Falling down safely

12 September 2013

Ingo Drummen (MARIN)

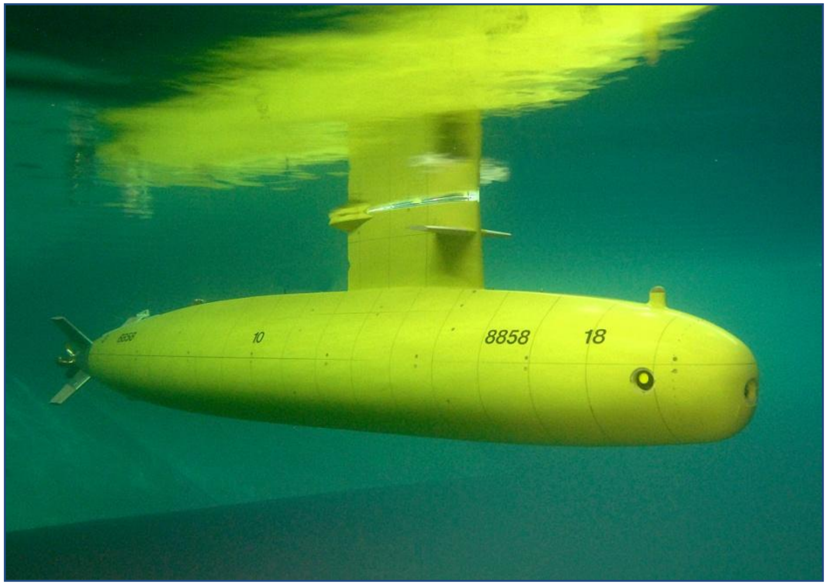
MARITIME RESEARCH INSTITUTE NETHERLANDS (MARIN)

Independent and innovative service provider for the maritime sector in hydrodynamic and nautical research

MARIN

DUAL MISSION

- To provide industry with innovative design solutions
- To carry out advanced research for the benefit of the maritime sector as a whole



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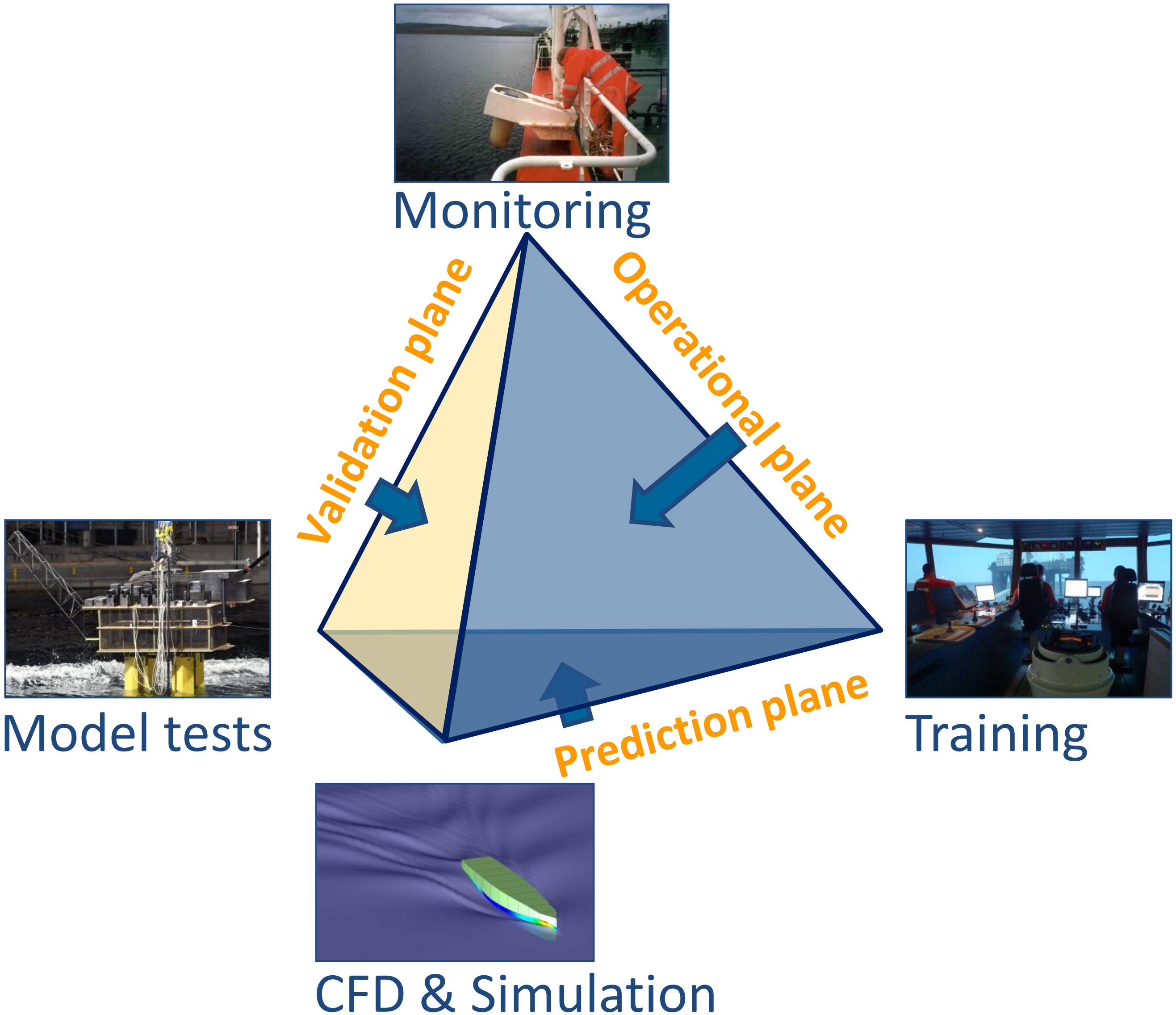
INTEGRATION OF MARIN ACTIVITIES



ORGANISATION

- Management
  - Quality Assurance
  - Personnel
  - Market & Communications
  - Finance & Control
  - Technology Transfer
  - R&D: Research Development
  - Production: Facilities Basins
  - MSG: Simulators Software
  - Offshore: Services
  - T&M: Full-scale Services
  - MSCN: Nautical Services
  - Ships: Services

LOCATION, FACTS AND FIGURES

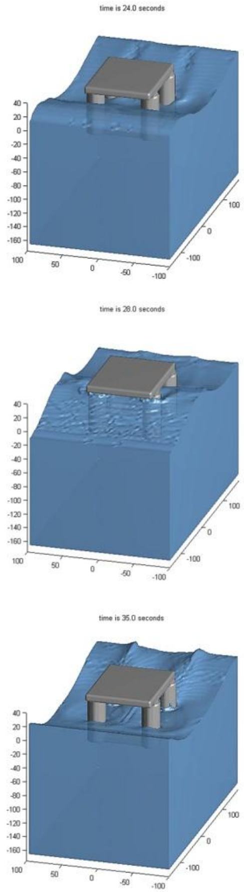
- One of the leading research institutes
- Located in the Netherlands and USA
- Joint Venture in China (SSSRI-MARIN Co. Ltd.)
- Agent in Brazil (Oceanica)

- 350 employees

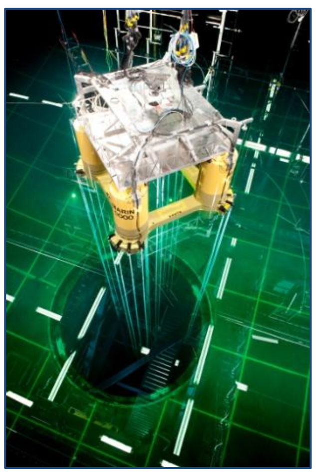
- Model tests since 1932
- Over 7300 propellers
- Over 9400 models

WORKING PRACTICE: TENSION LEG PLATFORM (TLPS)

- 30 metre deep pit
- Reliable wave motions, air-gap and deck impact loads
- Special set-up for VIM tests
- Full Scale



Simulation



Model testing

Full Scale

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FACILITIES

- Offshore Basin
- Seakeeping and Manoeuvring Basin
- Depressurised Wave Basin
- Deep Water Towing Tank
- Shallow Water Basin
- Concept Basin (MARIN Academy)
- Cavitation Tunnel
- Full Mission Simulators
- Tug Stations
- Vessel Traffic Simulator
- Full Scale Monitoring Systems
- Numerical Tools & Calculation Cluster

Introduction

Methodology

Simulation tools

Model scale experiments

Full scale experiments

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Full scale experiments

IN THE BEGINNING THERE WERE OPEN LIFE BOATS

- There were many accidents with open lifeboats
- In the late 19th century the idea of enclosed lifeboats came up
- The most notorious was Ole Brude's «Uræd» (1904) , which sailed across the Atlantic to the world exhibition in St. Louis. He arrived 4 months too late...

Length: 5.5 m

Width: 2.4m

Draft: 2.4m

Maximum capacity: ~40 people

Number of boats produced: 22

Reisen var en suksess, men verden var ikke klar for Ole Brude sin geniale oppfinnelse

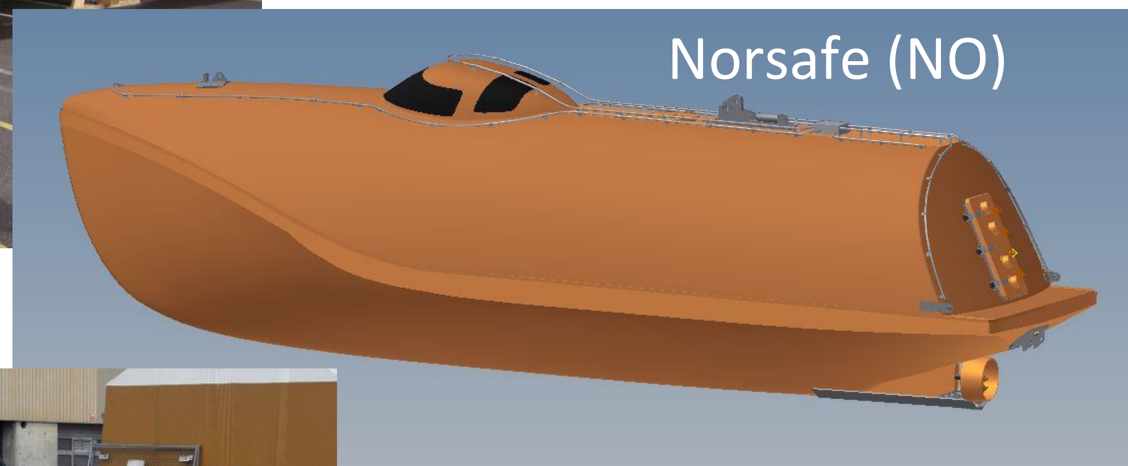
FREE FALL LIFE BOATS

- Free fall lifeboats started with Verhoef, 1962 (aluminium boats)
- Harding (USH), 1977 (composite)
- At present: on many platforms and ships
- “Skid” and “drop” versions are available.
- Present day designs will drop from higher and higher… the world record is now 66.8m

www.verhoef.eu

www.verhoef.eu

FREE FALL LIFE BOATS



VESLEFRIKK

- In June 2005 a lifeboat test was carried out at the «Veslefrikk» field in Norway, *without* people onboard
  - The entrance door was flung open
  - The canopy was compressed elastically
  - People sitting in the rear seats would have been killed
- This started a significant engineering and research activity for increasing safety of FFLBs
- Since 2010 MARIN has been working with the Norwegian Oil and Gas Association and Statoil to develop a methodology for assessing the sail-away capabilities of free fall lifeboats

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Introduction

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Full scale experiments

WHAT CAN BE EXPECTED FROM A LIFEBOAT?

Top requirement:

"A SAFE EXIT IN ALL CIRCUMSTANCES"

- Personnel shall be able to evacuate safe under all weather conditions
- Helicopter evacuation is preferred
- However, helicopter use is not possible…
  - above certain wind conditions (> 20 m/s wind velocity)
  - above certain platform motions (heave, pitch & roll)
- In these cases free fall lifeboats are used

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WHAT CAN BE EXPECTED FROM A LIFEBOAT?

Top requirement:

"A SAFE EXIT IN ALL CIRCUMSTANCES"

For free fall lifeboats, the main focus for "safe" is:

1. Structural integrity to be maintained
2. Acceptable g forces for people
3. Safe drop and safe sail-away

12-SEPTEMBER-'13: FALLING DOWN SAFELY

Company: *MARIN*
Speaker: *Ingo Drummen*
Position: *Senior Project Manager*
Company website: *www.marin.nl*

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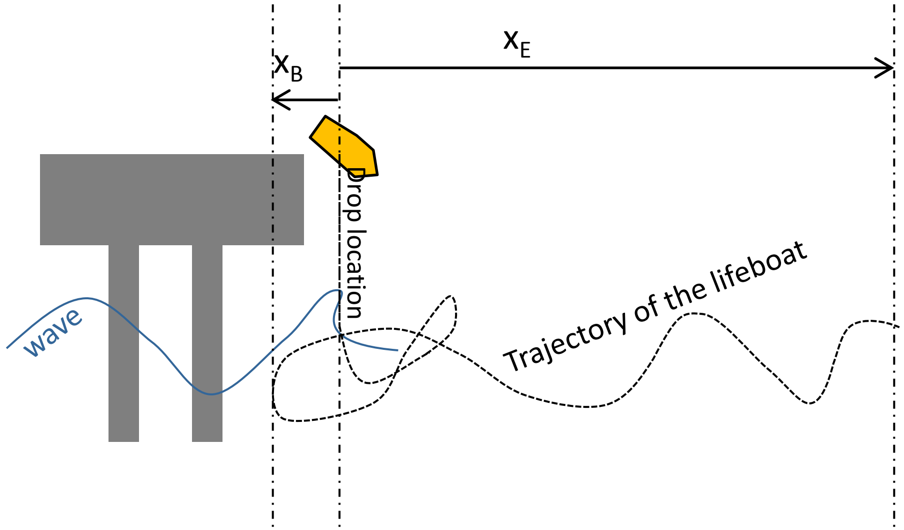
WHAT IS A 'SAFE DROP AND SAILAWAY'?

- No collision with the platform
- Being at a safe distance after *T* seconds (for example 60 seconds)

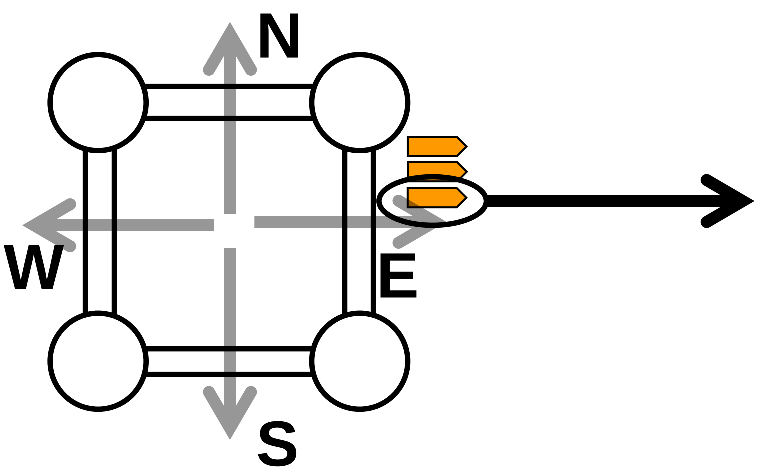


- x_B: maximum backdrift distance from the drop location during *T* seconds
- x_E : minimum required distance from the drop location after *T* seconds

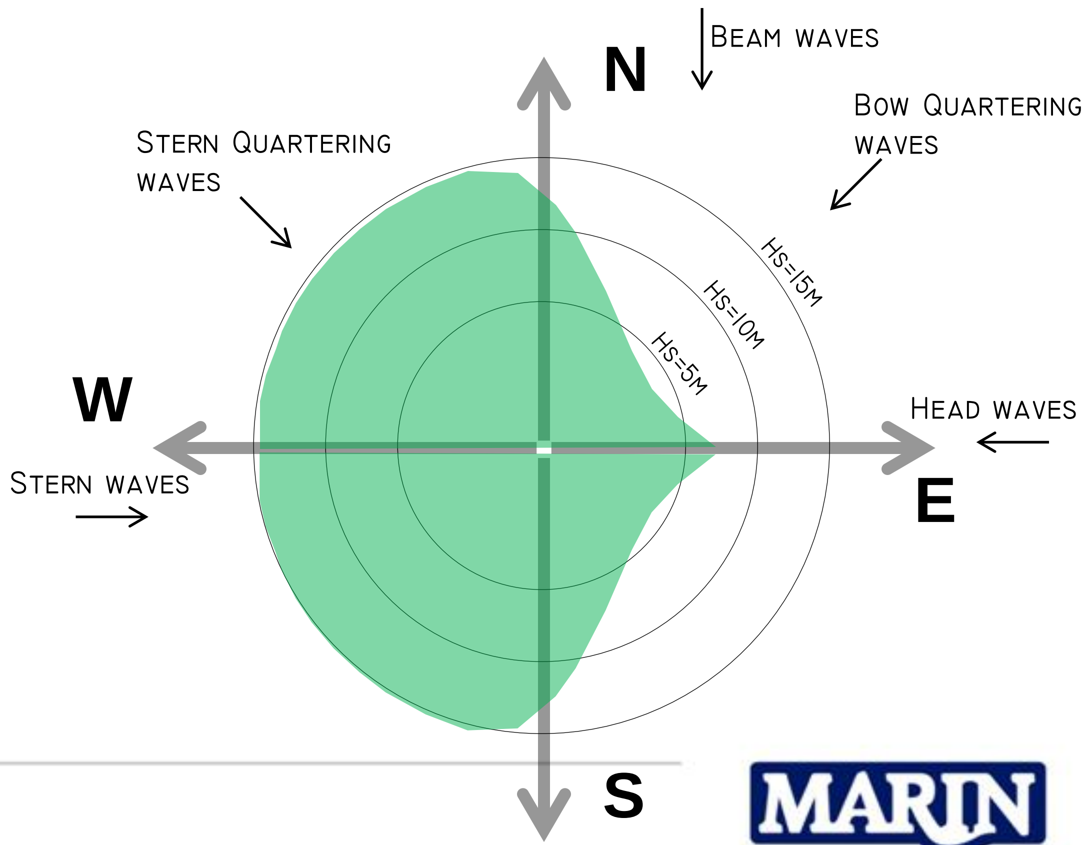
HOW TO DEMONSTRATE "SAFE DROP AND SAILAWAY"

- For every lifeboat on the platform, a polar diagram indicating safe drop and sailaway against wave direction and wave height

EXAMPLE TYPICAL PLATFORM



EXAMPLE POLAR DIAGRAM PER LIFEBOAT



STEPS IN METHODOLOGY

- Step 1: Estimate x_B and x_E based on limited number of simulations
- Step 2: Map this on wave scatter diagram
- Step 3: Multiply to obtain x_B and x_E per wave height

Estimated Limit of operation

Significant wave height Hs [m]																
17	-	-	-	-	-	-	-	-	-18	-8	0	8	14	20	25	29
16	-	-	-	-	-	-	-	-19	-8	2	10	16	22	28	32	37
15	-	-	-	-	-	-	-	-8	3	11	19	25	31	36	40	44
14	-	-	-	-	-	-	-	4	13	21	28	34	[illegible]	44	48	52
13	-	-	-	-	-	-	4	15	24	31	37	43	48	52	56	59
12	-	-	-	-	-	-	16	26	34	[illegible]	47	52	57	61	64	67
11	-	-	-	-	-	17	28	37	[illegible]	51	57	61	65	69	72	75
10	-	-	-	-	-	31	41	[illegible]	56	62	66	71	74	78	81	83
9	-	-	-	-	-	44	[illegible]	61	67	72	76	80	84	87	89	92
8	-	-	-	-	48	[illegible]	66	73	78	83	87	90	93	96	98	100
7	-	-	-	[illegible]	[illegible]	72	79	85	90	94	97	100	103	105	107	109
6	-	-	-	[illegible]	79	86	92	97	101	105	108	110	113	115	116	118
5	-	-	[illegible]	87	95	101	106	110	114	116	119	121	123	125	126	127
4	-	-	96	105	111	116	120	123	126	129	130	132	134	135	136	137
3	-	108	117	123	128	132	135	138	140	141	143	144	145	146	147	148
2	124	133	139	143	147	149	151	153	154	155	156	157	158	158	159	160
1	156	160	163	165	167	168	169	170	171	171	172	172	172	173	173	173
0	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Tp [s]	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

Hs (m)																			
>14																			
13-14																			
12-13												1	1	2	1	1			
11-12											1	3	5	5	3	1	1		
10-11									0	2	7	14	16	12	6	3	1		
9-10								0	2	12	31	45	40	25	11	4	1		
8-9							0	2	17	59	107	117	85	44	17	5	1		
7-8						0	2	21	96	220	290	245	144	63	22	6	1		
6-7					0	1	23	139	393	616	603	407	203	79	26	7	2		
5-6				0	1	26	191	633	1135	1263	965	548	246	91	29	8	2		
4-5			0	1	32	264	957	1865	2266	1914	1219	622	266	99	33	10	3	1	
3-4		0	2	46	399	1466	2912	3672	3294	2281	1296	632	274	108	40	14	5	3	1
2-3	0	2	82	697	2443	4669	5810	5297	3841	2349	1265	618	281	121	50	20	8	3	2
1-2	3	115	948	3046	5352	6270	5550	4030	2539	1444	762	381	183	86	39	18	8	4	3
0-1	20	215	718	1193	1289	1061	731	448	253	135	70	35	17	9	4	2	1	0	0
	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9 - 10	10 - 11	11 - 12	12 - 13	13 - 14	14 - 15	15 - 16	16 - 17	17 - 18	18 - 19	19 - 20	20 -

Hs (m)																				
>16	-	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	
15-16	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	
14-15	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0
13-14	-	-	-	-	-	-	-	-	0	0	0	0	0	0	0	0	0	0	0	0
12-13	-	-	-	-	-	-	-	0	0	0	0	7.356	8.276	18.15	9.78	10.4	0	0	0	54
11-12	-	-	-	-	-	-	-	0	0	0	2.535	8.531	15.55	16.71	10.64	3.726	3.887	0	0	62
10-11	-	-	-	-	-	-	0	0	0	1.721	6.741	14.71	18.01	14.3	7.495	3.901	1.346	0	0	68
9-10	-	-	-	-	-	-	0	0	0.669	4.482	12.6	19.55	18.35	11.99	5.481	2.059	0.529	0	0	76
8-9	-	-	-	-	-	-	0	0.274	2.602	9.805	18.96	21.83	16.55	8.878	3.536	1.067	0.218	0	0	84
7-8	-	-	-	-	-	0	0.122	1.433	7.097	17.3	23.95	21.05	12.79	5.756	2.059	0.573	0.097	0	0	92
6-7	-	-	-	-	-	0.03	0.762	4.979	14.93	24.5	24.89	17.32	8.864	3.525	1.182	0.324	0.094	0	0	101
5-6	-	-	-	-	0.016	0.461	3.646	12.77	23.9	27.51	21.6	12.55	5.745	2.161	0.699	0.195	0.049	0	0	111
4-5	-	-	-	0.01	0.338	2.99	11.41	23.1	28.92	25.03	16.26	8.435	3.658	1.378	0.464	0.142	0.043	0.014	0	122
3-4	-	-	-	0.316	2.924	11.24	23.07	29.84	27.31	19.22	11.07	5.46	2.39	0.95	0.354	0.125	0.045	0.027	0.009	134
2-3	-	-	0.384	3.447	12.53	24.57	31.17	28.85	21.17	13.07	7.098	3.492	1.597	0.691	0.287	0.115	0.046	0.017	0.012	149
1-2	-	0.569	4.869	16	28.56	33.83	30.2	22.08	13.98	7.988	4.231	2.122	1.022	0.481	0.219	0.101	0.045	0.023	0.017	166
0-1	0.645	6.934	23.16	38.48	41.57	34.22	23.58	14.45	8.16	4.354	2.258	1.129	0.548	0.29	0.129	0.065	0.032	0	0	200
	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9 - 10	10 - 11	11 - 12	12 - 13	13 - 14	14 - 15	15 - 16	16 - 17	17 - 18	18 - 19	19 - 20	20 - 21	

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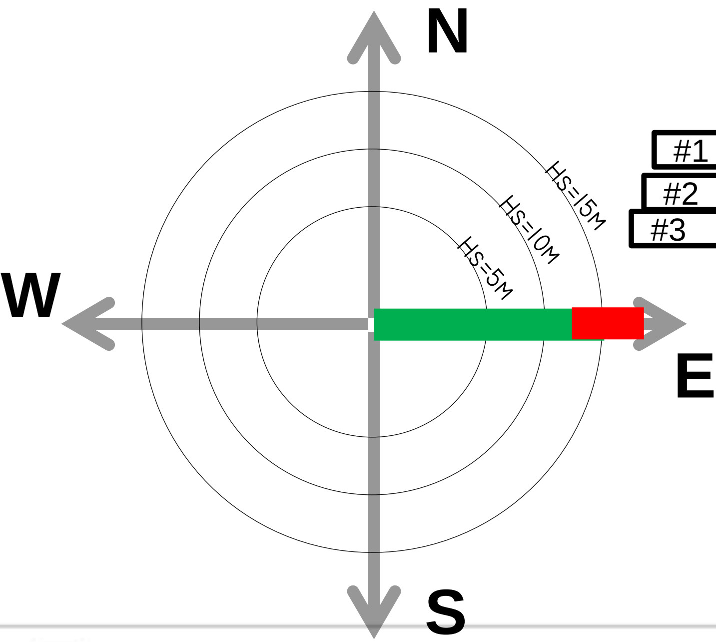
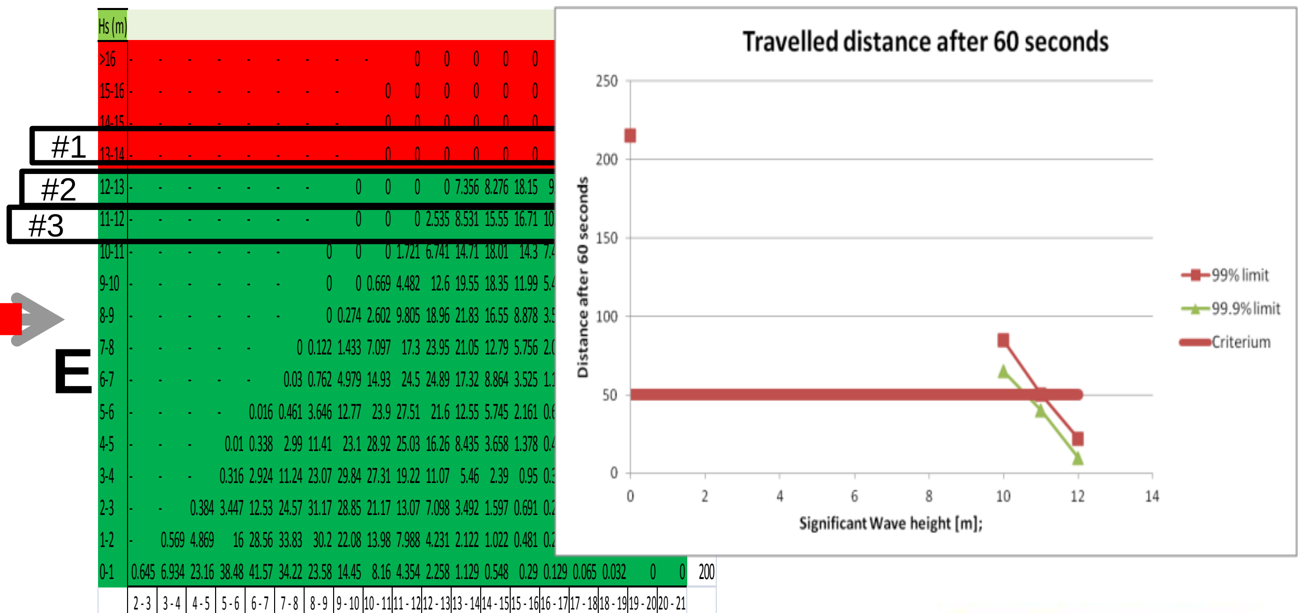
STEPS IN METHODOLOGY

- Step 4: Plot this in polar to get *estimated* limiting wave height

Polar diagram per lifeboat



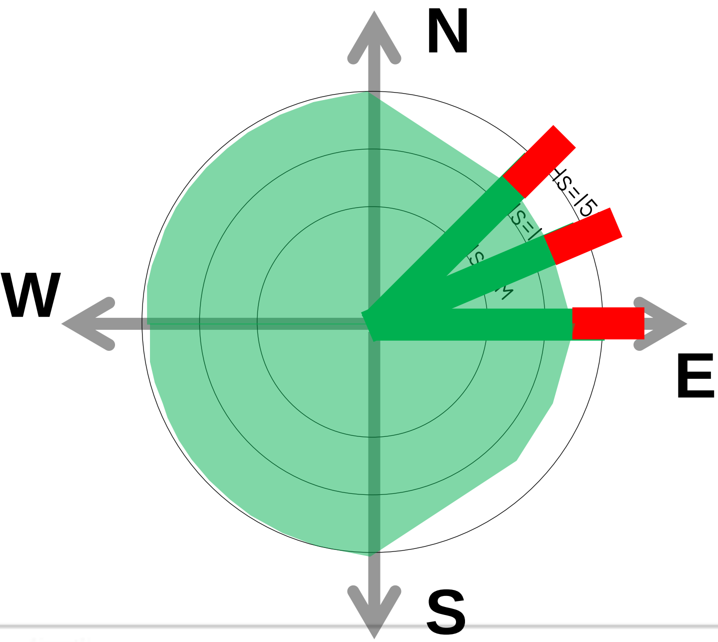
- Step 5: Defined required refinement step
- Step 6: Perform large number of simulations in the selected wave heights



STEPS IN METHODOLOGY

- Step 7: Plot this in polar to get *real* limiting wave height

Polar diagram per lifeboat



PRACTICAL IMPLICATIONS OF THIS METHODOLOGY

- Typically, about 500,000+ realisations are needed for one lifeboat and one location
  - Not practical in model tests
  - Not practical in CFD
  - Not practical on full scale tests
- The wave heights to be studied are huge
  - Too large for model tests (typical model size 1m, needs waves of 1.5 meter)
  - Not practical for full scale tests
- Fast time simulations tools (which are schematic) could be a solution

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Introduction

Methodology

Simulation tools

Model scale experiments

Full scale experiments

SCHEMATIC FAST TIME SIMULATIONS

- Software that predicts trajectories, motions and manoeuvres will be needed
- Software requirements
  - Able to cope with extreme weather (Hs 15meter)
  - Able to calculate approximately real time
  - Fully non-linear, hence time domain
  - Wind, (oblique) waves, propeller and (steerable) nozzle

POSSIBLE APPROACHES

Approach 1

- Simulations for a drop
  simulation for a sailaway

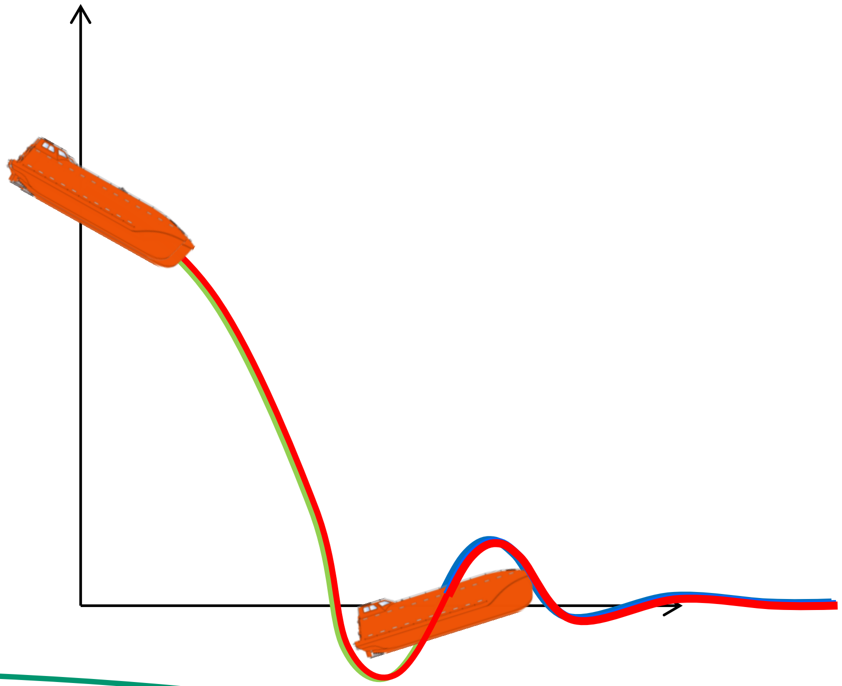
Approach 2

- Get a statistical prediction for the point of surfacing
- Simulate the other trajectory

Approach 3

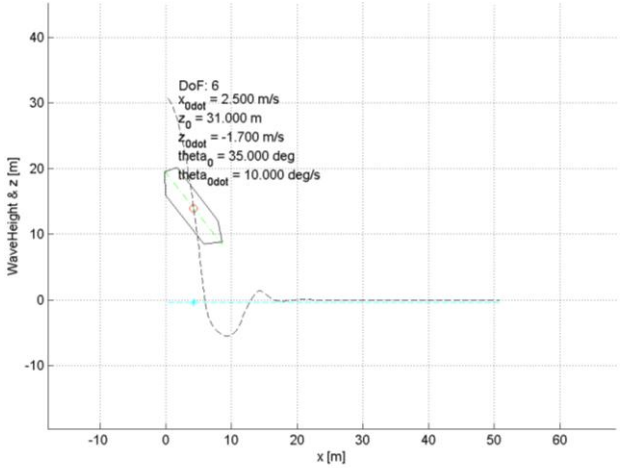
- Simulate everything in 1 go

Preferred approach = DROPSIM



WHAT IS DROPSIM?

- DROPSIM simulates a drop of a lifeboat (in calm water and sea states)
- DROPSIM is a 6-degrees of freedom time-domain simulation program
- DROPSIM is tailor-made for free fall lifeboats

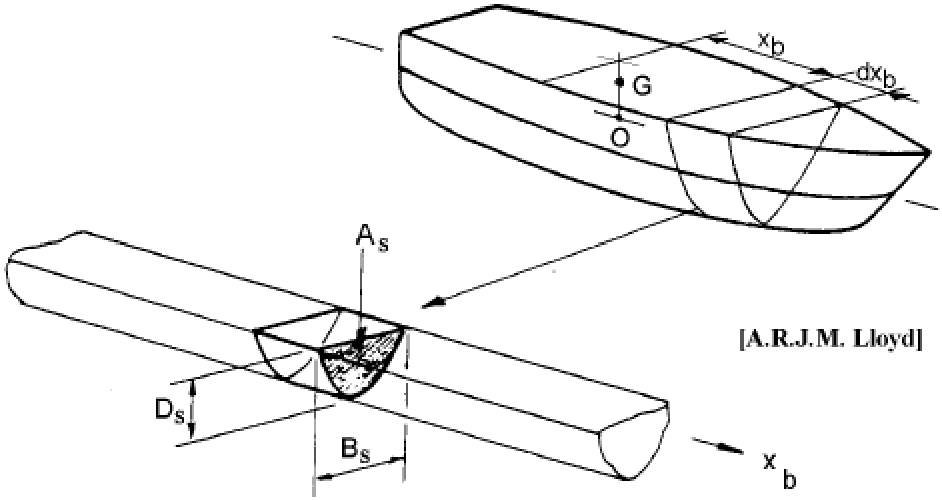


- The advantages about DROPSIM
  - It calculates very fast
  - It is affordable to perform large numbers of simulations for many conditions

- The disadvantages about DROPSIM are:
  - It is a crude schematisation of physics, based on first principles (which may be seen as an advantage too)
  - Consequently: it will not capture all detailed physics
  - Consequently: the accuracy in absolute sense is expected to be limited

BASIC APPROACH

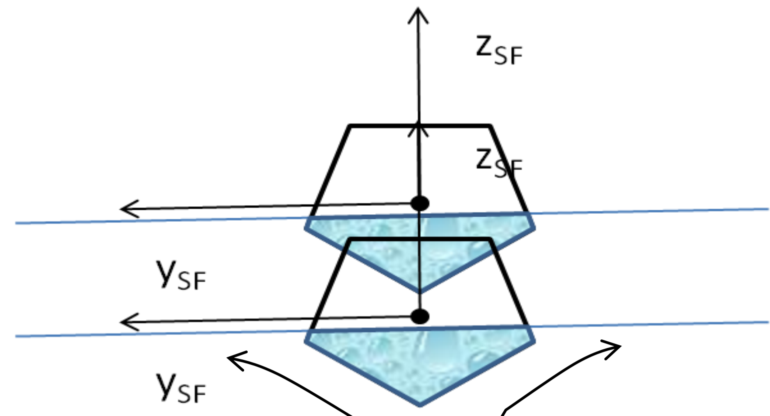
- Strip theory



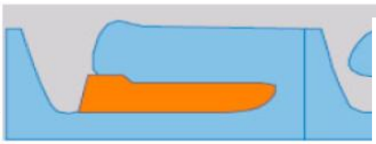
[A.R.J.M. Lloyd]

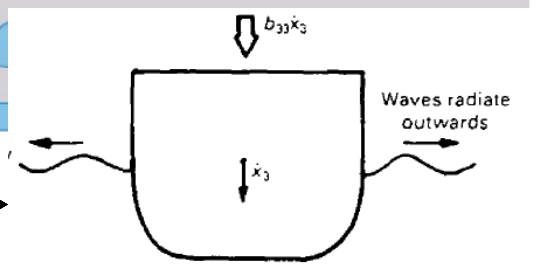
WHAT IS IN DROPSIM

- Forces which are acting on the body:
  - Gravity forces
  - Buoyancy forces
  - Impact forces
  - Resistance
  - Cross flow drag
  - Propeller & nozzle forces
  - Wind forces
  - Push force
  - Damping



$$Z_{DragSF} = \int_{x=A_{PP}}^{F_{PP}} -c_{Dx} \cdot \frac{1}{2} \cdot \rho \cdot W \cdot |W| \cdot b_x \cdot dx$$





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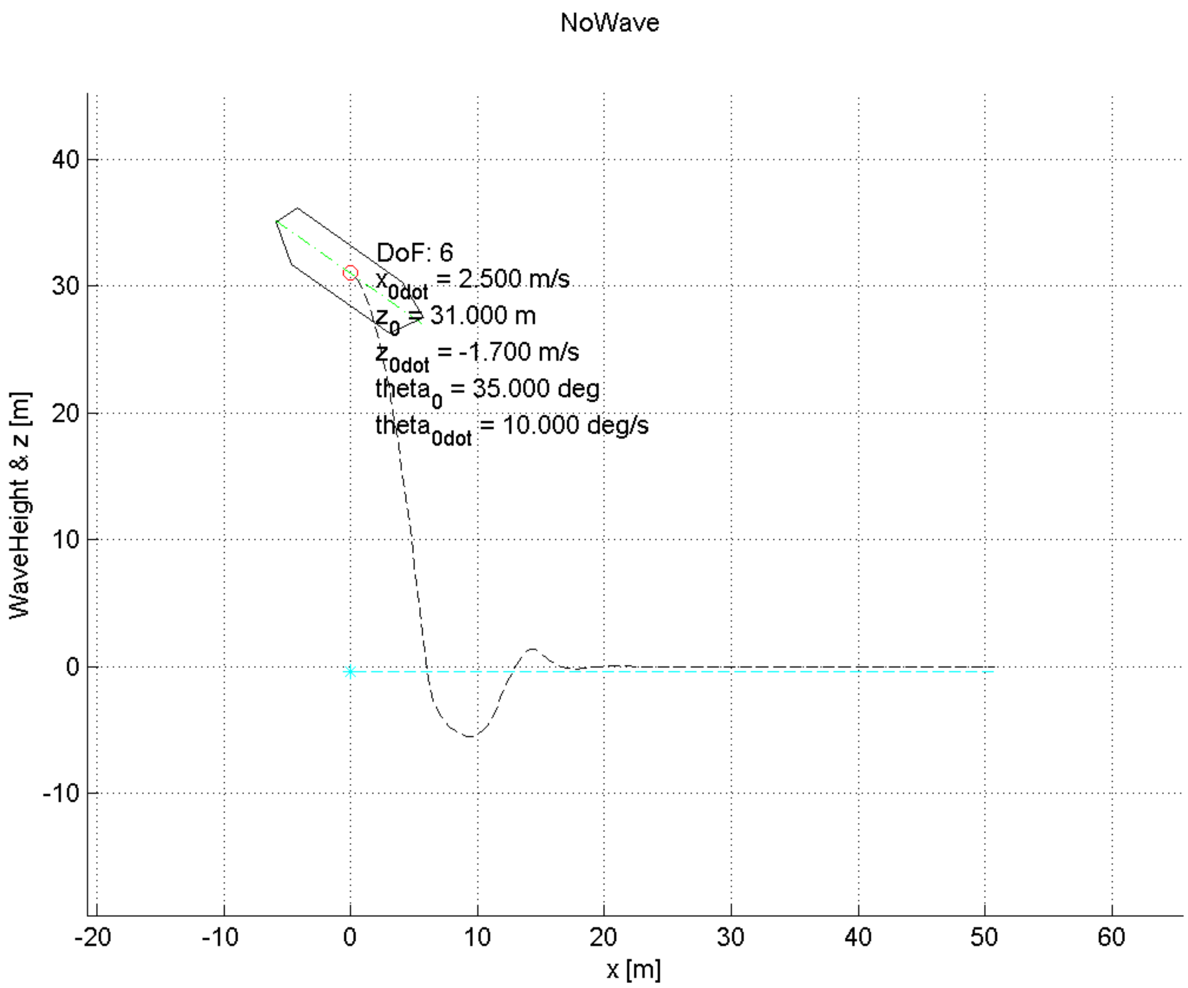
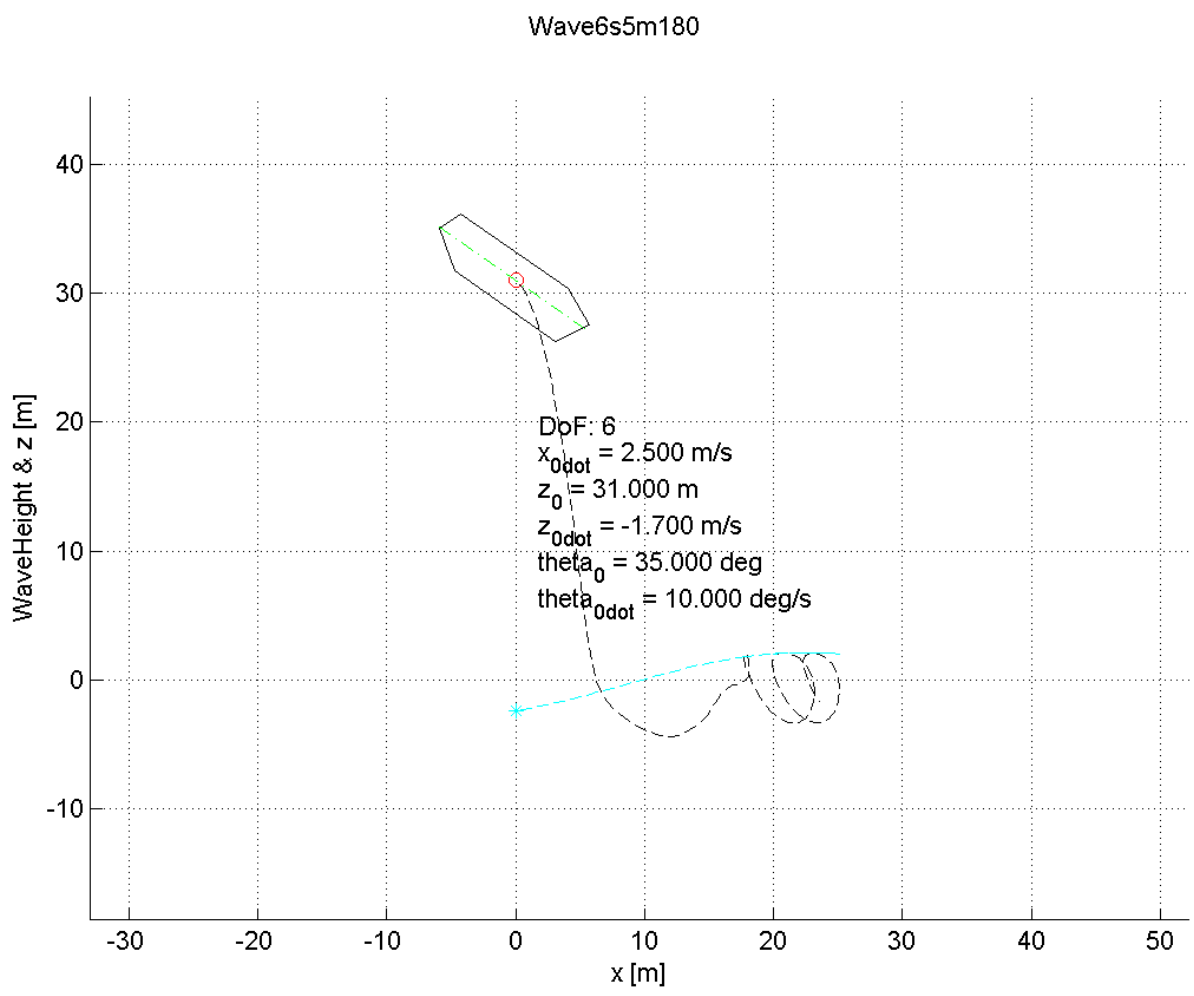
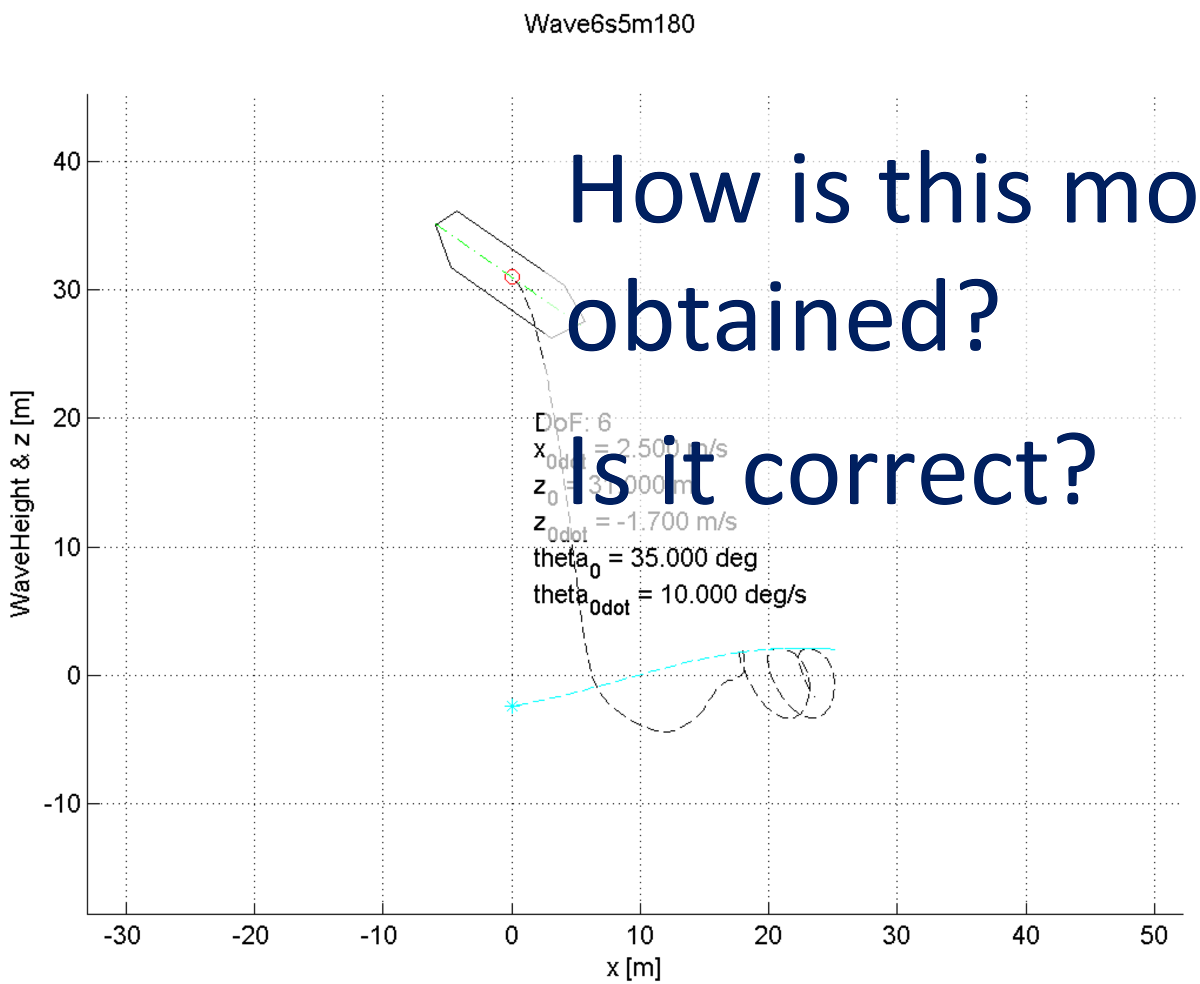
DROPSIM SIMULATIONS



DROPSIM SIMULATIONS





How is this model obtained?

Is it correct?


Challenging wind and waves
Linking hydrodynamic research to the maritime industry

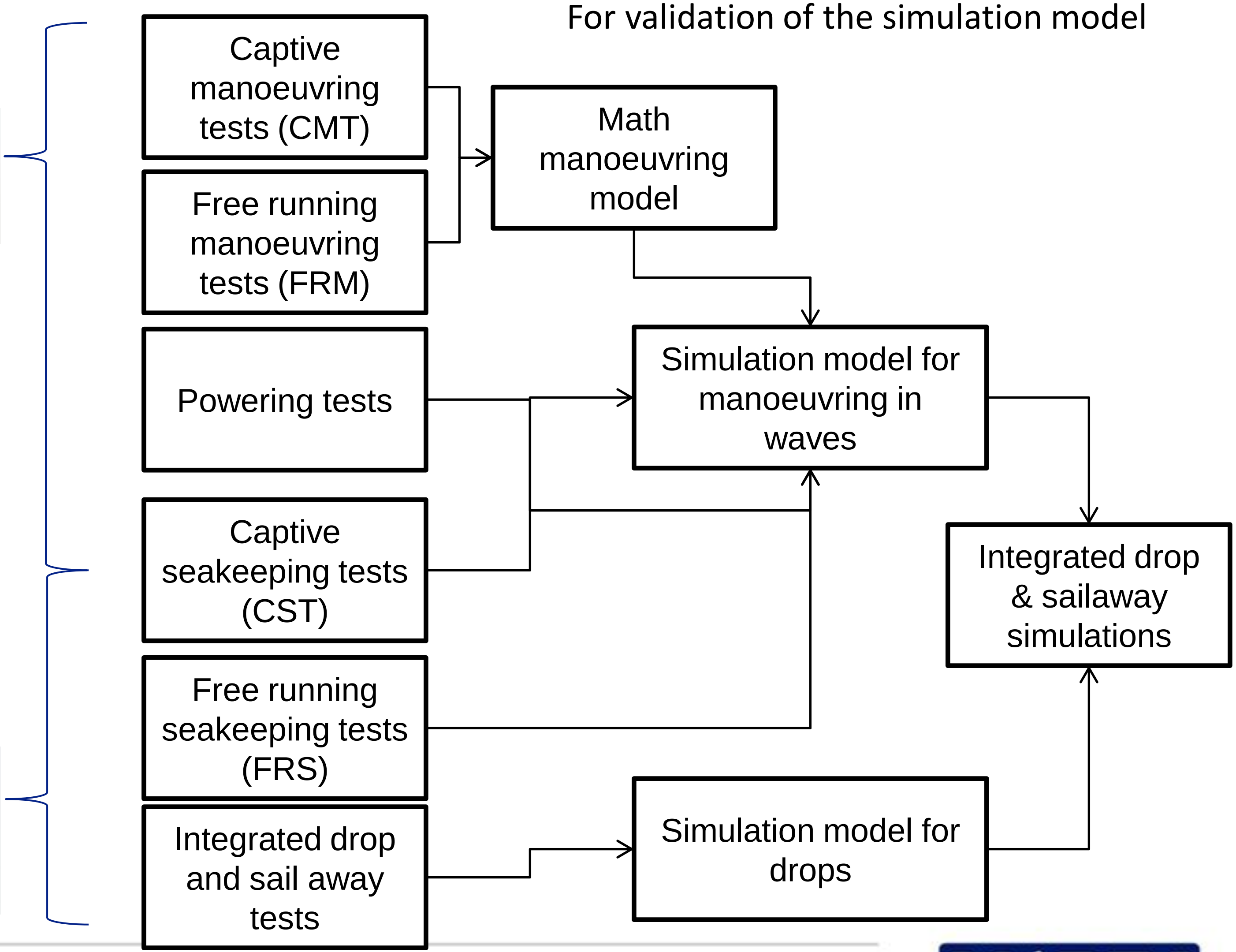
WHICH MATERIAL DO WE WANT?

Direct feed in the simulation model

For validation of the simulation model

SCALE +/- 1:5

SCALE +/- 1:12



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CAPTIVE MANOEUVRING TESTS

- **Captive manoeuvring tests (CMT)**
- Free running manoeuvring tests (FRM)
- Captive seakeeping tests (CST)
- Free running seakeeping tests (FRS)
- Powering tests
- Integrated drop and sail away tests

FREE RUNNING MANOEUVRING TESTS

Captive manoeuvring tests (CMT)

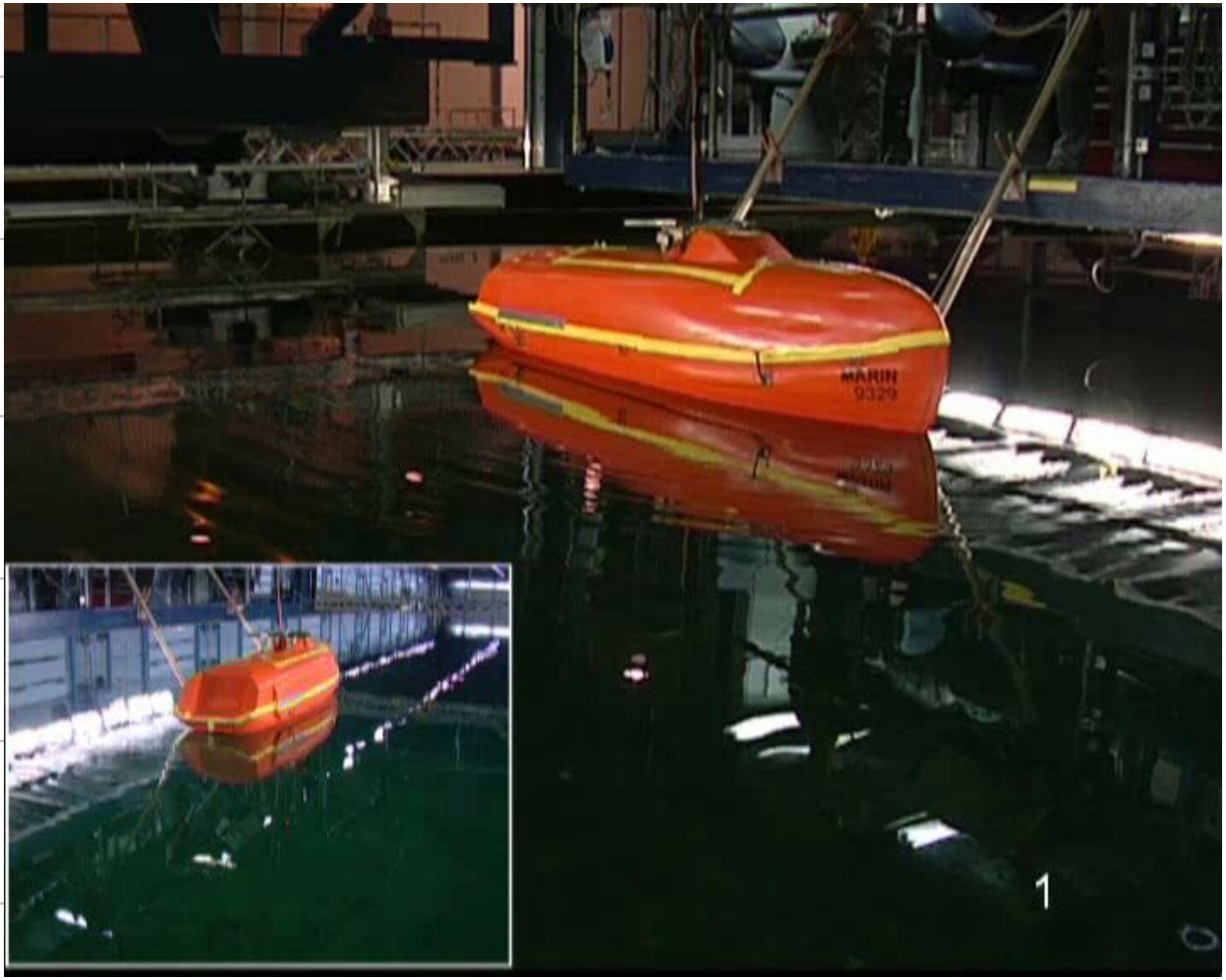
Free running manoeuvring tests (FRM)

Captive seakeeping tests (CST)

Free running seakeeping tests (FRS)

Powering tests

Integrated drop and sail away tests



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CAPTIVE SEAKEEPING TESTS (1:5)

- Captive manoeuvring tests (CMT)
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CAPTIVE SEAKEEPING TESTS (1:13)

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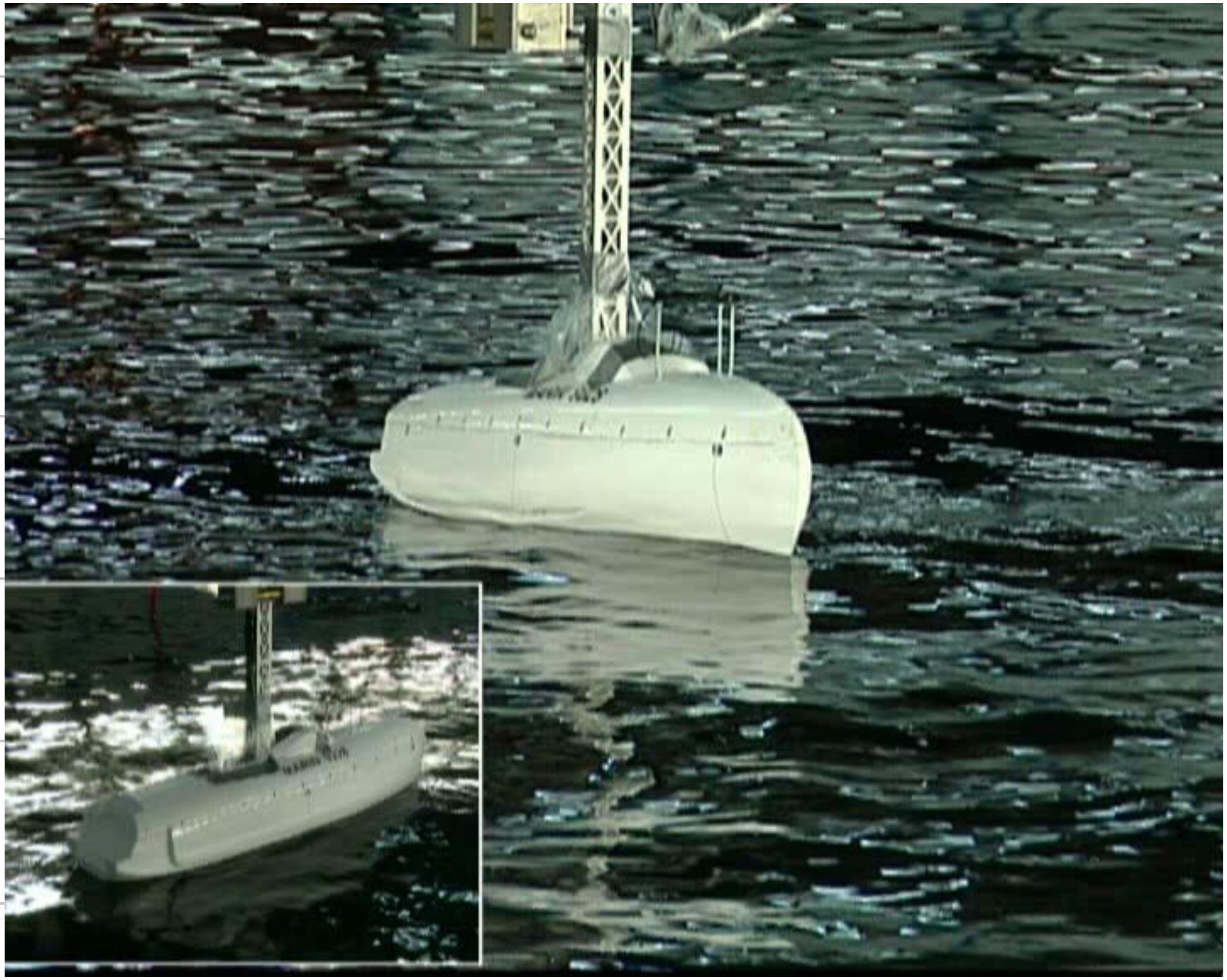

FREE RUNNING SEAKEEPING TESTS

Captive manoeuvring tests (CMT)

Free running manoeuvring tests (FRM)

Captive seakeeping tests (CST)

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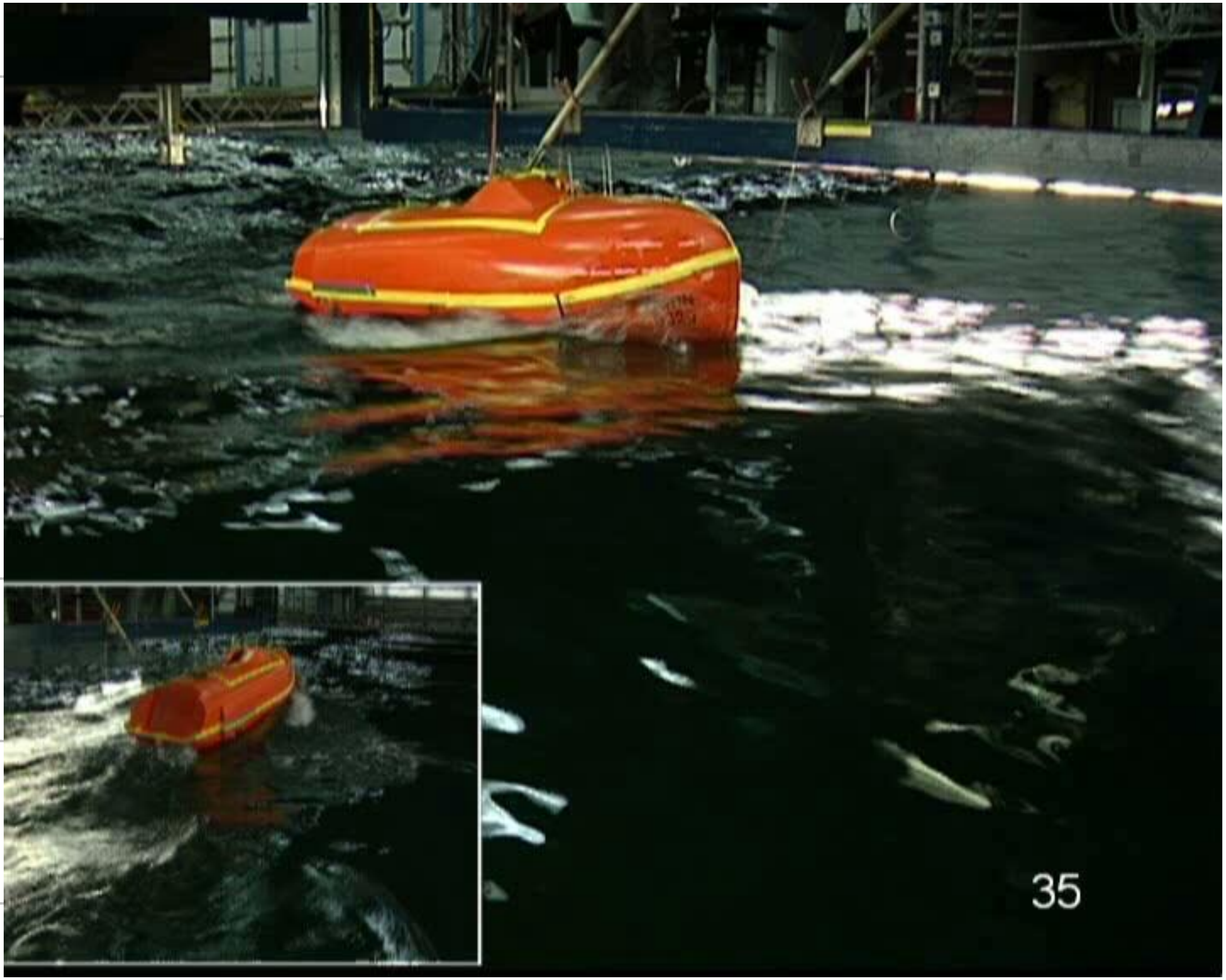
Powering tests

Integrated drop and sail away tests



POWERING TESTS

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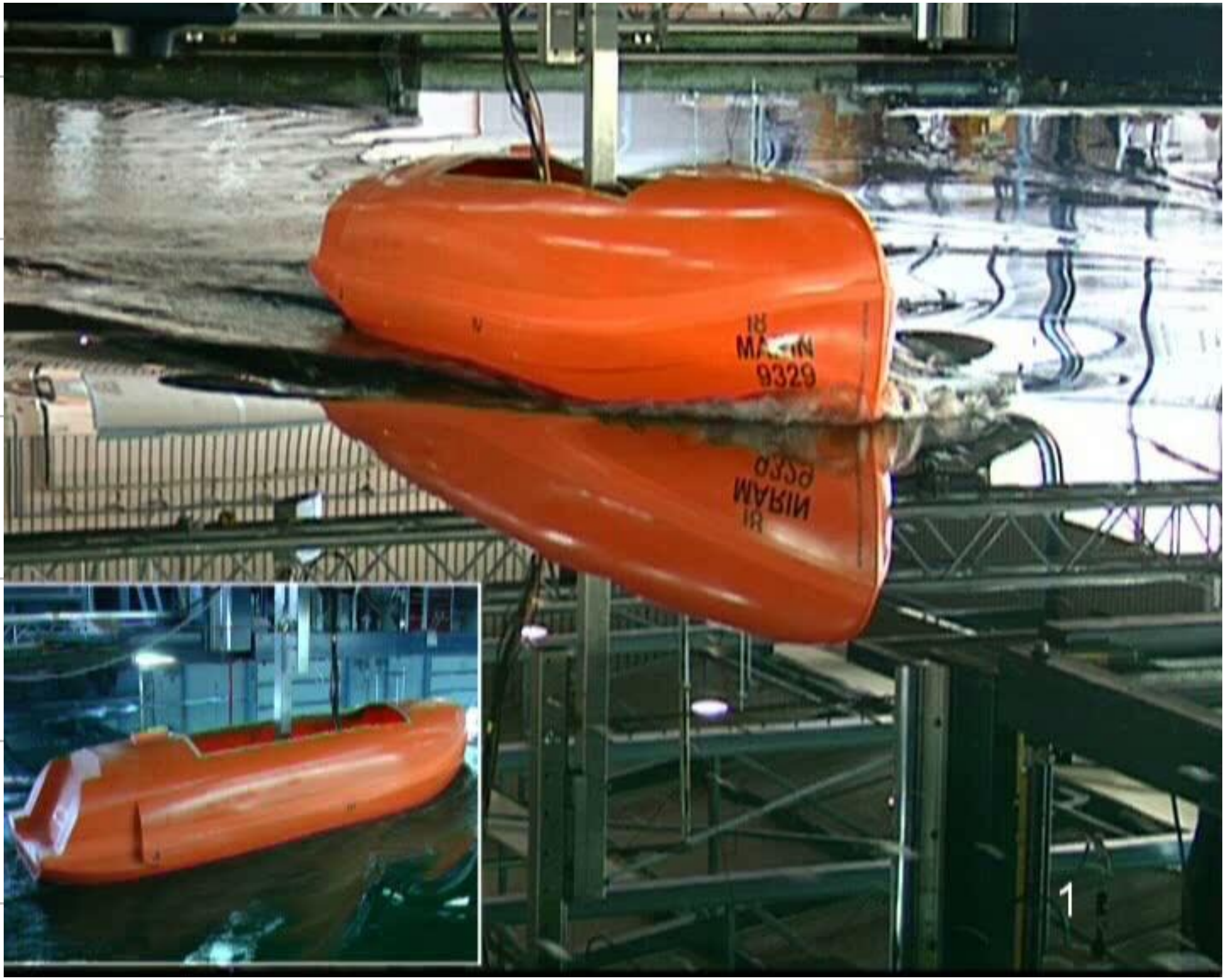
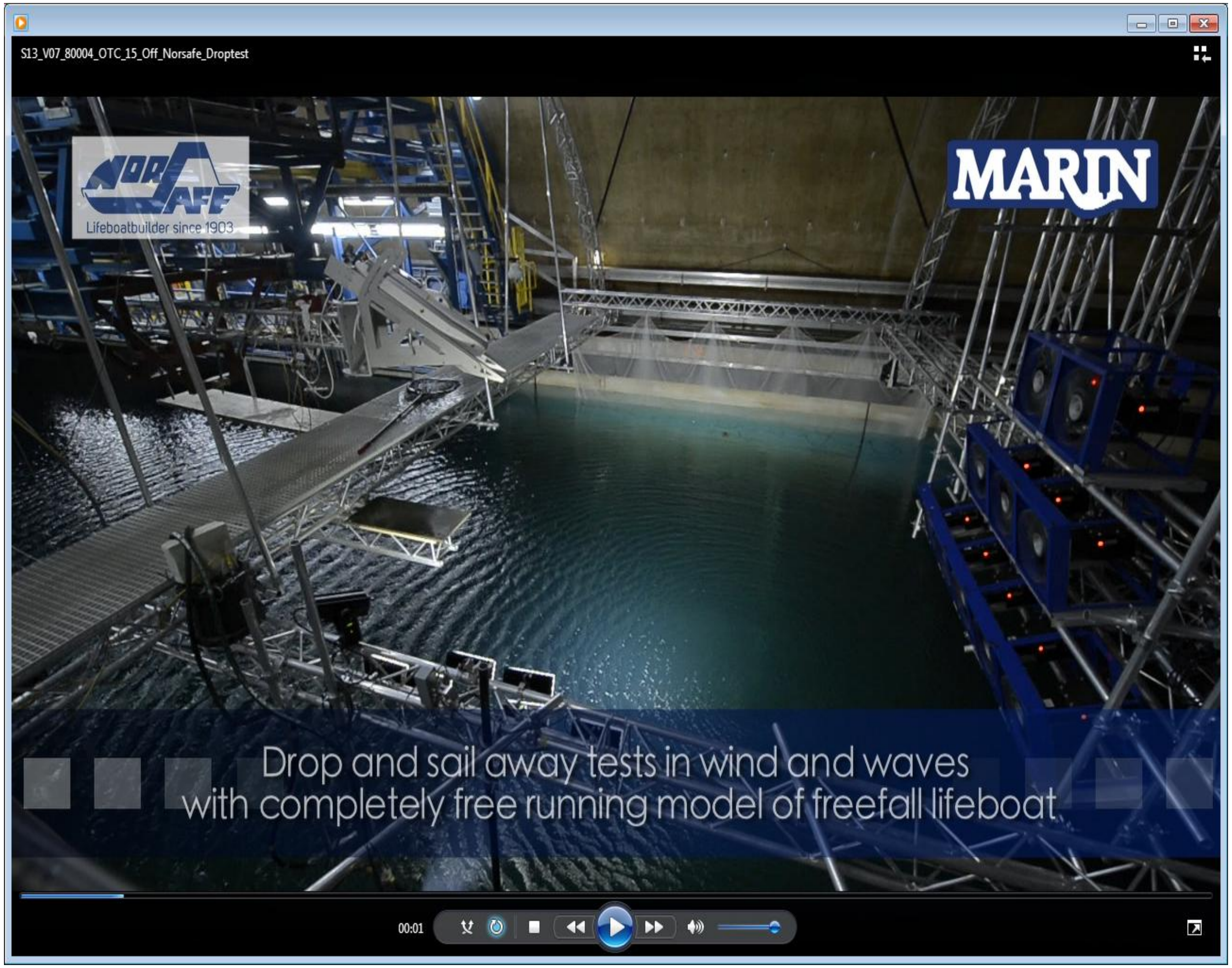
- **Powering tests**
- Integrated drop and sail away tests



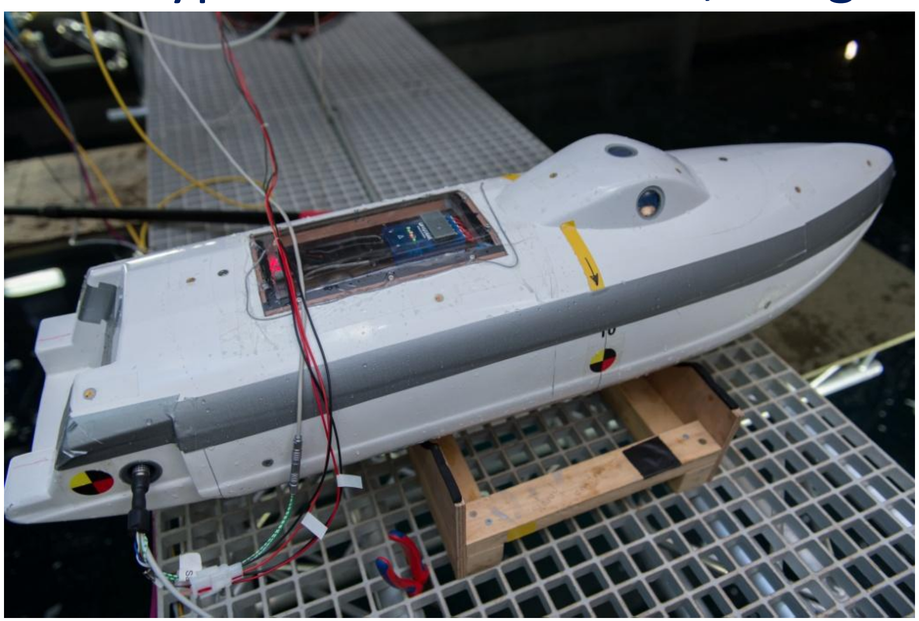
INTEGRATED DROP AND SAIL AWAY TESTS

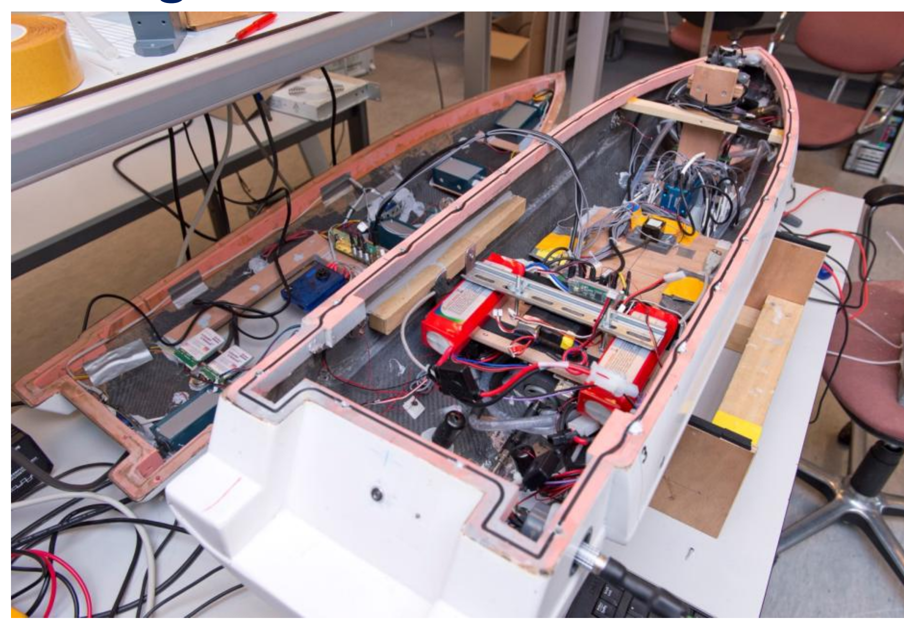
- Captive manoeuvring tests (CMT)
- Free running manoeuvring tests (FRM)
- Captive seakeeping tests (CST)
- Free running seakeeping tests (FRS)
- Powering tests
- **Integrated drop and sail away tests**



INTEGRATED DROP AND SAIL AWAY TESTS

- Self-propelled wireless model
- Motions measurements
- Synchronized measurements (pressures, accelerations) on board
- Typical model size 1m, weight 7-15 kg





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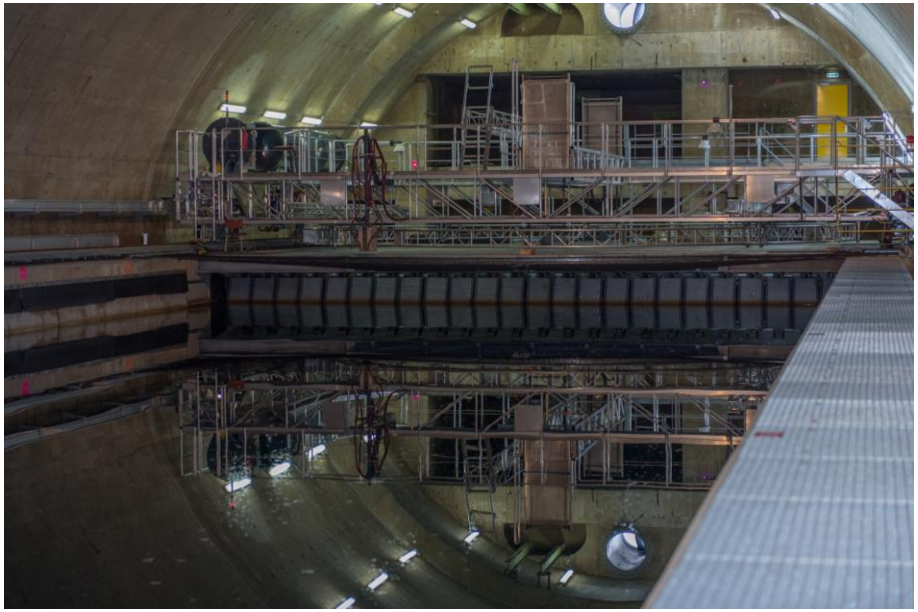
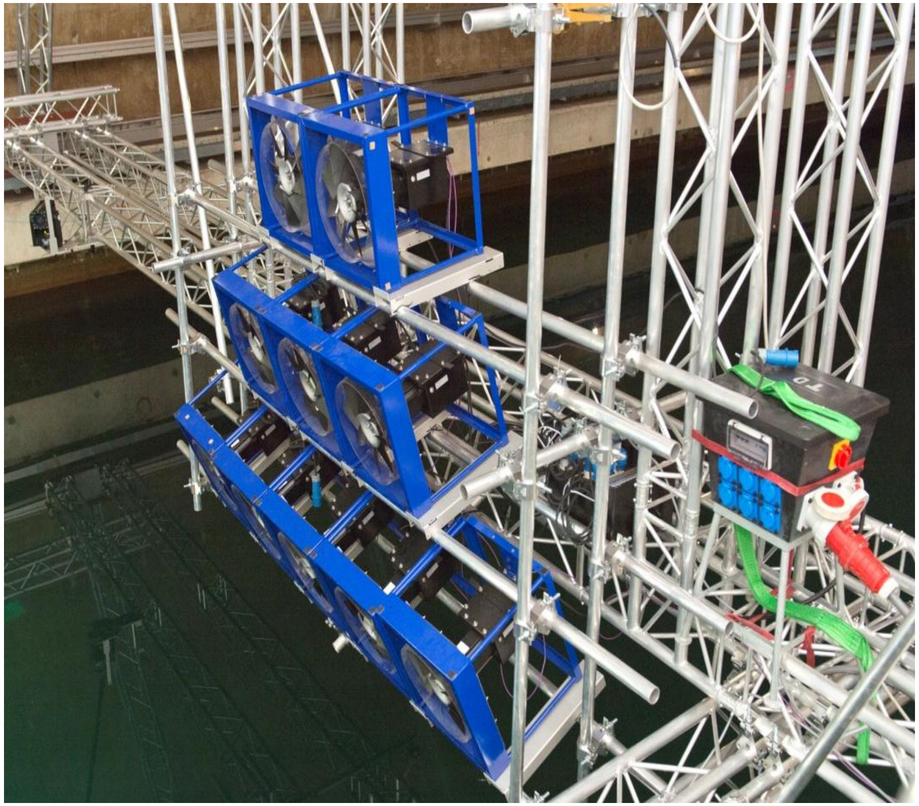
INTEGRATED DROP AND SAIL AWAY TESTS

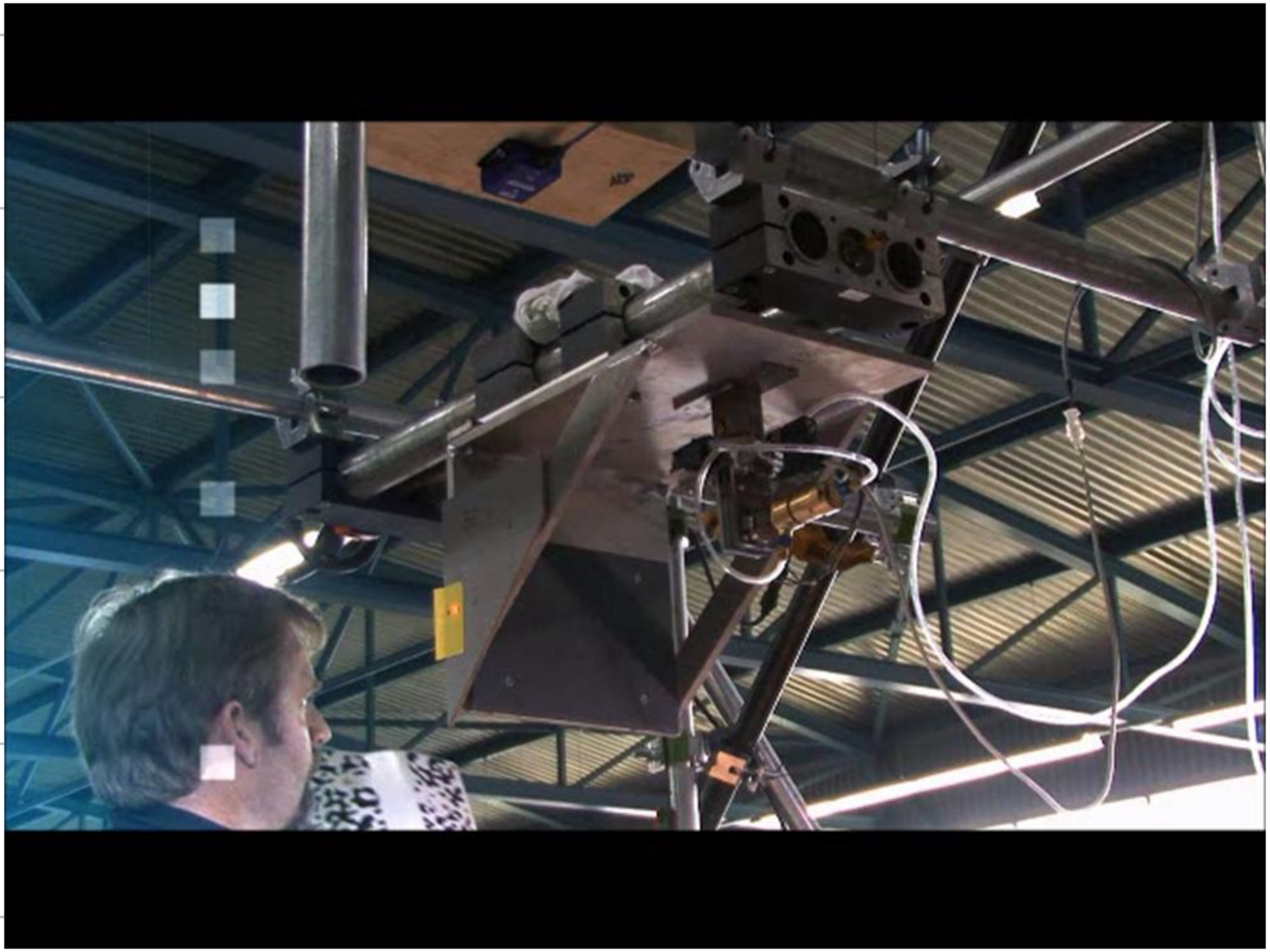
- Waves: 24 wave flaps (wave heights up to 10m at scale 13)
- Wind: 10 wind fans (up to 40m/s at scale 13)





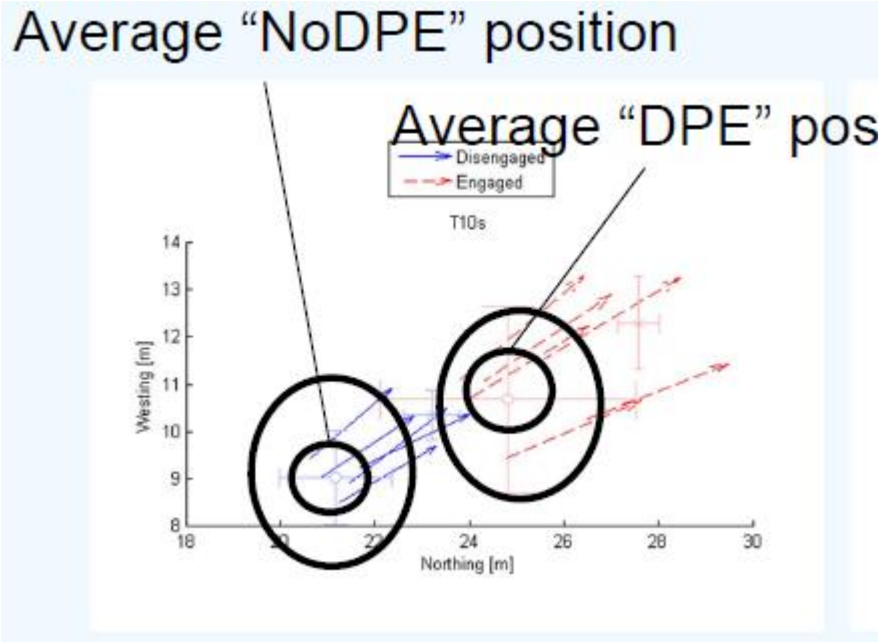
INTEGRATED DROP AND SAIL AWAY TESTS

- Captive manoeuvring tests (CMT)
- Free running manoeuvring tests (FRM)
- Captive seakeeping tests (CST)
- Free running seakeeping tests (FRS)
- Powering tests
- **Integrated drop and sail away tests**



SOME RESULTS

- Drops with and without the propeller engaged
- There is 'spreading' in the results
- With or without propeller engaged makes a difference



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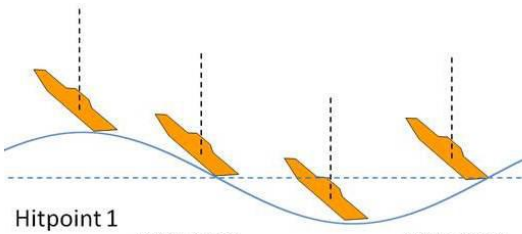
SOME RESULTS

- The 'hitpoint' in the waves makes a huge difference
- Bow quartering 'less severe' then head waves
- Wave steepness is of major importance



Drops without propeller engaged			Hitpoint 1	Hitpoint 2	Hitpoint 3	Hitpoint 4
	Short wave period	Head waves	22	35	26	17
		Bow Q waves	33	34	22	29
	Long wave period	Head waves	37	36	27	19
		Bow Q waves	37	36	29	27

Drops with propeller angaged			Hitpoint 1	Hitpoint 2	Hitpoint 3	Hitpoint 4
	Short wave period	Head waves	28	40	33	22
		Bow Q waves	40	42	31	26
	Long wave period	Head waves	39	37	30	35
		Bow Q waves	41	40	36	33

Introduction

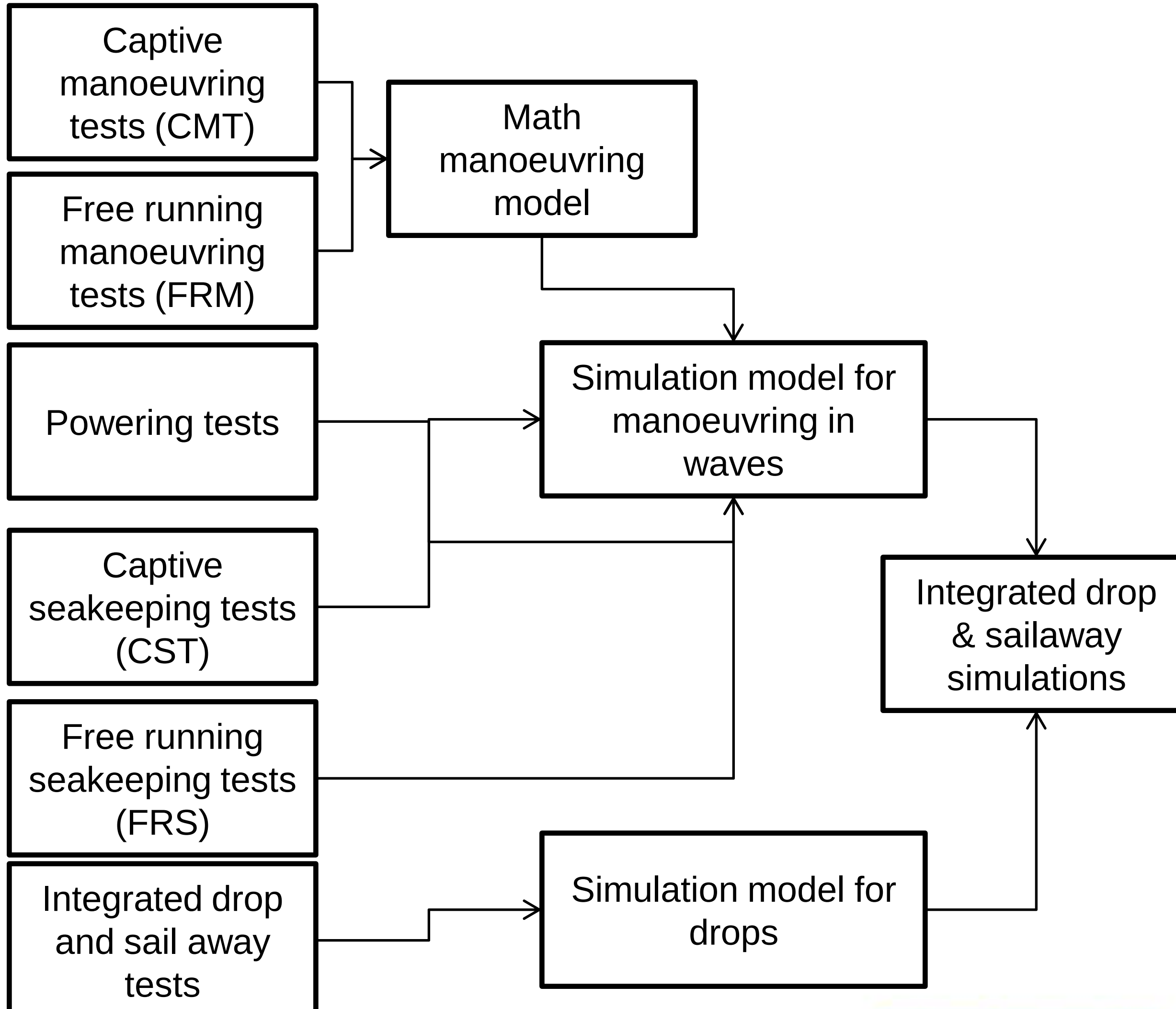
Methodology

Simulation tools

Model scale experiments

Full scale experiments

WHICH MATERIAL DO WE WANT?



FREE RUNNING SEAKEEPING TESTS

Captive manoeuvring tests (CMT)

Free running manoeuvring tests (FRM)

Captive seakeeping tests (CST)

Free running seakeeping tests (FRS)

Powering tests

Integrated drop and sail away tests

FREE RUNNING SEAKEEPING TESTS

- Goals
  - Document the mean headway of the lifeboat in steep waves
  - Collect data for validation of numerical models for predicting the mean headway in a broader range of conditions than encountered during the trials

FREE RUNNING SEAKEEPING TESTS

- Tests in waves of about 5m
- Wave buoy
- DGPS
- Motion sensor
- Anemometer
- Power & RPM sensor
- Rudder angle sensor

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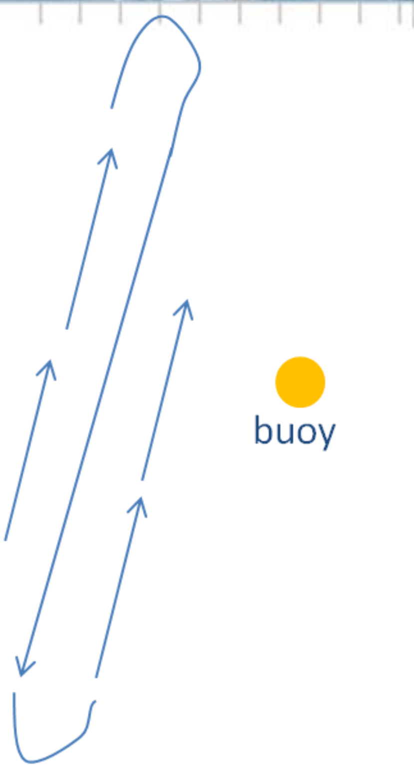
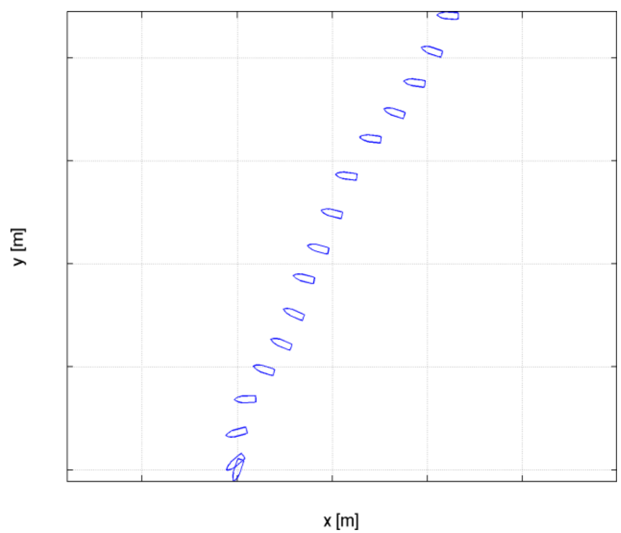
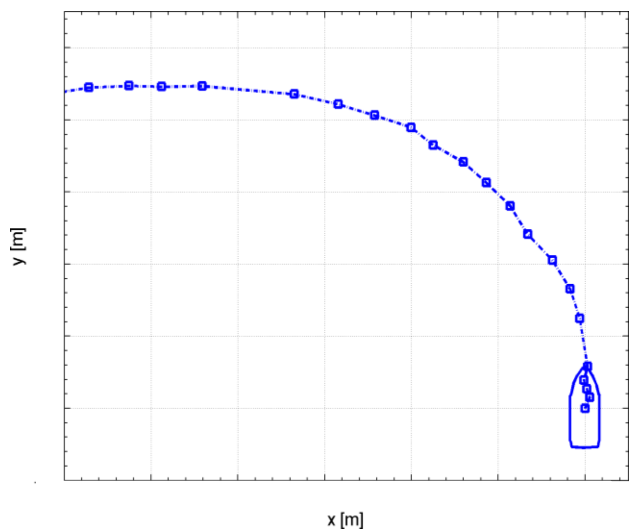
TEST PROGRAM

- Speed tests at different RPMs and wave directions
- Free drifting tests in different wave directions
- Acceleration turn tests, start with ship dead in the water and then power up







INTEGRATED DROP AND SAIL AWAY TESTS

Captive manoeuvring tests (CMT)

Free running manoeuvring tests (FRM)

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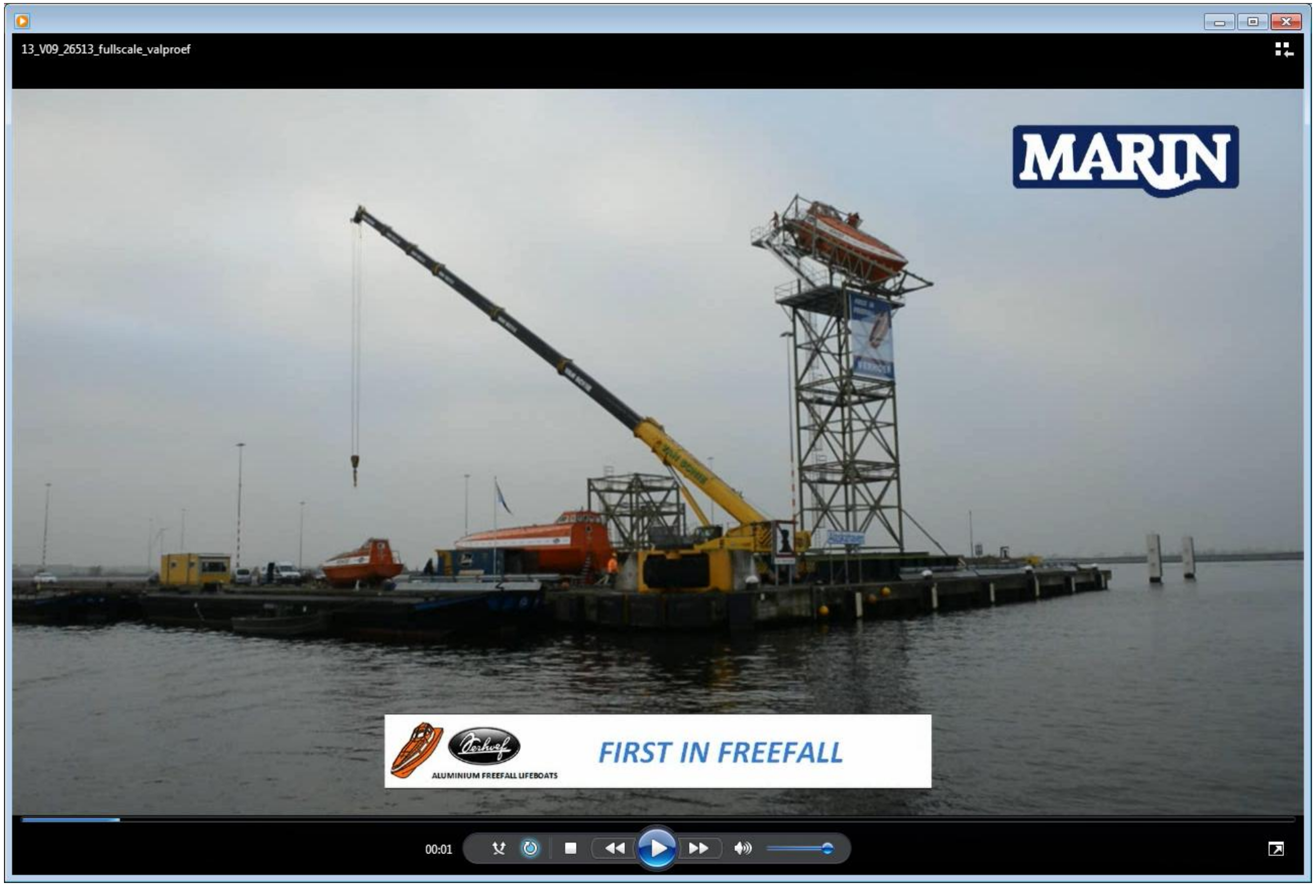

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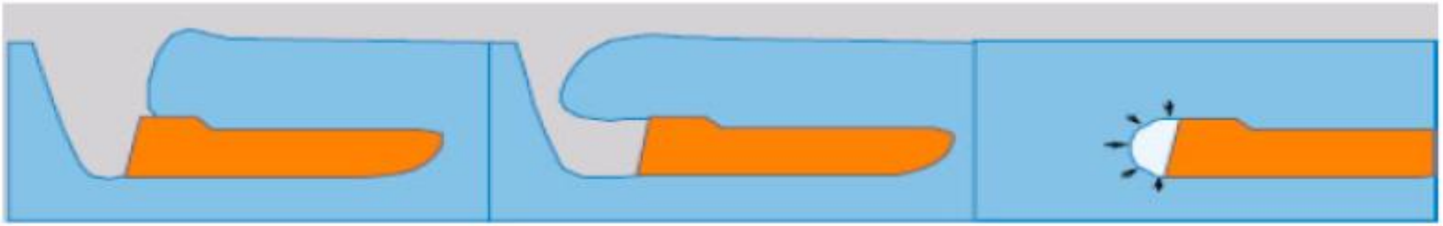
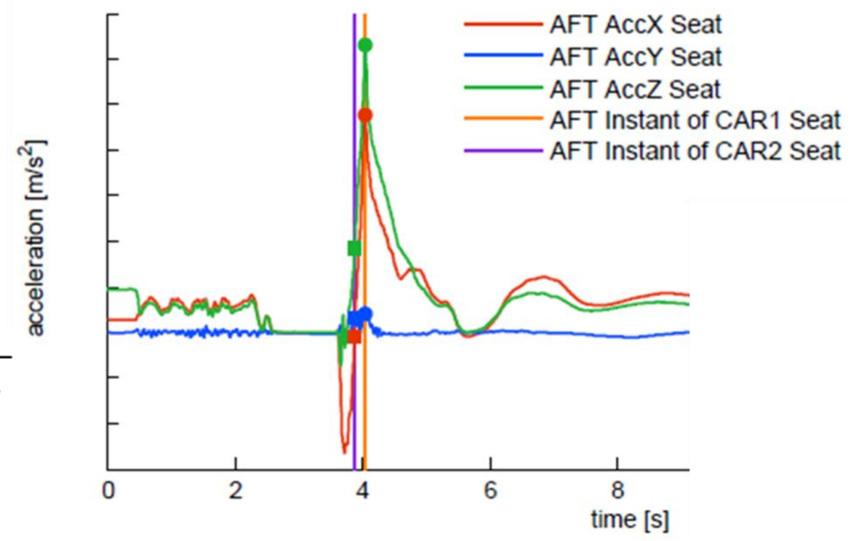
FREE RUNNING SEAKEEPING TESTS

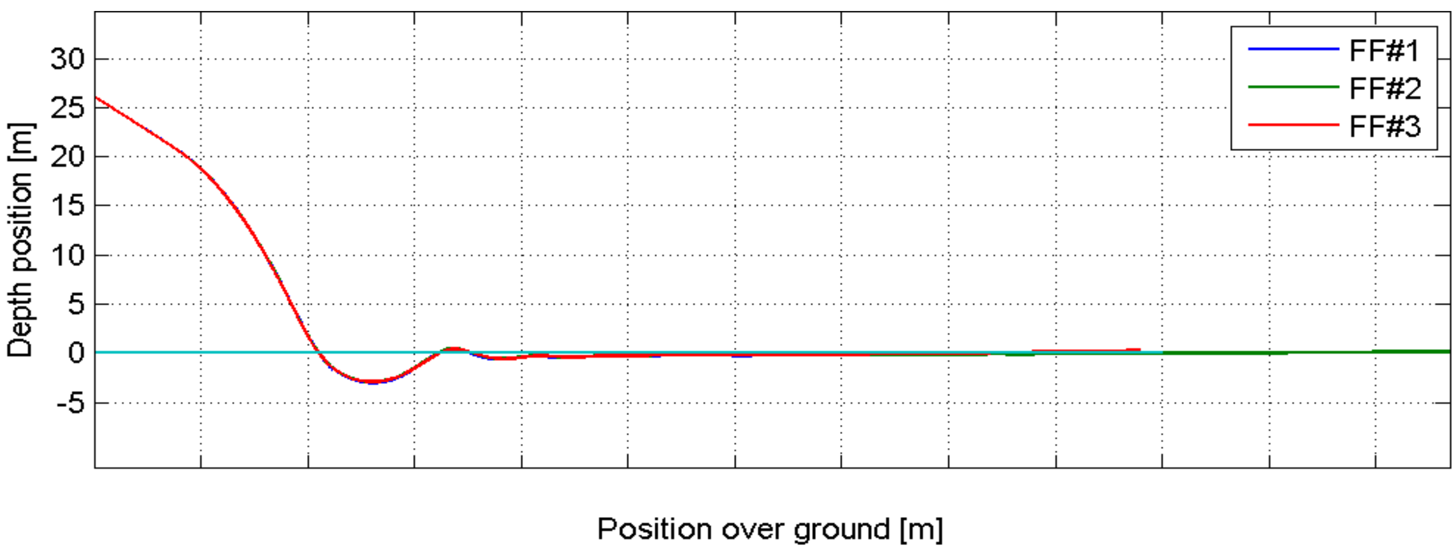
- Goals
  - Document the life boat performance during the drop and subsequent sailing phase in calm
  - Collect data for validation of analytical work and model scale testing



SOME RESULTS

$$CAR = \max \sqrt{\left(\frac{a_x}{18g}\right)^2 + \left(\frac{a_y}{7g}\right)^2 + \left(\frac{a_z}{7g}\right)^2}$$





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WORLD RECORD DROP 66.8M

THANKS YOU, QUESTIONS

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