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Scientific research accessibility of supply ships to Port of Ostend

Towing Sub report 2 – Towing tank test campaign O40

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Scientific research accessibility of supply ships to Port of Ostend

Towing Sub report 2 – Towing tank test campaign O40

Van Zwijnsvoorde T.; Villagómez J.; Eloot K.

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Abstract

This report is a “helper report” to the project 23_074. It describes the preparation of the test program and the execution of the test program for the O40 model ship as part of the project. The report does not describe the mathematical modelling which is done in another part of 23_074 by the external contractor VTT.

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1 Introduction and content

The 23_074 project aims at building mathematical models for a selection of design vessels which are representative for manoeuvres in the port of Ostend, Belgium. As the port area is a shallow water area for vessels with significant drafts, a specialised shallow water manoeuvring model needs to be built. At Flanders Hydraulics (FH), Towing Tank Tests, where a (physical) scaled version of the ships are studied, are used as input to build such specialised shallow water mathematical model.

Two reports are generated to document the model test series, one for each ship model. This report deals with the installation ship *Innovation*. The derived ship model is the *O40* which is the scaled *Innovation* at scale 1:35. The following chapters are included in the report :

- **Chapter 2 'Summary test matrix'** gives an overview table of the ENV and corresponding SHP files which were tested in this test campaign.
- **Chapter 3 'Ship properties'** properties of the full scale vessel used as basis to make the scale model. It also discusses the tendering and selection process for the scale models.
- **Chapter 4 'Scale model test preparation'** describes the preparation phase for the scale model test program (selection of loading conditions, temporary harbour, inertia measurement upgrade,…)
- **Chapter 5 'Test execution'** gives whoever wants to use the model test data insight in some of the challenges which were encountered and how they were managed.

The towing tank test definitions have been made by FH based on the expectations of VTT, the external party who is tasked with doing the mathematical modelling. This is the reason that the test types and their parameter choices differ at some points from what FH manoeuvring programs usually look like.

Disclaimer

Some references are made to documents on the project "P-drive". After completion of the project, this will be archived which will cause a change in the link to the folder. The folder structure within the project should remain intact however.

2 Test summary

Table 2-1 and Table 2-2 show the test series which have been executed with additional information. Further details on naming convention and parameters definitions are given in the following chapters. Slight differences in T[m] and h[m] exist as measured draft values on the model could slightly differ from the theoretical target values (given in the hydrostatics calculation, Attachment III). If they lay within ±1 mm of the theoretical value, they are accepted.

Table 2-1 : Summary O40 test campaign (23_074; Nov 2024- Feb 2025); part I

ENV	HULL	SHIP file	Start date	End date	h [m]	T_A [m]	T_M[m]	T_F [m]
O4001A02	Bare	O4001010101	30/10/2024	6/11/2024	0.240	0.200	0.200	0.200
O4001A01	Bare	O4001010101	8/11/2024	12/11/2024	0.400	0.200	0.200	0.200
O4002A02	Bare	O4001010201	14/11/2024	19/11/2024	0.199	0.166	0.166	0.166
O4002A01	Bare	O4001010201	21/11/2024	24/11/2024	0.332	0.166	0.166	0.166
O4003A02	App	O4002010101	26/11/2024	9/01/2025	0.240	0.199	0.200	0.202
O4003A01	App	O4002010201	10/01/2025	27/01/2025	0.400	0.199	0.200	0.202
O4004A02	App	O4003010101	28/01/2025	6/02/2025	0.199	0.166	0.166	0.166
O4004A01	App	O4003010101	7/02/2025	20/02/2025	0.331	0.166	0.166	0.166

Table 2-2 : Summary O40 test campaign (23_074; Nov 2024- Feb 2025); part II

ENV	STATX	PMMY	OSC	PMMPSI	MULTI	Total	Zeeman folder
O4001A02	27	11	4	19	16	77	V:\1735364
O4001A01	38	16	8	25	16	103	V:\1736142
O4002A02	20	11	8	19	16	74	V:\1736524
O4002A01	40	16	8	27	16	107	V:\1736674
O4003A02	264	0	0	13	0	277	V:\1737459
O4003A01	265	0	0	13	0	278	V:\1738910
O4004A02	273	0	0	18	0	291	V:\1739635
O4004A01	274	0	0	17	0	291	V:\1740679

3 Ship properties (model and full scale)

This report discusses the full scale installation vessel *Innovation* of the Deme fleet. Based on the properties of the ship, the scaled ship model *O40* (installation vessel is created. This chapter is the only chapter where the full scale equivalents will be threated and named as such.

3.1 Ship dimensions

The full scale properties and the model scale equivalent can be found in Table 3-1.

Table 3-1 : Full scale and model scale dimensions ship O40, Innovation.

Ship name	**Full scale**	**Model scale (1:35)**
General dimensions		
L_{OA} [m]	147.5	4.21
L_{pp} [m]	146.7	4.19
B [m]	42.0	1.20
T_d [m]	7.0	0.20
D [m]	11.0	0.314
Steering and propulsion (main)		
Description	4 azimuth L-drive propellers (ducted), FPP	4 azimuth L-drive propellers (ducted), FPP
D_p [m]	3.4	0.097
rpm	192	1136
Power / propeller [kW]	3500	/
Thrusters*		
Description	Three bow	/
D_p [m]	3.2	/
rpm	750	/
Power / propeller [kW]	2800	/

** The bow thrusters were not modelled as actual thrusters in the model. An indent in the hull, conform ITTC procedures, was foreseen during production.*

3.2 Data locations

Full scale ship dimensions as received by Jan De Nul / Deme are located on

P:\23_074-WetschapOnderzOostende\2_Input_gegevens\CONFIDENTIEEL_Schaalmodel2

Data shared with ship model manufacturer (selection of above) in

P:\23_074-WetschapOnderzOostende\2_Input_gegevens\Schaalmodel 2_BSHC

Information on the ship model is located on

W:\sleept\scheepsrompen_schroeven_roeren\O40

Overview of ship dimensions, background discussions on scaling etc can be found on the excel sheet 'voorbereiding_ontwerpschepen' on the 23_074 Pegasus project page.

The Zeeman software tool and its related databases form the core of the FH towing tank testing. As the Zeeman databases are 'background databases' which are not meant to access directly – only via the Zeeman GUI, the test definitions 'PFT" and test results "DOC" are kept on following locations : * **

- *W:\sleept\opwagen\23_074_O40* Location on W-drive where test definitions are placed (PFT)
- *W:\sleept\vanwagen\23_074_O40* Location on W-drive where test results are placed (DOC)

** At the time of writing the report, the Zeeman Proevendatabank was just about reactivated after a long period of being unused. This test series however was not yet put on this Proevendatabank. If the reader of this report wants to use the data in the future, they should check the status with the Zeeman applicatiebeheerder, which is currently Thibaut Van Zwijnsvoorde.*

*** Further processed files (KRT, DPT,…) are also available on \vanwagen*

Details on the SHP parameters (loading condition) and equipment (rudder, propeller, duct) as well as the equipment calibration can be found here . In the "lijst Prototypeschepen" and the lijst "Scheepsrompen" the items *Innovation* and *O40* are added respectively. Detailed information on the SHP files and their content is given in section 4.8.

3.3 Choice scale factor

The scale factor needs to be chosen so that the ship can be tested as optimal as possible in the towing tank, the following considerations are taken into account,

The scale factor should be chosen as large as possible (small ship model) so that

- The ship fits in the harbour of calibration *(Innovation* has wide beam compared to length)
- The ship's displacement is not too large (force measurement)
- The ship's full scale speed equivalent can be met easily
- The ship does not feel too much of the confinement of the tank

The scale factor should be chosen as small as possible (large ship model) so that

- The propeller radius is as large as possible, 10 cm is normally seen as the cut-off to get good data for assessing propeller properties and scaling to full scale
- The forces measured are not too small for the measuring equipment
- The ship's model scale speeds are not too small
- It could be tested in MOC in the future

Based on the above factors (see also discussion Excel sheet mentioned at start of chapter), the following scale factors have been chosen

Innovation at scale factor 1:35

Ensuring sufficient size of propellers was the dominant factor leading to the choice of scale factor. This leads to a beam of 1.20 m (Table 3-1) which caused the need for to built a temporary harbour to calibrate and ship model (section 4.5).

3.4 Ship model tendering

The ship models have been tendered following the OPZB – OnderhandelingsProcedure Zonder voorafgaande Bekendmaking.

The following tenders have been written

- WL2023_22 : ship hull *Innovation* , four ducted propellers. Bow thrusters not to be fabricated, only recess in hull needs to be foreseen
- WL2023_23 : drives for four ducted propellers ship model *Innovation*

The tenders and relevant communication can be found on EPM. The following responses were obtained for the tenders

- WL2023_22
    - SVATech Potsdam for 52200 € (excl. VAT)
    - BSHC for 42270 € (excl. VAT)

BSHC was chosen

- WL2023_23
    - STEWAL 25800 € (excl. VAT)
    - MECAFORM 27940 € (excl. VAT)

STEWAL was chosen

4 Scale model preparation

4.1 Reports and input E01

The *O40* ship has four azimuth main thrusters. This set-up has never been tested in the Towing Tank Antwerp. The best example to base ourselves on is the *E01* test series from 2009-2012. This is the only other ship with azimuth propulsion which has been tested in the towing tank. This is before the 'Zeeman era', so one needs to be careful with making direct comparisons. However, it was used with ATOS-PUSA system Antwerp, so it will have a connection with the towing carriage steering and measuring procedure.

An example of a measurement can be found here, when looking for "lijst" "projecten" , "projectsite" "Binnenvaart" . The file *E0101A01_MULTI.DPT* is considered. Here, the following measurements are available for the propulsion system

- Measured rpm (schroef 1 en schroef 2)
- Measured thrust and torque (schroef 1 en schroef 2) {comment by authors : should not have been measured, not used for the mathematical model. Maybe it is just random noise signal…}
- Measured azimuth angle (roer 1 en roer 2)
- Measured propeller X and Y force (roer 1 en roer 2)

It seems like the 'propeller' and 'rudder' structure where both used in the output file to gather {rpm} and {angle}, {X},{Y} respectively. The azimuth propulsion units are often denoted by the name 'roerpropeller' which makes a lot of sense considering the data definition structure, using parts of the predefined 'propeller' and 'rudder' structures. The term roerpropeller and its data structure (part propeller, part rudder) is therefore also used for the *O40* test series.

Project "809" contains many reports, including literature study, project updates,… The most relevant report seems to be Geerts et al (2011a) where a description of the model test program is given. It is mentioned that report Geerts et al (2011b) gives an update at the start of the model test program. The post-processing was done in Delefortrie et al (2014)

4.1.1 Geerts et al (2011a)

The test program is included in attachment I. There is no total number of tests given nor a counter of some sort. The following estimation of amount of tests (for the largest water depth?) is given here

- Paaltrekproeven 237
- statX 332
- PMMY 18
- PMMPSI 87
- Multi 275

Total number of model tests is 949 for one water depth and one loading condition.

4.1.2 Geerts et al (2011b)

Mentions where the executed tests differ from the test matrix in Geerts et al (2011):

- Tests at largest water depth serve as reference for lower water depths. The "shallow water effect" in a more general sense is then used for e.g. thruster-thruster estimations based on results largest water depth. Less tests are thus performed for shallower water / other loading condition
- The "Paaltrekproeven" were (partly?) replaced by "Multi tests" to decrease the total number of tests which needed to be executed.

4.1.3 Delefortrie et al (2014)

Very extensive report, where the author (Guillaume Delefortrie) explicitly states that the lengthiness serves the purpose of trying the give a detailed explanation of a complex and challenging path towards the mathematical model for *E01*. No explicit references are found to the total number of model tests used.

4.1.4 Mathematical modelling

R:\809_01 modelproeven_voorspelling_manoeuvreergedrag\8_data, can be used to get insight in the pre- and post-processing tools which were used at that time. It seems like the building of the mathematical model was done under project 12_106 (Delefortrie et al (2014)), folder R:\12_106-ImpEstVaarSim

In the report on page 1, the following statement is made

“ The current report is extensively written so that it can serve as an example for colleagues who want to model ship behaviour in the future. However, as with research and IT, the modernization and advances make it cumbersome to have the applications described in this report withstand time. So care is always needed. “

For information on the post-processing tool, see Appendix 2 of the report.

4.1.5 Search proevendatabank

As the E01 tests are relevant as starting point for the *O40* tests, a search on the Proevendatabank is conducted. This was also the first time TVZ used the Zoekmotor, it served also as purpose to reflect on the usage of the Zoekmotor / Proevendatabank. Details can be found in Attachment I.

4.2 Measurement and steering signals (ANIN,ANUIT,DIGIN,DIGUIT)

The ship is tested in captive mode, using the U-beam measurement mode. In the requirement section, the needed input and output channels are discussed, according the following convention:

- Data from Zeeman PFT to Towing Carriage = UIT
  - DIGUIT = Digital signal (0/1)
  - ANUIT = analogue signal (volt, typically from -10 V to + 10 V)
- Data from towing carriage to Zeeman DOC = IN
  - DIGIN = Digital signal (0/1)
  - ANIN = analogue signal (volt, typically from -10 V to + 10 V)

For the *O40* model, four azimuth propellers need to be controlled independently and feedback signals need to be gathered.

- The ATOS/PUSA framework allows to add this many ANIN and ANUIT signals
- In the Zeeman framework – test definition and post-processing – the larger test definitions files ‘PFT” and associated output data file “DOC” can also be processed.

In attachment II an overview is given as the signal channel definitions used for the appended *O40* test series. This has not been done for test programs in recent years. The intention is now to make such overview for all towing tank test series from this point onwards. They should be saved under the Modelvoorbereidingen[1]

[1] W:\sleept\modelvoorbereiding\IOSYS_definitions\23_074_O40

4.3 Selection of the loading conditions

The design loading condition for the ship is given in Table 3-1 : 0.20 m even keel (model scale). This will be selected as the first loading condition to be tested. In earlier study work for the Innovation shared with FH[2], it is seen that T = 5.8 m even keel was tested as second loading condition. This corresponds to a draft of T = 0.166 m even keel at model scale. A table with the details on the loading condition (hydrostatics) can be found in attachment III. As was mentioned in chapter 2, actual attainted values might slightly differ, as a tolerance of ± 1 mm is present on the draft (fore/mid/aft).

4.4 Force gauge range check

As the Innovation hull is a wide hull to be tested in the Towing Tank, large hull forces are expected. Prior to the execution of the experiments, some checks were performed (comparison with previous experiments and extrapolation to *O40* hull size). This can be found in attachment IV.

4.5 Temporary harbour

The width of the ship model – 1.20 m – exceeds the width of the 'usual harbour' where the ship model is prepared and calibrated. A temporary harbour is constructed in front of the harbour, around x_0 = 0 m, Figure 4-1. This means that

- Home position and command needed to be checked
- Test definition need to be adjusted taking into account the harbour
- The harbour is added as obstacle in the ENV file

In the end, the harbour is constructed to allow the ship to return to her (mechanical) home position. This means that the carriage position can be checked and reset during homing. Attachment V describes the preperation phase and includes some drawings of the set-up and photos of how the harbour was eventually conceived.

[2] P:\23_074-WetschapOnderzOostende\2_Input_gegevens\CONFIDENTIEEL_Schaalmodel2\Model tests

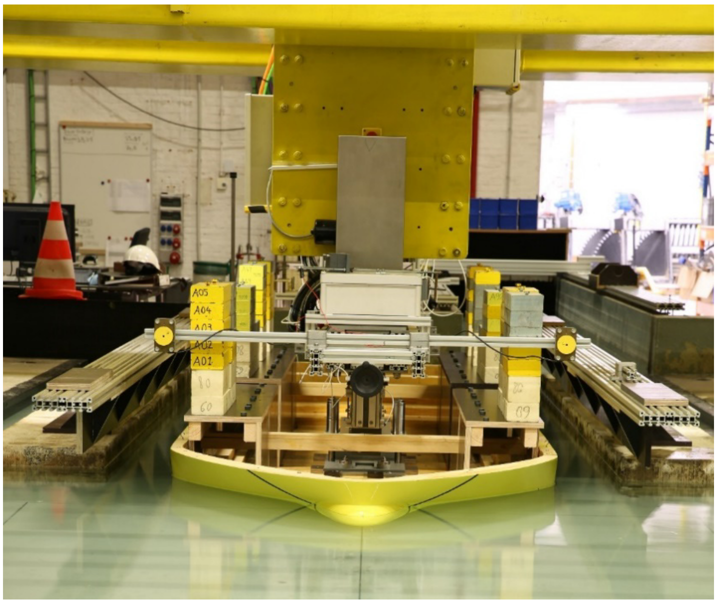


Figure 4-1 : Photo temporary harbour set-up for test campaign O40.

4.6 Schommel upgrade

Due to the width of the model – 1.20 m – a new schommel cradle is constructed to allow the wider vessel to be tested on the pendulum. The following procedure was followed for validation and verification.

- Centre of gravity experiment of the empty frame and inertia test of the empty new frame[3] are deduced from the standard experiment which is also used for the existing cradle.
- Inertia calculation of a reference beam with known inertia[4]. Table 4-1 shows the comparison of the results with the inertia provided by the manufacturer[5]:
- The calculated inertia values agree with the manufacturer inertial data considering the obtained uncertainty. The inertia calculation was considered as validated.

Table 4-1 : Validation of cradle used for O40 inertia determination.

Inertia	Manufacturer	Calculated
Ixx (kg.m^2)	1.68	2.08±2
Iyy (kg.m^2)	84.14	85.75±2

[3]Results of the inertia experiment of the empty new frame can be found here

[4] Results of the inertia experiment of the RoseKrieger beam can be found here:

[5] In 201an error in the inertia calculation was discovered. A verification of the procedure was carried out with a reference beam used also in this calculation. Report of inertia measurement.

Figure 4-2. RoseKrieger beam for intertia validation new frame O40.

4.7 Steering and propulsion

4.7.1 Roerpropeller engines

The ship *O40* is equipped with roerpropellers. They need two engines for each propeller, one engine to drive the propeller "propeller" and one engine to drive the rotation of the vertical axis "roer". The first engine needs to be dimensioned to deliver the model scale equivalent of the full scale 3500 kW power and 181.7 rpm. Scaled down this becomes 14 W and 1075 rpm. The "roer" of the full scale ship allows changing direction (180°) in 15-20 s according to the documentation, which means 180° in 2.53 s in model scale. The engines which were used for the *E01* ship could make a sinus with period 28 s and could turn 180° in 10 s. Faster turning becomes less accurate setpoint tracking.

- When looking at the full scale *E01* ship, according to report Delefortrie et al (2014), it could do 180° turn in 12 s on full scale, which leads to 2.4 s for 180° on model scale. Close to the needed capacity of the *O40* on model scale. The engines which were used for the model test program of the *E01* could not reach this number.
- When looking for a description of the model tests for *E01*, report Geerts et al (2011a) is consulted, where attachment I of the mentioned report shows the model tests and their test parameters. When looking at these data, it seems like the periods used for the captive model tests were large range 150 s to 300 s period for the sinus. This would explain why the roer-engines do not need to reach the maximum equivalent full scale speed.

Furthermore, E&O has assessed the possibility of having a faster engine, but did not succeed to find a satisfying solution. Faster engines had trouble with stable slow rotation – which seems to be key to build the manoeuvring model according to report Geerts et al (2011a) and also had trouble with keeping a fixed angle without showing any unwanted oscillation or instabilities.

Based on the above points, it is assumed that the current roer-engines could suffice for the captive manoeuvring tests part of this project. If in the longer future free running tests are executed, this needs to be reassessed.

4.7.2 Name convention rudder and propeller

On sleeptankoverleg 2024/09/04 it was mentioned that appendages should be numbered "in the direction of the positive y-axis" or "from left to right when looking from the aft". This means we start numbering PS outward to SB outward for propellers and rudders. *The H40 which is also part of 23_074 was not numbered according to this convention*. For *O40*, this convention is applied. Figure 4-3 shows the definitions used for this project.

- **Name :** We talk about BB and SB propellers, with at both sides one outer propeller "OUT" and one propeller towards the middle "MID".
- **Prop#** : Each component from the list componenten in the database list has a specific number. With each new appendage added to the list, the next integer number is taken. Propellers are 38-39-40-41 and ducts are 7-8-9-10.
- **Duct#** : see above **Prop#**
- **Plaats** : When using the componenten to build a SHP configuration in the list modules , a "Plaats" code needs to be defined. From BB to SB, they are defined as A-B-C-D. A indicates "BB out schroef *O40*" and 'BB out straalbuis *O40*". The exact coordinates of the units have been measured and added to the SHP list componenten in the database. See section 4.8 for further details.
- **ATOS i/O** : In the towing tank program, the propellers are controlled (ANUIT/DIGUIT) and measured (ANIN) via PIOC's. Attachment II lists the ANIN/ANUIT/DIGIN/DIGUIT numbering.

The BB propellers are right-handed propellers ; the SB side propellers are left-handed propellers.

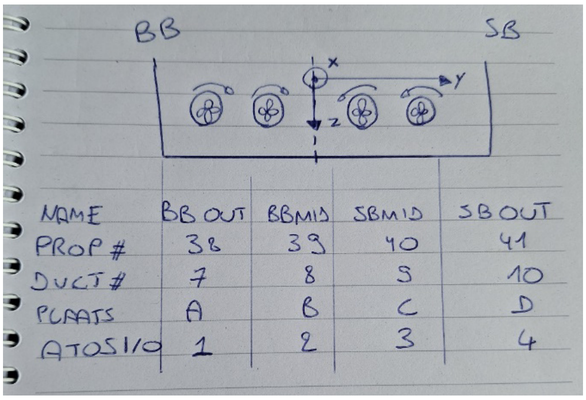


Figure 4-3 : Definitions appendages as used in the Towing tank Tests for ship O40

4.7.3 Neutral angle propellers

On the meeting of 2024/11/25 it was noticed that at page 2 of the GA [6] the thrusters were inclined inwards, which seems to indicate a 'non-zero' neutral position of the azimuth thrusters. The neutral angle is defined here was follows

The neutral angle is the physical angle that the four azimuth propellers have with respect to the ship axis system (x-axis at axis of symmetry of the ship and y-axis at Lpp/2). When the propellers are at this angle, the helm indication is 0 degrees.

A separate memo was written on the determination of these angles for all propellers. As a conclusion of this topic, Deme's Florian Stempinski commented that he sees no reason why a non-zero neutral angle would be present for this ship. This recommendation is followed and the azimuths were installed (2024/12/05) at 0° = parallel to centre axis ship. The force measurement gauges are mounted in a fixed position on the ship, according to the ship axis system (Figure 4-3). This means that F_x and F_y are measured and calibrated according this axis system.

[6] P:\23_074-WetschapOnderzOostende\2_Input_gegevens\CONFIDENTIEEL_Schaalmodel2\Drawings

4.8 Ship database and ENV definition

In chapter 2, Table 2-1 it is clearly mentioned which environment (ENV) and ship (SHP) file are used for the different test series. Attachment VI gives a detailed description of how the SHP files and ENV files were conceived. This includes the need to lower the ballast weight position due to interference between ballast blocks and beam at the larger of the two water depths, after testing the lower water depth.

4.9 Appended test matrix definitions

The appended test matrix has been defined in the period November – December 2024. Based on input from VTT, FH made a test matrix in line with FH Towing Tank and Zeeman convention. Table 4-2 summarizes the test definitions. On the left side, the definition of VTT is noted. On the right side of the table, the Zeeman definitions which correspond with the VTT definition are given. The combination of numbers and letters is needed as there are more than 100 tests defined for one speed index (C/D). Following additional notes

- All rpm values for the crabbing tests (see naming convention VTT, Table 4-2) are expressed relative to 100% helm position. This definition remain the same for the different UKC / loading conditions.
- All test parameters are defined as separate tests (no sub trajectory definition) from harbour to wavemaker on 2024/12/06. Some potential optimisations are discussed in section 4.10.
- For the transit type tests, the rpm settings depend on the self-propulsion point definition and thus depend on UKC and loading condition. Therefore, they are defined as TV's (TV1 and TV2) which need to be updated in the header of the test when copied for another UKC / loading condition.

Important to note is that the azimuth units can rotate over 360°, however they need to be defined between [-180,+180°] (they cannot rotate beyond -180° and +180°, which is a limitation for harmonic tests). Bear in mind that in the test matrix as discussed with VTT, no harmonic azimuth angle variations are included.

Table 4-2 : Test definition appended test series ship O40.

VTT definition P1	VTT definition P2	Zeeman test type	Speed index	Test index
crabbing	DP-mode	STATX0 _C	C 2 knots FS	1 A,B,C…* 2 A,B,C…
	Interaction thruster 1 – 2	STATX0 _C	C 2 knots FS	3 A,B,C… 4 A,B,C… 5 A,B,C…
	Interaction thruster 1 – 2 ; speed var	STATX0 _C	D 3 knots FS	3 A,B,C… 4 A,B,C… 5 A,B,C…
	Interaction thruster 2	STATX0 _C	C 2 knots FS	6 A,B,C… 7 A,B,C… 8 A,B,C…
	Interaction thruster 2 ; speed var	STATX0 _C	D 3 knots FS	6 A,B,C… 7 A,B,C… 8 A,B,C…

Transit	Pure yaw all thrusters	PMMPSI _G	f(cruise speed)**	1,2,3…
	Static all thrusters	STATX0 _C	f(cruise speed)	2 A,B,C…
	Determination self-propulsion ***	STATX0 _C	S ****	1 A,B,C…

** A combination of numbers and letters is needed as more than 99 tests are being defined for one speed index.*

*** The cruise speed is defined as the maximum speed which was reached in the bare hull test programs for the respective combinations of underkeel clearance and loading condition.*

**** The tests to determine the self-propulsion point at cruise speed are a result of the request by VTT to execute the "pure yaw all thrusters" and "static all thrusters" tests at 100% and 70% of the self-propulsion rpm.*

***** The self-propulsion tests are also defined at the cruise speed however a separate definition is made to include TV's with three rpm variations in one towing tank test , therefore speed index "S".*

4.10 Optimising the test matrix

The appended test matrix contains many STATX tests and low speeds with different drift angle and azimuth setting [0,180°][-180°,+180°,360°]. This means many tests which take a long time (due to low speed) and need to return to the starting position. It was investigated if we could lower the batch execution time by adding trajectvariabelen and/or adding trajectories from wavemaker to harbour. Both options are discussed in attachment VII. They were in the end not implemented.

5 Test execution (Nov 2024 – Feb 2025)

5.1 Test matrix

[TestPlanning_Installation_O40.xlsx]

Bear in mind the location / name of this file could change, however it should still exist.

5.2 Diary

[Towing_Tank_schedule_diary]

Bear in mind the location / name of this file could change, however it should still exist.

5.3 Running discussion FH-VTT

[Memo_ext.pptx]

Bear in mind the location / name of this file could change, however it should still exist.

5.4 I/O file adjustment during bare hull tests

From previous test program *H40* (23_074) and *B40* (23_028) it was seen that the DOC to RES to PFT post-processing could not be performed for the bare hull tests. This error message was investigated by DXC under 16_100. A further discussion on the error can be found there. Conclusion was that an adjustment of the ANUIT definitions was needed to match Zeeman PFT definitions. So even though the test is bare hull, the channel definitions of appendages (rudder, propeller) needed to match the default Zeeman setting. This was done in the middle of test series O4001A02. All tests prior to this adjustment were redone. As such, it is possible to generate DPT via RES for all bare hull tests of O4001A02.

When this I/O was adjusted, E&O also adjusted one of the ANIN signals related to water level measurement. This caused – for unknown reasons – errors in the DOC file, for all parameters from ANIN31 onwards. This is water level, temperature and humidity parameters. Restarting the PUSA software made this error dissapear. E&O will investigate this further. As the erroneous measurements are related to non-crucial measurements, it can be tolerated. This error will be present from the change of I/O file to 2024/11/08 10 AM when the PC was restarted. This means that all tests for O4001A02 will have incorrect parameters for water level, air and water temperature and humidity. For series O4001A01, the tests with incorrect parameters are redone over the long weekend of 2024/11/08.

5.5 Test without X-force limits

At higher speeds, the force gauges tend to reach their limit, as a combination of noise in measurement and unsteady effects in sinkage and trim. As the x-direction is mechanically secured, it is possible to go beyond the measurable region – signal should just top off. There is however no clear procedure for this. Following notes are taken on 2024/11/08

- This has been done before
- It makes the system susceptible to damage
- Certainly not recommended in batch mode

Concrete on 2024/11/08 in the AM, the test O4001A01_CJ01 has been performed with Xlimits in software at [+80,-80] N. The measurement reach is [+63,-63] N approx. (Acal * 10).

Notes meeting 2024/11/20

“The load cells are designed with a theoretical structural limit of 50N and 1XXN for X and Y directions respectively. This is related with the construction of the metallic box where the gages are fixed. The plates of the load cell box for X-force are thinner than the ones for Y in order to grant that the small deformation keep in the elastic zone in the range of the forces that will be measured. Higher forces may leave the elastic zone or a plastic deformation. The software limit is +/-60N and +/-140N when the test reach this values it is stopped immediately. If these software limits are removed, the test can continue but only the physical limit will be working (that is a contact when the load cell suffers a deformation (pre-set mechanically) in order or 1 or 2 millimetres. The value of the force corresponding to this extreme deformation is not known exactly (risky). The maximum voltage of the load cell is 10V, any higher force will be acquired as a flat line (in case is needed the amplification can be changed (but higher forces can produce a structural damage).“

Discussion sleeptankoverleg 2024/11/20 [Dutch]

“Limiet op de X-krachten. Uitschakelen? Of behouden (60N limiet op meetbereik 63N). Mag op zich uitgeschakeld worden voor versneller/vertragen. Maar in de regimezone moet signaal wel <63N zitten anders kan je niets weten. Krachten bij extremere proeven worden opgevangen door eindstoppen van de krachtenblokken. Bij die extremere proeven is slingermoment groot aandachtpunt! Die heeft geen mech eindstop. Waarom bestaat limiet op X? Want eindstoppen vangen op: is extra beveiligen om wagen te laten stoppen. Als krachtopnemers tegen eindstop botst zal de wagen niet stoppen. Bijvoorbeeld bij bodem raken“

5.6 Azimuth propeller signal verification

The azimuth system – equipment, steering, measurement – is a custom set-up for this project. As this system differs from the ‘common’ set-up, the signals are tested extensively. The following test types are defined

- O4003A02_CT** steady values propeller rate and azimuth angle
- O4003A02_MT** harmonic variations propeller rate and azimuth angle

The test details are given in attachment VIII. The fastest propeller change velocity and acceleration should be (Multi test = harmonic variation in signals)

- n_v = 30% * (2*PI/40s) = 4.7%/s = 55.7 rpm/s (max rpm = 1075)
- n_a = 30% * (2*PI/40s)^2 = 0.74%/s² = 8.75 rpm/s²

The fastest azimuth rates should be

- d_v = 50° * (2*PI/40s) = 7.85 °/s
- d_a = 50° *(2*PI/40s)^2 = 1.23 °/s²

Note (1) : azimuth angles should be defined [-180,+180], which is the range of the azimuth. This implies that test matrix definitions should be defined in this way. In Zeeman, tests with angle >180° and < -180° could be validated, so caution is needed.

Note (2) : for subsequent test series, a more generic IJKK test was defined and executed for the different environments, see section 5.8.

A short analysis of the signals was made [7].

- Steered and measured propeller rpm seem ‘on top of each other’ -> no indication of lag
- X force comparison (no ijkingscorrection) seems to show that for X<0 (negative rpm) the sum of all thrusters X = X hull force. For X>0 the sum of the thrusters is higher. When we look at the thrusters, the + thruster force for 1 and 4 is significantly higher than for 2 and 3 for the same rpm. In negative sense, this difference is smaller.

[7] W:\sleept\vanwagen\23_074_O40\O4003A02\@tryout\signal_analysis

- Steered and measured azimuth angle seem ‘on top of each other’ -> no indication of lag
- Measured rpm signals of three repeated tests seem to be ‘on top of each other’ -> repeatability seems to be ok

5.7 RPM fluctuations and reaching high rpm values

This issue was noticed when running tests from batch O4003A02 that with high rpm needs (95% max rpm for propeller one and two) as well as the tests with self-propulsion rpm (79.3%) – batch ran during the Christmas holidays. Issues were both considering reaching high rpm values – measured rpm was lower than the steered rpm and considering fluctuations in the rpm.

A PMMPSI tests executed from 2025/01/03 (early morning), _GG01 and generated a DPT file was investigated. Plots like Figure 5-1 can then be made. [8]

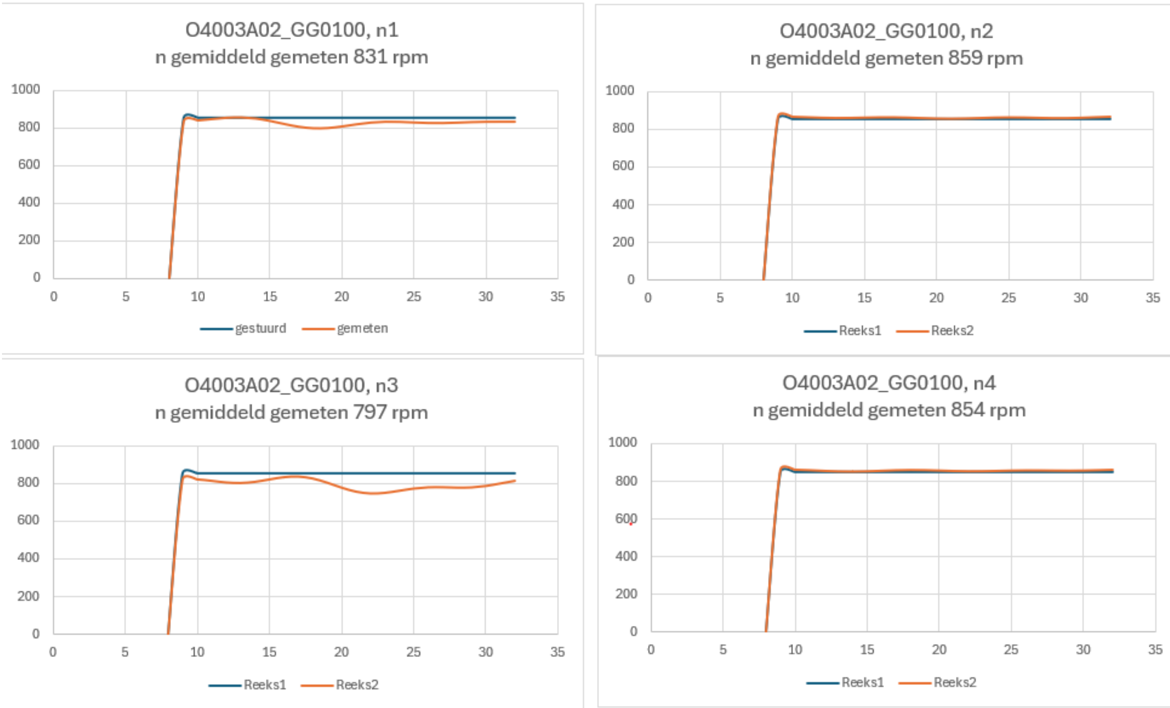


Figure 5-1 : Analysis of DPT output (RES->DPT) of test O4003A02_GG0100 for the four propellers.
Blue line is the target rpm, orange line the achieved rpm.

On 2025/01/03 the following action was taken

- “Stroomlimiet naar de L-drives aangepast in de "Escon" software om het toerental bij 1000 tr/min stabiel te krijgen.“
- “ The engine amper limit was changed form 3.9 A to 4.5 A.”

The test O4003A02_AA45 was performed after this adjustment and the DPT generation of the result O4003A02_AA4500 is given in Figure 5-2(30s test length)

[8] W:\sleept\vanwagen\23_074_O40\O4003A02\@tryout\rpm_fluctuation

	N1geg (rpm)	N1met (rpm)	N1T (N)	N1Q (Nmm)	N2geg (rpm)	N2met (rpm)	N2T (N)	N2Q (Nmm)	N3geg (rpm)	N3met (rpm)	N3T (N)	N3Q (Nmm)	N4geg (rpm)	N4met (rpm)	N4T (N)	N4Q (Nmm)
2	1075	1070.5922	-	-	1075	1078.2885	-	-	1075	1071.0510	-	-	1075	1078.0801	-	-

Figure 5-2 : DPT file of test O4003A02_AA4500

In order to follow up this, a daily test of AA45 was executed for a few days and compared. Results indicate that the rpm values are stable. It is seen however that for propeller 1 and 4 – who generate must thrust – the X-force seems to top off around 15N, at this point the Y-force starts to rise. This effect is physical (water flow), as the force cells are rated for 50N, calibrated at 15N. With the current Acal settings, not all bollard pull tests can actually be measured correctly as the measurement tops off at ± 15 N.

5.8 Generation of IJKK for signal check

In the section 5.7, daily PAAL tests were executed to follow up on the performance of the propellers. In section 5.6 MULTI tests were used to check the signals. In order to harmonize this and use for daily signal checking, two IJKK tests have been created, starting from O4003A01 (so not for O4003A02). Table 5-1 and Table 5-2 show the rudder and propeller parameters, with a = 47.5 : b = 90 ; c = 70 : d = 180 ; e = -90 . The u_0 = 0.261 m/s with a sway and yaw motion added with a period of 45°.

Table 5-1 : Propeller rate settings tryout trests systematic O400*A0*_IJKK tests

	n1 (%/%/s)				n2 (%/%/s)				n3 (%/%/s)				n4 (%/%/s)			
	m	**A**	**T**	**f**	**m**	**A**	**T**	**f**	**m**	**A**	**T**	**f**	**m**	**A**	**T**	**f**
IJKK01	a	a	b	e	a	a	b	e	a	a	b	e	A	a	b	e
IJKK02	c	0	10	0	c	0	10	0	c	0	10	0	c	0	10	0

Table 5-2 : Rudder rate settings tryout tests systematic O400*A0*_IJKK tests

	d1 (°/°/s)				d2 (°/°/s)				d3 (°/°/s)				d4 (°/°/s)			
	m	**A**	**T**	**f**	**m**	**A**	**T**	**f**	**m**	**A**	**T**	**f**	**m**	**A**	**T**	**f**
IJKK01	0	0	10	0	0	0	10	0	0	0	10	0	0	0	10	0
IJKK02	0	d	b	0	0	d	b	0	0	d	b	0	0	d	b	0

5.9 Noise comparison azimuth compared to regular propeller

During the preparation of the tests, it was found that the obtained signal of the rotation of the azimuth propellers showed a higher noise than the standard propellers used in the towing tank. However the average rpm value was less than 1% different from the required rpm value. It was decided to continue with these propeller signals.

6 References

Geerts, S.; Verwerft, B.; Vantorre, M.; Delefortrie, G.; Mostaert, F. (2011a). Modelproeven voorspelling manoeuvreergedrag binnenvaart: deelrapport C. Proevenprogramma estuair schip E01. Versie 2.0. *WL Rapporten*, 809_01. Waterbouwkundig Laboratorium: Antwerpen. IV, 13 + 40 p. bijl. pp.

Geerts, S.; Verwerft, B.; Vantorre, M.; Delefortrie, G.; Mostaert, F. (2011b) Modelproeven voorspelling manoeuvreergedrag binnenvaart: Deelrapport 7 - Derde driemaandelijkse rapportering wetenschappelijke bijstand UGent. Versie 2_0. WL Rapporten, 809_01. Waterbouwkundig Laboratorium: Antwerpen, België

Delefortrie, G.; Eloot, K.; Vos, S.; Peeters, P.; Mostaert, F. (2014). Estuary navigation: 6 DOF Manoeuvring Model. Version 4.0. *WL Rapporten*, 12_106. Flanders Hydraulics Research: Antwerp. XII, 87 + 8 p. appendices pp.

7 Attachment I : zoekmotor search E01

7.1 Proevendatabank

The Proevendatabank contains all model tests which are officially ‘approved’ by the lead engineer. It should thus serve a reliant source for the tests which were used to build the mathematical model. Please not that a ‘zoekmotor’ exists to actually find the data, which is described in the next section. In this section, it is tested if the proevendatabank in itself can be used to locate tests.

The proevendatabank is located at https://wlsow.vlaanderen.be/projecten/default.aspx.

7.1.1 Search effort

Here, a full description is given of the actions taken by Thibaut Van Zwijnsvoorde to find the data for the largest water depth, loading condition 1, environment *E0101*. Green words mark key words from the WLSOW Sharepoint.

Lijsten -> Projecten -> Binnenvaart -> Naar projectsite

These actions take you to a page which seems empty, however from this page, you can select

Bibliotheken

-> Autopilotbestanden no files, as no free-running tests have been executed with the E01 so far

-> Trajectbestanden pages come up, first 570 lines (10+ pages) show B01 results. Search bar is used “*E0101*” – no results. Are the *E01* results present in this projectsite?

-> Excelbestanden one page, *B01, D01, E01* -> files for *E01* should be on this site

-> Dptbestanden DPT files can contain overview of results of multiple model tests, so likely less amount of entries /pages. Page 3 already gives results for *E0101*

E0101A01_MULTI	14/03/2019 09:05	sa_wl_sow_parser
E0101A01_PAALTREK	14/03/2019 09:05	sa_wl_sow_parser
E0101A01_PMMPSI	14/03/2019 09:05	sa_wl_sow_parser
E0101A01_PMMY	14/03/2019 09:05	sa_wl_sow_parser
E0101A01_STATX	14/03/2019 09:05	sa_wl_sow_parser

-> E0101A01_MULTI When you click here, you download the DPT file

-> Hdrbestanden same feeling is with trajectbestanden

-> Krtbestanden same feeling is with trajectbestanden

-> Resbestanden same feeling is with trajectbestanden

-> Ongeclassificeerdebestanden no files

-> Documentbestanden ; contains DOC files ; same feeling is with trajectbestanden.

-> Gegevensbestanden seems to coincide with ‘proevenreeks’ as you would define them using present Zeeman. Less files than trajectbestanden but still 900+ until you arrive at *E0101*.

-> Amplitudebestanden starts with *E01* test series. same feeling as with trajectbestanden. Contains results of seakeeping analysis

-> TYDbestanden starts with *E01* test series. same feeling is with trajectbestanden. No idea what this is used for. Seems to indicate a time window for certain measured signals.

7.1.2 Conclusion

- *E0101* relevant test definitions (pre and post processing) seem to be present in the database
- Due to absence of 'search function' or other method for filtering, it is hard to find data using this interface for most Bibliotheken as there are too many files stored.

7.1.3 Open questions

- Can model tests be stored under multiple projectsite? It is possible that Binnenvaart schepen are tested in SchipSchip conditions, which projectsite are they stored?
- Is the projectsite an actual 'folder' or just a metadata item?

7.2 Zoekmotor

The zoekmotor uses the content of the Proevendatabank to allow the user to search for their needed model test data. Again, green text coincides by key words from the WLSOW sharepoint.

7.2.1 Search effort

Search 1

Target of this search is to find the PFT files for test program *E0101*.

Toepassingsgebied -> Binnenvaart

Zoekcriteria -> Nieuw blok -> Naam omgevingsbestand -> Bevat -> *E0101*

Start zoekopdracht -> 2323 zoekresultaten

Sorteren op gives some options, however it is not clear if any sorting is performed.

With the search results, it gives which SHP and ENV file coincide with the item.

Issue here is that we actually want to find the PFT files which are probably part of the 2323 files. It is not clear how you get to the PFT files, which filter to use…

Attempt to add Nieuw blok -> Naam -> Bevat -> *PFT* ; Start zoekopdracht -> no search results?

Delete block ; Add Eigenschap within the block Naam omgevingsbestand. -> Naam -> Bevat *PFT*

Start zoekopdracht -> no search results?

Add Eigenschap within the block Naam omgevingsbestand. - > Type -> Bevat *PFT* ; no search results?

Search 2

Target of this search is to find files for test program *E0101* related to tests performed at water depth < 0.25m. This seems to work well by doing

Toepassingsgebied -> Binnenvaart

Zoekcriteria -> Nieuw blok -> Naam omgevingsbestand -> Bevat -> *E0101*

Add Eigenschap within the block Naam omgevingsbestand. -> Waterdiepte (H1) -> Kleiner dan -> 0.25 m

Start zoekopdracht -> Search results are obtained and the water depth filter seems to work correctly.

Search 3

Target of this search is to find files for test program *E0101* related to tests performed before 5th of March 2011.

Toepassingsgebied -> Binnenvaart

Zoekcriteria -> Nieuw blok -> Naam omgevingsbestand -> Bevat -> *E0101*

Add Eigenschap within the block Naam omgevingsbestand. -> Datum proef (DATUM) -> Vroeger dan -> 05/03/2011

Start zoekopdracht -> seems to work well, choosing the correct format for Datum was a guess

Add Eigenschap within the block Naam omgevingsbestand. -> Datum proef (DATUM) -> Vroeger dan -> katten -> It seems like it does not run, but it is not clear if it is that or there are no results (no error handling).

7.2.2 Conclusion

- The filter option to get PFT files back was not found, so requested results could not be retrieved.
- It seems tricky to understand what type of filters you need to select to come to a (straightforward?) result to a question to find *PFT* files for environment *E0101*.
- The difference between search criteria within a block and defining new blocks is not intuitive?
- No description of the expected format (number, time, date,…) could lead to empty results.
- In relation to previous point no feedback for user on correctness request (error handling)

7.2.3 Documentation on Proevendatabank 00_006 – deelrapport 5

The abstract describes "a major update of the Proevendatabank in 2014, which caused a strong interweaving with Zeeman (zoekmotor?)".

- P7 : the level of detailing which the user can specify is large (zoekmotor search methods)
- P8 : when search results have been inserted incorrectly, an error message should be displayed. I did not see this appear when I tried the searches above. It should even have the possibility to display different types of error messages. -> was there already a migration which disabled some functionalities?
- P13 and following : description how to add tests which are not processed by Zeeman to Proevendatabank. Seems to be a complex task.

7.2.4 Open questions

- When has the Proevendatabank and Zoekmotor been developed? Have they already been migrated before? Is there after 00_006 – deelrapport 5 more documentation?

7.3 Import of GEG file into Zeeman

7.3.1 Action

Zeeman offers the functionality to import GEG definitions into the system. This would mean that the test matrix for *E01* can be reconstructed in Zeeman. This is tested by downloading a few example GEG files from the Proevendatabank.

Lijsten -> Projecten -> Binnenvaart -> Naar projectsite

Bibliotheken -> Gegevensbestanden

- E0101A01_AA1.GEG
- E0101A01_CD.GEG
- E0101A01_MG.GEG

Test series type PMMPSI and PMMY, code 'F' and 'G' according to 809_01_C could not be found in the Proevendatabank via the above search path.

The above three GEG files are now loaded into Zeeman Production 1.4.2. The GEG files are stored on the location P:\23_074-WetschapOnderzOostende\3_Uitvoering\analysis_model_tests_E01

Figure 7-1 - Figure 7-2 - Figure 7-3 show that _AA1 and _MG can be imported, _CD cannot be imported. When _MG and _AA1 are saved "opslaan", the system shows "Action failed", so it failed at this step. Another reason can be that the GEG file at time of *E01* was ASCII format; when exporting GEG now in Zeeman, it gives GEG in XML stylesheet format.

It is possible that OMG and SHP file are not (correctly) linked, the ENV file for example does not show up when searching in Zeeman. The question then is where to find the environment file *E0101A01*? Via the Zoekmotor (Figure 7-4) the SHP and ENV seem to show up, however when <clicking>, nothing happens?

7.3.2 Conclusion

- Not all GEG files seem to be present on the Proevendatabank. Maybe the PFT files are present, but these are hard to find using the Proevendatabank / Zoekmotor
- Two of the three GEG files can be successfully loaded in, those two files show ‘action failed’ however when you want to save them.

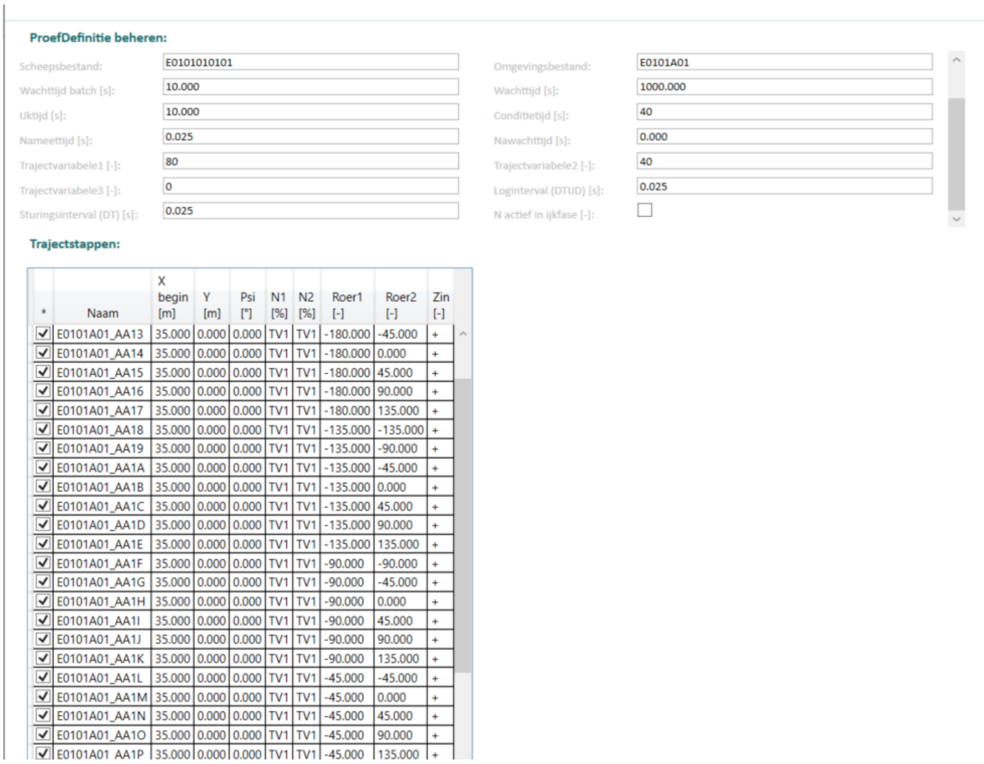


Figure 7-1 : Import of E0101A01_AA1.GEG in Zeeman Production 1.4.2

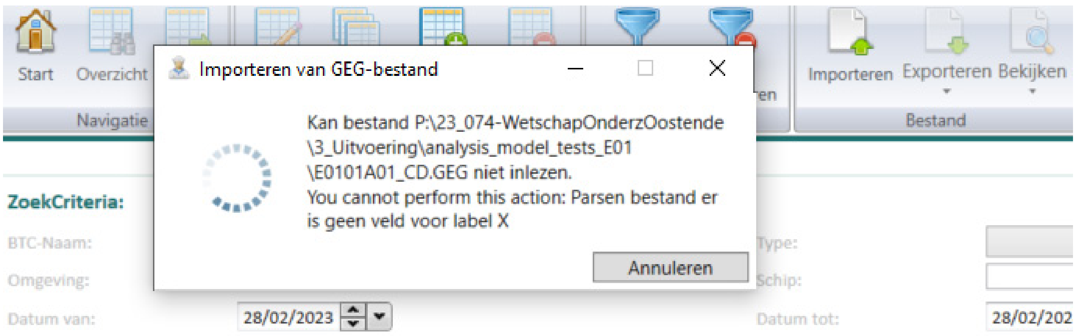


Figure 7-2 : Import of E0101A01_CD.GEG in Zeeman Production 1.4.2

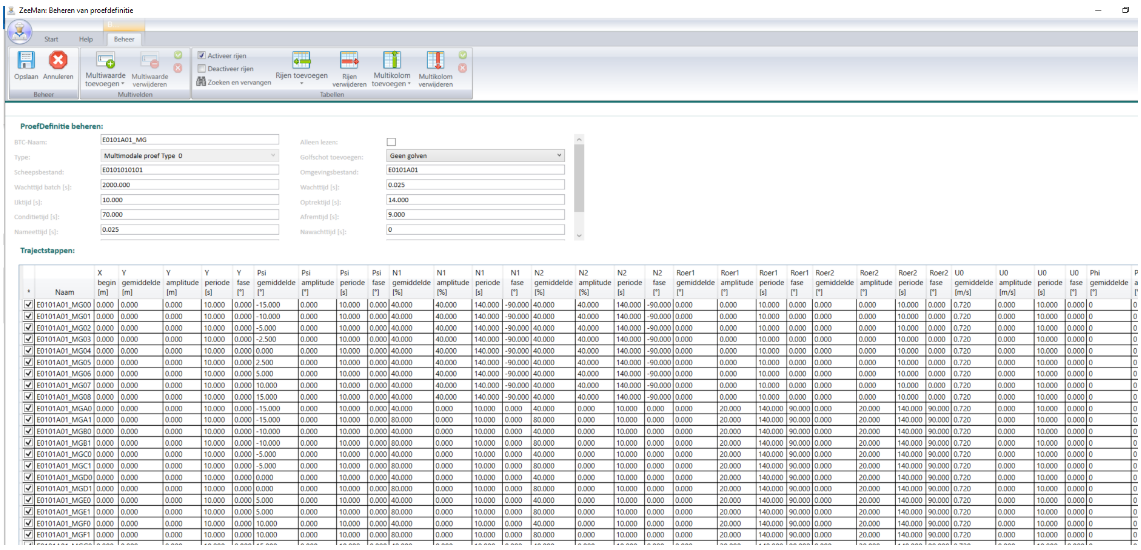


Figure 7-3 : Import of E0101A01_MG.GEG in Zeeman Production 1.4.2

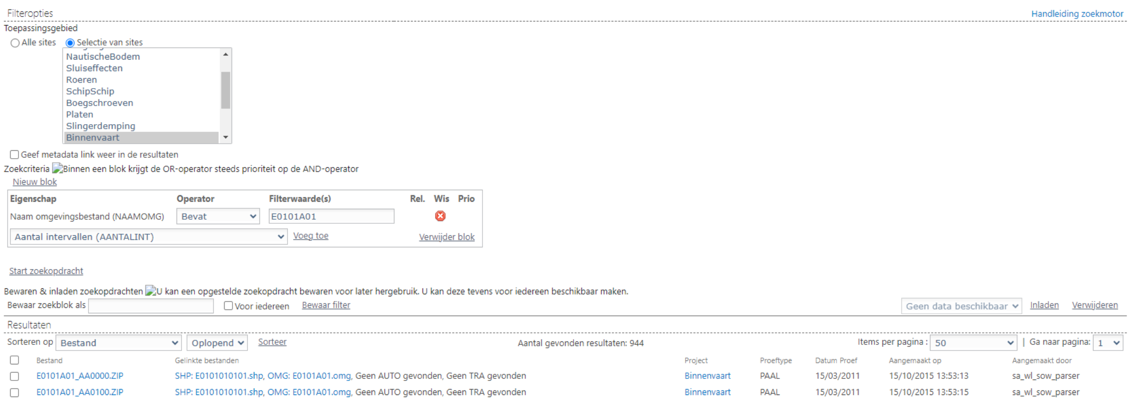


Figure 7-4 : Search result ‘Zoekmotor’.

8 Attachment II : Model test set-up appended tests

Force	ANUIT	DIGUIT	convention	ANIN	DIGIN	convention
Xvoor				ANIN01		X force positive forward
Xachter				ANIN03		X force positive forward
Yvoor				ANIN02		Y force positive to SB
Yachter				ANIN04		Y force positive to SB
rolkracht		DIGUIT06 DIGUIT07	enable slingermotor (0/1) ; voeding slingermotor (0/1)	ANIN16	DIGIN13	P moment positive over SB ; home slingermotor
sinkage	**ANUIT**	**DIGUIT**	**convention**	**ANIN**	**DIGIN**	**convention**
z voor BB				ANIN07	DIGIN01	sinkage, positive downwards//physical contact(0/1)
z voor SB				ANIN08		sinkage, positive downwards//physical contact(0/1)
zachter BB				ANIN09	DIGIN02	sinkage, positive downwards//physical contact(0/1)
z achter SB				ANIN10		sinkage, positive downwards//physical contact(0/1)
propulsion	**ANUIT**	**DIGUIT**	**convention**	**ANIN**	**DIGIN**	**convention**
d roer1	ANUIT05		angle azimuth, positive clockwise (steering) , [-180°,180°]	ANIN40		angle azimuth, positive clockwise (measurement)
n schroef1	ANUIT01	DIGUIT01	propeller rpm(steering), positive rpm = positive thrust//enable propeller	ANIN41		propeller rpm (measurement)
X roer1				ANIN42		X-force on propeller; axis system ship
Y roer1				ANIN43		Y-force on propeller; axis system ship
d roer2	ANUIT06		angle azimuth, positive clockwise (steering) , [-180°,180°]	ANIN44		angle azimuth, positive clockwise (measurement)
n scrhoef2	ANUIT02	DIGUIT02	propeller rpm(steering), positive rpm = positive thrust//enable propeller	ANIN45		propeller rpm (measurement)
X roer2				ANIN46		X-force on propeller in axis system ship (fixed)
Y roer2				ANIN47		Y-force on propellerin axis system ship (fixed)
d roer3	ANUIT07		angle azimuth, positive clockwise (steering) , [-180°,180°]	ANIN48		angle azimuth, positive clockwise (measurement)
n schroef3	ANUIT03	DIGUIT03	propeller rpm(steering), positive rpm = positive thrust//enable propeller	ANIN49		propeller rpm (measurement)
X roer3				ANIN50		X-force on propeller in axis system ship (fixed)
Y roer3				ANIN51		Y-force on propeller in axis system ship (fixed)
d roer4	ANUIT08		angle azimuth, positive clockwise (steering) , [-180°,180°]	ANIN52		angle azimuth, positive clockwise (measurement)
n schroef4	ANUIT04	DIGUIT04	propeller rpm(steering), positive rpm = positive thrust//enable propeller	ANIN53		propeller rpm (measurement)
X roer4				ANIN54		X-force on propellerin axis system ship (fixed)
Y roer4				ANIN55		Y-force on propellerin axis system ship (fixed)
environment	**ANUIT**	**DIGUIT**	**convention**	**ANIN**	**DIGIN**	**convention**
WL haven				ANIN31		water level measurement at harbour side tank
watertemp				ANIN32		water temperature
luchtvocht				ANIN33		air humidity
luchttemp				ANIN34		air temperature
WL golfschot				ANIN35		water level measurement at wave maker side tank
hoogte overstortbakje				ANIN36		?
fout op WL				ANIN37		?
wave gauges	**ANUIT**	**DIGUIT**	**convention**	**ANIN**	**DIGIN**	**convention**
golf1				ANIN17		lowering of water level = positive ; not connected
golf2				ANIN18		lowering of water level = positive ; not connected
golf3				ANIN19		lowering of water level = positive ; not connected

9 Attachment III : loading conditions

Table 9-1 : Hydrostatics loading conditions (model scale).

	O40010101	O40010102	O40020101	O40020102	O40030101
m (kg)	798.2	644.7	805.2	805.2	654
x_G (m)	-0.038	-0.011	-0.036	-0.036	-0.012
y_G (m)	0	0	0	0	0
z_G (m)	-0.247	-0.222	-0.227	-0.218	-0.196
T_M (m)	0.2	0.166	0.2	0.2	0.166
T_A (m)	0.2	0.166	0.2	0.2	0.166
T_V (m)	0.2	0.166	0.2	0.2	0.166
I_{xx} (kgm²)	258	194.2	309.8	303.4	244.4
I_{yy} (kgm²)	928.3	768.7	1043	1036.6	966.4
I_{zz} (kgm²)	1011	843.3	1135	1135.5	1053.5
S (m²)	6.071	5.646	6.071	6.071	5.646
KB (m)	0.105	0.087	0.105	0.105	0.087
KM_T (m)	0.744	0.849	0.744	0.744	0.849
KM_L (m)	7.016	7.959	7.016	7.016	7.959

Table 9-2 : Hydrostatics loading conditions (full scale).

	O40010101	O40010102	O40020101	O40020102	O40030101
m (kg)	34222825	27641513	34522950	34522950	28040250
x_G (m)	-1.33	-0.385	-1.26	-1.26	-0.42
y_G (m)	0	0	0	0	0
z_G (m)	-8.645	-7.77	-7.945	-7.63	-6.86
T_M (m)	7	5.81	7	7	5.81
T_A (m)	7	5.81	7	7	5.81
T_V (m)	7	5.81	7	7	5.81
I_{xx} (kgm²)	1.36E+10	1.02E+10	1.63E+10	1.59E+10	1.28E+10
I_{yy} (kgm²)	4.88E+10	4.04E+10	5.48E+10	5.44E+10	5.08E+10
I_{zz} (kgm²)	5.31E+10	4.43E+10	5.96E+10	5.96E+10	5.53E+10
S (m²)	7436.975	6916.35	7436.975	7436.975	6916.35
KB (m)	3.675	3.045	3.675	3.675	3.045
KM_T (m)	26.04	29.715	26.04	26.04	29.715
KM_L (m)	245.56	278.565	245.56	245.56	278.565

10 Attachment IV : force gauge range check

10.1.1 First analysis force range

Depending on ship size (displacement) and L/T, B/T, L/B ratios, the forces and sinkages which are measured in the towing tank will vary between the projects. In fact, the expected forces should be checked with the measurement gauges which are present in the towing tank set-up. As this is not something which was done in the past – or at least not systematically– this chapter forms a start for such process.

An assessment of the main properties of the *O40* ship can be found in the excel sheet '[voorbereiding_ontwerpschepen'](voorbereiding_ontwerpschepen) on 23_074 Pegasus, tab 'fore_gauge_range_check'.

The installation vessel *O40* is by far the widest ship (excl. push convoys) that has been tested at the Antwerp Towing Tank. The displacement at the maximum draft (T = 0.2 m even keel) is about 805 kg, it exceeds the displacement of the *T0Z* ship model (740 kg). Also due to the wide beam, the projected width of the ship will quickly enlarge as shown in the Excel sheet. This means that large forces can be expected and that the compatibility with the force gauges is a point of focus when defining the tests (speed, drift angle, period,…).

In push convoy tests (15_001), the heaviest combination (virtual ship J0A according to table 14 of report WL2015R15_001_1) had a total weight of 873.9 kg and a total width of 0.9120 m. The weight comes quite close to *O40*, the beam is however significantly smaller.

When comparing lateral area of the ships, *O40* has an estimated lateral area of 0.842 m² (0.20*4.21), *T0Z* has an estimated lateral area of (0.277*4.34) 1.2 m². The lateral area of *O40* is thus not extra-ordinary.

10.1.2 Second analysis force range

The O40 model is the bigger model ever tested in the Antwerp towing tank. It will be submitted to a different test matrix that the used by FH for manoeuvring models. Additionally, the centre of gravity is considerably higher than previous tests. These factors can lead to a higher inertial and hydrodynamic force/moments. The instrumentation must be protected from any overload or damage that may interrupt the progress of the campaign. This section describes a preliminary estimation of the forces/moments.

Considering the highest acceleration in harmonic tests of the previous bare hull campaign (Dredger – H4001A01) and the maximum draft (more inertial condition) it is possible to make an estimation of:

- The increase of the maximum inertial lateral force
- The increase of the maximum inertial roll moment

In the bare hull tests of the Dredger model, the vertical centre of gravity was -0.012m (around 1 cm above the water line). If we assume initially that the measured moment is totally hydrodynamic (the inertial moment part, F_inertial x (distance from the roll moment sensor to the vertical centre of gravity) should be near to zero. Being F_inertial = m x (lateral acceleration). It is possible to estimate the roll moment due to the increasing of the VCG to, for instance, a position of 0.28 m above the water line (as the O40 model). The **Fout! Verwijzingsbron niet gevonden.** shows the difference in the time histories of the estimated lateral force and roll moment. The conclusion is that the lateral force and the moment almost double because the increasing of the VCG. This means that the more extreme test will be executed almost in the limit of the system.

<u>Notes</u>

- *In the DOC files the roll moment is presented as channel/column named as "Moment x" and after the post-processing it is changed to channel/column "SK".*
- *The lateral force is the sum of the two independent load cells that can have different sign, so the maximum of the sum, it is not the maximum of individual load cell. On this first estimation only, the total sum is considered.*

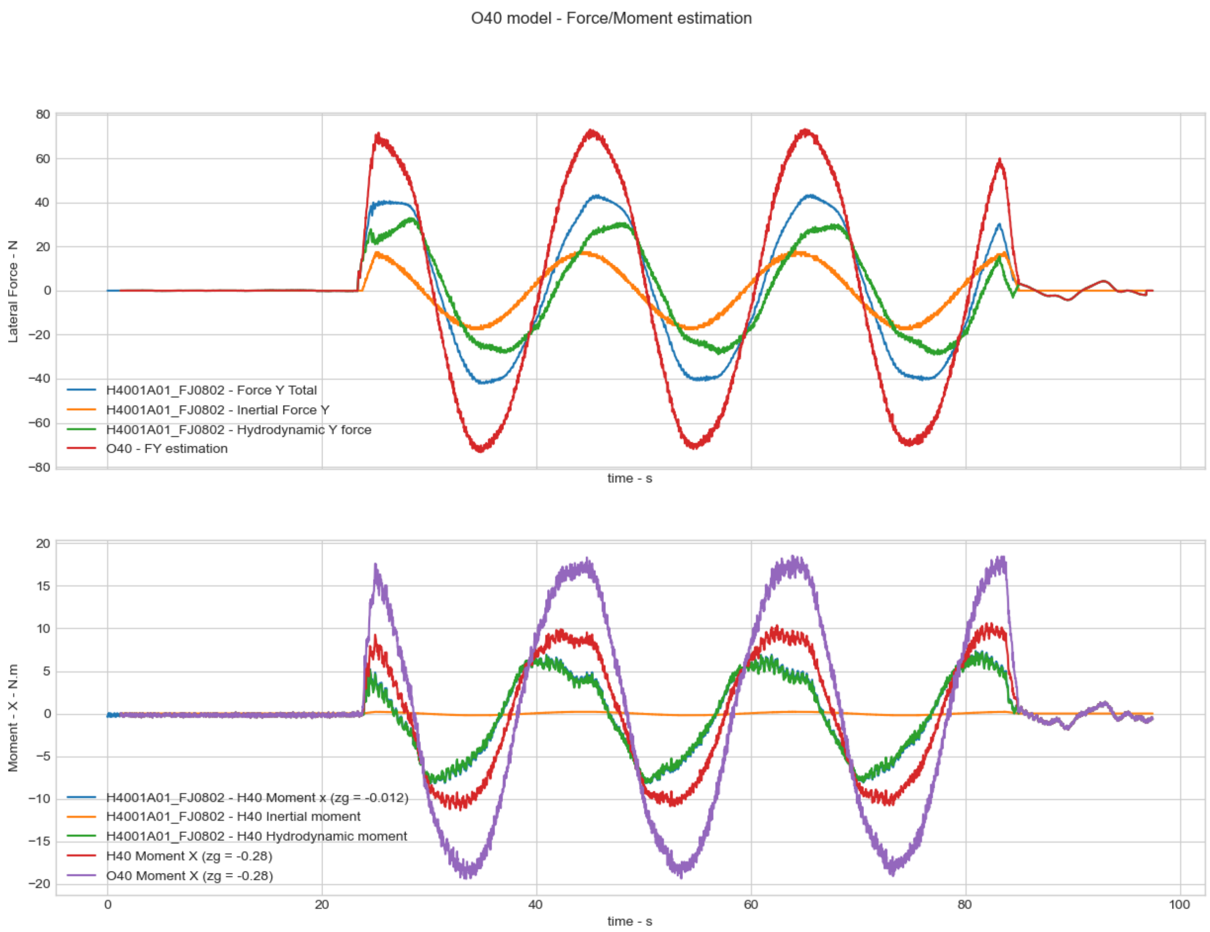


Figure 10-1. RoseKrieger beam for intertia validation new frame O40 set-up

11 Attachment V : temporary harbour

On 2024/10/24, some test definitions "O4001A01_CK**" were made based on ENV O4001A01, SHP O4001010101. In the ship file, the safety rectangle was defined as 1.05% B, so 2.5% Beam each side or 3 cm.

- Figure 11-1 shows the ENV file with the obstacles at portside (PS) and starboard (SB) side which denote the harbour. The harbour has been extended laterally to $y_{0\,=}$ = -3.5 m and y_0 = +3.5 m for PS and SB side respectively. The inner limits of the harbour in y0 direction, which denote the available space for the ship, are slightly asymmetric with respect to y_0 = 0. At SB side y_0 = +0.745 m and at PS y_0 = -0.755 m. The elements run from x_0 = -2.8 m to x_0 = +2.37 m.
- Figure 11-2 : In this set-up, test _CK12 could not be validated (ψ = 5°), _CK11 could still be validated (ψ = 3°). The test _CK07 could be validated, which has end position x_0 = 68 m of ship middle, so x_0 = 68 m +4.21/2 = 70.105 m foremost point of the bow. _CK08 and _CK09 could not be validated (foremost position bow past x_0 = 71.0 m hard tank limit).

After this exploration of the implementation of the harbour in the OMG file, the OMG file O4001A02 was generated and used for the first test series (bare hull, T = 0.2 m, UKC = 20%). This OMG file was subsequently copied for the other test environments.

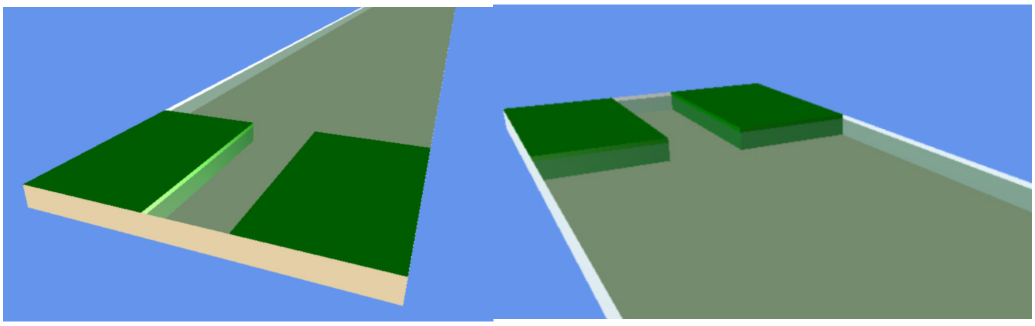
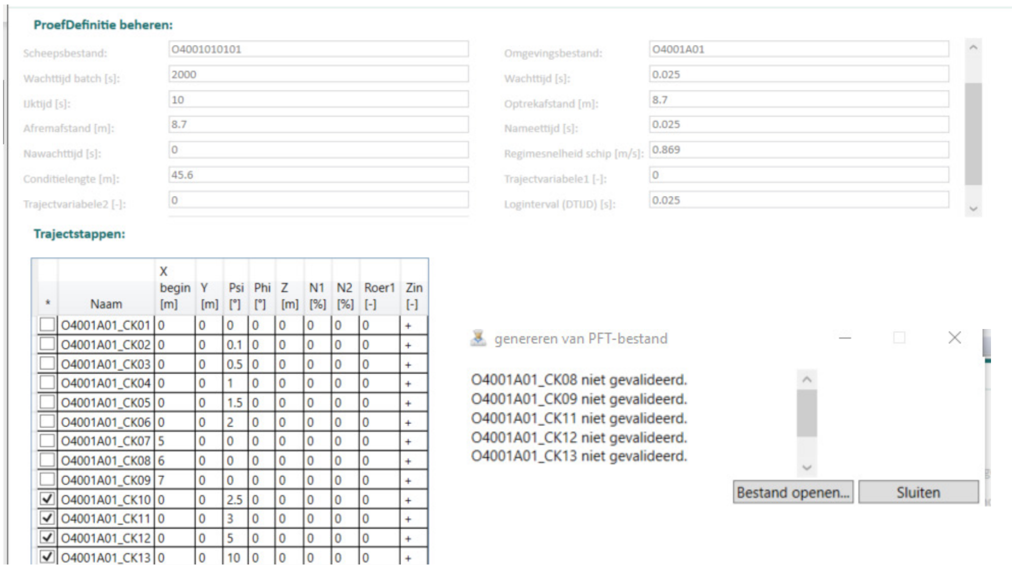


Figure 11-1 : Visualisation of O4001A01 as generated and exported to Proevendatabank (2024/10/22).



ProefDefinitie beheren:

Scheepsbestand:	O4001010101	Omgevingsbestand:	O4001A01
Wachttijd batch [s]:	2000	Wachttijd [s]:	0.025
IJktijd [s]:	10	Optrekafstand [m]:	8.7
Afremafstand [m]:	8.7	Nameettijd [s]:	0.025
Nawachttijd [s]:	0	Regimesnelheid schip [m/s]:	0.869
Conditielengte [m]:	45.6	Trajectvariabele1 [-]:	0
Trajectvariabele2 [-]:	0	Loginterval (DTIJD) [s]:	0.025

Trajectstappen:

*	Naam	X begin [m]	Y [m]	Psi [°]	Phi [°]	Z [m]	N1 [%]	N2 [%]	Roer1 [-]	Zin [-]
☐	O4001A01_CK01	0	0	0	0	0	0	0	0	+
☐	O4001A01_CK02	0	0	0.1	0	0	0	0	0	+
☐	O4001A01_CK03	0	0	0.5	0	0	0	0	0	+
☐	O4001A01_CK04	0	0	1	0	0	0	0	0	+
☐	O4001A01_CK05	0	0	1.5	0	0	0	0	0	+
☐	O4001A01_CK06	0	0	2	0	0	0	0	0	+
☐	O4001A01_CK07	5	0	0	0	0	0	0	0	+
☐	O4001A01_CK08	6	0	0	0	0	0	0	0	+
☐	O4001A01_CK09	7	0	0	0	0	0	0	0	+
☑	O4001A01_CK10	0	0	2.5	0	0	0	0	0	+
☑	O4001A01_CK11	0	0	3	0	0	0	0	0	+
☑	O4001A01_CK12	0	0	5	0	0	0	0	0	+
☑	O4001A01_CK13	0	0	10	0	0	0	0	0	+

genereren van PFT-bestand

O4001A01_CK08 niet gevalideerd.
O4001A01_CK09 niet gevalideerd.
O4001A01_CK11 niet gevalideerd.
O4001A01_CK12 niet gevalideerd.
O4001A01_CK13 niet gevalideerd.

Bestand openen... | Sluiten

Figure 11-2 : Test definition O4001A01_CK**.

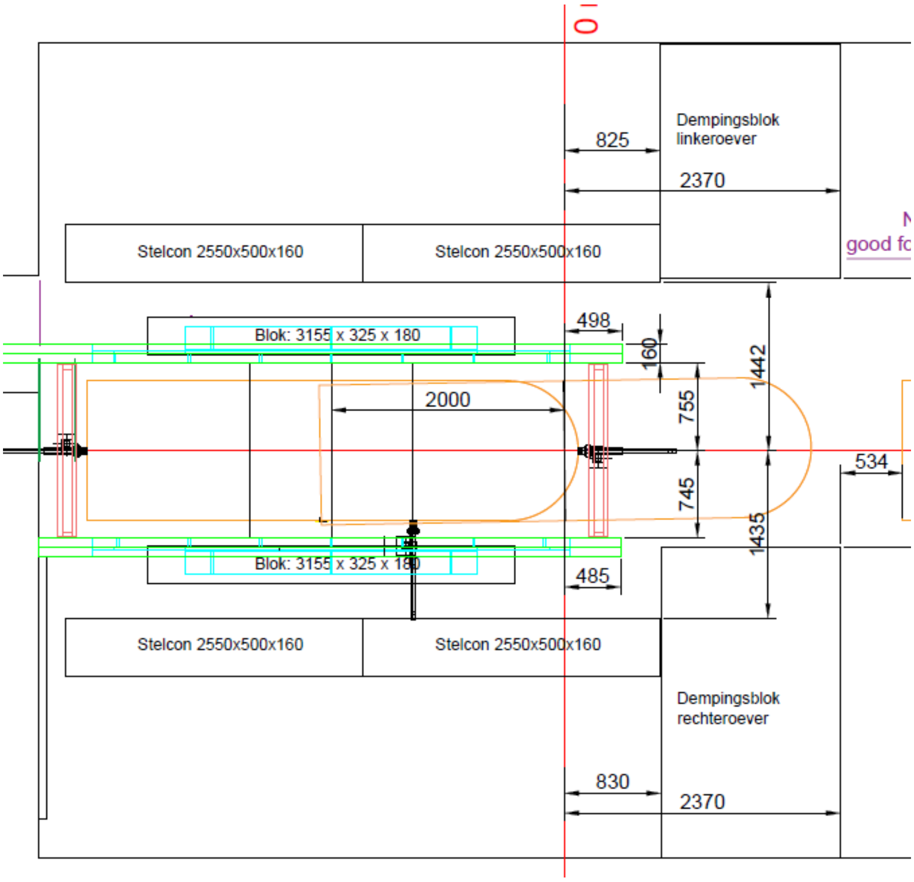


Figure 11-3 : Harbour plan as shared by email on 2024/10/23.

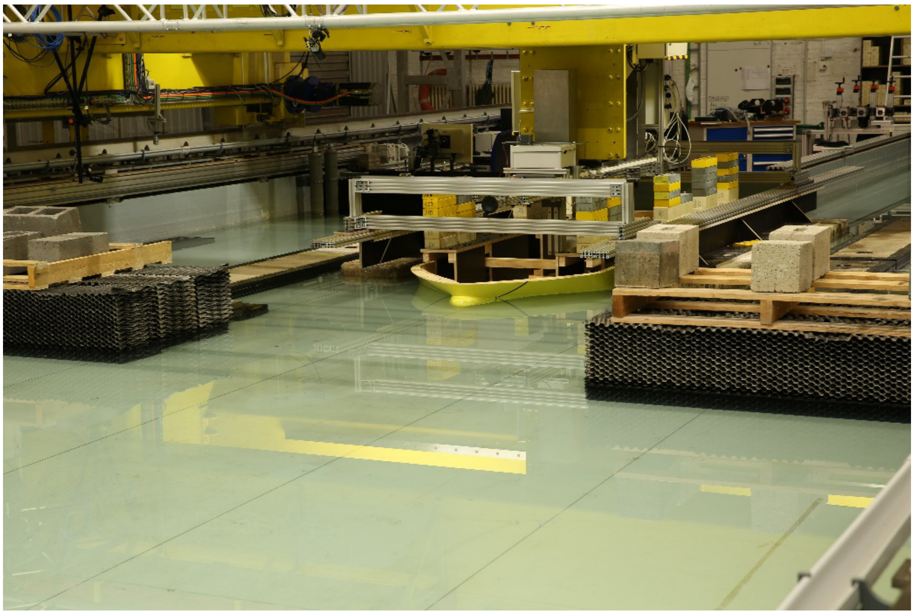


Figure 11-4 : Photo temporary harbour set-up (1).

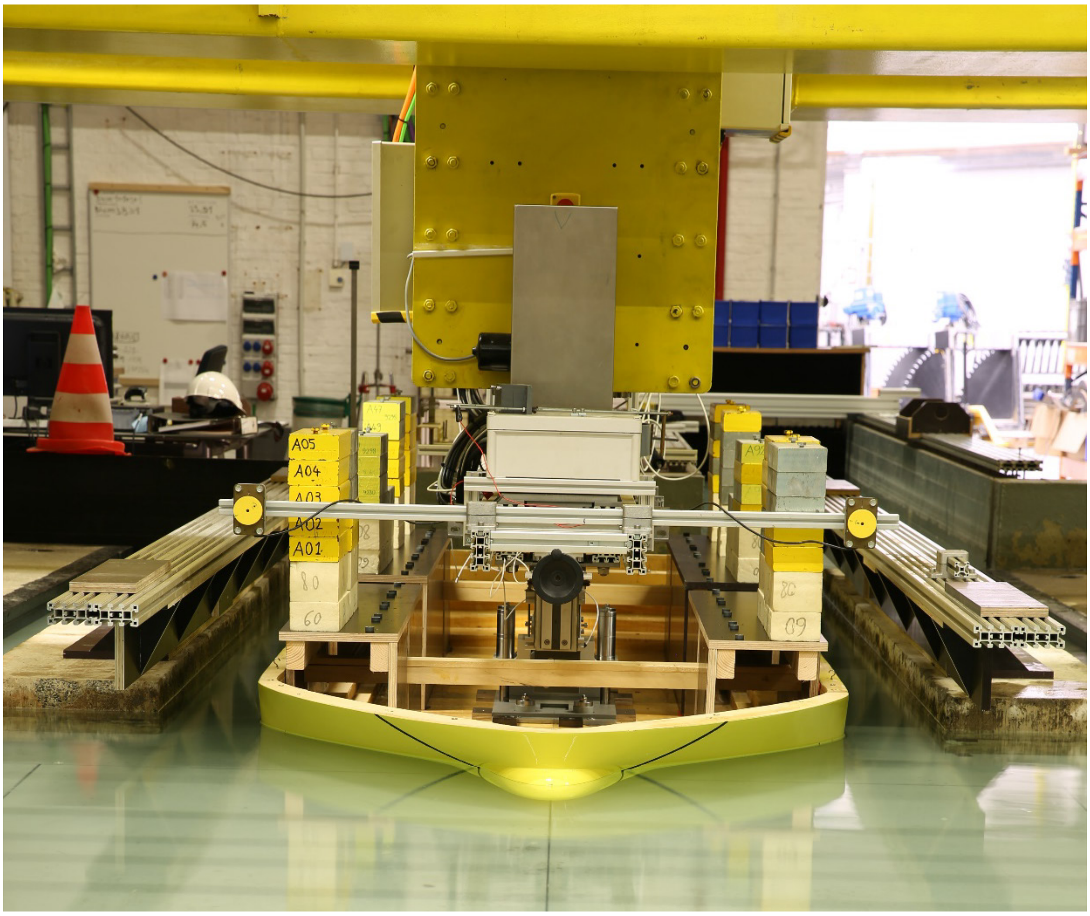


Figure 11-5 : Photo temporary harbour set-up (2).

Figure 11-6 : Photo temporary harbour set-up (3).

12 Attahment VI : SHP and ENV file details

12.1 Bare hull, $T_M = T_F = T_A = 0.200$ m

Table 12-1 : SHP file O4001010101 used in ENV O4001A01,O4001A02

List	**Name**	**Remarks**
Scheepsrompconfiguratie	O4001	Max rpm at 1075, safety rectangle at (-0.55 ; 1.) and (0.55;1) *As this is a bare hull condition, the max rpm setting here was irrelevant and should be checked below in section 12.3.*
Modules	O400101	Nothing.app added
Ladingscondities	O40010101	ok
Ijkingswaarden	O4001010101	ok
Omgevingsfiles	O4001A01 / O4001A02	ok

12.2 Bare hull, $T_M = T_F = T_A = 0.166$ m

Table 12-2 : SHP file O4001010201 used in ENV O4002A01,O4002A02

List	**Name**	**Remarks**
Scheepsrompconfiguratie	O4001	Max rpm at 1075, safety rectangle at (-0.55 ; 1.) and (0.55;1) *As this is a bare hull condition, the max rpm setting here was irrelevant and should be checked below in section 12.3.*
Modules	O400101	Nothing.app added
Ladingscondities	O40010102	ok
Ijkingswaarden	O4001010201	ok
Omgevingsfiles	O4002A01 / O4002A02	ok

12.3 Appended hull, $T_M = T_F = T_A = 0.200$ m (for O4003A02)

Table 12-3 : SHP file O4002010101 used in ENV O4003A02

List	**Name**	**Remarks**
Scheepsrompconfiguratie	O4002	Max rpm at 1075, safety rectangle at (-0.6 ; 1.05) and (0.6;1.05)
Modules	O400201	See W:\sleept\scheepsrompen_schroeven_roeren\O40\position_propeller_duct

<table>
<tr><td></td><td></td><td>
Values are measured on CAD model which is used to construct the model
Propeller (see Table 12-4)

properties from BSHC report
x = end of hub - start of propeller , prop 1 = prop 4 = -1867.25 mm (=4190/2 – 277.75) ; prop 2 = prop 3 = -2002.84 mm (4190/2 – 92.16)
y = mid of propeller axis : prop 1 = (-) prop 4 = - 471.43 mm ; prop 2 = (-) prop 3 = - 271.43
z = mid of propeller axis : prop 1 = prop 2 = prop 3 = prop 4 = 62.76 mm
theta = 0, phi = 0, psi = 0

Duct (see Table 12-4)

diameter : inside of the duct taken DDEN = 117.09 mm DDEX = 99.24 mm
length : 48.57 mm
x,y,z = centre point duct = x,y,z propeller
theta = 0, phi = 0, psi = 0

Due to an unknown error in the WLSOW database, the duct “SB OUT” coordinates could not be updated. The values found in the SHP file are thus incorrect.
Table 12-4 : summary x,y,z propeller and duct
<table>
<tr><td></td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>X</td><td>-1.86725</td><td>-2.00284</td><td>-2.00284</td><td>-1.86725</td></tr>
<tr><td>Y</td><td>-0.47143</td><td>-0.27143</td><td>0.27143</td><td>0.47143</td></tr>
<tr><td>Z</td><td>0.06276</td><td>0.06276</td><td>0.06276</td><td>0.06276</td></tr>
<tr><td>Psi</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>
</td></tr>
<tr><td>Ladingscondities</td><td>O40020101</td><td>Ok</td></tr>
<tr><td>Ijkingswaarden</td><td>O4002010101</td><td>ok</td></tr>
<tr><td>Omgevingsfiles</td><td>O4003A02</td><td>Ok</td></tr>
</table>

12.4 Appended hull, $T_M = T_F = T_A = 0.200$ m (for ENV O4003A01)

At the beginning of the execution of this series, it was detected an interference between the carriage structure and the ballast distribution of the model (Figure 12-1). An adapted ballast plan had to be implemented generating a new SHP file O4002010201. The adaptation consisted of decrease the high of the weight positions reducing the amount of foam blocks in the positions where the interference was found (from 14cm to 6cm foam, see **ballast plan**). The diminishing of the VCG was 9mm in relation with the previous ballast plan). The draft was verified using the sinkage measuring before and after the adaptation (neglectable difference, thus in the new SHP file O4002010201 the draft values remain with the previous draft.

All the tests of this series were executed with this weight distribution.

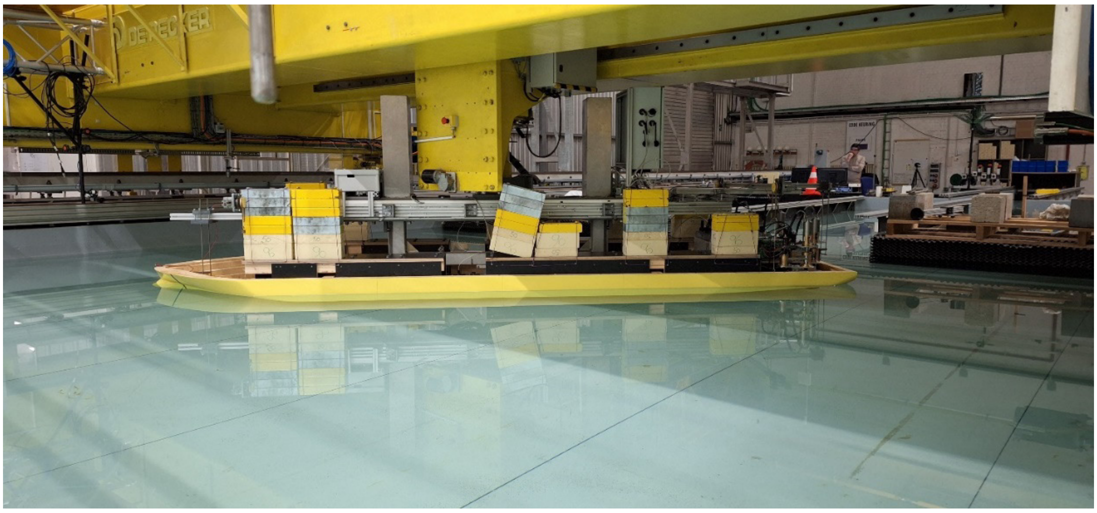


Figure 12-1 : Interference between the weigths distribution and the carriage structure.

Table 12-5 : SHP file O4002010201 used in ENV O4003A01.

List	Name	Remarks
Scheepsrompconfiguratie	O4002	Max rpm at 1075, safety rectangle at (-0.6 ; 1.05) and (0.6;1.05)
Modules	O400201	See description in Table 12-3 *Due to an unknown error in the WLSOW database, the duct "SB OUT" coordinates could not be updated. The values found in the SHP file are thus incorrect.*
Ladingscondities	O40020102	Ok
Ijkingswaarden	O4002010201	ok
Omgevingsfiles	O4003A01	Ok

12.5 Appended hull $T_M = T_F = T_A = 0.166$ m

Table 12-6 : SHP file O4003010101 used in ENV O4004A01,O4004A02.

List	Name	Remarks
Scheepsrompconfiguratie	O4002	Max rpm at 1075, safety rectangle at (-0.6 ; 1.05) and (0.6;1.05)
Modules	O400201	See description in Table 12-3 *Here, the coordinates of the duct "SB OUT"*
Ladingscondities	O40020102	Ok
Ijkingswaarden	O4002010201	ok
Omgevingsfiles	O4003A01	Ok

13 Attachment VII : optimising the test matrix

On 2024/12/05, the foreseen batch size is 298 appended tests in ENV O4003A02. This means that small gains on the total batch could lead to large gains in time for the full test series. At first test matrix (2024/12/05) was generated in Zeeman as separate tests all stating at x_0 = 5 m and running in the positive tank direction (+ , harbour to wave maker). Possible optimisations – for other UKC and loading conditions include

- Introduction of sub-trajectories and trajectvariables. During the meeting on 2024/12/02 there was warned for oscillations in measured signals in the sense that the trajectory should be long enough for signals to be analysed properly, e.g. via a Fourier Transform.
- Definition of paths running from wavemaker to harbour, saving on the time for terugglooptrajecten. For these definitions, it should be investigated if the orientation of the test has an effect on way the defined ψ value in the test definition is translated to a trajectory. Either psi related to the ship's heading (relative to the orientation of the trajectory) or to the position of the yaw table (absolute and not related to the orientation of the trajectory) In order to investigate this, four example tests are made , O4003A02_CT07-08-09-10, defined in Figure 13-1
    - CT07 psi = 0° u > 0 ship's heading = 0°
    - CT08 psi = 0 u < 0 ship's heading = 180°
    - CT09 psi = 180° u >0 ship's heading = 180°
    - CT10 psi = 180° u > 0 ship's heading = 0°

  <u>So the psi in trajectory definition is the absolute position of the psi-axis system</u>. Changing the orientation of the ship causes the ship's heading to shift with 180° relative to the psi-axis definition in the PFT file. This is substantiated when consulting the Zeeman manual WL2020R16_100_1, page 7. The following relationship is defined

$$\psi_{ship} = \psi_{table} \quad for\ test\ harbour\ to\ wavemaker\ (zin +)$$

$$\psi_{ship} = \psi_{table} + 180 \quad for\ test\ wavemaker\ to\ harbour\ (zin -)$$

This second observation be useful for two goals

- Test psi = 225° without entering the psi-axis forbidden zone
- Define tests from wavemaker to harbour to save time between two tests.

The alternative test definitions are defined in Table 13-1.

In the end, sufficient time was available to perform the test program without any of aforementioned optimisations.

*	Naam	X begin [m]	Y [m]	Psi [°]	Phi [°]	Z [m]	N1 [%]	N2 [%]	N3 [%]	N4 [%]	Roer1 [-]	Roer2 [-]	Roer3 [-]	Roer4 [-]	Zin [-]
☐	O4003A02_CT03	5	0	0	0	0	0	10	0	0	0	30	0	0	+
☐	O4003A02_CT04	5	0	0	0	0	0	0	15	0	0	0	-50	0	+
☐	O4003A02_CT05	5	0	0	0	0	0	0	0	20	0	0	0	-70	+
☐	O4003A02_CT06	5	0	-130	0	0	0	0	0	20	0	0	0	-70	+
☑	O4003A02_CT07	5	0	0	0	0	0	0	0	20	0	0	0	-70	+
☑	O4003A02_CT08	68	0	0	0	0	0	0	0	20	0	0	0	-70	-
☑	O4003A02_CT09	5	0	180	0	0	0	0	0	20	0	0	0	-70	+
☑	O4003A02_CT10	68	0	180	0	0	0	0	0	20	0	0	0	-70	-

Figure 13-1 : Definition of O4003A02_CT07-08-09-10.

Table 13-1 : Proposal alternative test definitions O40 tests in Zeeman.

ψ_{ship}	ψ_{table}	$\psi_{ship} = \psi_{table}$	$\psi_{ship} = \psi_{table} + 180$	Orientation "Zin"
0	0	✓		+
5	5	✓		+
10	10	✓		+
20	20	✓		+
45	45	✓		+
90	90	✓		+
135	135/-45	✓	✓	+
180	0		✓	-
225/-135	45		✓	-
270/-90	90		✓	-
315/-45	135		✓	-

14 Attachment VIII : propeller and azimuth verification tests

Table 14-1 : Propeller rate settings tryout trests O4003A02.

	n1 (%/%/s)			n2 (%/%/s)			n3 (%/%/s)			n4 (%/%/s)		
	m	A	T	m	A	T	m	A	T	m	A	T
O4003A02_MT01	50	30	40	30	30	60	70	30	80	40	20	100
O4003A02_MT02	50	20	40	30	30	60	40	30	80	40	20	100
O4003A02_MT03	0	50	100	0	50	100	0	50	100	0	50	100
O4003A02_CT01	5			10			15			20		
O4003A02_CT02	5											
O4003A02_CT03				10								
O4003A02_CT04							15					
O4003A02_CT05										20		

Table 14-2 : Rudder rate settings tryout tests O4003A02.

	d1 (°/°/s)			d2 (°/°/s)			d3 (°/°/s)			d4 (°/°/s)		
	m	A	T	m	A	T	m	A	T	m	A	T
O4003A02_MT01	50	50	40	150	50	60	-50	50	80	-100	30	100
O4003A02_MT02	50	50	40	100	50	60	-50	50	80	-100	30	100
O4003A02_MT03	0	0	0	0	0	0	0	0	0	0	0	0
O4003A02_CT01	10			30			-50			-70		
O4003A02_CT02	10											
O4003A02_CT03				30								
O4003A02_CT04							-50					
O4003A02_CT05										-70		

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