Towards Active Cable Reburial Monitoring using Distributed Fiber-Optic Sensing over 40 km of a High Voltage Marine Interconnector

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ABSTRACT

Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS) measurements were acquired over a 40 km section of the 137 km long Skagerrak 4 (SK4) subsea cable before and during a retrenching operation. Five sections of the cable between 140 m and 280 m in length had been identified for reburial using conventional geophysical and video techniques. DTS data taken over a three week period prior to the reburial clearly showed cold spots at all of the planned reburial sites. Absolute temperature at these locations fluctuated by over 8°C, which is interpreted as being in response to temporally and spatially varying bottom water temperatures. The reburial process itself was accurately monitored in real-time using DAS. After reburial, consistent DTS temperatures within ±1°C were measured at all reburial sites, comparable to the adjacent buried sections of the cable and thereby confirming reburial was successful.

KEYWORDS

Cable Survey, Cable Reburial, Distributed Temperature Sensing, Distributed Acoustic Sensing, Exposed Cables, Subsea Cable Monitoring

INTRODUCTION

Distributed Temperature Sensing (DTS) technology based on Raman scattering is widely used for measuring high voltage cable temperature for distances up to ~70 km [1], and its ability to detect exposed cable sections is now well established [2]. Distributed Acoustic Sensing (DAS) technology allows continuous real-time measurements of acoustic emissions and strain changes along power cables. DAS has previously been used to locate sources of acoustic disturbances over large distances ~80 km in terrestrial environments [3]. This paper presents the combined use of DTS and DAS to identify and undertake pre-, syn- and post-reburial monitoring of sections of a marine HV interconnector.

The submarine section of the Skagerrak 4 (SK4) high voltage interconnector runs between Bulbjerg, Denmark, and Kristiansand, Norway, covering a distance of 137 km (Fig. 1). The SK4 cable is a Nexans 500 kV HVDC Mass-Impregnated Non Draining (MIND) cable with a typical fluctuating load profile of up to 1432 A. The cable was installed, in the summer of 2013, to a depth of 0.5 – 2 m below seabed, using a Nexans Capjet trencher in fine to medium sands. Along the whole transect water depths range from 0 to -523 meters relative to sea level (mMSL) (Fig. 1). Burial depths were confirmed using a TSS350 cable survey system.

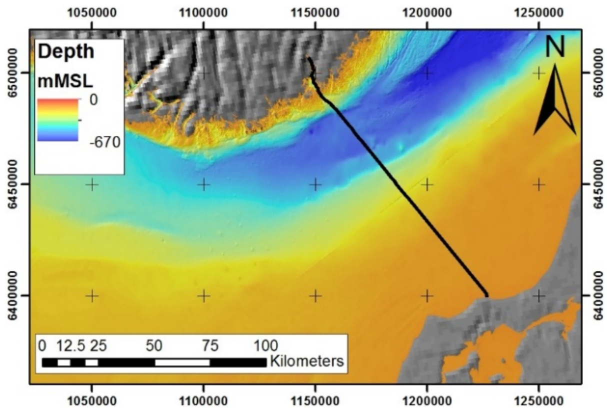

Fig. 1: The location of Skagerrak 4 cable overlaid on the EMODnet Digital Terrain Model [4]

In July 2017 during a scheduled post-installation re-survey (using a combination of high-resolution swath bathymetry, side scan sonar and ROV based video) five cable exposures were identified in the first 35 km of the cable off the Danish coast. Exposure widths ranged from 5 - 60 m and they occurred in water depths between -15.5 and -31 mMSL (Fig. 2). A reburial campaign was subsequently planned for July 2018 and this provided an opportunity to test the potential of combined DTS and DAS study of the reburial process. The bathymetry in Fig. 2 is from July 2018 and shows downstream scour that has developed in the 12 months between the two survey campaigns.

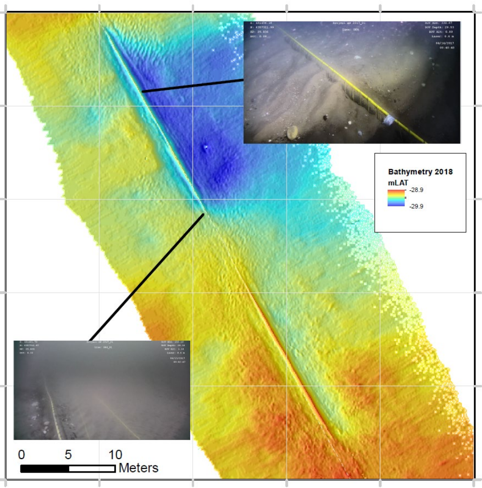

Fig. 2: High resolution swath bathymetry of an exposed section of cable. Insets show video stills of exposure of the cable and external fiber optic cable