

A Frequency Domain Approach to Estimate DP Footprint

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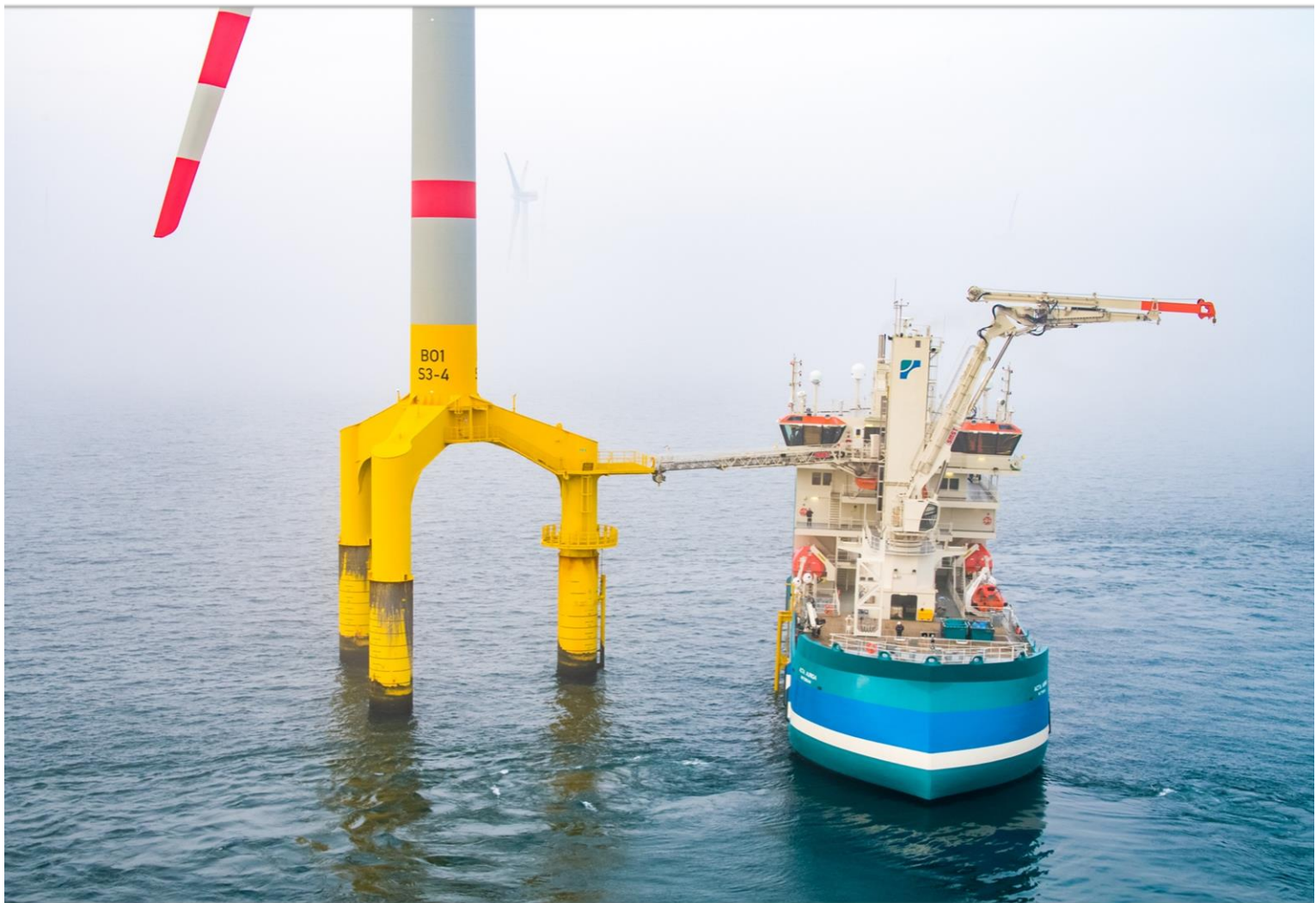


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OFFSHORE & DREDGING ENGINEERING

A Frequency Domain Approach to Estimate DP Footprint

By

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Abstract

Offshore operations are increasingly executed by vessels operating on dynamic positioning (DP) due to advantages it has for short operations, such as maintenance and crew transfer but also for track keeping operations and projects in deeper water. Currently, DP capability plots are used to indicate whether an operation can be performed, but this is based on static calculations and it does not consider the offsets that are found due to motions of the vessel, while the offsets can be critical in case a structure is present or if a certain accuracy of a station keeping operation is necessary.

Currently, to determine the offsets of a vessel on DP, the system is modelled using a time domain approach. Multiple simulation runs are carried out to calculate the expected extreme offsets in a given time interval, which is known as the most probable maximum offset (MPM offset). This is a complex and time consuming process and therefore it is not always done in practice before an operation starts. In this research, a method is developed to estimate the surge MPM offsets of a vessel on DP due to the wave drift forces using a frequency domain approach, as this can lead to faster estimates. But two problems are faced: The first is that there is no mathematical model available describing a vessel on DP which can be used to accurately calculate the offsets in the frequency domain. The second problem is that there is no known relation between the offsets and the extreme behaviour, which leads to the MPM offsets.

To find the MPM offsets, first of all a one dimensional time domain model of a vessel on DP is made, considering only the surge degree of freedom. Next, to determine the surge offset response using a frequency domain approach, the differential equations of the system are linearised, which gives the transfer functions from the environmental forces to the surge offsets. This is used to estimate the surge offset response in the frequency domain. The accuracy of this method is determined by comparing the root mean square value (RMS) and the zero up crossing period to that of the time domain results. Then, two alternative methods are developed to calculate the MPM offsets from the surge offset response characteristics directly. The methods use the RMS and zero up crossing period of the surge offsets calculated in the frequency domain, to determine the extreme behaviour statistically without the use of multiple simulation runs.

Using the linearised model of the vessel on DP, it is found that the surge offset response can be calculated within an accuracy of 4% of the results generated by the time domain simulations, based on the root mean square value and the zero crossing period. Therefore, an accurate estimate of the surge offsets is found using a frequency domain approach. Both alternative MPM offset calculation methods, using the surge offset results of the linearised model, give MPM offset estimates within approximately 10% of the results of the time domain simulation approach. Taking into account the strong variability found in the MPM offsets calculated by the time domain approach, the estimates from the frequency domain approach are regarded as good estimates.

It is concluded that the methods developed in this research can lead to faster and therefore timely MPM offset estimates to use for the safety and accuracy of operations. This can improve the way of working for many offshore operations where often no use is made of MPM offset estimates due to the disadvantages of the methods currently used in practice. It is recommended to extend the method developed in this research to three degrees of freedom, such that it can be implemented in practice.

