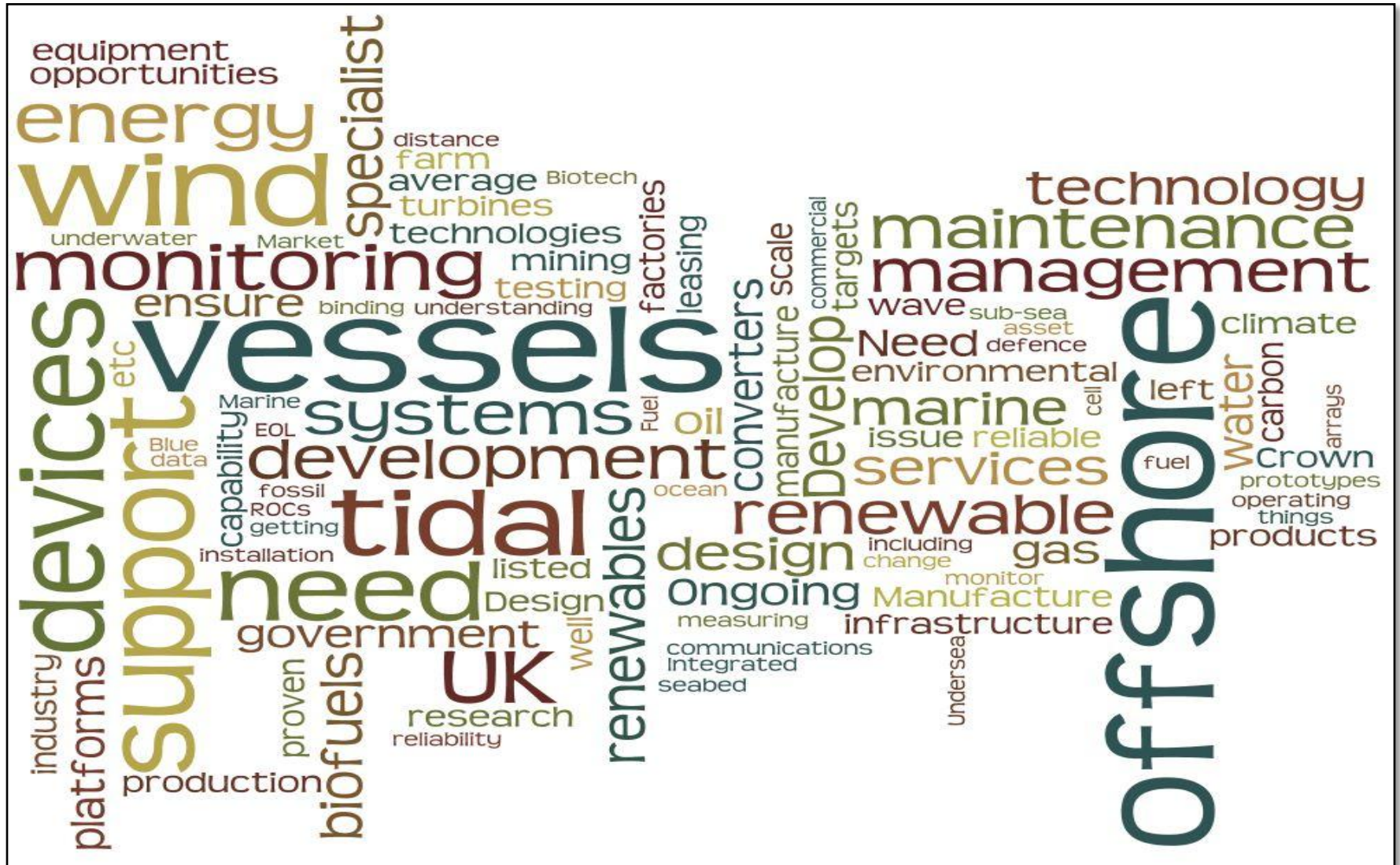


UK Marine Industries Roadmap & Capability Study

Workshop B: Offshore Renewables & Marine Resources, 1 November 2011



Executive Summary

This report results from a one-day workshop to assist the Technology Strategy Board, BIS, UK Marine Industries Alliance and the Transport KTN to develop a roadmap to identify future priority opportunities and capability needs for the UK Marine Industries. The workshop was the second of five “Deep Dive” explorations of the sector, focussing on Renewables and Marine Resources. The workshop took place at the University of Strathclyde on 1 November 2011, with input from over 20 experts drawn from across the Marine Industry, academia and other stakeholders. The workshop took a sub-set of the landscape roadmap, developed in June 2011, which was then developed further to identify priority trends & drivers and then to identify and characterise around 40 Market Opportunities in Renewables and Marine Resources.

Participants contributed before the workshop by providing their perspectives in a roadmap template – identifying priority Drivers, Opportunities, Capabilities and Enablers in the Short, Medium and Long timeframes. These were consolidated ahead of the workshop to provide a start point to which further issues were added and priorities identified. The most important market opportunities were then highlighted, where UK capability could deliver against major global market needs. These assessments were based on defined criteria for Value (global & UK market, competitive strength, added value and impact on societal and environmental challenges) and Capability (in the marine industry, academia, research organisations and from adjacent industries – see Appendix C for details.)

In prioritising relevant Trends & Drivers (see section 1), there was a strong emphasis on energy scarcity and the needs to mitigate and adapt to climate change, driving the importance of renewables; and the importance of government policy (joined up between departments and across the UK) directing funding, incentives and regulation in creating an environment where public and private funding will be directed at to this area. Challenges around cost-effectiveness and through-life costs need to be overcome but the potential impact in delivering UK leadership in this key area of the “Green Economy” was seen as tremendous.

Executive Summary (continued)

Priority Opportunities (see section 4) were identified across a range of areas, though largely focussed on renewables. The leading opportunities included: Logistics, services, asset management & operation for offshore renewables (inc new business models); Grid integration & electrical systems; Deep Water - extending operations into more challenging locales; Underwater sensors & monitoring systems; Specialist vessels for offshore renewables construction/support; Technology for and construction of affordable & reliable wind, wave & tidal power devices; Submarines and autonomous vehicles; and Integration of offshore renewable assets at the "Power station" / systems level. Opportunities for other marine resources were highlighted, including marine biofuels; mariculture; blue-biotech and underwater extraction / factories; however these were not highly prioritised as the necessary expertise were under-represented in the workshop participants.

Of these opportunities, the first six were explored in more detail – to characterise the market value and identify relevant sources of UK capability for delivery (and potential gaps that will need to be filled – see section 7)

In support of these opportunities, a wide range of capabilities were identified from within the Marine Industries but also in academia and research organisations. The most relevant areas of capability to support these market opportunities were: Simulation & modelling; Control, automation & autonomy; Sensors, measurement and monitoring technology; Data management; Condition Monitoring; Systems integration / engineering; Sub-sea technology; Service & Support; Maintenance; and Decision support systems.

The workshop also identified other key enablers for success, underpinning these capabilities as: Facilities, infrastructure & manufacturing capacity; Funding & investment; Supply chain / logistics; Skills availability; Training & Education; Partnerships & Networks; Major pathfinder projects to establish UK position; and Technology transfer from other industries

Contents

Executive Summary

1. Roadmap Landscape
2. Linkages
3. Trends & Drivers
4. Market Opportunities
5. Capabilities
6. Enablers
7. Detailed exploration of Market Opportunities

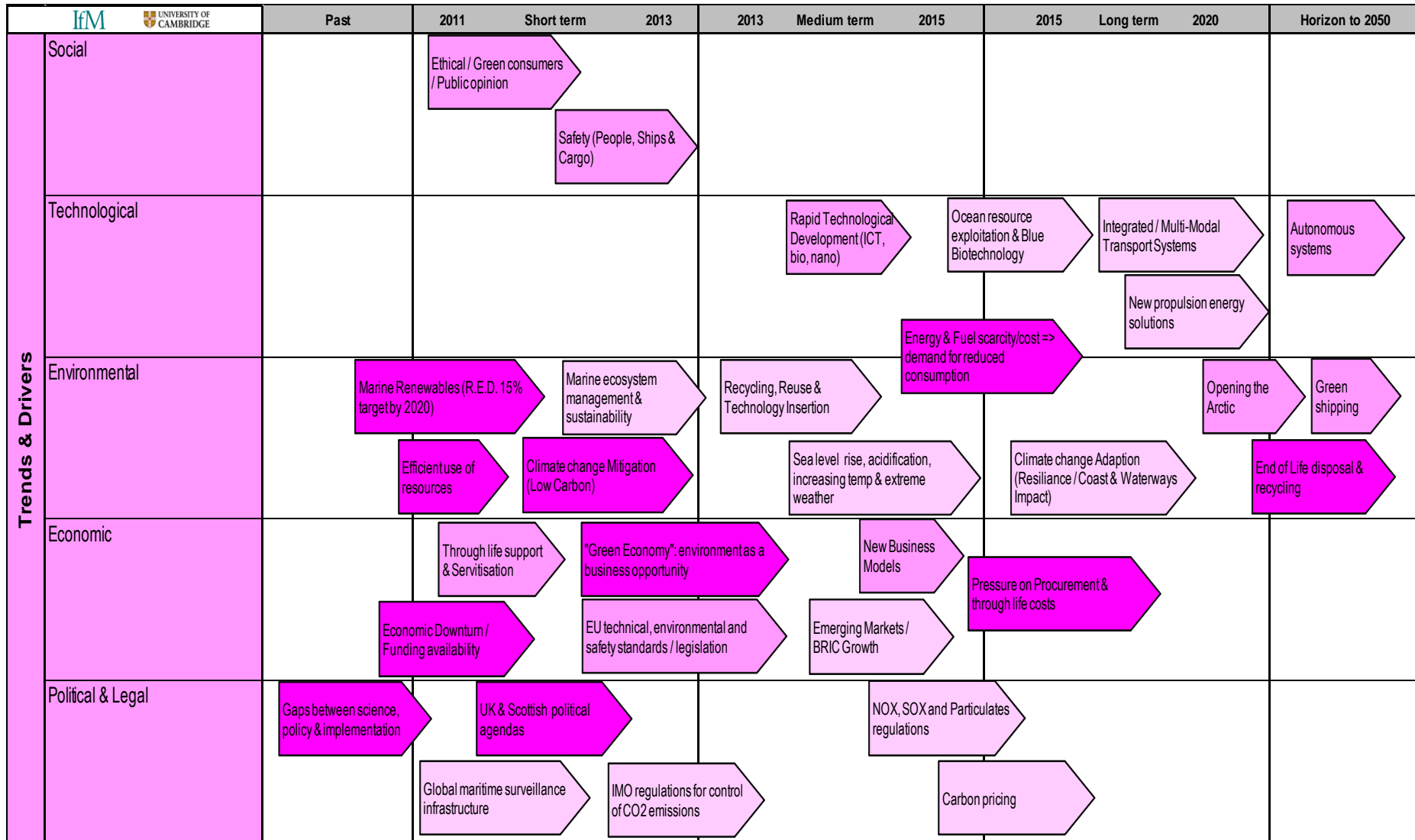
Appendices

- A. Participants

2. Landscape Linkages

Trends & Drivers												Capabilities																			Enablers																													
Efficient use of resources	Energy & Fuel scarcity/cost => demand for reduced consumption	Safety (People, Ships & Cargo)	Through life support & Servilisation	Autonomous systems	Pressure on Procurement & through life costs	Marine Renewables (R.E.D. 15% target by 2020)	Sea level rise, acidification, increasing temp & extreme weather	"Green Economy": environment as a business opportunity	Green shipping	Climate change Mitigation (Low Carbon)	New propulsion energy solutions																																																	
	1	2	3	4	5	6	7	8	9	10	11	12	Market Opportunities																																															
													A	Logistics & Services for Offshore Renewable Operations	5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	1	2	3	4	5	6	7	8	9	10	11	12													
	1		1	1	1								B	Grid Integration & Electrical Systems (inc Power Station Scale Ops)	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1	2	3	3	1	3	3	2	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	56
											1		C	Deep Water - 760m? (Extending operations to more challenging geographies) Offshore wind	2	3	3	3	3	3	3	3	2	2	2	3	3	3	3	3	3	3	2	3	2	3	2	3	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	63		
	1	1	1	1	1	1	1	1	1				D	Sensors/Monitoring & Autonomous underwater vehicles	8	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	2	3	3	2	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	33
	1									1			E	Specialist Vessels for offshore renewables construction support	3	3	2			1			3	2				2	3	2	2	2	3		2	1	1	1	1	1	1	1	1	1	1			1								31				
	1					1	1						F	Technology for wind, wave & tidal power (more affordable & reliable)	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1	3	3	3	3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	55	
	5	3	2	2	2	2	2	2	2	1	1	1				18	17	15	15	16	15	14	14	13	10	11	12	13	9	12	11	11	9	8	11	6	6	4	4	3	3	3	3	2	2	2	2	2	2	2	2	2	2	2	2	2				

3.1 Trends & Drivers



3.2 Trends & Drivers (1 to 20)

Rank	Driver	%
1	Energy & Fuel scarcity/cost => demand for reduced consumption	10%
2	Marine Renewables (R.E.D. 15% target by 2020)	7%
3	Economic Downturn / Funding availability	7%
4	Pressure on Procurement & through life costs	6%
5	Climate change Mitigation (Low Carbon)	5%
6	End of Life disposal & recycling	5%
7	Gaps between science, policy & implementation	5%
8	UK & Scottish political agendas	5%
9	Efficient use of resources	4%
10	"Green Economy": environment as a business opportunity	4%
11	Safety (People, Ships & Cargo)	3%
12	Through life support & Servitisation	3%
13	New Business Models	3%
14	EU technical, environmental and safety standards / legislation	3%
15	Ethical / Green consumers / Public opinion	3%
16	Opening the Arctic	3%
17	Rapid Technological Development (ICT, bio, nano)	2%
18	New propulsion energy solutions	2%
19	Green shipping	2%
20	Autonomous systems	2%

3.2 Trends & Drivers (cont)

Rank	Driver	%
21	Climate change Adaption (Resilience / Coast & Waterways Impact)	2%
22	Global maritime surveillance infrastructure	2%
23	Carbon pricing	2%
24	IMO regulations for control of CO2 emissions	2%
25	Recycling, Reuse & Technology Insertion	1%
26	NOX, SOX and Particulates regulations	1%
27	Integrated / Multi-Modal Transport Systems	1%
28	Ocean resource exploitation & Blue Biotechnology	1%
29	Emerging Markets / BRIC Growth	1%
30	Marine ecosystem management & sustainability	1%
31	IMO Ballast Water Convention	1%
32	Migration of freight from road to inland waterways & coastal shipping	1%
33	Sea level rise, acidification, increasing temp & extreme weather	1%
34	EU integrated maritime strategy	1%
35	Risk management	1%

3.3 Trends & Drivers Linkages

Rank	Driver	A Logistics & Services for Offshore Renewable Operations	B Grid Integration & Electrical Systems (inc Power Station Scale Ops)	C Deep Water - 760m? (Extending operations to more challenging geographies) Offshore wind	D Sensors/Monitoring & Autonomous underwater vehicles	E Specialist Vessels for offshore renewables construction support	F Technology for wind, wave & tidal power (more affordable & reliable)	Total
4	Efficient use of resources	1	1		1	1	1	5
26	Energy & Fuel scarcity/cost => demand for reduced consumption		1	1	1			3
5	Safety (People, Ships & Cargo)	1			1			2
6	Through life support & Servitisation	1			1			2
8	Autonomous systems	1			1			2
14	Pressure on Procurement & through life costs	1			1			2
16	Marine Renewables (R.E.D. 15% target by 2020)		1				1	2
36	Sea level rise, acidification, increasing temp & extreme weather				1		1	2
42	"Green Economy": environment as a business opportunity		1		1			2
1	Green shipping					1		1
2	Climate change Mitigation (Low Carbon)			1				1
7	New propulsion energy solutions					1		1
15	Positioning & Communications Technologies	1						1
21	New Business Models	1						1
22	Ocean resource exploitation & Blue Biotechnology						1	1
23	3D CAD/CAM/CAE / simulation & modelling / rapid tooling					1		1
25	Emerging Markets / BRIC Growth						1	1
30	EU technical, environmental and safety standards / legislation					1		1
31	End of Life disposal & recycling	1						1
35	Increasing global demand for seafarers				1			1
40	Gaps between science, policy & implementation						1	1
41	Ethical / Green consumers			1				1

4.1 Market Opportunities

IfM UNIVERSITY OF CAMBRIDGE		Past	2011	Short term	2013	2013	Medium term	2015	2015	Long term	2020	Horizon to 2050
Opportunities & Market Needs	Construction of offshore energy assets	Grid integration & electrical systems		Control & Instrumentation			Test Rigs			Construction of offshore renewable energy assets		
	Services for offshore power plant	Logistics & Services for offshore (inc new business models)		Asset management & operation		Environmental Impact Assessment		Services for operation, maintenance & management of offshore power plant				
	Specialist vessels/platforms		Vessel support (eg dry docks, facilities...)		Specialist vessels for offshore renewables construction/support			Specialist vessels/platforms for exploitation of new oil reserves		Offshore Service Hubs		Offshore settlements
	Marine biofuels & blue biotech						Marine biofuels			Blue biotech		
	Marine biological resource exploitation		Fisheries				Mariculture		Offshore Carbon capture & storage facilities	Marine biological resource exploitation		Integration of mariculture & renewables
	Mineral extraction				Mineral extraction, sea-bed mining							Underwater factories.
	Underwater sensors, monitoring & subs					Underwater sensors & monitoring systems		Submarines and autonomous vehicles.		(Bio)-Sensor developments		
	Marine eco-systems management		Systems for marine protected areas		Pollution/waste management and control		Marine & Coastal environmental services		Integrated coastal zone management / planning			Marine eco-systems management
	Other	Ports & Infrastructure	Metocean data sharing	Insurance & Risk management		Training & safety for offshore		Certification services (eg for reliability / IMO emissions...)	Oil-free lubrication		Energy storage (eg Fuel Cells)	

4.2 Market Opportunities (1 to 20)

Rank	Opportunities	Market Attractive	Capability Fit	Total	
1	Logistics & Services for offshore (inc new business models)				A
2	Grid integration & electrical systems				B
3	Deep Water - extending operations into more challenging locale				C
4	Underwater sensors & monitoring systems				D
5	Specialist vessels for offshore renewables construction/support				E
6	Technology for Wave & Tidal power (affordable / reliable) including cost-reduction				F
7	Submarines and autonomous vehicles.				inc D
8	Asset management & operation				inc A
9	Integration of offshore renewable assets - "Power station" / systems level				inc B
10	Construction of offshore renewable energy assets				inc F
11	Training & safety for offshore operations				
12	Vessel support (eg dry docks, facilities...)				
13	Insurance & Risk management services for offshore				
14	Test Rigs				
15	Certification services (eg for reliability / IMO emissions...)				
16	Services for operation, maintenance & management of offshore power plant				inc A
17	Marine biofuels				
18	Energy storage (eg Fuel Cells)				
19	Offshore Carbon capture & storage facilities				
20	Control & Instrumentation				

4.2 Market Opportunities (cont)

Rank	Opportunities	Market Attractive	Capability Fit	Total	
21	Supply chain for wind, wave & tidal energy generation assets				
22	Mariculture				
23	Ports & Infrastructure				
24	Oil-free lubrication				
25	Integration of mariculture & renewables				
26	Mineral extraction, sea-bed mining				
27	Marine & Coastal environmental services				
28	Environmental Impact Assessment				
29	Underwater factories.				
30	(Bio)-Sensor developments				
31	Offshore Service Hubs				
32	Metocean data sharing				
33	Offshore settlements				
34	Specialist vessels/platforms for exploitation of new oil reserves				
35	Marine biological resource exploitation				
36	Marine eco-systems management				
37	Blue biotech				
38	Integrated coastal zone management / planning				
39	Fisheries				
40	Systems for marine protected areas				
41	Pollution/waste management and control				
42	Resource Assesment				

5.1 Capabilities & Enablers

IfM UNIVERSITY OF CAMBRIDGE		Past	2011	Short term	2013	2013	Medium term	2015	2015	Long term	2020	Horizon to 2050
Technologies & Capabilities	Design & Development	Simulation & modelling	Tools & Techniques	Human factors	CAE / CAD / CAM	Design processes &	Naval architecture	Marinisation	Development testing & validation	Analysis tools		
	Construction, Structural & Mechanical			Mechanical systems		Offshore wind		Sub-sea technology	Tidal & wave power			
	Materials & Manufacturing	Materials technology	Coatings technology	Manufacturing technology	Processing technology (eg Wastewater)		Joining technologies (eg Welding)	Lightweighting	Low volume manufacturing / rapid prototyping			
	Propulsion, Energy & Power	Internal combustion engine			Electrical systems, storage & power infrastructure	Power systems management	Propulsion technology	Mechanical energy & storage	Electric drive technology			
	Information, Communication & Control	Sensors, measurement and	Control, automation &	Data management	Navigation technology	Logistics / traffic management	Voyage management	Decision support	Communications (LAN / Wireless)	Telecoms (wide-area)		
	Life-cycle technologies	Service & Support	Maintenance	Life-cycle analysis	End of life / recycling / Decommissioning	Technology insertion &	Condition Monitoring	Supply Chain management	In-service testing	Design & manufacture for		
	Safety & security	Offensive & defensive	National security	Personal safety	Active safety	Safety testing						
	Other			Consulting	Risk management & actuarial		Biotech & biological	Marine life sciences	Systems integration / engineering	Integrated Transport Systems	Oceanography / Environment (eg)	
Enablers	Funding & Resources			Focused Research	Funding & investment		Business Model Innovation	Incentives to industry to adopt new technology	Marine technology			
	Marketing & Brand		Understanding Customer / Owner / Operator needs			Major pathfinder projects to establish UK position						
	People & Skills	Skills availability		Professional Institutions	Training & Education		Oceanographic research centres	Technology translators				
	Facilities & Infrastructure		Facilities, infrastructure & manufacturing			Partnerships & Networks		International collaboration				
	Partnerships & Supply Chain			Supply chain / logistics	IP security & Licensing							
	Standards & Regulation	Safety legislation	Standards			Open architectures	Environmental Regulation					
	Other			Technology transfer from other industries				Integration with planning & Local Gov't				

5.2 Capabilities

5.2 Capabilities		A	B	C	D	E	F	G	
		Marine Consulting (Submarine)	Ship Management Systems - I-ships	Training & Education incl. Virtual training	In-service Support of Military & Civilian Assets	Marine ICT & Information Infrastructure	Decision Support Services	Marine & Coastal Environmental Services	
A	Design & Development								0
A1	Simulation & modelling	3	3	3	3	3	3	3	
A2	Tools & Techniques	0	0	3	0	0	3	3	
A3	Human factors	3	0	3	0	3	0	2	
A4	CAE / CAD / CAM	0	2	3	0	0	3	1	
A5	Design processes & Modularisation	0	3	3	0	0	3	2	
A6	Naval architecture	0	2	2	0	3	2	0	
A7	Marinisation	0	3	1	0	0	3	3	
A8	Development testing & validation	0	2	3	3	0	3	2	
A9	Analysis tools	3	3	3	0	0	3	3	
A Total	Design & Development	9	18	24	6	9	23	19	
C	Construction, Structural & Mechanical								
C1	Mechanical systems	0	1	2	0	2	3	0	
C2	Offshore wind	0	3	3	0	0	3	0	
C3	Tidal & wave power	0	3	3	0	0	3	0	
C4	Sub-sea technology	3	3	2	3	0	3	2	
C5	Naval & Civilian platforms	0	0	0	0	0	0	0	
C Total	Construction, Structural & Mechanical	3	10	10	3	2	12	2	
M	Materials & Manufacturing								
M1	Materials technology	0	2	3	0	2	1	1	
M2	Coatings technology	0	2	3	0	3	2	0	
M3	Manufacturing technology	0	1	1	0	3	2	0	
M4	Processing technology (eg Wastewater)	0	0	1	0	0	0	0	
M5	Joining technologies (eg Welding)	3	2	2	0	3	1	0	
M6	Lightweighting	0	3	3	0	0	1	0	
M7	Low volume manufacturing / rapid prototyping	0	0	3	0	0	0	0	
M8	Command & Control	0	0	0	0	0	0	0	
M Total	Materials & Manufacturing	3	10	16	0	11	7	1	
P	Propulsion, Energy & Power								
P1	Internal combustion engine technology	0	0	0	0	2	0	0	
P2	Electric drive technology	0	3	3	2	2	3	0	
P3	Mechanical energy & storage technology	0	2	3	0	0	0	0	
P4	Electrical systems, storage & power infrastructure	0	3	3	0	2	3	0	
P5	Power systems management	0	3	3	0	2	3	1	
P6	Propulsion technology	0	0	2	2	2	0	0	
P Total	Propulsion, Energy & Power	0	11	14	4	10	9	1	

5.2 Capabilities (cont)

5.2 Capabilities (cont)		A	B	C	D	E	F	G	
		Marine Consulting (Submarine)	Ship Management Systems - I-ships	Training & Education incl. Virtual training	In-service Support of Military & Civilian Assets	Marine ICT & Information Infrastructure	Decision Support Services	Marine & Coastal Environmental Services	
I	Information, Communication & Control								
I1	Sensors, measurement and monitoring technology	3	3	3	3	0	3	3	
I2	Control, automation & autonomy	3	3	3	3	2	3	2	
I3	Data management	3	3	3	3	0	3	3	
I4	Navigation technology	2	0	3	0	2	0	0	
I5	Logistics/ traffic management	2.5	0	3	0	1	0	0	
I6	Voyage management	3	0	3	0	1	0	0	
I7	Decision support systems	3	1	3	3	0	0	3	
I8	Communications (LAN / Wireless)	3	2	3	0	0	0	2	
I9	Telecoms (wide-area)	2	2	3	0	0	0	2	
I Total	Information, Communication & Control	24.5	14	27	12	6	9	15	
L	Life-cycle technologies								
L1	Service & Support	3	3	2	0	3	3	2	
L2	Maintenance	3	3	2	0	2	3	2	
L3	Life-cycle analysis	3	2	2	0	0	3	0	
L4	End of life / recycling / Decommissioning	3	1	1	0	1	1	0	
L5	Technology insertion & reconfigurability	3	0	2	0	0	2	0	
L6	Condition Monitoring	3	3	3	3	1	3	1	
L7	Supply Chain management	3	1	3	0	2	3	0	
L8	In-service testing	3	2	2	0	2	0	0	
L9	Design & manufacture for sustainability	3	0	3	0	0	0	2	
L Total	Life-cycle technologies	27	15	20	3	11	18	7	
S	Safety & security								
S1	Offensive & defensive systems	0	1	3	0	0	0	0	
S2	National security	1	0	3	0	0	0	0	
S3	Personal safety	3	3	2	0	1	0	0	
S4	Active safety	3	0	3	0	0	0	0	
S5	Safety testing	3	2	3	0	0	1	0	
S Total	Safety & security	10	6	14	0	1	4	0	
O	Other								
O1	Biotech & biological processing	0	0	2	0	0	0	0	
O2	Marine life sciences	0	2	2	0	0	3	2	
O3	Consulting	3	3	3	0	0	0	3	
O4	Risk management & actuarial	3	3	2	0	0	3	0	
O5	Integrated Transport Systems	2.5	0	3	0	0	0	0	
O6	Oceanography / Environment (eg currents & ice caps)	2	1	2	0	0	3	3	
O7	Systems integration / engineering	3	3	3	3	0	3	2	
O Total	Other	13.5	12	17	3	0	12	10	

5.3 Capability - Ranked

Capabilities	A	B	C	D	E	F	G	TOTAL Theme A Marine Services & ICT
	Marine Consulting (Submarine)	Ship Management Systems - I-ships	Training & Education incl. Virtual training	In-service Support of Military & Civilian Assets	Marine ICT & Information Infrastructure	Decision Support Services	Marine & Coastal Environmental Services	

Ranked capabilities (top-level grouping)								
I Total	Information, Communication & Control							
A Total	Design & Development							
L Total	Life-cycle technologies							
O Total	Other							
P Total	Propulsion, Energy & Power							
M Total	Materials & Manufacturing							
C Total	Construction, Structural & Mechanical							
S Total	Safety & security							

Ranked capabilities (detail)								
A1	Simulation & modelling	3	3	3	3	3	3	3
I2	Control, automation & autonomy	3	3	3	3	2	3	2
I1	Sensors, measurement and monitoring technology	3	3	3	3	0	3	3
I3	Data management	3	3	3	3	0	3	3
L6	Condition Monitoring	3	3	3	3	1	3	1
O7	Systems integration / engineering	3	3	3	3	0	3	2
C4	Sub-sea technology	3	3	2	3	0	3	2
L1	Service & Support	3	3	2	0	3	3	2
L2	Maintenance	3	3	2	0	2	3	2
I7	Decision support systems	3	1	3	3	0	0	3
A8	Development testing & validation	0	2	3	3	0	3	2
A9	Analysis tools	3	3	3	0	0	3	3
P2	Electric drive technology	0	3	3	2	2	3	0
A3	Human factors	3	0	3	0	3	0	2
L7	Supply Chain management	3	1	3	0	2	3	0
P5	Power systems management	0	3	3	0	2	3	1
M5	Joining technologies (eg Welding)	3	2	2	0	3	1	0
O3	Consulting	3	3	3	0	0	0	3
O6	Oceanography / Environment (eg currents & ice caps)	2	1	2	0	0	3	3
P4	Electrical systems, storage & power infrastructure	0	3	3	0	2	3	0

6.1 Enablers

Rank	Enablers	A Logistics & Services for Offshore Renewable Operations	B Grid Integration & Electrical Systems (inc Power Station Scale Ops)	C Deep Water - 760m? (Extending operations to more challenging geographies) Offshore	D Sensors/Monitoring & Autonomous underwater vehicles	E Specialist Vessels for offshore renewables construction support	F Technology for wind, wave & tidal power (more affordable & reliable)	Total
11	Facilities, infrastructure & manufacturing capacity	1	1	1	1	1	1	6
13	Funding & investment	1	1	1	1	1	1	6
2	Supply chain / logistics	1	1	1			1	4
5	Skills availability	1		1		1	1	4
6	Training & Education	1				1	1	3
14	Partnerships & Networks	1		1		1		3
17	Major pathfinder projects to establish UK position	1	1	1				3
22	Technology transfer from other industries	1		1	1			3
12	Standards	1	1					2
18	Incentives to industry to adopt new technology		1			1		2
21	Integration with planning & Local Gov't			1			1	2
23	Focussed Research programmes		1		1			2
1	Open architectures				1			1
3	Safety legislation	1						1
4	Understanding Customer / Owner / Operator needs	1						1
8	Business Model Innovation					1		1
9	Environmental Regulation				1			1
10	Professional Institutions		1					1
19	Marine technology revolution						1	1

7. Priority Market Opportunities (explored in breakout groups)

Rank	Opportunities	Breakout Group
1	Logistics & Services for offshore (inc new business models)	A
2	Grid integration & electrical systems	B
3	Deep Water - extending operations into more challenging locale	C
4	Underwater sensors & monitoring systems	D1
5	Specialist vessels for offshore renewables construction/support	E
6	Technology for Wave & Tidal power (affordable / reliable) including cost-reduction	F
7	Submarines and autonomous vehicles.	D2
8	Asset management & operation	inc A
9	Integration of offshore renewable assets - "Power station" / systems level	inc B
10	Construction of offshore renewable energy assets	inc F
11	Training & safety for offshore operations	See Theme A
12	Vessel support (eg dry docks, facilities...)	inc 1 & See Theme E
13	Insurance & Risk management services for offshore	See Theme A
14	Test Rigs	
15	Certification services (eg for reliability / IMO emissions...)	
16	Services for operation, maintenance & management of offshore power plant	inc A
17	Marine biofuels	
18	Energy storage (eg Fuel Cells)	
19	Offshore Carbon capture & storage facilities	
20	Control & Instrumentation	

See over for outputs from breakout group exploration of Priority Market Opportunities.

Key: **Black text – original team input**
 Red text – carousel group comments

7. Priority Market Opportunities (summary)

Opportunities		Market Attractiveness:					Triple bottom-line		Value	Fit with UK Capability					Fit	Total
		Global Market Size	Home (UK) market size	Strength of competition	Added Value / Margin	Cross-sector opportunity	Planet / Environmental	People / Societal		Weighted Value	Marine Industry	University / Academic	RTO / Design Services	Other Industry		
Topic	Opportunity															
A	Logistics & Services for Offshore Renewable Operations	4	4	2	4	2.5	2	3		4	2.5	3	4	3.5	3	
B	Grid Integration & Electrical Systems (inc Power Station Scale Ops)	4	4	1	1	0	3	1		3	3	3	2	1	3	
C	Deep Water - 760m? (Extending operations to more challenging geographies) Offshore wind	4	4	1	1	4	2	3		3	4	4	2	1	2	
D1	Sensors/Monitoring	2	1	1	3	3	3	2		2	2	2	3	4	1	
D2	Autonomous/Underwater Vehicles	2	1	2	3	1	1	1		1	1	2	4	4	1	
E	Specialist Vessels for offshore renewables construction support	4	3	1	1	0	1	3		2	3	3.5	1	3	1	
F	Technology for wind, wave & tidal power (more affordable & reliable)	4	4	2	3	1.5	3	2		3	4	4	3	3	2	

See over for outputs from breakout group exploration of Priority Market Opportunities.

Key: **Black text – original team input**
 Red text – carousel group comments

Opportunity		A		Logistics & Services for Offshore Renewable Operations		Team	LF, PC, PG
						Score	3.3
Value				Basis for Characterisation & Evidence		Score	This opportunity is attractive because:
Market Attractiveness:	Global Market Growth Opportunity	V. Large £5bn	>	Whole market size. Need to access accessibility, Germany refocusing on offshore wind, not nuclear		4.0	Crucial for rest of supply chain
	Home (UK) Market Growth	V. Large £2bn	>	£100k/MW installed = OPEX per annum. 19Gw by 2020 = £1bn pa. Say 10Gw by 2015 over 2 years - 2Bn		4.0	
	Strength of competition (Global)	Strong / Established		No-one established in deep water wind, wave, tidal. Scale of wind farms can't be matched by scale of support service		2.0	
	Added Value in UK	90%		Can be home-grown & UK based		4.0	
	Cross-sector opportunity	Medium > £500m		Defence, oil & gas, commercial maritime, ports sector		2.5	
Triple bottom-line	Planet / Environmental	Modest				2.0	Knowledge Gaps (in team):
	People / Societal	Major		Big reliance on people to deliver maintenance & operate UONs etc. 10's of thousands of new jobs cf - Carbon Trust or R.UK Data		3.0	
Capability				Where is the capability?	What are the Gaps?	Score	UK has the capability to deliver...
Fit with UK Capability	Marine Industry	World-Leading & significant scale		Naval, commercial & oil & gas, ports	Applying/adapt existing experience to offshore renewables	4.0	Integrated offering not just OEM service support. Energy Technology Institute looking at system integration of WE arrays. Do EMEC/NAREC etc help with ops research? Think it might be a gap
	University / Academic	Strong but below critical mass		R-UK setting up centres of excellence with indy & academia. Supergen marine consortium, Edinburgh Uni, Cardiff & Herriot	""	2.5	
	R&T Org. / Design	World-Leading OR significant scale		Consultants & test sites. Logistic modelling so minimise efficiency?	Integrated offering	3.0	
	Non-Marine / Other	World-Leading & significant scale		Aerospace F1/automotive, utilities, insurance, financial indy		4.0	
	Other UK resources	World-Leading & significant scale		Island nation, wind wave & tidal resource (data from R-UK)	Govt policy consistency	3.5	Knowledge Gaps (in team):
Timeliness	UK Capability matches market need	Pace setting			3.0		

Opportunity		B	Grid Integration & Electrical Systems (inc Power Station Scale Ops)		Team	AM, GM, SW	
					Score	2.4	
Value				Basis for Characterisation & Evidence		Score	This opportunity is attractive because:
Market Attractiveness:	Global Market Growth Opportunity	V. Large > £5bn	Critical enabler for offshore renewables. Emerging technology > scope for innovation. Inter-array, transmission & buffering/storage		4.0	Established need large market UK/International. Opp.to lead thru round 3 deployment. UK strength in: offshore eng, systems design/management, project management, Uni capacity	
	Home (UK) Market Growth	V. Large > £2bn	~ £200bn offshore wind till 2020 30% for elec. Network		4.0		
	Strength of competition (Global)	Dominant / Entrenched	Equipment manufacturers mainly overseas. Halland, Germany esp.		1.0		
	Added Value in UK	10%	UK strength in systems management. Design UK inter-array cabling - strong knowledge base (suppliers & oil & gas exp). Consultancy strength. Research		1.0		
	Cross-sector opportunity	Small < £100m	oil & gas: connectors, umbilical's. Control & In Str. Smart networks		0.0		
Triple bottom-line	Planet / Environmental	Major	Enabler not primary		3.0	Knowledge Gaps (in team): None!! :)	
	People / Societal	None	""		1.0		
Capability				Where is the capability?	What are the Gaps?	Score	UK has the capability to deliver...
Fit with UK Capability	Marine Industry	World-Leading OR significant scale	Construction/design (McNulty, KBR, Fluor), contracting Oil & gas, sea ploughs cable install	Equipment manufacturers, standards & cert	3.0	Knowledge Gaps (in team):	
	University / Academic	World-Leading OR significant scale	Manchester, Strathclyde, Southampton, Herriot-Watt, Liverpool, Imperial & marine enviro (Nene, Southampton, Str, BMI)	DC, low freq. AC. Others inc NL (Delft etc), NO (NTNU)	3.0		
	R&T Org. / Design	World-Leading OR significant scale	PB power, SKM, Arup, IHI, SMD, NAREC (E.g. Systems design)	Superconductivity Strong capability in low cost superconductivity materials/application	3.0		
	Non-Marine / Other	Moderate / Emerging / Dispersed	National grid, SSE Integr (e.g.. Siemens, arena) Converteam	Elec equipment, design & manufacture	2.0		
	Other UK resources	None	ETI? Broadly: wind & marine energy resource Battery tech?	Energy storage	1.0		
Timeliness	UK Capability matches market need	Pace setting	1. Systems 2. Equipment		3.0		

Opportunity		C	Deep Water - > 60m (Extending operations to more challenging)		Team	SH, SP, JS	
					Score	2.8	
Value		Basis for Characterisation & Evidence			Score	This opportunity is attractive because:	
Market Attractiveness:	Global Market Growth Opportunity	V. Large > £5bn	UK 3k turbine round 3 (floating). Matching Euro funding. Deep water (UK) capability first to encounter. Deep water. Europe - 60= £16m. US market - export > 3k turbines > design to drive cost efficiency. Don't forget life after round 3 may be bigger & deeper		4.0	Emerging technology/capability e.g. defence. UK growth - exportable tech & expertise. Market requirement to do so. New to the UK - domestic market	
	Home (UK) Market Growth	V. Large > £2bn	UK round 3 + Euro + US - exportable skills - cross sector knowledge - oil/gas		4.0		
	Strength of competition (Global)	Dominant / Entrenched	Strong but developing - e.g. Norway. Risk - oil & gas in market. Attracting labour from other sectors - oil & gas (higher salaries) Importing skills		1.0		
	Added Value in UK	10%	Offshore capability - imported labour. Fixed design. Manufacture - anywhere not just UK > impact @ 70% require significant investment - infrastructure issues		1.0		
	Cross-sector opportunity	V. Large > £2bn	Project size - skills & tech transfer from oil & gas & other marine sectors such as submarine manufacture - auto industry cost drivers (ktn?) (Cost, DFA, mass manufacture). Stability technologies - marine equip, marine bio (engineering - auto, ship/boat build, academia - innovation transfer) DFA systems integrators - (IBM) Other deep water facilities - mariculture, mining, factories		4.0		
Triple bottom-line	Planet / Environmental	Modest	Sustainability. Contribution to climate change. Such concepts offer sustainability potentials but they are difficult to sustain!		2.0	Knowledge Gaps (in team): The subject matter. New to the UK	
	People / Societal	Major	Security of supply. Jobs, Growth		3.0		
Capability		Where is the capability?		What are the Gaps?	Score	UK has the capability to deliver...	
Fit with UK Capability	Marine Industry	World-Leading OR significant scale	Offshore oil & gas - maritime, vessel availability, vessels in marine environments. Transferable skills from oil & gas. Insufficient knowledge transfer as indicated by lack of attendance from oil & gas companies today. Marine equip manufacturing in the UK is worth £3bn pa so exploit existing volume production skills		Cost/manufacture, skills competing. Does marine realise capability - opp. Large scale port facilities	3.0	Knowledge & deployment. Operations & delivery (Auto eg)
	University / Academic	World-Leading & significant scale	Ditto Cambridge		Ditto Southampton, Plymouth, Hull?	4.0	
	R&T Org. / Design	World-Leading & significant scale	Excellent at R&T - S&T		Joining up - realised opportunity market/business case	4.0	
	Non-Marine / Other	Moderate / Emerging / Dispersed	Auto - DFM/DFA/Automation production processing >>>>>>>			2.0	
	Other UK resources	None	Defence = S, Finance = M, Logistics, Professional services. Huge wind wave tidal resource. World-leading O&G construction logistics & production planning		Transport infrastructure inputs into deep water not on radar!	1.0	
Timeliness	UK Capability matches market need	Lagging but could recover	80% - £1 goes abroad!			2.0	Knowledge Gaps (in team): Transferable knowledge. World-leading capabilities in non-marine sectors (e.g. Defence, finance, logistics) BUT utilising/applying these capabilities to develop deep water technologies is not on the agenda for the sectors where this capability exists

Opportunity		D1	Sensors/Monitoring		Team	
Equipment health monitoring, Environment: Noise, wind, temp, sea state, chemical, sea life, sediment, movement. Data collection, transmission, data storage. Diagnostics/modelling, diagnostics performance					Score	2.2
Value			Basis for Characterisation & Evidence		Score	This opportunity is attractive because:
Market Attractiveness:	Global Market Growth Opportunity	Modest > £200m	Applicable to all offshore renewable energy/assets worldwide		2.0	Large cross sectional potential with significant triple bottom line benefits
	Home (UK) Market Growth Opportunity	Small < £100m	Suppliers to onshore wind/marine/offshore		1.0	
	Strength of competition (Global)	Dominant / Entrenched	Suppliers to onshore wind/marine/offshore oil & gas. UK well-placed for transfer to offshore renewables		1.0	
	Added Value in UK	70%			3.0	
	Cross-sector opportunity	Large > £1bn	Multi-sector - transport, environmental impact		3.0	
Triple bottom-line	Planet / Environmental	Major	optimum efficiency operation, marine life monitoring		3.0	Knowledge Gaps (in team): Research base knowledge
	People / Societal	Modest	Enables better environment. Improved safety		2.0	
Capability			Where is the capability?	What are the Gaps?	Score	UK has the capability to deliver...
Fit with UK Capability	Marine Industry	Moderate / Emerging / Dispersed	Underwater communications for wave & tidal control schemes. ANSI, BNEA, UKNEST, Oceanology e.g. QinetiQ, Thales, RR, Bae, Atlas Elektronik UK	Diagnostics/prognostics	2.0	Strong/World leading capability
	University / Academic	Moderate / Emerging / Dispersed	Agree knowledge transfer should receive more attention	Application to marine	2.0	
	R&T Org. / Design	Moderate / Emerging / Dispersed		Military not commercial	2.0	
	Non-Marine / Other	World-Leading OR significant scale	Military both. Automotive aerospace	Lack of large scale component suppliers	3.0	
	Other UK resources	World-Leading & significant scale	Environmental, military		4.0	
Timeliness	UK Capability matches market need	Already "missed the boat"		Lagging for civil applications	1.0	Knowledge Gaps (in team): Civil apps - e.g. Diagnostic & prognostics

Opportunity		D2	Autonomous/Underwater Vehicles		Team	PG2, JM, TD
Remote control/autonomous/injection of offshore assets, monitoring from service centres					Score	1.8
Value			Basis for Characterisation & Evidence		Score	This opportunity is attractive because:
Market Attractiveness:	Global Market Growth Opportunity	Modest > £200m	Applicable to all offshore renewable energy/assets worldwide		2.0	Large cross-sectional potential with significant triple bottom line profits
	Home (UK) Market Growth Opportunity	Small < £100m			1.0	
	Strength of competition (Global)	Strong / Established	US military		2.0	
	Added Value in UK	70%			3.0	
	Cross-sector opportunity	Small < £100m	Possibly fishing, cable laying		1.0	
Triple bottom-line	Planet / Environmental	None	Supports sensing , reduces human intervention		1.0	Knowledge Gaps (in team): Research base knowledge
	People / Societal	None	Reduced manning in harsh environments		1.0	
Capability			Where is the capability?	What are the Gaps?	Score	UK has the capability to deliver...
Fit with UK Capability	Marine Industry	None		Autonomy	1.0	Strong/world leading capability
	University / Academic	None		Application to marine	1.0	
	R&T Org. / Design	Moderate / Emerging / Dispersed		Military not commercial	2.0	
	Non-Marine / Other	World-Leading & significant scale	Military		4.0	
	Other UK resources	World-Leading & significant scale	Environmental, military		4.0	
Timeliness	UK Capability matches market need	Already "missed the boat"		Lagging for civil applications	1.0	Knowledge Gaps (in team): Civil apps - e.g. Diagnostic & prognostics

Opportunity		E	Specialist Vessels for offshore renewables construction support		Team	SC, BC2, AS
					Score	2.1
Value			Basis for Characterisation & Evidence		Score	This opportunity is attractive because:
Market Attractiveness:	Global Market Growth Opportunity	V. Large > £5bn	23m support vessels 150+. Turbine installation vessels 50ish. Cable laying vessel 20-30. Foundation installation 20		4.0	
	Home (UK) Market Growth	Large > £1bn	up to 2020. Opportunity for low cost vessels for installation for tidal		3.0	
	Strength of competition (Global)	Dominant / Entrenched	UK stronger in smaller vessels. UK weak for large vessels. Agree, emphasis should be on high capacity/high volume vessels. Generally Norwegian/Dutch domination for large vessels. Installation contractors are not UK companies		1.0	
	Added Value in UK	10%	UK already has good value added in smaller vessels		1.0	
	Cross-sector opportunity	Small < £100m	Limited cross sector benefits. Design from O&G hot build. Considering design not build £1bn not? Commercial oil & gas deep water mining ship design experience. Offshore oil & gas. Harness shared needs in offshore oil & gas? E.g. Joint/collaborative investment in UK supply base. Marine/shipbuilding sector! & Renewables		0.0	
Triple bottom-line	Planet / Environmental	None	Time and CAPEX is more important Future pressure on life cycle energy/CO2 may drive propulsion effy improvements		1.0	Knowledge Gaps (in team): Need to upgrade existing capabilities
	People / Societal	Major	Very visible, material output		3.0	
Capability			Where is the capability?	What are the Gaps?	Score	UK has the capability to deliver...
Fit with UK Capability	Marine Industry	Moderate / Emerging / Dispersed	Design & manufacture of small vessels. Equipment & propulsion design & supply. Facilities	Upgrade of facilities & management . Capability exists (for now) Labour cost profitability ship build? Specialist vessels: Any benefits associated with recent UK/Norway agreement on energy? Norway strong in ship building	2.0	Weakness in UK manufacture
	University / Academic	World-Leading OR significant scale		Not sure if UK university ship design capability is world leading re: Europe. Integrated offering - all the pieces	3.0	
	R&T Org. / Design	World-Leading & significant scale	Design offices. Innovative product development		3.5	
	Non-Marine / Other	None			1.0	
	Other UK resources	World-Leading OR significant scale	Environmental forces		3.0	Knowledge Gaps (in team):
Timeliness	UK Capability matches market need	Already "missed the boat"			1.0	

Opportunity		F	Technology for wind, wave & tidal power (more affordable & reliable)		Team	MS, DK, CL
					Score	3.0
Value			Basis for Characterisation & Evidence		Score	This opportunity is attractive because:
Market Attractiveness:	Global Market Growth Opportunity	V. Large £5bn >	O&M for offshore wind 30% of total cost > improvement in reliability reduce O&M costs. Estimates of harvestable resource multiplied by tech costs - total value well in excess of £5b. Investment in industry by 2020 > £100b across all offshore renewables		4.0	
	Home (UK) Market Growth	V. Large £2bn >	UK targets of 1GW for W&T and 30g for offshore wind need huge investment by 2020. Tidal: Black & Veatch estimates of resource. 18TWH/year indicate big value . Supply chain opportunity for manufacturing, installation maintenance & support for W&T is significant		4.0	
	Strength of competition (Global)	Strong / Established	W&T has potential to establish world leading sector > competition & designs still evolving > main developer > difficult to becomes ESP for SME's. Supply chain & services, modelling tools up for grabs. Wind > supply chain established elsewhere > again services, modelling tools etc present opportunity		2.0	
	Added Value in UK	70%	UK modelling tools & services high quality and in demand. Components of manufacturing under threat or established elsewhere (wind) > cost competitiveness dominant factor		3.0	
	Cross-sector opportunity	Modest > £100m	Specific technologies an cross fertilise. Coatings/components		1.5	
Triple bottom-line	Planet / Environmental	Major	Prevent climate change. It will take many years before that happens! Not sure about game-changing. Probably significant or major.		3.0	Knowledge Gaps (in team):
	People / Societal	Modest	Renewable UK research indicates 10,000 people employed in W&T sector by 2020		2.0	
Capability			Where is the capability?	What are the Gaps?	Score	UK has the capability to deliver...
Fit with UK Capability	Marine Industry	World-Leading OR significant scale	UK shipping /defence industries. Offshore wind/W/T developers. BIFAB & SSA members	Strong, cost effective manufacturing base. Ability to marinise. Tools & techniques (modelling & measurement). True understanding of marine environment > design/op choices. Access to data (tidal/wind etc). Don't forget farm	3.0	Financial & insurance infra very strong. Overall technology plans & development in UK academia: talk to SuperGen Marine Consortium (of Edinburgh Uni)
	University / Academic	World-Leading & significant scale	Super Gen hubs. Edinburgh, Strathclyde, Manchester, Southampton, Oxford, Imperial, Cardiff. Test facilities		4.0	
	R&T Org. / Design	World-Leading & significant scale	NAREC. Wave Hubs, EMEC, QinetiQ	lack of co-ordination and knowledge of test facilities	4.0	
	Non-Marine / Other	World-Leading OR significant scale	Aviation. Rail. Consultancies		3.0	
	Other UK resources	World-Leading OR significant scale	Utilities as intelligent buyers. Site developers/owners. Crowne Estate. Supportive regulators. Military		3.0	Knowledge Gaps (in team): Enabling political environment key to achieving aims of industry
Timeliness	UK Capability matches market need	Lagging but could recover	Is this likely to happen? <		2.0	

Appendices

- A. Participants
- B. Workshop Feedback
- C. Workshop Process
- D. Market Opportunities Detail
- E. Participant pre-work

Appendix A: Workshop Participants

Name	Surname	Organisation
Patrick	Carnie	QinetiQ
Simon	Cormack	MDI
Paul	Critchley	L-3 Marine Systems UK
Tessa	Darley	Transport KTN
Liam	Forbs	Babcock International Group
Paul	Greaves	Rolls-Royce
Philip	Green	BMT Defence Services
Stephen	Hart	Technology Strategy Board
Atilla	Incecik	University of Strathclyde
Jonathan	Sedgwick	University of Edinburgh
David	Krohn	RenewableUK
Carrie	Lambert	Rolls-Royce
William	Medd	Babcock International Group
George	Mermeris	Strathclyde University
Andrew	Mill	National Renewable Energy Centre
John	Mitchell	MET Office
Sam	Pick	Renewables Network
Ash	Sinha	SSA
Michael	Starling	BMT Renewables
Simon	Wrigley	Ricardo
Dominic	Oughton	IfM
Jonathan	Hughes	IfM