CONTENTS

1 INTRODUCTION AND OBJECTIVE

The purpose of the workshop is to benchmark the capabilities of different ship manoeuvring simulation methods such as those based on model tests, empirical calculations and CFD based methods by comparison of the results for the each of the following cases: a tanker, a container ship and a surface combatant. Predictions will be compared to each other and with free model test data. Predictions can be made using provided PMM and CMT (circular motion mechanism/rotating-arm) data or CFD data.

There are different possible ways to predict trajectories for manoeuvring ships. In particular the methods which are based on fitted forces have various possibilities. Every possible combination will result in different trajectories. This is illustrated in Figure 1.

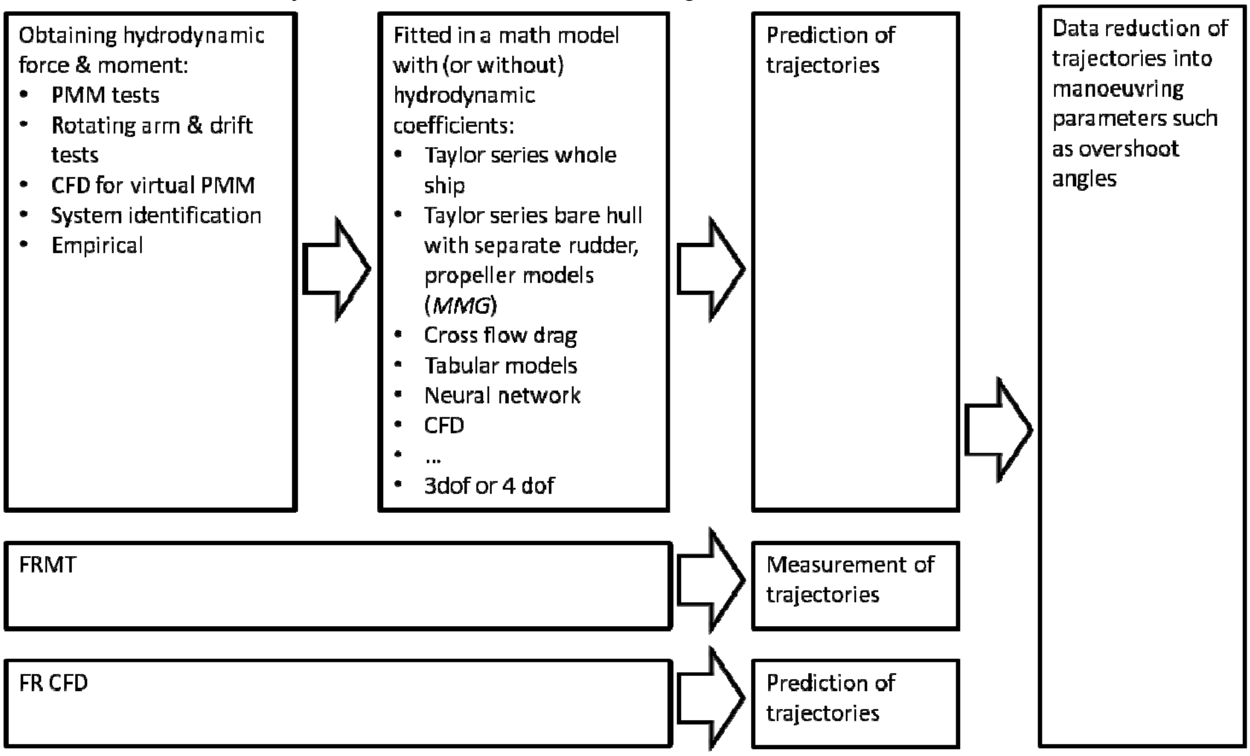

Figure 1: Different methods to predict trajectories and manoeuvring parameters

In the first edition of the workshop. SIMMAN 2008, it was observed that in particular the class of methods based on simulations showed quite large deviations, due to a variety of reasons. It is of importance for the hydrodynamicists all over the world to have insight in the reasons for the variety in predicted trajectories. In the SIMMAN2014 workshop we want to clarify this thoroughly.

Participants are asked to make manoeuvring predictions for one (or more) ships using one (or more) of the many existing methods. Empirical methods, hybrid methods and CFD based methods will be compared with both PMM/CMT and free model test data. The organisation will gather the results and compile the comparisons of the methods to each other.

Free model tests will be used for comparisons. The results of free model tests from the 2008 SIMMAN workshop are available, but the new free sailing results will be kept "blind" for all participants. This data will *not* be provided prior to the workshop. Until December 31, 2013, before the workshop, participants can submit predictions. The organizing committee will assemble all predictions and prepare comparisons for presentation at the workshop. In order to make this comparison a manageable task, all participants are requested to submit data according to the pre-defined formats defined in this document.

The objective of the workshop is:
To give feedback to participants on how their manoeuvring prediction method performs with respect to other prediction methods and in particular with respect to the 'ultimate results' i.e. in this case: the free model tests.
To establish a platform in which one can freely discuss the used methods with other open-minded participants.

2 SHIPS AND MANOEUVRES

2.1 Selectable ships

The participants can select one or more of the following ships:

Name	**Ship type**
KVLCC2	Full block single screw tanker
KCS	Single screw container ship
5415	Twin screw naval combatant

Table 1: Selectable ships

The necessary data for these ships is available on the website www.simman2014.dk. Lines plans, hydrostatic data and data of appendages including rudders and propellers can be downloaded.

2.2 Manoeuvres to be simulated

Dependent on the chosen water depth (deep or shallow), the participants are asked to make simulations of the following manoeuvres:

Deep water:

- 10/10 deg zig-zag tests including at least the first two overshoots with first execute of rudder to both port and starboard[1]
- 20/20 deg zig-zag tests including at least the first two overshoots with first execute of rudder to both port and starboard
- 35 deg turning circle tests with rudder to both port and starboard including pull-out, where rudder is put back at 0 deg after steady state has been reached

Shallow water:

- 10/2.5 deg zig-zag tests including at least the first two overshoots with first execute of rudder to both port and starboard
- 20/5 deg zig-zag tests including at least the first two overshoots with first execute of rudder to both port and starboard
- 35 deg turning circle tests with rudder to both port and starboard including pull-out, where rudder is put back at 0 deg after steady state has been reached
- Back and fill manoeuvre

Simulations should be performed for the speeds and test conditions given in the following table:

	Approach speed	Froude number[2]	Helm rate	h/T[3]	Corresp. captive test series (PMM / CMT)
KVLCC2	15.5 kn	0.142	2.32 deg/s	∞	INSEAN, HMRI / NMRI
KVLCC2	7.0 kn	0.063	2.32 deg/s	1.2 / 1.5 / 1.8	FHR, BSCH / -
KCS	24.0 kn	0.260	2.32 deg/s	∞	FORCE / NMRI / HHI
KCS	8.75 kn	0.095	2.32 deg/s	1.2 / 1.5 / 2.0 / 2.5	FHR, MOERI / -
5415	30.0 kn	0.413	9.0 deg/s	∞	MARIN / -

Table 2: Speeds and test conditions for manoeuvring simulations(*)

(*) Note that for all simulations propeller RPM corresponding to self-propulsion point of model and constant RPM strategy should be applied.

The simulations will be compared with the results of the corresponding free model tests.

[1] Positive rudder angles make ship turn to port; negative rudder angles make ship turn to starboard.
[2] Froude number based on Lpp.
[3] Water depth to draught ratio to indicate deep or shallow water

3 SUBMISSION PROCEDURES

This chapter describes what the participants have to submit prior to the workshop. Naturally, each organization can participate with several methods and is also welcome to make predictions for more than one ship.

Participants should submit 2 types of data files as follows:

For each predicted manoeuvre:

1. **1.** Time series of *positions and motions* i.e. time varying values of ship position, velocities, rudder angle and propeller RPM, referred to as the "motion file".
2. **2.** Time series of forces acting on the ship, i.e. hull forces, propeller forces, rudder forces, bilge keel forces, stabiliser forces (the last two were present on the 5415M), this file is referred to as the "force file"

To document the mathematical model:

1. Tables of total hydrodynamic forces (hull + propeller + rudder+stabilisers+bilge keels) used in the mathematical model, referred to as the "table file".

When making comparisons, it will be difficult to understand why the different methods are giving different results. This cannot be done solely by comparison of the time series of trajectories and velocities. It is the intention to compare the hydrodynamic forces used in the different mathematical models, which is the reason for including type no. 3.

Please submit all two types of data, but if it is not possible (for example due to restraints in the prediction program), participants should at least submit time series of the trajectories and velocities (type 1).

The data files should be prepared as described in the following sections.

3.1 General

Submission of the 2 types of data files:

- Data should be submitted in <u>full scale</u> values(*)
- SI units should be used throughout. Exceptions are angles in degrees and propeller revolutions in RPM.
- All data files are to be supplied in ASCII format, either a comma separated file or a fixed format file.

(*) Note that no scale effect corrections should be made on the resistance (or other forces) i.e. only Froude scaling should be applied. This enables direct comparison of results based on different model sizes.

3.1.1 Definitions

The following definitions are used:

total ship speed: $V_s = \sqrt{u^2 + v^2}$, where u is longitudinal velocity and v is transverse velocity

drift angle: $\beta = -\operatorname{atan}\frac{v}{u}$

rate of turn: $\gamma = r' = \frac{r \cdot L_{pp}}{V_s}$

3.1.2 Coordinate system and sign convention

The general coordinate system is ship-fixed, horizontal and right-handed with the z-axis *downwards*. The origin is defined at <u>midships</u>, on the centerline and at the waterline. This means that the forces are positive for: X-force forwards, Y-force to starboard, K-moment starboard into the water and N-moment bow to starboard.

The ship position (x_0,y_0) should be given in an Earth-fixed coordinate system with x_0 pointing North and y_0 pointing East. Heading angle at start of manoeuvre is defined as 0 deg.

All angles are defined positive clockwise i.e. heading positive for bow to starboard; rudder angle positive to trailing edge to portside.

3.2 File name convention

The name of data files should be: *organisation_method_ship_manoeuvre_rudder_type.dat*

where:

- *manoeuvre* is 'tc' for turning circle or 'zz' for zig-zag
- *rudder* is the applied rudder angle
- *type* is 'm' for motion time series, 'f' for force time series or 't' for tables of hydrodynamic forces

For example:

HSVA_PMM_KVLCC2_tc_-35_m.dat	indicates HSVA's file of motions based on PMM for the KVLCC2 in a turning circle test with -35 degrees (starboard) rudder angle.
MARIN_EMP-MPP_5415_zz_10_f.dat	indicates MARIN's file of hull, rudder and propeller forces based on an empirical prediction using the code MPP for the 5415 in a zig-zag test with 10 degrees rudder (and heading change) angles.
NMRI_CMT_KCS_t.dat	indicates NMRI's file of tabular hydrodynamic forces based on CMT tests for the KCS. Indication of manoeuvre and rudder are not necessary for the 't' type.

The following code names should be used for the different methods:

PMM	for manoeuvres predicted based on the analysis of PMM tests
CMT	for manoeuvres predicted based on the analysis of rotating arm / circular motion tests
EMP-xxyy	for manoeuvres predicted using an empirical method "xxyy"
NONV-zz	for manoeuvres predicted using a CFD method based on the non-viscous code "zz"
RANS-TD	for manoeuvres predicted using a full time domain RANS CFD method
RANS-COEF	for manoeuvres predicted using a RANS CFD method for determination of hydrodynamic derivatives for subsequent use in simulations
SI	for manoeuvres predicted based on system identification: the analysis of free model tests and the prediction of other free model tests from them
FREE	for free model test results (benchmark)

3.3 Contents of data files

3.3.1 Type 1 – Time series of positions and motions

The "motion file" with time series of motions should have the following layout:

The first 4 lines are comment lines, where the participant should identify the contents of the file. Ex.:

```
Organisation N, Empirical method XXYY
KCS container vessel
Zig-zag manoeuvre :  10.0 / -10.0
Time series of motions
```

Below follows a block of columns containing the time series data in the order given in Table 3.

Column	Symbol	Unit	Meaning	Reference
1	t	s	time	manoeuvre starts at zero i.e. the rudder starts to move at t=0. Time step for example 0.5 s (full scale).
2	x	m	x-position	position of ship origo[4] in Earth-fixed coordinate system (North). t=0 should conform to x=0. The starting track means that the ship moves along the x-axis.
3	y	m	y-position	position of ship origo in Earth-fixed coordinate system (East). t=0 should conform to y=0.
4	phi	deg	heel angle	starboard side in the water is a positive
5	psi	deg	heading angle	bow to starboard is positive
6	u	m/s	long. velocity	speed through the water of ship origo
7	v	m/s	transv. velocity	speed through the water of ship origo
8	p	deg/s	roll velocity	ship origo, starboard downwards is positive
9	r	deg/s	yaw velocity	ship origo, bow towards starboard is positive
10	delta	deg	rudder angle	trailing edge to portside is positive
11	n	RPM	prop. revolutions	positive clockwise seen from aft

Table 3: List of columns in "motion file"

An example of a (section of a) data file with time series of motions is given in Appendix I.

[4] Origin of ship: intersection between midships, centerline and waterline.

3.3.2 Type 2 – Time series of hull, rudder, propeller, fin stabiliser and bilge keel forces

The "force file" with time series of hull, rudder and propeller forces should have the following layout:

- The first 4 lines are comment lines, where the participant should identify the contents of the file. Ex.:

```
Organisation N, Empirical method XXYY
KCS container vessel
Turning circle manoeuvre : 35
Time series of total forces (hull + propeller + rudder force)
```

- Below follows a block of columns containing the time series data in the order given in Table 4.

Column	Symbol	Unit	Meaning	Reference
1	t	s	time	manoeuvre starts at zero i.e. the rudder starts to move at t=0. Time step for example 0.5 s (full scale).
2	Xh	N	hull force	contribution of total forces/moments originating from the hull, in ship-fixed, horizontal coord. System These forces EXCLUDE the centrifugal forces of m·v·r, m·u·r, and m·x_G·u·r.
3	Yh	N	hull force	
4	Kh	Nm	hull moment	
5	Nh	Nm	hull moment	
6	Xr	N	rudder force	contribution of total forces/moments originating from the rudder, in ship-fixed, horizontal coord. system
7	Yr	N	rudder force	
8	Kr	Nm	rudder moment	
9	Nr[5]	Nm	rudder moment	
10	Xp	N	propeller force	contribution of total forces/moments originating from the propeller, in ship-fixed, horizontal coord. system
11	Yp	N	propeller force	
12	Kp	Nm	propeller moment	
13	Np	Nm	propeller moment	
14	Xr2	N	rudder force	ONLY FOR 5415M contribution of total forces/moments originating from the 2nd rudder, in ship-fixed, horizontal coord. system
15	Yr2	N	rudder force	
16	Kr2	Nm	rudder moment	
17	Nr2	Nm	rudder moment	
18	Xp2	N	propeller force	ONLY FOR 5415M contribution of total forces/moments originating from the 2nd propeller, in ship-fixed, horizontal coord. system
19	Yp2	N	propeller force	
20	Kp2	Nm	propeller moment	
21	Np2	Nm	propeller moment	
22	X st1	N	stabiliser force	ONLY FOR 5415M contribution of total forces/moments originating from the STARBOARD STABILISER, in ship-fixed, horizontal coord. system
23	Y st1	N	stabiliser force	
24	K st1	Nm	heeling moment due to stabiliser	
25	N st1	Nm	yawing moment due to stabiliser	
26	X st2	N	stabiliser force	ONLY FOR 5415M contribution of total forces/moments originating from the PORTSIDE STABILISER, in ship-fixed, horizontal coord. system
27	Y st2	N	stabiliser force	
28	K st2	Nm	heeling moment due to stabiliser	

[5] Note that for the twin screw ship (5415) columns nos. 6-13 should refer to the starboard side and corresponding columns for the port side should be added as columns nos. 14-21.

29	N st2	Nm	yawing moment due to stabiliser	
30	X bk1	N	bilge keel force	ONLY FOR 5415M contribution of total forces/moments originating from the STARBOARD BILGE KEEL, in ship-fixed, horizontal coord. system
31	Y bk1	N	bilge keel force	
32	K bk1	Nm	heeling moment due to bilge keel	
33	N bk1	Nm	yawing moment due to bilge keel	
34	X bk2	N	bilge keel force	ONLY FOR 5415M contribution of total forces/moments originating from the PORTSIDE BILGE KEEL, in ship-fixed, horizontal coord. system
35	Y bk2	N	bilge keel force	
36	K bk2	Nm	heeling moment due to bilge keel	
37	N bk2	Nm	yawing moment due to bilge keel	

Table 4: List of columns in "force file".

3.3.3 Type 3 – Tables of total hydrodynamic forces

The “table file” containing tables of total hydrodynamic forces should have the following layout:

The first 4 lines are comment lines, where the participant should identify the contents of the file. Ex.:

```
Organisation N, Empirical method XXYY
KCS container vessel
Hydrodynamic forces
Drift angle and Rate of turn, X-force
```

- Below follows 3 x 4 (X, Y, K, N) tables containing the total hydrodynamic force/moment in N/Nm for the appended hull (hull + propeller + rudder) in the self-propulsion state at the approach speed. The 3 sets of tables are the combinations of:

drift angle (β) and rate of turn (γ)
drift angle (β) and rudder angle (δ)
rate of turn (γ) and rudder angle (δ)

Here the ranges should be: β from -20 to 20 deg, in steps of 2 deg
γ from -1.0 to 1.0, in steps of 0.2
δ from -35 to 35 deg, in steps of 5 deg

An example of a (section of a) file with tabular hydrodynamic forces is given in appendix II.

3.4 Upload of data

Participants should supply the data files by uploading them to the FORCE Technology FTP server. Data files should be placed in the given main folder in a sub-folder with the participant’s name. Login instructions and deadline for submission is given on the website www.simman2014.dk.

4 PRESENTED RESULTS AT THE WORKSHOP

It is the intention to compare and discuss various aspects at the workshop. Prior to the workshop the organizers will prepare comparison plots for every submitted ship/manoeuvre/method and the results will be presented and discussed.

4.1 Plots of time series of motions

The following plots will be generated:
Ship position x_0 versus y_0
Time series of δ, r, ϕ , β, V_s and sin β/γ

The free model test results will be used as benchmark data on these plots. An example of these comparison of time series is given in Figure 2.

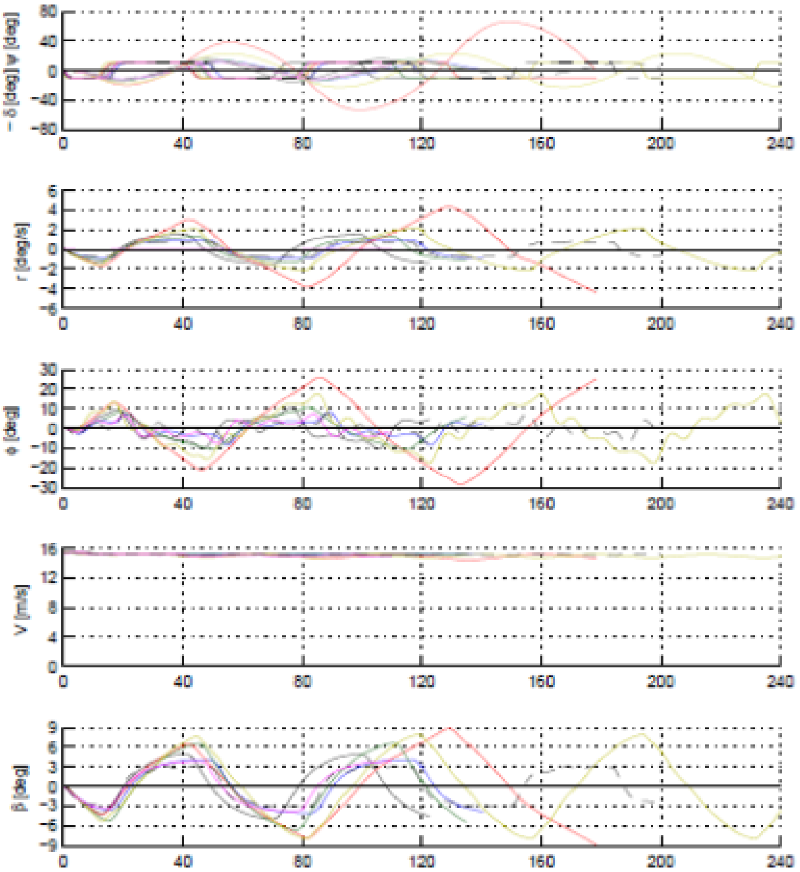

Figure 2: Comparison of time series of motions (rudder angle, heading, rate of turn, heel angle, velocity and drift angle)

4.2 Plots of hydrodynamic forces

The hydrodynamic forces and moments will be plotted against drift angle, turn rate and rudder angle to see where differences occur between the predictions and the PMM/CMT test results.

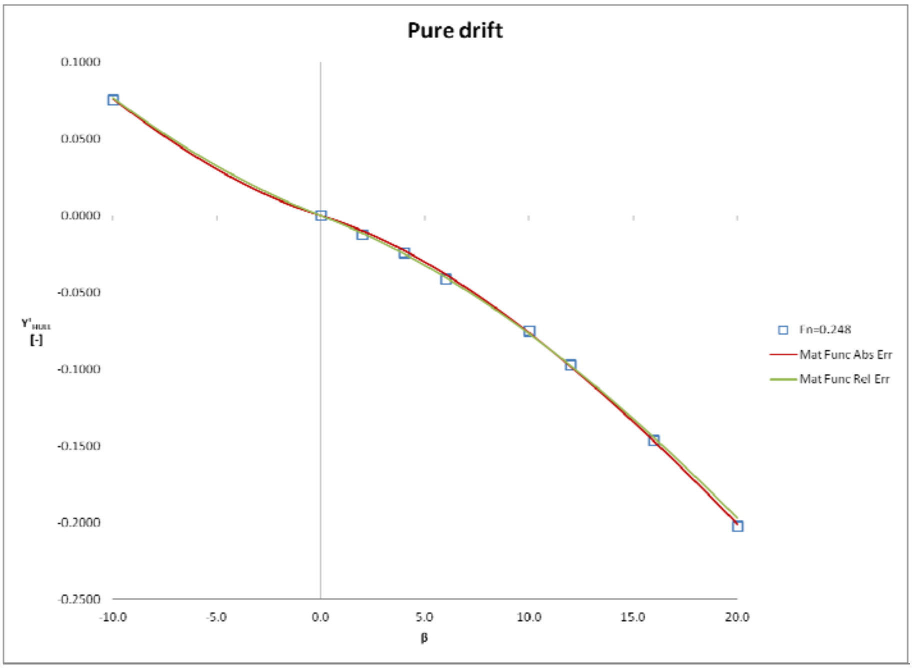

Figure 3: Plot of measured lateral force against drift angle (note the drift angle is in this example defined as β=atan(v/u), it will however be expected as β=-atan(v/u))

4.3 Plots of deduced results

The time series will be deduced to deduced manoeuvring key parameters such as advance, tactical diameter, overshoot angles, but also to other parameters. For the turning circle manoeuvre, this will be for example the constant rate of turn during a turning circle, the constant drift angle and the speed loss. For the zigzag manoeuvres, this will be for example the maximum rate of turn during the zigzag, the maximum heel angle, and the overshoot time.

These will be presented in bar-charts comparing the different results to each other. An example of such a bar-chart is given in Figure 4.

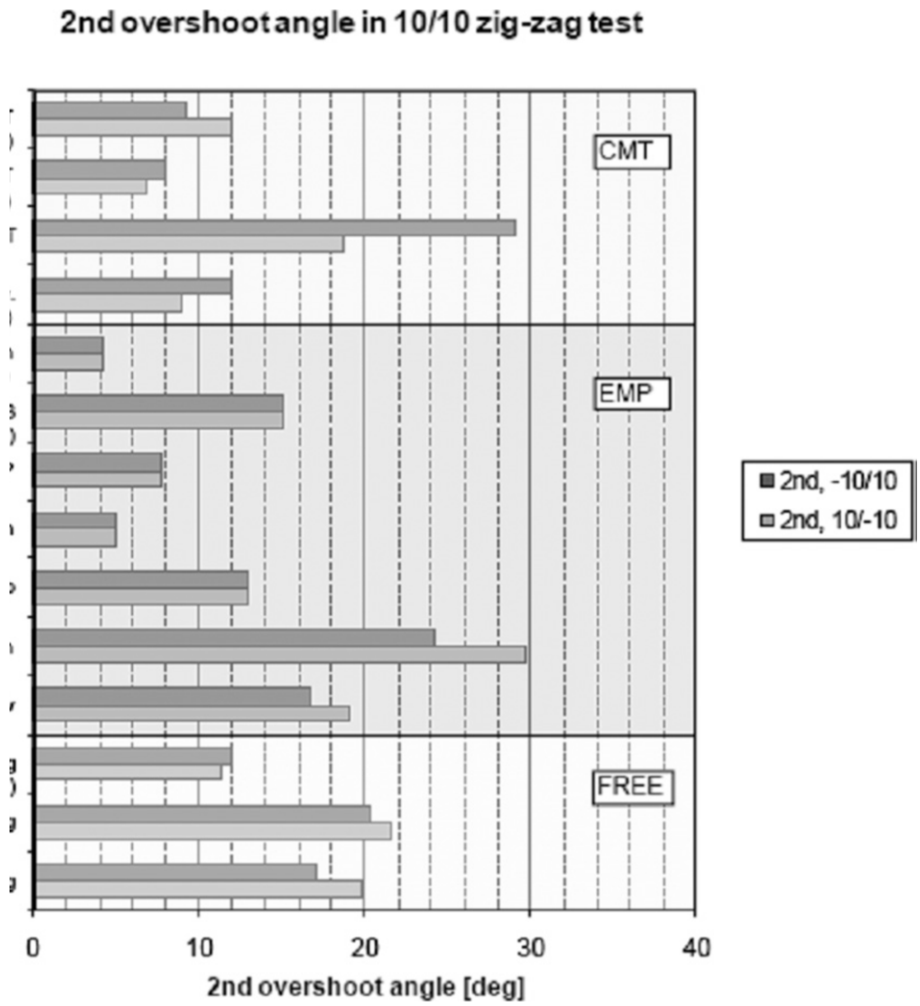

Figure 4: Bar charts comparison of resulting manoeuvring parameters

4.4 Foreseen further analyses

In order to clarify which aspects may lead to understanding the different predictions, the following analyses will be carried out. They are part of understanding the different step indicated in Figure 1.

4.4.1 Comparison of the forces and moments underlying manoeuvring simulations

By comparison of the measured and predicted forces and moments we hope to observe a difference in force levels as function of drift angle, rotation rates and rudder angles. Comparison are possible between different measurement techniques (PMM, CMT) and prediction methods (obtained through the data from section 3.3.3..

4.4.2 Comparison of fitting methods

Methods based on simulations are using either a fit or a tabular model. These fits are used to perform initial value time domain simulations. The formulas underlying the fit through measurement results will be different: modular models versus whole-ship models, MMG models versus 4 quadrant models, etcetera

4.4.3 4 dof versus 3 dof

There will be predictions based on mathematical models which are 3 dof, 3+1 dof or 4 dof. These mathematical models will result in different predictions. A comparison of the differences between the predictions and an explanation of the results.

4.4.4 Differences between free running tests

Based on the differences between the different FRMT, recommendations are made with respect to these test methods

4.4.5 Differences between FRMT and FR CFD

It is expected that also completely free running time domain CFD results are made by some participants. The differences between these are highlighted.

4.4.6 Analysis of PMM

In 2008, it was perceived that the more complicated test set-up, measurement and analysis of PMM tests may have lead to errors, especially with the organisations which were less experienced with PMM. This PMM analysis is investigated more thoroughly.

APPENDIX I: EXAMPLE OF FILE WITH TIME SERIES OF MOTIONS

```
MARIN, PMM
KCS container vessel
Zig-zag manoeuvre :  10.0 / -10.0
Time series of motions
0         0.00E+00  0.00E+00  0.00E+00  0.00E+00  5.14E+00  0.00E+00  0.00E+00  0.00E+00  0.00E+00  4.14E+02
0.5       2.57E+00  9.76E-06  1.23E-04  -4.80E-05 5.14E+00  7.66E-05  4.81E-04  -3.17E-04 1.16E+00  4.14E+02
1         5.14E+00  1.02E-04  5.44E-04  -4.38E-04 5.14E+00  3.66E-04  1.15E-03  -1.36E-03 2.32E+00  4.14E+02
1.5       7.72E+00  3.63E-04  1.22E-03  -1.51E-03 5.14E+00  8.78E-04  1.53E-03  -3.05E-03 3.48E+00  4.14E+02
2         1.03E+01  8.67E-04  2.05E-03  -3.59E-03 5.14E+00  1.62E-03  1.76E-03  -5.35E-03 4.64E+00  4.14E+02
2.5       1.29E+01  1.68E-03  2.96E-03  -6.96E-03 5.14E+00  2.58E-03  1.88E-03  -8.22E-03 5.80E+00  4.14E+02
3         1.54E+01  2.84E-03  3.92E-03  -1.19E-02 5.14E+00  3.77E-03  1.93E-03  -1.16E-02 6.96E+00  4.14E+02
3.5       1.80E+01  4.39E-03  4.87E-03  -1.87E-02 5.14E+00  5.19E-03  1.84E-03  -1.55E-02 7.93E+00  4.14E+02
4         2.06E+01  6.35E-03  5.72E-03  -2.74E-02 5.15E+00  6.77E-03  1.54E-03  -1.96E-02 8.60E+00  4.14E+02
4.5       2.32E+01  8.69E-03  6.39E-03  -3.83E-02 5.14E+00  8.47E-03  1.11E-03  -2.38E-02 9.05E+00  4.14E+02
5         2.57E+01  1.14E-02  6.83E-03  -5.12E-02 5.14E+00  1.02E-02  6.82E-04  -2.79E-02 9.35E+00  4.13E+02
5.5       2.83E+01  1.43E-02  7.08E-03  -6.61E-02 5.14E+00  1.21E-02  3.05E-04  -3.19E-02 9.56E+00  4.13E+02
6         3.09E+01  1.75E-02  7.15E-03  -8.30E-02 5.14E+00  1.39E-02  -1.07E-05 -3.57E-02 9.70E+00  4.13E+02
6.5       3.34E+01  2.07E-02  7.08E-03  -1.02E-01 5.14E+00  1.58E-02  -2.64E-04 -3.95E-02 9.80E+00  4.13E+02
7         3.60E+01  2.41E-02  6.89E-03  -1.23E-01 5.14E+00  1.77E-02  -4.60E-04 -4.30E-02 9.86E+00  4.13E+02
7.5       3.86E+01  2.74E-02  6.63E-03  -1.45E-01 5.14E+00  1.96E-02  -6.06E-04 -4.65E-02 9.91E+00  4.13E+02
8         4.12E+01  3.06E-02  6.29E-03  -1.69E-01 5.14E+00  2.15E-02  -7.12E-04 -4.97E-02 9.94E+00  4.13E+02
8.5       4.37E+01  3.37E-02  5.92E-03  -1.95E-01 5.14E+00  2.34E-02  -7.86E-04 -5.29E-02 9.96E+00  4.13E+02
9         4.63E+01  3.65E-02  5.51E-03  -2.22E-01 5.14E+00  2.53E-02  -8.34E-04 -5.59E-02 9.97E+00  4.13E+02
9.5       4.89E+01  3.90E-02  5.09E-03  -2.51E-01 5.14E+00  2.72E-02  -8.63E-04 -5.89E-02 9.98E+00  4.13E+02
10        5.14E+01  4.12E-02  4.65E-03  -2.81E-01 5.14E+00  2.90E-02  -8.77E-04 -6.17E-02 9.99E+00  4.13E+02
10.5      5.40E+01  4.29E-02  4.21E-03  -3.12E-01 5.14E+00  3.09E-02  -8.81E-04 -6.44E-02 9.99E+00  4.13E+02
11        5.66E+01  4.40E-02  3.77E-03  -3.45E-01 5.14E+00  3.28E-02  -8.77E-04 -6.71E-02 9.99E+00  4.13E+02
11.5      5.92E+01  4.46E-02  3.34E-03  -3.79E-01 5.14E+00  3.46E-02  -8.68E-04 -6.97E-02 1.00E+01  4.13E+02
12        6.17E+01  4.46E-02  2.91E-03  -4.15E-01 5.14E+00  3.64E-02  -8.56E-04 -7.22E-02 1.00E+01  4.13E+02
12.5      6.43E+01  4.38E-02  2.48E-03  -4.51E-01 5.14E+00  3.82E-02  -8.41E-04 -7.47E-02 1.00E+01  4.13E+02
13        6.69E+01  4.23E-02  2.07E-03  -4.89E-01 5.14E+00  4.00E-02  -8.26E-04 -7.71E-02 1.00E+01  4.13E+02
13.5      6.94E+01  3.99E-02  1.66E-03  -5.29E-01 5.14E+00  4.18E-02  -8.10E-04 -7.94E-02 1.00E+01  4.13E+02
14        7.20E+01  3.66E-02  1.26E-03  -5.69E-01 5.14E+00  4.36E-02  -7.93E-04 -8.17E-02 1.00E+01  4.13E+02
14.5      7.46E+01  3.24E-02  8.63E-04  -6.10E-01 5.14E+00  4.53E-02  -7.78E-04 -8.40E-02 1.00E+01  4.13E+02
15        7.72E+01  2.72E-02  4.78E-04  -6.53E-01 5.14E+00  4.71E-02  -7.62E-04 -8.62E-02 1.00E+01  4.13E+02
15.5      7.97E+01  2.09E-02  1.01E-04  -6.96E-01 5.14E+00  4.88E-02  -7.47E-04 -8.84E-02 1.00E+01  4.13E+02
16        8.23E+01  1.35E-02  -2.69E-04 -7.41E-01 5.14E+00  5.05E-02  -7.33E-04 -9.05E-02 1.00E+01  4.13E+02
16.5      8.49E+01  4.90E-03  -6.33E-04 -7.87E-01 5.14E+00  5.22E-02  -7.20E-04 -9.26E-02 1.00E+01  4.13E+02
17        8.74E+01  -4.93E-03 -9.89E-04 -8.34E-01 5.14E+00  5.39E-02  -7.07E-04 -9.47E-02 1.00E+01  4.13E+02
17.5      9.00E+01  -1.60E-02 -1.34E-03 -8.82E-01 5.14E+00  5.55E-02  -6.95E-04 -9.67E-02 1.00E+01  4.13E+02
18        9.26E+01  -2.85E-02 -1.68E-03 -9.30E-01 5.14E+00  5.72E-02  -6.84E-04 -9.88E-02 1.00E+01  4.13E+02
18.5      9.51E+01  -4.24E-02 -2.02E-03 -9.80E-01 5.14E+00  5.88E-02  -6.73E-04 -1.01E-01 1.00E+01  4.13E+02
19        9.77E+01  -5.77E-02 -2.36E-03 -1.03E+00 5.14E+00  6.04E-02  -6.63E-04 -1.03E-01 1.00E+01  4.13E+02
19.5      1.00E+02  -7.45E-02 -2.69E-03 -1.08E+00 5.14E+00  6.20E-02  -6.53E-04 -1.05E-01 1.00E+01  4.13E+02
20        1.03E+02  -9.28E-02 -3.01E-03 -1.14E+00 5.14E+00  6.36E-02  -6.43E-04 -1.07E-01 1.00E+01  4.13E+02
20.5      1.05E+02  -1.13E-01 -3.33E-03 -1.19E+00 5.14E+00  6.52E-02  -6.34E-04 -1.09E-01 1.00E+01  4.13E+02
21        1.08E+02  -1.34E-01 -3.64E-03 -1.24E+00 5.14E+00  6.67E-02  -6.26E-04 -1.10E-01 1.00E+01  4.13E+02
21.5      1.11E+02  -1.58E-01 -3.96E-03 -1.30E+00 5.14E+00  6.82E-02  -6.18E-04 -1.12E-01 1.00E+01  4.13E+02
22        1.13E+02  -1.83E-01 -4.26E-03 -1.36E+00 5.14E+00  6.97E-02  -6.10E-04 -1.14E-01 1.00E+01  4.13E+02
22.5      1.16E+02  -2.10E-01 -4.57E-03 -1.41E+00 5.14E+00  7.13E-02  -6.02E-04 -1.16E-01 1.00E+01  4.13E+02
23        1.18E+02  -2.38E-01 -4.86E-03 -1.47E+00 5.14E+00  7.27E-02  -5.94E-04 -1.18E-01 1.00E+01  4.13E+02
23.5      1.21E+02  -2.69E-01 -5.16E-03 -1.53E+00 5.14E+00  7.42E-02  -5.87E-04 -1.19E-01 1.00E+01  4.13E+02
24        1.23E+02  -3.01E-01 -5.45E-03 -1.59E+00 5.14E+00  7.57E-02  -5.80E-04 -1.21E-01 1.00E+01  4.13E+02
24.5      1.26E+02  -3.36E-01 -5.74E-03 -1.65E+00 5.14E+00  7.71E-02  -5.73E-04 -1.23E-01 1.00E+01  4.13E+02
25        1.29E+02  -3.73E-01 -6.03E-03 -1.71E+00 5.14E+00  7.85E-02  -5.67E-04 -1.25E-01 1.00E+01  4.13E+02
25.5      1.31E+02  -4.11E-01 -6.31E-03 -1.78E+00 5.14E+00  7.99E-02  -5.60E-04 -1.26E-01 1.00E+01  4.13E+02
26        1.34E+02  -4.52E-01 -6.59E-03 -1.84E+00 5.14E+00  8.13E-02  -5.54E-04 -1.28E-01 1.00E+01  4.13E+02
26.5      1.36E+02  -4.95E-01 -6.86E-03 -1.91E+00 5.14E+00  8.27E-02  -5.48E-04 -1.30E-01 1.00E+01  4.13E+02
27        1.39E+02  -5.40E-01 -7.13E-03 -1.97E+00 5.14E+00  8.41E-02  -5.41E-04 -1.31E-01 1.00E+01  4.13E+02
27.5      1.41E+02  -5.87E-01 -7.40E-03 -2.04E+00 5.14E+00  8.54E-02  -5.35E-04 -1.33E-01 1.00E+01  4.13E+02
28        1.44E+02  -6.37E-01 -7.67E-03 -2.10E+00 5.14E+00  8.68E-02  -5.29E-04 -1.34E-01 1.00E+01  4.13E+02
28.5      1.47E+02  -6.89E-01 -7.93E-03 -2.17E+00 5.14E+00  8.81E-02  -5.24E-04 -1.36E-01 1.00E+01  4.13E+02
29        1.49E+02  -7.44E-01 -8.19E-03 -2.24E+00 5.14E+00  8.94E-02  -5.18E-04 -1.38E-01 1.00E+01  4.13E+02
29.5      1.52E+02  -8.00E-01 -8.45E-03 -2.31E+00 5.13E+00  9.07E-02  -5.12E-04 -1.39E-01 1.00E+01  4.13E+02
30        1.54E+02  -8.60E-01 -8.70E-03 -2.38E+00 5.13E+00  9.20E-02  -5.07E-04 -1.41E-01 1.00E+01  4.13E+02
30.5      1.57E+02  -9.22E-01 -8.96E-03 -2.45E+00 5.13E+00  9.33E-02  -5.01E-04 -1.42E-01 1.00E+01  4.13E+02
31        1.59E+02  -9.86E-01 -9.20E-03 -2.52E+00 5.13E+00  9.45E-02  -4.96E-04 -1.44E-01 1.00E+01  4.13E+02
31.5      1.62E+02  -1.05E+00 -9.45E-03 -2.59E+00 5.13E+00  9.58E-02  -4.90E-04 -1.45E-01 1.00E+01  4.13E+02
32        1.65E+02  -1.12E+00 -9.70E-03 -2.67E+00 5.13E+00  9.70E-02  -4.85E-04 -1.47E-01 1.00E+01  4.13E+02
32.5      1.67E+02  -1.20E+00 -9.94E-03 -2.74E+00 5.13E+00  9.82E-02  -4.80E-04 -1.48E-01 1.00E+01  4.13E+02
```

APPENDIX II: EXAMPLE OF FILE WITH TABULAR FORCES

```
MARIN, PMM
KCS container vessel
Hydrodynamic forces
Drift angle and Rate of turn, Y-force
           -1.00     -0.80     -0.60     -0.40     -0.20      0.00      0.20
 -20.0  3.45E+06  2.33E+06  1.93E+06  1.64E+06  1.43E+06  1.28E+06  1.21E+06
 -18.0  2.84E+06  1.97E+06  1.64E+06  1.38E+06  1.19E+06  1.06E+06  1.03E+06
 -16.0  2.27E+06  1.65E+06  1.38E+06  1.15E+06  9.74E+05  8.63E+05  8.61E+05
 -14.0  1.76E+06  1.36E+06  1.14E+06  9.38E+05  7.82E+05  6.90E+05  7.13E+05
 -12.0  1.31E+06  1.10E+06  9.28E+05  7.48E+05  6.10E+05  5.39E+05  5.81E+05
 -10.0  8.99E+05  8.70E+05  7.38E+05  5.80E+05  4.59E+05  4.09E+05  4.64E+05
  -8.0  5.38E+05  6.63E+05  5.65E+05  4.31E+05  3.27E+05  2.98E+05  3.60E+05
  -6.0  2.22E+05  4.74E+05  4.06E+05  2.97E+05  2.13E+05  2.04E+05  2.70E+05
  -4.0 -5.42E+04  2.99E+05  2.58E+05  1.76E+05  1.17E+05  1.25E+05  1.91E+05
  -2.0 -2.95E+05  1.35E+05  1.19E+05  6.33E+04  3.46E+04  5.77E+04  1.16E+05
   0.0 -5.06E+05 -2.00E+04 -1.47E+04 -4.34E+04 -4.17E+04  0.00E+00  4.17E+04
   2.0 -5.41E+05 -1.53E+05 -1.41E+05 -1.45E+05 -1.16E+05 -5.77E+04 -3.46E+04
   4.0 -6.02E+05 -2.88E+05 -2.65E+05 -2.44E+05 -1.91E+05 -1.25E+05 -1.17E+05
   6.0 -6.88E+05 -4.26E+05 -3.87E+05 -3.42E+05 -2.70E+05 -2.04E+05 -2.13E+05
   8.0 -7.98E+05 -5.65E+05 -5.08E+05 -4.38E+05 -3.60E+05 -2.98E+05 -3.27E+05
  10.0 -9.29E+05 -7.05E+05 -6.27E+05 -5.36E+05 -4.64E+05 -4.09E+05 -4.59E+05
  12.0 -1.08E+06 -8.46E+05 -7.44E+05 -6.42E+05 -5.81E+05 -5.39E+05 -6.10E+05
  14.0 -1.24E+06 -9.88E+05 -8.65E+05 -7.62E+05 -7.13E+05 -6.90E+05 -7.82E+05
  16.0 -1.42E+06 -1.13E+06 -9.91E+05 -8.96E+05 -8.61E+05 -8.63E+05 -9.74E+05
  18.0 -1.60E+06 -1.28E+06 -1.13E+06 -1.04E+06 -1.03E+06 -1.06E+06 -1.19E+06
  20.0 -1.79E+06 -1.43E+06 -1.28E+06 -1.21E+06 -1.21E+06 -1.28E+06 -1.43E+06

MARIN, PMM
KCS container vessel
Hydrodynamic forces
Drift angle and Rate of turn, N-moment
           -1.00     -0.80     -0.60     -0.40     -0.20      0.00      0.20
 -20.0  1.84E+08  1.24E+08  1.00E+08  8.05E+07  6.36E+07  4.89E+07  3.58E+07
 -18.0  1.60E+08  1.11E+08  9.07E+07  7.24E+07  5.62E+07  4.23E+07  3.14E+07
 -16.0  1.38E+08  9.91E+07  8.13E+07  6.46E+07  4.93E+07  3.63E+07  2.71E+07
 -14.0  1.18E+08  8.77E+07  7.24E+07  5.70E+07  4.27E+07  3.07E+07  2.30E+07
 -12.0  9.92E+07  7.72E+07  6.37E+07  4.97E+07  3.65E+07  2.56E+07  1.90E+07
 -10.0  8.26E+07  6.74E+07  5.54E+07  4.25E+07  3.05E+07  2.08E+07  1.51E+07
  -8.0  6.79E+07  5.83E+07  4.74E+07  3.55E+07  2.48E+07  1.64E+07  1.14E+07
  -6.0  5.51E+07  4.98E+07  3.99E+07  2.87E+07  1.92E+07  1.22E+07  7.72E+06
  -4.0  4.42E+07  4.20E+07  3.27E+07  2.23E+07  1.38E+07  8.16E+06  4.11E+06
  -2.0  3.50E+07  3.48E+07  2.60E+07  1.63E+07  8.71E+06  4.12E+06  2.30E+05
   0.0  2.75E+07  2.81E+07  1.98E+07  1.08E+07  4.00E+06  0.00E+00 -4.00E+06
   2.0  2.84E+07  2.29E+07  1.42E+07  5.83E+06 -2.30E+05 -4.12E+06 -8.71E+06
   4.0  2.85E+07  1.79E+07  9.05E+06  1.29E+06 -4.11E+06 -8.16E+06 -1.38E+07
   6.0  2.81E+07  1.33E+07  4.43E+06 -2.76E+06 -7.72E+06 -1.22E+07 -1.92E+07
   8.0  2.73E+07  9.22E+06  3.93E+05 -6.30E+06 -1.14E+07 -1.64E+07 -2.48E+07
  10.0  2.61E+07  5.61E+06 -3.05E+06 -9.39E+06 -1.51E+07 -2.08E+07 -3.05E+07
  12.0  2.49E+07  2.62E+06 -5.86E+06 -1.23E+07 -1.90E+07 -2.56E+07 -3.65E+07
  14.0  2.37E+07  2.86E+05 -8.12E+06 -1.52E+07 -2.30E+07 -3.07E+07 -4.27E+07
  16.0  2.27E+07 -1.38E+06 -9.94E+06 -1.81E+07 -2.71E+07 -3.63E+07 -4.93E+07
  18.0  2.20E+07 -2.43E+06 -1.15E+07 -2.10E+07 -3.14E+07 -4.23E+07 -5.62E+07
  20.0  2.18E+07 -2.91E+06 -1.30E+07 -2.39E+07 -3.58E+07 -4.89E+07 -6.36E+07
```