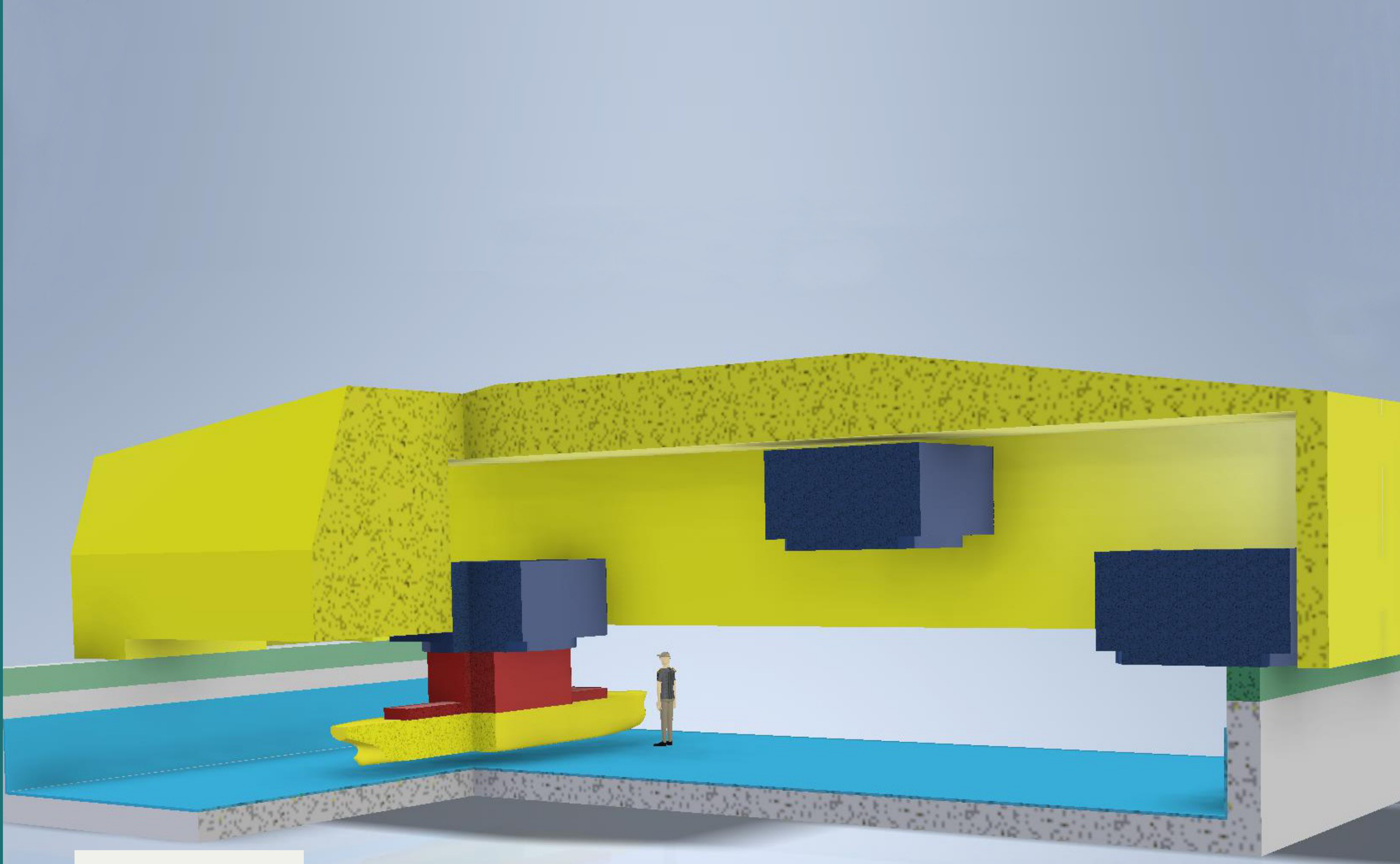

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Design Towing Carriage

Sub report 2
Site Acceptance Tests

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Design Towing Carriage

Sub report 2 – Site Acceptance Tests

Delefortrie, G.; Geerts, S.; Lataire, E.; Mostaert, F.

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Abstract

This report describes the details of the site acceptance tests for the delivery of a towing carriage at the towing tank in the Flanders Maritime Laboratory, Ostend, Belgium. Part of this report has been published in the tender for the carriage design EVFH_2019_04.

Safety > Risk Analysis > Scale Model Tests.

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1 Introduction

This report describes the tests that will be carried out on site to approve the new towing carriage. These will be performed in the following order:

1. Visual check of the (main components of the) carriage and rails
2. Verification of the functionality of the (manual) commands
3. Verification of the functionality of the safety
4. Documentation and plans, i.e.:
    a. User manual
    b. Maintenance schedule
    c. Main equipment data sheets
    d. Datasheet of spare parts
    e. Recommended spare parts list
    f. Certificate of compliance
    g. As built technical plans (electrical, hydraulic, mechanical, pneumatic,…)
    h. Calibration certificates
5. Operator training
6. Test runs:
    a. Kinematic operation
    b. Dynamic operation
    c. Realistic operation

The present report provides more details on the test runs. The kinematic operation will check the functionality of the carriage exploring the limiting positions, velocities and accelerations. The dynamic operation will check the functionality of the carriage exploring the load limits. The realistic operation will check the behaviour in normal, realistic test runs.

2 Kinematic and load design of the carriage

To set the ideas the tables mentioning the design kinematic and dynamic conditions of the carriage are mentioned here. However, the values written in the tender prevail. Heave and pitch steering are only relevant for a hexapod setup. See the tender for more information on the axis system.

Table 1 – Design kinematic conditions of the carriage during manual positioning.

DOF	Position in tank	Velocities (if steered)	Accelerations (if steered)
Surge	Between -17 m and (XTMAX[1] - 2 R_{ym}[2])	± 1.000 m/s	± 0.400 m/s²
Sway	± 9.75 m (except harbour limitations)	± 1.000 m/s	± 0.400 m/s²
Heave	Between 0.25 m and 2.25 m above tank bottom	± 0.100 m/s	± 0.050 m/s
Roll	± 20°	± 5°/s	± 1°/s²
Pitch	± 6°	± 5°/s	± 1°/s²
Yaw	Between -365° and +365° (except harbour limitations)	± 5°/s	± 1°/s²

Table 2 – Design kinematic conditions of the carriage during test execution.

DOF	Position in tank	Velocities (if steered)	Accelerations (if steered)
Surge	Between (XTMIN + 2 R_{ym}) and (XTMAX - 2 R_{ym})	± 3.000 m/s	± 0.400 m/s²
Sway	± 9.75 m	± 1.300 m/s	± 0.700 m/s²
Heave	± 0.20 m	± 0.700 m/s	± 0.700 m/s²
Roll	± 20°	± 16°/s	± 32°/s²
Pitch	± 6°	± 16°/s	± 16°/s²
Yaw	Between -365° and +365°	± 16°/s	± 8°/s²

The slip errors should be below:

- SLPX = 0.01 m for the longitudinal carriage;
- SLPY = 0.005 m for the lateral carriage;
- SLPPSI = 0.100° for the yaw mechanism;

[1] Physical tank boundary (wall)
[2] Yaw shaft radius

Table 3 – Kinematic accuracy during tests.

DOF	Resolution	Position accuracy	Velocity accuracy (if steered)	Acceleration accuracy (if steered)
Surge	0.1 mm	1.5 mm	The maximum of 0.5 mm/s and 0.50%	0.5 N error: [3] 0.025 mm/s²
Sway	0.1 mm	1.3 mm Position accuracy when performing a harmonic sway motion: 0.70% of the motion amplitude, but never larger than 10 mm.	The maximum of 0.5 mm/s and 0.50%	0.5 N error: 0.025 mm/s²
Heave	0.05 mm	0.15 mm	The maximum of 0.5 mm/s and 0.50%	2.5 N error: 0.050 mm/s²
Roll	0.01°	0.03° Position accuracy when performing a harmonic roll motion: 0.70% of the motion amplitude	The maximum of 0.08 °/s and 3.00%	0.1 Nm error: 0.08°/s²
Pitch	0.01°	0.03° Position accuracy when performing a harmonic pitch motion: 0.70% of the motion amplitude	The maximum of 0.08 °/s and 3.00%	0.5 Nm error: 0.03°/s²
Yaw	0.01°	0.03° Position accuracy when performing a harmonic yaw motion: 0.70% of the motion amplitude	The maximum of 0.08 °/s and 3.00%	0.5 Nm error: 0.03°/s²

[3] Acceptable errors on a ship model with a displacement of 1 ton.

Table 4 – Design loads.

<table>
<tr><th rowspan="2">DOF</th><th colspan="2">Maximal load on ship model
(Range of dynamometers)</th><th colspan="2">Maximal load on carriage</th></tr>
<tr><th>Captive mode</th><th>Free running mode</th><th>Captive mode</th><th>Free running mode</th></tr>
<tr><td>Surge</td><td>1.0 kN</td><td rowspan="6">p.m.</td><td>6.4 kN</td><td rowspan="6">p.m.</td></tr>
<tr><td>Sway</td><td>1.0 kN</td><td>8.0 kN</td></tr>
<tr><td>Heave</td><td>10.0 kN</td><td>≥10.0 kN[(4)]</td></tr>
<tr><td>Roll</td><td>1.0 kNm</td><td>2.0 kNm</td></tr>
<tr><td>Pitch</td><td>8.0 kNm</td><td>≥8.0 kNm</td></tr>
<tr><td>Yaw</td><td>8.0 kNm</td><td>16.0 kNm</td></tr>
</table>

[4] A safety factor has to be agreed for ≤. The maximal weight of a ship model is for instance 65 kN. This load will apply when the towing tank is emptied involuntary. In such case a safety mechanism must be implemented, in this example the ship model could be lowered.

3 Design vessels

3.1 Overview

The dynamic and realistic tests will be carried out with two public domain vessels, which are widely used in manoeuvring and towing tanks over the world, namely the KVLCC2[5] and the KCS[6]. The forces acting on these vessels while manoeuvring are sufficiently known. FHR will have the ship models ready as described in the following paragraphs.

3.2 KVLCC2

The dynamic load of the carriage will be checked with a 1/40 scale model of the KVLCC2 (T80).

Table 5 – Ship data of T80 at design draft (even keel)

KVLCC2 (T80) – single propeller – single rudder			
L_{OA} (m)	8.125	#propeller blades	4
L_{PP} (m)	8.000	D_P (m)	0.2465
B (m)	1.450	P/D (-)	0.721
T (m)	0.520	AEP (-)	0.431
C_B (-)	0.810	A_R (m²)	0.0698
m (kg)	4890	Model scale	1:40
$\overline{KM}_T$ (m)	0.6073	$\overline{KM}_L$ (m)	9.9625

The ship model will be ballasted at full draft, with the following expected inertia, referred to the ship bound axis system (origin amidships on the water plane):

$$\overline{\boldsymbol{x}}_{\boldsymbol{G}} = \begin{bmatrix} 0.280 \pm 0.008 \\ 0 \\ \pm 0.01 \end{bmatrix} m;$$

$$\bar{\boldsymbol{I}} = \begin{bmatrix} 1000 \pm 250 & 0 & minimized \\ 0 & 19000 \pm 500 & 0 \\ minimized & 0 & 19000 \pm 500 \end{bmatrix} kgm^2$$

The water depth will be 1000 mm.

The maximum sailing speed is determined based on the blockage $m = \frac{BT}{hW} = \frac{1.45 \cdot 0.52}{1 \cdot 20} = 0.0377$. The critical Froude number is:

$$Fr_{h,crit1} = \left(2sin\left(\frac{arcsin(1-m)}{3}\right)\right)^{3/2} = 0.7657$$

The critical speed is then 2.398 m/s. The maximum test speed is 84% of that speed or 2.015 m/s. This value is rounded to **2 m/s as maximum speed for the load test**.

The ship model will be rigidly connected to the carriage (without dynamometers), but remains free to heave and pitch in the 4 DOF setup.

[5] http://www.simman2019.kr/contents/KVLCC2.php
[6] http://www.simman2019.kr/contents/KCS.php

3.3 KCS

The realistic operation of the carriage will be checked with a 1/29 scale model of the KCS (C80).

Table 6 – Ship data of C80 at design draft (even keel)

KCS (C80) – single propeller – single rudder			
L_{OA} (m)	8.017	#propeller blades	4
L_{PP} (m)	7.931	D_P (m)	0.2724
B (m)	1.110	$^P/_D$ (-)	1.000
T (m)	0.3724	AEP (-)	0.700
C_B (-)	0.651	A_R (m²)	0.0646
m (kg)	2134	Model scale	1:29
$\overline{KM}_T$ (m)	0.5154	$\overline{KM}_L$ (m)	13.333

The ship model will be ballasted at full draft, with the following expected inertia, referred to the ship bound axis system (origin amidships on the water plane):

$$\overline{\boldsymbol{x}}_{\boldsymbol{G}} = \begin{bmatrix} -0.118 \pm 0.008 \\ 0 \\ -0.05 \pm 0.01 \end{bmatrix} m;$$

$$\overline{\boldsymbol{I}} = \begin{bmatrix} 300 \pm 50 & 0 & \text{minimized} \\ 0 & 8400 \pm 250 & 0 \\ \text{minimized} & 0 & 8400 \pm 250 \end{bmatrix} kgm^2$$

The water depth will be 986.9 mm (165% ukc).

The maximum sailing speed is determined based on the blockage $m = \frac{BT}{hW} = \frac{1.11 \cdot 0.3724}{0.9869 \cdot 20} = 0.0209$. The critical Froude number is:

$$Fr_{h,crit1} = \left(2\sin\left(\frac{\arcsin(1-m)}{3}\right)\right)^{3/2} = 0.8247$$

The critical speed is then 2.5829 m/s. The maximum test speed is 84% of that speed or 2.1696 m/s. During the realistic test program the maximum speed will be 1.624 m/s (75% of the critical speed).

The ship model will be connected to the carriage with dynamometers and remains free to heave and pitch in the 4 DOF setup.

4 Kinematic acceptance

The kinematic acceptance is performed without ship model attached to the carriage and in a dry tank.

4.1 Positioning

In manual mode the carriage elements will be subsequently and independently positioned to their maximal values mentioned in Table 1.

4.2 Operation

The tests described in the following paragraph will be carried out and the results will be checked with Table 3.

4.2.1 Longitudinal carriage

Only the longitudinal carriage is moved, the lateral carriage, yawing and rolling tables are positioned at their origin. The acceleration a to steady speed u is performed during a time T as follows ($t: 0 \rightarrow T$):

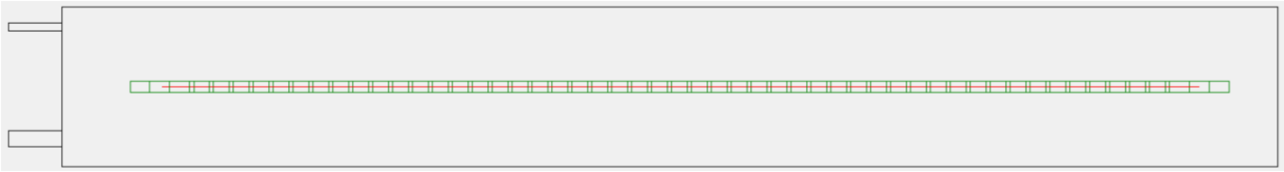
$$a(t) = \frac{6ut}{T^3}[T - t]$$

The acceleration (= deceleration) distance is $d = \frac{uT}{2}$. The five tests mentioned in Table 7 will be performed starting at one of the mentioned positions.

Table 7 – Kinematic test runs for the longitudinal carriage

Test run	u (m/s)	d (m)	Steering interval (ms)	Steady distance (m)	Start position (m)
K_C001	0.05	0.0375	250	130	0 OR 134
K_C101	0.25	0.1250	125	130	0 OR 134
K_C501	0.75	1.0594	25	130	0 OR 134
K_CA01	1.50	4.2188	25	125	0 OR 134
K_CB01	3.00	16.8750	25	100	0 OR 134

Figure 1 – Kinematic test runs for the longitudinal carriage: trajectory sketch



4.2.2 Lateral carriage

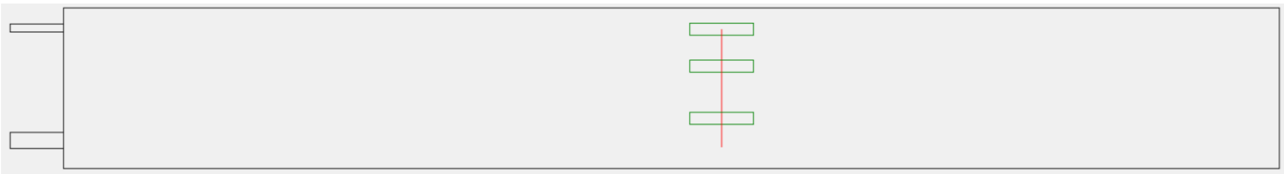
Only the lateral carriage is moved. The longitudinal carriage is positioned at 70 m, the yawing and rolling tables are positioned at their origin.

The two tests mentioned in Table 8 will be performed starting at one of the mentioned positions. The acceleration is performed using the same methodology as for the longitudinal carriage, but this time the acceleration times are given.

Table 8 – Kinematic test runs for the lateral carriage

Test run	v (m/s)	T (s)	Steering interval (ms)	Steady time (s)	Start position (m)
K_M001	0.65	1.400	25	25	-8.58 OR +8.58
K_M101	1.30	2.800	25	8.5	-7.345 OR +7.345

Figure 2 – Kinematic test runs for the lateral carriage: trajectory sketch



4.2.3 Yaw table

Only the yaw table is moved. The longitudinal carriage is positioned at 70 m, the lateral carriage and rolling table are positioned at their origin.

The five tests mentioned in Table 9 will be performed starting at one of the mentioned positions. The acceleration is performed using the same methodology as for the longitudinal and lateral carriages.

Figure 3 – Kinematic test runs for the yaw table: trajectory sketch

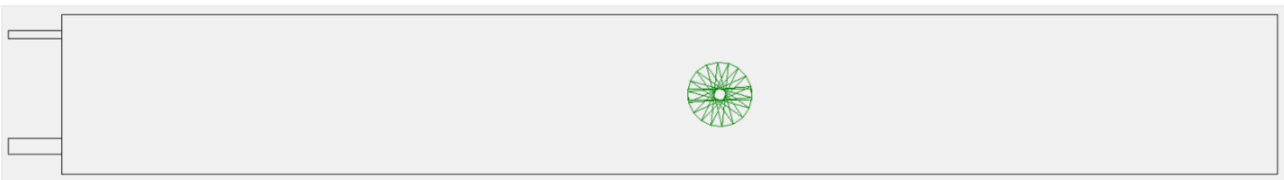


Table 9 – Kinematic test runs for the yaw table

Test run	r (°/s)	T (s)	Steering interval (ms)	Steady time (s)	Start position (°)
K_M201	0.32	0.6	100	2249	-359.84 OR +359.84
K_M301	2.18	0.425	25	329	-358.61 OR +358.61
K_M401	4.00	0.750	25	168	-337.50 OR +337.50
K_M501	8.00	1.500	25	84	-342.00 OR +342.00
K_M601	16.00	3.000	25	42	-360.00 OR +360.00

4.2.4 Roll table

Only the roll table is moved. The longitudinal carriage is positioned at 70 m, the lateral carriage and yawing table are positioned at their origin.

The test mentioned in Table 10 will be performed in one of the mentioned directions. A harmonic roll motion is imposed. The initial acceleration is performed using a similar methodology as for the other sub carriages and takes one roll period. The steady state conditions lasts for 20 s. The start angle is always 0°.

Table 10 – Kinematic test runs for the roll table

Test run	φ_A (°)	T (s)	Steering interval (ms)	Roll period (s)	Start direction (°)
K_M201	8	π	100	π	+/-

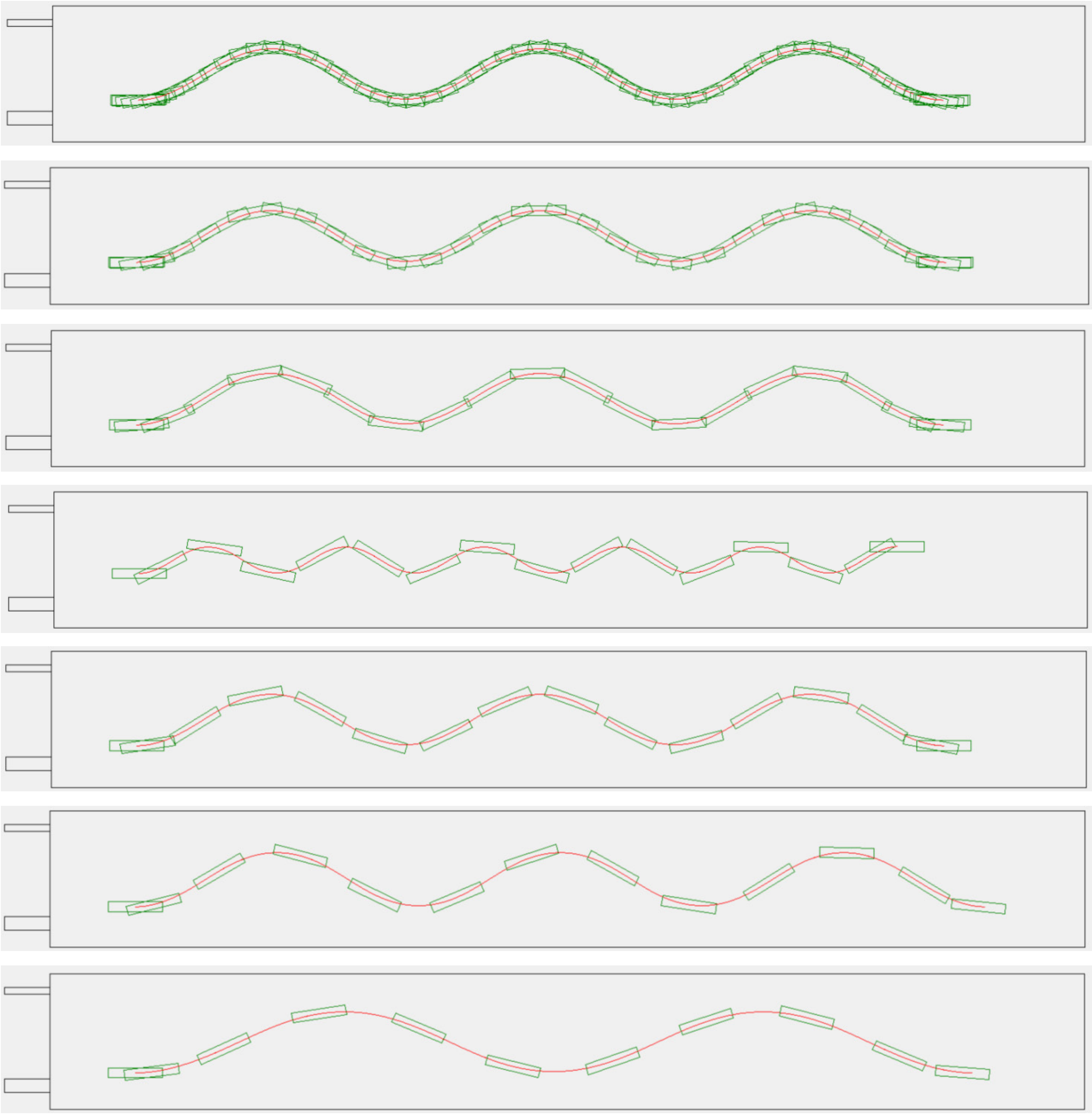
4.2.5 Combination of longitudinal carriage, lateral carriage and yaw table

These combinations are tested with the execution of harmonic yaw tests, during which the roll table is fixed at its origin. The initial acceleration and the deceleration phase take half a period of the harmonic motion. The steering interval is always 25 ms. The tests start at x = 0 m for the positive direction and x = 130 m for the negative direction. Each test of Table 11 will be carried out in one of these directions. The test velocities are expressed in the ship bound axis system (of the virtual ship).

Table 11 – Kinematic test runs for the combination of horizontal sub mechanisms

Test run	ψ_A (°)	u (m/s)	Period (s)	r_{MAX} (°/s)	$\dot{r}_{MAX}$ (°/s²)	Start direction (°)
K_G001	32	0.50	86.00	2.3	0.2	+/-
K_G101	32	1.00	43.00	4.7	0.7	+/-
K_G201	32	1.50	28.67	7.0	1.5	+/-
K_G301	32	1.75	12.57 (4π)	16.0	8.0	+/-
K_G401	32	2.00	21.50	9.4	2.7	+/-
K_G501	31	2.50	18.1	10.8	3.7	+/-
K_G601	25	3.00	21.7	7.2	2.1	+/-

Figure 4 – K_G001 – K_G006 : trajectory sketches



4.2.6 Combination of all sub mechanisms

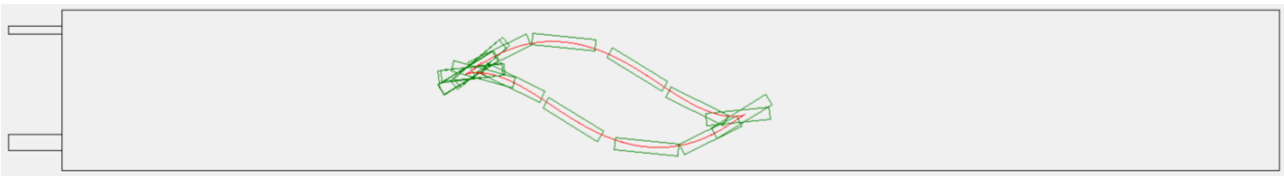
The combination of all sub mechanisms will be tested with the parameters mentioned in Table 12. This test is a combination of a harmonic longitudinal speed, harmonic roll motion and harmonic yaw motion. All are expressed in the ship bound axis system (of the virtual ship). The steering interval is 25 ms. The initial positions of the sub carriages are:

- x = 40.000 m;
- y = -3.492 m;
- φ = 0.00°;
- ψ = -40.89°.

Table 12 – Kinematic test run for the combination of all sub mechanisms

Test run	u_A (m/s)	T_u (s)	φ_u (°)	p_A (°/s)	T_p (s)	φ_p (°)	r_A (°/s)	T_r (s)	φ_r (°)
K_MV01	2.00	60	0	4	10	45	7	30	135

Figure 5 – Kinematic test run for the combination of all sub mechanisms: trajectory sketch (top view only)



5 Dynamic acceptance

All tests have to be carried out with the loaded scale model of the KVLCC2, as mentioned in 3.2. There are no dynamometers connected to the ship model. The loads are predicted bases on a manoeuvring model determined with scale model tests in the present towing tank (Delefortrie *et al.*, 2016). As these predictions are extrapolations, the predicted loads are kept significantly below the design loads.

5.1 Longitudinal carriage

During the longitudinal tests the following force acts on the ship model:

$$X = (X_{\dot{u}} - m)\dot{u} + \frac{1}{2}\rho L T u^2 X'^{(\beta=0°)}$$

For the design ship KVLCC2, the following values are used: $(X_{\dot{u}} - m)$ = -6100 kg and $\frac{1}{2}\rho L T X'^{(\beta=0°)}$ = -520 kg/m. The maximal design load is 6400 N. The test shown in Table 13 will be carried out at maximal acceleration at one of the shown start positions. The expected load is below 50% of the design load.

Table 13 – Dynamic test run for the longitudinal carriage

Test run	u (m/s)	Absolute force (N)		Start position (m)
		At maximal acceleration	At maximal speed	
T8001A01_CC01	2.00	2960	2080	0 OR 134

5.2 Lateral carriage

During the lateral tests the following main force acts on the ship model:

$$Y = (Y_{\dot{v}} - m)\dot{v} + \frac{1}{2}\rho L T v^2 Y'^{(\beta=\pm 90°)}$$

For the design ship KVLCC2, the following values are used: $(Y_{\dot{v}} - m)$ = -12500 kg and $\frac{1}{2}\rho L T Y'^{(\beta=\pm 90°)}$ = -4000 kg/m. The maximal design load is 8000 N. The applied maximal acceleration is 0.35 m/s², in this way the expected load is below 60% of the design load.

Table 14 – Dynamic test run for the lateral carriage

Test run	v (m/s)	Absolute force (N)		Start position (m)
		At maximal acceleration	At maximal speed	
T8001A01_M001	0.65	4800	1700	-8.58 OR +8.58

5.3 Yaw table

During the yaw test the following main moment acts on the ship model:

$$N = (N_{\dot{r}} - I_{zz})\dot{r} + \frac{1}{2}\rho L^2 T \left(\frac{1}{2} r L\right)^2 N'^{(\gamma=\pm 90°)}$$

For the design ship KVLCC2, the following values are used: $(N_{\dot{r}} - I_{zz})$ = -40000 kgm² and $\frac{1}{2}\rho L^2 T N'^{(\gamma=\pm 90°)}$ = -4000 kg. The maximal design load is 16000 Nm. The expected load is below 50% of the design load.

Table 15 – Dynamic test run for the yaw table

Test run	r (°/s)	Absolute moment (Nm)		Start position (°)
		At maximal acceleration	At maximal speed	
T8001A01_M601	16.00	6800	5000	-360.00 OR +360.00

5.4 Roll table

During the roll test the following main moment acts on the ship model:

$$K = \left(K_{\dot{p}} - I_{xx}\right)\dot{p} + K_p p - \Delta \overline{GM}_T \varphi$$

For the design ship KVLCC2, the following values are used: $\left(K_{\dot{p}} - I_{xx}\right)$= -1500 kgm² and$K_p$ = -160 kgm². The maximal design load is 2000 Nm. The expected load is below 50% of the design load.

Table 16 – Dynamic test run for the yaw table

Test run	φ_A (°)	Roll period (s)	Absolute moment (Nm)		Start direction (°)
			At maximal speed	At maximal acceleration	
T8001A01_M201	5	π	30	900	+/-

5.5 Combination of longitudinal carriage, lateral carriage and yaw table

Table 17 gives an overview of the two harmonic yaw tests that will be carried out.

Table 17 – Dynamic test runs for the combination of horizontal sub mechanisms

Test run	ψ_A (°)	u (m/s)	Period (s)	r_{MAX} (°/s)	$\dot{r}_{MAX}$ (°/s²)	γ_{MAX} (°)	Start direction (°)
T8001A01_G301	32	1.75	12.57 (4π)	16.0	8.0	18.1	+/-
T8001A01_G401	32	2.00	21.50	9.4	2.7	16.7	+/-

The governing forces and moments during these tests are:

$$X = \frac{1}{2}\rho L T u^2 X'^{(\beta=0°)} + \frac{1}{2}\rho L T \left[u^2 + \left(\frac{1}{2}rL\right)^2\right] X'^{(\gamma)}$$

$$Y = (Y_{\dot{r}} - m x_G)\dot{r} + \frac{1}{2}\rho L T \left[u^2 + \left(\frac{1}{2}rL\right)^2\right] Y'^{(\gamma)}$$

$$N = (N_{\dot{r}} - I_{zz})\dot{r} + \frac{1}{2}\rho L^2 T \left[u^2 + \left(\frac{1}{2}rL\right)^2\right] N'^{(\gamma)}$$

For the design ship KVLCC2, the following values are used:

- $\frac{1}{2}\rho L T X'^{(\beta=0°)}$ = -520 kg/m;
- $X'^{(\gamma)}$ = 0.006;
- $Y_{\dot{r}}$ = -0.08 mL;
- $Y'^{(\gamma)}$ = 0.03;
- $(N_{\dot{r}} - I_{zz})$ = -40000 kgm²;
- $N'^{(\gamma)}$ = 0.035.

The maximal predicted loads are (see Table 18):

- 36% of the design load for the longitudinal direction;
- 17% of the design load for the lateral direction;
- 76% of the design load for the yawing table.

Table 18 – Dynamic test runs for the combination of horizontal sub mechanisms: expected load (absolute values)

Test run	X (N)		Y (N)		N (Nm)	
	$f(u)$	$f(u,r)$	$f(\dot{r})$	$f(u,r)$	$f(\dot{r})$	$f(u,r)$
T8001A01_G301	1593	232	628	1160	5585	10820
T8001A01_G401	2080	245	212	1225	1885	1486

6 Realistic operation

All tests have to be carried out with the loaded scale model of the KCS, as mentioned in 3.2. The ship is connected with dynamometers to the carriage. Accelerations are significantly below the carriage capabilities.

6.1 Straight line tests

Four tests selected from Table 19 will be carried out. Tests at positive velocity start at x = 0 m. Tests at negative velocity start at x = 130 m. The lateral carriage is always at zero position.

Table 19 – Straight line test parameters

Test run	Longitudinal carriage velocity (m/s)	Yaw table position (°)	Roll table position (°)
C8001A01_CB10	0.1911	0	0
C8001A01_CB11	0.1911	2.5	0
C8001A01_CB12	0.1911	5	0
C8001A01_CB13	0.1911	10	0
C8001A01_CB14	0.1911	25	0
C8001A01_CB15	0.1911	40	0
C8001A01_CB16	0.1911	55	0
C8001A01_CB17	0.1911	70	0
C8001A01_CB18	0.1911	90	0
C8001A01_CBP0	0.1911	0	2.5
C8001A01_CBP1	0.1911	0	5
C8001A01_CBP2	0.1911	0	-2.5
C8001A01_CBP3	0.1911	0	-5
C8001A01_CBP4	0.1911	5	5
C8001A01_CBP5	0.1911	5	-5
C8001A01_CBP6	0.1911	-5	5
C8001A01_CBP7	0.1911	-5	-5

Test run	Longitudinal carriage velocity (m/s)	Yaw table position (°)	Roll table position (°)
C8001A01_CC00	0.3344	0	0
C8001A01_CC11	0.3344	5	0
C8001A01_CC12	0.3344	10	0
C8001A01_CC13	0.3344	-5	0
C8001A01_CC14	0.3344	-10	0
C8001A01_CE00	0.6687	0	0
C8001A01_CE11	0.6687	5	0
C8001A01_CE12	0.6687	10	0
C8001A01_CF00	0.8359	0	0
C8001A01_CFP0	0.8359	0	2.5
C8001A01_CFP1	0.8359	0	-2.5
C8001A01_CI00	1.6240	0	0
C8001A01_CY00	-0.1911	0	0
C8001A01_CYP0	-0.1911	0	2.5
C8001A01_CYP1	-0.1911	0	-2.5
C8001A01_CY23	-0.1911	10	0
C8001A01_CY26	-0.1911	25	0
C8001A01_CY29	-0.1911	-10	0
C8001A01_CY32	-0.1911	-25	0
C8001A01_CZ00	-0.4776	0	0
C8001A01_CZP0	-0.4776	0	2.5
C8001A01_CZP1	-0.4776	0	-2.5
C8001A01_CZ23	-0.4776	10	0
C8001A01_CZ26	-0.4776	25	0
C8001A01_CZ29	-0.4776	-10	0
C8001A01_CZ32	-0.4776	-25	0

6.2 Longitudinal acceleration tests

The two tests selected from Table 20 will be carried out. Tests at positive velocity start at x = 0 m. Tests at negative velocity start at x = 130 m. The lateral carriage, yaw table and roll table are always at zero position.

Table 20 – Longitudinal acceleration test parameters

Test run	Average carriage velocity (m/s)	Amplitude of carriage velocity (m)	Period of harmonic motion (s)
C8001A01_ML00	-0.1911	-0.1911	100
C8001A01_MN01	0.4776	0.4776	100

6.3 Harmonic sway tests

Four tests selected from Table 21 will be carried out. Tests at positive velocity start at x = 0 m. Tests at negative velocity start at x = 130 m. The yaw and roll table are always at zero position.

Table 21 – Harmonic sway test parameters

Test run	Longitudinal carriage velocity (m/s)	Amplitude of lateral carriage (m)	Period of harmonic motion (s)
C8001A01_FB00	0.1911	0.3	50
C8001A01_FB01	0.1911	0.3	80
C8001A01_FB02	0.1911	0.3	105
C8001A01_FB03	0.1911	0.3	130
C8001A01_FD00	0.4776	0.3	36
C8001A01_FD01	0.4776	0.3	80
C8001A01_FE00	0.6687	0.3	32
C8001A01_FY00	-0.1911	0.3	130
C8001A01_FY01	-0.1911	0.3	90

6.4 Harmonic yaw tests

Four tests selected from Table 22 will be carried out. Tests at positive velocity start at x = 0 m. Tests at negative velocity start at x = 130 m. The roll table is always at zero position. The lateral carriage is moved in such way to enable the harmonic yaw motion

Table 22 – Harmonic yaw test parameters

Test run	Longitudinal ship speed (m/s)	Average position of yaw table (°)	Amplitude of yaw table (°)	Period of harmonic motion (s)
C8001A01_GA00	0.09555	70	5	135
C8001A01_GB00	0.1911	0	15	67
C8001A01_GB01	0.1911	0	25	67
C8001A01_GB02	0.1911	0	35	67
C8001A01_GB03	0.1911	5	25	67
C8001A01_GB04	0.1911	-5	25	67
C8001A01_GB05	0.1911	10	25	67
C8001A01_GB06	0.1911	-10	25	67
C8001A01_GB07	0.1911	0	15	46
C8001A01_GB08	0.1911	0	25	46
C8001A01_GB09	0.1911	0	35	46
C8001A01_GB20	0.1911	0	10	67
C8001A01_GB21	0.1911	25	10	67
C8001A01_GB22	0.1911	-25	10	67
C8001A01_GD00	0.4776	0	5	34
C8001A01_GD01	0.4776	0	10	34
C8001A01_GD02	0.4776	0	15	34
C8001A01_GD03	0.4776	5	10	34
C8001A01_GD04	0.4776	-5	10	34
C8001A01_GD05	0.4776	10	10	34

Test run	Longitudinal ship speed (m/s)	Average position of yaw table (°)	Amplitude of yaw table (°)	Period of harmonic motion (s)
C8001A01_GD06	0.4776	-10	10	34
C8001A01_GD07	0.4776	0	5	23
C8001A01_GD08	0.4776	0	10	23
C8001A01_GD09	0.4776	0	15	23
C8001A01_GF00	0.8359	0	5	20
C8001A01_GF01	0.8359	0	10	20
C8001A01_GF02	0.8359	0	15	20
C8001A01_GF03	0.8359	5	10	20
C8001A01_GF04	0.8359	-5	10	20
C8001A01_GG00	1.1464	0	5	15
C8001A01_GG01	1.1464	0	10	15
C8001A01_GG02	1.1464	0	15	15
C8001A01_GZ00	-0.4776	0	15	46
C8001A01_GZ01	-0.4776	0	25	46
C8001A01_GZ02	-0.4776	0	35	46
C8001A01_GZ03	-0.4776	2.5	25	46
C8001A01_GZ04	-0.4776	-2.5	25	46
C8001A01_GZ05	-0.4776	5	25	46
C8001A01_GZ06	-0.4776	-5	25	46
C8001A01_GZ07	-0.4776	10	25	46
C8001A01_GZ08	-0.4776	-10	25	46
C8001A01_GZ30	-0.4776	0	5	46

6.5 Harmonic roll tests

Four tests selected from Table 23 will be carried out. Tests at positive velocity start at x = 0 m. Tests at negative velocity start at x = 130 m. Tests at zero velocity are at x = 70 m.

Table 23 – Harmonic roll test parameters

Test run	Longitudinal ship speed (m/s)	Position of yaw table (°)	Amplitude of roll table (°)	Period of harmonic motion (s)
C8001A01_MAP0	0	90	5	14
C8001A01_MAP1	0	90	5	7
C8001A01_MAP2	0	90	4	3
C8001A01_MBP0	0.1911	0	5	600
C8001A01_MBP1	0.1911	5	5	600
C8001A01_MBP2	0.1911	10	5	600
C8001A01_MBP3	0.1911	25	5	600
C8001A01_MBP4	0.1911	40	5	600
C8001A01_MBP5	0.1911	55	5	600
C8001A01_MBP6	0.1911	70	5	600
C8001A01_MBP7	0.1911	90	5	600
C8001A01_MBP8	0.1911	-5	5	600
C8001A01_MBP9	0.1911	-10	5	600
C8001A01_MBPA	0.1911	-25	5	600
C8001A01_MBPB	0.1911	-40	5	600
C8001A01_MBPC	0.1911	-55	5	600
C8001A01_MBPD	0.1911	-70	5	600
C8001A01_MBPE	0.1911	-90	5	600
C8001A01_MCP0	0.3344	0	5	14
C8001A01_MCP1	0.3344	0	5	7
C8001A01_MCP2	0.3344	0	4	3

Test run	Longitudinal ship speed (m/s)	Position of yaw table (°)	Amplitude of roll table (°)	Period of harmonic motion (s)
C8001A01_MEP0	0.6687	0	5	14
C8001A01_MEP1	0.6687	0	5	7
C8001A01_MEP2	0.6687	0	4	3
C8001A01_MGP0	1.1464	0	5	14
C8001A01_MGP1	1.1464	0	5	7
C8001A01_MGP2	1.1464	0	4	3
C8001A01_MYP0	-0.1911	0	5	14
C8001A01_MYP1	-0.1911	0	5	7
C8001A01_MYP2	-0.1911	0	4	3
C8001A01_MZP0	-0.4776	0	5	14
C8001A01_MZP1	-0.4776	0	5	7
C8001A01_MZP2	-0.4776	0	4	3

7 References

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