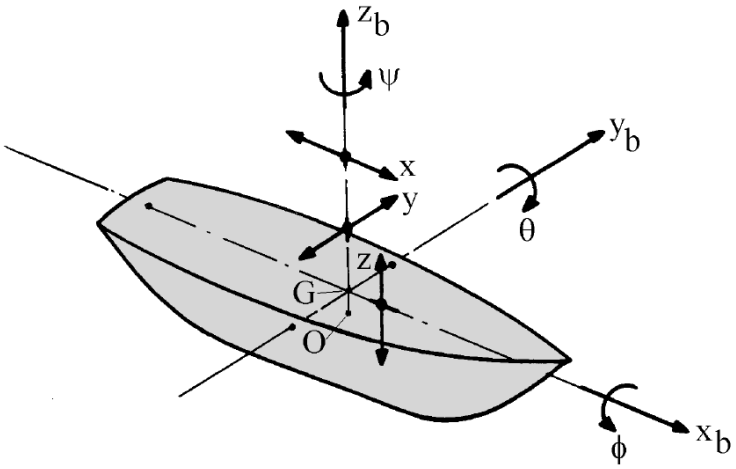
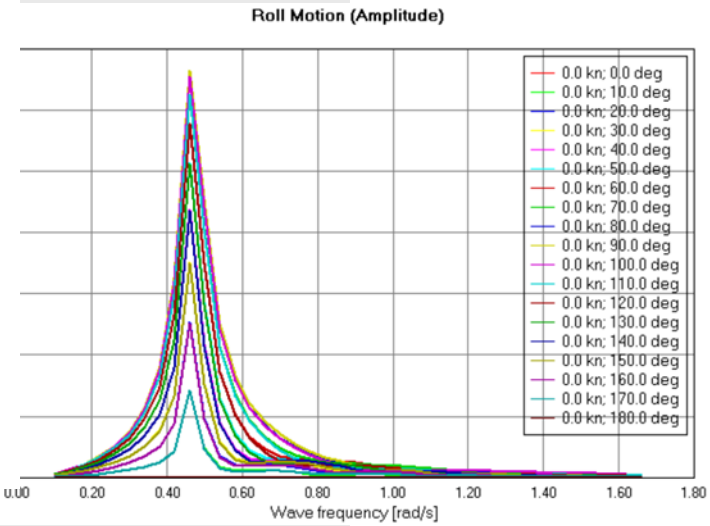
DUTCH
OFFSHORE
INNOVATORS

MOTION EN OPERABILITY ANALYSIS – GENERAL STEP BY STEP

1. Calculate ship motions, velocities and accelerations in 6 degrees of freedom.

- three translations of the ship's center of gravity (**CoG** or G) in the direction of the x-, y- and z-axes:
  - surge in the longitudinal x-direction, positive forwards,
  - sway in the lateral y-direction, positive to port side, and
  - heave in the vertical z-direction, positive upwards.



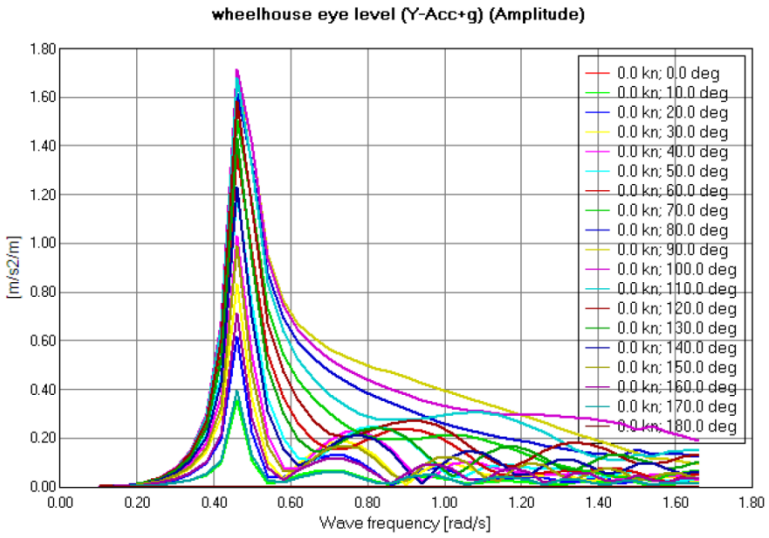


- three rotations about these axes:
  - roll about the x-axis, positive right turning,
  - pitch about the y-axis, positive right turning, and
  - yaw about the z-axis, positive right turning.

DOI uses the MOSES motion calculation software by Bentley to calculate ship motions responses. MOSES is based on linear diffraction theory and therefore very suitable to analyze motions of ships at zero speed. The result of the ship motion calculation is a Response Amplitude Operator, which shows the motion, velocity or acceleration of the vessel as a function of the wave height.

The image above to the right shows a typical graph for a Response Amplitude Operator. In this case it gives the roll motions of the vessel as a function of the wave height for various headings of the vessel. ▸

2. Use ship motions, velocities and accelerations to calculate (vertical) motions, velocities and accelerations in defined points.



The image to the above shows a typical graph showing the vertical accelerations as a function of the wave height for various headings of the vessel. ▶

3. Use (vertical) motions, velocities and accelerations in defined points, sea scatter of geographical location and operability criteria to calculate operability percentage for various headings.

AREA K13

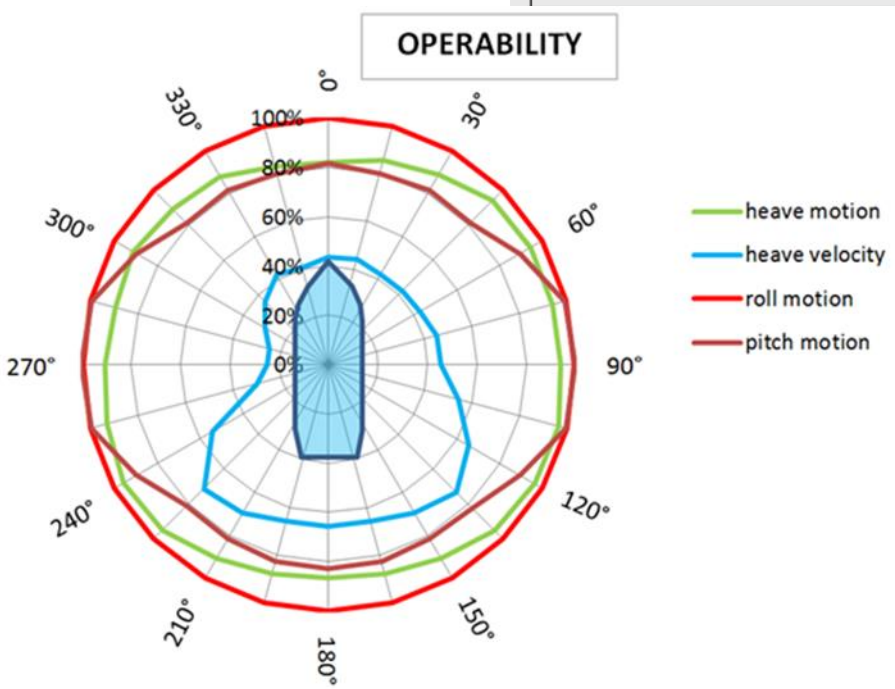
annual wave statistics

all directions

significant wave height (m)	< 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9 - 10	10 - 11	11 - 12	12 - 13	> 13
total	9,290	18,527	14,077	3,903	642	108	14	1	-	-	-
>14											
13 - 14											
12 - 13											
11 - 12	-	-	-	-	-	-	-	-	-	-	-
10 - 11	-	-	-	-	-	-	-	-	-	-	-
9 - 10	-	-	-	-	-	-	-	-	-	-	-
8 - 9	-	-	-	-	-	-	-	1	-	-	-
7 - 8	-	-	-	-	-	1	5	-	-	-	-
6 - 7	-	-	-	-	15	29	3	-	-	-	-
5 - 6	-	-	-	15	122	38	2	-	-	-	-
4 - 5	-	1	5	376	220	17	-	-	-	-	-
3 - 4	-	8	757	1,520	144	7	-	-	-	-	-
2 - 3	-	877	6,288	1,018	85	9	1	-	-	-	-
1 - 2	992	11,428	5,674	793	29	5	3	-	-	-	-
0 - 1	8,298	6,213	1,353	181	27	2	-	-	-	-	-

zero crossing period (s)

operation	motion	limit
crane operations (0-75t)	roll	< 2.5deg
	pitch	< 2.5deg
	heave	3.2m
		2.0 m/s
		1.8 m/s^2
crane operations (75-150t)	roll	< 2.5deg
	pitch	< 2.5deg
	heave	3.2m
		1.0 m/s



The image on the previous page shows a typical wave scatter diagram. An example of operational criteria is shown on the top right. DOI analyzes operability of ships using in-house developed software. This enables us to present the results in easy to understand polar plots, showing the operability of a ship given by a number of limiting criteria at various headings of the vessel relative to the environment. As an example, the plot above shows the operability as a percentage of time for 75-150t crane lifts using the criteria in the table above. Plots like these can be used by ship operators to evaluate the feasibility of projects and also as a marketing tool.

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