A useful application of vessel motion data in cable installation operations

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Introduction

To reduce the environmental influences (waves/weather) during offshore operations, offshore construction vessels usually collect the vessel motion data with their motion reference unit (MRU) equipment. These data will then be fed into the dynamic positioning (DP) system of the vessel or the heave compensation of offshore cranes, for any motion compensation during marine operations.
The vessel motion data can also be used in the live assessment of weather window prior to start of operations, also known as “vessel motion for decision support”, which is a less well-known application of these data. In this application, the recorded vessel motions will be used to forecast upcoming vessel motions, together with the seafarer experiences of vessel crew, to make a sound decision whether the intended operation can be carried out. However, it is observed that the “vessel motion for decision support” method is seldom practiced in the offshore power cable laying industry, in comparison to offshore heavy lifting and military (missile firing, etc.) operations. In this article, we will further discuss the benefits and methods behind this application for the power cable industry, in order for them to utilize the forecasted vessel motions during their cable installation operations.

Background

In uncertain or unfavourable weather conditions, it is critical to decide whether an offshore cable installation campaign can be continued, or must be put into a waiting on weather (WoW) scenario. This decision is made by means of offshore experiences (construction manager, captain, engineer), marine warranty surveyor (MWS) and weather forecast, and sometimes based on a set of installation weather limitations developed from installation analyses during the design phase.

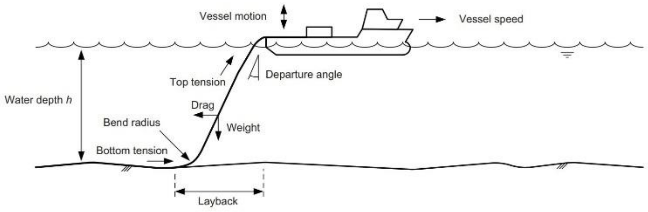

Figure 1: Free cable lay operation terminology (source: DNV GL)

In most cases, the weather limitations derived from installation analysis are conservative due to conservatism in the development of the hydrodynamic model and the requirements from the classification society standards. This conservation will usually lead to a gap between analysis (theoretical weather limitation) and operational experiences from the construction team, and may produce unnecessary conflicts among the construction team, see illustration of a typical free cable lay operation in Figure 1.

Why should we use vessel motions for decision support?

So how can this gap between operational experiences and theoretical weather criteria be reduced? One contributor is to make use of real time vessel motion.

Below we have shortlisted the four main benefits with utilising vessel response data for decision support compared to a typical design weather limitation.

Reduced weather assessment process: By utilisation of vessel motion criteria for decision support, the number of parameters being investigated on-site will be reduced, and the decision-making process will be simplified. Normally the weather criteria are determined by Hs (both wind waves and swell), peak period, wave heading relative vessel bearing, wave spreading, etc. However, if vessel motion is used as criteria during cable installation, the operation window can be determined by one parameter, namely the vertical wheel/chute motion. By comparing Figure 2 and Figure 3 the number of parameters to assess is highly reduced if forecasted vessel motion is used for decision support.

Decision Support Approach 1: Vessel RAOs (response amplitude operators) and onsite weather forecast is used to derive forecasted vessel motions, see Figure 3. The predicted vessel motions can be presented in a similar manner as the weather forecast received every sixed hour which is normally used to live-assess the weather window. A normal weather forecast is presented in Figure 2. In addition, real time vessel motions are used to verify earlier predicted vessel motions and the conservatism in the hydrodynamic model will be better understood.

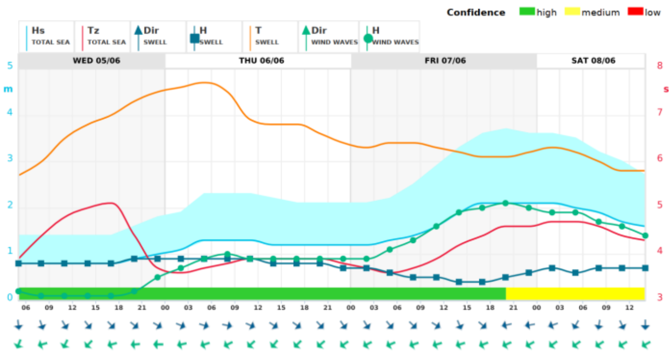

Figure 2: Typical weather forecast received every sixed hour when offshore. (source: StormGeo)

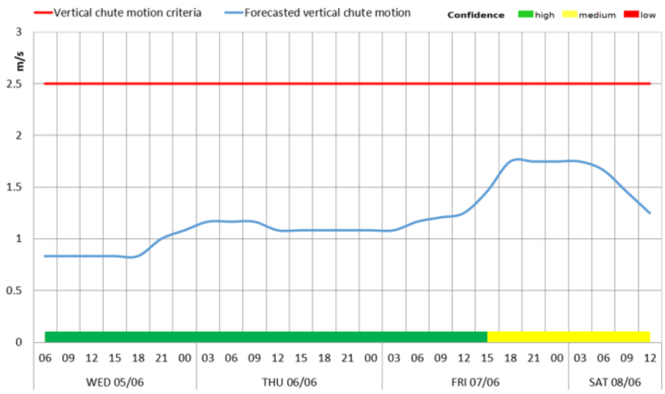

Figure 3: Typical vertical wheel/chute motion forecast received every sixed hour. The graph is based on vessel RAOs and onsite weather forecast. It can be seen from the forecasted that chute motion will stay well below allowed chute motion for the next few days (source: Havkonsult)

Decision Support Approach 2: Real time vessel motion can be used to forecast future vessel motions. For instance, 20 minutes real time vessel motion data can be used to predict a 3-hour maximum response by means of extreme value distributions, always under the assumption that the input parameters, such as sea state or vessel heading, are not likely to change. Consequently, if the weather is coming up the forecasted vessel motions under Approach 2 is no longer valid. However, forecasted vessel motion under Approach 1 is still valid, but keep in mind that these forecasted values are based on RAOs.

Data Storing and Processing: By recording real time vessel motions, these historical data can be further used to simulate how the vessel behaves in different sea states, and the hydrodynamic models of the vessel can be further improved. In many cases vessel models are developed without significant experimental data that can be used to reduce their conservatism. Over time and with sufficient amount of data, the database of recorded vessel motions can be used to forecast vessel motions without the need for model RAOs and wave spectrums. Approach 1 will be less dependent on hydrodynamic simulations.

Why can we use vessel motion for decision support?

Now back to the main subject of this article. How can we make sure that the vessel response tells us, with confidence, the behaviour of the power cable on the seabed?
From a simple time-lapse of a free cable lay simulation in Orcaflex it can be easily seen that the cable bending at the touch down point peaks just after where the lay wheel/chute has the highest velocity, see Figure 4. Figure 4 also shows that the oscillating behaviour for the two parameters is equivalent.

Based on numerous simulations with different Parameters (cable properties, water depths, laybacks, seastates, etc.), the results confirm that the vessel motion and cable behaviour are correlated.

Figure 5 shows the correlation between chute velocity and minimum bending radius (MBR) and chute velocity and minimum touchdown tension for three different laybacks. Followingly, it means that we can define a chute velocity limit which will indicate whether the cable integrity is compromised or not. As a comparison, if subsea structures are to be installed it is not possible to only define the operational criteria by means of crane tip motions as the structure behaviour also depends on water surface motions. Surface motion effects on a thin cylinder (cable) moving up and down in the water column can be neglected.

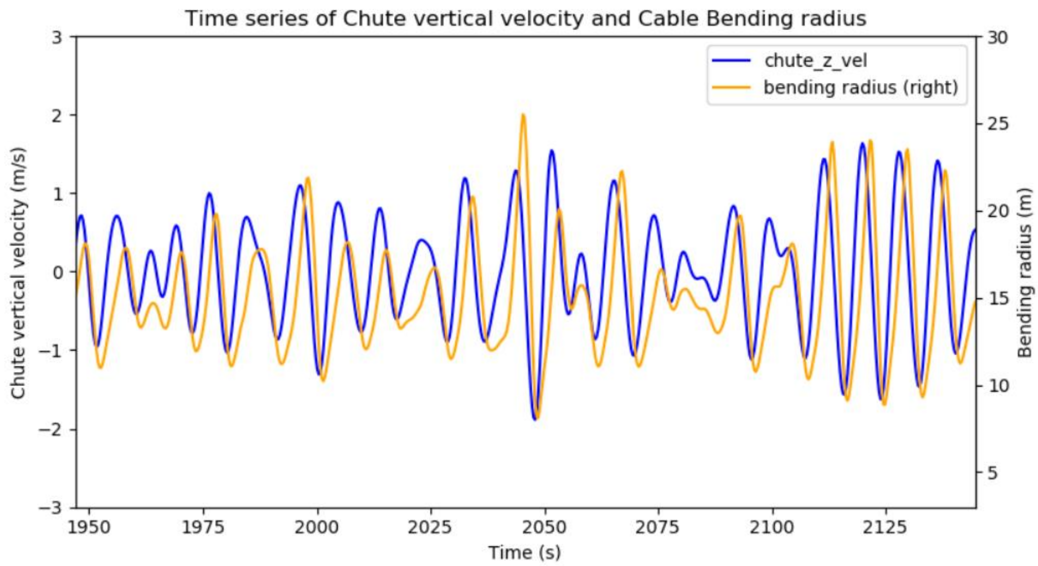

Figure 4: Time series of chute velocity (left axis) and cable bending at touch down point (right axis) from simulation in Orcaflex. (source: Havkonsult)

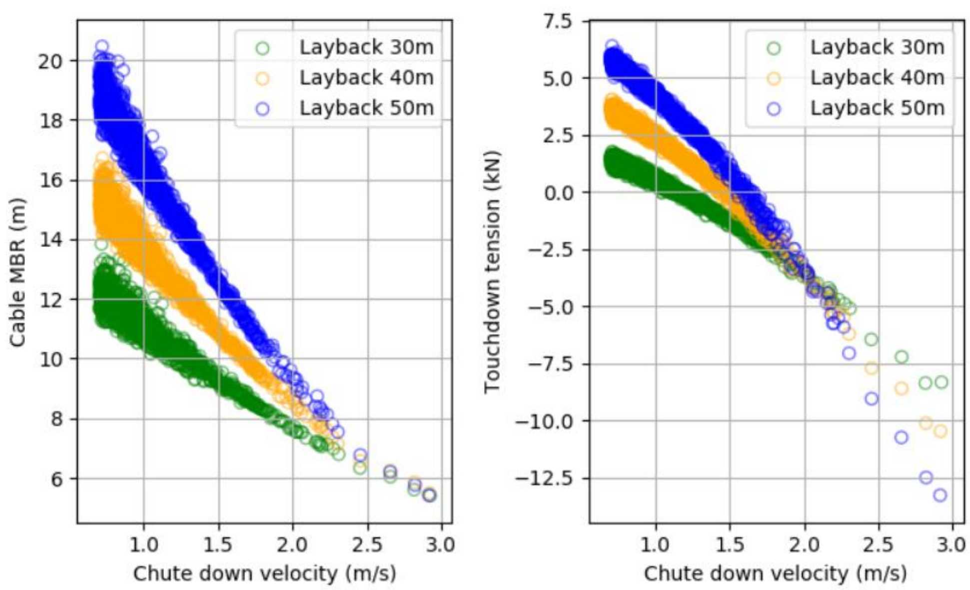

Figure 5: Relationship between min. MBR and chute velocity and min. cable tension and chute velocity. If the forecasted vessel motion, including alpha factors, indicates a max velocity of 2.0m/s the cable MBR will not go below approx. 7 meter and the cable integrity is not compromised (source: Havkonsult)

Conclusion

It is in our opinion that the vessel motion should be used for decision support during offshore cable laying operations. By utilizing Approach 1 and/or Approach 2 the number of parameters which needs to be assessed on-site is significantly reduced. The offshore team will have tools and figures available which gives a closer relation to real time motions compared to weather limitation criteria derived from conservative installation analysis. Finally, storing MRU data for different sea states gives the opportunity to provide forecasts which are less dependent on vessel models and generic wave spectrums.

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