MARKETING BROCHURE

July 2011

TIDALSENSE

The TidalSense consortium was formed in August 2009 to develop a remote structural health monitoring system for the tidal energy industry. The current development stage is funded by the European Commission's FP7 programme and will conclude in August this year.

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.

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 application takes proven technology from the oil and gas industry and applies it to the emerging tidal energy sector.

The TidalSense technology has the potential to reduce cost and improve quality through the following key aspects:

ABOVE: a storm in the Pentland Firth, Scotland. This harsh environment is also one of the most sort after tidal energy sites in world today. Machine survival confidence is critical.

BELOW: The River Sails concept, developed by TidalSense project Tidal Sails, and an end user for the technology.

QUALITY CONTROL	Enabling manufacturers to quality check their components prior to release, reducing risk and improving customer warranty confidence.
ADVANCED FAILURE WARNING	Enabling machine operators to pre-empt component failure, decide whether to shutdown the machine, and plan to replace rather than being forced to adopt a reactive approach to component degradation.
REDUCED ONSITE MAINTENANCE	Enabling machine operators to reduce the frequency of machine inspection reducing risk and cost by providing this ability remotely. Tests can be run from the safety of the shore, and more frequently.
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 *Marine Current Turbines*, *Atlantis* and *OpenHydro* have all succumbed to machine stopping blade failures.

To find out more about the TidalSense project or to get in touch, contact:

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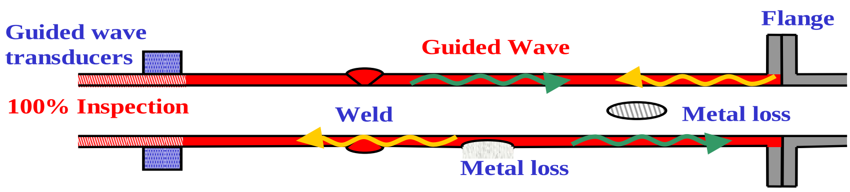
LONG RANGE ULTRASONIC TECHNOLOGY (LRUT)

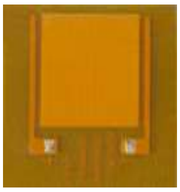
LRUT, also known as guided wave ultrasonic inspection, uses arrays of ultrasound transducers to detect inconsistencies in long (high aspect ratio) components. The transducer operates as a sensor and actuator, 'listening' for the initiation and propagation of defects, and using a guided response to identify and classify these defects.

A pulser-receiver system called Teletest® will be employed to inspect the cables on the Tidal Sails system. It will also be used for the generation of guided waves to inspect the composite blades in the tidal stream generator structures. Teletest® is a long-range ultrasonic non-destructive testing technology developed to generate guided waves for detecting metal loss in pipe work when access is difficult. It is a pulse echo system aimed at testing large volumes of material from a single test point. Teletest® is primarily a screening tool with the added feature of focusing the sound energy into a specific region to measure the distribution of the defects forfurther evaluation using other NDE methods.

Guided waves

The inspection of engineering structures using long-range guided waves is attractive because it is possible to investigate complete material volumes in regions over 100m away from the point of measurement. Guided wave ultrasonic inspection is different from conventional ultrasonic inspection, since an array of transducers fitted round the outside of the part being inspected sends a sound wave along the length of the component, rather than through it. The component itself constrains the waves along the pipe wall. The received signal depends on the nature of the reflecting surface. Therefore, discontinuities such as corrosion or metal loss can be detected analysing the reflected wave.





Flexible interdigitated Macro Fibre Composite (MFCs) transducers are proposed for the onset of defect detection. Experimental analysis using MFCs is presented in the TWI paper 'Assessment of Defects in Wind and TidaL Turbine Blades using Guided Waves' submitted to FESI for the upcoming 'ESIA11 - Engineering Structural Integrity Assessment' conference on the 24th-25th May 2011 in Manchester.

To find our more about LRUT, [click here] to visit project partner and industry experts, TWI.

CONSORTIUM R&D ACTIVITIES

The TidalSense consortium is made up of expert companies from the structural health monitoring, software and electronics and tidal energy industry. Key R&D partners Kaunas University of Technology, Cereteth and TWI having been developing the core of the TidalSense project over the past 18 months.

Kaunas University of Technology (KTU) have undertaken an extensive review of the suitable methods for numerically modelling the characteristics of guided waves in composite materials and cables. This has allowed them to best select the appropriate method of wave propagation analysis and LRUT transducer operating frequencies.

The semi-analytical finite element (SAFE) method has been proposed for the estimation of dispersion curves and the finite element method for overall analysis of wave propagation in non-uniform, laminated composite structures. The SAFE method has been used to numerically model a typical turbine blade structure proposed by project partner IT Power.

The work carried out by KTU provides conclusions that enables the selection of suitable operating frequency ranges, modes and direction of wave propagation for the inspection of the semi-structural GFRP* blade skin and internal CFRP** structural spar typical to most tidal turbine blades.

*Glass Fibre Reinforced Plastic **Carbon Fibre Reinforced Plastic.

KTU have carried out laboratory tests on a representative GFRP composite sample to develop the transducer array layout. The laboratory setup demonstrated the ability of LRUT to successfully identify simulated defects in the test sample.

KTU's numerical modelling and laboratory work on the use of LRUT in cables presents a more complex challenge for TidalSense particularly with the length and constantly moving nature of the River Sails power take off cables. The system has been tested and can be shown to differentiate between defective (simulated with cables clamps) and defect free cables up to a length of 2m. TidalSense will continue to investigate the cable application as the project progresses, culminating in a demonstration at TWI in August 2011.

This laboratory work has fed directly into the transducer hardware development work being carried out by project partner Cereteth.

The Centre For Research and Technology, Thessaly (Cereteth) have, with assistance from KTU taken the theoretical proposal for the SHM system and developed a prototype marinised transducer for use in arrays on composite tidal turbine blades. Cereteth have also been developing the data and power architecture connecting the transducer array to the data processing system and ultimately to the user. Cereteth's work to date has focused on the development of the composite monitoring system rather than the cable monitoring system.

Encapsulated Transducer Design

The design of the prototype transducer is aimed at retro-fitting the module to the surface of turbine blades, allowing for flexible installation whilst the system is still at the development stage. In future the technology will, for composite structures in particular, be fabricated with the composite structure (an understood process from the aerospace industry). Cereteth have been careful to ensure that the transducer response is not affected by the transducer housing.

Each array module is made up of two significant parts, a flexible, piezo-electric, macro fibre composite (MFC) transducer closely adhered to the surface of the turbine blade. The second part is a tough, streamlined, waterproof housing that protects the MFC transducer and routes the associated cable from the transducer into the seawater environment.

The encapsulation module is being designed to have a rating IP68, meaning it will have a minimum life of 5 years (43800h) at 5 bar hydrostatic pressure. Cereteth will be testing to 8 to 10 bar and extrapolating the anticipated life from short period tests. It is likely that most tidal turbines will be operated at depths corresponding to a pressure of no more than 5 bar. These pressure tests will therefore give the consortium the confidence required to validate the prototype module.

The transducer modules will be tested at TWI's laboratories in summer 2011 within the complete LRUT system.

Data and Power Architecture

Cereteth are also responsible for the development of the data and power infrastructure required by the LRUT transducer array. Cereteth have made an extensive assessment of the data transmission options. In addition to standard cabled options, acoustic, optical and electromagnetic wireless options, and power-line data transfer has also been investigated.

TidalSense will not test the LRUT system on a tidal turbine in the marine environment during the FP7 stage of the project. As a result, standard data and power architecture will be used to set the system up for testing at TWI in the summer. The TidalSense system will be designed to integrate closely with the other actuator and sensor systems likely to prevalent in most tidal turbines

TWI has investigated the ultrasonic propagating characteristics within GFRP and CFRP components. Analysis of delamination and disbond defects within a GFRP/CFRP blade mock-up sample is ongoing. To date, results have indicated that disbond defects can be successfully detected using LRUT featuring transmitter and receiver arrays of MFCs. Optimisation of these arrays is underway.

iKnowHow	Software development
InnotecUK	Data processing architecture developer
IT Power	Development steering end user and information dissemination
Tidal Sails	Development steering end user
EnerOcean	Development steering end user
I&T Nardoni	Field testing

To find out more about the project partners or to get in touch, click here

CAPABILITY

The TidalSense system is initially being developed to monitor machine components that will result in the critical failure of turbine blades and braided steel cables. These particular components are key to project partners Tidal Sails in the case of their power take off cables; and consultants IT Power in relation to their turbine blade experience and current client needs. Work under the FP7 project focuses on these particular areas, but technology is capable of providing much wider, general SHM for tidal turbine components where a clear cost case can be made for in service SHM.

The system will be capable of providing the following inspection services, detecting and with further technology development, classifying these common sources of component failure.

Turbine blades:

- Composite layer de-lamination
- Bonding errors / inconsistencies during fabrication
- Bonding errors / inconsistencies during installation
- Skin puncture
- Crack propagation
- Fibre-matrix dissociation

Power take-off cables:

- Loss of cable material due to corrosion
- Cable fibre failure (including internal fibre failures)
- Cable surface damage and significant indentation

MARKET OPPORTUNITY

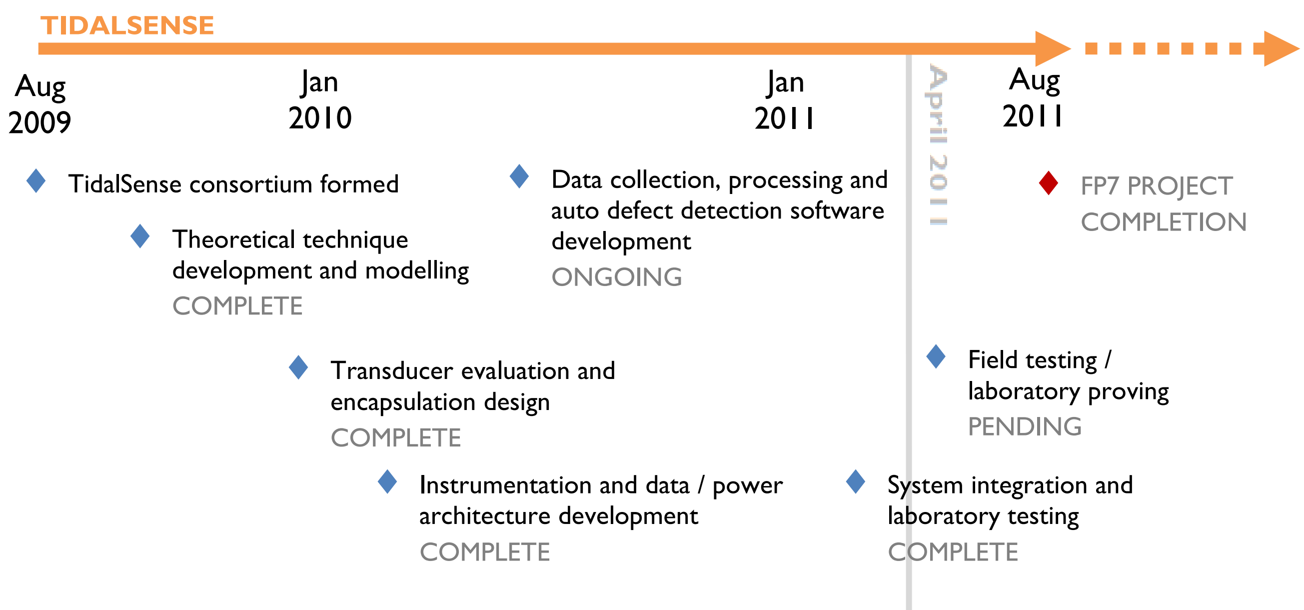
Tidal technology is on the cusp of commercialisation, with numerous technology developers demonstrating their concepts at commercial, 1.0MW plus scale. Whilst these developers seek large scale funding, 100s of MWs of large scale projects are in planning, pre-empting the success of the technology. Much of the global growth in the tidal energy sector is currently occurring in the UK, plans to install 1.3GW of tidal energy by 2020, representing over a thousand turbines. This technology uptake is expected to continue the world over as the price of tidal energy reduces.

TidalSense is well positioned to make use of this expanding market. With the development of TidalSense taking place at the beginning of the commercialisation of the sector, the technology can be closely integrated with tidal turbine developer thinking and design.

Once proven successful, TidalSense will provide technology developers and owners with a tool to reduce risk, improve machine reliability and reduce costs. With successful long-term integration, SHM technology will play an important role in achieving machine accreditation and reducing insurance premiums.

TECHNOLOGY DEVELOPMENT TIMELINE

The TidalSense technology development timeline to date:



See our website for the latest news

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