The Composites Group at Edinburgh

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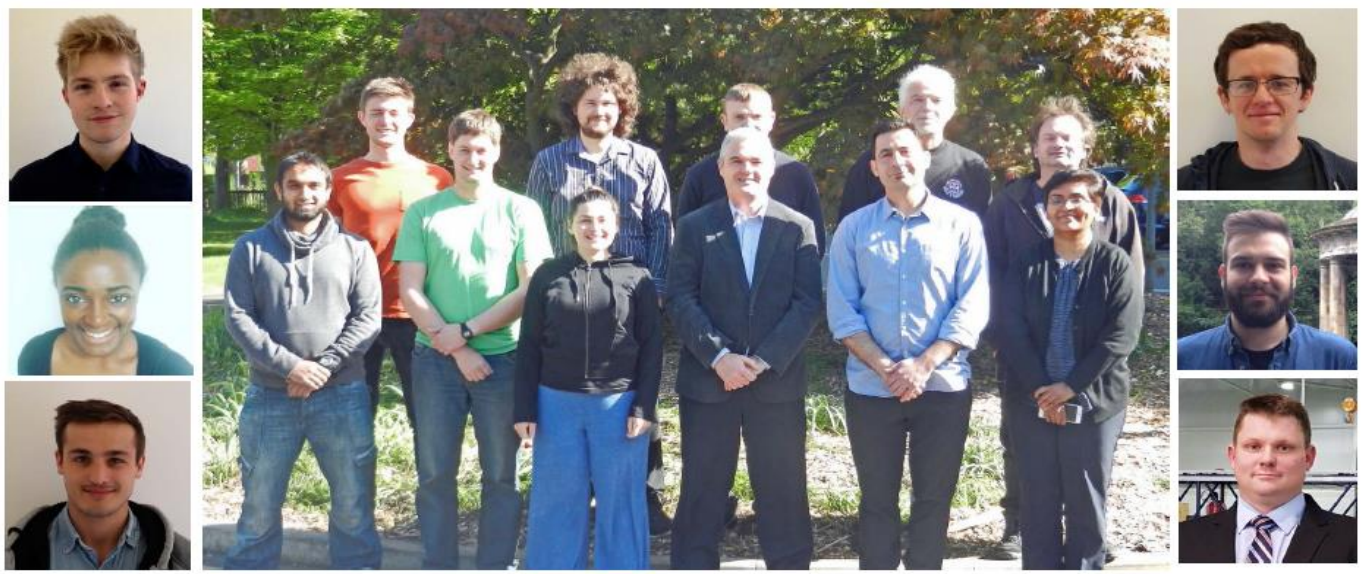
Dr. Edward McCarthy
Lecturer in Composites Design & Testing.

Dr. Colin Robert
Chancellor's Fellow.

The Edinburgh Composites Group (Est. 2015)

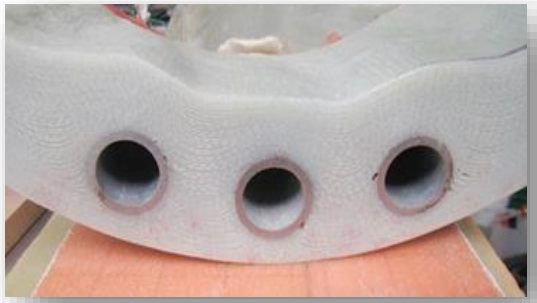


Composites Group: Some Industry Partners

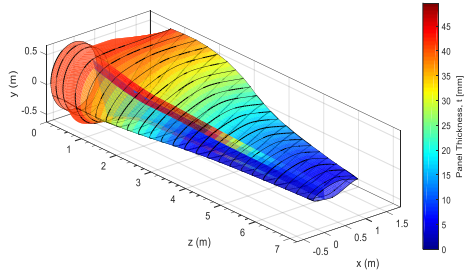
These are just some of the industrial partners that the Composites Group works with

Composites Expertise at The University of Edinburgh

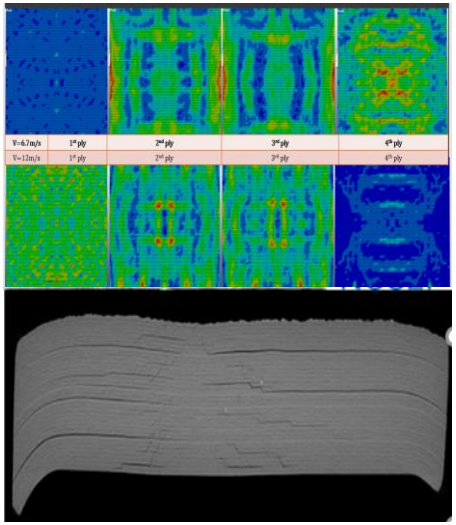
Powder Resin Impregnation of Carbon/Glass Tapes



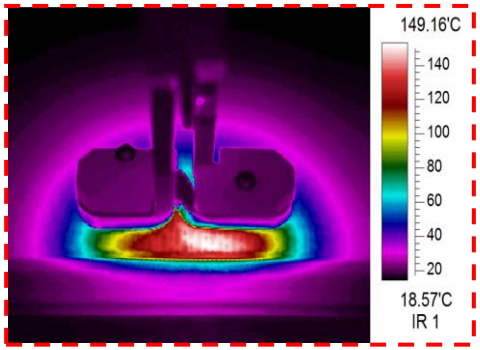
Wind/Tidal Blade manufacture using Advanced Powder Epoxy Composites



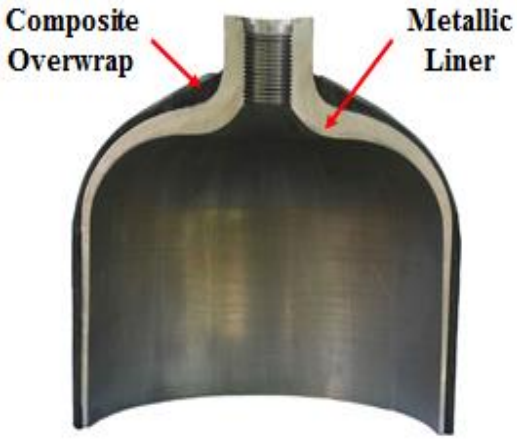
Stress Analysis/Design of Blades



Modelling of Impact Damage



Induction Welding of Thermoplastic Composites.



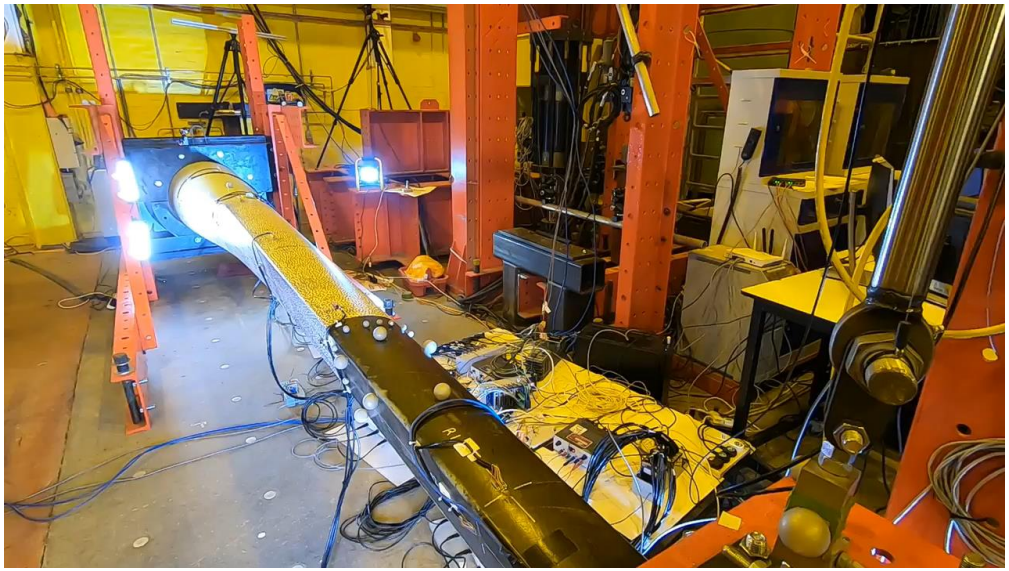
Composite-Wrapped Pressure Vessels

Project 1 - Powder Epoxy Wind Blade Prototype

The use of powdered rather than liquid epoxies have several advantages for processing of thick section composites such as wind and tidal turbine blades

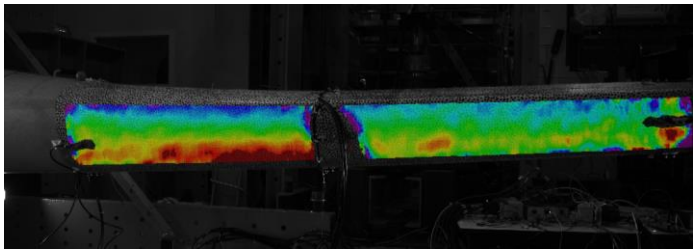
POWDERBLADE

HORIZON 2020

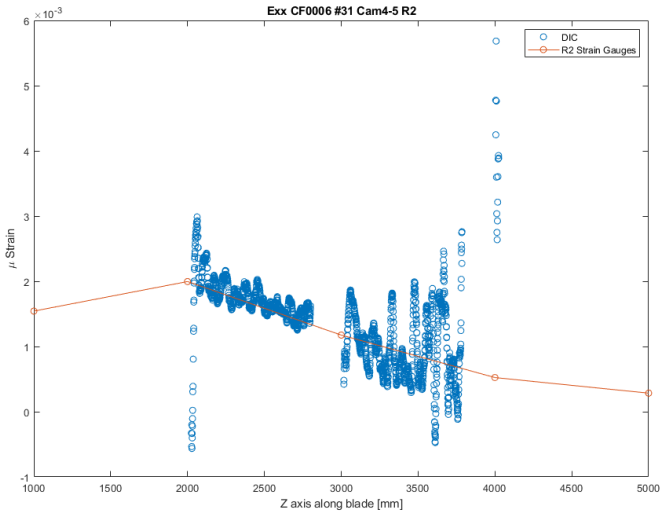


Full-scale testing of 6.0m powder-epoxy wind turbine blade demonstrator at the University of Edinburgh. Tapered hollow box-section with inboard glass fibre and outboard carbon fibre reinforcement

Floreani et al., SAMPE Europe Conference, Amsterdam, Netherlands, Sept. 2020



3D Digital Image Correlation Output



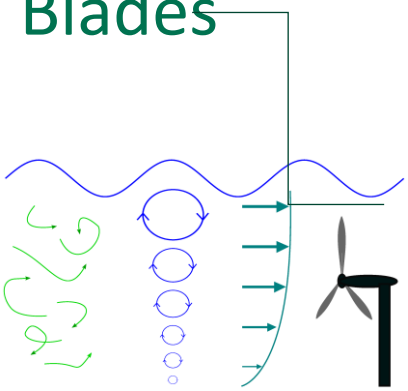
Strain Gauge vs DIC Output

Contact: c.obradaigh@ed.ac.uk

Project 2 – Fatigue Testing of Large Tidal Blades

What is FASTBLADE ?

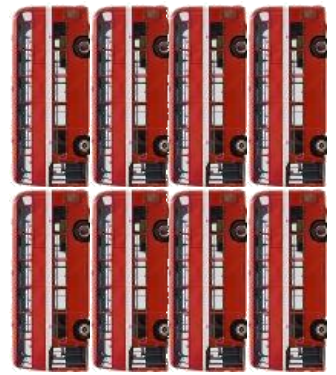
Engineering and Physical Sciences Research Council

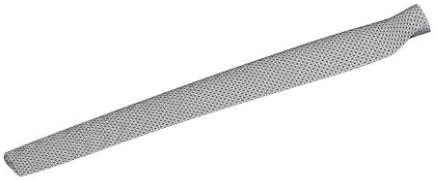


An innovative structural composites test facility funded by the EPSRC for FULL scale hydraulic fatigue testing of:

- TIDAL BLADES
- Marine & Defence Structures
- Aircraft wing boxes
- **Stiff and slender structures**

15MNm Static Moment	3MN Static Load	8 x *FASTER*	2021
5MNm Fatigue Moment	1MN Fatigue Load	75% Efficient	£4.1M CAPEX





Contact: jeff.steynor@ed.ac.uk

Project 2 – Fatigue Testing of Large Tidal Blades

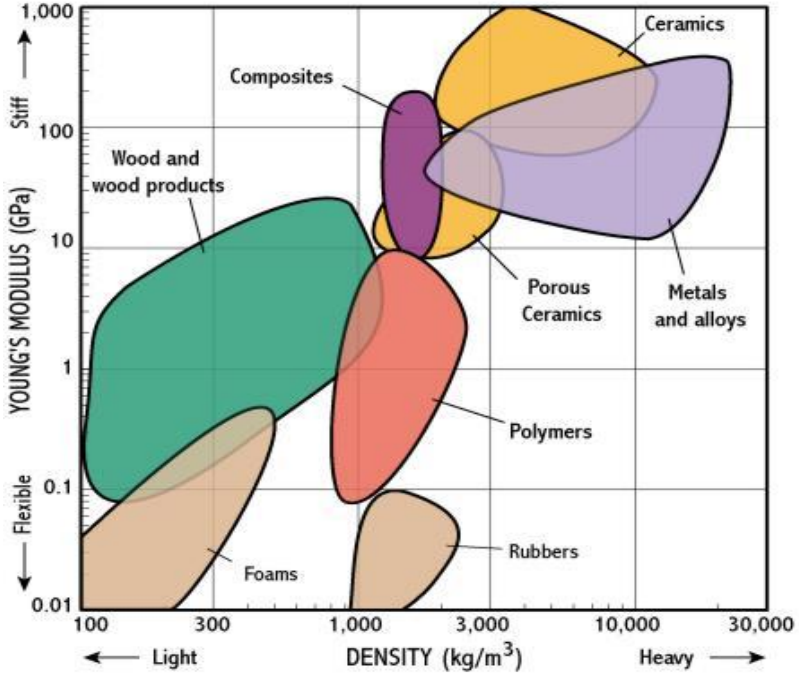
FASTBLADE Animation

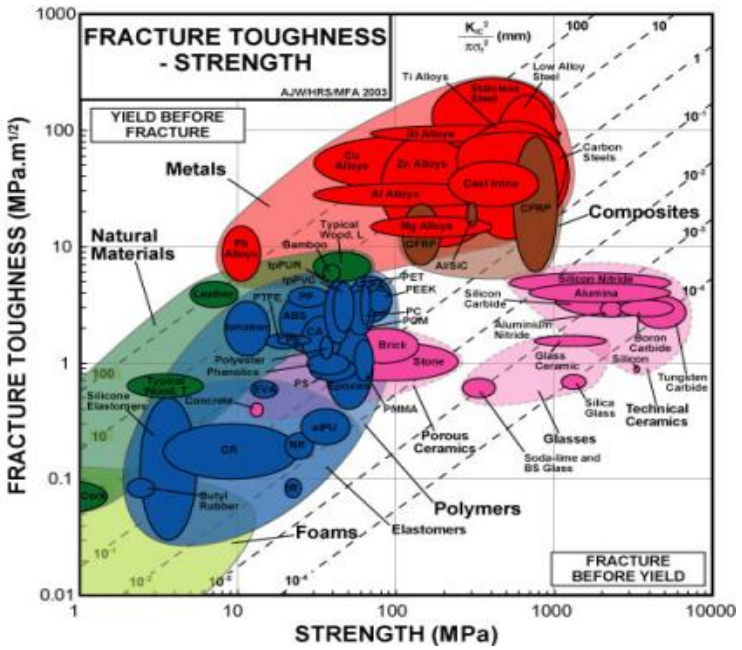
Estimated Commissioning Date: END 2021

Contact: jeff.steynor@ed.ac.uk

Choosing Materials and Material Systems for Ocean Energy

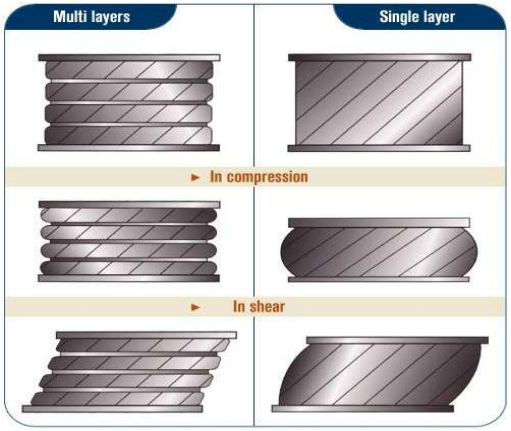
Typical Comparison of Competitor Materials by Properties – Bubble/Ashby Charts



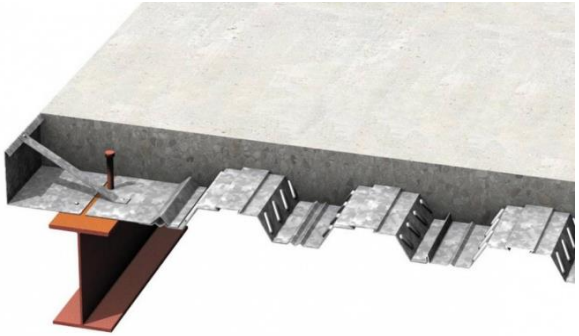


- The first step in choosing materials for a design is usually a direct property comparison across a number of key properties.
- But this belies the complexity of deploying materials in hybrid systems where not all, or sometimes any, of their best properties are properly exploited.
- The reality is that **we need to think of material systems rather than individual materials**

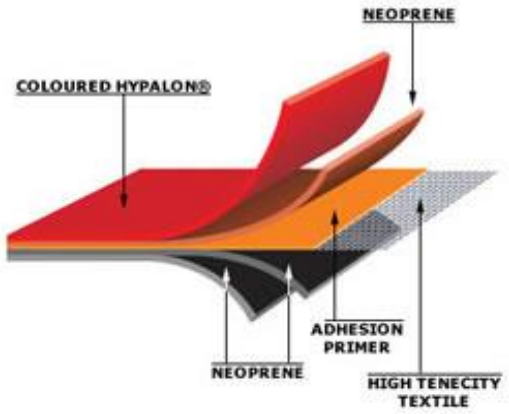
But Materials are rarely deployed alone in any system….we nearly always use Hybrid Systems



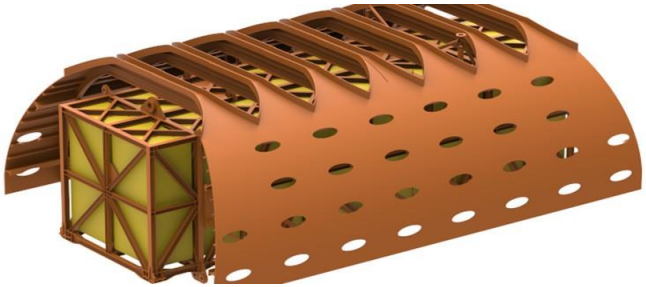
Laminated Elastomeric Components



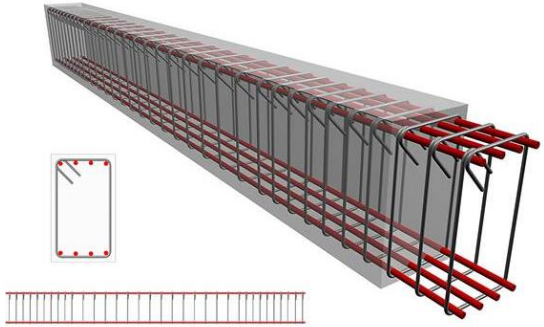
Steel-concrete structures



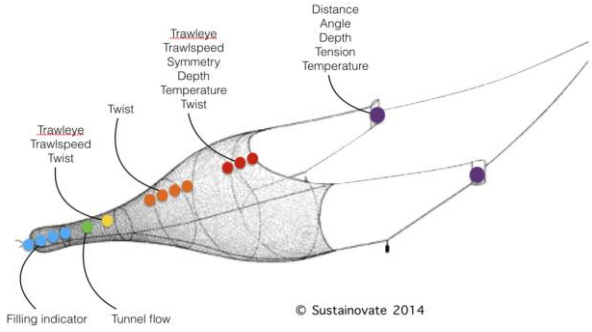
Multilayer coatings



Composite Mid-Water Arch



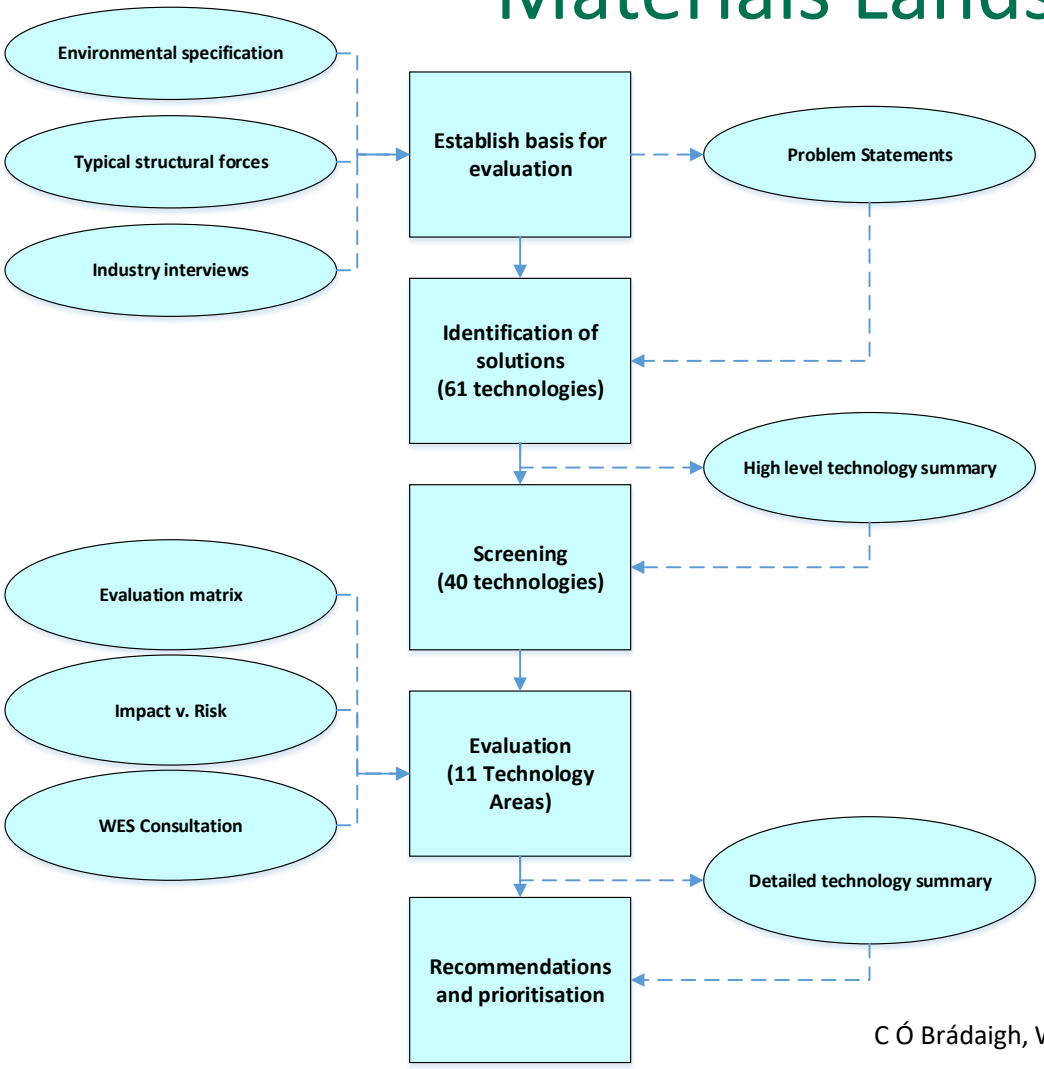
Concrete-rebar structures



Tensile Systems ('fish net')

C Ó Brádaigh, Wave Energy Scotland, Materials Landscaping Study, Final Report, Document No.UE.WS.494.01.REP.024.1, 2016

Methodology for Assessing Material Systems Materials Landscaping Study 2016



- The chart on the left shows the process followed to evaluate materials in three screening phases
- The first phase surveyed operating conditions and industrial views via a partner survey.
- The second phase consolidated these various technologies
- The third phase did a risk evaluation on the remaining 40 technologies to identify 11 with highest potential for impact.

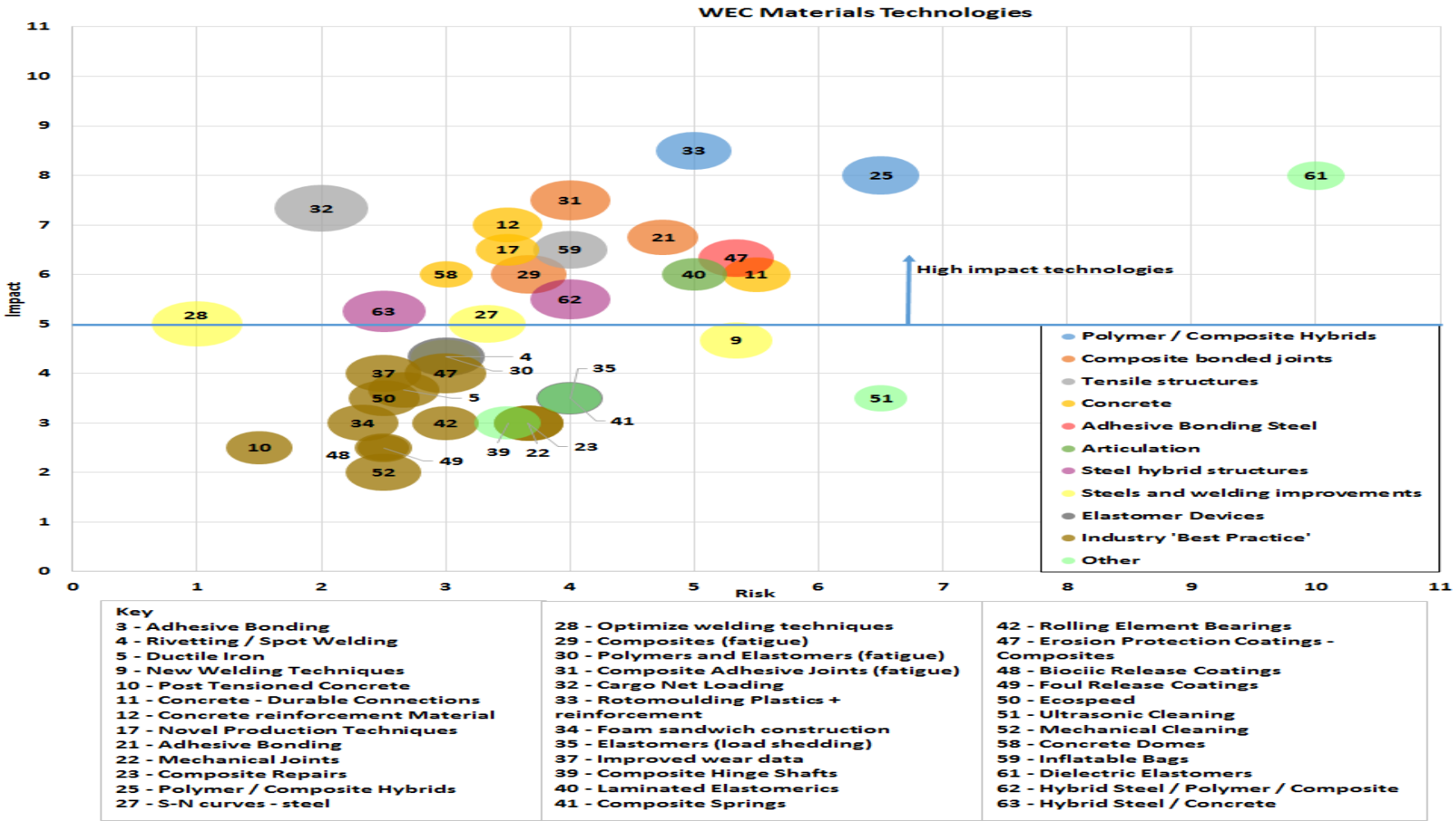
C Ó Brádaigh, Wave Energy Scotland, Materials Landscaping Study, Final Report, Document No.UE.WS.494.01.REP.024.1, 2016

Evaluation Matrix for Downselection

Attribute	Scoring Guide		Weighting
Manufacturing Cost	1=Expensive,	5=Cheap	x 2
Material Cost	1=Expensive,	5=Cheap	x 2
Capital Cost (NRCs)	1=Expensive,	5=Cheap	x 1
Maintenance & Repair	1=Difficult	5=Easy	x 1
Joining (To self)	1=Poor Quality / Difficult	5=Excellent Quality / Easy	x 2
Joining (To Other)	1=Poor Quality / Difficult	5=Excellent Quality / Easy	x 2
Durability / Survivability	1=Poor	5=Excellent	x 1
Logistics / Installation	1=Expensive,	5=Cheap	x 1

C Ó Brádaigh, Wave Energy Scotland, Materials Landscaping Study, Final Report, Document No.UE.WS.494.01.REP.024.1, 2016

Scatter Plot of Impact V. Risk



Key

3 - Adhesive Bonding
4 - Rivetting / Spot Welding
5 - Ductile Iron
9 - New Welding Techniques
10 - Post Tensioned Concrete
11 - Concrete - Durable Connections
12 - Concrete reinforcement Material
17 - Novel Production Techniques
21 - Adhesive Bonding
22 - Mechanical Joints
23 - Composite Repairs
25 - Polymer / Composite Hybrids
27 - S-N curves - steel
28 - Optimize welding techniques
29 - Composites (fatigue)
30 - Polymers and Elastomers (fatigue)
31 - Composite Adhesive Joints (fatigue)
32 - Cargo Net Loading
33 - Rotomoulding Plastics + reinforcement
34 - Foam sandwich construction
35 - Elastomers (load shedding)
37 - Improved wear data
39 - Composite Hinge Shafts
40 - Laminated Elastomerics
41 - Composite Springs
42 - Rolling Element Bearings
47 - Erosion Protection Coatings - Composites
48 - Biociic Release Coatings
49 - Foul Release Coatings
50 - Ecospeed
51 - Ultrasonic Cleaning
52 - Mechanical Cleaning
58 - Concrete Domes
59 - Inflatable Bags
61 - Dielectric Elastomers
62 - Hybrid Steel / Polymer / Composite
63 - Hybrid Steel / Concrete

C Ó Brádaigh, Wave Energy Scotland, Materials Landscaping Study, Final Report, Document No.UE.WS.494.01.REP.024.1, 2016

Ranking of Materials Systems by Impact (2016)

Ranking	Materials and Process Technology
1	Hybrid structures incorporating rotationally moulded polymers, fibre reinforced composites and / or steel
2	Tensile Structures
3	Steels and Welding Improvements
4	Elastomers
5	Concrete Structures
6	Adhesive Bonding of Composites
7	Adhesive Bonding of Dry Steels
8	Articulation with Laminated Elastomeric Composites

- C Ó Brádaigh was asked to rank various material system options in 2016 to identify areas most in need of strengthening and development for maximum impact in wave energy devices specifically, (perhaps indirectly tidal).
- **Hybrid systems combining the advantages of multiple materials ranked first.**

C Ó Brádaigh, Wave Energy Scotland, Materials Landscaping Study, Final Report, Document No.UE.WS.494.01.REP.024.1, 2016

Conclusions

- It's not always meaningful to compare individual materials head on and make premature selections on this basis.
- We need to think of hybrid material systems, their connections and the **system net properties** when developing designs.
- The connection and integration strategy for hybrid materials **needs further development**, and we continue to believe the greatest marginal performance improvements will emerge in this area.
- Lastly, there is **increasing development in functional materials** such as autoadaptive electroactive elastomers that can enable smart, responsive structures, but which may not require elaborate control systems (e.g. passively morphing blades)