# ONR Tumblehome (ONRT)

## Description

The aim of this test case is to assess the capability of free-running CFD to predict the course keeping ability and motions of a ship in regular head and stern quartering waves. Special attention is given the CFD setup (mass properties, GM, and roll decay) and validation of the surge and sway forces and the yaw moment as well as to the propeller and rudder loads. The ONR Tumblehome (ONRT) model 5613 is a preliminary design of a modern surface combatant, which is publicly accessible for fundamental research. The 1/48.935 scaled ship model is appended with skeg and bilge keels. The model has a wave piercing hull design with 10° tumblehome sides and transom stern. The model also has spade rudders, shafts and propellers with propeller shaft brackets.  No full-scale ship exists.

Free-running tests, including course keeping, zigzag, and turning in calm water and regular waves, were performed at the IIHR Hydraulics Wave Basin Facility, and the results were reported in (Sanada et al., 2013 and 2018). In addition, IIHR will soon provide new EFD data, including rudder forces and shaft moments, propeller thrust, torque, and propeller shaft side forces. Forces and moment decomposition from X, Y, and N measurements under semi-captive conditions is provided as an option.

The hull geometry, propeller open water data and sample submission files can be found on the W2025 website under https://w2025.nl/instructions/onr-tumblehome-onrt. For the purposes of the CFD setup, the design values that are considered and provided are the offsets and official waterline (length between perpendiculars (L), beam (B), draft (T), displacement volume ($\nabla$), longitudinal and vertical centre of buoyancy ($L_{CB}$ and KB), transverse metacentre above centre of buoyancy (BM)), transverse metacentric height (GM), and vertical centre of gravity above keel (KG). The roll/pitch/yaw radii of gyration around the principal axis x, y and z – $k_{xx}$, $k_{yy}$, and $k_{zz}$ ($k_{yy} = k_{zz}$) – depend on ballasting and are generally assumed to be $k_{xx}$ = 0.35-0.40B (depending on the ship geometry), and $k_{yy} = k_{zz}$ = 0.25L. For ONRT, length of the waterline ($L_{WL}$) and maximum moulded breadth at the design water line ($B_{WL}$) are used as representative lengths. The target values of radii of gyration are based on the achieved ballast conditions reported in Bishop et al., (2005): 0.377$B_{WL}$, 0.251$L_{WL}$, and 0.251$L_{WL}$ for roll, pitch, and yaw, respectively. Following ITTC recommendations, the CFD hydrostatic setup should be based on the offsets/IGES file and official waterline such that displacement, $L_{CB}$, KB, BM and KG are grid dependent and therefore considered validation variables.

Guidelines for the output from the CFD predictions are given under Instructions to Participants. Note that there are specific instructions as well as a questionnaire to be filled out for each method.

**References**

[1] Sanada, Y., Tanimoto, K., Takagi, K., Toda, Y., Stern, F., “Trajectories and Local Flow Field Measurements around ONR Tumblehome in Manoeuvring Motion,” Ocean Engineering, Vol. 72, 2013, pp. 45-65.

[2] Sanada, Y., Elshiekh, H., Toda, Y. and Stern, F., “ONR Tumblehome course keeping and maneuvering in calm water and waves,” J Mar Sci Technol., Vol. 24, 2019, pp. 948-967.

[3] Bishop, RC., Belknap, W., Turner, C., Simon, B., Kim, JH., “Parametric Investigation on the Influence of GM, Roll Dampening, and Above-Water Form on the Roll Response of Model 5613”, 2005.

[4] ITTC – Recommended Procedures Fresh Water and Seawater Properties 7.5-02 -01-03, 2011

## Nomenclature

| Symbol | Description | Unit |
|---|---|---|
| $A_R$ | Rudder area | $[m^2]$ |
| $B_{WL}$ | Maximum moulded breadth at design waterline | $[m]$ |
| $D_P$ | Propeller diameter | $[m]$ |
| $F_N$ | Rudder normal force | $[N]$ |
| $F_N'$ | Nondimensional rudder normal force | $[-]$ |
| $F_r$ | Froude number | $[-]$ |
| $F_T$ | Rudder tangential force | $[N]$ |
| $F_T'$ | Nondimensional rudder tangential force | $[-]$ |
| $f_w$ | Wave frequency | $[Hz]$ |
| $g$ | Gravitational acceleration | $[m/s^2]$ |
| $GM$ | Transverse metacentric height | $[m]$ |
| $H$ | Wave height | $[m]$ |
| $I_x$ | Roll moments of inertia around principal axis $x$ | $[kg \cdot m^2]$ |
| $I_y$ | Pitch moments of inertia around principal axis $y$ | $[kg \cdot m^2]$ |
| $I_z$ | Yaw moments of inertia around principal axis $z$ | $[kg \cdot m^2]$ |
| $KB$ | Vertical centre of buoyancy above keel | $[m]$ |
| $KM$ | Transverse metacentre above keel | $[m]$ |
| $K_Q$ | Torque coefficient | $[-]$ |
| $K_T$ | Thrust coefficient | $[-]$ |
| $K_Y$ | Shaft side force coefficient | $[-]$ |
| $k_{xx}$ | Roll radius of gyration around principal axis $x$ | $[m]$ |
| $k_{yy}$ | Pitch radius of gyration around principal axis $y$ | $[m]$ |
| $k_{zz}$ | Yaw radius of gyration around principal axis $z$ | $[m]$ |
| $L_{CB}$ | Longitudinal centre of buoyancy | $[m]$ |
| $L_{WL}$ | Length of waterline | $[m]$ |
| $n$ | Propeller revolutions | $[rps]$ |
| $p$ | Roll angular velocity in ship-fixed coordinates | $[\mathrm{rad/s}]$ |
| $q$ | Pitch angular velocity in ship-fixed coordinates | $[\mathrm{rad/s}]$ |
| $r$ | Yaw angular velocity in ship-fixed coordinates | $[\mathrm{rad/s}]$ |
| $R_e$ | Reynolds number | $[-]$ |
| $Q$ | Propeller torque | $[Nm]$ |

| | | |
|---|---|---|
| $S_0$ | Wetted surface area | $[m^2]$ |
| $T$ | Draft | $[m]$ |
| $T$ | Propeller thrust | $[N]$ |
| $u$ | Surge velocity in ship-fixed coordinates | $[m/s]$ |
| $v$ | Sway velocity in ship-fixed coordinates | $[m/s]$ |
| $w$ | Heave velocity in ship-fixed coordinates | $[m/s]$ |
| $Y_P$ | Propeller shaft side force | $[N]$ |
| $\Delta$ | Displacement mass | $[kg]$or $[ton]$ |
| $\delta$ | Rudder angle | $[deg]$ |
| $\zeta$ | Wave elevation | $[mm]$ |
| $\theta$ | Pitch angle | $[deg]$ |
| $\lambda$ | Wavelength | $[m]$ |
| $\nabla$ | Displacement volume | $[m^3]$ |
| $\nu$ | Kinematic viscosity of water | $[m^2/s]$ |
| $\rho$ | Density of water | $[kg/m^3]$ |
| $\phi$ | Roll angle | $[deg]$ |
| $\psi$ | Yaw angle | $[deg]$ |

*Table 1: Hull data and conditions.*

| **Main Particulars** | | **Model (scale 1:48.935)** | **Full** |
|---|---|---|---|
| Length of waterline | $L_{WL}(m)$ | 3.147 | 154.0 |
| Maximum moulded breadth at design water line | $B_{WL}(m)$ | 0.384 | 18.8 |
| Depth | $D$ (m) | 0.296 | 14.5 |
| Draft | $T$ (m) | 0.112270 | 5.50 |
| Displacement volume (fully appended) | $\nabla$ (m$^3$) | 0.0726019 | 8508 |
| Displacement mass (fully appended) | $\Delta$ | 72.5 kg<br>(Fresh Water at 18 °C) | 8790 ton<br>(Salt Water) |
| Wetted surface area (fully appended) | $S_0$ ( $m^2$) | 1.5354 | 3676.7 |
| Block coefficient (CB) | $\nabla/(L_{WL}B_{WL}T)$ | 0.53544 | 0.53544 |
| Longitudinal centre of buoyancy | $L_{CB}$ (m) aft of FP | 1.6263 | 79.6 |
| Transverse metacentre above keel<br>(calculated from offset) | KM (m) | 0.198570 | 9.72 |
| Transverse metacentric height<br>(official value for all the cases) | $GM(m)$ | 0.040870 | 2.0 |
| Roll radius of gyration around the principal axis x | $k_{xx}/B_{WL}$ | 0.377 | 0.377 |
| Pitch radius of gyration around the principal axis y<br>(Yaw radius of gyration around the principal axis z) | $k_{yy}/L_{WL}$<br>$(= k_{zz}/L_{WL})$ | 0.251 | 0.251 |
| Propeller diameter | $D_P(m)$ | 0.1066 | 5.217 |
| Propeller centre, long. location<br>(from Fore Waterline End, FP) | $x/L_{WL}$ | 0.9267 | |
| Propeller centre, lateral location (from CL) | $\pm y/L_{WL}$ | 0.02661 | |
| Propeller centre, vert. location (below WL) | $-z/L_{WL}$ | 0.03565 | |
| Propeller shaft angle (downward positive) | $\varepsilon$ (deg) | 5 | 5 |
| Propeller rotation direction (view from stern) | | inward over the top | inward over the top |
| Maximum rudder rate | | 35.0 deg/s | 5.0 deg/s |
| Rudder Area | $A_R$ (m$^2$) | 0.0206886 | 48.94 |
| Rudder shaft location from the leading edge | | 35 mm | |
| Rudder shaft centre, long. Location<br>(from Aft Waterline End, AP) | $x/L_{WL}$ | 0.04469 | |
| Rudder shaft centre, lateral location (from CL) | $\pm y/L_{WL}$ | 0.02002 | |

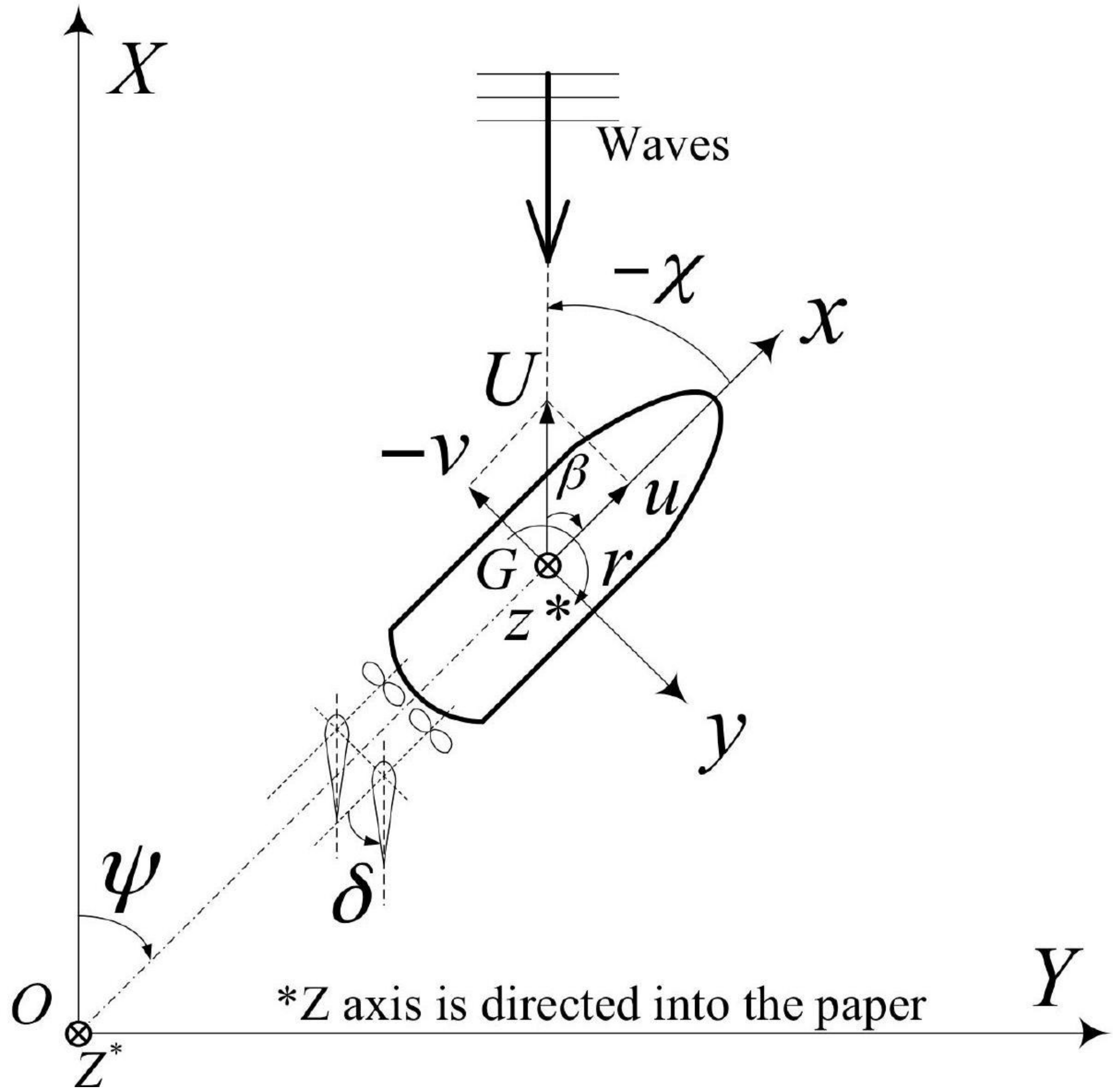


*Figure 1: Earth and ship-fixed coordinate system.*

*Table 2: Values of water properties (EFD water temperature 18℃) and gravitational acceleration to be used.*

| Property | | Units | Value |
|---|---|---|---|
| Density | ρ | kg/m$^3$ | 998.5986 |
| Kinematic viscosity | ν | m$^2$/s | 1.0542E-06 |
| Gravitational acceleration | $g$ | m/s$^2$ | 9.81 |

*Table 3: Requested computations ("Mandatory" cases denoted by *).*

| Case # | 0.1* | 0.2* | 1.0* | 1.1* | 1.2* |
|---|---|---|---|---|---|
| Wave State | Calm | Calm | Calm | Head<br>c=0° | Stern quartering<br>c=-135° |
| Condition | Incline Test<br>(Port* and Starboard) at zero speed<br>(Including hydrostatic calculation) | Free-roll decay 5° and 10° (Port* and Starboard) at zero speed | Self-Propulsion<br>Free running | Course Keeping<br>Free running | Course Keeping<br>Free running |
| Attitude* | $FR_{z\phi\theta}$ | $FR_{all}$ | $FR_{all}$ | $FR_{all}$ | $FR_{all}$ |
| Validation Variables | Displacement volume ($\nabla_{CFD}$),<br>Longitudinal centre of buoyancy ($L_{CB}$),<br>Vertical centre of buoyancy above keel (KB),<br>(Optional: Transverse metacentre above centre of buoyancy (BM)) | | Propeller revolutions [rps],<br>Nondim. thrust,<br>Nondim. torque | Propeller revolutions [rps],<br>Nondim. thrust,<br>Nondim. torque,<br>Nondim. shaft side force | Propeller revolutions [rps],<br>Nondim. thrust,<br>Nondim. torque,<br>Nondim. shaft side force |
| | | | Rudder angle [deg] | Rudder angle [deg],<br>Nondim rudder normal force,<br>Nondim. rudder tangential force | Rudder angle [deg],<br>Nondim rudder normal force,<br>Nondim. rudder tangential force |
| | Vertical centre of gravity above the waterline (zcg_o),<br>Roll angle [deg] | 6DoF motions | 6DoF motions | 6DoF motions | 6DoF motions |
| | | (Roll periods and damping coefficients analysed by the organizer) | | Speed loss | Speed loss |
| EFD Provider | IIHR | IIHR | IIHR | IIHR | IIHR |

*FR subscripts indicate which motions are free (e.g.: $FR_{all}$: The ship is free in all 6 degrees of freedom, $FR_{z\phi\theta}$: The ship is free in heave (z), roll ($\phi$), and pitch ($\theta$) motions)

Before starting any of the free-running simulations, Case 0.1 must be conducted, followed by Case 0.2. Case 0.1 is to check that the official GM is set correctly within the CFD and provide the KG value needed for this purpose.

In Case 0.1, the displacement volume ($\nabla_{CFD}$), longitudinal centre of buoyancy ($L_{CB}$), vertical centre of buoyancy above keel (KB) based on the grid used for the simulation needs to be calculated by hydrostatic calculation. The waterline is defined as the intersection of the hull and z=0 plane as defined by the IGES file. The LCB needs to be calculated so as to satisfy this waterline. This $L_{CB}$ is used as longitudinal centre of gravity ($L_{CG}$) in the following cases. The vertical centre of gravity above keel (KG) needs to be adjusted to satisfy the official GM shown in Table 1 following Case 0.1. The transverse metacentre above keel (KM) shown in Table 1 can be used as a reference value to determine the initial guess for KG before adjustment to satisfy the official GM. Note that this KM value in Table 1 was calculated from the offset data and KM will vary depending on the grids. Therefore, there is no need for the KM value obtained by adding the adjusted KG and the official GM to be the same as this value. Additionally, while the organizer requests participants to submit the transverse metacentre above centre of buoyancy (BM) value as an optional item, this may be waived if the calculation is difficult due to your CFD software or grid type. The mass of the ship ($M$) must be determined using the density ($\rho$, shown in Table 2) based on the formula $M = \rho\nabla_{\mathrm{CFD}}$. The roll and pitch moments of inertia around principal axis x and y ($I_{xx}$ , $I_{yy}$) to be used in the equations of motion must be calculated as $I_{xx} = M \cdot k_{xx}^2$ and $I_{yy} = M \cdot k_{yy}^2$, where $k_{xx}$and $k_{yy}$ are roll and pitch radius of gyration around principal axis x and y. Yaw moment of inertia around the principal axis z is assumed to be the same as $I_{yy}$ ($I_{zz} = I_{yy}$). These $M$ and $\nabla_{\mathrm{CFD}}$ must be reported.

The $k_{xx}$ and $k_{yy}$ (=$k_{zz}$) shown in the above table are measured values in air. Setting values other than those shown in the table here for any of the cases is only permitted after results are submitted using the official values, as these values are used to assess the CFD capability for predicting roll decay with zero forward speed (period and damping), which may be subject to turbulence modelling limitations and affect the free running results. Results using tuning of $k_{xx}$ for improved roll period and damping predictions will only be accepted if un-tuned results are also submitted.

In Case 0.2, the time series data for roll and roll rate ($\phi$ and $p$) need to be submitted, and the analysis of the period and damping will be performed by the organizer.

The propeller open water test is not a mandatory case, but it is recommended that it be carried out before Case 1.0.

Case 1.0 must be carried out before Case 1.1 to evaluate the speed loss.

6DoF motions require x, y, z, $\phi$, $\theta$, $\psi$, u, v, w, p, q, r.

Hull Attitude Definitions:

- $FR_{z\phi\theta}$ = Heave, Roll and Pitch are free
- $FR_{all}$ = 6 degrees of freedom

IGES

- Hull Geometry (with gaps above the rudders)
- Rudder Geometry
- Propeller and Hub Cap Geometry
- Propeller Open Water Characteristics (IIHR, April 2021).

# Case 0.1

## Conditions

- Hydrostatic calculations and Incline test – Port (mandatory) and Starboard (optional)
- With propellers, with rudders
- With bilge keels
- Zero forward speed
- $FR_{z\phi\theta}$
- Hydrostatic calculation in standard condition with the location of the centre of gravity along the Y-axis on the waterplane, ycg_o/$L_{WL}$ = 0.
- Hydrostatic calculation in inclined condition with the location of the centre of gravity along the Y-axis on the waterplane, ycg_o/$L_{WL}$ = ±0.000344036 (ycg_o = 0 during normal simulations).

## Computational Setup

1. All calculations are to be conducted for model scale conditions.
2. All simulation results should be provided in the format described in the next section.
3. The displacement volume, longitudinal centre of buoyancy, vertical centre of buoyancy from the keel, and transverse metacentric radius (optional) should be calculated in the standard condition.
4. For the inclined condition, the centre of gravity in the transverse direction should be set to ycg_o/$L_{WL}$ = ±0.000344036.
5. The rudders and propellers should be stationary.
6. Nondimensional transverse metacentric height $\overline{GM}$ should be calculated by the following equation with given ycg_o and obtained roll angle ϕ.

$$\frac{\overline{GM}}{L_{WL}} = \frac{ycg\_o/L_{WL}}{\tan\phi} \tag{1}$$

7. The setting value of the vertical centre of gravity above keel (KG) should be adjusted such that the correct official transverse metacentric height (GM) value is obtained by this method.

## General Format for Submissions

1. The obtained displacement volume ($\nabla_{CFD}$), longitudinal centre of buoyancy ($L_{CB}$) and vertical centre of buoyancy above keel (KB) based on the grid used for the simulation needs to be calculated by hydrostatic calculation in the standard condition. The mass of the ship ($M$) must be determined using the density ($\rho$, shown in Table 2) based on the formula $M = \rho\nabla_{CFD}$.
2. Based on the results in the inclined condition, the setting location of the vertical centre of gravity above keel (KG) (for draft (T) and centre of gravity above the waterline (zcg_o), KG = T + zcg_o), converged roll angle (ϕ) in degrees, and transverse metacentric height (GM/$L_{WL}$) should be reported for both port and starboard incline tests.
3. Values should be reported with Float precision (to the seventh decimal place).

*Table 4: Case 0.1 Validation Variables*

| Validation Variable | Symbol | Unit | Note |
|---|---|---|---|
| Displacement volume | $\nabla_{CFD}$ | [-] | Grid based displacement volume |
| Longitudinal centre of buoyancy | $L_{CB}$ | [m] | |
| Vertical centre of buoyancy above keel | KB | [m] | |
| Transverse metacentre above centre of buoyancy | BM | [-] | Optional |
| Setting location of centre of gravity above the waterline | zcg_o | [-] | |
| Vertical centre of gravity above keel | KG | [m] | KG = T + zcg_o |
| Converged incline roll angle | ϕ | [deg] | |
| Obtained transverse metacentric height | $GM/L_{WL}$ | [-] | $\frac{\overline{GM}}{L_{WL}} = \frac{ycg_o/L_{WL}}{\tan\phi}$ |

## Submission Instructions:

- [Identifier] should be [Institute Name]-[Solver Name]. For example, if your institute is NMRI and solver is SURFv7, identifier should be NMRI-SURFv7.
- The hydrostatic calculation results, final setting value for vertical centre of gravity, the obtained roll angle, and calculated transverse metacentric height should be reported in the provided template excel spreadsheet.

# Case 0.2

## Conditions

- Free roll decay test, Port (mandatory) and Starboard (optional)
- With propeller, with rudder
- With bilge keels
- Zero forward speed
- $FR_{all}$
- $R_e = 3.317 \times 10^6 (F_r = 0.20)$ at EFD water temperature 18 °C
- Initial roll angle: $|\phi_0|$ = 5° and 10°

Note: This case is a roll decay with zero forward speed, but the same Reynolds number as the following cases (Cases 1.0 through 1.2) is used.

t: dimensional time in model scale [s]

$R_e$ : Reynolds number, the Reynolds number when ship runs in calm water with constant propeller revolutions.

$F_r$ : Froude number, the Froude number when ship runs in calm water with constant propeller revolutions.

$R_e$ and $F_r$ are defined by calm water approach speed $(V_A)$, and waterline length $(L_{WL})$ :

$$F_r = \frac{V_A}{\sqrt{g \cdot L_{WL}}},\ R_e = \frac{V_A \cdot L_{WL}}{\nu} \tag{2}$$

## Computational Setup

1. All calculations are to be conducted for model scale conditions.
2. All simulations results should be provided in the format described in next section.
3. The rudders and propellers should be stationary.
4. The simulation should be run until the ship has reached rolling amplitude angles smaller than 0.5°, or a minimum of 8 periods.

## General Format for Submissions

1. Time histories are based on dimensional time (t [s]) in model scale. The time histories of roll (ϕ) and roll rate (p), respectively, after the ship was released (t = 0 [s]) should be submitted. The roll angle is defined as positive for pushing starboard into the water; however, for visual comparison the port free roll decay time histories are mirrored about the x-axis.
2. Analysis of the period and damping based on these timeseries will be performed by the organizer.

*Table 5: Case 0.2 Validation Variables.*

| Validation Variable | Symbol | Unit | Note |
|---|---|---|---|
| Roll time history | $\phi$ | [deg] | |
| Roll rate time history | *p* | [deg/s] | |

## Submission Instructions

- [Identifier] should be [Institute Name]-[Solver Name]. For example, if your institute is NMRI and solver is SURFv7, identifier should be NMRI-SURFv7.
- Identifier in the Figure should be [Institute Name]/[Solver Name]. For example, if your institute is NMRI and solver is SURFv7, identifier should be NMRI/SURFv7.

*Table 6: Case 0.2 Figure Submission Instructions.*

| Table/Figure# | Items | | EFD Data | Submission Instruction | |
|---|---|---|---|---|---|
| | | | | Image files | Sample + Tecplot layout file |
| Case 0.2-1 | for $\|\phi_0\|$ = 5° | Time histories of ship motions: roll (ϕ) and roll rate (p) | New EFD data will be provided soon. | Filename:<br>ONRT_0.2-1_[Identifier]_phi.png (for $\phi$)<br>ONRT_0.2-1_[Identifier]_p.png (for $p$)<br>X-axis range:<br>$0 \le Time\ [s] \le 35$<br>Y-axis range:<br>$-15 \le \phi\ [deg] \le 15$<br>$-40 \le p\ [deg/s] \le 40$<br>Style:<br>CFD dashed line<br>EFD solid line | ./sample/ONRT_0.2/ONRT_0.2-1.lay |
| Case 0.2-2 | for $\|\phi_0\|$ = 10° | Time histories of ship motions: roll (φ) and roll rate (p) | Refer to sample file for detail. | Filename:<br>ONRT_0.2-2_[Identifier]_phi.png (for $\phi$)<br>ONRT_0.2-2_[Identifier]_p.png (for $p$)<br>X-axis range:<br>$0 \le Time\ [s] \le 35$<br>Y-axis range:<br>$-15 \le \phi\ [deg] \le 15$<br>$-40 \le p\ [deg/s] \le 40$<br>Style:<br>CFD dashed line<br>EFD solid line | ./sample/ONRT_0.2/ONRT_0.2-2.lay |

# Case 1.0

## Conditions

- Free running self-propulsion in calm water (mandatory)
- With propellers, With rudders
- With bilge keels
- $FR_{\text{all}}$
- $R_e = 3.317 \times 10^6, F_r = 0.20$ at EFD water temperature 18 °C
- $L_{WL} = 3.147$ [m], approach speed in calm water $V_A = 1.11$ [m/s]
- Target Yaw angle: $\psi_C = 0°$
- Rudder angle and propeller revolutions should be controlled as explained in the following Computational Setup.

$R_e$ : Reynolds number, the Reynolds number when ship runs in calm water with constant propeller revolutions.

$F_r$ : Froude number, the Froude number when ship runs in calm water with constant propeller revolutions.

Time is non-dimensionalized such that t* = (t-t$_{\text{end}}$) * V$_A$ / L$_{WL}$ with t$_{\text{end}}$ defined as specified below in General Format for Submissions.

## Computational Setup

1. All calculations are to be conducted for model scale conditions.
2. All simulations results should be provided in the format described in next section.
3. The simulation should be run until a constant rate of revolution $n$ is reached at model speed corresponding to Fr = 0.20.
4. To match the experiment, the rudders should be controlled by following autopilot:

$$\delta(t) = K_P(\psi_C - \psi(t)) \tag{3}$$

where $\delta(t)$ is rudder angle, proportional gain $K_P$ is $1.0, \psi_C$ is the target yaw angle and $\psi(t)$ is yaw angle. The maximum rudder rate should be assigned to $35.0$[deg/s].

## General Format for Submissions:

1. The trajectory $\left(\frac{X-X_{\text{end}}}{L_{WL}}, \frac{Y-Y_{\text{end}}}{L_{WL}}\right)$ and time histories of heave $(\frac{Z}{L_{WL}})$, angular motions $(\phi, \theta, \psi - \psi_C)$, velocities for 6DOF motions $(u, v, w, p, q, r)$, rudder angle $(\delta)$, nondimensional rudder normal and tangential force $(F_N{}', F_T{}')$ for each rudder, thrust coefficient $(K_T)$, torque coefficient $(K_Q)$, and shaft side force coefficient $(K_Y)$, for each propeller, and propeller rate of revolution $(n)$ [rps] should be submitted.
2. The ship position or trajectory should be given in an Earth-fixed coordinate system with $X$ pointing North, $Y$ pointing East, and $Z$ pointing downward as shown in Figure 1. Heave motion (Z) should be 0 with the ship at rest. The ship position is $(X_{\text{end}}, Y_{\text{end}})$ when $t^* = t_{end}$. The roll angle $(\phi)$ is positive for pushing starboard into the water, pitch $(\theta)$ is positive for bow up position and yaw angle $(\psi)$ is positive for bow turned to starboard. The reported trajectory should be normalized by $L_{WL}$ and angular motions should be reported in degrees. The reported yaw angle should be the deviation of yaw angle respect to the target yaw i.e. $\psi - \psi_C$.

3. All velocities for 6DOF motions $(u, v, w, p, q, r)$ should be reported in ship-fixed coordinate system with $x$ axis positive toward bow, $y$ axis positive toward starboard and $z$ axis positive downward. The reported velocities should be non-dimensionalized based on calm water approach speed as:

$$\begin{pmatrix} u \\ v \\ w \end{pmatrix} = \frac{1}{V_A}\begin{pmatrix} \dot{x} \\ \dot{y} \\ \dot{w} \end{pmatrix} \tag{4}$$

4. Rudder angle $(\delta)$ is positive when trailing edge moves to starboard.

5. The propeller thrust $T$ and torque $Q$ for each propeller should be reported in shaft coordinate system with $x$ axis positive toward the engine. The sign of Q is defined as positive for the port side and negative for the starboard side, respectively. The propeller shaft side force $Y_P$ should be reported in the ship fixed coordinate system. Values should be normalized by the density of water $\rho$, propeller diameter $(D_P)$, and $n$ as follows.

$$K_T = \frac{T}{\rho n^2 {D_P}^4},\ K_Q = \frac{Q}{\rho n^2 D_P^5}, K_Y = \frac{Y_P}{\rho n^2 {D_P}^4} \tag{5}$$

6. Rudder normal force $(F_T)$ and tangential force $(F_N)$ should be normalized by r, rudder area $(A_R)$ and $V_A$. See Figure 2 for definitions of positive directions.

$${F_T}' = \frac{F_T}{\frac{1}{2}\rho A_R {V_A}^2}, \qquad {F_N}' = \frac{F_N}{\frac{1}{2}\rho A_R {V_A}^2} \tag{6}$$

7. All motions should be reported **<u>at the centre of gravity</u>**.

*Table 7: Case 1.0 Validation Variables*

| Validation Variable | Symbol | Unit | Note |
|---|---|---|---|
| Trajectory | $\frac{X-X_{\mathrm{end}}}{L_{WL}}, \frac{Y-Y_{\mathrm{end}}}{L_{WL}}$ | [-] | |
| Heave time history | $\frac{Z}{L_{WL}}$ | [-] | |
| Angular motion time histories | $\phi, \theta, \psi - \psi_C$ | [deg] | |
| 6DOF motion velocity time histories | *u, v, w, p, q, r* | [-], [deg/s] | Surge, sway, and heave velocities normalized by nominal approach speed. |
| Rudder angle | δ | [deg] | |
| Time histories of nondimensional rudder normal and tangential forces (for each rudder) | $F_N{}', F_T{}'$ | [-] | $F_T{}' = \frac{F_T}{\frac{1}{2}\rho A_R V_A{}^2}$ $F_N{}' = \frac{F_N}{\frac{1}{2}\rho A_R V_A{}^2}$ |
| Time histories of nondimensional propeller thrust coefficient, torque coefficient, and shaft side force coefficient (for each propeller) | $K_T, K_Q, K_Y$ | [-] | $K_T = \frac{T}{\rho n^2 D_P{}^4}$ $K_Q = \frac{Q}{\rho n^2 D_P^5}$ $K_Y = \frac{Y_P}{\rho n^2 D_P{}^4}$ |
| Propeller rate of revolution | n | [rps] | |

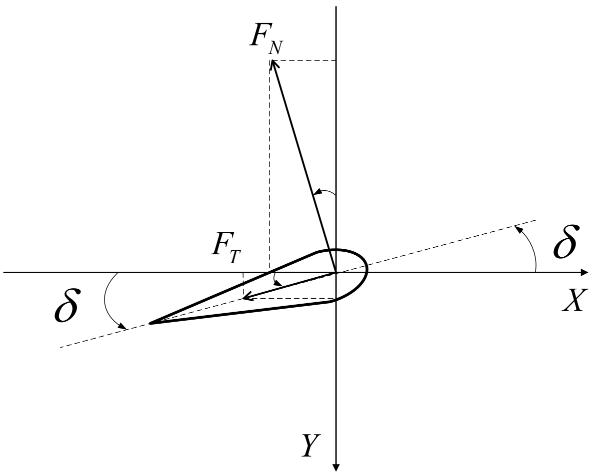


*Figure 2: Rudder coordinate system (Top view of regular ship fixed coordinate).*

## Submission Instructions

- [Identifier] should be [Institute Name]-[Solver Name]. For example, if your institute is NMRI and solver is SURFv7, identifier should be NMRI-SURFv7.
- Identifier in the Figure should be [Institute Name]/[Solver Name]. For example, if your institute is NMRI and solver is SURFv7, identifier should be NMRI/SURFv7.

*Table 8.1: Case 1.0-1 Figure Submission Instructions.*

<table>
<tr><th rowspan="2">Table/Figure#</th><th rowspan="2">Items</th><th rowspan="2">EFD Data</th><th colspan="2">Submission Instruction</th></tr>
<tr><th>Image files</th><th>Sample + Tecplot layout file</th></tr>
<tr><td>Case 1.0-1</td><td>Trajectory<br>$\left(\frac{X-X_{end}}{L_{WL}}, \frac{Y-Y_{end}}{L_{WL}}\right)$<br><br>Time histories of ship motions and rudder angle<br>$\left(\frac{Z}{L_{WL}}, \phi, \theta, \psi-\psi_C, u, v, w, p, q, r, \delta\right)$</td><td>Refer to sample file for detail</td><td>Filename:<br>ONRT_1.0-1_[Identifier]_XY.png<br>ONRT_1.0-1_[Identifier]_Z.png<br>ONRT_1.0-1_[Identifier]_phi.png<br>ONRT_1.0-1_[Identifier]_theta.png<br>ONRT_1.0-1_[Identifier]_psi.png<br>ONRT_1.0-1_[Identifier]_u.png<br>ONRT_1.0-1_[Identifier]_v.png<br>ONRT_1.0-1_[Identifier]_w.png<br>ONRT_1.0-1_[Identifier]_p.png<br>ONRT_1.0-1_[Identifier]_q.png<br>ONRT_1.0-1_[Identifier]_r.png<br>ONRT_1.0-1_[Identifier]_delta.png<br><br>X-axis range:<br>$-15 \leq \frac{X-X_{end}}{L_{WL}} \leq 1$<br>(for trajectory)<br>$-15 \leq \frac{(t-t_{end}) \cdot V_A}{L_{WL}} \leq 1$<br>(for time histories)<br>Y-axis range:<br>$-1 \leq \frac{Y-Y_{end}}{L_{WL}} \leq 1$<br>(for trajectory)<br>$-0.005 \leq \frac{Z}{L_{WL}} \leq 0.005$<br>$-2 \leq \phi \leq 2$<br>$-2 \leq \theta \leq 2$<br>$-2 \leq \psi - \psi_c \leq 2$<br>$-0.25 \leq u \leq 0.25$<br>$-0.05 \leq v \leq 0.05$<br>$-0.05 \leq w \leq 0.05$<br>$-1 \leq p \leq 1$<br>$-1 \leq q \leq 1$<br>$-1 \leq r \leq 1$<br>$-1 \leq \delta \leq 1$<br><br>Style:<br>CFD solid line<br>EFD open circles</td><td>./sample/ONRT_1.0/ONRT_1.0-1_XYZ-uvw-delta.lay<br><br>./sample/ONRT_1.0/ONRT_1.0-1_RPY-pqr.lay</td></tr>
</table>

*Table 8.2. Case 1.0-2 and 1.0-3 Figure Submission Instructions*

<table>
<tr><td rowspan="2">Table/Figure#</td><td rowspan="2">Items</td><td rowspan="2">EFD Data</td><td colspan="2">Submission Instruction</td></tr>
<tr><td>Image</td><td>Sample + Tecplot layout file</td></tr>
<tr><td>Case 1.0-2</td><td>Time histories of propulsion coefficients and propeller revolutions<br>$(K_T, K_Q, n)$</td><td>Refer to sample file for detail</td><td>Filename:<br>ONRT_1.0-2_[Identifier]_KT.png<br>ONRT_1.0-2_[Identifier]_KQ.png<br>ONRT_1.0-2_[Identifier]_n.png<br><br>X-axis range:<br>$$-15 \le \frac{(t - t_{end}) \cdot V_A}{L_{WL}} \le 1$$<br>Y-axis range:<br>$$0 \le K_T \le 6$$<br>$$-0.2 \le K_Q \le 0.2$$<br>$$8 \le n \le 10$$<br><br>Style:<br>CFD<br>Port side solid line<br>Starboard side dashed line<br>EFD<br>Port side open circles<br>Starboard side open triangles</td><td>./sample/ONRT_1.0/ONRT_1.0-2_KT-KQ-n</td></tr>
<tr><td>Case 1.0-3</td><td>Time histories of propeller shaft side forces and rudder tangential and normal forces<br>$(K_Y, F_T{}', F_N{}')$</td><td>New EFD data will be provided soon.</td><td>Will be updated once new CFD data is provided.</td><td></td></tr>
</table>

# Case 1.1

## Conditions

- Free running at model point in head waves (mandatory)
- With propeller, With rudder
- With bilge keels
- $FR_{\text{all}}$
- $R_e = 3.317 \times 10^6, F_r = 0.20$ at EFD water temperature 18 °C
- $L_{WL} = 3.147$ [m], approach speed in calm water $V_A = 1.11$ [m/s]
- Target Yaw angle: $\psi_C = 0°$
- Rudder angle and propeller revolutions should be controlled as explained in the following Computational Setup.
- Design wave condition: $\frac{\lambda}{L_{WL}} = 1.0, \frac{H}{\lambda} = 0.02$

$R_e$ : Reynolds number, the Reynolds number when ship runs in calm water with constant propeller revolutions.

$F_r$ : Froude number, the Froude number when ship runs in calm water with constant propeller revolutions.

$\lambda$ : wavelength [m]

$f_w$: wave frequency $f_w = \sqrt{\frac{g}{2pl}}$ = 0.70 [Hz]

$H$ : wave height [m]

$\zeta_a$: wave amplitude, $\zeta_a = \frac{H}{2}$ [m]

$k$: wave number, $k = \frac{2\pi}{\lambda}$

All quantities are non-dimensionalized by calm water approach speed $(V_A)$, and waterline length $(L_{WL})$ as in Case 1.0.

Time is non-dimensionalized such that $t^* = (t-t_0) * V_A / L_{WL}$ with $t_0$ defined as specified below in General Format for Submissions.

## Computational Setup

1. All calculations are to be conducted for model scale conditions.
2. All simulations results should be provided in the format described in next section.
3. Constant propeller rate of revolution $n$ should be applied throughout the simulation. $n$ should correspond to the self propulsion point of the model for $V_A$=1.11m/s in calm water (see Case 1.0) (Note that measured value of $n$ in EFD is 8.97 [rps]).
4. The rudder should be controlled by the same autopilot as in Case 1.0.
5. The wave elevation $(\zeta_w/L_{WL})$, which is positive upward, should be reported at 0.031776$L_{WL}$ (100[mm] in model scale) right from FP at rest.

6. Data acquisition (t* = 0) should begin with the ship located initially at the target yaw angle $\psi_C$, propeller revolution constant and corresponding to the self-propulsion point, and ship speed at the sustained speed in waves. The wave crest should be located at the wave elevation measurement point. The simulation will be continued until the number of encountered waves reaches at least ten.

## General Format for Submissions

1. The trajectory $\left(\frac{X-X_0}{L_{WL}}, \frac{Y-Y_0}{L_{WL}}\right)$ and time histories of heave $(\frac{Z}{\zeta_a})$, angular motions $\left(\frac{\phi}{k\zeta_a}, \frac{\theta}{k\zeta_a}, \frac{\psi-\psi_C}{k\zeta_a}\right)$, velocities for 6DOF motions $(u, v, w, p, q, r)$, rudder angle $(\delta)$, nondimensional rudder normal and tangential force $(F_N{}', F_T{}')$

for each rudder, thrust coefficient $(K_T)$, torque coefficient $(K_Q)$, and shaft side force coefficient $(K_Y)$, for each propeller, propeller rate of revolution $(n)$ [rps], and wave elevation $(\frac{\zeta_w}{L_{WL}}$, at the location described above in computational setup 5) after the ship was released $(t^* = 0)$, should be submitted.

2. The ship position or trajectory should be given in the same Earth-fixed coordinate system as Case 1.0.

3. All velocities for 6DOF motions $(u, v, w, p, q, r)$ should be reported in ship-fixed coordinate system with $x$ axis positive toward bow, $y$ axis positive toward starboard and $z$ axis positive downward. The reported u, v, and w velocities should be non-dimensionalized based on calm water approach speed as in Case 1.0. The p, q, and r velocities should be non-dimensionalized as:

$$\begin{pmatrix} p \\ q \\ r \end{pmatrix} = \frac{1}{\omega_e k \zeta_a} \begin{pmatrix} \dot{\phi} \\ \dot{\theta} \\ \dot{\psi} \end{pmatrix} \quad (7)$$

where $\omega_e$ is circular wave frequency of encounter defined as $\omega_e = \sqrt{kg} + kV_A$. In Equation (7), the unit of $\dot{\phi}, \dot{\theta}$ and $\dot{\psi}$ is $[\mathrm{rad/s}]$.

4. The rudder angle, propeller thrust, propeller torque, propeller shaft side force, rudder normal force, and rudder tangential force should be normalized and reported in the same manner as in Case 1.0.

5. All motions should be reported **<u>at the centre of gravity</u>**. The wave elevation $(\zeta_w/L_{WL})$, which is positive upward, should be reported at $0.031776L_{WL}$ (100[mm]in model scale) right from FP at rest. Note that the sign is different from that of the Earth and ship-fixed coordinate systems shown in Figure 1, only for waves. (The sign is positive when the wave is a crest and negative when it is a trough.)

6. The time traces for simulations should be shifted such that the state at the initial time shows the ship at the sustained speed in waves, and the wave crest located at the wave elevation measurement point.

*Table 9: Case 1.1 and 1.2 Validation Variables*

| Validation Variable | Symbol | Unit | Note |
|---|---|---|---|
| Trajectory | $\frac{X-X_0}{L_{WL}}, \frac{Y-Y_0}{L_{WL}}$ | [-] | |
| Heave time history | $\frac{Z}{\zeta_a}$ | [-] | |
| Angular motion time histories | $\frac{\phi}{k\zeta_a}, \frac{\theta}{k\zeta_a}, \frac{\psi-\psi_C}{k\zeta_a}$ | [deg] | |
| 6DOF motion velocity time histories | *u, v, w* | [-] | Surge, sway, and heave velocities normalized by nominal approach speed. |
| | *p, q, r* | [-] | Roll, pitch, and yaw velocities normalized by $\omega_e k\zeta_a$. |
| Rudder angle time history | δ | [deg] | |
| Wave elevation time history | $\frac{\zeta_W}{L_{WL}}$ | [-] | |
| Time histories of nondimensional rudder normal and tangential forces (for each rudder) | $F_N{}', F_T{}'$ | [-] | $F_T{}' = \frac{F_T}{\frac{1}{2}\rho A_R V_A{}^2}$ $F_N{}' = \frac{F_N}{\frac{1}{2}\rho A_R V_A{}^2}$ |
| Time histories of nondimensional propeller thrust coefficient, torque coefficient, and shaft side force coefficient (for each propeller) | $K_T, K_Q, K_Y$ | [-] | $K_T = \frac{T}{\rho n^2 D_P{}^4}$ $K_Q = \frac{Q}{\rho n^2 D_P^5}$ $K_Y = \frac{Y_P}{\rho n^2 D_P{}^4}$ |
| Time history of propeller rate of revolution | n | [rps] | |

## Submission Instructions

- [Identifier] should be [Institute Name]-[Solver Name]. For example, if your institute is NMRI and solver is SURFv7, identifier should be NMRI-SURFv7.
- Identifier in the Figure should be [Institute Name]/[Solver Name]. For example, if your institute is NMRI and solver is SURFv7, identifier should be NMRI/SURFv7.

*Table 10.1: Case 1.1-1 Figure Submission Instructions.*

| Table/Figure# | Items | EFD Data | Submission Instruction | |
|---|---|---|---|---|
| | | | Image files | Sample +<br>Tecplot layout<br>file |
| Case 1.1-1 | Trajectory<br>$\left(\frac{X-X_0}{L_{WL}}, \frac{Y-Y_0}{L_{WL}}\right)$<br><br>Time histories of ship motions, rudder angle, and wave elevation<br>$\left(\frac{Z}{\zeta_a}, \frac{\phi}{k\zeta_a}, \frac{\theta}{k\zeta_a}, \frac{\psi-\psi_C}{k\zeta_a}, u, v, w, p, q, r, \delta, \frac{\zeta_w}{L_{WL}}\right)$ | Refer to sample file for detail | Filename:<br>ONRT_1.1-1_[Identifier]_XY.png<br>ONRT_1.1-1_[Identifier]_Z.png<br>ONRT_1.1-1_[Identifier]_phi.png<br>ONRT_1.1-1_[Identifier]_theta.png<br>ONRT_1.1-1_[Identifier]_psi.png<br>ONRT_1.1-1_[Identifier]_u.png<br>ONRT_1.1-1_[Identifier]_v.png<br>ONRT_1.1-1_[Identifier]_w.png<br>ONRT_1.1-1_[Identifier]_p.png<br>ONRT_1.1-1_[Identifier]_q.png<br>ONRT_1.1-1_[Identifier]_r.png<br>ONRT_1.1-1_[Identifier]_delta.png<br>ONRT_1.1-1_[Identifier]_zeta.png<br><br>X-axis range:<br>$0 \le \frac{X-X_0}{L_{WL}} \le 10$<br>(for trajectory)<br>$0 \le \frac{(t-t_0)\cdot V_A}{L_{WL}} \le 14$<br>(for time histories)<br>Y-axis range:<br>$-5 \le \frac{Y-Y_0}{L_{WL}} \le 5$<br>(for trajectory)<br>$-1.5 \le \frac{Z}{\zeta_a} \le 1.5$<br>$-0.4 \le \frac{\phi}{k\zeta_a} \le 0.4$<br>$-1 \le \frac{\theta}{k\zeta_a} \le 1$<br>$-0.5 \le \frac{\psi-\psi_C}{k\zeta_a} \le 0.5$<br>$0.7 \le u \le 1.1$<br>$-0.05 \le v \le 0.05$<br>$-0.15 \le w \le 0.15$<br>$-0.08 \le p \le 0.08$<br>$-1 \le q \le 1$<br>$-0.25 \le r \le 0.25$<br>$-2 \le \delta \le 2$<br>$-0.25 \le \frac{\zeta_w}{L_{WL}} \le 0.25$<br>Style:<br>CFD solid line<br>EFD open circles | ./sample/ONRT_1.1/ONRT_1.1-1_XYZ-uvw-delta-zeta.lay<br><br>./sample/ONRT_1.1/1.1-1_RPY-pqr.lay |

*Table 10.2: Case 1.1-2 and 1.1-3 Figure Submission Instructions.*

<table>
<tr><th rowspan="2">Table/Figure#</th><th rowspan="2">Items</th><th rowspan="2">EFD Data</th><th colspan="2">Submission Instruction</th></tr>
<tr><th>Image files</th><th>Sample +<br>Tecplot layout file</th></tr>
<tr><td>Case 1.1-2</td><td>Time histories of propulsion coefficients and propeller revolutions<br>$(K_T, K_Q, n)$</td><td>Refer to sample file for detail.</td><td>Filename:<br>ONRT_1.1-2_[Identifier]_KT.png<br>ONRT_1.1-2_[Identifier]_KQ.png<br>ONRT_1.1-2_[Identifier]_n.png<br><br>X-axis range:<br>$0 \leq \frac{(t-t_0)\cdot V_A}{L_{WL}} \leq 14$<br><br>Y-axis range:<br>$0 \leq K_T \leq 0.6$<br>$-0.2 \leq K_Q \leq 0.2$<br>$8 \leq n \leq 10$<br><br>Style:<br>CFD<br>Port side solid line<br>Starboard side dashed line<br>EFD<br>Port side open circles<br>Starboard side open triangles</td><td>./sample/ONRT_1.1/ONRT_1.1-2_KT-KQ-n.lay</td></tr>
<tr><td>Case 1.1-3</td><td>Time histories of propeller shaft side forces and rudder tangential and normal forces</td><td>New EFD data will be provided soon.</td><td>Will be updated once new CFD data is provided.</td><td></td></tr>
</table>

# Case 1.2

## Conditions

- Free running at model point 135° following waves.
- With propeller, With rudder
- With bilge keels
- $FR_{\text{all}}$
- $R_e = 3.317 \times 10^6, F_r = 0.20$ at EFD water temperature 18 °C
- $L_{WL} = 3.147$ [m], approach speed $V_A = 1.11$ [m/s]
- Target Yaw angle: $\psi_C = -135°$ (from starboard side)
- Rudder angle and propeller revolutions should be controlled as explained in the following Computational Setup.
- Design wave condition: $\frac{\lambda}{L_{WL}} = 1.0, \frac{H}{\lambda} = 0.02$
- $R_e$ : Reynolds number, the Reynolds number when ship runs in calm water with constant propeller revolutions.
- $F_r$ : Froude number, the Froude number when ship runs in calm water with constant propeller revolutions.
- $\lambda$ : wavelength
- $f_w$: wave frequency $f_w = \sqrt{\frac{g}{2pl}}$ = 0.70 [Hz]
- $H$ : wave height
- $\zeta_a$: wave amplitude, $\zeta_a = \frac{H}{2}$
- $k$: wave number, $k = \frac{2\pi}{\lambda}$

All quantities are non-dimensionalized by calm water approach speed ($V_A$), and waterline length ($L_{WL}$) as in Case 1.0.

## Computational Setup

Same as Case 1.1.

## General Format for Submissions

Same as Case 1.1.

## Submission Instructions

- [Identifier] should be [Institute Name]-[Solver Name]. For example, if your institute is NMRI and solver is SURFv7, identifier should be NMRI-SURFv7.
- Identifier in the Figure should be [Institute Name]/[Solver Name]. For example, if your institute is NMRI and solver is SURFv7, identifier should be NMRI/SURFv7.

*Table 11.1: Case 1.2-1 Figure Submission Instructions.*

<table>
<tr><td rowspan="2">Table/Figure#</td><td rowspan="2">Items</td><td rowspan="2">EFD Data</td><td colspan="2">Submission Instruction</td></tr>
<tr><td>Image files</td><td>Sample +<br>Tecplot layout file</td></tr>
<tr><td>Case 1.2-1</td><td>Trajectory<br>$\left(\frac{X-X_0}{L_{WL}},\frac{Y-Y_0}{L_{WL}}\right)$<br><br>Time histories of ship motions, rudder angle, and wave elevation<br>$\left(\frac{Z}{\zeta_a},\frac{\phi}{k\zeta_a},\frac{\theta}{k\zeta_a},\frac{\psi-\psi_C}{k\zeta_a},\ u,v,w,p,q,r,\delta,\frac{\zeta_w}{L_{WL}}\right)$</td><td>Refer to sample file for detail</td><td>Filename:<br>ONRT_1.2-1_[Identifier]_XY.png<br>ONRT_1.2-1_[Identifier]_Z.png<br>ONRT_1.2-1_[Identifier]_phi.png<br>ONRT_1.2-1_[Identifier]_theta.png<br>ONRT_1.2-1_[Identifier]_psi.png<br>ONRT_1.2-1_[Identifier]_u.png<br>ONRT_1.2-1_[Identifier]_v.png<br>ONRT_1.2-1_[Identifier]_w.png<br>ONRT_1.2-1_[Identifier]_p.png<br>ONRT_1.2-1_[Identifier]_q.png<br>ONRT_1.2-1_[Identifier]_r.png<br>ONRT_1.2-1_[Identifier]_delta.png<br>ONRT_1.2-1_[Identifier]_zeta.png<br><br>X-axis range:<br>$-6\le\frac{X-X_0}{L_{WL}}\le 4$<br>(for trajectory)<br>$0\le\frac{(t-t_0)\cdot V_A}{L_{WL}}\le 6$<br>(for time histories)<br><br>Y-axis range:<br>$-6\le\frac{Y-Y_0}{L_{WL}}\le 4$<br>(for trajectory)<br>$-1\le\frac{Z}{\zeta_a}\le 1$<br>$-5\le\frac{\phi}{k\zeta_a}\le 5$<br>$-0.8\le\frac{\theta}{k\zeta_a}\le 0.8$<br>$-1.6\le\frac{\psi-\psi_C}{k\zeta_a}\le 1.6$<br>$0.7\le u\le 1.2$<br>$-0.12\le v\le 0.12$<br>$-0.15\le w\le 0.15$<br>$-5\le p\le 5$<br>$-1\le q\le 1$<br>$-0.8\le r\le 0.8$<br>$-6\le\delta\le 4$<br>$-0.02\le\frac{\zeta_w}{L_{WL}}\le 0.02$<br>Style:<br>CFD solid line<br>EFD open circles</td><td>./sample/ONRT_1.2/ONRT_1.2-1_XYZ-uvw-delta-zeta.lay<br><br>./sample/ONRT_1.2/ONRT_1.2-1_RPY-pqr.lay</td></tr>
</table>

*Table 11.2: Case 1.2-2 and 1.2-3 Figure Submission Instructions.*

| Table/Figure# | Items | EFD Data | Submission Instruction | |
|---|---|---|---|---|
| | | | Image Files | Sample + Tecplot layout file |
| Case 1.2-2 | Time histories of propulsion coefficients and propeller revolutions $(K_T, K_Q, n)$ | Refer to sample file for detail | Filename:<br>ONRT_1.2-2_[Identifier]_KT.png<br>ONRT_1.2-2_[Identifier]_KQ.png<br>ONRT_1.2-2_[Identifier]_n.png<br><br>X-axis range:<br>$0 \le \frac{(t-t_0)\cdot V_A}{L_{WL}} \le 6$<br><br>Y-axis range:<br>$0 \le K_T \le 0.6$<br>$-0.2 \le K_Q \le 0.2$<br>$8 \le n \le 10$<br><br>Style:<br>CFD<br>Port side solid line<br>Starboard side dashed line<br>EFD<br>Port side open circles<br>Starboard side open triangles | ./sample/ONRT_1.2/ONRT_1.2-2_KT-KQ-n.lay |
| Case 1.2-3 | Time histories of propeller shaft side forces and rudder tangential and normal forces | New EFD data will be provided soon. | Will be updated once new CFD data is provided. | |

# Document Revisions

- 2024-11-29: Initial version for the website.