Performing oceanographic surveys on tidal energy sites using a data buoy

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Summary: A met-ocean survey buoy (*DataFish*®), invented by D Rigg (MEng Oxon.) has been developed by North Sea Systems to collect oceanographic data from tidal energy sites. This report discusses the development process of *DataFish*® beginning with the hydrodynamic modelling of the hull using *OrcaFlex*® (computer software for dynamic analysis of offshore marine systems). The electrical system including battery capacity, compatible sensors, data logging capabilities and data transmission methods are then discussed. *DataFish*® specifically targets current profiling through the use of Acoustic Doppler Current Profilers (ADCPs) and Acoustic Doppler Velocimeters ADVs), acoustic measurements with hydrophones and wave measurements with accelerometers.

Introduction

Collecting data from tidal energy sites is notoriously difficult primarily due to the speed of the tidal stream and the short working windows available during slack tide periods. There are many examples of failed surveys, where buoys are dragged under or break their moorings, or data is found to be of poor quality once the sensors are retrieved. *DataFish*® was designed to overcome these challenges by being hydrodynamically shaped, remaining stable in fast streams and providing real time access to the data it collects. *DataFish*® carries a 660Ah 12V battery bank, data logging and transmission capabilities making it a state of the art marine survey platform. This report discusses the engineering design process of *DataFish*® and future development work.

Design Methodology

The basis of design for *DataFish*® hull focussed on the survivability during tidal streams of up to 6m/s and significant wave heights of 5m. Other considerations that affected the hull design were the logistical requirements to transport and deploy the buoy and the need to accommodate electrical equipment within the hull. A naval architect was contracted to design the shape of the hull, which is fabricated from vacuum infused glass fibre. The environmental conditions and mooring line properties were used to define the initial *OrcaFlex*® model. Using the results of the hydrodynamic analysis an iterative approach was used to generate the minimum hull volume required for the buoy to remain on the surface worst case conditions, except for occasional submergence due to wave action. This model was then subjected to a variety of environmental load cases to generate peak loads and assess motions and stability during service and towing.

Electrical System

The importance of knowing that *DataFish*® is secure and operating successfully was paramount in the design of the system. Therefore, the data from the sensors is collated using a data logger, which then transmits the data to a web based data hosting service (cloud) using a General Packet Radio Service (GPRS) modem in order that the data can be retrieved remotely in real time. To date, the following sensors have been deployed:

- Global Positioning System (GPS) antenna for location monitoring
- Load Shackle to monitor the load in the mooring
- Anemometer for wind velocity measurement
- Accelerometer for determining wave height and frequency
- ADCP for current profiling
- Hydrophone for underwater acoustic surveys

The power consumption of this standard set-up is approximately 4 Watts depending upon the settings, which results in a maximum deployment duration of 66 days as shown in the equation below:

$$\begin{aligned} Battery\ Life\ (days) &= \frac{Battery\ Capacity\ (Ah) * Depth\ of\ Discharge(\%) * Voltage(V)}{Power\ Consumption\ (W) * Hours\ per\ day} \\ &= \frac{660 * 0.8 * 12}{4 * 24} \\ &= 66\ days \end{aligned} \quad (1)$$

Torpedo - Additional sensor housing module

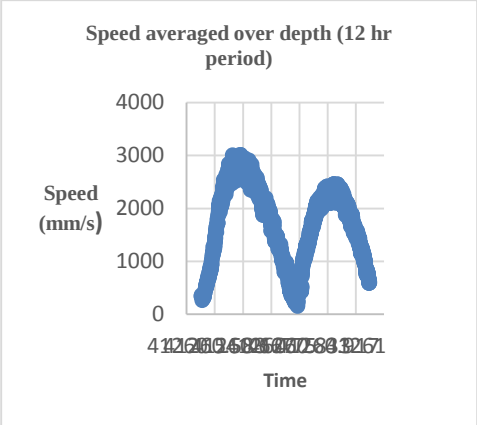
In December 2013, *DataFish*® was deployed with *Torpedo*, a low drag structure connected via a linkage to the mooring line that housed a hydrophone, although it has a second purpose as an ADV housing. This configuration is shown in figure 1 below. The ADV or hydrophone can be positioned at a known height in the water column and although this height will vary proportionately with the water velocity it remains relatively stable and points into the direction of the flow. It is easy to envisage a number of ADVs being placed at various heights along the mooring umbilical. The hydrophone deployment proved that a baseline acoustic survey could be carried out using the torpedo as a housing and *DataFish*® as a source of power and data collection platform.

Further Development

North Sea Systems has recently been awarded a Technology Strategy Board (TSB) grant to develop *DataFish*® so that it can power and communicate with sensors on the sea floor. This will be achieved through the use of a special umbilical that will act as the mooring line as well as the transmitter of power and data. The buoy will also be fitted with a hydro generator and solar panels such that the system can be deployed for durations of up to 6 months without any human intervention. This project is due for completion at the end of August this year. Testing of the complete new system will be taking place in July this year. Stage gate tests are being conducted of individual components and modules to prove their performance in isolation.

Results

DataFish® has been tested in the Anglesey Skerries, North Wales and off the South coast of England near Poole and in The Solent. The harshest conditions were seen in The Skerries, with significant wave heights (H_s) of 2m and tidal streams in excess of 2.5m/s as shown in graph 1 below. The conditions in the South of England were H_s=1m and tidal streams of up to 2m/s. This was where the hydrophone trial deployment was carried out in collaboration with Kongsberg Maritime who processed the acoustic data and correlated shipping noise with shipping movements shown on Automatic Identification System (AIS) software.



Graph 1 - Speed vs Time (Skerries)

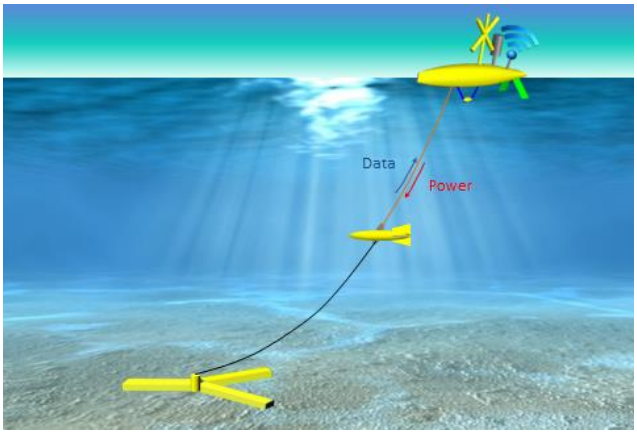


Figure 1 - DataFish, Torpedo and clump weight

Conclusions

A thorough design process was undertaken to develop the initial design of *DataFish*®. This design has not been validated at extremes but there is good correlation of the measured load shackle readings compared to those predicted by the *OrcaFlex*® model. *DataFish*® was monitored throughout the various trials and it was observed that the stability of the buoy improves as the water velocity increases. This is because a higher water velocity results in a higher mooring tension, and the mooring acts as a keel, with the mooring tension replacing the lead ballast. Data gathered to date has been of high quality and value to turbine developers and environmentalists. The TSB development project is on track for completion at the end of August this year and this will allow sensors to be bottom mounted and communicated with in real time.

Acknowledgements

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