Dr Zaman Sarker, Principal Engineer at Royal HaskoningDHV outlines a practical and cost-effective method for the evaluation of likely operational downtime at a berth based on waves in the initial stages of a project.

Bulk Terminals are of critical importance to the seaborne trade and transportation of dry bulk commodities such as crude oil, iron ore, coal, grain, bauxite, alumina and rock phosphate. Bulk commodities which are those loaded or discharged in loose or fluid form account for the biggest share of the world seaborne trade. Crude oil and petroleum products are tanker cargoes while iron ore, coal, grains, bauxite, alumina and rock phosphate constitute the main dry bulk cargoes and are referred to as the major dry bulks. They are traded in large quantities and shipped almost exclusively in specialised bulk carriers of different sizes ranging from handy sized (10,000 – 55,000 dwt) to large specialised ships of >200,000 dwt. Bulk terminals have become one of the well-established features in international seaborne trade. Such terminals may simply have an anchorage or a berth or include items such as dredging and breakwaters. As a minimum a bulk terminal comprises a berthing facility for loading or unloading ships and marine works for the safe access and operation of ships. Operational downtime due to adverse wave conditions for loading and unloading of vessels at berth is an important technical and commercial aspect in the planning and development of a bulk terminal or a port. This article describes a practical technique for the preliminary assessment of operational downtime at a proposed dry bulk terminal.

As part of the assessment process, numerical modelling of wave transformation was carried out using the MIKE21 Spectral Wave (SW) model developed by DHI to derive inshore wave conditions at the bulk terminal. Operational downtime due to wind-waves and swell-waves was calculated for the head and beam seas separately for a wide range of vessel sizes. The limiting wave heights $H_s$ as well as the significant wave height $H_m$ were used in the downtime calculations. Wave climate varies throughout the year resulting in different operational downtime at different months of the year. Annual downtime assists with the financial feasibility analysis of a new berth whereas a month by month downtime assessment assists with port management such as planning for storage capacity. Therefore, besides an annual downtime assessment, it was also assessed for each month of the year. The methodology has been successfully applied to a real project in the Black Sea, Russia and the results presented in this paper are from this project. The methodology and lessons learnt from the study would be useful for the development of any sea port or bulk terminal worldwide.

**Meteorological conditions**

The study site is situated between the -12m and -14m seabed contour lines. However, a dredged depth of -17.3m will be maintained at the berths, in the turning circle and the navigational approach channel. Three-hourly time-series wind and wave data for 10.83 years (1 January 2000 to 31 October 2010) was purchased from BMT ARGOSS (2011). The wind and wind-wave roses are shown in Figures 1 and 2. Winds blow predominantly from the north-east and south-west sectors whereas most of the small wind-waves come from the north-easterly direction. The astronomical tidal level variation at the study site is negligible and does not exceed 50mm. Global sea level rise for various scenarios was extracted from the Intergovernmental Panel on Climate Change (IPCC, 2007). A sea level rise of 0.5m has been adopted for the next century.

**Numerical modelling: waves**

- **Model Setup**

  The MIKE21 Spectral Wave (SW) model of DHI was used to transfer offshore waves into the study site [DHI, 2011]. The model area covers the study site and the surrounding area so that the impact of headlands and nearshore bathymetry is included in the simulations. Overall the area covered by the model was...
Numerical modelling was undertaken using the MIKE21 SW model to derive wave conditions at the berths of a proposed bulk terminal. Synthetic time-series data covering both wind-waves and swell-waves between 2000 and 2010 was used in the study. The model results were used to calculate operational downtime due to head and beam seas for a range of vessel sizes. The downtime results are presented in Tables 2 and 3. From the results it can be seen that:

- Operational downtime due to wind-waves is significantly higher than that of swell-waves
- Operational downtime for beam seas is higher than that for head seas.

The above assessment of operational downtime at berth is presented for vessel displacement tonnage as defined in SNiP 2.06.04-82. For bulk carriers the vessel displacement tonnage is about 1.2-1.3 times the vessel deadweight tonnage (dwt). Based on vessel displacement tonnage of 1.25 times vessel dwt, Figure 8 shows the operational downtime at berth due to resultant-waves for vessels in the range 5-160,000dwt. The approach described in this paper provides a practical and cost-effective method for the evaluation of likely operational downtime at a berth based on waves in the initial stages of a project. In the later stages of a project numerical (or physical) modelling techniques to look at operational downtime based on ship motion at the berth are likely to be required. The wave data from the study will provide inputs to these ship motion studies.