SCOTTISH ASSOCIATION for MARINE SCIENCE · HR Wallingford *Working with water* · The University of Edinburgh · University of Strathclyde Glasgow · University of Exeter · IDCORE Industrial Doctoral Centre for Offshore Renewable Energy

Material selection and structural design of wave energy devices

L Barker Ewart, D Findlay, N Barltrop, T Stratford, P R Thies

Albatern Wave Energy

Introduction

Much of the research in the wave energy industry focusses on the energy capture technology; material choice and structural design issues have often been a secondary concern. The aims of this project are:

- To minimise overall CAPEX and O&M requirements through optimal material selection and production method design;
- To ensure that the structure is robust and reliable throughout the design life by developing and following a risk based design process.

This poster details some of the avenues of investigation that are being carried out in order to achieve these aims, in relation to the Albatern Squid WEC and WaveNET array.

Overview of Albatern device

The Albatern Squid module is an articulated floating system, with omni-directional power capture through relative motion of adjacent node. Individual modules are connected together in WaveNET arrays, and development is being carried out on two different scales:

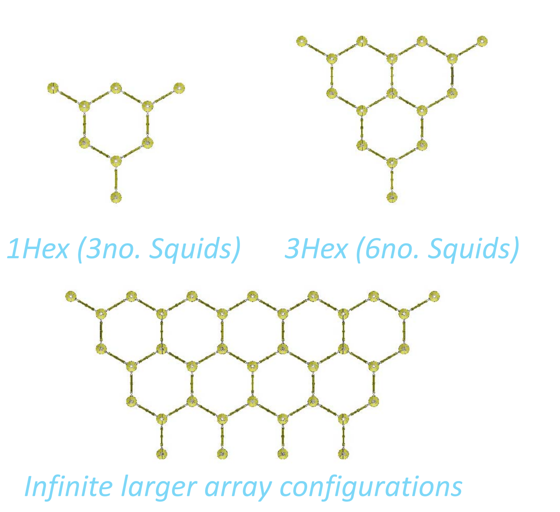

Fig 1: Array configurations

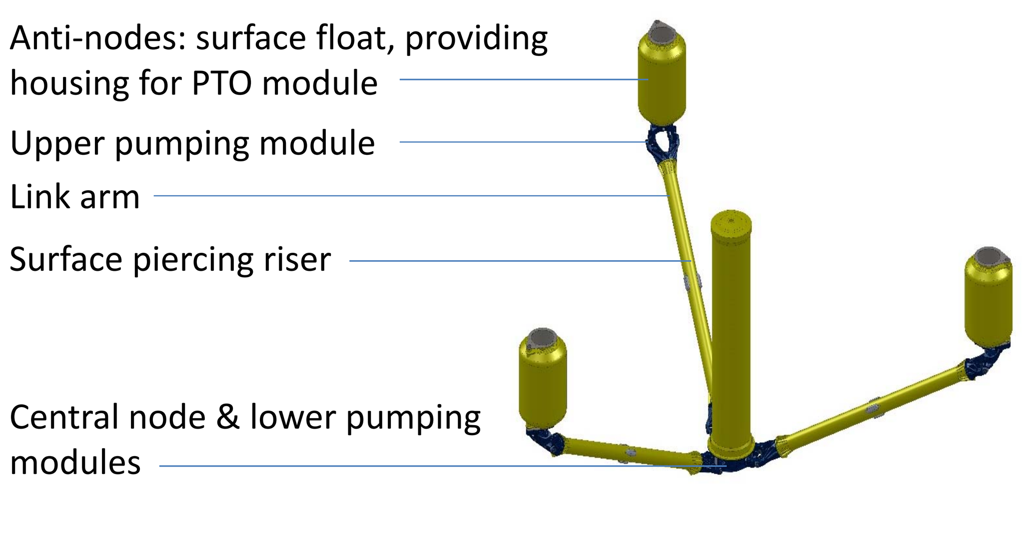

Fig 2: Squid 6 unit – 7.5kW (Hs ~ 6m), undergoing sea trials. Ultimate market: small, off-grid applications e.g. aquaculture

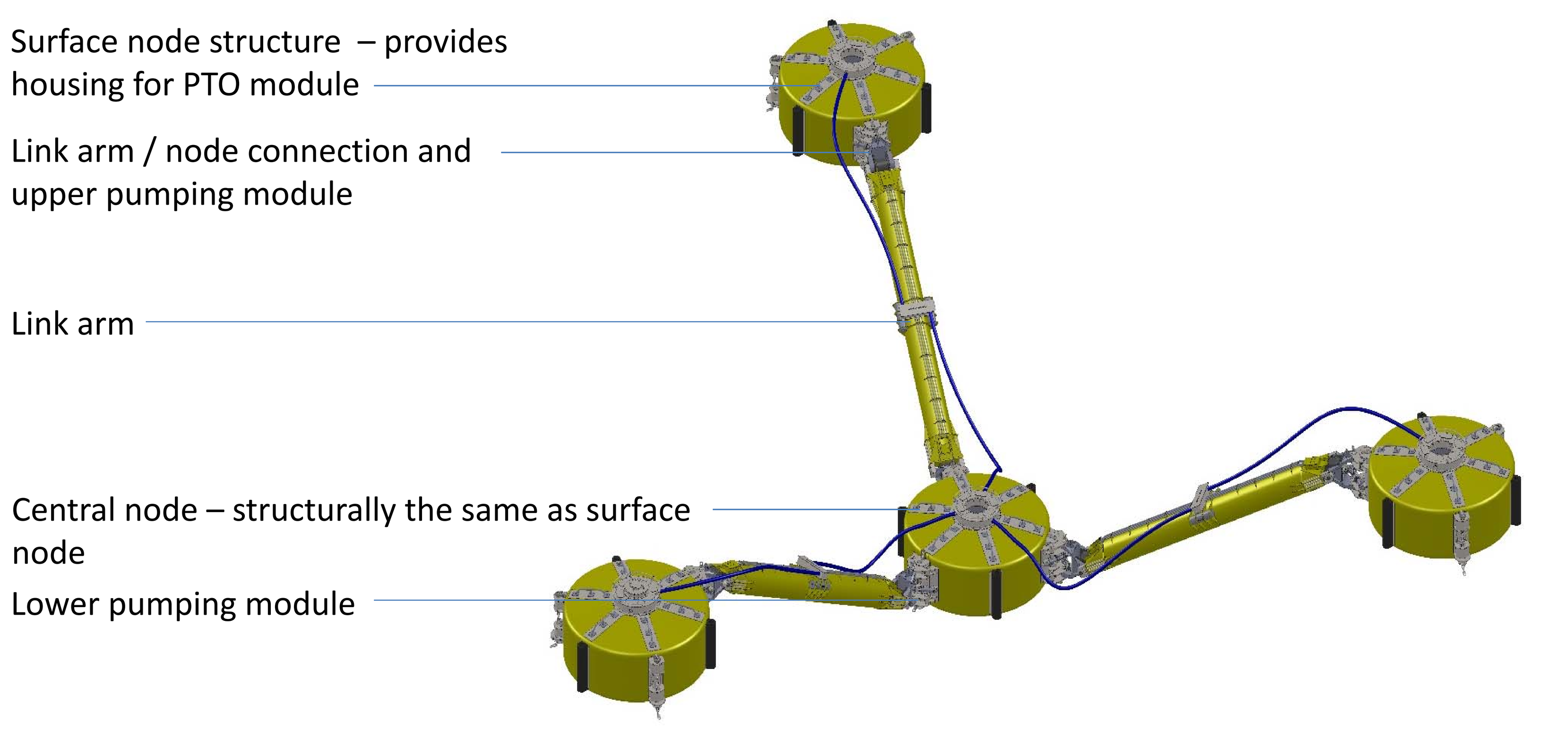

Fig 3: Proposed Squid 12 unit– 75kW (Hs~12m). Currently in development. Ultimate market: utility scale

Concrete as a structural material

An techno-economic study identified reinforced concrete as the preferred structural material for the nodes of the 12S Squid Unit. Benefits of concrete over steel include:

- Cost effective material, especially for volume manufacture
- Good corrosion properties, providing that mix design and detailing takes into account the specific challenges of the marine environment.
- Good fatigue properties; important in structures subject to dynamic loading

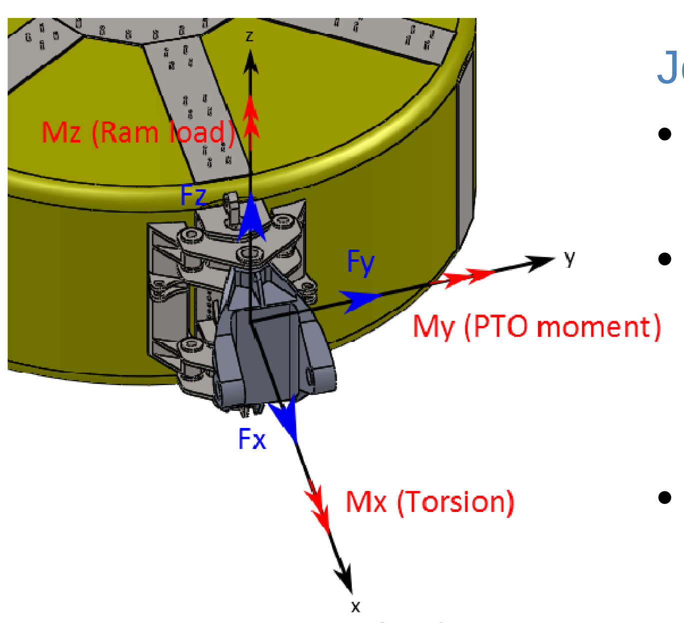

Fig 4: Connection loads

Joint issues

- Main area of uncertainty for concrete is the method of connection to adjacent steel sections.
- The joint between the link and nodes is critical as it is required to transfer all the dynamic loads from the pumping modules into the node without damage or leakage.
- Uncertainty surrounding the connection behaviour is to be investigated through a series of mechanical tests of different joint options.

Structural design process

- Wave energy devices are novel structures which fall outside the scope of available design codes. (e.g. DNV codes based on large static floating structures, in comparison with dynamic, responsive WECs).
- A risk based design process (illustrated in Fig 5) is therefore essential to reduce uncertainty and increase confidence in the reliability of the technology.

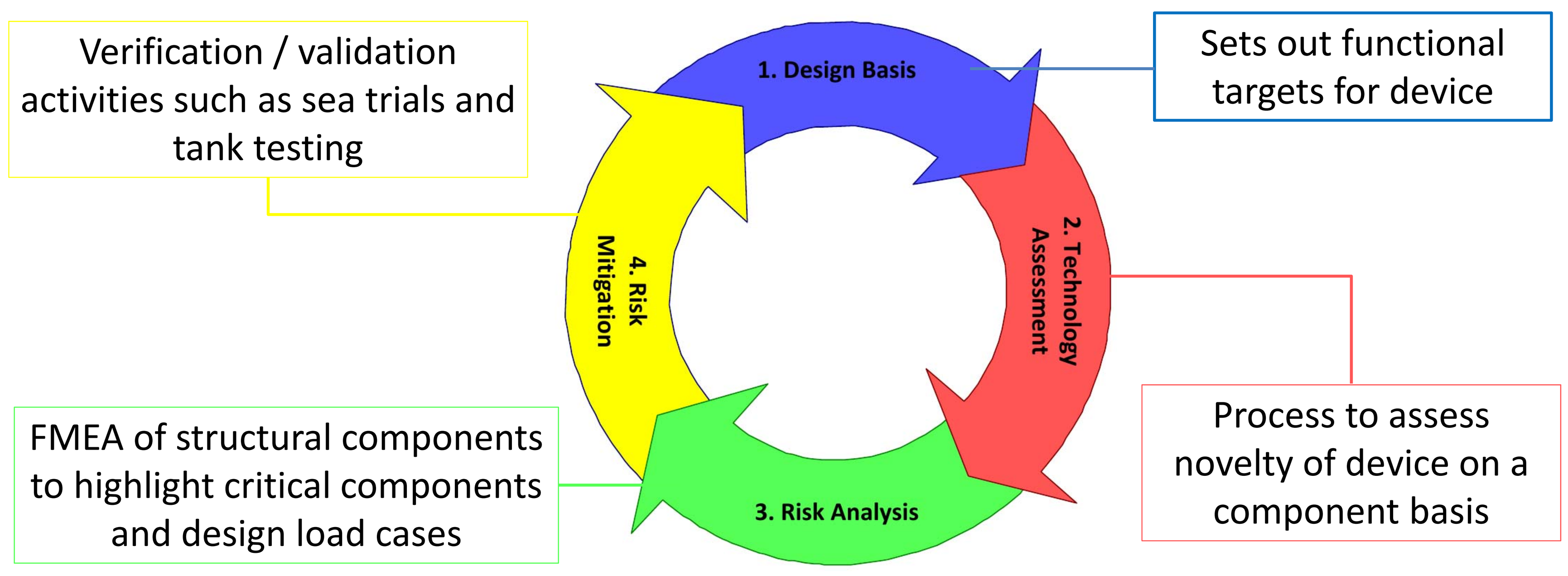

Fig 5: Risk based design process [1]

Validation – sea trials (6 series)

- Design currently based on the output of numerical hydrodynamic models.
- Validation of these models is an important step to reduce uncertainties in design.
- 6no. series 6 devices currently unc sheltered sea trials.
- Data from these sea trials will be used to:
  - o validate numerical models;
  - o verify power output predictions; and
  - o provide knowledge to help to accelerate development.

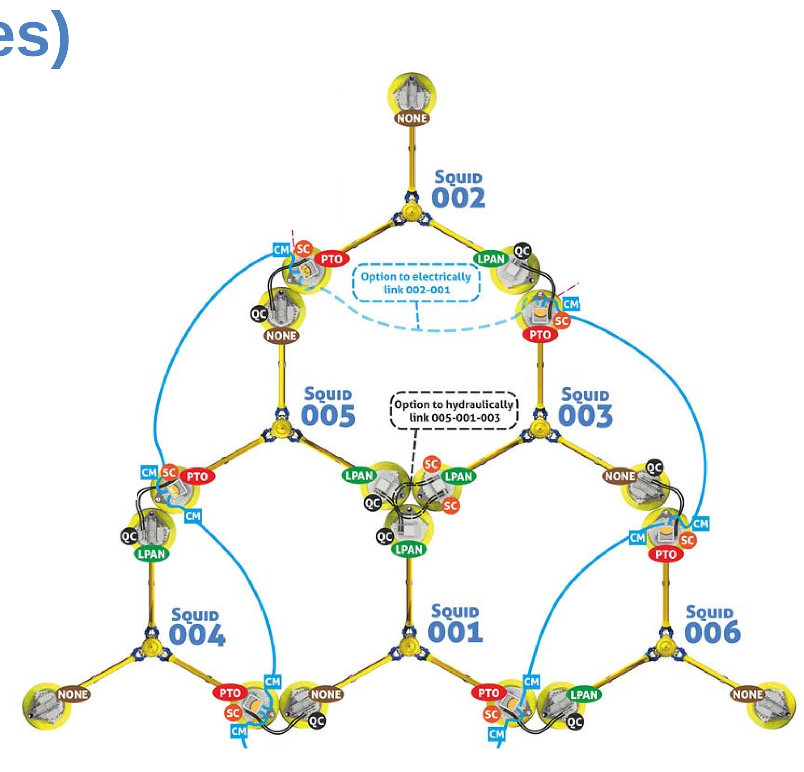

Fig 6: Plan layout of array

Fig 7: 3Hex 6S series array in testing at Kishorn Loch, September 2015

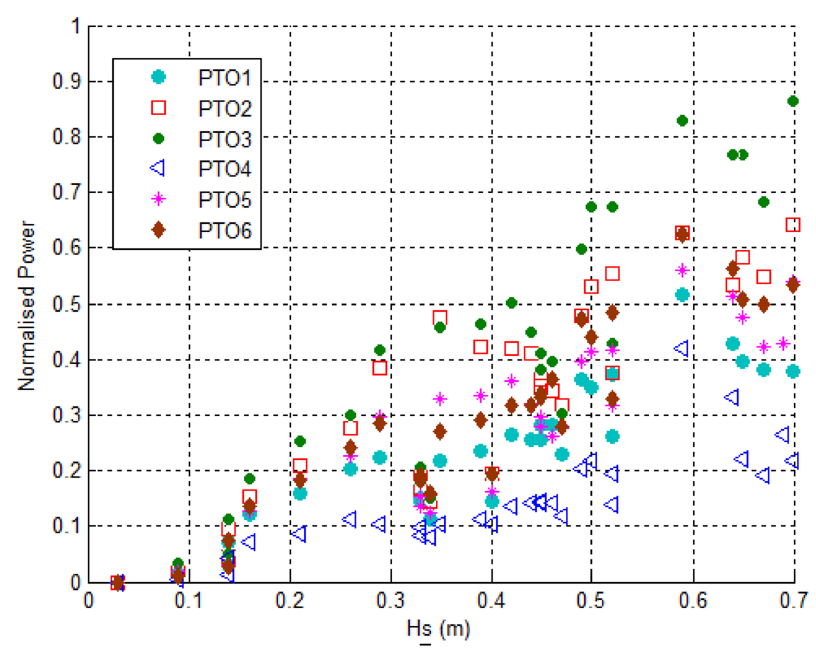

Fig 8: Absorbed power during sea trials 13/09/15

- Initial data shows power absorbed in low sea states (see Fig 8).
- Ongoing trials in more exposed locations will give information across a greater range of the design wave scatter diagram.
- Strain gauges and load cells will also be incorporated in order to validate the loading regime.
- Comparisons of power output, control states and loading will be carried out to help optimise control and survival strategies.

Validation – tank testing (12 series)

Tank testing of the 12S scale device is scheduled for 2016 in order to:

- Quantify effect of modifications compared to 6S configuration
- Provide further information for validation of numerical models
- Provide additional loading information to aid with ongoing structural design process

Reference: [1] *SDWED Deliverable 5.2 Generic WEC Risk Ranking and Failure Mode Analysis*, Borna Hamedni & Claudio Bittencourt Ferreira, 2014

ALBATERN *Wave Energy*

Albatern Ltd
Midlothian Innovation Centre
Midlothian, EH25 9RE
Contact: l.ewart@ed.ac.uk

energy technologies institute · Research Councils UK Energy *For a Low Carbon Future*