# Toward Detecting Ship Characteristics and Movements using DAS and Machine Learning

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## *ABSTRACT*

*This study is to the best of our knowledge the first demonstration of detecting ships crossing the water surface above an undersea power cable, using Distributed Acoustic Sensing (DAS) technology and Machine Learning (ML) algorithms. Two different ML algorithms were applied to data from a subsea power cable, and a comparison carried out. Due to the small size of the dataset, image augmentation techniques were applied to increase the virtual pool of data. As an initial investigation, we show that detecting ships using ML applied to DAS signals is effective.*



## *KEYWORDS*

Distributed Acoustic Sensing, DAS, Machine Learning, Convolutional Neural Networks, Fibre Optic Cable, Power Cable, Pipeline, Ship Detection, Support Vector Machines.


## INTRODUCTION

This study demonstrates the possibility of using Distributed Acoustic Sensing (DAS) technology to augment the current maritime navigation systems that monitor ship movements above linear assets such as subsea power cables and pipelines. The current Automatic Identification System (AIS)[1] tracks ships using GPS and transponders on ships; however these can be switched off, often during illegal practices such as fishing, smuggling, and drug trafficking [2]. These untracked ships can pose a danger to the subsea power cables, such as anchor and trawler board damage. AIS is also not widely used around some developing countries.

Recent advances in DAS technology have demonstrated the ability to measure small changes of the optical path length, down to the picometer, of fibre optic cables (FOCs) buried below the seabed. These FOCs are often paired with subsea power cables, either buried in the same trench or as part of the power cable. DAS makes use of small impurities in the fibre that cause Rayleigh backscattering of a phase-coherent laser pulse with a known frequency.

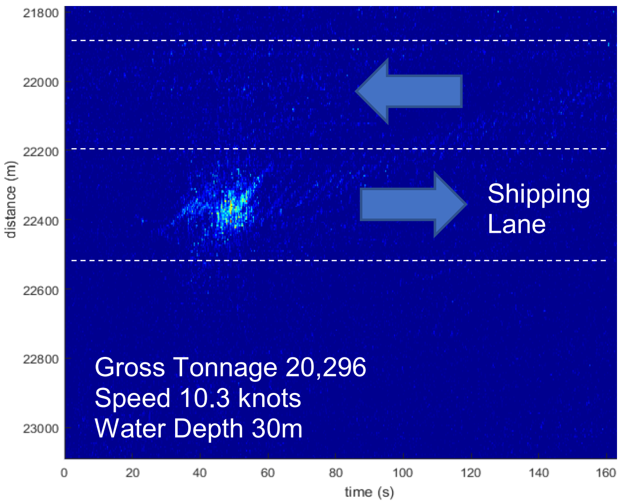


**Figure 1: An example FBE image of a ship crossing a subsea power cable**

The time of flight of the laser pulse down the fibre provides an accurate measure of the distance whilst properties of the backscattered signal can be interrogated to extract the change in length of the fibre down to pico-strain resolution.

The optical path length of the fibre can be changed through a number of effects including the thermo-optic and acousto-optic effects. Therefore, both pressure and thermal effects can be monitoring using the DAS, with pressure waves being the dominant effect in ship monitoring.

The DAS technology is well suited to monitoring long linear assets such as power cables and pipelines due to the long-range monitoring capability of the latest technology.

Recently, monitoring of power cables exceeding 125km has been reported [3].

**Figure 2: A Fibre Optic DAS system consisting of an optical interrogator unit, IU, (top) and a data processing unit, DPU, (bottom)**

It is common practice to interpret the DAS signals in the frequency domain. The phase signals are converted to Frequency Band Energy (FBE) using Fast Fourier Transform (FFT) techniques. The FBE measurements consist of the sum of the energy between two frequencies which can be configured by the user or default settings used [4]. The result is an FBE plot that shows the vibrational energy for each 1.28 metres of the cable, with a time resolution of 0.25 seconds. See Figure 1 and Figure 5.

Figure 2 above represents a DAS system together with the data processing unit.

An FBE example of a ship crossing a cable with a water depth of 30m is shown in Figure 1. The measurement was taken at a distance of 22.4km from the instrument. The time and location of the ship crossing can be clearly observed from the data. The challenge addressed by this paper is to