Tension Technology International

Elastomer Use in Sustainable Energy Generation

NETBUOY: Inflatable elastomer membrane structures for wave energy devices

A novel prime mover designed for low cost and robustness

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19th Mar 2021

wave energy SCOTLAND

I·M3 Institute of Materials, Minerals & Mining

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- TTI Intro
- Wave Energy Scotland
- Wave Energy and Wave Energy Convertors
- Conventional structures and their problems (the need)
- NetBuoy (a solution)
- What we have done to increase Technology Readiness Level
- Next steps
- Other interesting elastomer based devices

Tension Technology International

TTI was founded in 1986 and is headquartered in UK

It has two subsidiaries **TTI Testing Ltd (Rope & Cable Testing Laboratory)** and Scottish-based **TTI Marine Renewables Ltd**

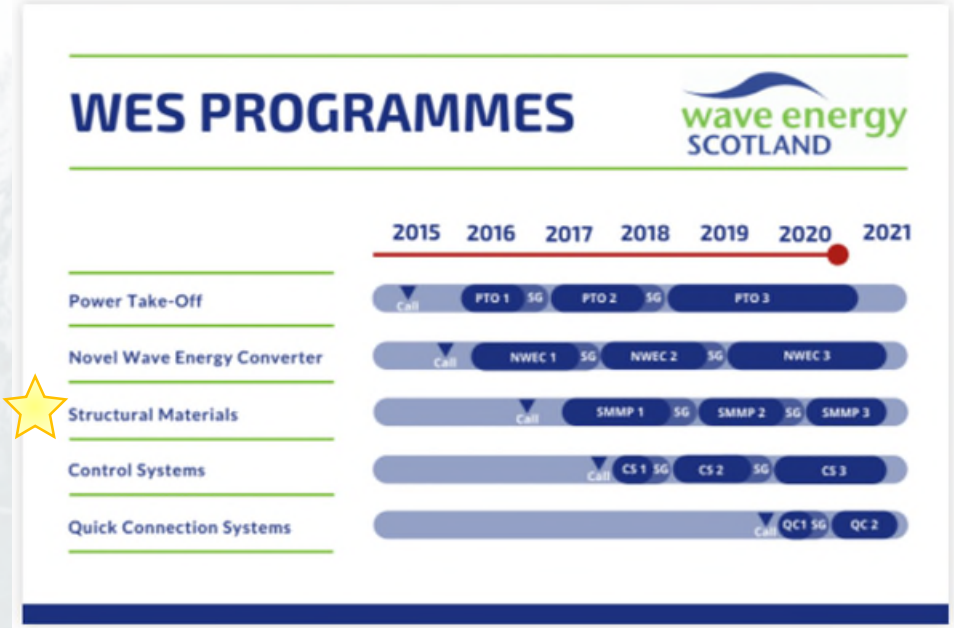
Core Disciplines & Expertise: Naval Architecture**, Mechanical Engineering** Hydrodynamics**, Mooring System Design,** Tank Testing**, Rope & Electro-mechanical Cable Testing**, Product Development (rope, anchors, mooring connectors, tensioning systems), **Net manufacture,** Mooring Software Development (Optimoor), **Marine Operations**, Field Tests & Instrumentation.

TTI Testing Laboratory

TTI Testing offers a full range of consultancy, research, development and forensic analysis in fields related to the design, inspection, operation, testing, appraisal and discard of tension elements. We have internationally recognised expertise in wire and fibre ropes, chains, electromechanical cables, hoses and related interface components in the onshore, industrial and offshore markets. We offer a full range of additional industrial mechanical testing.

Wave Energy Scotland (WES)

- Established in 2014 as a subsidiary of Scottish Government development body Highlands and Islands Enterprise (HIE)
- To lead the search for innovative solutions to challenges in wave energy sector
- Competitive procurement of R&D
- Support a range of projects focused on the key systems and sub-systems of Wave Energy Converters (WECs)



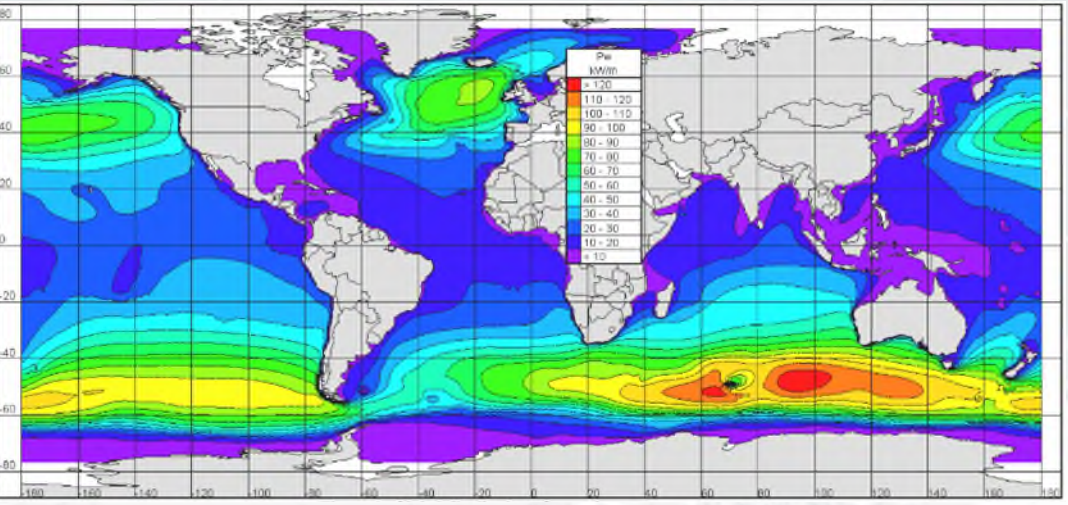
- Aim is to produce reliable technology which will result in cost effective wave energy generation
- To date: 95 contracts, £41.6m 230 separate organisations, 13 countries
- NetBuoy started Novel Materials program early 2017 and now in Stage III

What is Wave Power?

Wave power is the capture of energy in wind waves to do useful work; e.g. electricity generation

The waves store and transport kinetic energy

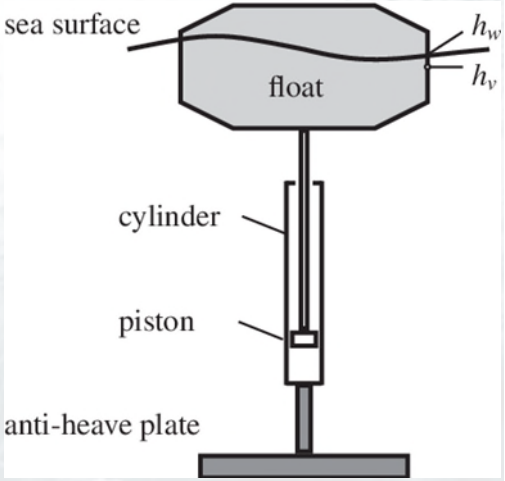
Cornett, Andrew. (2008). A Global Wave Energy Resource Assessment.

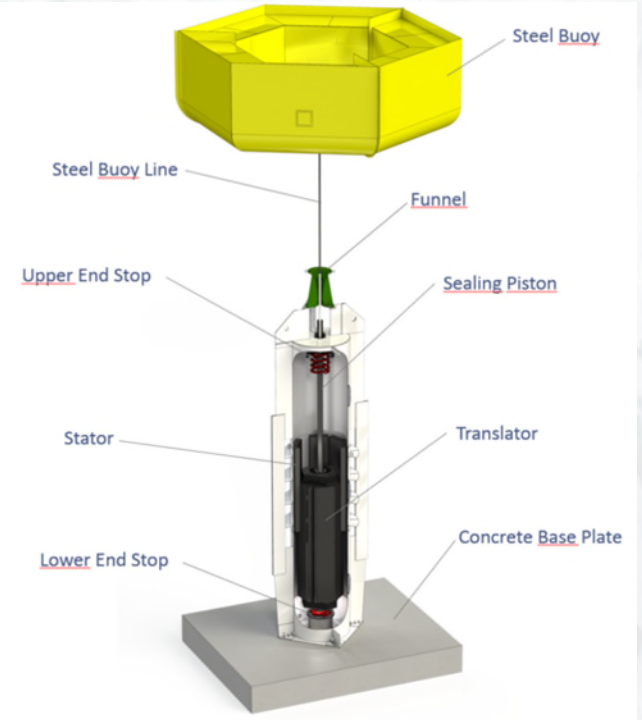


One key challenge (amongst many) of wave energy conversion is that energetic sites have a large ratio between commonly occurring wave heights (the ones we want to interact with) and the extreme waves that we must survive

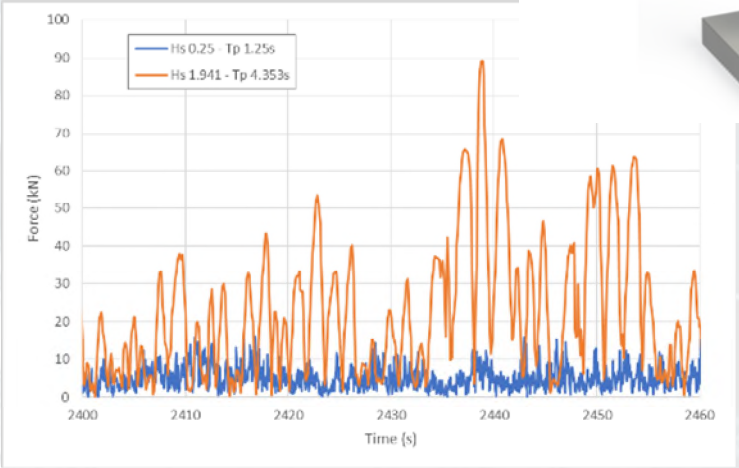
Wave Energy convertors (WECs)

- There are many different types of WEC
- One of the simplest is a float that actuates some form of linear power-take-off (PTO) due to the changing elevation of the sea surface
- The PTO damps the motion and converts the mechanical work into electricity or…





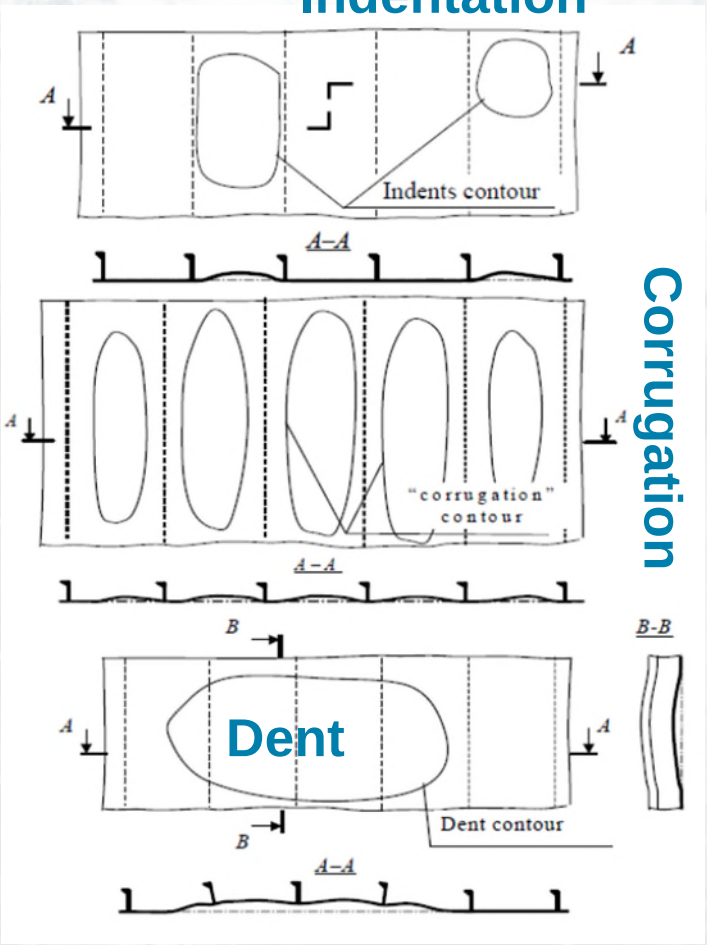
https://seabased.com/the-technology



Problem definition: conventional steel hulls?

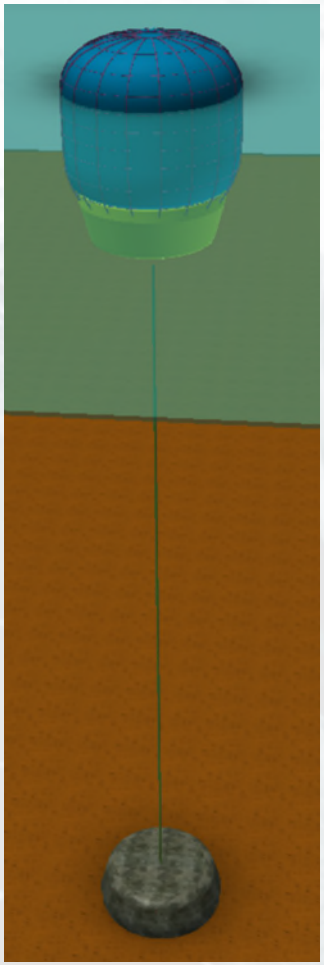
- Strain yield limit of 0.002
- Heavy and rusty
- Fabrication costs (lots of manual ops)
- Need to provide exceedingly stiff and heavy structure to resist extreme loads
- Don’t want or need this stiffness/mass most of the time = wasted $$$$

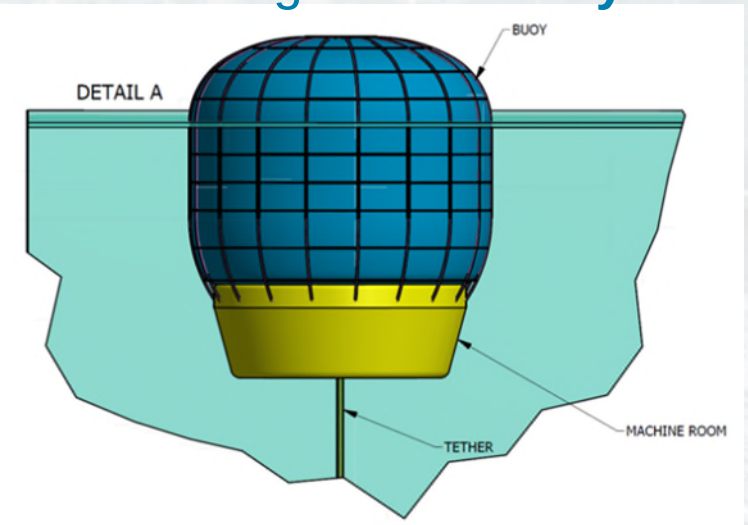
Proceedings of the 17th International Ship and Offshore Structures Congress

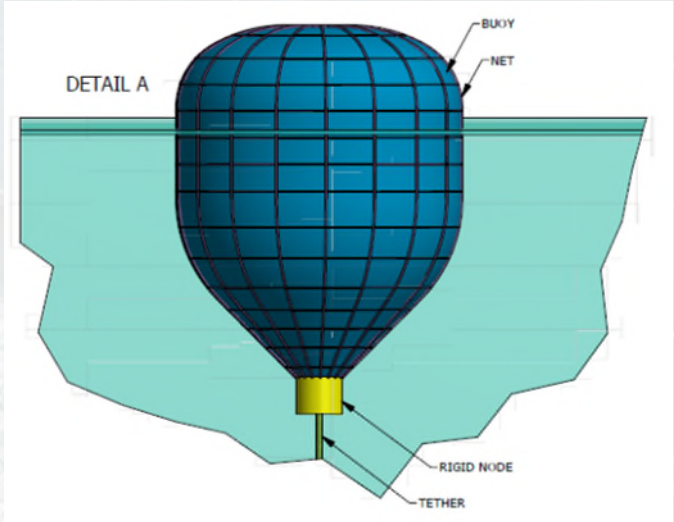


Proposed solution

- Replace rigid steel hull with inflated reinforced elastomer membrane
- But this is not well suited to connecting to rigid structures e.g. PTO or mooring system
- So encapsulate in fibre rope net to distribute restraint forces over membrane area
- Introducing the **NetBuoy**

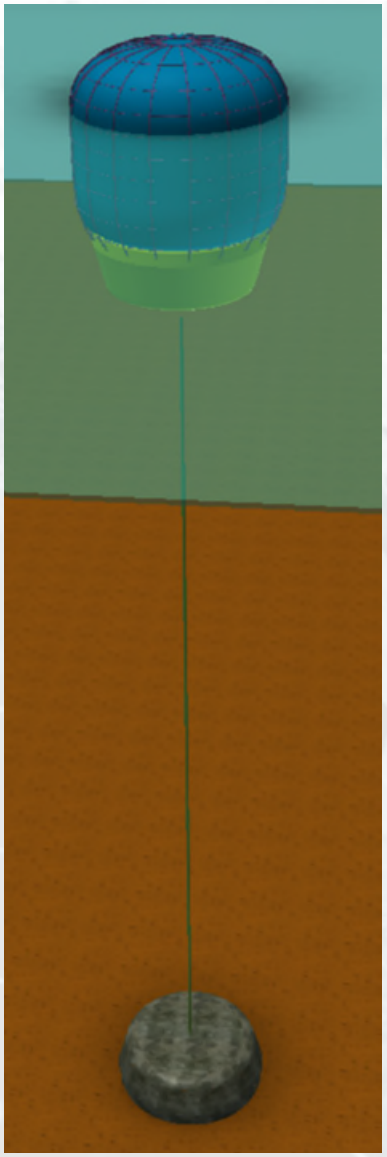






Solution advantages

- Elastic response in peak load events
- Light weight
- More cost effective than steel hull
- More suited to mass manufacture
- Applicable to range of WEC types
- Inherently peak-load shedding
- No corrosion
- Fold it up and put in a box for transport
- Installation advantages

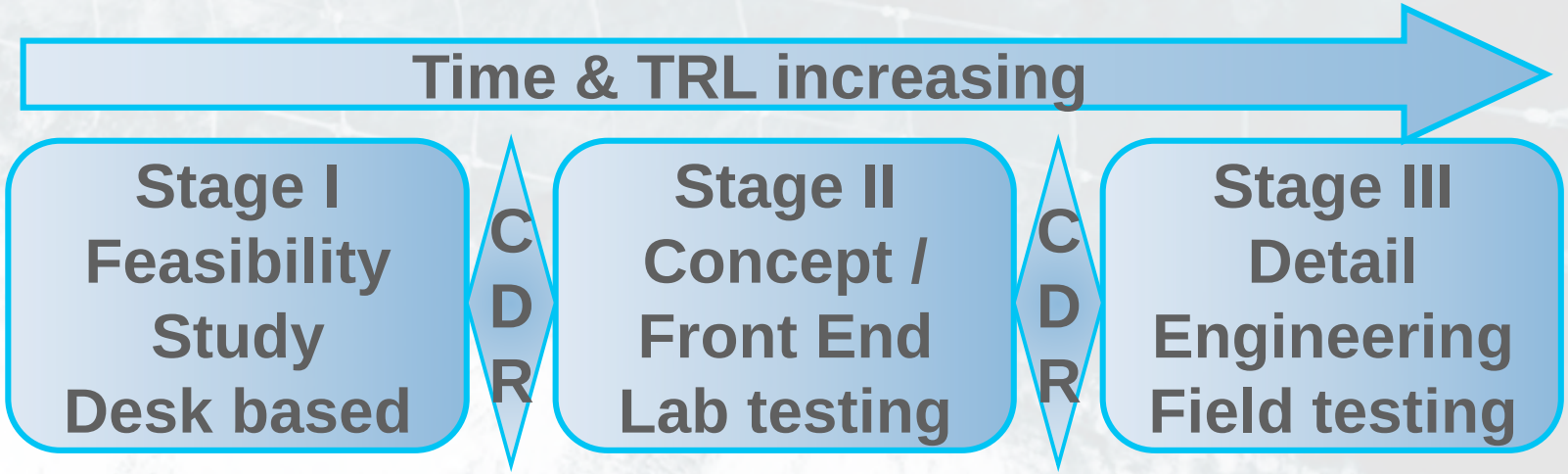


Transportation benefit

- Transport from fabrication yard to installation site

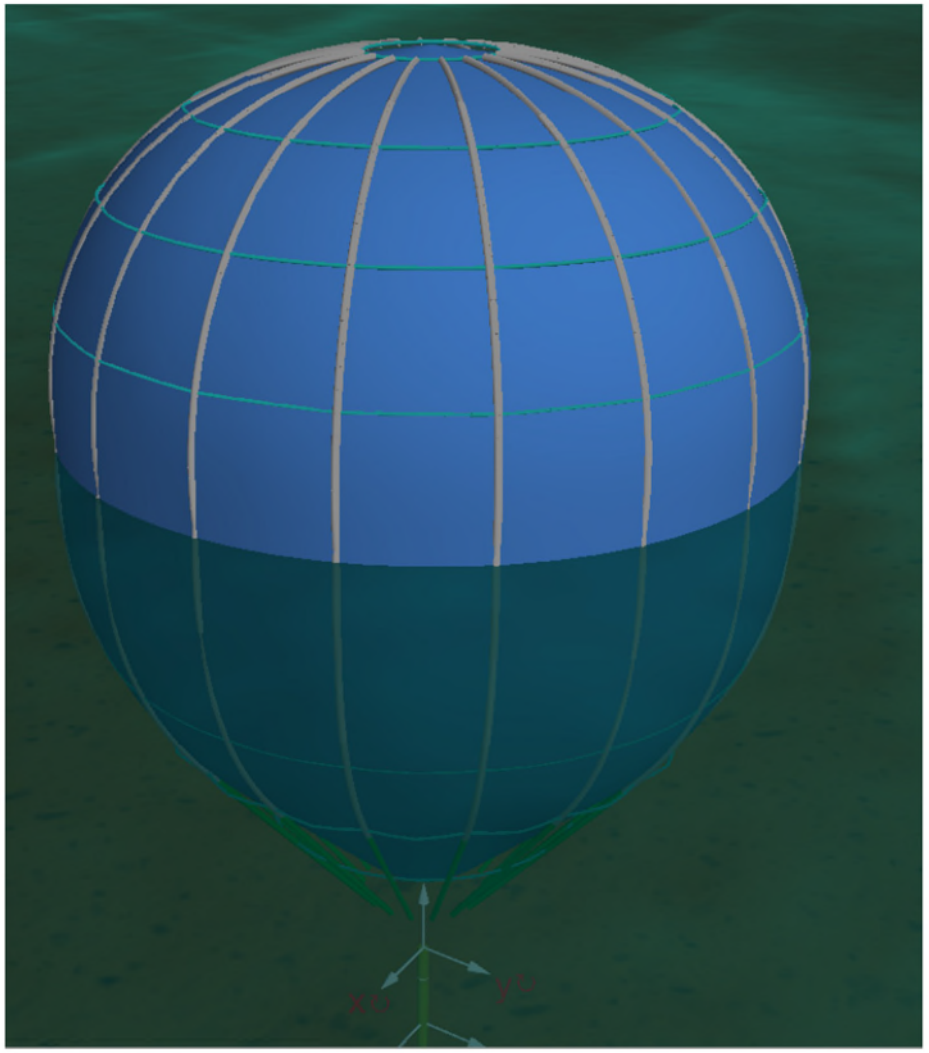
Development process

- Guided by structured New Product Introduction systems engineering process
- Identify risks and build qualification plan to derisk / mitigate / design out
- Steadily increase Technology Readiness Level through design, analysis and testing



Stage I overview

- Global system modelling in Orcaflex
- Material landscaping studies
- Shape studies
- Build qualification plan



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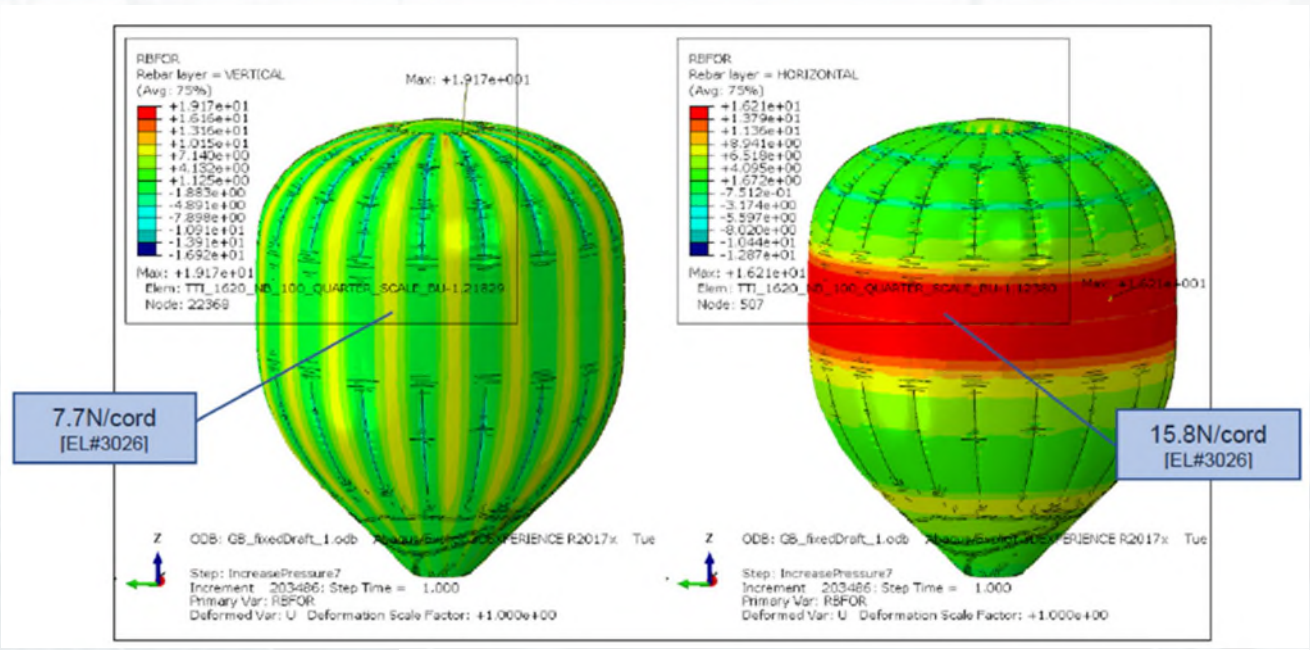
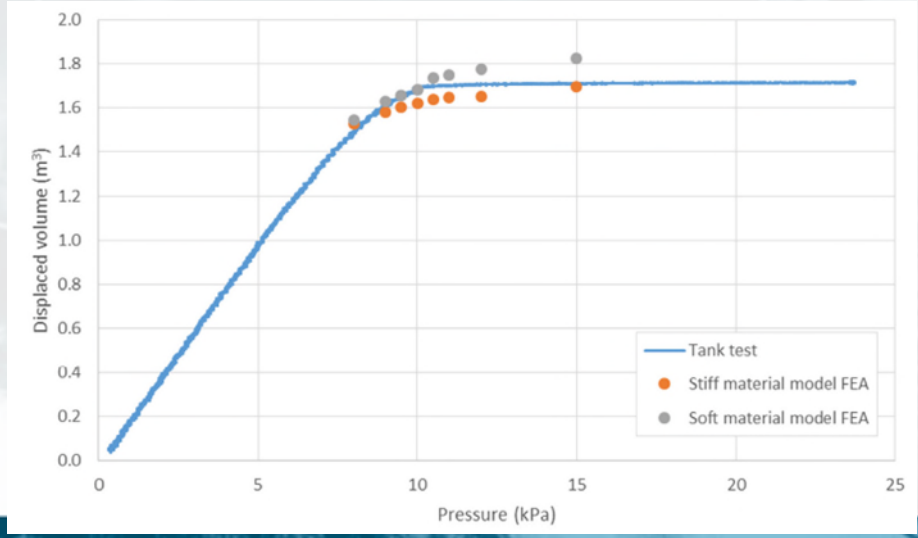
Stage I overview

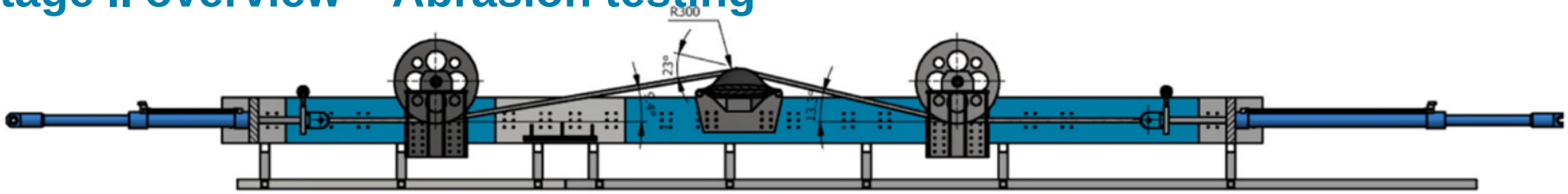
- Detailed non-linear finite element analysis
- Developing material specification
- Small scale prototyping

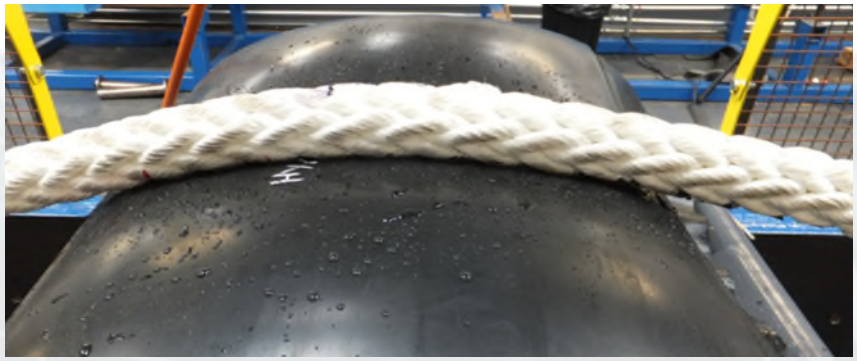


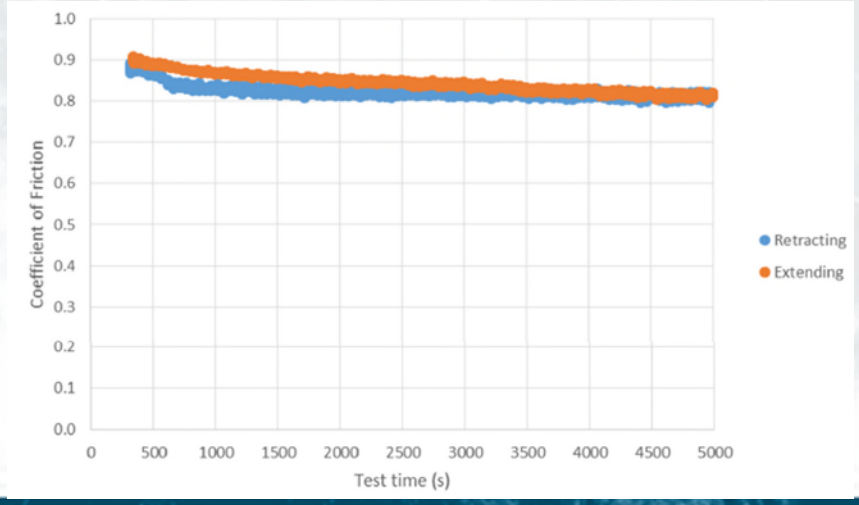


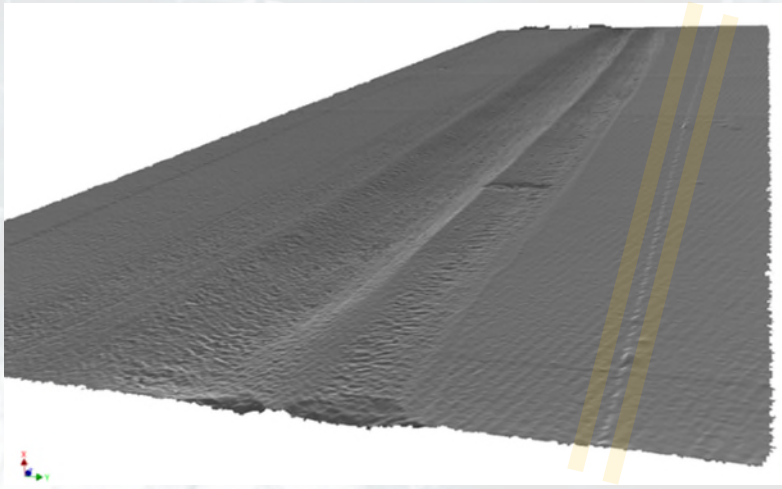
Stage I Gate

Stage II overview – Abrasion testing



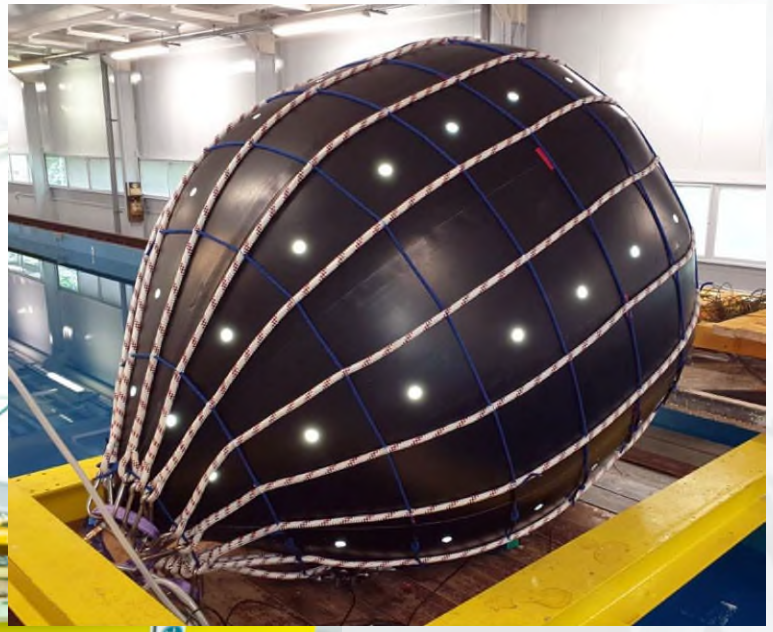


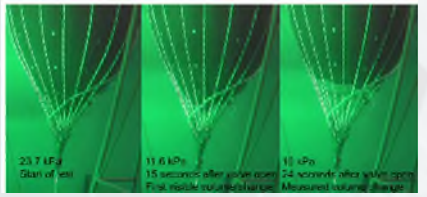


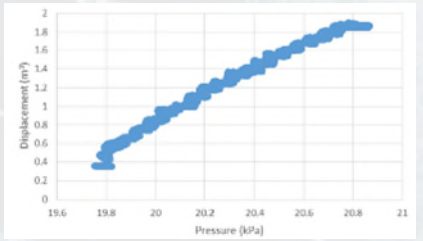


Stage II overview – Abrasion testing

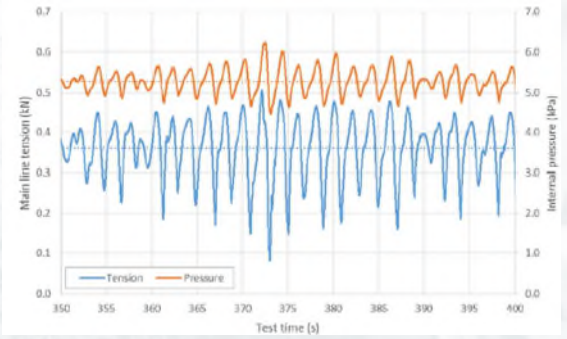
Stage II overview – hydrostatic testing

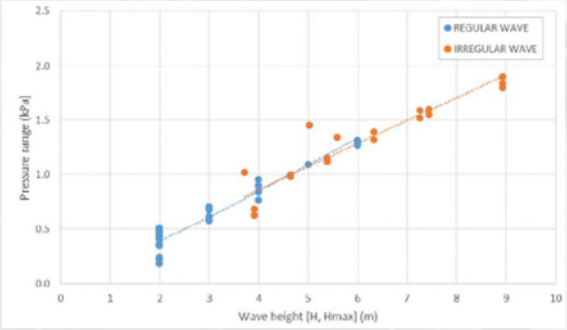






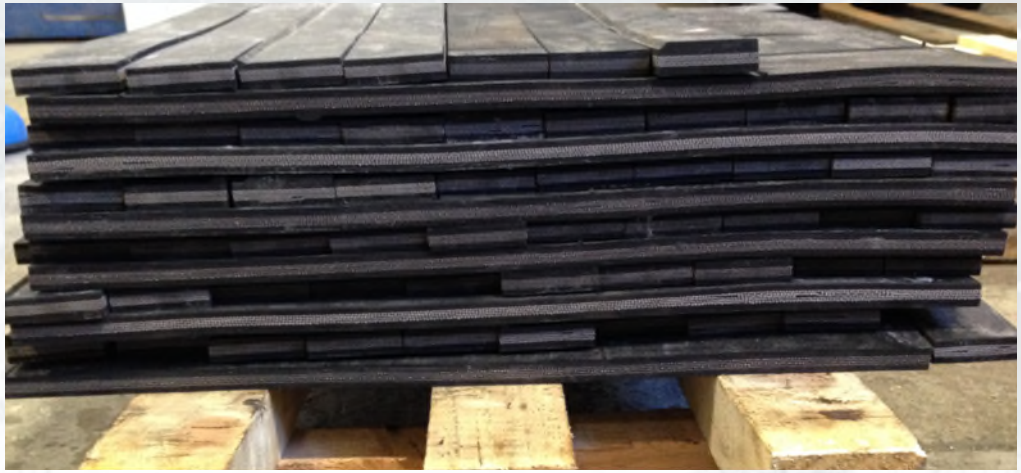
Stage II overview – hydrodynamic testing





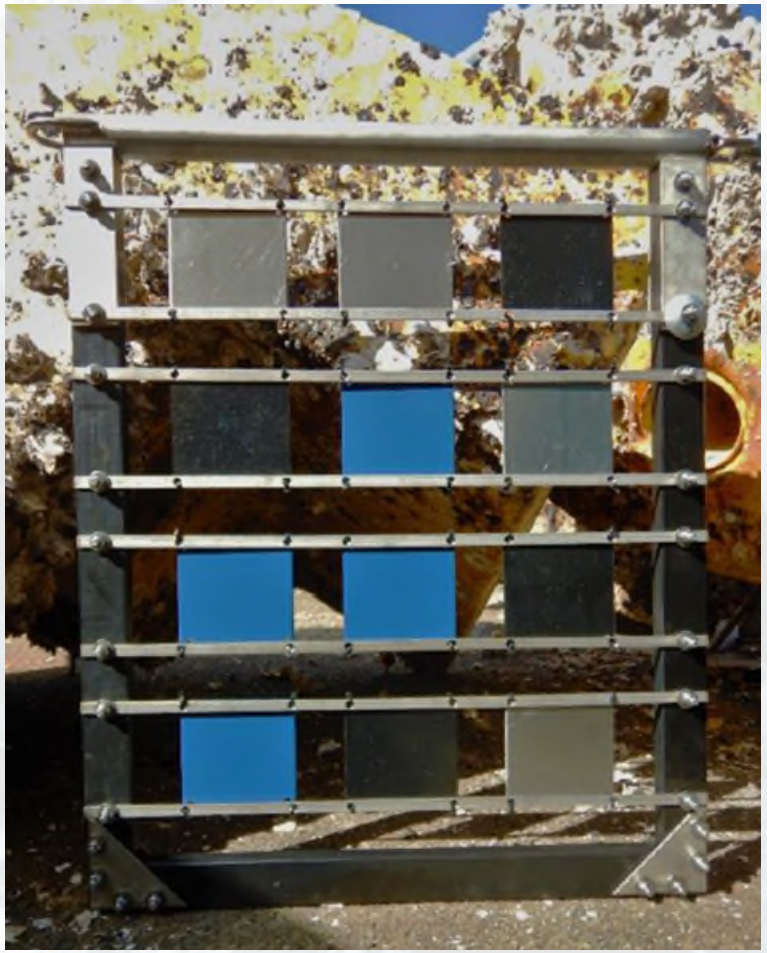
Stage II Gate

Stage III overview – fatigue (type) testing



Stage III overview – biofouling

Assessing response of elastomers and synthetic fibre rope to accumulating biofouling mass in representative environment



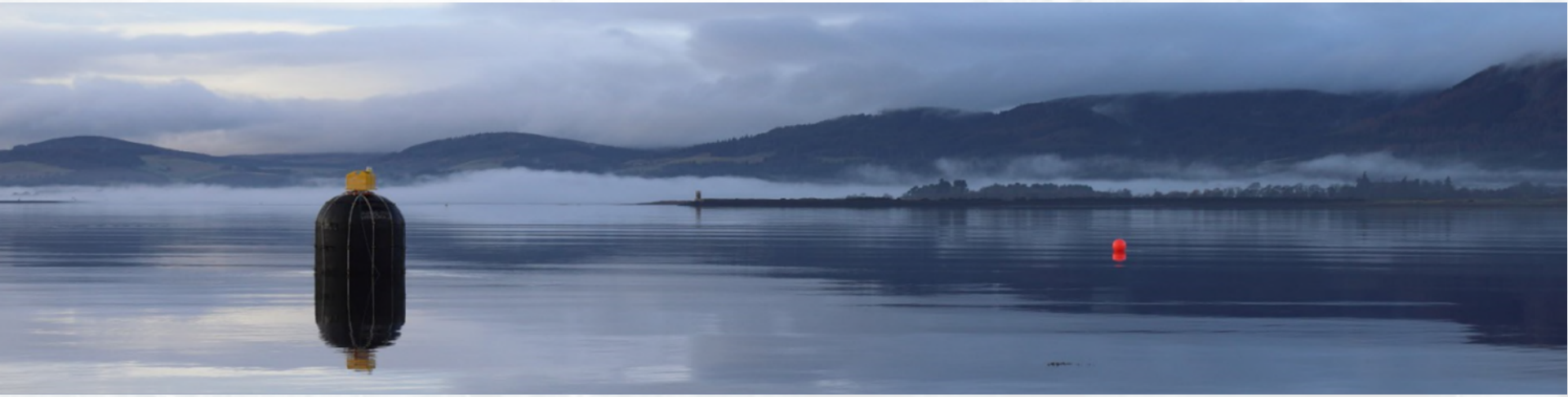
https://www.hw.ac.uk/news/articles/2021/orkney-scientists-help-boost-offshore-energy.htm

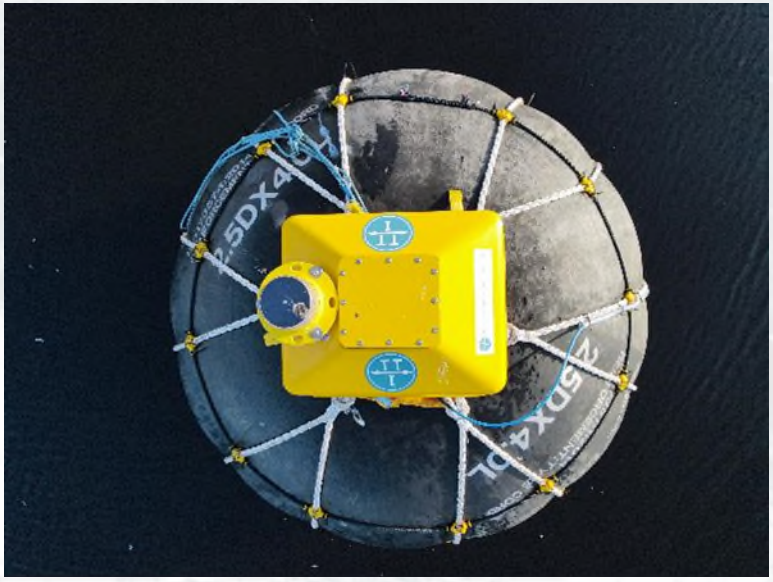
Stage III overview – field trials

Problem: cannot afford tooling for one-off custom buoyant pod

Solution: use conventional pneumatic fender! Satisfies majority of test requirements

Stage III overview – field trials





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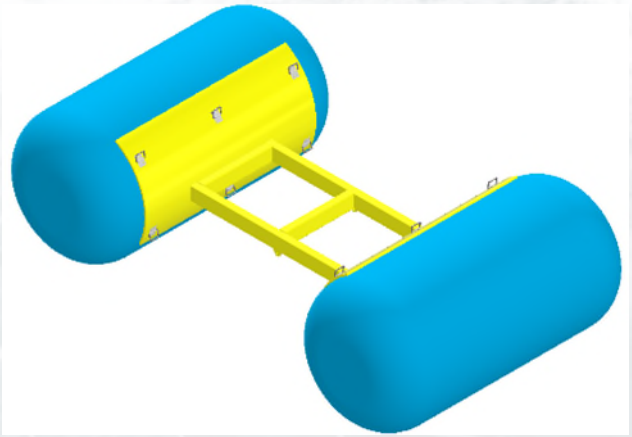
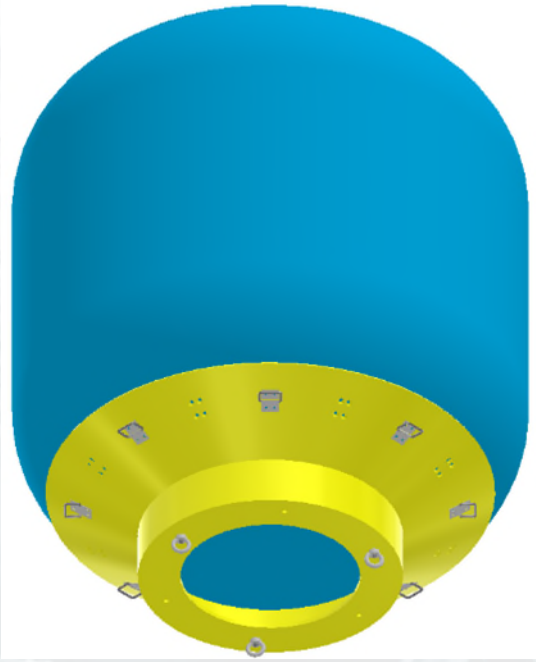
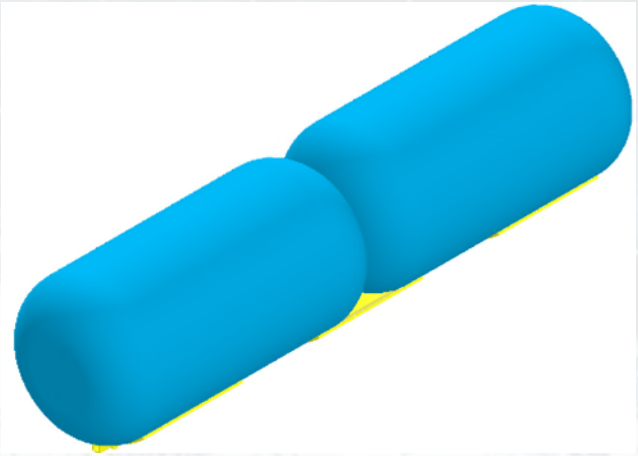
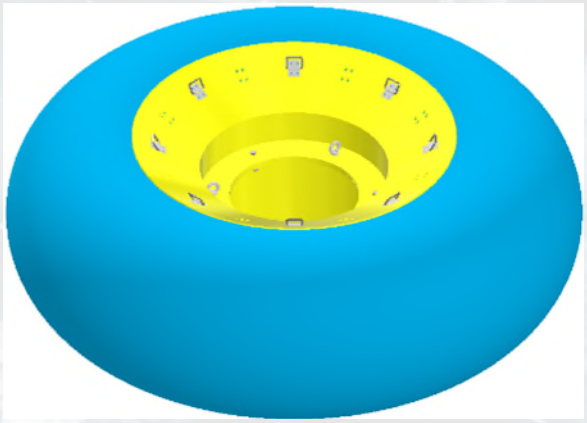
Stage III overview – (more) tank testing

- What if potential client doesn't want a point absorber??
- Increase Commercial Readiness Level and Technology Readiness Level







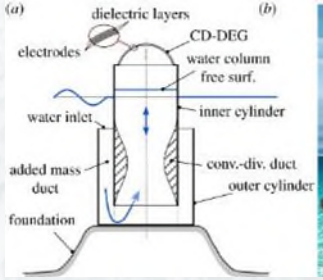


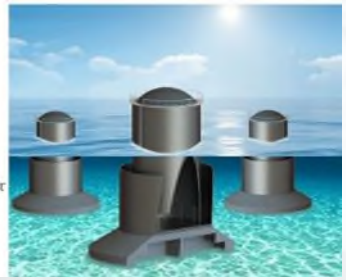
What next?

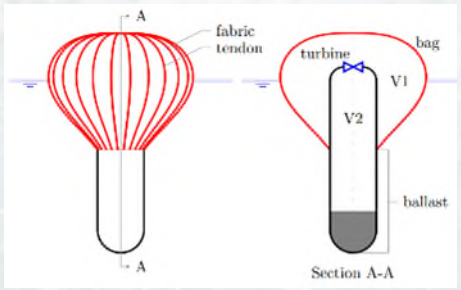
- Complete Stage III trials and report
- Continue to mitigate residual risks
- Commercialisation
- Integrate with full WEC system – field test
- Develop for other applications (e.g. aquaculture)

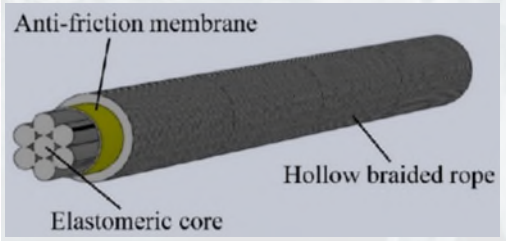
Other elastomer based WECs

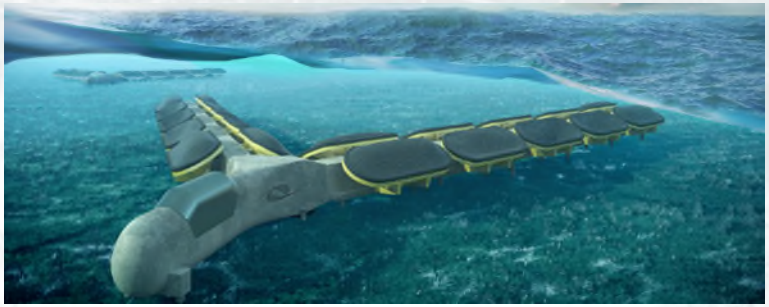
Dielectric elastomers / Electroactive polymers
Straining volume change
Extensible tendons (mooring system)
Non-straining volume change (sweeping)
“Snakes” – EAP or distensible bulge waves











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www.tensiontech.com
www.netbuoy.co.uk (soon)

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Thanks:

For listening

IOM3 for having me

David Cawthra at Rubber Heart for making the link

The NetBuoy and wider team at TTI and TTI Testing

Project partners/suppliers

And of course Wave Energy Scotland

(NICE) QUESTIONS