MODELLING SEABED MOBILITY FOR OFFSHORE GRID SECURITY

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ABSTRACT

Power cables at sea are buried into the seabed to protect them from external threats, such as dragged fishing gear, dragged anchors and other seabed penetrating objects. In engineering the initial burial depth of these cables, a lifecycle balance is to be found between the cost and impact of deeper initial installation on the one hand and the uncertainties of seabed changes over the lifetime of the cables on the other. This is particularly challenging in areas with mobile seabeds, where, as a result of seabed mobility, the protective cover can be eroded over time.

Minimizing the lifecycle costs to society for the installation, operation and maintenance of subsea power cables can be attained through establishing a non-mobile reference level (NMRL), that is, the lowest seabed level over the lifetime of a subsea power cable. It can be used as a reference level for the burial of the cables to ensure cover on the cable over its lifetime. In engineering the NMRL, deterministic methods are commonly used. The disadvantage of such methods is that they do not provide insight into the probabilistic aspects of the NMRL.

In this paper, we present a new, data-driven, probabilistic method to predict seabed mobility in offshore areas where sand waves are prominent. It relies on the repeated random sampling of local sand wave migration and growth-decay rates from a set of probability density functions and uses these parameters in a Monte Carlo simulation to produce not a single, but a distribution of NMRLs for a set time frame. With this method we are able to give a quantitative estimate on the likelihood of a certain NMRL to be exceeded. As such, the burial depth of subsea power cables can be assessed on a probabilistic basis. We demonstrate the method's suitability using the IJmuiden Ver Wind Farm Zone (IJVWFZ) high voltage subsea power export cables of TenneT TSO B.V. as a case study.

INTRODUCTION

Subsea power cables are threatened by dragged fishing gear, dragged anchors and many other seabed penetrating objects. It is a historically grown given that human activities which take place above these cables with the potential to do damage, are practically unrestricted. However, the costs to society associated with a damaged power export cable at sea, are disproportionally large when compared to the benefits of the unrestricted activities threatening the cable. It is very seldom that the corridors of subsea power export cables are restricted areas. Therefore, it is of utmost importance that the protection given to power cables by their burial into the seabed is well-engineered and, if and where needed, well-maintained. Unnecessary deep burial of power cables into the seabed results in higher installation costs and a larger environmental impact. A balance is to be found between cost and impact of deeper initial installation on the one hand and the uncertainties of seabed changes over the lifetime of the cables on the other. Engineering this lifecycle balance is particularly challenging in areas with mobile seabeds. As a result of seabed mobility (erosion), the protective cover on subsea power cables can change over time. Reinstating the cover is costly and introduces risks to the integrity of cables. Knowledge and practical insight into the mobility of the seabed, and how it affects the cover on a cable, is required when aiming at minimum lifecycle costs to society for the installation, operation and maintenance of subsea power cables.

In this paper, we present a new, data-driven, probabilistic method to predict seabed mobility in offshore areas where sand waves are prominent. The method relies on repeated random sampling of local sand wave migration and growth rates from a set of probability density functions (PDF) and uses these parameters in a Monte Carlo method to produce a distribution of non-mobile reference levels (NMRLs), which is the most likely lowest seabed level at a given location for the prediction horizon considered (typically related to the lifetime of the cable).

Prior to outlining the method in detail, we briefly describe the general field of application and existing methods for modelling seabed mobility and introduce the case study used to demonstrate the suitability of the method.

BACKGROUND

Bedforms in Dutch North Sea

The seabed in the Dutch North Sea features bedforms at a variety of spatial and temporal scales, ranging from ripples and megaripples to tidal ridges, oftentimes superimposed on each other (see Figure 1). The temporal scale on which these bedforms are subject to change, is to a large extent dependent on their size: small bedforms, such as ripples and megaripples, are generally very dynamic – having migration rates up to a few meters per week –, and migrate faster than larger bedforms, such as sand waves – having migration rates up to 10 m/year – or tidal ridges – which are essentially static over the lifetime of subsea power cables (±50 years).

Though ripples and megaripples migrate fast in comparison to their large-scale counterparts, their height is typically too low (about 0.01-0.1 m and 0.1-0.5 m respectively, based on high-resolution MBES surveys in the Dutch North Sea) to pose a threat to the burial depth of subsea power cables. Sand waves however, having typical lengths of 100-1,500 m and heights up to 10 m, do have the ability to erode the protective soil cover on subsea power cables beyond the minimum requirements. It is for this reason that sand waves are the primary bedform of concern when engineering the burial depth of subsea power cables.