Hydro 17 extended abstract

A crystal ball for approaching waves

More uptime and less risk for offshore operations

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Introduction

For many offshore and maritime operations, large waves and resulting ship motions lead to unsafe situations that need to be avoided. Common practice to do so is by only operating in sufficiently mild wave conditions.

Next Ocean is introducing technology that can predict *when* and *where* high waves will occur, several minutes ahead. This enables crew to anticipate: avoiding high wave events for the critical phase of their operation, and grabbing predicted windows of opportunity with low waves.

Higher workability, less risk

There are many applications / situations for which waves and induced motions of ships are critical. Installation of offshore wind turbines, crew / cargo transfer from ships to offshore platforms or wind turbines, the work on the deck of an anchor handling tug, landing a helicopter on the deck of a (navy) ship are just a few examples. Common practice is to assess the safety /workability of such operations from a *statistical* point of view: For expected wave conditions, the probability of occurrence of an undesired event is determined. Then this wave condition is considered to be workable in case the probability is sufficiently low. Large safety margins are involved in such workability assessments, since the risks can be huge. An example: suppose that a wave event of 3 m height is the limit up to which a certain operation is safe. Then sea state for, with a significant wave height of 2 m, would be considered as not workable, since the probability of a 3 m wave event is way too high. However, in this sea state 4, 93 % of the time is part of time windows with a length of at least 2 minutes, during which the waves are well below the 3 m limit. So predicting when these higher wave occur, leaves a lot of time in between to safely operate.

Technology

The wave predicting technology is based on using an ordinary navigation radar as a remote wave sensor: waves at sea result in certain reflections of the electromagnetic pulses transmitted by the radar system. See figure 1 for an example of a raw radar image. This so-called sea clutter can reveal valuable information about the waves when analysed smartly. Techniques to obtain directional spectra and surface current from navigation radar data have been around for some years. Obtaining a wave spectrum, without needing to employ a wave buoy, is very useful since it provides the required input for the classical statistical approach to operability as described earlier. See figure 2 for an example of a wave spectrum obtained from the radar data. However, a wave spectrum does not provide any information about *when* and *where* high or low waves occur.

The main purpose of Next Ocean's technology is to extend the techniques for analysing radar data, in order to provide not just a spectrum, but additionally *time traces* of the approaching waves, some minutes in advance: a Wave Predictor.

Test campaign with the Wave Predictor

A first proof of concept confirming that it was possible to accurately predict approaching waves and resulting ship motions in a time specific way was obtained during research carried out at Delft University of Technology. (See [1]). In order to strengthen this proof of concept additional testing was done by Next Ocean, in co-operation with Alphatron Marine and Damen Shipyards during fall 2016:

The tests were performed on the North Sea near the Dutch coast, on board of a 42 m Damen Stan Patrol vessel. Raw radar data was acquired from the vessel's X-band navigation radar system and fed into the Wave Predictor software. The obtained wave prediction was then used to generate a prediction of the resulting ship motions (by using a classical linear transfer function approach). Simultaneously a motion reference unit (MRU) installed on the vessel recorded the ship motions. This enabled comparison of the motions as predicted by the software and those actually measured by the MRU.

Conditions during these tests were significantly more challenging than those encountered during the earlier test campaign: With peak periods around 8 seconds and significant wave height of 2.5 m, the waves were significantly shorter and steeper, making their propagation by the real time wave model more challenging. The involved ship was much smaller resulting in more severe antenna motions and a lower antenna position, with a more limited visible range as a result. Unlike during the trials mentioned in [1], the vessel was not kept accurately in place by a DP system, but freely floating or slowly sailing.

A view on the sea from the position of the radar antenna during the tests is shown by figure 3.

Test results

Results however were again comparable to the earlier campaign. Figure 4 shows a sample result of the comparison between the measured heave motion and the prediction done by the Wave Predictor software 60 sec in advance. Accuracy (in terms of correlation coefficient) of the actual heave motion amounted to 0.80 for 60 second predictions and significantly higher for shorter prediction times.

For many practical applications, it is sufficient to get a prediction of the group behaviour of the waves and motions: i.e. when does a group of high or lower waves approach rather than the exact arrival time of the individual wave crests and troughs. Therefore, the so-called envelope of the prediction and measurement, indicated with the dashed lines in figure 4, were examined as well. It was observed that envelopes were predicted with at least 0.90 correlation up to at least 240 seconds ahead.

Further development

Currently, the Wave Predictor is being incorporated in a real time modular software package that will be available by the end of 2017, optionally providing wave spectra, surface current information and Wave Predictor output to support crew's on-board decision making. In co-operation with various potential end-users, effort is put into the design of a standard and intuitive user interface.

By means of a straightforward data transfer format, integration into 3rd party systems of the functionality provided by all the software modules will be supported: the aim is to enable the use of tailor made user interfaces for specific applications, optimizing the benefit from the wealth of information that can be provided a simple navigation radar.

References

1. Naaijen, P., Roozen, D. K. & Huijsmans, R. H. M. REDUCING OPERATIONAL RISKS BY ON-BOARD PHASE RESOLVED PREDICTION OFWAVE INDUCED SHIP MOTIONS. in *Proceedings of 35th International Conference on Ocean, Offshore and & Arctic Engineering* (2016).

2. www.nextocean.nl

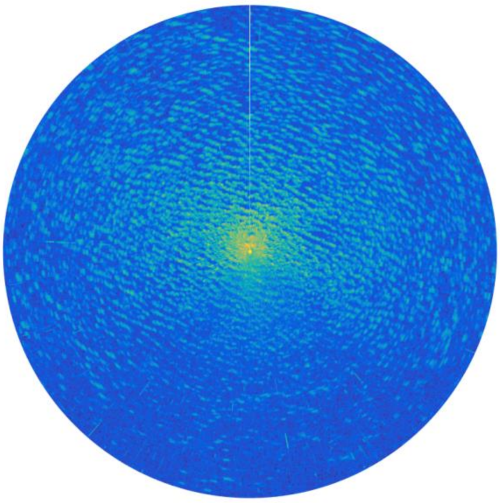

Figure 1, example of raw radar image

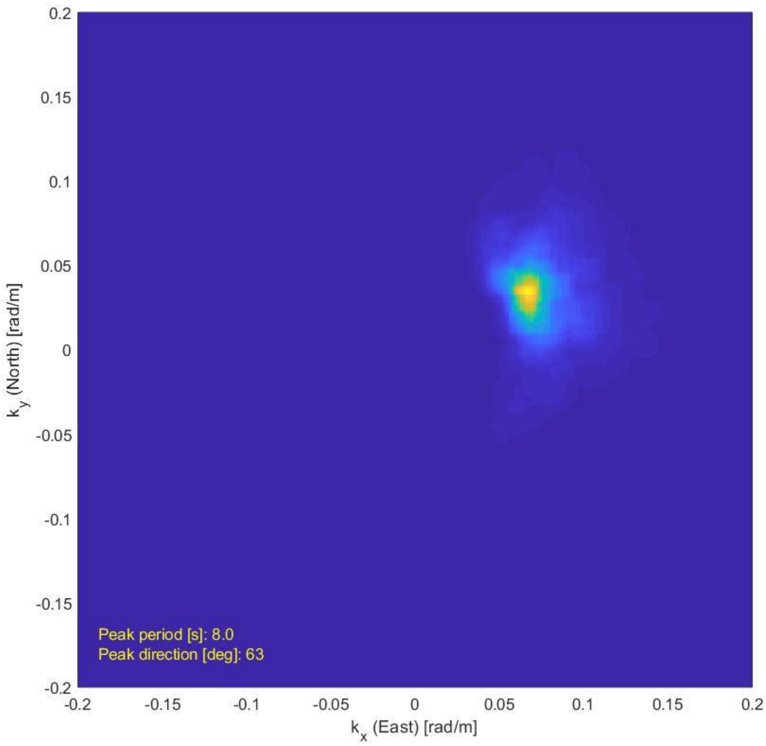

Figure 2, directional wave spectrum obtained from radar data

Figure 3, view on the sea from the radar antenna position

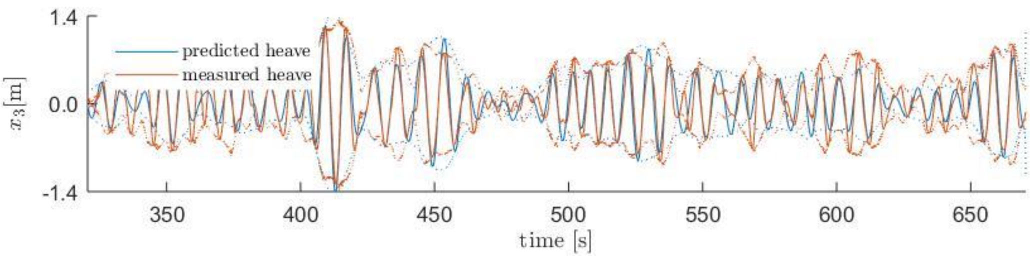

Figure 4, measurement and 60 s prediction of heave motion