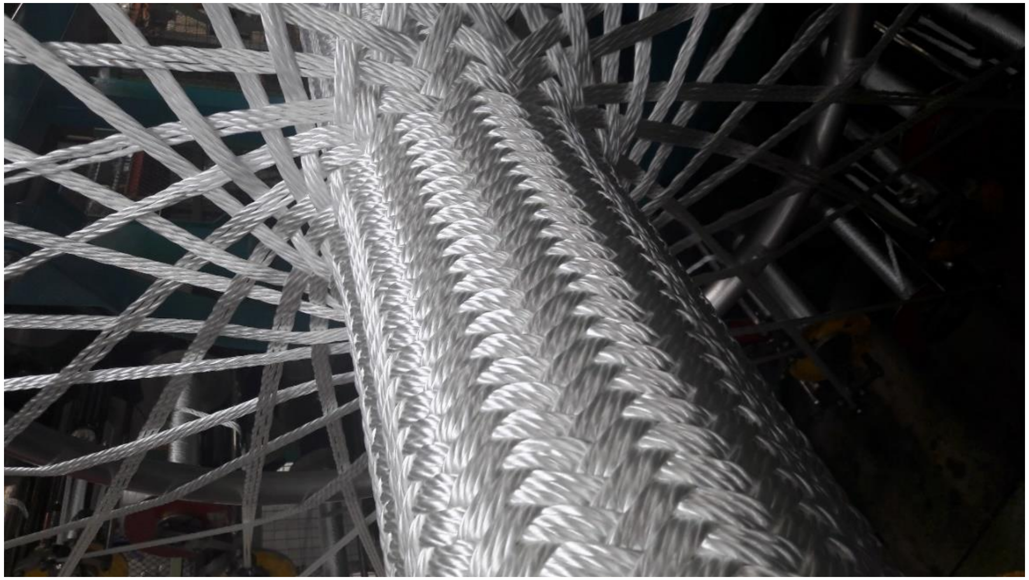
The Role of Synthetic Ropes in Optimal Mooring Design



Dr Sam Weller *Tension Technology International & Mor Engineering*

Marine-I Mooring and Anchoring Solutions Webinar

5th November 2020

Tension Technology International Group

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 (Consultancy)**

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.

tensiontech.com

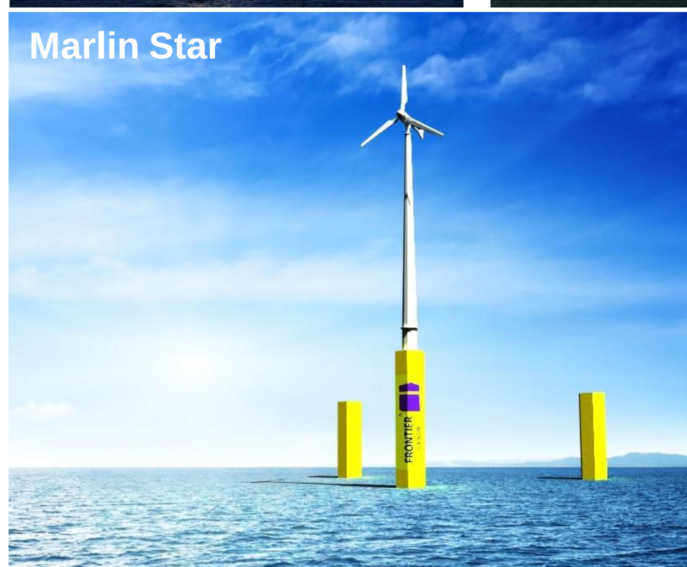
Relevant Projects

6th Scale FOWT Demonstrator, PLOCAN, Canary Islands, 2016-2019

2MW FOWT Demonstrator (x2) Japan 2019-2022

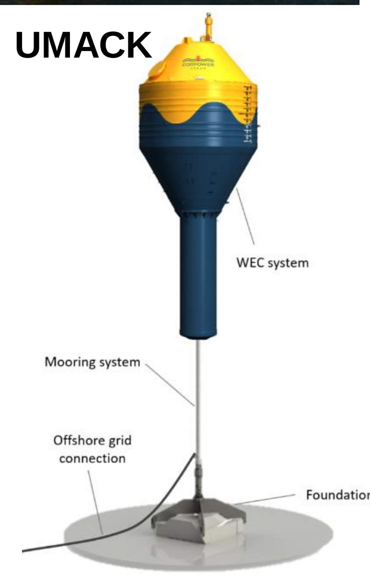
Marine Renewable Commercialisation Fund 2014-2016

TIM (Towards an Industrialized single point Mooring system)



Marlin Star

UMACK



Extensive Offshore Use

Development of large-scale rope manufacturing, test facilities and certification guidance occurred in the 1980s with the demand for oil and gas exploration in ultra deep waters (>2000m).

Suitable for use in catenary, semi-taut and taut mooring systems either with and without chain, wire etc.

Permanent Mooring Failures

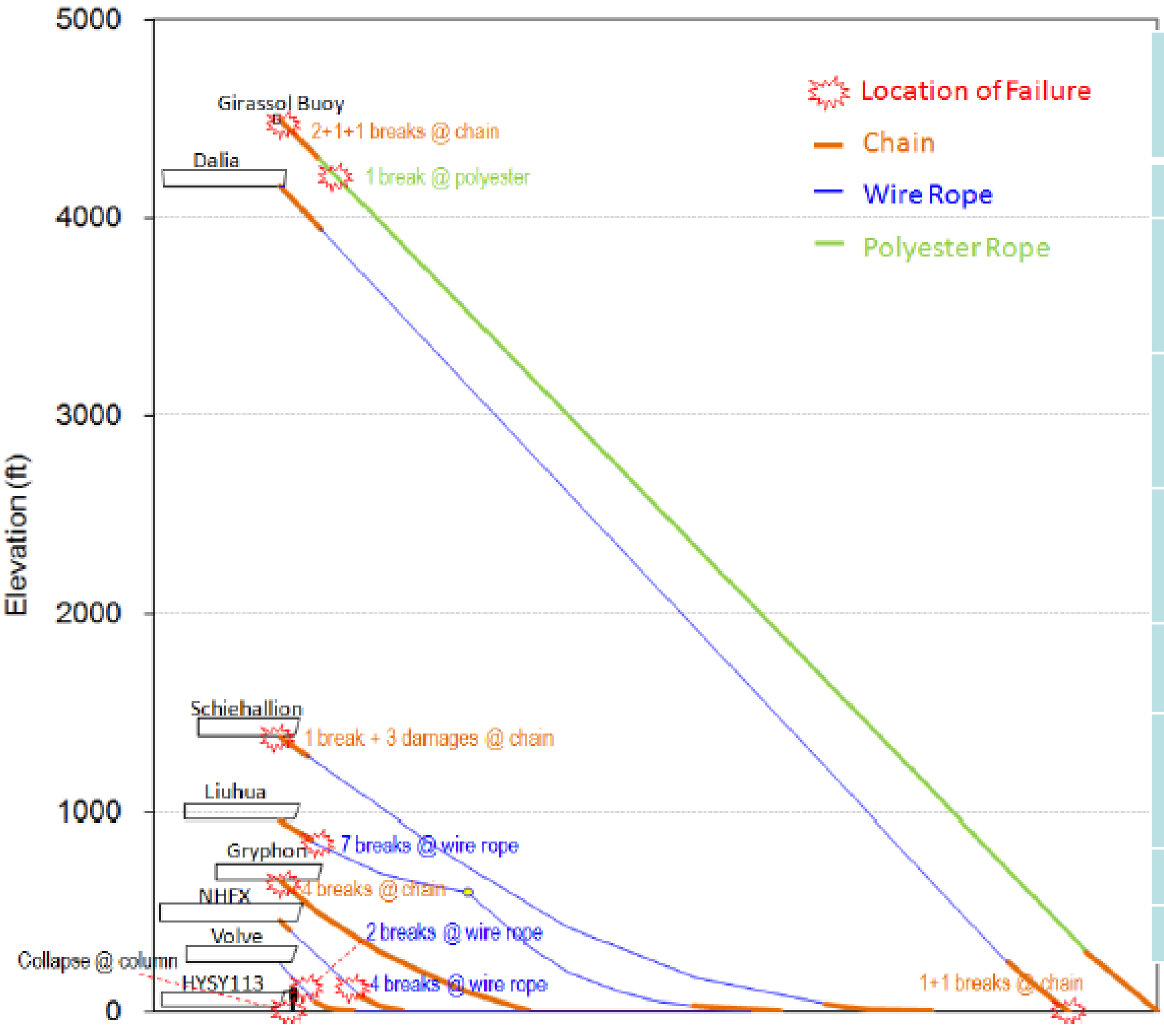


Figure 1: Examples of Break Locations along Mooring Profiles

(image from Ma, K-t et al. (2013) OTC 24025, Houston USA)

Date	Name	Result
2002	Girassol buoy	3 (+2) of 9 lines
2006	Liuhua	7 of 10 lines parted. vessel drift, riser broken
2009	Hai Yang Shi You	Entire system collapse, vessel drift, riser broken
2009	Nan Hai Fa Xian	4 of 8 lines parted, vessel drift, riser broken
2010	Jubarte	3 lines parted (2008-2010)
2011	Gryphon Alpha	4 of 8 lines parted, vessel drift, riser broken
2011	Volve	2 of 9 lines parted
2011	Banff	5 of 10 lines parted

Typical floating platform line failure rate: 2.5×10^{-2} per annum
Drori, G. (2015)

Steel vs. Synthetic

Material	Density (g/cm^3)	Melting /charring point (°C)	Moisture (%)[1]	Modulus (N/tex, GPa)	Tenacity (mN/tex)	Strength (MPa)	Break extension (%)
Steel	7.85	1600	0	20, 160	330	2600	2[4]
HMPE	0.97	150	0	100, 100	3500	3400	3.5
Aramid	1.45	500	1-7	60, 90	2000	2900	3.5
PET	1.38	258	<1	11, 15	820	1130	12
PP	0.91	165	0	7, 6	620	560	20
PA6[2]	1.14	218	5	7[3], 8[3]	840[6]	960	20

Synthetic

Low density

Low modulus

High strength

Compliant

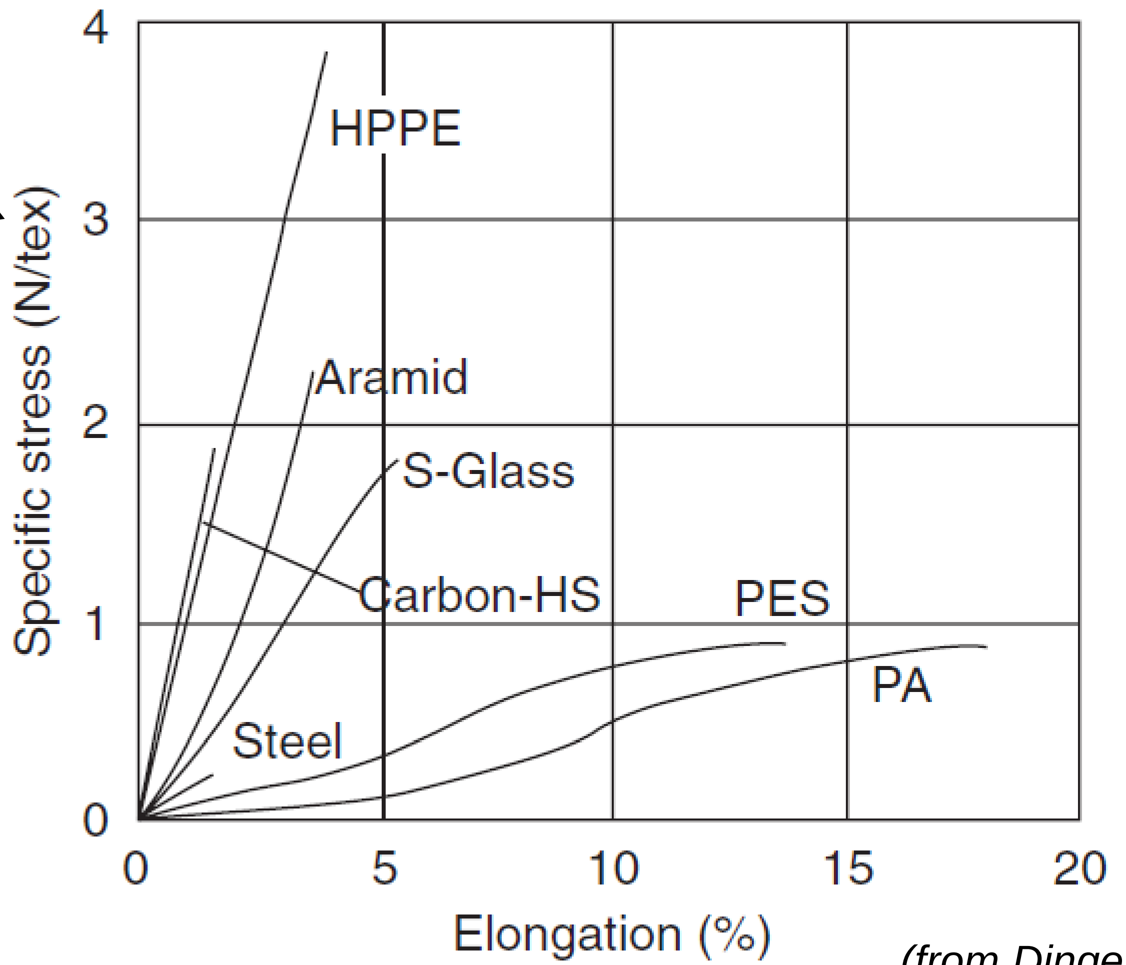
Low cost: Example: braid-on-braid polyester ~50% lower cost than studlink chain with the same break load (140kN).

[1] At 65% rh and 20° C.
[2] PA6.6 has a higher melting point (258° C) than PA6.
[3] The modulus and strength of nylon is approximately 15% lower when wet (McKenna et al.)
[4] Yield point of steel.

(values from McKenna et al. 2004)

Synthetic Fibre Properties

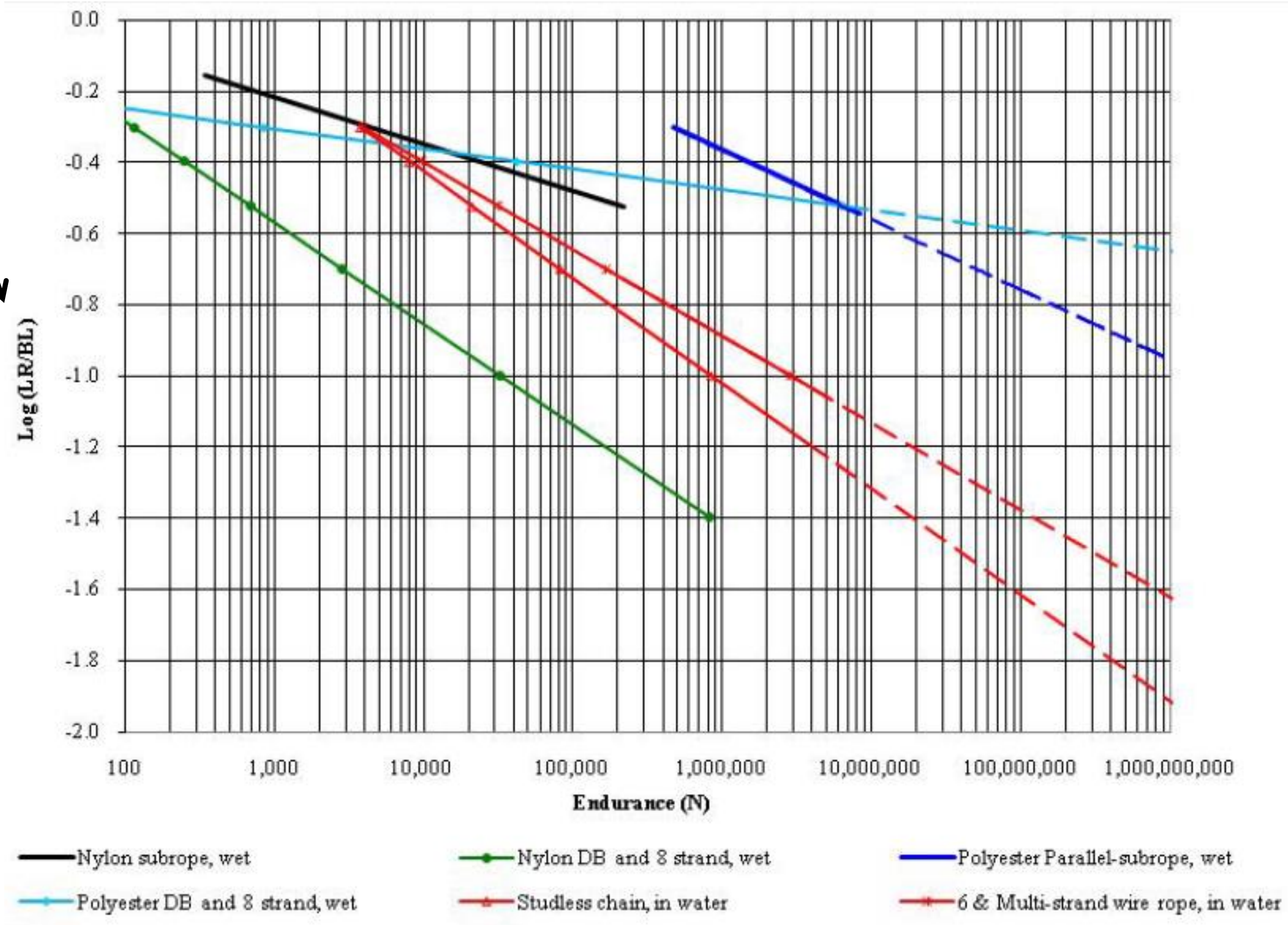
Tex units: g/km



(from Dingenen, 2001)

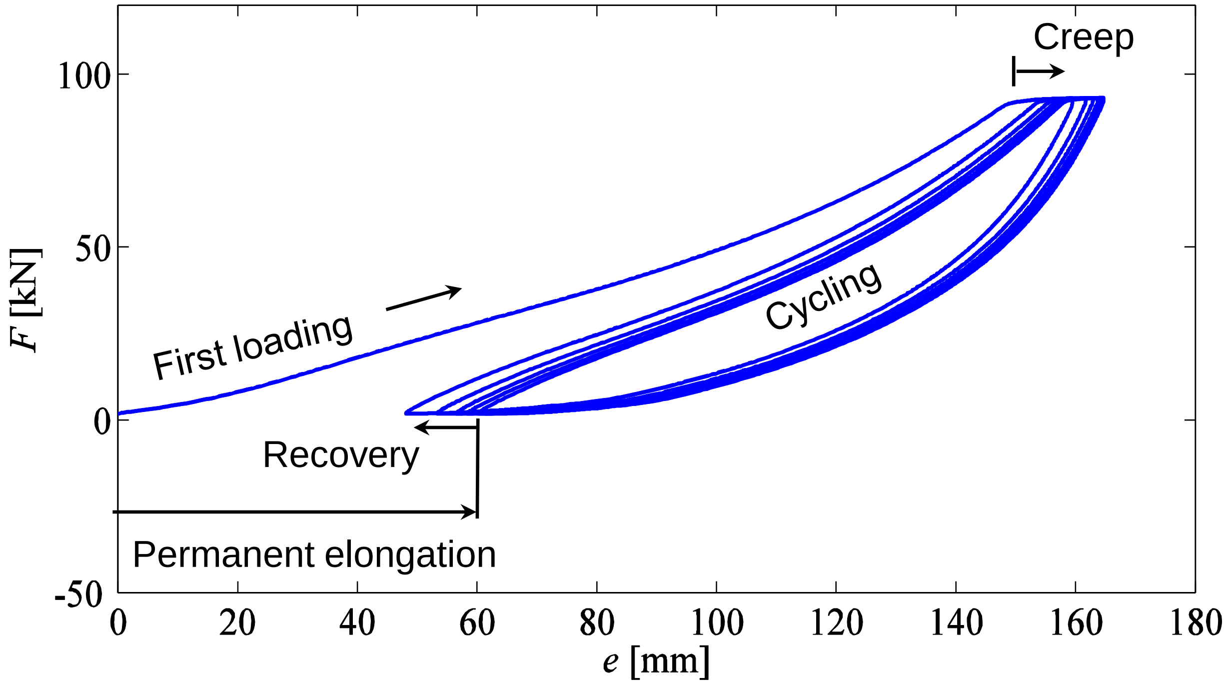
Fatigue Performance

LR: Load range
BL: Break load



(from Ridge et al. 2010)

Behaviour

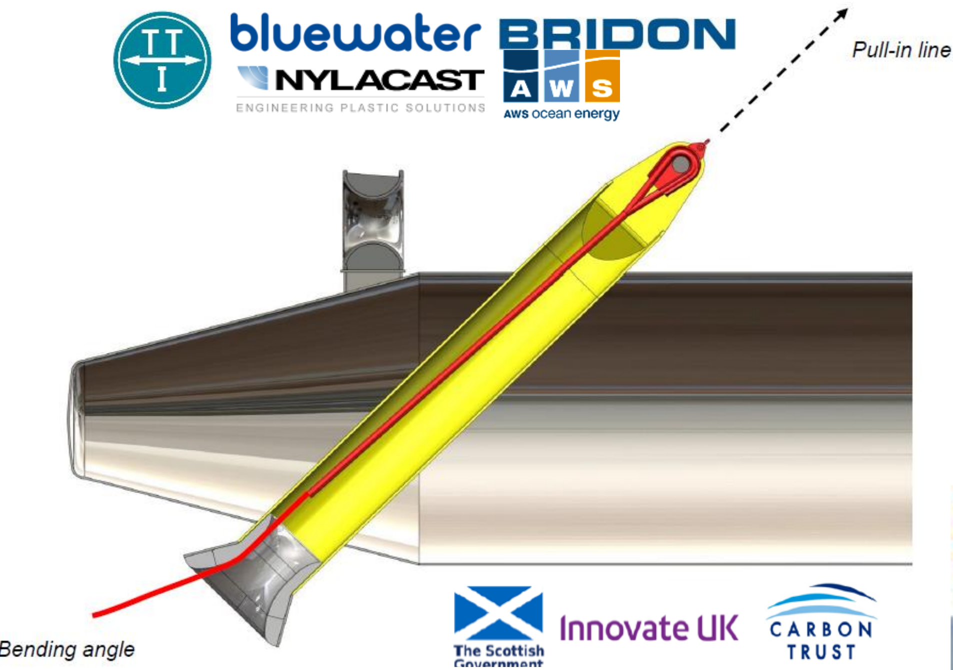


Load-extension behaviour of a new nylon mooring rope sample subjected to 10 cycles of bedding-in (*Weller et al. 2014*)

Synthetic ropes display complex behaviour requiring specialist knowledge

TTI consultants have been involved in the development of international mooring standards, e.g. **OCIMF, ABS, API, DNVGL** and **IEC** and also published the **Handbook of Fibre Rope Technology** (Woodhead Publishing, 2004)

Qualification for ORE systems



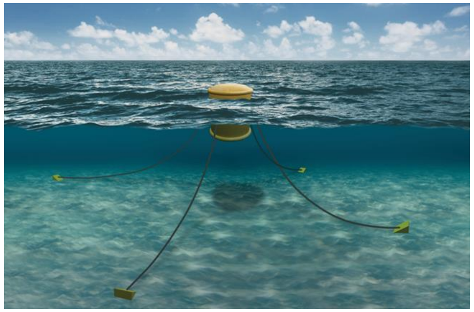
Marine Energy: Supporting Array Technologies (MESAT) 2013-2016
Synthetic Fibre Rope Polymer Line Fairleads

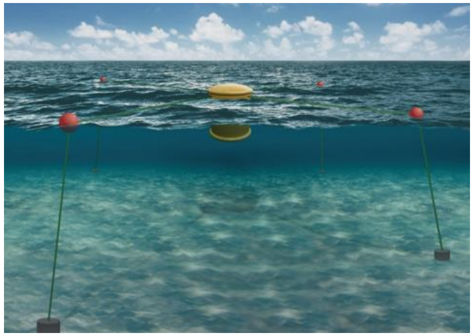
Marine Renewables Commercialisation Fund (MRCF) 2014-2016
Testing, Qualification & Commercialisation of Synthetic Mooring System

Landscape Study

Cost Reduction in Supporting Infrastructure Moorings & Foundations

TTI role: Project lead and author





This landscape study commissioned by Wave Energy Scotland, demonstrates that there are clear opportunities to make an impact on the cost of energy of wave power through further development and innovation in mooring components, foundations and associated subsystems.

- **State-of-the-Art (Landscape)**
- **Voice of the Customer (VOC-Survey)**
- **Moorings & Foundations Innovation (TRIZ workshop)**
- **Mooring & Foundation Case Studies**

Findings are relevant for WECs, TECs, FLOW, aquaculture etc.

Full report available to download here

UNIVERSITY OF EXETER

BLACK & VEATCH

wave energy SCOTLAND

TTI Ltd., University of Exeter and Black & Veatch Ltd (2018) **Mooring and Foundation Landscaping**, *Wave Energy Scotland Knowledge Library*

Weller SD, Banfield SJ, Canedo J. (2018) **Parameter Estimation for Synthetic Rope Models**, Proceedings of the 37th OMAE conference

Weller SD, Johanning L, Davies P and Banfield SJ (2015) **Synthetic mooring ropes for marine renewable energy applications**, *Renewable Energy*, 83, pp. 1268–1278.

Thanks!

Dr Sam Weller
weller@tensiontech.com