DIGITAL SERVICES / MARINE & PORTS

ABB Decision Support Software
Increasing workability, safety and efficiency during offshore operations

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ABB's Decision Support Software is the most advanced system for decision support during weather-sensitive offshore operations. The system is actively used in many different types of offshore operations.

Introduction

An offshore installation typically consist of a sequence of phases, like DP-setup, lifting in air, cross the splash zone, lowering the payload until just above the seabed and, finally, the landing phase. Each phase can have different limiting criteria.

An offshore installation typically consist of a sequence of phases, like DP-setup, lifting in air, cross the splash zone, lowering the payload until just above the seabed and, finally, the landing phase. Each phase can have different limiting criteria. Typically, the crane's Safe Working Load (SWL), the Dynamic Hook Load (DHL), the tugger wire loads, sling loads or the clearance to the ship are critical. During the landing phase, the vertical velocity shall not exceed a certain value, to avoid unacceptable impact loads on the fragile equipment to be installed on the seabed.

Due to the increasing water depths for offshore operations, there is an increasing risk for resonance in the lowering system which may result in:

• Large vertical motions at time of landing
• Large dynamic tension in the cables, with risk of overloading or slacking
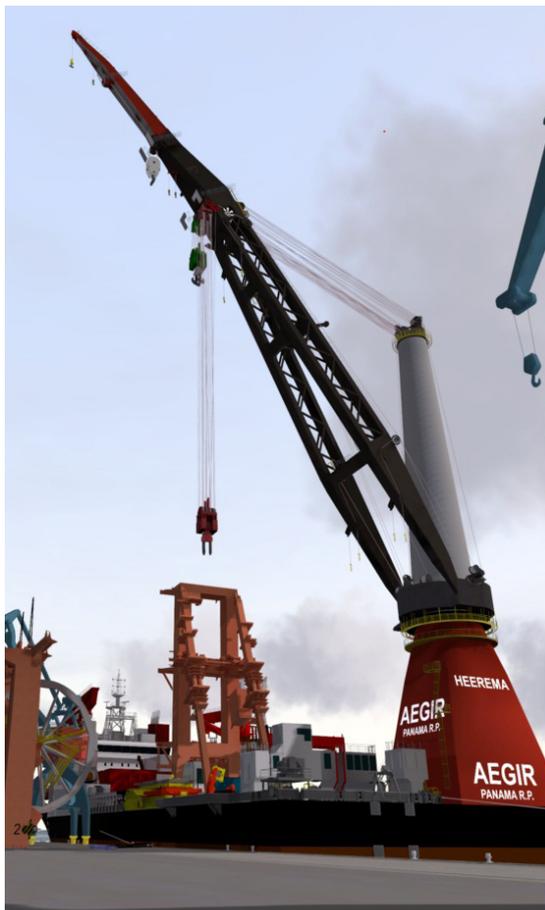
Before carrying out an offshore operation, extensive analyses are carried to calculate the design seastates in which the operation can be done. Different types of analyses can be done. Frequency domain analyses can be carried out for a large range of environmental conditions. Fully-nonlinear time domain analyses are only done for a selection of cases. Using the results of those analyses, one or more design sea states are derived.

These analyses are valuable to get an idea about the workability of the vessel in the engineering phase. During the real operation, however, there is always the difficulty of interpreting the environmental conditions, and the impact thereof on the vessel's dynamics, and in particular of the crane tip and the resulting motions of the payload in the hook. The design sea state is only an idealized description of an environmental condition, in which the operational limits are encountered. When offshore, it is important to monitor and be able to forecast whether the motions or loads will become critical or not, for any kind of sea state (combinations of sea and swell, multi-directional, arbitrary spectrum shapes, etc).
Fortunately, even though the risk for clashing, the DAF and loads in tugger lines may behave nonlinear, they are all governed by the motions of the hang-off point (crane tip or sheave of the A&R winch). Therefore, the best way forward is to combine measurements onboard with accurate prediction models for the motions of the vessel, of the hang-off point and of the payload in the hook.

In the following sections, it is described how ABB's Decision Support Software can assist in this.

Motion Measurements

Motion measurements using existing ship's sensors

ABB's Marine Software suite features a flexible motion monitoring system. First of all, the system can interface with various widely-used motion sensors, like MRU5, MRU5+, Octans, MiniPos, etc. The signals of these sensors can be displayed within the software user interface. It can also read and display the ROV's motion sensor via its umbilical. When the ROV is connected to the subsea structure, the motions of the subsea structure can be monitored this way. ABB's Marine Software gives an alarm when a certain level is exceeded.

Virtual Motion Reference Points

Within the software, one can define an unlimited number of Virtual Motion Reference Points. ABB's decision support tool will calculate real time the motions, velocities and accelerations in these user-defined points, based on the physical sensors available. In order to achieve accurate results for motions, velocities and accelerations in virtual reference points, it is required to have a) very accurate sensors configured for accurate motion measurements in all six modes of motions, or b) a grid of sensors like ABB's motion measurement module based on three sensors. In various comparisons, it has been demonstrated that by using three 3-axis accelerometers spread over the vessel (aft/fwd; starboard/portside; high/low) very accurate motions, velocities and accelerations can measured in any location of the vessel . The difference between a virtual measurement and the measurements using a physical sensor in the Virtual Motion Reference Point are negligible. This cannot be achieved using for example the DP's MRU5, which will result in large errors for locations in which all the modes of motion contribute (mainly due to inaccuracies in the rotations and due to filter settings). Details about the motion measurement system TMS-3 can be provided on request.

Crane tip as Virtual Motion Reference Point

When ABB's Marine Software tool is interfaced with the crane to receive parameters like the slewing angle and boom angle, the time-varying (x,y,z)-coordinates of the hang-off point can automatically be calculated within the application. This way, the crane tip can be specified as a dynamic Virtual Motion Reference Point, for which the software can monitor the motions/velocities/accelerations in 6DOF.

Recording of motions

ABB's decision support platform can store all the measured data onboard. This may result in large amounts of data in short time. Therefore, it is also possible to start a motion recording on demand. Records are stored on disk for all the defined motion reference points. These recordings (in ASCII format) can be used for off-line analysis and post-processing of the data. On the following pages, different screens are shown how the motion monitoring can be done (time traces, spectra, spectral parameters).

Offline simulation

The recorded motions of the hang-off point can serve as input for a separate analysis of the motions of the payload in the hook while lowering. This way, the DAF and loads in the lifting equipment can be calculated offline. Onboard the the motion recording of the crane tip is used as input for an offline Orcaflex analysis (similar procedure as described in /1/).

Such a post-processing of the recorded motions of the crane tip gives the best-possible estimate about the situation to be encountered when the real operation would be carried out at that moment. When the simulation results are all within the limiting criteria, this is the best possible indication that the operation can be done safely (if the conditions are expected to be constant of course).

Planning of the operation

Motion forecasts

Knowing the actual motions by monitoring is one thing. Knowing how the motions can be reduced by changing the heading, or how the motions will develop over time given the weather forecasts, may even be more important. ABB software offers the most-advanced tool for onboard motion forecasting:

- ABB's decision support tool can use pre-calculated motion RAO's, for example the ones which were used during an engineering study.
- The system can calculate the RAO's onboard using the actual or a simulated loading condition. The incorporated motion solver is based a 3D-diffraction solver (WAMIT or WASIM), nonlinear treatment of viscous damping in al modes of motion, stochastic linearization, anti-roll tanks, etc.
- The software can import various weather forecast systems, wave buoys and wave radars, for which the motion forecast is made for all vessel headings and speeds.
- Manual input of wave observation is also possible.
- Motions can be calculated for any number of Motion Reference Points.
- Motion forecasts and motion measurements can be plotted in the same graph. This makes it very easy for the operator to judge the now-situation and compare it what is coming up, or how the situation onboard could be improved by changing the vessel's heading.

DP-capability forecasts

The best way to enhance the situation during a critical lowering operation or lift, is to reduce the motions of the crane tip. As explained above, the software calculates the motions for any heading, and indicates the optimum heading defined as the heading where the response envelope has its minimum.

The next step is to evaluate whether the vessel really can maintain its position and heading at the, from motion dynamics point of view, optimum heading. For that purpose, the software calculates the forces acting on the DP-system (wave drift forces, wind- and current forces). Below, a sample display is shown, indicating which headings the vessel is able to keep or not, based on the available and required thruster power.

In the graph at the bottom, the combinations of periods and headings are indicated where the vessel can keep its heading and position (green) or not.

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Figure 1: Display indicating the response envelope as a function of vessel heading. Using this display, the operator can easily find the optimum heading, i.e. the heading where the motion response at the crane tip is at its minimum (for example).

Operational windows

The operational window forecast is the result of a post-processing of the operation-critical RAOs with one or more weather forecasts, and applying the limiting criteria.

Below, the2D- operational window is plotted, consisting of two critical parameters: the crane tip motion and the DP-capability. On the vertical axis of the graphs, the vessel heading is shown. The horizontal axis is the time span of the weather forecast.

The graph at the bottom clearly shows how the optimum heading changes over time from NW (330 deg) via South (after 20 hrs) to East (90deg) after 24 hrs. This is important information when an operation becomes critical and the decision has to be taken to change heading or stop abort an operation. The same info is also needed prior to (re-)starting an operation, at which heading to setup for DP, when to mobilize, etc.

Gangway motion forecast

When operating a vessel with a gangway, it is crucial to know how the motion behavior of the vessel and her gangway will be influenced by changing weather conditions. The gangway functionality within the software gives a clear advice for operation in heavy weather conditions. The weather forecast(s) and measurements are transferred in an actual response forecast. ABB's Marine Software automatically imports the needed information, calculates the hydrodynamic properties and displays the expected responses for all headings and weather conditions. This way during transit, too heavy motions and accelerations of the gangway can be avoided. Different displays for heading control and optimization, and visualization and planning of operational windows are available.

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Figure 2: Display of the forecast of the operational window. In this example: operational window defined by the vertical crane tip motion (upper window) and the DP-capability (middle window). The lowest graph represents the net operational window.
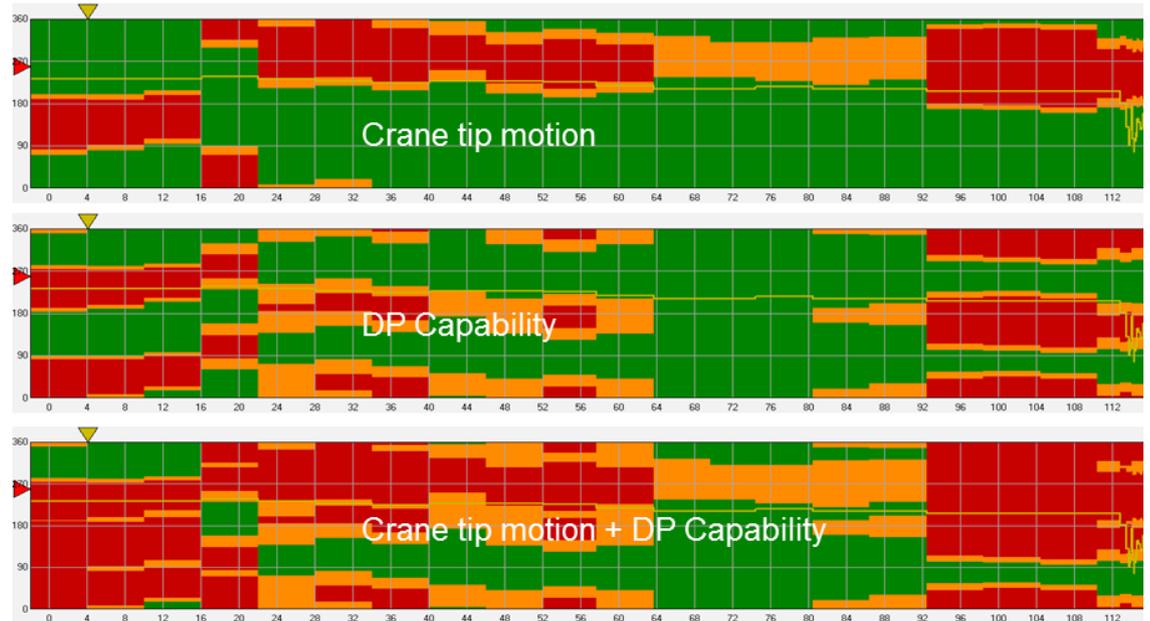
Summary

ABB's Decision Support Software is the most advanced system for decision support during weather-sensitive offshore operations.

The system is actively used in many different types of offshore operations. A typical application onboard an installation vessel could be as follows:

- During the engineering phase, the design limitations should preferably be established in terms of maximum allowable crane tip motions, loads and DAF (exact list of parameters depends on the type of operation). Not only design waves, which are a back-calculation from design loads to assumed underlying idealized environmental conditions.
- The software is configured to monitor motions, velocities and accelerations in a set of user-defined virtual motion reference points, such as the crane tip.
- The system is configured to calculate the RAO's and motion response statistics for the same locations using measured or forecasted waves as input.
- The recorded motions of the crane tip can be used offline as input for an Orcaflex or SIMO simulation. Motions, line tension and DAF can be checked for the actual conditions. These results serve as input to decide to start the actual lowering or not. A simple 1D-simulation could also be done using a spreadsheet.
- During the actual lowering, the system could calculate real-time the line tension, motions and DAF, using the measured crane tip motions as input (this feature has not been implemented yet).
- If the situation gets critical, the software is used by the Master to optimize the vessel's heading, taking into account the motion forecasts and the forecast of the vessel's DP-capability.
- The system calculates the operational windows using weather forecasts as input. The calculated operational windows form the basis for the decision whether the operation can be started, whether the vessel's heading should be changed, or whether the operation should be interrupted or cancelled. Any number and combination of responses can be considered when calculating operational windows. Typically, the vertical crane tip motion, roll, pitch and DP-capability shall be included.

When using the digital application as described above, one has the clear option to plan better for optimum weather windows, optimize headings, and keep motions, loads and DAF as low as possible over time.

All the data can be shared via Internet within the project team. The operation can be valuated afterwards using the logged data.

References
/1/   Legras, J-L., Jue Wang, Criteria for the operation of lowering a structure to the seabed based on the installation vessel motion, OTC 21250, 2011

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