WAVE FORECASTING AT THE SITE -- A PRACTICAL SOLUTION FOR TERMINAL OPERATION AND PLANNING

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INTRODUCTION

Due to the capital investment cost, procurement and construction schedule, and in some cases the permissions and environmental restrictions, the oil and LNG terminals tend to move more offshore nowadays. Survivability of the facility and operational downtime becomes an issue because of the considerably more challenging metocean conditions. In most cases, metocean conditions (typically related to swell) that dictate terminal operations are determined from ship mooring studies. A slight variation in wave height, period or direction could shift the condition from 'operational' to 'downtime'. However, how do commissioned terminals make critical decisions on whether or when to shut down operations? A precise wave forecast at the terminal site becomes more critical than ever for terminal planning and operation.

METHODOLOGY

Existing wave forecasts available from private sector and governmental agencies (such as US NOAA National Weather Service, Environment Canada, the MET office in the UK and BOM at Australia) provide general offshore conditions, irrespective of local site characteristics, such as geography and bathymetry variation, thus lacking the site-specific confidence that is required for planning or operating an offshore terminal. Additionally, existing site specific wave measurement systems only provide the "now" conditions. The wave forecast approach proposed in this paper connects the offshore forecast to a terminal site through the following requirements:

- A reliable offshore wave forecast
- A mechanism of wave transformation from offshore to the terminal site
- Wave measurements at the project site for method validation and forecast adjustment

The offshore wave forecast continuously improves with the enhancements in both wind and wave models. Figure1 shows the comparison between the NOAA WAVEWATCH III (WW3) offshore wave forecast (blue line) and the wave measurements at a project site (red dot) in Central America. The high correlation between the two data sets indicates a well matched wave forecast by WW3. Figure 2 shows the varying wave height forecast at the offshore site in the 7 day forecast series. It shows that the 5 to 7 day forecasts (yellow-green) may vary more, but the forecasts within 4 days are very consistent, which gives a high confidence level in the forecast.

The transformed wave condition at the terminal site shown in Figure 1 (black line) was obtained from Spectral Wave modeling. The wave transformation should be first developed and validated based on wave measurements at the site. The wave transformation methods can be numerical wave modeling (Spectral Wave, Boussinesq Wave), neural network tools, and direct correlation, depending on how well the offshore forecast and the site measurement compare. A look-up table or matrix which covers all the possible offshore wave conditions can then be generated and the conditions at the terminal site are then related. Real-time wave measurement at the terminal site can be used to compare with the predicted waves based on the offshore forecast and may provide adjustment to the uncertainties in the offshore forecast.

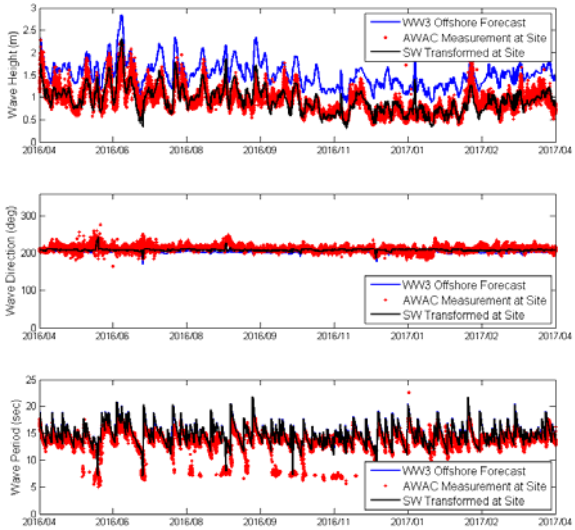

Figure 1 - Example of Wave Transformation at A Project Site Based on WW3 Offshore Wave Forecast

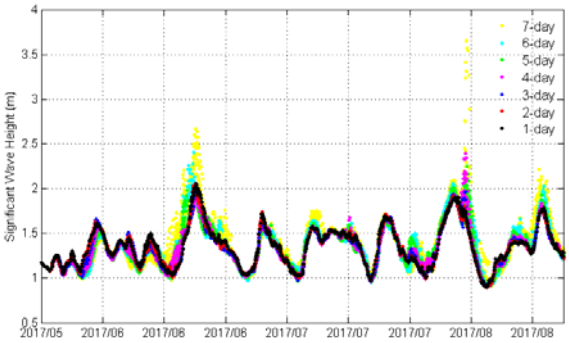

Figure 2 - Example of WW3 Offshore Wave Forecast

PROJECT CASE STUDIES

The wave forecast method presented has raised interest among terminal planners and operators. It has been evaluated through multiple terminal sites including Central, South America, and China, etc. These case studies will be presented in the full paper and a qualitative estimate on the effects and confidence in terminal operation will be also presented.