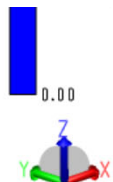


Time Domain VIV

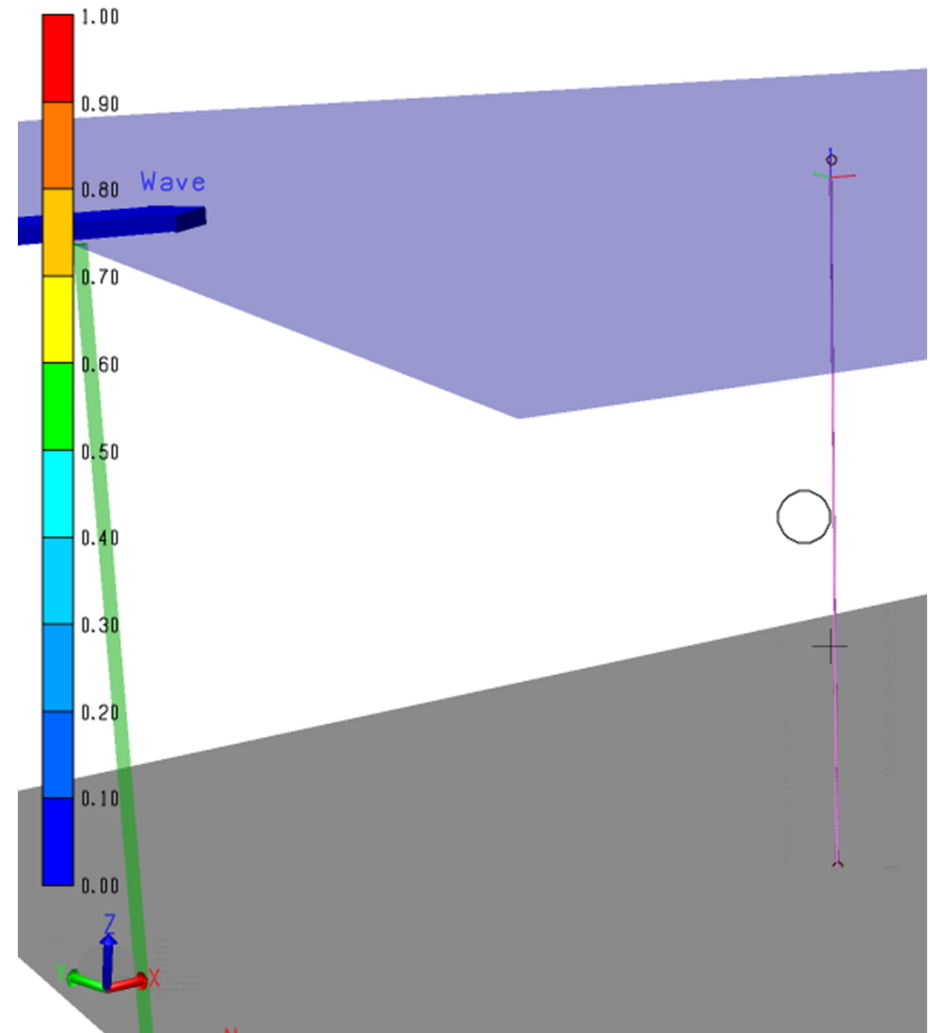
Model TTR500m - cross flow TVIV load





Example: TTR 500m

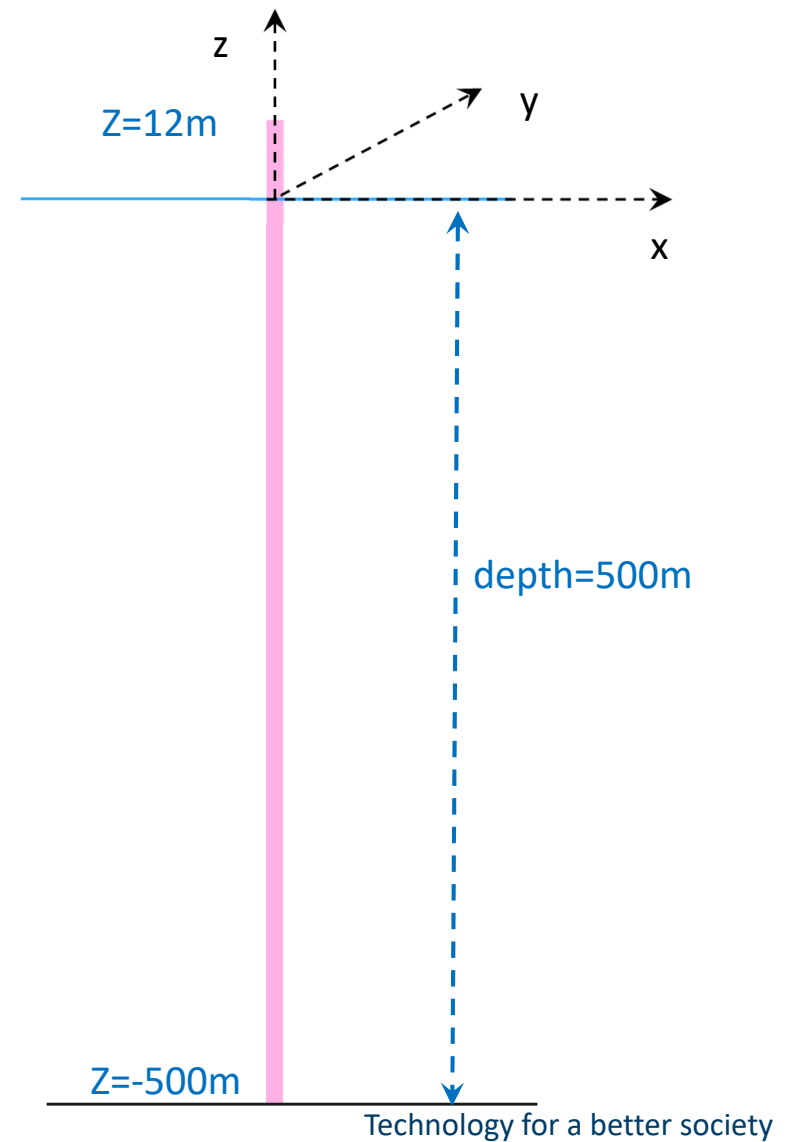
- Simple, vertical top tensioned riser
- Shared to the JIP members





TTR 500m

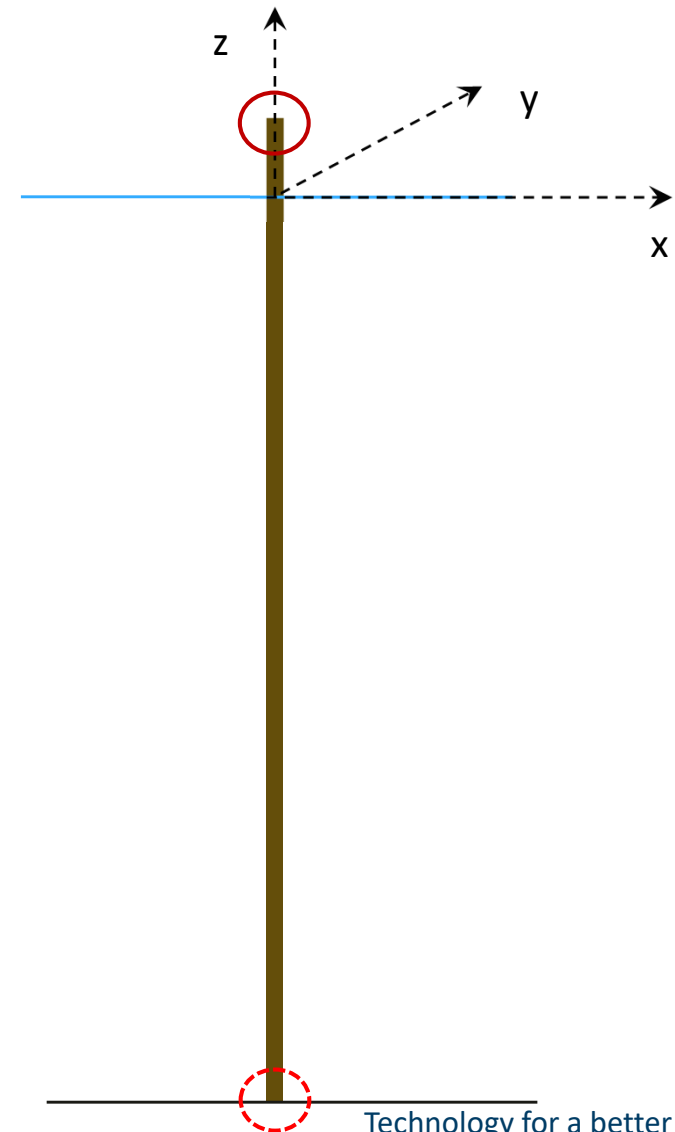
Constants	value	SI-Unit	Comments
Water depth	500	m	
Upper end	12	m	above surface
Lower end	-500	m	below surface, at seabed
Total length	512	m	
Density, pipe	7850	kg/m ³	
Mod of elasticity	206000	MPa	
Density int. fluid	1400	kg/m ³	
Densit sea water	1025	kg/m ³	
Gravity	9.81	m/s ²	
Cd	0.8		
Cm	1		
Tension at low. end	400	kN	
Strouhal number	0.2		





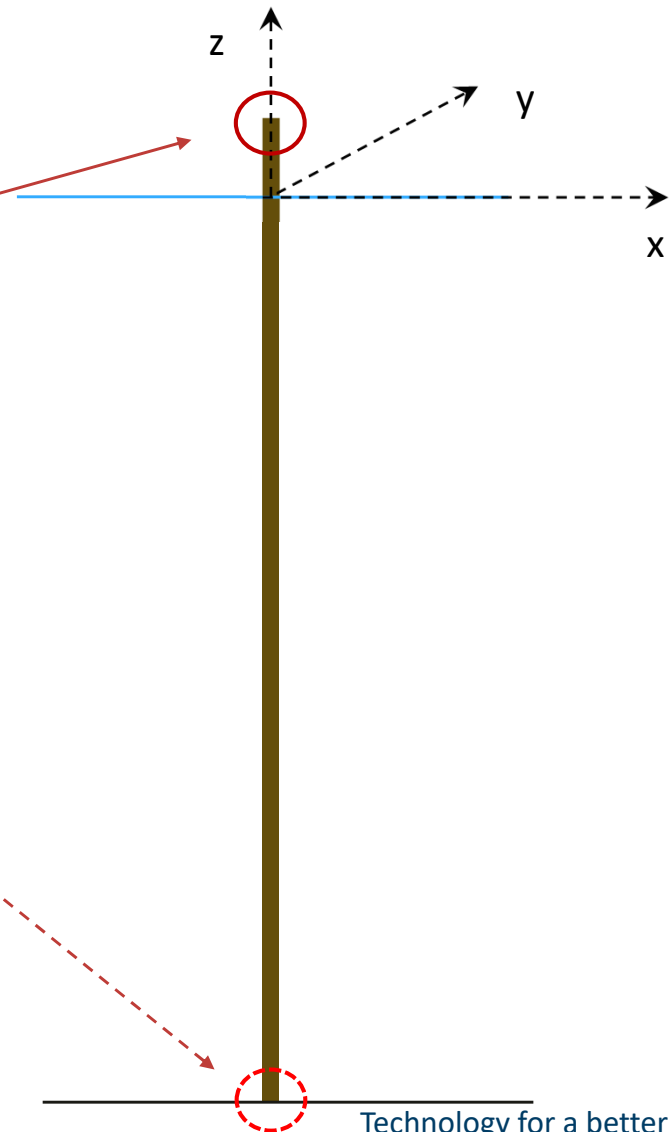
Structural properties – cross section

Bare riser data	value	SI-Unit
External diam	0.6	m
Wall thickness	0.02	m
Internal diam	0.56	m
Internal area	0.2463	m ²
External area	0.2827	m ²
Cross sect area	0.0364	m ²
Mom of inert	0.00153	m ⁴
Mass of pipe	286.07343	t/m
Mass of content	344.82121	t/m
Total mass, air	630.89464	t/m
Total mass in water	920.70656	t/m
Wet effective weight	3346.02143	kN/m
Dry effective weight	6189.07639	kN/m
Tot effect. weight	1747279.63	kN
Needed top tension	1747679.63	kN
EI	316051	kN/m ²
EA	7507150	kN/m
Average tension	874039.8	kN



Boundary conditions

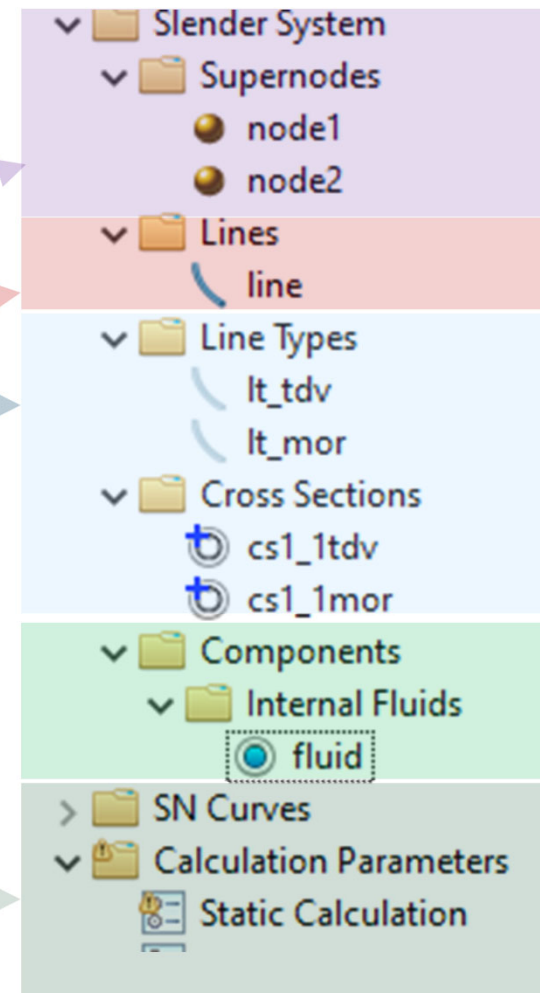
Constants	value	SI-Unit
	<i>upper end</i>	<i>lower end</i>
<i>displ, x</i>	fixed	fixed
<i>displ, y</i>	fixed	fixed
<i>displ, z</i>	free	fixed
<i>rot, x</i>	free	free
<i>rot, y</i>	free	free
<i>rot, z</i>	fixed	free





Slender system

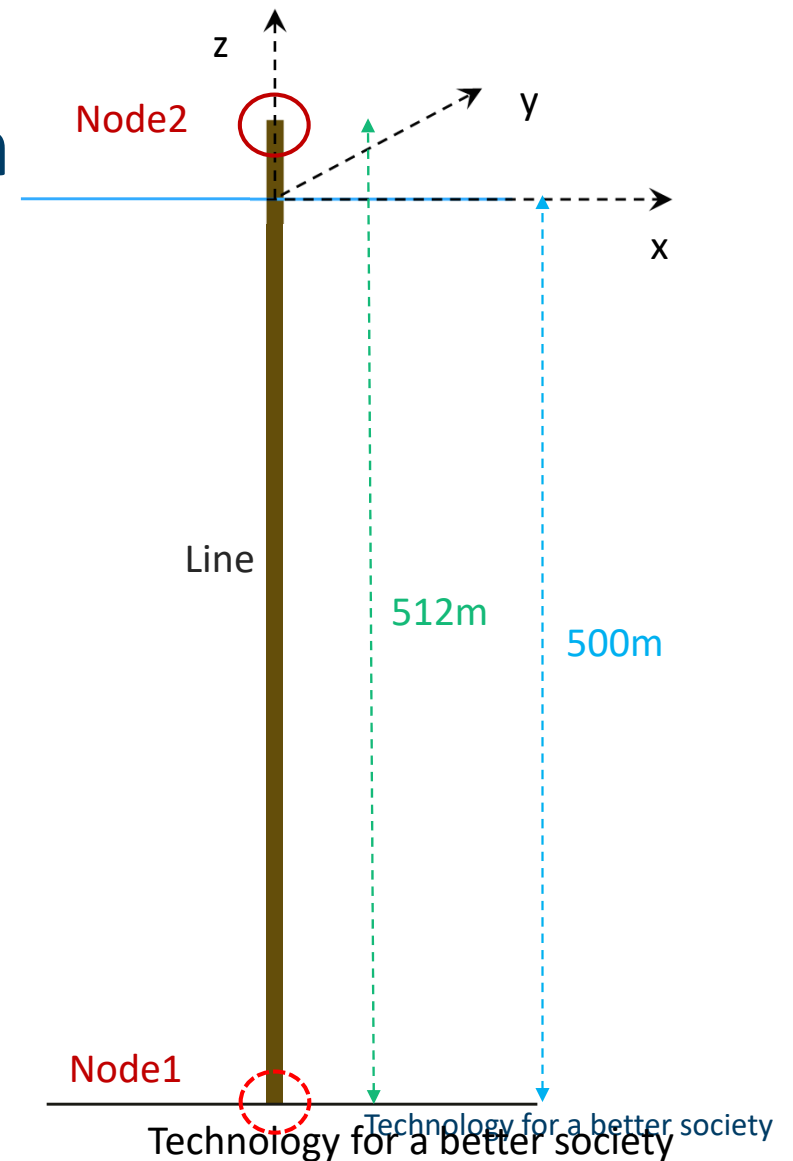
- Two super nodes with boundary conditions
- One line between the two nodes
- The line type consist of
 - Four segments (i.e. typical a length of the line with a specific cross section type)
 - Cross section with hydrodynamic load
- The riser is filled with fluid (i.e. a component type)
- The riser is top tensioned
 - The force is specified in the static calculation
 - Specified in the static calculation parameters





Define the slender system

- One line → four segments → one cross section
 - Line from node1 to node2
 - Line of line type with different hydrodynamic loads
 - Lt_tdv
 - Cross section with CF and IL calculated separately
 - Lt_mor
 - Morison only
 - Added for comparison






Location

- Physical constants
 - Gravity, water depth etc, density etc
- Sea surface
- Sea floor
 - Here: flat bottom

Physical constants:

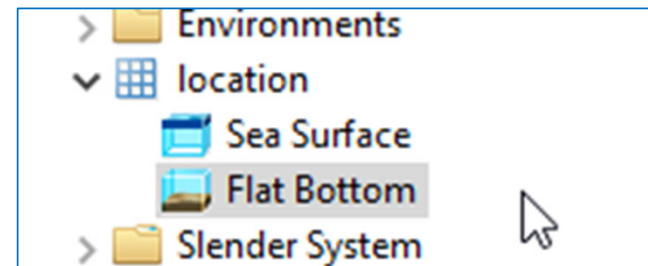
Acc Of Gravity	Water Density	Air Density	Kinematic water depth	Kinematic Viscosity Water	Kinematic Viscosity Air
9.81	1025.0	1.25	500.0	1.188e-06	default

Relative Compass Angle:



UTM:

Utm X	Utm Y	Grid Zone
0.0	0.0	



Define an axisymmetric cross section

- Cross- section properties

Axisymmetric cross section 'cs1_1tdv' in ttr500mTDV

Name:

Description:

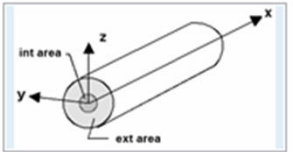
☒ Cross-section properties
 ☐ Stiffness properties
 ☐ Damping specification
 ☐ Hydrodynamic force coefficients
 ☐ Aerodynamic force coefficients (Morison-type)

Mass coeff.	Ext. Area	Int. Area	Gyratation Radius
286.07	0.2827	0.2463	0.0116

Default Thermal/Pressure Expansion: ☐

Temperature	Alpha	Beta
20.0	0.0	0.0

Default contact radius and stress calculation input: ☒





Stiffness properties

- Beam elements
- Axial stiffness
- Bending stiffness
- Torsion stiffness

Cross-section properties | **Stiffness properties** | Damping specification | Hydrodynamic fo

Cross-section type: ☐ Bar ☒ Beam

Hysteresis Option: ☒ No hysteresis ☐ Generated hysteresis

Coupled bending and torsion: ☐

▼ Axial Stiffness

Type: ☒ Constant ☐ Tension-elongation

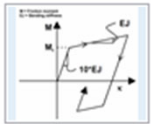
Axial Stiffness:

▼ Bending Stiffness

Type: ☒ Constant ☐ Moment-curvature

Bending Stiffness:

Shear Stiffness:



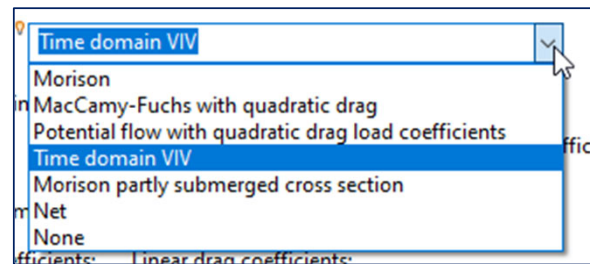
▼ Torsion Stiffness

Type:

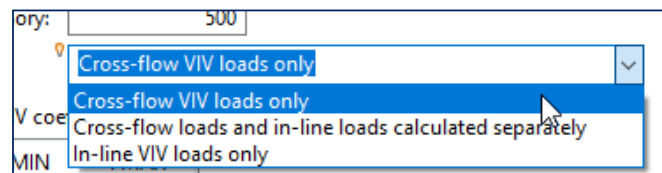
Torsion stiffness:

Hydrodynamic force coefficients

- Choose the load formulation (drop down list)



- Time domain VIV



Axisymmetric cross section 'cs1_1tdv' in ttr500mTDV

Name: cs1_1tdv

Description:

Cross-section properties | Stiffness properties | Damping specification | **Hydrodynamic force coefficients**

Load Formulation: Time domain VIV

Froude-Krylov scaling: ☐

Input code: ☐ Dimensional coefficients ☒ Nondimensional coefficients

Hydrodynamic diameter: 0.6

Quadratic drag coefficients:

CQx	CQy
0.0	1.0

Linear drag coefficients:

CLx	CLy
0.0	0.0

CAx: 0.0, CAy: 1.0

Number of time steps in memory: 500

Viv Load Formulation: Cross-flow VIV loads only

Nondimensional cross-flow VIV coefficients:

CV	FNULL	FMIN	FMAX
1.3	0.13	0.1	0.26

Higher order VIV coefficient:

CHH
0.0



TDV coefficients

- [See User Manual \(SIMA 4.6.3\)](#)

Table 1. Suggested VIV empirical parameters used for $CHTVIV=CF$, i.e. Cross flow only. CQY and CAY are nondimensional drag force and added mass coefficients in normal direction.

Flow conditions	Structure type		Parameters					
			CV	CQY	CAY	FNULL	FMIN	FMAX
Constant current	Bare riser section		1.3	1.0	1.0	0.13	0.10	0.26
	Buoyancy section ($L_b/L_r=1/2$)	Bare riser	1.2	0.9	1.0	0.18	0.10	0.22
		Buoyancy element	0.08	0.3	1.0	0.10	0.05	0.15
	Buoyancy section ($L_b/L_r=1/1$)	Bare riser	0.8	1.2	1.0	0.18	0.10	0.26
		Buoyancy element	0.5	0.6	1.0	0.10	0.05	0.15
Vessel motion induced VIV	Bare riser & buoyancy section		0.8	1.2	1.0	0.216	0.10	0.26



Other

- Damping
- Aerodynamic force coefficients
- Capacity



Super nodes

- Node1 – sea floor
- Node 2 – at the top of the ttr

The 'Initial' tab contains initial position of nodes while 'Static' tab shows position of nodes after prescribed (static) displacements have been applied.

Name	Constraint	X G Initial	Y G Initial	Z G Initial	Automatic Initial Position	Reference Line	Reference Frame
node1	Fixed or Prescribed	0.0	0.0	-500.0	<input type="checkbox"/>		- GLOBAL -
node2	Fixed or Prescribed	0.0	0.0	12.0	<input type="checkbox"/>		- GLOBAL -

Below the table is a toolbar with icons for adding (+), deleting (-), saving (floppy disk), and other functions.

- Sea Surface
- Flat Bottom
- Slender System
 - Supernodes
 - node1
 - node2
 - Lines
 - line
 - Line Types
 - lt_tdv
 - lt_mor
 - Cross Sections
 - cs1_1tdv
 - cs1_1mor
 - Components
 - SN Curves
 - Calculation Parameters
- Conditions
 - wf_compare
 - ST_ttr500m
 - ttr500m.pdf
 - 500m_bouy
 - 500m_strakeTDV
 - 3000m_bouyTDV
 - 1500m_bouyTDV
 - DV
 - TDV
 - nr1500m_TDV
 - iplePostProcessorOperations
 - perations
 - odels
 - putSignals
 - _PostProcExamples

Error Log

ns to display at this time.

Description:

☐ Free
 Constraint: ☒ Fixed or Prescribed
☐ Slave

Reference Frame: - GLOBAL -

Automatic Initial Position: ☐

Initial Position

Global position:

Xg	Yg	Zg
0.0	0.0	-500.0

Radial: ☐

Fixed or Prescribed Configuration

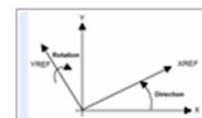
Support Vessel:

Static global Position:

Xg	Yg	Zg
0.0	0.0	-500.0

Specified rotation:

Rotation	Direction
0.0	0.0



Boundary Condition Frame: Global

Boundary condition: [free all](#) [fix all](#) [fix translation](#) [fix rotation](#)

X	Y	Z	RX	RY	RZ
Fixed	Fixed	Fixed	Free	Free	Fixed



Line type

Line Type 'lt_tdv' in ttr500mTDV

Name:

Description:

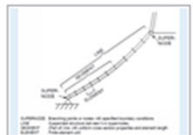
Segments:

Simple Complete

No	Cross Section	Length	Acc length	Num Elements	El length	Nodal Component	Stressfree Length
1	cs1_1tdv	75.0	75.0	40	1.875		default
2	cs1_1tdv	350.0	425.0	175	2.0		default
3	cs1_1tdv	75.0	500.0	40	1.875		default
4	cs1_1tdv	12.0	512.0	4	3.0		default

End Component:

Internal Fluid:





Line between two super nodes of a line type

- Link the line to the super nodes and line type you want to use

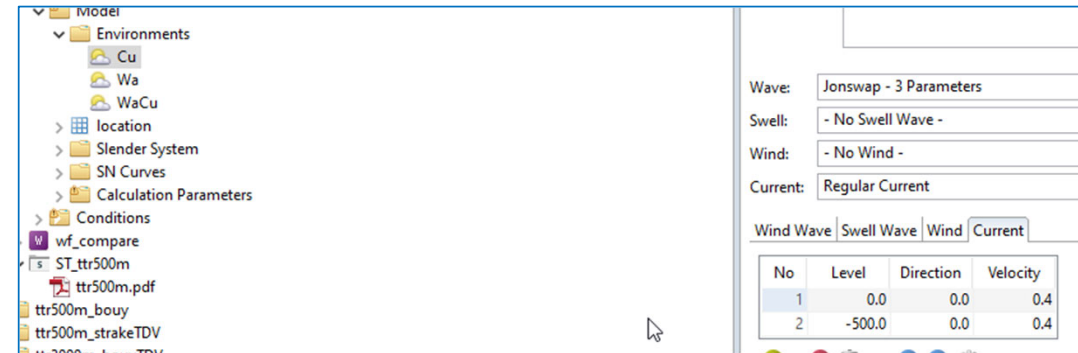
Name	Line Type	End1	End2	Length	Distance	Disabled
line	lt_tdv	node1	node2	512.0	512.0	<input type="checkbox"/>

The Line definition table is used to connect supernodes with lines and associate each line with a linetype, which in turn are associated with a cross-section.
Several lines may be connected to a single node and linetypes may be (re)used on several lines.
The length between supernodes must be equal to the length defined in the linetype.
Note that relations between nodes, linetypes and lines may be scripted.

same length as the line type (here: lt_tdv)



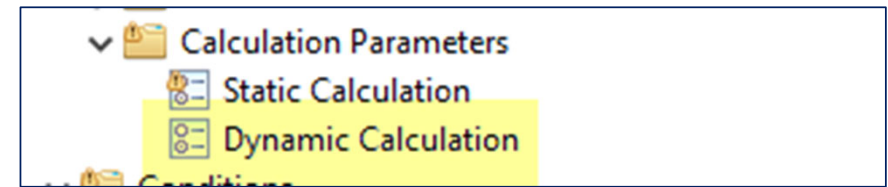
Environments



- In the example, there are three environments
 - Current only (Cu)
 - Waves only (Wa)
 - Waves and current (WaCu)
- Referred to by *conditions*



Dynamic parameters



- Set up the dynamic analysis
 - Simulation length and time steps
- Time series generation parameter
 - Related to pre-generated kinematics
 - NOTE:
 - Requested time series length > Simulation length

Irreg. Analysis		Reg. Analysis		Procedure		Dynamic loads		Storage		HLA	
Simulation Length	Time Step										
500.0	0.1										
▼ Time series generation parameters											
Wave seed	Use Stochastic Amplitudes										
1	<input type="checkbox"/>										
Requested time series length	Time Increment	Applied Time Series Length	Frequency Resolution	Number Of Steps							
1000.0	0.5	1024.0	0.00097656	2048							
► Irregular wave and motion timeseries parameters											



- Dynamic procedure
 - Random number, integration and damping parameters
 - Force model
 - Nonlinear integration procedure
 - Convergence criteria
- Dynamic loads
- Storage of data
 - Displacement

Irreg. Analysis | Reg. Analysis | Procedure | Dynamic loads | Storage | HLA

▼ Time domain procedure

Method: ☒ Nonlinear ☐ Linear

▼ Random number generator

Random Generator: ☒ Legacy ☐ Mersenne twister

▶ Integration and damping parameters

▶ Common force model

▶ Nonlinear force model

▶ **Nonlinear integration procedure**

Reg. Analysis | Reg. Analysis | Procedure | Dynamic loads | Storage | HLA

The shortest time increment for storage is equal to the time step, which is: 0.1

Select topic to highlight content:

Displacements

Force response

Sum force response

Curvature response

Envelope curve

Stress Storage

Wave kinematics

Turbine response

Turbine blade response

Support vessel results

Hydrodynamic loads

▼ Displacements

Store: ☒

Storage Step:

File format:

Nodes:

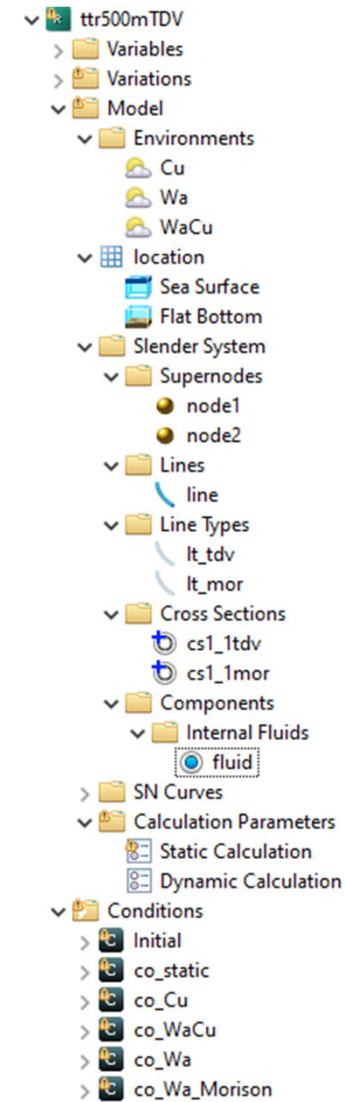
Line	Line Type	All Segments	Segment	Node Number	All Nodes
line	lt_tdv	<input type="checkbox"/>	2	100	<input type="checkbox"/>

+ - [trash] [check] [undo] [redo]



Full model

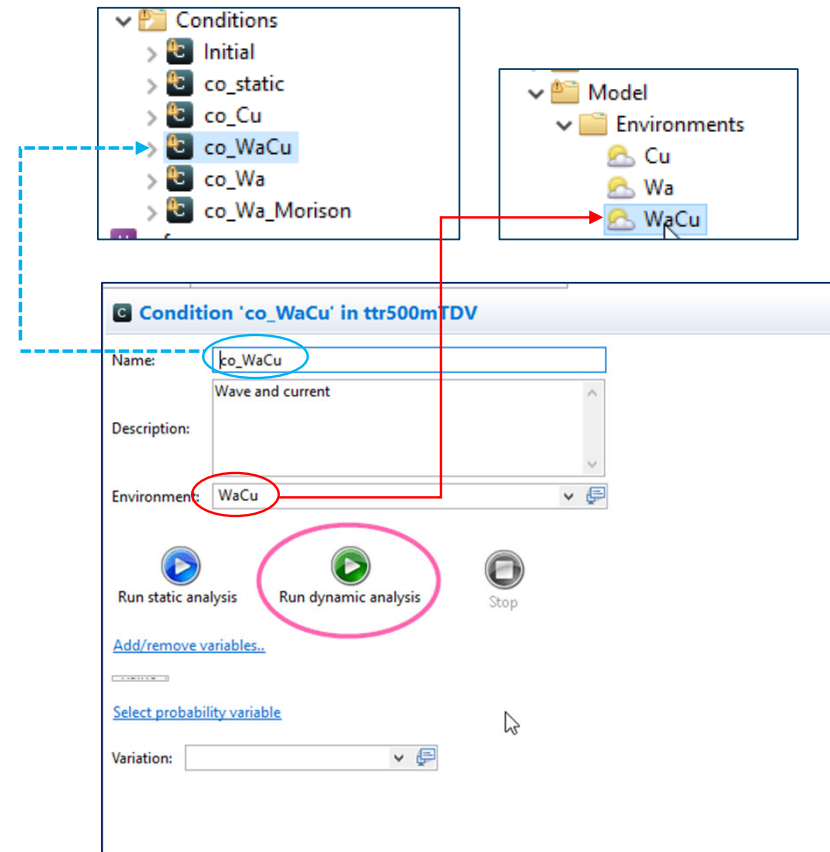
- Environment
- Location
- Slender system – where the TTR is defined
 - Super nodes
 - Lines and Line types
 - Cross sections
 - Components
 - Internal fluid
- SN curves
- Calculation parameters
 - Static & dynamic settings
- Conditions of the model
 - Initial is the base case
 - Initial always use the first listed environment





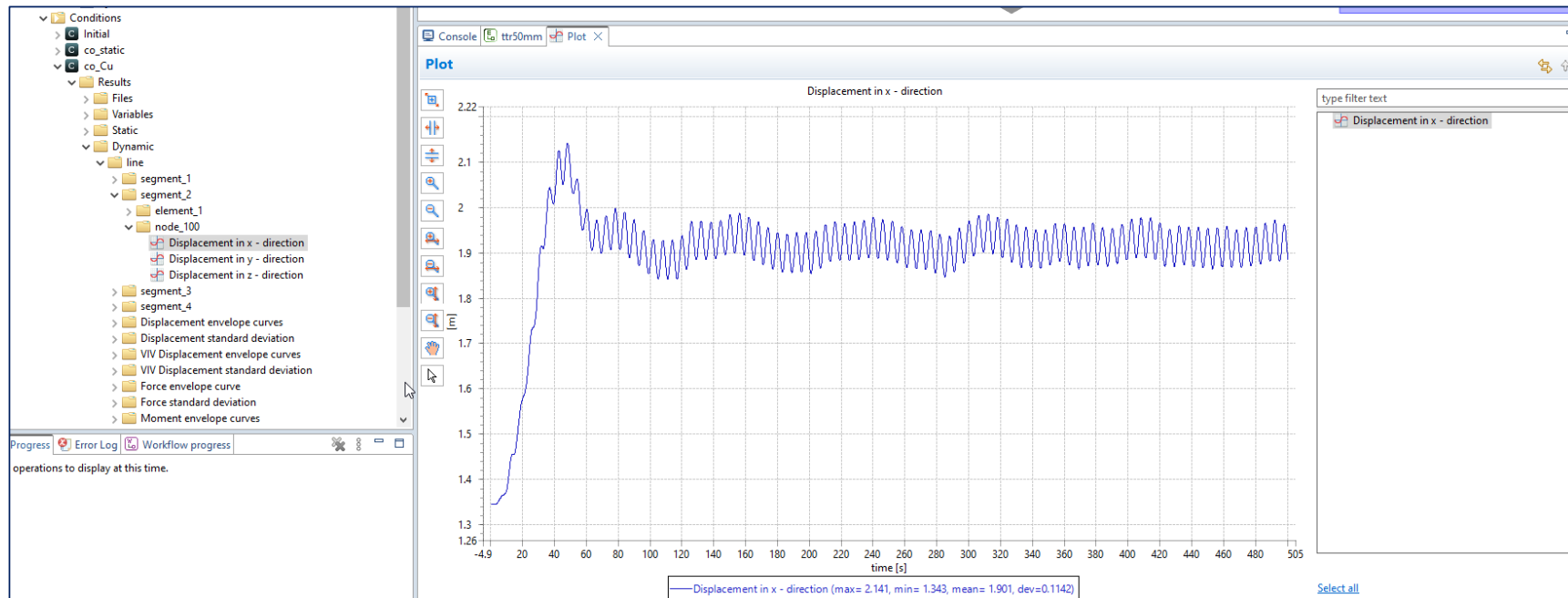
Run a condition

- Choose condition
- Run dynamic
- Example:
 - Condition: Co_WaCu
 - Environment *WaCu* (Wave and Current)
 - $H_s=5m$, $T_p=15s$
 - Uniform current $0.4m/s$
 - Line type with TDV loads on cross sections (default)



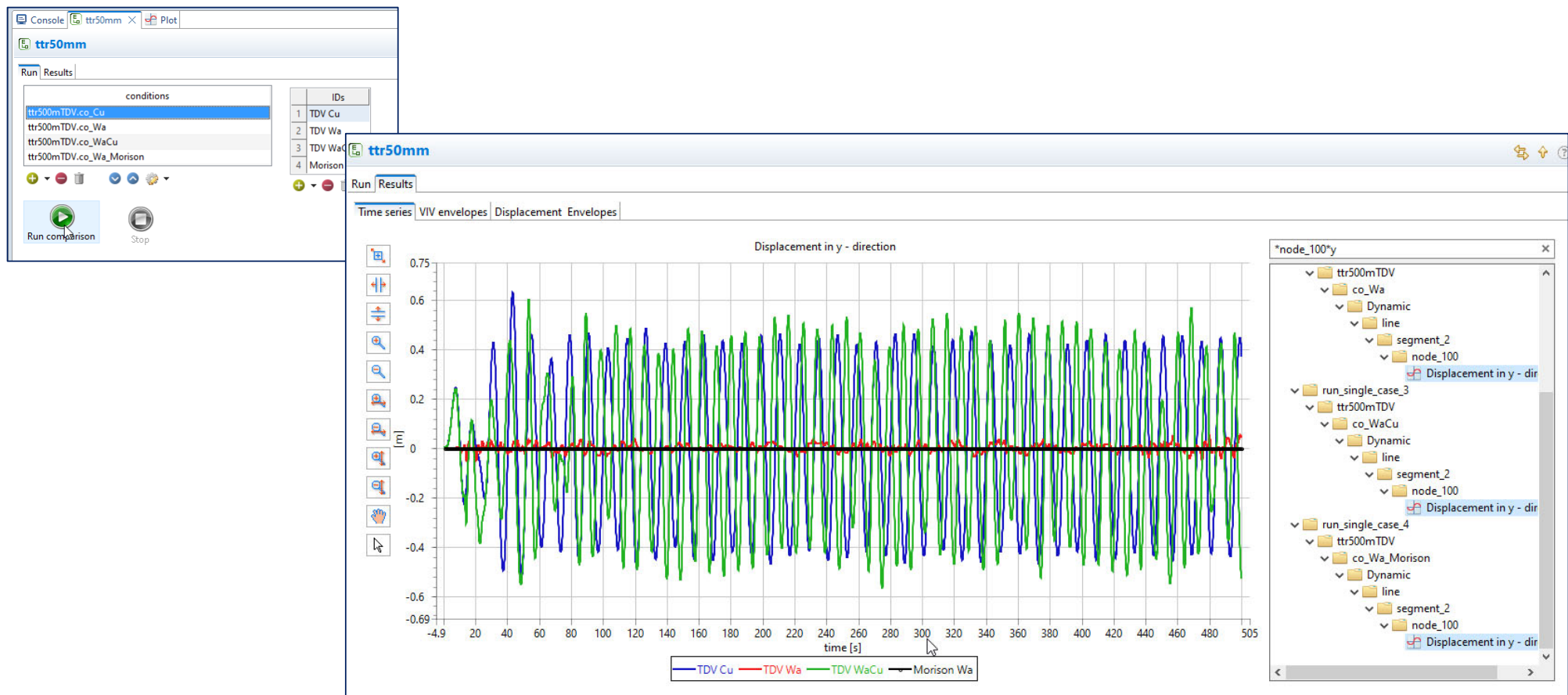


Look at results





Compare environments & TDV v Morison



Technology for a better society



SINTEF

Technology for a better society