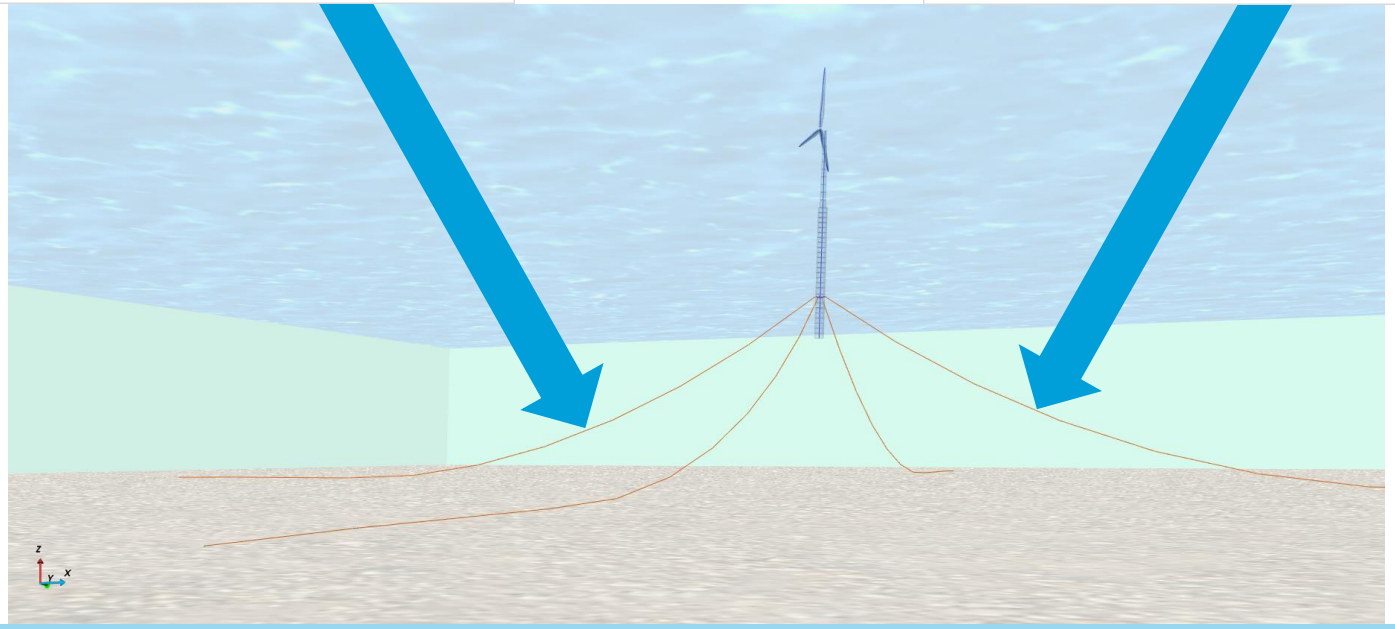
Verification against OrcaFlex (2)

Regular Wave



- Height = 7m
- Period ≈ 12
- Left to right below





Thanks for listening...

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