Description of MSS Vessel Models: Configuration Guidelines for Hydrodynamic Codes

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Contents

1 Coordinate Systems

The hydrodynamic codes use different coordinate systems. MSS, however, use one coordinate system for simulation and processing of hydrodynamic data. Consequently, all computed data must be transformed to MSS axes during postprocessing of the hydrodynamic output files.

1.1 MSS Coordinate System

The MSS axes are defined by a right-handed coordinate system

- x-axis (forward)
- y-axis (starboard)
- z-axis (downwards)

with coordinate origin

CO – in the still water plane on the centerline a distance $L_{pp}/2$ from AP

where AP denotes the aft perpendicular. All motions and variables are given in these axes. The hydrodynamic codes should use CO for computations. The configuration procedures for this are described in the subsequent sections.

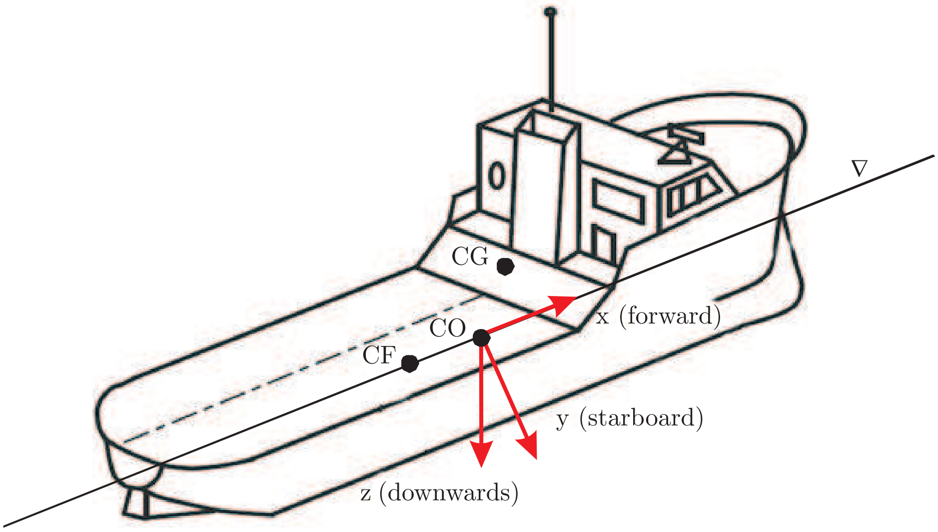

Figure 1: MSS coordinate system with origin CO in the still water plane on the centerline a distance $L_{pp}/2$ from AP.

1.2 Coordinate Systems used by Hydrodynamic Codes

The coordinate systems for WAMIT, ShipX and Octopus Seway are defined below.

1.2.1 WAMIT

CO coincides with the *global coordinate system* in WAMIT. This point is used for hydrodynamic computations unless the user redefines this.

The WAMIT axes are: x (forward), y (port) and z (upwards). Hence, the y- and z-axes are pointing in opposite direction of the MSS axes while the x-axis is in the same direction. The sign corrections needed to transform the data to MSS axes are done when postprocessing the WAMIT output files, see *wamit2vessel.m*.

1.2.2 ShipX (Veres)

For ShipX it is possible to compute the hydrodynamic data in the following points:

CG – center of gravity

CO* – in the still water plane line on the centerline with the z-axis pointing through CG

The preferred point is CO* which is on the center line in the still water plane. The reason for this, is that for ships this point is close to the center of flotation (CF), that is the centroid of the water plane area for small roll and pitch angles. The CF is usually located a distance LCF aft of mid-ships and the ship will rotate (roll and pitch) about this point. Consequently, the roll and pitch periods as well as viscous roll damping terms can be computed in the CF using the decoupled roll equation since this point is the rotation center. If a different coordinate origin is used, coupling to the other DOF will affect the results and a coupled analysis in 6 DOF is needed. Hence, CO or CO* are preferred points for hydrodynamic computations.

The ShipX axes are: x (backwards), y (starboard) and z (upwards) which is different from the MSS axes. Rotation matrices are used to transform the computed data to MSS axes when postprocessing the ShipX output files, see *veres2vessel.m*.

1.2.3 Octopus Seaway

Octopus Seaway can also compute the hydrodynamic data in CG and CO.

The Octopus Seaway axes are pointing in similar directions as the WAMIT axes: x (forward), y (port), z (upwards). Hence, only a sign correction is needed to obtain the MSS axes convention. The sign correction is applied when postprocessing the Octopus Seaway output files, see *seaway2vessel.m*.

2 Description of WAMIT Models

MSS Hydro [2] contains several example models generated by WAMIT [7] which is a computer program based on 3D panel methods for analyzing hydrodynamic interactions with floating or submerged bodies, in the presence of ocean waves. WAMIT computes motion and force transfer functions (RAOs), wavedrift coefficients, added mass and potential damping coefficients. In later versions of WAMIT there is an option to link WAMIT with the *Relational Geometry Kernel* of the CAD program MultiSurf [3]. This facilitates a seamless transition from design to hydrodynamic analysis.

MSS Hydro contains several Matlab commands for analysis and simulation of 6 DOF vessel motions in the time-domain using Simulink. The WAMIT models in MSS Hydro are listed in Table 1.

Table 1: WAMIT example models in Section 2.2.

Vessel	m (tonnes)	L_{pp} (m)	B (m)	T (m)	vessel data	fluid memory
Semisub	51.980	115.0	80.0	21.0	semisub.mat	semisubABC.mat
FPSO	100.410	200.0	44.0	12.0	fpso.mat	fpsoABC.mat
Tanker	94.620	246.0	46.0	10.0	tanker.mat	tankerABC.mat

The WAMIT models are located in the catalogue:

```
$MATLAB\mss\hydro\vessels\wamit
```

2.1 How to Generate a WAMIT Model for MSS

In order to generate a WAMIT model for MSS, the vessel hull must be panelized and represented as a WAMIT `*.GDF` geometry file. This is usually done by using CAD/CAM programs like Multisurf [3] and Rhinoceros [4]. For simple geoemtries like semi-submersibles, cylinders, barges, FPOS etc., the WAMIT manual contains several examples files describing how you can do this. For this purpose the integer parameter IGDEF is used to specify the manner in which the geometry of the body is defined:

IGDEF = 0. The geometry of each patch is a flat quadrilateral, with vertices listed in the GDF file.

IGDEF = 1. The geometry of each patch is represented by B-splines, with the corresponding data in the GDF file.

IGDEF = 2. The geometry is defined by inputs from a MultiSurf MS2 file [3].

IGDEF < 0. Analytical representation of the geometry (Table 2).

Table 2: Analytical WAMIT representations of the GDF geometry file (IGDEF < 0) using the FORTRAN library GEOMXACT.F.

IGDEF	Subroutine	Vessel description
-5	BARGE	Barge
-6	BARGEMP	Barge with rectangular moonpool in its center
-9	TLP	Tension leg platform
-10	SEMISUB	Semi-sub with two parallel pontoons and N cylindrical columns
-11	FPSO	FPSO hull with elliptic bow, rectangular mid-body, prismatic stern
-13	AUV	Axisymmetric body with hemispherical nose, cylindrical midbody and conical tail
-16	FPSO2	Modified FPSO with one extra patch on the bottom of the bow and separate midbody bottom
-21	FPSOINT	Modified FPSO with internal tanks

WAMIT comes with the FORTRAN library file GEOMXACT.F which contains several analytical representations of different vessels. The most useful geometry representations for simulation of vessel motions in 6 DOF are listed in Table 2.

The semisub and FPSO examples in Appendices 2.2.1 and 2.2.2 use the analytical representations IGDEF = -10 and IGDEF = -16, respectively, while the tanker in Section 2.2.3 is panelized and exported as IGDEF = 0 by the CAD/CAM program Rhinoceros [4].

2.1.1 MSS requirements for WAMIT input files

When generating a new WAMIT model the input files must comply with the MSS data structure which is generated by `wamit2vessel.m`. For WAMIT, the FRC and POT input files must satisfy:

WAMIT file myvessel.pot (MSS requirement). The example shows the use of POT-file alternative 1 but it is also possible to use POT-file alternative 2 (WAMIT version 6).

```
Myvessel
0
0
-1 0.00 0.00 0.00 0.00
0 0 0
1 1
1 1 1 1 1 1        (MSS: all 6 DOF must be included)
15                 (MSS: the 0 and INF frequencies must be included, i.e. -1, 0)
-1 0 4 5 6 7 8 9 10 11 12 13 14 15 20
19                 (MSS: 19 headings from 0-180 must be included)
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
```

WAMIT file myvessel.frc (MSS requirement). The example shows the use of FRC-file alternative 1 but it is also possible to use FRC-file alternative 2 (WAMIT version 6).

```
Myvessel
1 0 1 1 0 0 0 0 1   (MSS: IOPTN 1, 2 (or 3) ,4, 8 (or 9) must be used)
1.00
33.0 0.00 0.00
0.00 34.0 0.00
0.00 0.00 37.5
0
0
```

WAMIT file myvessel.cfg (MSS requirement).

```
...
IPERIO=1                (MSS: IPERIO=1, that is periods in seconds must be used)
USERID_PATH=C:\WAMITv63 (MSS: this is the path to your WAMIT installation)
```

2.1.2 Postprocessing of WAMIT output files

The hydrodynamic codes generate different output files which must be processed in order to run the model in Simulink. The WAMIT computations are done by running the project file in the command window, for example:

Windows CMD Window (run WAMIT semisub model)

```
>cd c:\Program Files\Matlab\R2007b\toolbox\mss\hydro\vessels\wamit\semisub
>c:\wamitv63\wamit semisub
```

Alternatively, you can execute WAMIT from MATLAB by using:

Matlab CMD Window

```
>>cd('c:\Program Files\Matlab\R2007b\toolbox\mss\hydro\vessels\wamit\semisub')
>>dos('c:\wamitv63\wamit.exe &');
```

For WAMIT data, the following Matlab commands can be used to generate the *MSS vessel structure*:

Matlab (postprocessing of WAMIT output files)

```
>>vessel = wamit2vessel('myvessel') - generate MSS vessel structure myvessel.mat
>>vessel2ss(vessel)     - compute fluid memory state-space model myvesselABC.mat
```

where `'myvessel'` refers to the WAMIT output file `myvessel.out`. This gives two Matlab `*.mat` files that are needed to run the Simulink model. Each time you run a new model, the vessel parameters can be loaded into the workspace by using:

Matlab (load vessel data)

```
>>load myvessel                  - load MSS vessel structure
>>load myvesselABC               - load fluid memory state-space model
>>display(vessel)
```

The vessel data can be further analyzed in Matlab by using the following commands:

Matlab (plot vessel data)

```
>>plotTF(vessel,'motion','rads',1) - plot motion RAOs for velocity #1
>>plotTF(vessel,'force','rads',1)  - plot force RAOs for velocity #1
>>plotWD(vessel,'rads',1)          - plot wavedrift coeffs. for velocity #1
>>plotABC(vessel,'A')              - plot zero speed added mass versus frequency
>>plotABC(vessel,'B')              - plot zero speed damping versus frequency
>>plotABC(vessel,'C')              - plot zero speed restoring terms
>>plot_wamitgdf('myvessel')        - plot WAMIT geoemtry file myvessel.gdf
```

Matlab (load condition)

```
>>loadcond(vessel)                  - Plot/verify load condition data
>>DPperiods(vessel,1)               - DP periods and damping
```

2.2 WAMIT Example Vessels

2.2.1 Semi-submersible

The MSS semi-submersible in Figure 2 is build using Example 15 in the WAMIT manual [7] (IGDEF = -10). Main particulars for an offshore semi-submersible are used to specify

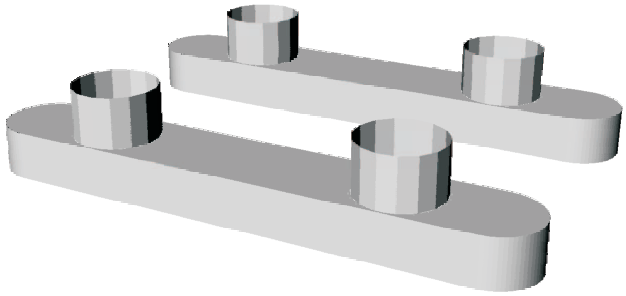

Figure 2: WAMIT semi-submersible (m = 51.980 tonnes, L_{pp} = 115.0 m, B = 80.0 m, T = 21.0 m).

a realistic response of the vessel motions. The semi-submersible is defined by the following WAMIT input files:

fnames.wam (WAMIT input file containing project file names)

```
semisub.cfg
semisub.pot
semisub.frc
semisub.gdf
```

semisub.cfg (WAMIT CFG-file)

```
IPLTDAT=5
ILOWGDF=5
KSPLIN=3
IQUADI=4
IQUADO=3
IALTFRC=2
IALTPOT=1
ISOLVE=1
MAXSCR=2046
ILOWHI=1
MAXITT=100
IPERIO=1
USERID_PATH=C:\WAMITv63
```

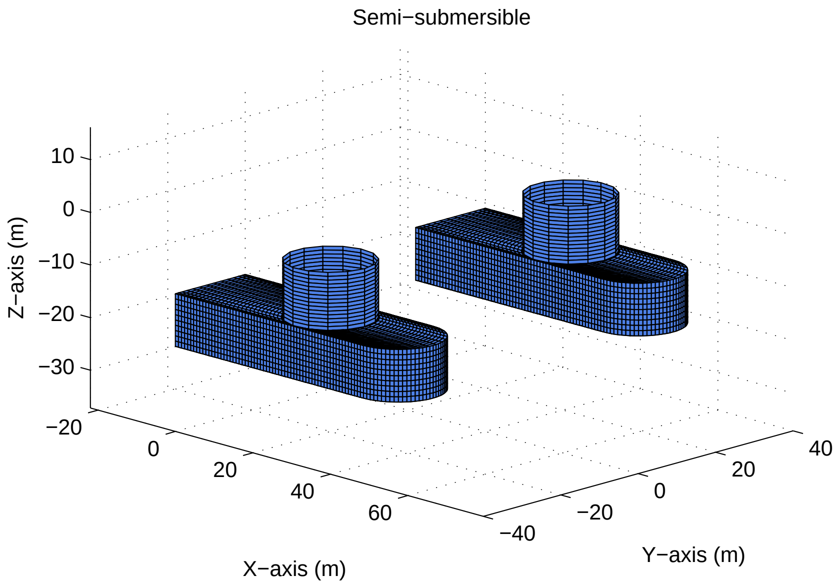

Figure 3: WAMIT semi-submersible plotted using: `>>plot_wamitgdf('semisub_low')`.

semisub.pot (WAMIT POT-file alternative 1)

```
Semisub Lpp = 115.0, B = 80.0, T = 21.0, NCOL = 2, IGDEF = -10
0
0
-1 0.00 0.00 0.00 0.00
0 0 0
1 1
1 1 1 1 1 1
26
-1 0 4.5 5 5.5 5.8 6 6.5 6.8 7 7.5 8 8.5 9 9.5 10 11 11.5 12 13 14 15 20 30 40 50
19
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
```

semisub.frc (WAMIT FRC-file alternative 1)

```
Semisub Lpp = 115.0, B = 80.0, T = 21.0, NCOL = 2, IGDEF = -10
1 0 1 1 0 0 0 0 1
1025.00
```

```
0.00 0.00 -0.5
1
51979800.00 0.00 0.00 0.00 -25989900.00   0.00
0.00 51979800.00 0.00 25989900.00 0.00   0.00
0.00 0.00 51979800.00 0.00 -0.00   0.00
0.00 25989900.00 0.00 56606002200.00 0.00   0.00
-25989900.00 0.00 -0.00 0.00 60088648800.00   0.00
0.00 0.00 0.00 0.00 0.00 73096593750.00
1
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 2e9  0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
1
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0
0
```

semisub.gdf (WAMIT geometry file)

```
Semisub Lpp = 115.0, B = 80.0, T = 21.0, NCOL = 2, IGDEF = -10
1.  9.81     ULEN GRAV
1   1        ISX  ISY
6 -10        NPATCH IGDEF
2            NLINES
115.0 22.0 40.0 -21.0 -11.0 XL, Y1, Y2, Z1, Z2
62.0 8.8 2  DCOL, RCOL, NCOL
```

semisub.spl (WAMIT SPL-file)

```
Semisub Lpp = 115.0, B = 80.0, T = 21.0, NCOL = 2, IGDEF = -10
9  3        NU NV                (patch  - pontoon bottom)
32 2        NU NV                (patch  - pontoon sides and end)
5  3        NU NV                (patch  - deck to first column)
3  3        NU NV                (patch  - surface of 1st column)
```

```
5  2        NU NV                  (patch  - annulus around 1st column)
4  3        NU NV                  (patch  - deck forward)
```

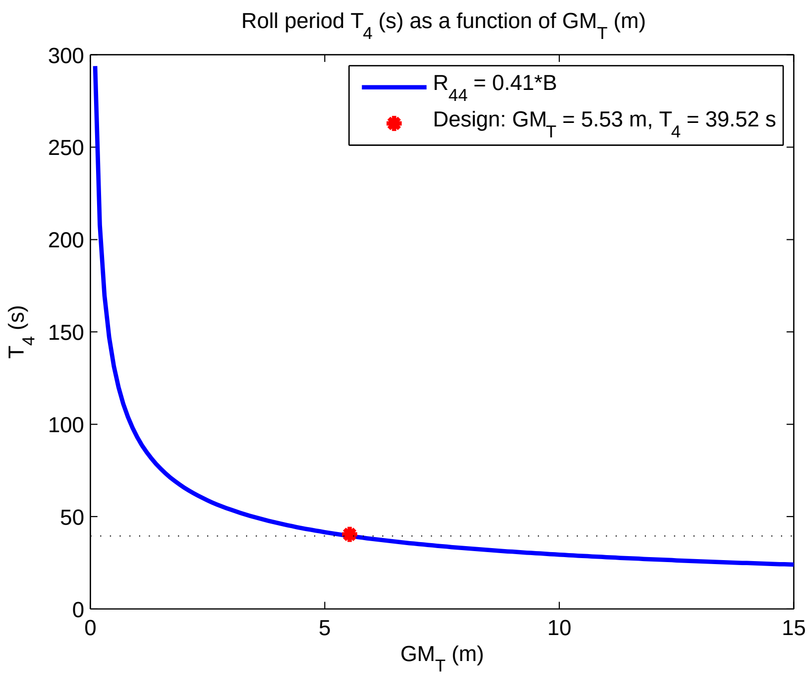

Figure 4: Roll period as function of $\overline{GM}_T$ for the semi-sub. Plot is generated using: `>>loadcond(vessel)`.

The main particulars of the semi-submersible can be loaded to the workspace as:

Matlab (load vessel main particulars)

```
>>load semisub
>>display(vessel.main)
```

```
name: 'semisub'
   T: 21            - draught (m)
   B: 80            - breadth (m)
 Lpp: 115           - Length between perpendiculars (m)
 k44: 33            - radius of gyration in roll (m)
 k55: 34            - radius of gyration in pitch (m)
```

```
     k66: 37.5000          - radius of gyration in yaw (m)
     rho: 1025             - density of water (kg/m3)
       g: 9.8100           - acceleration of gravity (m/s2)
   nabla: 50712            - volume displacement (m3)
       m: 51979800         - mass (kg)
      CB: [0 0 7.2162]     - center of buoyancy w.r.t baseline and Lpp/2 (m)
    GM_T: 5.5284           - transverse metacentric height (m)
    GM_L: 5.5284           - lateral metacentric height (m)
      CB: [0 0 7.22]       - center of buoyancy w.r.t baseline and Lpp/2 (m)
      CG: [0 0 20.5]       - center of gravity w.r.t baseline and Lpp/2 (m)
```

2.2.2 FPSO

The MSS Floating Production, Storage and Offloading (FPSO) unit in Figure 5 is based on an analytical geometry file in WAMIT (IGEDF = -11). An FPSO unit is a type of floating tank system used by the offshore oil and gas industry and designed to take all of the oil or gas produced from a nearby platforms, process it, and store it until the oil or gas can be offloaded onto waiting tankers, or sent through a pipeline. The FPSO unit is defined by the following WAMIT input files:

fnames.wam (WAMIT input file containing project file names)

```
fpso.cfg
fpso.pot
fpso.frc
fpso.gdf
```

tanker.cfg (WAMIT CFG-file)

```
IPLTDAT=5
ILOWGDF=5
KSPLIN=3
IQUADI=4
IQUADO=3
IALTFRC=1
IALTPOT=1
ISOLVE=1
MAXSCR=2046
ILOWHI=1
MAXITT=100
IPERIO=1
USERID_PATH=C:\WAMITv63
```

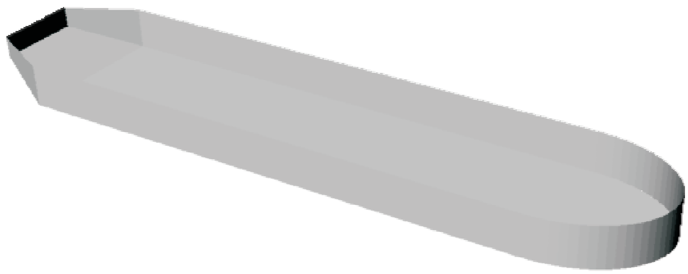

Figure 5: WAMIT FPSO (m = 100.410 tonnes, L_{pp} = 200.0 m, B = 46.0 m, T = 10.0 m).

tanker.pot (WAMIT POT-file alternative 1)

```
FPSO Lpp = 200.0, B = 44.0, T = 12.0, IGDEF=-11
0
0
-1 0.00 0.00 0.00 0.00
0 1 0
1 1
1 1 1 1 1 1
23
24
-1 0 0.7 0.8 1 1.5 1.8 1.9 2.05 2.1 2.5 3 3.5 4 5 5.5 6 7 8 10 15 30 40 50
19
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
```

tanker.frc (WAMIT FRC-file alternative 1)

```
FPSO Lpp = 200.0, B = 44.0, T = 12.0, IGDEF=-11
1 0 1 1 0 0 0 0 1
-1.00
16.3 0.00 0.00
0.00 54.0 0.00
0.00 0.00 54.0
0
0
```

The main particulars of the FPSO can be loaded to the workspace as:

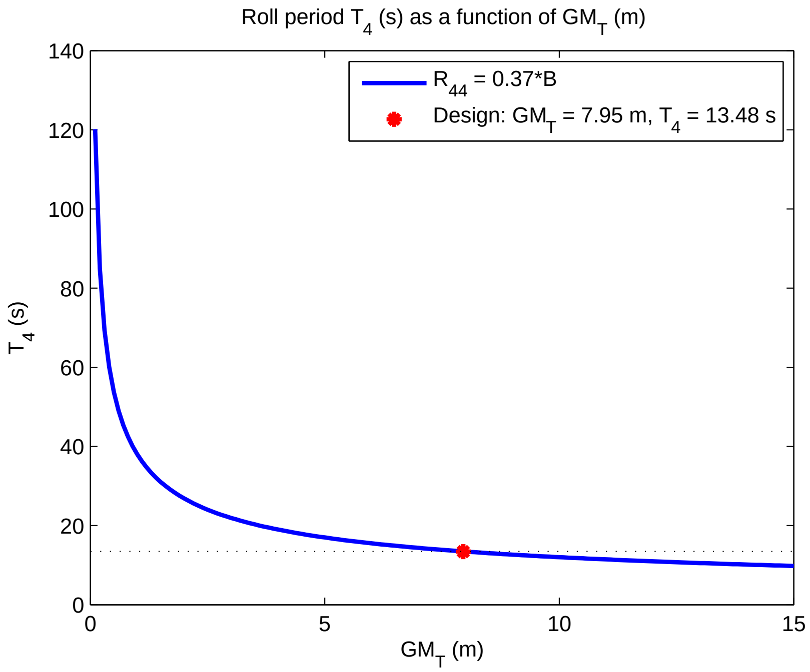

Figure 6: Roll period as function of $\overline{GM}_T$ for the FPSO. Plot is generated using: `>>loadcond(vessel)`.

Matlab (load vessel main particulars)

```
>>load fpso
>>display(vessel.main)
```

```
   name: 'fpso'
      T: 12                      - draught (m)
      B: 44                      - breadth (m)
    Lpp: 200                     - Length between perpendiculars (m)
    rho: 1025                    - density of water (kg/m3)
    k44: 16.3000                 - radius of gyration in roll (m)
    k55: 54                      - radius of gyration in pitch (m)
    k66: 54                      - radius of gyration in yaw (m)
      g: 9.81                    - acceleration of gravity (m/s2)
  nabla: 97961                   - volume displacement (m3)
      m: 100409923               - mass (kg)
     CB: [0.7886 0 0.60772]      - center of buoyancy w.r.t baseline and Lpp/2 (m)
   GM_T: 7.9539                  - transverse metacentric height (m)
   GM_L: 251.4268                - lateral metacentric height (m)
```

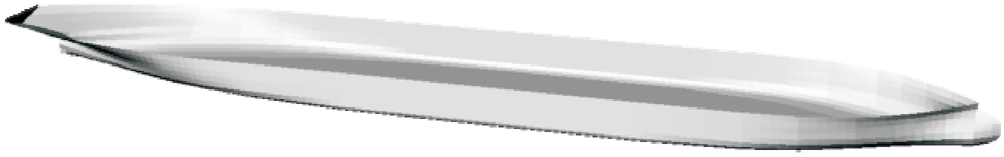

Figure 7: WAMIT tanker ($m = 94.620$ tonnes, $L_{pp} = 246.0$ m, $B = 46.0$ m, $T = 10.0$ m).

```
CG: [0 0 11]              - center of gravity w.r.t baseline and Lpp/2 (m)
```

2.2.3 Tanker

The MSS tanker in Figure 7 is based on a CAD/CAM drawing which is imported into Multisurf [3] and exported as a low-order WAMIT geometry file *tanker.gdf* (IGDEF = 0). The tanker is defined by the following WAMIT input files:

fnames.wam (WAMIT input file containing project file names)

```
tanker.cfg
tanker.pot
tanker.frc
tanker.gdf
```

tanker.cfg (WAMIT CFG-file)

```
IALTFRC=2
IALTPOT=1
ISOLVE=1
MAXSCR=2046
ILOWHI=0
MAXITT=100
IPERIO=1
USERID_PATH=c:\WAMITv63
```

tanker.pot (WAMIT POT-file alternative 1)

```
Tanker  Lpp = 246.0m, B = 46.0 m, T = 10.0, IGDEF = 0
1
```

```
3
-1 0.00 0.00 0.00 0.00
0 0 0
1 1
1 1 1 1 1 1
18
-1 0 2 2.5 3 3.5 4 4.5 5 5.5 6 7 8 10 15 30 50 100
19
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180
```

tanker.frc (WAMIT FRC-file alternative 2)

```
Tanker  Lpp = 246.0m, B = 46.0 m, T = 10.0, IGDEF = 0
1 0 1 1 0 0 0 0 1
1025.00
3.93 0.00 2.50
1
94620210.00 0.00 0.00 0.00 236550525.00   0.00
0.00 94620210.00 0.00 -236550525.00 0.00   0.00
0.00 0.00 94620210.00 0.00 -371857425.30   0.00
0.00 -236550525.00 0.00 27409620280.88 0.00   0.00
236550525.00 0.00 -371857425.30 0.00 387080076077.14   0.00
0.00 0.00 0.00 0.00 0.00 417428070207.44
1
410000.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 1560000000.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
1
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0.00 0.00 0.00 0.00 0.00 0.00
0
0
```

The main particulars of the tanker can be loaded to the workspace as:

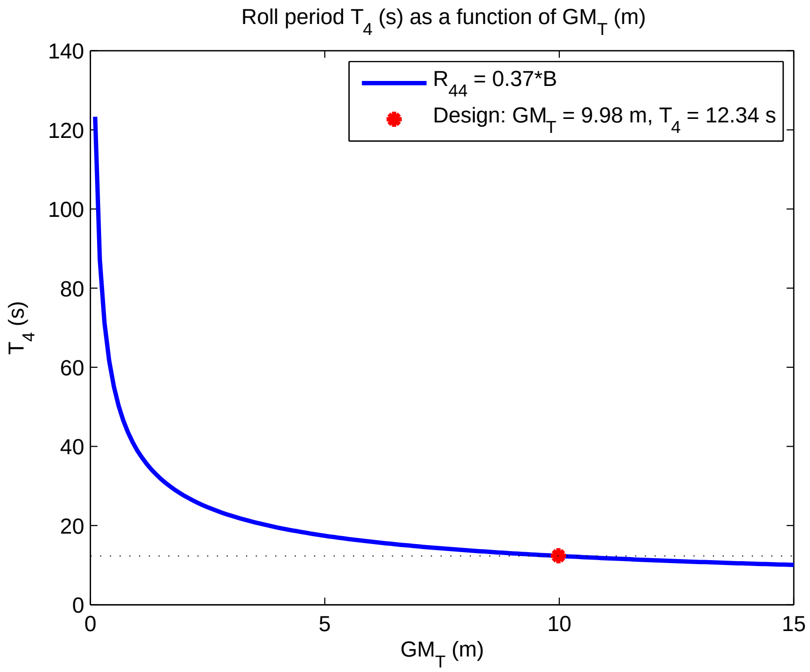

Figure 8: Roll period as function of $\overline{GM}_T$ for the tanker. Plot is generated using: `>>loadcond(vessel)`.

Matlab (load vessel main particulars)

```
>>load tanker
>>display(vessel.main)
```

```
    name: 'tanker'
       T: 10                          - draught (m)
       B: 46                          - breadth (m)
     Lpp: 246                         - Length between perpendiculars (m)
       m: 94620210                    - mass (kg)
     rho: 1025                        - density of water (kg/m3)
     k44: 17.0200                     - radius of gyration in roll (m)
     k55: 63.9600                     - radius of gyration in pitch (m)
     k66: 66.4200                     - radius of gyration in yaw (m)
       g: 9.8066                      - acceleration of gravity (m/s2)
   nabla: 9.2312e+004                 - volume displacement (m3)
      CB: [3.9259 0 5.1845]           - center of buoyancy w.r.t baseline and Lpp/2 (m)
    GM_T: 9.9823                      - transverse metacentric height (m)
    GM_L: 475.3504                    - lateral metacentric height (m)
```

```
CG: [3.9300 0 12.5000]     - center of gravity w.r.t baseline and Lpp/2 (m)
```

3 Description of ShipX Models

MSS Hydro [2] contains several example models generated by ShipX VEssel RESponse program (VERES) [1] which is a 2D strip theory programs based on [6]. The program computes motion and force transfer functions (RAOs), wavedrift coefficients, global wave induced loads, short and long term statistics, postprocessing of slamming pressures, operability etc. Input to the program is an ASCII file of table-of-offsets representing the hull geometry. The ShipX models in MSS Hydro are listed in Table 3.

Table 3: ShipX (VERES) example models in Section 3.2.

Vessel	m (tonnes)	L_{pp} (m)	B (m)	T (m)	vessel data	fluid memory
S175	24.609	175.0	25.4	9.5	s175.mat	s175ABC.mat
Supply Vessel	6.362	82.8	19.2	6.0	supply.mat	supplyABC.mat

The ShipX models are located in the catalogue:

```
$MATLAB\mss\hydro\vessels\shipx
```

3.1 How to Generate a ShipX Model for MSS

In order to generate a ShipX model for MSS, the vessel hull must be represented by table-of-offsets. The cross-sections of the hull are specified by a number of offset points (y,z) along the x-axis, which are further interpolated upon in VERES. Normally 20 offset points on each half section will provide an adequate description of the sectional shape and assure that correct added mass and damping coefficients are obtained. The VERES geometry file format looks as follows (Figure 9):

ShipX file myvessel.mgf (table-of-offsets)

```
Text string 1
Text string 2
Text string 3
Text string 4
LPP
Section_number
X-position
Number_of_points
y(Section_number,1) z(Section_number,1)
y(Section_number,2) z(Section_number,2)
. .
```

```
. .
y(Section_number,Number_of_points) z(Section_number,Number_of_points)
Next_section_number
...
```

where the x-axis is pointing towards stern implying that the fore section (section number 1) has a negative x value.

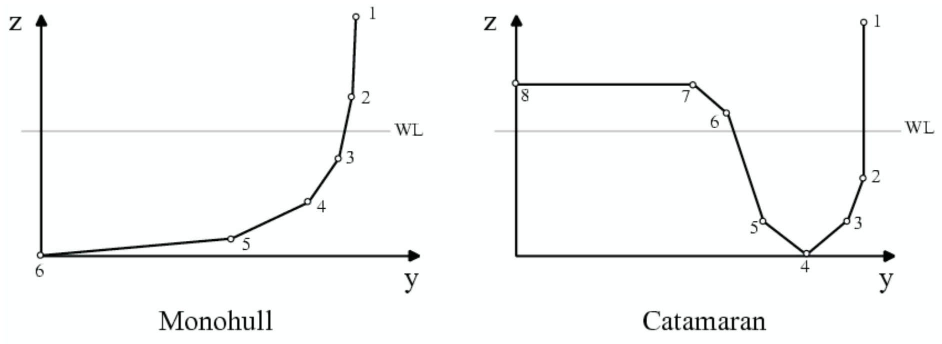

Figure 9: Description of the hull offset points [1].

3.1.1 MSS requirements for ShipX configuration

When generating a new ShipX model the VERES vessel response calculations must comply with the MSS data structure which is generated by `veres2vessel.m`. The following *calculations options* must be chosen:

- Ordinary strip theory (recommended but other methods can be used)
- Added resistance - Gerritsma & Beukelman
- Generate hydrodynamic coefficient files (*.re7 and *.re8)
- Calculation options: choose z-coordinates from CO (coordinate origin in the water line on the centerline a distance $L_{pp}/2$ from AP)

The condition information for frequency-domain simulations must be chosen according to:

- Vessel velocities must always include the zero velocity: it is optionally to add more velocities that are needed for maneuvering

- Wave periods: it is recommended to use values in the range 2.0s to 60.0s, for instance: 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0 8.5 9.0 9.5 10.0 10.5 11.0 11.5 12.0 12.5 13.0 13.5 14.0 14.5 15.0 15.5 16.0 17.0 18.0 19.0 20.0 25.0 30.0 60.0
- The wave headings must be chosen as: 0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180

3.1.2 Postprocessing of ShipX output files

The hydrodynamic codes generate different output files which must be processed in order to run the model in Simulink. For ShipX data, the following Matlab commands can be used to generate the *MSS vessel structure*:

Matlab (postprocessing of ShipX output files)

```
>>vessel = veres2vessel('input')    - generate MSS vessel structure myvessel.mat
>>vessel2ss(vessel)     - compute fluid memory state-space model myvesselABC.mat
```

where `'input'` refers to the ShipX output files:

```
input.hyd  - hydrostatic data (vessel.main)
input.re1  - motion RAOs (vessel.motionRAO)
input.re2  - wavedrift data (vessel.driftfrc)
input.re7  - added mass, damping, restoring forces
input.re8  - force RAOs (vessel.forceRAO)
```

This gives two Matlab `*.mat` files that are needed to run the Simulink model. Each time you run a new model, the vessel parameters can be loaded into the workspace by using:

Matlab (load vessel data)

```
>>load myvessel                    - load MSS vessel structure
>>load myvesselABC                 - load fluid memory state-space model
>>display(vessel)
```

The vessel data can be further analyzed in Matlab by using the following commands:

Matlab (plot vessel data)

```
>>plotTF(vessel,'motion','rads',1) - plot motion RAOs for velocity #1
>>plotTF(vessel,'force','rads',1)  - plot force RAOs for velocity #1
>>plotWD(vessel,'rads',1)          - plot wavedrift coeffs. for velocity #1
```

```
>>plotABC(vessel,'A')            - plot zero speed added mass versus frequency
>>plotABC(vessel,'B')            - plot zero speed damping versus frequency
>>plotABC(vessel,'C')            - plot zero speed restoring terms
```

Matlab (load condition)

```
>>loadcond(vessel)                - Plot/verify load condition data
>>DPperiods(vessel,1)             - DP periods and damping
```

3.2 ShipX Example Vessels

3.2.1 Container ship S175

The example hull of ShipX is the container ship S-175 located in the catalogue

```
c:\Program\Files\SHIPX\PlugIns\VERES\Examples
```

Below is an example of the first lines for the S-175 hull with a few comments to the right:

s175.mgf (ShipX table-of-offsets)

```
VERES Geometry file
Demo
S-175 Container Ship,
Basic design, Draught = 9.5 m.
175.0 Lpp
1 section number 1
-87.500 x-location for section 1
15 number of offset-points
0.280 11.000 (y,z) for offset-point 1
0.110 10.000 (y,z) for offset-point 2
0.100 9.000
0.200 8.000
0.350 7.000
0.560 6.000
0.820 5.000
1.100 4.000
1.320 3.000
1.340 2.000
1.050 1.000
0.910 0.750
```

```
0.660 0.500
0.540 0.250
0.000 0.130 (y,z) for offset-point 15
2 section number 2
-83.125 x-location for section 2
15 number of offset-points
1.210 11.000 (y,z) for offset-point 1
0.960 10.000 (y,z) for offset-point 2
0.800 9.000
0.670 8.000
...
```

The main particulars of the S-175 can be loaded to the workspace as:

Matlab (load vessel main particulars)

```
>>load s175
>>display(vessel.main)
```

```
    name: 's175'
       T: 9.5                      - draught (m)
       B: 25.4                     - breadth (m)
     Lpp: 175                      - Length between perpendiculars (m)
       m: 24609620                 - mass (kg)
     rho: 1025                     - density of water (kg/m3)
     k44: 8.3310                   - radius of gyration in roll (m)
     k55: 42.000                   - radius of gyration in pitch (m)
     k66: 42.000                   - radius of gyration in yaw (m)
       g: 9.81                     - acceleration of gravity (m/s2)
   nabla: 2.4009e+004              - volume displacement (m3)
      CB: [-2.5470 0 5.2070]       - center of buoyancy w.r.t baseline and Lpp/2 (m)
    GM_T: 0.9960                   - transverse metacentric height (m)
    GM_L: 204.4360                 - lateral metacentric height (m)
    C_B: 0.5690                    - block coefficient
     CG: [-2.5475 0 9.5500]        - center of gravity w.r.t baseline and Lpp/2 (m)
      S: 4.9276e+003               - wetted surface
```

3.2.2 Supply vessel

The supply vessel load condition is shown in Figure 11.

The main particulars of the supply vessel can be loaded to the workspace as:

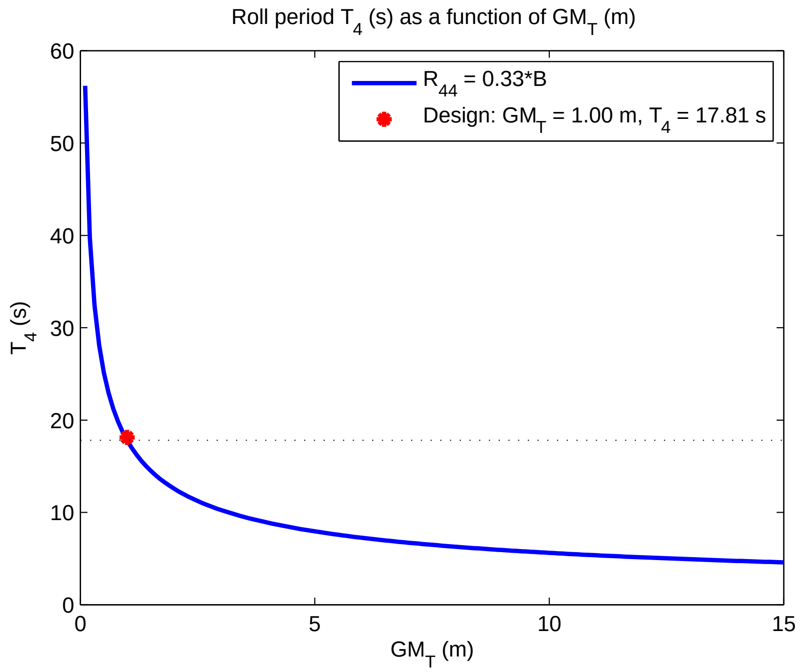

Figure 10: Roll period as function of $\overline{GM}_T$ for the tanker. Plot is generated using: `>>loadcond(vessel)`.

Matlab (load vessel main particulars)

```
>>load supply
>>display(vessel.main)
```

```
     name: 'supply'
        T:  6.0                        - draught (m)
        B: 19.2                        - breadth (m)
      Lpp: 82.8                        - Length between perpendiculars (m)
        m: 6.3622e+006                 - mass (kg)
      rho: 1025                        - density of water (kg/m3)
      k44: 6.7200                      - radius of gyration in roll (m)
      k55: 2.7000                      - radius of gyration in pitch (m)
      k66: 20.700                      - radius of gyration in yaw (m)
        g: 9.81                        - acceleration of gravity (m/s2)
    nabla: 6.2070e+003                 - volume displacement (m3)
       CB: [-5.3860 0 3.3340]          - center of buoyancy w.r.t baseline and Lpp/2 (m)
     GM_T: 2.1440                      - transverse metacentric height (m)
     GM_L: 103.6280                    - lateral metacentric height (m)
```

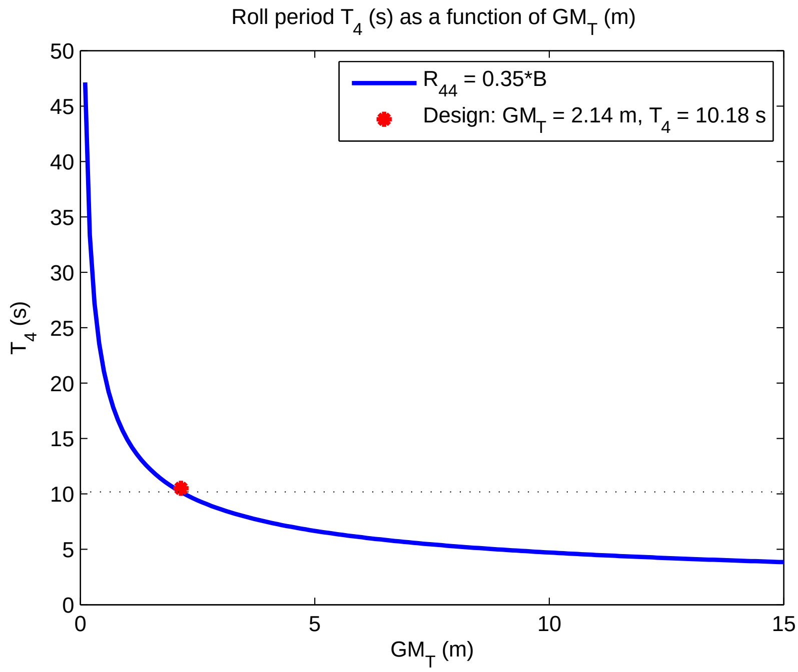

Figure 11: Roll period as function of $\overline{GM}_T$ for the tanker. Plot is generated using: `>>loadcond(vessel)`.

```
  C_B: 0.6510                    - block coefficient
   CG: [-5.3859 0 7.3000]        - center of gravity w.r.t baseline and Lpp/2 (m)
    S: 1.8202e+003               - wetted surface
```

References

[1] ShipX (VERES), *User's Manuals*. MAINTEK AS, see `http://www.sintef.no`.

[2] MSS, *Marine Systems Simulator*. Available online at `http://www.marinecontrol.org`.

[3] Multisurf, *Documentation*. Aerohydro Inc. Available online at `http://www.aerohydro.com`.

[4] Rhinoceros, *Training Manuals*. Available online at `http://www.rhino3d.com`.

[5] OCTOPUS Seaway, *User Manual of Seaway*. Amarcon b.v. Available online at `http://www.amarcon.com`.

[6] Salvesen, N., E. O. Tuck and O. M. Faltinsen (1970). *Ship Motions and Sea Loads*. Trans. SNAME, 78:250-287.

[7] WAMIT, *User's Manual.* WAMIT Inc. Available online at www.wamit.com.