# METHODOLOGY FOR TIDAL ENERGY RESOURCE ESTIMATION AND EXPLOITABILITY: QSAIL APPROACH

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Tidal Energy is one of the most promising renewable energy sources to be picked up. Tidal energy conversion presents a complex engineering challenge: to produce affordable, competitive energy in one of the most challenging natural environments, where access for maintenance is expensive and high risk
During the last decade various types of the tidal power plant prototypes were developed, some of them contain special hydrofoils, other based on blades similar to the ones used in wind energy and other alternative solutions, like sails.
The TidalSense system will address part of this challenge by using long range ultrasonic technology (LRUT) to provide remote structural health monitoring (SHM) of significant tidal turbine structures. Structures under investigation at this stage of development are load bearing cables and composite structures (specifically turbine blades), but the technology can ultimately extend to all significant TEC structures.
The TidalSense technology has the potential to reduce cost and improve quality through the following key aspects:

QUALITY CONTROL: Enabling to check their components prior to release, reducing risk and improving customer warranty confidence.

ADVANCED FAILURE WARNING: Enabling operators to pre-empt component failure, decide whether to shutdown the machine, and planned maintenance rtaher tan reactive maintenance.

REDUCED ONSITE MAINTENANCE: To reduce the frequency of machine inspection reducing risk and cost by providing this ability remotely. Tests more frequent and from the safety of the shore.

DESIGN ENHANCEMENT: Providing machine developers with a highly valuable assessment of in service degradation of structures and design weak points, enabling parallel development of improved machinery and early warning for common design errors (product recall / improved maintenance before failure).
Even at its nascent stage of development, the tidal energy industry has already suffered serious failures that could have benefitted from remote structural health monitoring systems, both to pre-empt failure and to learn valuable lessons in the event of those failures. Industry leaders have already succumbed to machine stopping blade failures.
Due to continuous operation under the harsh marine conditions, such constructions should have been periodically tested against the faults. In the TIDALSENSE project two concepts are being studied, the inspection of Multi-Wire Steel Cables Using Long Range Ultrasonic Testing (LRUT) and the use of ultrasonic guided waves for the condition monitoring of the composite material elements.
Multi-wire steel cables are used in many engineering infrastructures. They are considered to be safety critical components. In marine energy they are used for tensión mooring and as driving elements in several devices. The location and operation of the multi-wire steel cable ensures they can be subject to variations in; temperature, pressure, and pre-/post- stress. These conditions can potentially induce cracks, corrosion, delimitations and brittleness within the multi-wire steel cables. This could results in a potential source of unreliability, which could lead to failure. Therefore, there is a need for an effective examination technique that can assess the condition of the multi-wire steel cables before any malfunction takes place. Long Range Ultrasonic Testing (LRUT) has been selected as Non-Destructive Testing (NDT) technique to inspect cables for defects or discontinuities. LRUT uses ultrasonic guided waves in the kilohertz range (typically between 20-300 kHz) to inspect for defects from single point of access for many meters (up to 100m) with full volumetric coverage. The aim of this work is to demonstrate the ability of LRUT to propagate and detect defects within the multi-wire steel cables. The work was conducted using FEA analysis along with experimental validations. The findings show that the fundamental axi-symmetric wave mode, L(0,1), can propagate within the multi-wire steel cable (up to 8m) at a frequency region between 16-20 kHz with the ability to detect defects over a  distance of many meters away from the ultrasonic excitation/reception region.
Talking of the monitoring of composite material elements, the case sudy was an hydrofoil. The overall structure of hydrofoil is very complicated as the skin and the main spar are made from glass fibre and carbon fibre composite, filled by foam. Inspection of so complex object is a great challenge for conventional non-destructive testing (NDT) techniques.
The objective of the presented work was to determine the most critical regions of hydrofoil to be tested, to select the modes of ultrasonic guided waves to be used and to determine the parameters of their excitation, propagation along the sample and interaction with non-homogeneities.
The analysis of the multi-layered structure of the hydrofoil to be inspected using ultrasonic guided waves was performed. The geometry, material type, properties and the critical regions of the hydrofoil that should be tested were identified. The dispersion curves of phase velocity of the guided waves propagating in the multi-layered structure of hydrofoil have been determined using SAFE method. The propagating modes of guided waves in the multi-layered structures of the skin and the main spar were identified using modelling and experiments. It was estimated, that in order to use the fundamental modes, the frequency range of operation below 200 kHz should be used for inspection of the skin and even lower for inspection of the main spar. The testing of main spar should be performed in longitudinal direction and other parts of hydrofoil - along perpendicular direction due to special orientation of fibres in the composite. It was  shown that even in the case of limited number of transducers embedded into recommended positions the necessary coverage of the object can be achieved.

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