Making Marine Energy a Reality

The Role of Prototypes

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With the European Marine Energy Centre in Orkney and Wavehub in the South-West dedicated to testing emerging wave and tidal technologies it is timely to consider the role of prototypes in making marine energy a reality. Developers will be installing prototype devices - part or full-scale first generation versions of their proposed technology – and exposing them to the extremes of the ocean environment. How successful will they be? Moreover, what makes a prototype 'successful'? Jonathan Armstrong, Technical Manager at Frazer-Nash Consultancy, advocates the need for a clear vision of success and a healthy degree of pragmatism.

Most wave and tidal developers regard a successful prototype as a key stage in the commercialisation of their technology. A small number of wave and tidal devices have already been tested in representative sea states and there have been successes and failures. Now we are approaching a stage in the industry's development when many more developers will start to deploy prototype devices at sea. Expectations are high and there is much at stake. Successful prototypes will open the door to the £42 million Marine Renewables Deployment Fund, further private capital and the road to commercial success. Conversely, repeated failures may stall the whole industry. So what is involved?

Prototyping is a way of managing risk when developing new technology. By deploying a prototype, a developer gains insight into the technology risks of how their device will perform in the actual environment in which it will operate. Gaining insight into the project risks of deployment, operation, maintenance and recovery is also important to support investment in commercial developments. Crucially, a prototype allows the developer to gather vital information on real-life performance that can be used to inform the design of the final production device. With limited experience of how such devices respond in the ocean environment and the complex interactions between wave, tide and wind, prototyping buys greater confidence than computer modelling. Confidence leads to investment and many developers see a successful prototype as the key to the further investment necessary to achieve a production device. Herein lies the nub, because without a clear vision of success expectations may not be met, leading to a loss of confidence or the need for expensive engineering that adds little to the overall technology development plan.

Prototyping is by no means unique to marine energy. Lessons can be learnt from other industries, and a relevant example can be found within Frazer-Nash. Neil McDougall, Frazer-Nash Engineering Director, was previously Project Director of FLAVIIR at Cranfield University. FLAVIIR is a technology development programme to produce maintenance free, low-cost unmanned aerial vehicles (UAVs). Here prototypes were used to provide real in-flight data to validate flight control modelling. This shortened the development programme and reduced costs by avoiding the need for several years of computer model development. Of most interest here though was the vision of success for the prototypes – they had to fly to be able to generate the data needed to validate the models, but a successful mission did not necessarily need to include the landing. McDougall reported that in reality it didn't matter if the UAV crashed after providing in-flight data. In fact, such a mishap might have helped demonstrate the adventure in the research they were undertaking. Consequently, this allowed fit-for-purpose prototypes to be built at greatly reduced cost.

So what would constitute success for a marine energy prototype? The predominant requirement is to gain the information to confidently *predict* performance, rather than actually *achieve* high performance. Analogous to the requirement that the FLAVIIR prototype had to fly, this requires that the prototype must survive to allow data gathering to take place. However, the prototype does not need to demonstrate high energy yield, nor indeed survive all of the environmental conditions that a production device will be subjected to (such as, for example, storm conditions). Such systems-level thinking about the purpose of the prototype can be usefully captured in a technology roadmap. The roadmap underpins the development plan by clearly defining the vision of success for all development activities, such as computer modelling, scale model testing and final design of the commercial model.

By avoiding the need to achieve high performance, the developer is free to make pragmatic engineering decisions consistent with the vision of success for the prototype. This in turn can lead to reductions in development timescales and costs:

- The diminishing returns of trying to develop ever more accurate models can be curtailed by the use of bounding assumptions. Device optimisation and value engineering of the production device can then be undertaken with the benefit prototype experience and calibrated models.
- Instead of designing a prototype to survive a 1 in 100 year storm, the developer may have the option to recover the device if extreme weather is forecast.
- Instead of designing for a commercial lifetime, the prototype can be designed for a lifetime consistent with accruing the necessary data.

So are there any universal dos and don'ts? The vision of success for a surface-based wave prototype may be different from that for a sub-sea tidal prototype, but the following points are generic:

- *Do* make sure that you have a clear vision of success for any prototype.
- *Do* place the role of the prototype within the context of an overall technology development plan, always thinking ahead to the end goal of a production device.
- *Do* develop the overall prototype system consistently. There is little point having the structure at a high level of maturity without paying any attention to the instrumentation that will provide the data which is fundamental to the prototype's role. The FLAVIIR UAV prototype was designed with instrumentation in mind from the outset.
- *Do* make pragmatic engineering decisions to control cost based on the vision of success for the prototype.
- *Don't* cut costs that could undermine the vision of success. This is not the time to take short-cuts in design or manufacture – a robust structure, installed spares and redundant control systems are cheap compared to the cost of a failed prototype programme.
- *Don't* consider the prototype as a one-off version of the production device.

- *Don't* ignore the insights that a prototype programme can bring to project risks such as deployment, maintenance, recovery and health & safety.

In the end, the success of a prototype programme will be measured against the expectations that were set. If developers' stakeholders are expecting 40% efficiency and 95% availability then the probability of failure is high. Alternatively, if the expectation is the generation of data to validate modelling that can predict performance and survivability in all sea states, then success begins to look achievable. Confusing the end goal of a production device with the requirements of a prototype can lead to loss of confidence by investors, government and the public. Success breeds confidence and the marine energy industry needs to build confidence to allow its stakeholders to make bold decisions; decisions to invest in the technology, to implement grid upgrades, to simplify the planning process – decisions that are needed for the UK to maintain its position as the global leader in this industry.

Marine energy will become a reality but it will mean device developers, investors and the public sector working together more closely than ever. A shared realistic vision of success for wave and tidal device prototypes is vital to build the confidence that will allow these decisions to be made.

Frazer-Nash are working with device developers, investors and the public sector to help make marine energy a reality. For more information, visit www.fnc.co.uk/renewables or contact renewables@fnc.co.uk,