UK Marine Industries Roadmap & Capability Study

Workshop D: Shipbuilding and Repair, 16 November

Technology Strategy Board
Driving Innovation

UK Marine Industries Alliance

Knowledge Transfer Networks

BIS Department for Business Innovation & Skills

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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 fourth of five "Deep Dive" explorations of the sector, focussing on Shipbuilding and Repair. The workshop took place in Bristol on 16 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 Shipbuilding and Repair.

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 & fuel scarcity/cost , EU regulations and climate change mitigation all driving the need for low carbon / "green" shipping with reduced fuel consumption, requiring new propulsion energy solutions. Skills shortage (and prevention of further loss of scarce skills) was seen as a key challenge, particularly at a time of economic downturn, declining UK Naval market and resulting pressure on initial and through life costs. Responses to these would see an increased demand for autonomous systems and new business models around through life support & servitisation. The changing nature of military threat and other security risks (eg piracy) would see a need for more versatile, agile and reconfigurable systems. Increasing global (& low cost) competition might result in increasing international collaboration, particularly at an EU level.

Executive Summary (continued)

Priority Opportunities (see section 4) were identified across a range of areas, though largely focussed on design and ship systems / equipment rather than build (due to the relative lack of capacity in UK for manufacturing large vessels). The leading opportunities included alternative fuels / electrification & hybrids (including commercial sail); efficient propulsion & energy management; optimised multi-modal transport including short-sea shipping; vessels for offshore support; unmanned autonomous vehicles; export of warship designs & military ships; in-service support of military and civilian vessels (incl. lifecycle design); new submarines (military & commercial including for deep-sea exploration). Opportunities for consultancy (eg Green ship services); luxury, commercial and leisure vessels (especially for BRIC markets); ship management systems: I-ship; and training (eg for operators / maintainers) were also prioritised but have already been explored in earlier workshops.

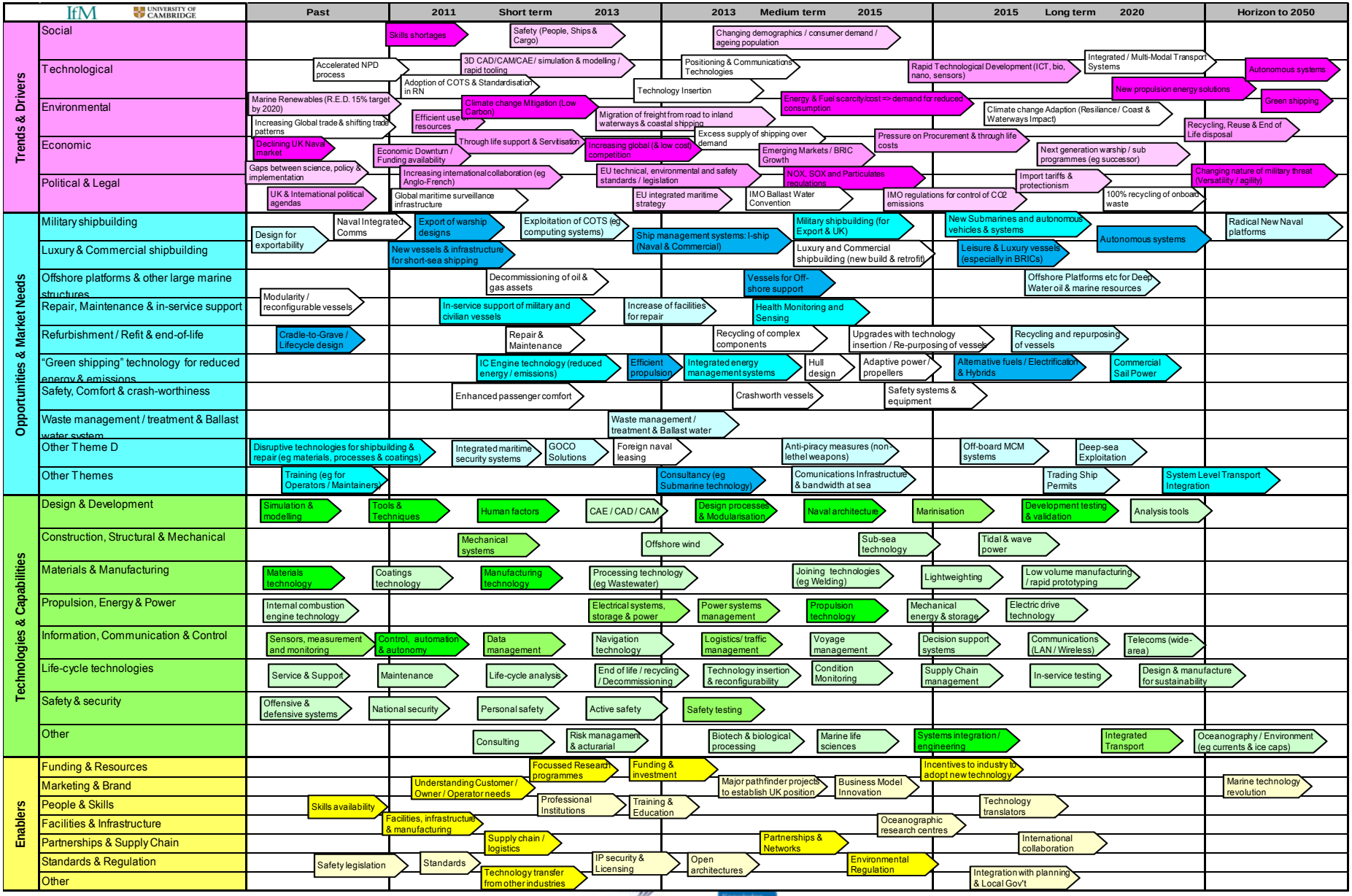
Of these opportunities, the first eight were explored in more detail – to characterise the market value and identify relevant sources of UK capability for delivery (and potential gaps that will need to be filled – see section 7)

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: naval architecture, systems integration / engineering; simulation & modelling; tools & techniques; human factors; materials technology ;development testing & validation; control, automation & autonomy; design processes & modularisation; manufacturing technology and propulsion technology

The workshop also identified other key enablers for success, underpinning these capabilities as: funding & investment ; understanding customer / owner / operator needs; skills availability; environmental regulation; facilities, infrastructure & manufacturing capacity; focussed research programmes; supply chain / logistics; partnerships & networks; incentives to industry to adopt new technology and technology transfer from other industries.

Contents

1. Roadmap Landscape



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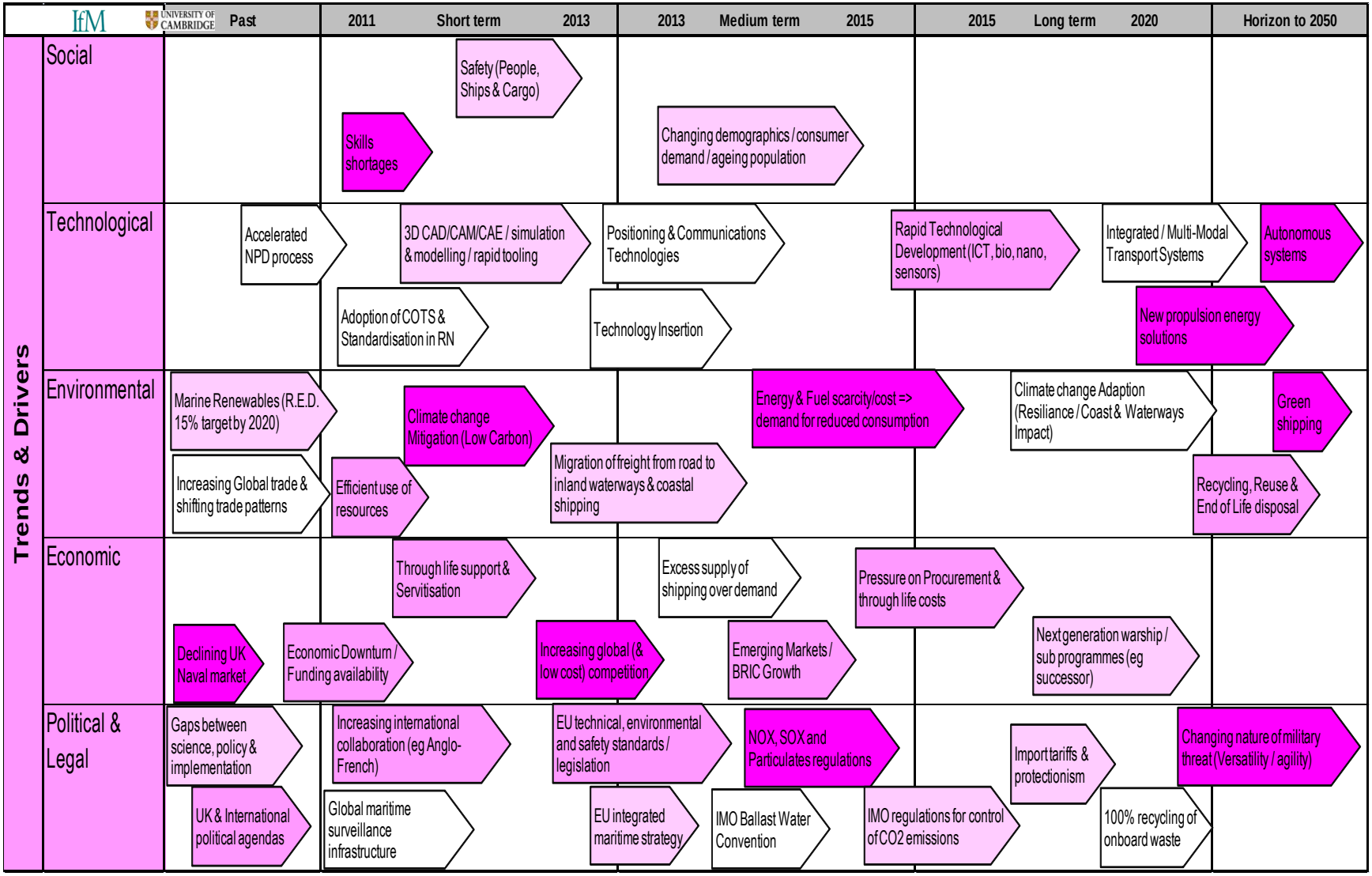
2. Landscape Linkages

Trends & Drivers														Capabilities																						Enablers												
	New propulsion energy solutions	Pressure on Procurement & through life costs	"Green Economy": environment as a business opportunity	Green shipping	Energy & Fuel scarcity/cost => demand for reduced consumption	IMO regulations for control of CO2 emissions	Carbon pricing	Climate change Mitigation (Low Carbon)	Efficient use of resources	Through life support & Servitisation	Recycling, Reuse & Technology Insertion	Increasing Global trade & shifting trade patterns			Naval architecture	Systems integration / engineering	Simulation & modelling	Tools & Techniques	Human factors	Materials technology	Development testing & validation	Control, automation & autonomy	Design processes & Modularisation	Manufacturing technology	Propulsion technology	Logistics/ traffic management	Electric drive technology	Safety testing	Mechanical systems	Power systems management	Integrated Transport Systems	Sensors, measurement and monitoring technology	Marinisation	Data management		Funding & investment	Understanding Customer / Owner / Operator needs	Skills availability	Environmental Regulation	Facilities, infrastructure & manufacturing capacity	Focussed Research programmes	Supply chain / logistics	Partnerships & Networks	Incentives to industry to adopt new technology	Technology transfer from other industries	Major pathfinder projects to establish UK position	Marine technology revolution	
	1	2	3	4	5	6	7	8	9	10	11	12		**Market Opportunities**	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	1					1	A	Alternative fuels, Electrification & Hybrids including Sail	6	3	3	3	3	3	3	3	3	3				3	3	3	3			3	3		1		1					1	1	1	50
1	1	1	1	1	1	1	1	1				B	Efficient Propulsion & Energy Management	9	3	3	3	3	1	3	3	3	2	3	2	2	2	1	2	3	2	3	1	3		1		1		1		1	1	1			54
			1	1	1	1	1	1			1	C	Optimised Marine Transportation (inc Short Sea Shipping)	7	1		3	1							3					3				1			1	1		1	1					16
		1	1							1	1	D	Offshore Support Vessels	4	3	2			3			2		2	1			2	2			2		1		1	1	1		1	1			1		26
												E	Unmanned vehicles operated from / instead of ships	0	2	3	2		1	3	3	3			2	1		2		2		3		3												30
1	1	1										F	Export Naval Ship Design & (surface) Military ships	3	3	3		3	2	2	2		3	3	3		2						2		1	1	1		1			1			1	34
	1									1	1	G	In Service Support of Ships & lifecycle design & systems	3	1	3	3	2	2	3	1	3	2	1	1	2	1	3	2	2		3	1	3	1	1	1		1	1	1		1	1			47
1	1											H	New Submarines & U/W Systems	2	3	2	2	2	1	1	2	3		1	2	1	2	3	2	3		3		1	1		1		1	1							38
4	4	4	3	3	3	3	2	2	2	2	2				19	19	16	14	13	15	14	17	10	10	11	9	10	14	11	13	5	14	7	13		5	4	4	4	4	4	3	3	3	3	2	2	

3.1 Trends & Drivers



3.2 Trends & Drivers (1 to 20)

Rank	Driver	%
1	Energy & Fuel scarcity/cost => demand for reduced consumption	9%
2	New propulsion energy solutions	8%
3	Skills shortages	8%
4	Autonomous systems	6%
5	NOX, SOX and Particulates regulations	6%
6	Changing nature of military threat (Versatility / agility)	5%
7	Climate change Mitigation (Low Carbon)	5%
8	Declining UK Naval market	5%
9	Green shipping	5%
10	Increasing global (& low cost) competition	5%
11	Through life support & Servitisation	4%
12	EU technical, environmental and safety standards / legislation	3%
13	Increasing international collaboration (eg Anglo-French)	3%
14	Recycling, Reuse & End of Life disposal	3%
15	Green Economy	3%
16	Economic Downturn / Funding availability	2%
17	Efficient use of resources	2%
18	Emerging Markets / BRIC Growth	2%
19	Rapid Technological Development (ICT, bio, nano, sensors)	2%
20	UK & International political agendas	2%

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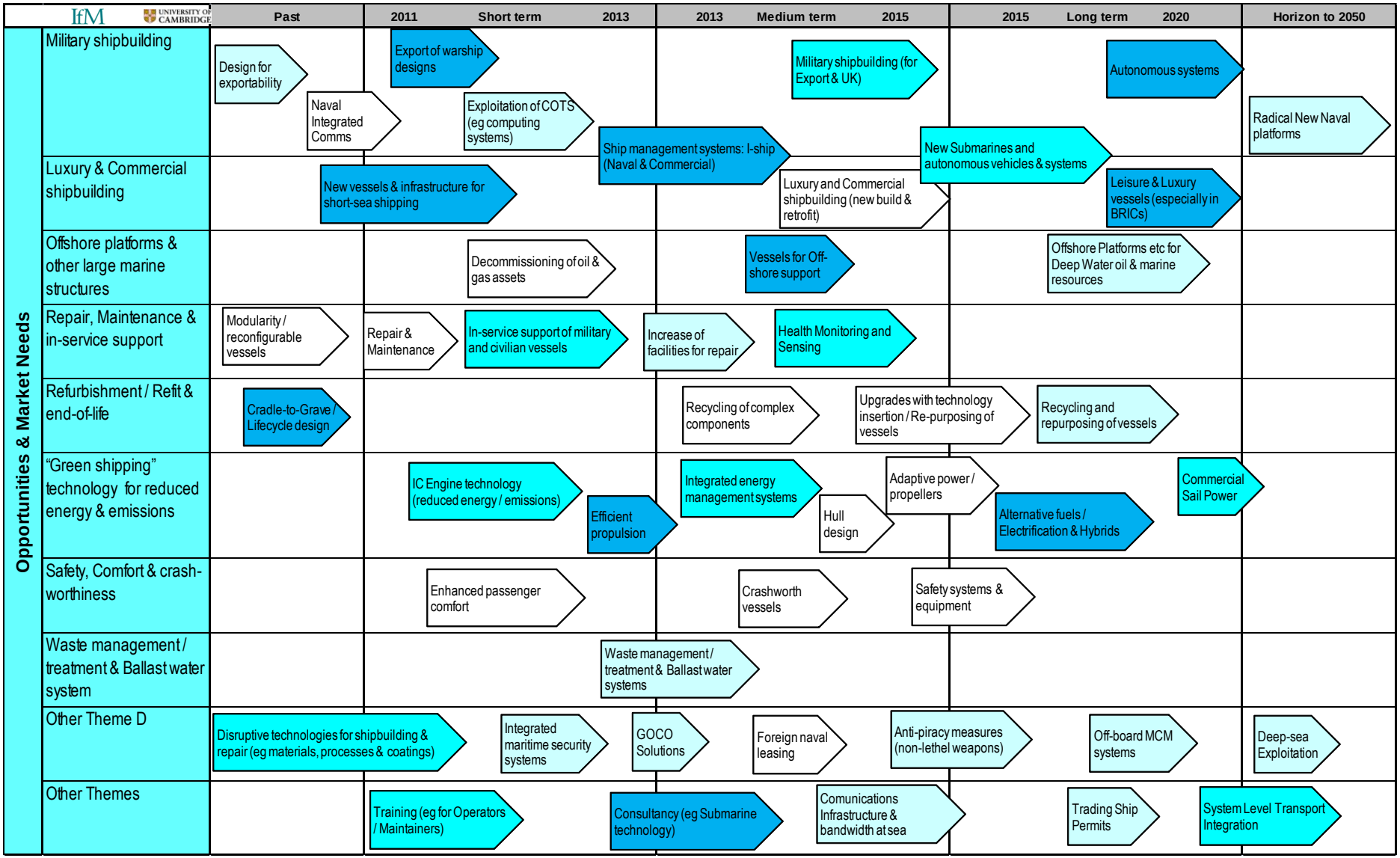
3.2 Trends & Drivers (cont)

Rank	Driver	%
21	EU integrated maritime strategy	2%
22	Gaps between science, policy & implementation	2%
23	Next generation warship / sub programmes (eg successor)	2%
24	New business models	2%
25	3D CAD/CAM/CAE / simulation & modelling / rapid tooling	1%
26	Changing demographics / consumer demand / ageing population	1%
27	IMO regulations for control of CO2 emissions	1%
28	Import tariffs & protectionism	1%
29	Marine Renewables (R.E.D. 15% target by 2020)	1%
30	Migration of freight from road to inland waterways & coastal shipping	1%
31	Safety (People, Ships & Cargo)	1%
32	100% recycling of onboard waste	
33	Adoption of COTS & Standardisation in RN	
34	Excess supply of shipping over demand	
35	Global maritime surveillance infrastructure	
36	IMO Ballast Water Convention	
37	Increasing Global trade & shifting trade patterns	
38	Integrated / Multi-Modal Transport Systems	
39	Positioning & Communications Technologies	
40	Pressure on Procurement & through life costs	
41	Security (eg Piracy & Terrorism)	
42	Technology Insertion	

3.3 Trends & Drivers Linkages

		A	B	C	D	E	F	G	H	
Rank	Driver	Alternative fuels, Electrification & Hybrids including Sail	Efficient Propulsion & Energy Management	Optimised Marine Transportation (inc Short Sea Shipping)	Offshore Support Vessels	Unmanned vehicles operated from / instead of ships	Export Naval Ship Design & (surface) Military ships	In Service Support of Ships & lifecycle design & systems	New Submarines & U/W Systems	Total
1	New propulsion energy solutions	1	1				1		1	4
2	Pressure on Procurement & through life costs		1				1	1	1	4
3	"Green Economy": environment as a business opportunity	1	1		1		1			4
4	Green shipping		1	1	1					3
5	Energy & Fuel scarcity/cost => demand for reduced consumption	1	1	1						3
6	IMO regulations for control of CO2 emissions	1	1	1						3
7	Carbon pricing	1	1	1						3
8	Climate change Mitigation (Low Carbon)		1	1						2
9	Efficient use of resources		1	1						2
10	Through life support & Servitisation				1			1		2
11	Recycling, Reuse & Technology Insertion				1			1		2
12	Increasing Global trade & shifting trade patterns	1		1						2
13	Changing nature of military threat						1		1	2
14	EU integrated maritime strategy			1	1					2
15	UK & Regional political				1				1	2
16	Economic downturn/funding availability							1	1	2
17	Rapid Technological Development (ICT, bio, nano)								1	1
18	NOX, SOX and Particulates regulations		1							1
19	Marine Renewables (R.E.D. 15% target by 2020)				1					1
20	Integrated / Multi-Modal Transport Systems			1						1
21	New Business Models							1		1
22	Ocean resource exploitation & Blue Biotechnology								1	1
23	Emerging Markets / BRIC Growth								1	1
24	EU technical, environmental and safety standards / legislation							1		1
25	End of Life disposal & recycling				1					1
26	Migration of freight from road to inland waterways & coastal shipping			1						1
27	Ethical / Green consumers	1								1
28	Opening the arctic								1	1

4.1 Market Opportunities



4.2 Market Opportunities (1 to 20)

Rank	Opportunities	Market Attractiveness	Capability Fit	Total
1	Alternative fuels / Electrification & Hybrids			
2	Efficient propulsion			
3	New vessels & infrastructure for short-sea shipping			
4	Vessels for offshore support			
5	Consultancy (eg Green ship services)			
6	Luxury, Commercial and Leisure Vessels (esp for BRICs)			
7	Ship management systems: I-ship (Naval & Commercial)			
8	Autonomous systems			
9	Export of warship designs			
10	Cradle-to-Grave / Lifecycle design			
11	IC Engine technology (reduced energy / emissions)			
12	In-service support of military and civilian vessels			
13	New Submarines and underwater systems			
14	Training (eg for Operators / Maintainers)			
15	Disruptive shipbuild and repair materials and processes			
16	System Level Transport Integration			
17	Integrated energy management systems			
18	Commercial Sail Power			
19	Military shipbuilding (for Export & UK)			
20	Health Monitoring and Sensing			

4.2 Market Opportunities (cont)

Rank	Opportunities	Market Attractiveness	Capability Fit	Total
21	Deep-sea Exploitation			
22	Recycling and repurposing of vessels			
23	Waste management / treatment & Ballast water systems			
24	Increase of facilities for repair			
25	Off-board MCM systems			
26	Offshore platforms etc in deeper water for oil and marine energy resources			
27	Anti-piracy measures (non-lethel weapons)			
28	GOCO Solutions			
29	Comunications Infrastructure & bandwidth at sea			
30	Design for exportability			
31	Exploitation of COTS (eg computing systems)			
32	Integrated maritime security systems			
33	New Naval Platforms			
34	Trading Ship Permits			
35	Adaptive power / propellers			
36	Crashworth vessels			
37	Decommissioning of oil & gas assets			
38	Enhanced passenger comfort			
39	Foreign naval leasing			
40	Hull design			
41	Leisure & Luxury vessels (especially in BRICs)			
42	Modularity / reconfigurable vessels			
43	Naval Integrated Comms			
44	Recycling of complex components			
45	Repair & Maintenance			
46	Safety systems & equipment			
47	Upgrades with technology insertion / Re-purposing of vessels			

5.1 Capabilities & Enablers

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5.2 Capabilities

		A	B	C	D	E	F	G	H	
		Alternative fuels, Electrification & Hybrids in Sail	Efficient Propulsion & Energy Management	Optimised Marine Transportation (inc Short Sea Shipping)	Offshore Support Vehicles	Unmanned vehicles operated from instead of ships	Export Naval Ship Design & (surface) Military ships	In Service Support of Ships & lifecycle design & systems	New Submarines & U/W Systems	
A	**Design & Development**								0	0
A1	Simulation & modelling	3	3	3	0	2	0	3	2	
A2	Tools & Techniques	3	3	1	0	0	3	2	2	
A3	Human factors	3	1	0	3	1	2	2	1	
A4	CAE / CAD / CAM	3	3	0	0	0	0	1	2	
A5	Design processes & Modularisation	3	2	0	0	0	3	2	0	
A6	Naval architecture	3	3	1	3	2	3	1	3	
A7	Marinisation	3	1	0	0	0	2	1	0	
A8	Development testing & validation	3	3	0	0	3	2	1	2	
A9	Analysis tools	3	3	0	0	0	0	1	1	
A Total	**Design & Development**	27	22	5	6	8	15	14	13	
C	**Construction, Structural & Mechanical**								0	
C1	Mechanical systems	3	2	0	2	0	0	2	2	
C2	Offshore wind	3	0	0	3	0	0	0	0	
C3	Tidal & wave power	0	0	0	2	0	0	3	0	
C4	Sub-sea technology	0	0	0	2	3	0	0	1	
C5	Naval & Civilian platforms	0	0	0	0	0	0	0	0	
C Total	**Construction, Structural & Mechanical**	6	2	0	9	3	0	5	3	
M	**Materials & Manufacturing**								0	
M1	Materials technology	3	3	0	0	3	2	3	1	
M2	Coatings technology	0	3	0	0	2	2	3	0	
M3	Manufacturing technology	0	3	0	2	0	3	1	1	
M4	Processing technology (eg Wastewater)	0	0	0	0	0	0	0	0	
M5	Joining technologies (eg Welding)	0	3	0	0	0	2	2	1	
M6	Lightweighting	0	0	0	0	1	2	2	0	
M7	Low volume manufacturing / rapid prototyping	3	2	0	0	0	1	0	1	
M8	Command & Control	0	0	0	0	0	0	0	0	
M Total	**Materials & Manufacturing**	6	14	0	2	6	12	11	4	
P	**Propulsion, Energy & Power**								0	
P1	Internal combustion engine technology	0	2	0	0	0	0	1.5	0	
P2	Electric drive technology	3	2	0	0	0	2	1	2	
P3	Mechanical energy & storage technology	0	0	0	0	0	0	1	2	
P4	Electrical systems, storage & power infrastructure	3	3	0	0	0	0	1	3	
P5	Power systems management	3	3	0	0	2	0	2	3	
P6	Propulsion technology	0	2	0	1	2	3	1	2	
P Total	**Propulsion, Energy & Power**	9	12	0	1	4	5	7.5	12	

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5.2 Capabilities (cont)

		A	B	C	D	E	F	G	H	
		Alternative fuels, Electrification & Hybrids in Sail	Efficient Propulsion & Energy Management	Optimised Marine Transportation (inc Short Sea Shipping)	Offshore Support Vehicles	Unmanned vehicles operated from instead of ships	Export Naval Ship Design & (surface) Military ships	In Service Support of Ships & lifecycle design & systems	New Submarines & U/W Systems	
I	**Information, Communication & Control**								**0**	
I1	Sensors, measurement and monitoring technology	0	**3**	0	2	**3**	0	**3**	**3**	
I2	Control, automation & autonomy	**3**	**3**	0	2	**3**	0	**3**	**3**	
I3	Data management	**3**	**3**	0	0	**3**	0	**3**	1	
I4	Navigation technology	**3**	2	0	2	2	0	0	1	
I5	Logistics/ traffic management	0	2	**3**	0	1	0	2	1	
I6	Voyage management	0	2	2	0	0	0	0	1	
I7	Decision support systems	0	**3**	0	0	**3**	0	**3**	2	
I8	Communications (LAN / Wireless)	0	1	0	0	0	0	2	**3**	
I9	Telecoms (wide-area)	0	1	0	0	**3**	0	2	2	
I Total	**Information, Communication & Control**	**9**	**20**	5	6	**18**	0	**18**	**17**	
L	**Life-cycle technologies**								**0**	
L1	Service & Support	0	1	0	**3**	2	0	**3**	1	
L2	Maintenance	0	**3**	0	**3**	2	0	**3**	1	
L3	Life-cycle analysis	0	**3**	0	0	0	0	**3**	1	
L4	End of life / recycling / Decommissioning	0	0	0	**3**	0	0	**3**	2	
L5	Technology insertion & reconfigurability	0	**3**	0	0	**3**	0	**3**	1	
L6	Condition Monitoring	0	**3**	0	1.5	1	0	**3**	2	
L7	Supply Chain management	0	1	2	0	0	0	**3**	1	
L8	In-service testing	0	2	0	0	0	0	**3**	1	
L9	Design & manufacture for sustainability	0	0	0	0	0	0	**3**	1	
L Total	**Life-cycle technologies**	0	**16**	2	**10.5**	**8**	0	**27**	**11**	
S	**Safety & security**								**0**	
S1	Offensive & defensive systems	0	0	0	0	2	0	0	0	
S2	National security	0	0	0	0	0	0	0	0	
S3	Personal safety	0	0	0	0	0	0	**3**	0	
S4	Active safety	0	0	0	0	1	0	0	**3**	
S5	Safety testing	**3**	1	0	2	2	0	**3**	**3**	
S Total	**Safety & security**	3	1	0	2	5	0	6	6	
O	**Other**								**0**	
O1	Biotech & biological processing	0	2	0	0	0	0	2	0	
O2	Marine life sciences	0	2	0	0	0	0	0	0	
O3	Consulting	0	**3**	0	0	0	0	0	1	
O4	Risk managament & acturarial	0	1	0	0	0	0	2	1	
O5	Integrated Transport Systems	0	2	**3**	0	0	0	0	0	
O6	Oceanography / Environment (eg currents & ice caps)	0	2	0	0	0	0	0	1	
O7	Systems integration / engineering	**3**	**3**	0	2	**3**	**3**	**3**	2	
O Total	**Other**	3	**15**	3	2	3	3	**7**	5	

5.3 Capability - Ranked

Capabilities		A	B	C	D	E	F	G	H	
		Alternative fuels, Electrification & Hybrids including Sail	Efficient Propulsion & Energy Management	Optimised Marine Transportation (inc Short Sea Shipping)	Offshore Support Vessels	Unmanned vehicles operated from / instead of ships	Export Naval Ship Design & (surface) Military ships	In Service Support of Ships & lifecycle design & systems	New Submarines & U/W Systems	Total
Ranked capabilities (top-level grouping)										
A Total	Design & Development									
I Total	Information, Communication & Control									
M Total	Materials & Manufacturing									
L Total	Life-cycle technologies									
P Total	Propulsion, Energy & Power									
O Total	Other									
C Total	Construction, Structural & Mechanical									
S Total	Safety & security									
Ranked capabilities (detail)										
A6	Naval architecture	3	3	1	3	2	3	1	3	
O7	Systems integration / engineering	3	3	0	2	3	3	3	2	
A1	Simulation & modelling	3	3	3	0	2	0	3	2	
A2	Tools & Techniques	3	3	1	0	0	3	2	2	
A3	Human factors	3	1	0	3	1	2	2	1	
M1	Materials technology	3	3	0	0	3	2	3	1	
A8	Development testing & validation	3	3	0	0	3	2	1	2	
I2	Control, automation & autonomy	3	3	0	2	3	0	3	3	
A5	Design processes & Modularisation	3	2	0	0	0	3	2	0	
M3	Manufacturing technology	0	3	0	2	0	3	1	1	
P6	Propulsion technology	0	2	0	1	2	3	1	2	
I5	Logistics/ traffic management	0	2	3	0	1	0	2	1	
P2	Electric drive technology	3	2	0	0	0	2	1	2	
S5	Safety testing	3	1	0	2	2	0	3	3	
C1	Mechanical systems	3	2	0	2	0	0	2	2	
P5	Power systems management	3	3	0	0	2	0	2	3	
O5	Integrated Transport Systems	0	2	3	0	0	0	0	0	
I1	Sensors, measurement and monitoring technology	0	3	0	2	3	0	3	3	
A7	Marinisation	3	1	0	0	0	2	1	0	
I3	Data management	3	3	0	0	3	0	3	1	

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6.1 Enablers

		A	B	C	D	E	F	G	H	
Rank	Enablers	Alternative fuels, Electrification & Hybrids including Sail	Efficient Propulsion & Energy Management	Optimised Marine Transportation (inc Short Sea Shipping)	Offshore Support Vessels	Unmanned vehicles operated from / instead of ships	Export Naval Ship Design & (surface) Military ships	In Service Support of Ships & lifecycle design & systems	New Submarines & U/W Systems	Total
1	Funding & investment			1	1		1	1	1	5
2	Understanding Customer / Owner / Operator needs	1	1				1	1		4
3	Skills availability				1		1	1	1	4
4	Environmental Regulation	1	1	1	1					4
5	Facilities, infrastructure & manufacturing capacity			1	1			1	1	4
6	Focussed Research programmes		1				1	1	1	4
7	Supply chain / logistics			1	1			1		3
8	Partnerships & Networks		1	1	1					3
9	Incentives to industry to adopt new technology		1				1	1		3
10	Technology transfer from other industries	1	1					1		3
11	Major pathfinder projects to establish UK position	1			1					2
12	Marine technology revolution	1					1			2
13	International collaboration						1		1	2
14	Open architectures								1	1
15	Training & Education						1			1
16	Business Model Innovation							1		1
17	Standards								1	1
18	Integration with planning & Local Gov't				1					1
19	Human factors	1								1
20	UK shipbuilding capacity & propulsion system		1							1

7. Priority Market Opportunities (explored in breakout groups)

	Opportunities (grouped)	Breakout Group
1	Alternative fuels / Electrification & Hybrids (including commercial sail)	**A**
2	Efficient propulsion & Energy management	**B**
3	Optimised multi-modal transport including short-sea shipping	**C**
4	Vessels for offshore support	**D**
5	Unmanned Autonomous Vehicles	**E**
6	Export of warship designs & militiary ships	**F**
7	In-service support of military and civilian vessels (incl. Lifecycle design)	**G**
8	New Submarines (military & commercial inc Deep-Sea exploration)	**H**
9	IC Engine technology (reduced energy / emissions)	Related to A
10	Through life-cycle design	inc in G
11	Consultancy (eg Green ship services)	Theme A
12	Luxury, Commercial and Leisure Vessels (esp for BRICs)	Theme C
13	Ship management systems: I-ship (Naval & Commercial)	Theme A
14	Training (eg for Operators / Maintainers)	Theme A
15	Disruptive shipbuild and repair materials and processes	Enabler
16	System Level Transport Integration	inc in C
17	Integrated energy management systems	inc in B
18	Commercial Sail Power	Inc in A
19	Military shipbuilding (for Export & UK)	inc in F
20	Health Monitoring and Sensing	inc in G
21	Deep-sea Exploitation	inc in H

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

Key: **Black text – original team input**

Red text – carousel group comments

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7. Priority Market Opportunities (summary)

Opportunities		Market Attractiveness:					Triple bottom-line		Value	Fit with UK Capability						Fit	Total
Topic	Opportunity	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	Other UK resources	Timeliness	Weighted Capability	Combined Value & Fit
A	Alternative fuels, Electrification & Hybrids including Sail	4	3	3	3	4	4	3		2	2	3	3	3.5	2		
B	Efficient Propulsion & Energy Management	4	2	1	1	0	3	3		2	3	3	3	4	1		
C	Optimised Marine Transportation (inc Short Sea Shipping)	4	3	1.5	0	2	2.5	2.5		1.5	3	1.5	1.5	0	1		
D	Offshore Support Vessels	4	3.5	1.5	1.5	3	2	2.5		2	2.5	1.5	0	0	1.5		
E	Unmanned vehicles operated from / instead of ships	3	1	1.5	3	2	1	3		2.5	2.5	1	2	1	1		
F	Export Naval Ship Design & (surface) Military ships	4	1.5	1.5	3.5	2	3	3		3	3.5	3	3.5	3.5	1.5		
G	In Service Support of Ships & lifecycle design & systems	3	1	2	2	3	2	3		2	1	1	2	1	1		
H	New Submarines & U/W Systems	4	ratio	1	3.5	ority	2	rket	por	3	1	1	3	1	3		

Key: **Black text – original team input**

Red text – carousel group comments

Opportunity	A	Alternative fuels, Electrification & Hybrids in Sail		Team	DG SH BE
				Score	2.9

Value			Basis for Characterisation & Evidence	Score	This opportunity is attractive because:
Market Attractiveness:	Global Market Growth Opportunity	**V. Large > £5bn**	Cost of oil resource. Decarbonisation, Hybrid sail together. Energy security. American research into algae.	4.0	Aerospace/aviation cross over. Space race - flagship. Oil price - material resources. New market opportunity in marine. Limited application in marine. Take more risk from marine into new markets - demo/trial. Cost of ownership. Customer driven requirements (CSR). + bottom line (Carbon) emission reductions. Moving the problem to ship owners. Transport system optimisation strategy (DfT). Key UK export opportunity
	Home (UK) Market Growth Opportunity	Large > £1bn	Leisure & commercial boats/ships as above. Space race/flagship! Large scale opportunity! Too big, lack of visions	3.0	
	Strength of competition (Global)	Weak / Emerging	High development in other sectors - limited application in marine	3.0	
	Added Value in UK	70%	Knowledge/innovation/skills in UK. Research to market gas v natural resource(Lithium etc). Urban mining (policies). Renewable/sustainable issue - systems approach/thinking - propulsion systems	3.0	
	Cross-sector opportunity	**V. Large > £2bn**	Technical knowledge transfer opportunity. Whole system threat! Systems thinking for energy management (well to wheel/ship). Massive for maritime - harness UK capability & expertise for global markets	4.0	
Triple bottom-line	Planet / Environmental	**Game-Changing**	Create green credentials in maritime - no ship building driving new business planning. Legislation driven. Insurance - it's going to happen! UK innovation capability	4.0	Knowledge Gaps (in team): Expand horizons in Naval architecture. Low volume manufacturing cost effective processing - rapid prototyping
	People / Societal	Major	Willingness - lack of direction (VHS/Betamax?) Breadth of knowledge, embrace 99% - emotive solutions - behaviour change,	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 & development	Propulsion systems MFRs. Market opportunity isn't it?	2.0	Automotive design & engineering. High tech offshore racing. Fusion fuels
	University / Academic	Moderate / Emerging / Dispersed	Propulsion	Alternative - larger scale. Nuclear - market/cruiseships	2.0	
	R&T Org. / Design	World-Leading OR significant scale		Currently - Far East developments	3.0	
	Non-Marine / Other	World-Leading OR significant scale	Automotive. Others: space, aerospace	Harnessing in marine	3.0	
	Other UK resources	**World-Leading & significant scale**	Maritime heritage		3.5	Knowledge Gaps (in team):
Timeliness	UK Capability matches market need	Lagging but could recover		Accelerate capability globally	2.0	

Opportunity	B	Efficient Propulsion & Energy Management		Team	KF AW SW
				Score	2.3

Value			Score	This opportunity is attractive because:
Market Attractiveness: Global Market Growth Opportunity	**V. Large > £5bn**	Applicable to all ships globally. Increasing pressure on fuel costs & CO2.	4.0	Small gains, high impact. Economic. Social. Environmental. Build on existing capability. Lightweight composite props pump sets. Modelling/design performance/noise.
Market Attractiveness: Home (UK) Market Growth Opportunity	Modest > £100m	Hull design & superstructure > reduced drag. Sterngear. Monitoring & control for optimisation of FC. Prop comp	2.0	
Market Attractiveness: Strength of competition (Global)	Dominant / Entrenched	Established in EU: Martin (NL), HSVA (DE), Wartsila, VOITH, Energy management via engine manufacturers (EU/JP/KO). Marintek (NO), SSPA (Sweden), CTO (Poland)	1.0	
Market Attractiveness: Added Value in UK	10%	Consultancy & design & IP licensing. Monitoring & control system supply.	1.0	
Market Attractiveness: Cross-sector opportunity	Small < £100m	Import of tech & expertise from aerospace, automotive, rail	0.0	
Triple bottom-line: Planet / Environmental	Major	EG. 5% fuel saving in world shipping	3.0	Knowledge Gaps (in team):
Triple bottom-line: People / Societal	Major	Health benefits (pollution)	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	Rolls Royce. Naval architecture. Shipyards e.g. A&P small prop manufacturers e.g. CJR. BAE systems, QinetiQ	Props @ large size. Hull Build	2.0	Tech & idea, consulting in design. Systems for monitoring & control. Limited shipbuilding & propulsion systems suppliers
Fit with UK Capability: University / Academic	World-Leading OR significant scale	Testing: Southampton, Strath, Newc. Design & analysis (Unis). Wind tunnels: Wolfson		3.0	
Fit with UK Capability: R&T Org. / Design	World-Leading OR significant scale	Testing: QinetiQ, Haslar. Modelling & control: Ricardo & others. BMT? Many small consultancies. Good CFD capability		3.0	
Fit with UK Capability: Non-Marine / Other	World-Leading OR significant scale	Sensors, control suppliers. Data management= ? Innovative SME's.		3.0	
Fit with UK Capability: Other UK resources	**World-Leading & significant scale**	International Paints (antifouling & Low F). Aerospace materials & aerodynamics. ACCIS Bristol (composites); ADN; MFG; TIC		4.0	Knowledge Gaps (in team): Limited knowledge of UK supply base (systems)
Timeliness: UK Capability matches market need	Already "missed the boat"		Propulsion system & hull build	1.0	

Opportunity	C	Optimised Marine Transportation (inc Short Sea Shipping)		Team	DD PW TD
				Score	1.8

Value		Basis for Characterisation & Evidence	Score	This opportunity is attractive because:
Market Attractiveness: Global Market Growth Opportunity	**V. Large > £5bn**	Wold wide. Problem/Opp, 3X market. 80% CO2 reduction	4.0	How to optimise a marine transportation system for 2050 with > than 80% CO2 reduction: SSS, Inland waterways, Model???, new design vessels, port-based logistics, integrated (with land based systems), TBT
Market Attractiveness: Home (UK) Market Growth Opportunity	Large > £1bn	Island nation & trading nation	3.0	
Market Attractiveness: Strength of competition (Global)	Strong / Established	NL /Germany strong. Asia/Africa weak	1.5	
Market Attractiveness: Added Value in UK	10%		0.0	
Market Attractiveness: Cross-sector opportunity	Modest > £100m		2.0	
Triple bottom-line: Planet / Environmental	Significant		2.5	Knowledge Gaps (in team):
Triple bottom-line: People / Societal	Significant		2.5	

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/spec/consulting. Higher. Build/operation - low	Strengthened & cohesive. Quality data on freight activities to design & invest in 2050 transport infrastructure. Build up UK	1.5	Long-term/coherent. Regulator FR'work. S&C's. UK/EU. Build capability & cabotage. Rail etc to integrate. Jones Act not helped US industry. Need to have better cabotage model
Fit with UK Capability: University / Academic	World-Leading OR significant scale			3.0	
Fit with UK Capability: R&T Org. / Design	Moderate / Emerging / Dispersed			1.5	
Fit with UK Capability: Non-Marine / Other	Moderate / Emerging / Dispersed			1.5	
Fit with UK Capability: Other UK resources	None				Knowledge Gaps (in team):
Timeliness: UK Capability matches market need	Already "missed the boat"			1.0	

Opportunity	D	Offshore Support Vehicles		Team	GW AH PC
				Score	2.0

Value			Basis for Characterisation & Evidence	Score	This opportunity is attractive because:
Market Attractiveness:	Global Market Growth Opportunity	**V. Large > £5bn**	Crew transfer vessels. Construction vessel. Cable layers. Motherships. £30bn. Decommissioning £47bn	4.0	Large potential revenue (R2/R3 committed spent) On doorstep & can be economic to do. Can drive skills & potentially support 'naval' capability. Integral to UK economic recovery. £75bn spend. Global competition. Global over capacity. Cost is key driver
	Home (UK) Market Growth Opportunity	**V. Large > £2bn**	Design & technology input & a proportion of the construction & conversion opportunities	3.5	
	Strength of competition (Global)	Strong / Established	Strong competition in terms of vessel construction both in price & capacity	1.5	
	Added Value in UK	30%	Real value to UK but limited by capacity	1.5	
	Cross-sector opportunity	Large > £1bn	Opportunities for fabrication outside of shipyards	3.0	
Triple bottom-line	Planet / Environmental	Modest	Present day modest change in technology may improve	2.0	Knowledge Gaps (in team): Yes
	People / Societal	Significant	Huge numbers of unemployed/young to upskill for O&M & construction	2.5	

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	Small boatyards. Marine consultancies. A&P/cemmels/able? Operators. Mil shipbuilding/support & supply chain	Coherence of design/Fab/outfit. Large vessel capability. Skills volume/strategy	2.0	Some of this with targeted investment
	University / Academic	Strong but below critical mass	lack of capacity for Grads. V.good post-grads but non-UK. Strathclyde, NCE, Southampton, UCL, Oxbridge		2.5	
	R&T Org. / Design	Moderate / Emerging / Dispersed	Individual world-class organisations but overall lacking Critical mass. IHC/EB< Rolls, Mactacgart-scott	No sustained investments	1.5	
	Non-Marine / Other	None			0.0	
	Other UK resources	None			0.0	Knowledge Gaps (in team): Yes
Timeliness	UK Capability matches market need	Lagging but could recover	Wind service vessels OK, consultancies OK but no easy Bunce. Lack of finance in UK		1.5	

Opportunity	E	Unmanned vehicles operated from instead of ships		Team	NJM JS
				Score	1.9

Value			Basis for Characterisation & Evidence	Score	This opportunity is attractive because:
Market Attractiveness:	Global Market Growth Opportunity	Large > £2bn	Global change in MCM. Pressure to counter growing submarine threat. Economics of reduced crew, inc piracy etc. Individual unmanned systems are relatively low value items. Market not that big!	3.0	Emerging hi-tech platform/systems & hi-value. UK has most of the capabilities but lacks coherence and investment. 1. remote MCM is a requirement. 2. Piracy protection is a need. 3. Naval airborne platform requirement. Lacks a requirement, lacks a need. can't add cost to platform
	Home (UK) Market Growth Opportunity	Small < £100m	UK portable/off board MCM & RN deployed UAV's. Stated requirement but lack R&D funding	1.0	
	Strength of competition (Global)	Strong / Established	Strong offshore UAV development inc USA & EU	1.5	
	Added Value in UK	70%	Strong UK industry potential in design, manufacture & integration (airframes & payloads) vehicle	3.0	
	Cross-sector opportunity	Modest > £100m	Pull through maritime & aerospace civil/mil tech	2.0	
Triple bottom-line	Planet / Environmental	None	Commercial marine security improved	1.0	Knowledge Gaps (in team): operational economics
	People / Societal	Major	Manpower (Naval) reduction but new skills in data management. People out of harms way	3.0	

Capability			Where is the capability?	What are the Gaps?	Score	UK has the capability to deliver...
Fit with UK Capability	Marine Industry	Strong but below critical mass	Offshore sub sea. Naval R&D & submarines & UK defence electronics	UK lacking vehicle platform development solutions	2.5	Yes, can deliver complete systems. But inhibited by need for more 'multi-sector' investment (def/oil & gas) Lack of Government led investment /pilot programmes.
	University / Academic	Strong but below critical mass	Universities & specialist small companies	Technology pull through, integration of platforms/systems	2.5	
	R&T Org. / Design	None	Niche Companies. Oil/offshore	lack of UK customer invest & domestic programmes	1.0	
	Non-Marine / Other	Moderate / Emerging / Dispersed	Aerospace	Ability to pull through to military /security solutions	2.0	
	Other UK resources	None	Specialists in materials. High endurance batteries / F cells		1.0	Knowledge Gaps (in team): Airspace management, offshore & surface U/W control management
Timeliness	UK Capability matches market need	Already "missed the boat"	Lacking in TDP's but could recover		1.0	

Opportunity	F	Export Naval Ship Design & (surface) Military ships		Team	PG, PM, AG
Scores relate to design only				Score	2.9
Value		Basis for Characterisation & Evidence		Score	This opportunity is attractive because:
Market Attractiveness: Global Market Growth Opportunity	**V. Large > £5bn**	Design - analysis, integration, systems, programme management of build (offshore). Design & build		4.0	Strong design skills capabilities, experience, systems & brand (RN), world class in specific areas e.g. Power & propulsion high speed. Design led by MOD - for export need to change
Market Attractiveness: Home (UK) Market Growth Opportunity	Modest > £100m	Design. Design & build: Bias to complex ships		1.5	
Market Attractiveness: Strength of competition (Global)	Strong / Established	Design. Design & build. Germany & Spain are market leaders. Design & build is UK limited. Damen/schelde competitor? Export will include design/tech transfer		1.5	
Market Attractiveness: Added Value in UK	**90%**	Design. Design & build. European, mid & far east closing ship design capability fast, combat systems still western/sov bloc presence for now		3.5	
Market Attractiveness: Cross-sector opportunity	Modest > £100m	Design - transferable skills/technologies. Design & build - processes. Transferable designs risks medium term emergence of completion not enough development to discriminate later		2.0	
Triple bottom-line: Planet / Environmental	Major	Design - new propulsion systems, materials, emissions technology. Design & build		3.0	Knowledge Gaps (in team): Risk averse. Not good at lobbying/exploitation. Collaboration/partnerships. Market requirement/need/technology need. Human development. Poor political track record
Triple bottom-line: People / Societal	Major	Design. Design & build		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	Design - RR, BMT, Bae, Babcocks (Frazer Nash), QinetiQ, Thales, GEC, Lloyds Register. Design & build - Bae, Babcocks	Skills shortages - engineering science. Now > but increasing	3.0	
Fit with UK Capability: University / Academic	**World-Leading & significant scale**	Design - UCL< Newcastle, Soton, Plymouth, Strathclyde, Imperial	Higher degrees - overseas students	3.5	
Fit with UK Capability: R&T Org. / Design	World-Leading OR significant scale	Design - TWI, QinetiQ, PERA, National Composites Centre, Lloyds Register	Maintaining sufficient funding to keep capability ahead of competition	3.0	
Fit with UK Capability: Non-Marine / Other	**World-Leading & significant scale**	Automotive (F1), Aerospace, Power generation		3.5	
Fit with UK Capability: Other UK resources	**World-Leading & significant scale**	Financial institutions & insurance companies. MoD, MCA, other Government organisations		3.5	Knowledge Gaps (in team): Systems (Comms), decision/intelligent systems, integrated ship design, maintaining knowledge
Timeliness: UK Capability matches market need	Lagging but could recover			1.5	

Opportunity	G	In Service Support of Ships & lifecycle design & systems		Team	PK JO MP
				Score	1.8

Value			Basis for Characterisation & Evidence	Score	This opportunity is attractive because:
Market Attractiveness:	Global Market Growth Opportunity	Large > £2bn	Overseas. Military > Commercial > UK depends on large commercial fleet & pays for it - how do we make more £ stick to the UK? Large build programmes c.j submarines hence in-service x multiplier. Growth of support 'clients' internationally	3.0	Earn ££ from reducing costs in a large market. Military & civil. Produce more services using UK taxpayers & UK kit/infrastructure. Enables UK owned ships to last longer
	Home (UK) Market Growth Opportunity	Small < £100m	UK. Military < or same. Commercial < or same	1.0	
	Strength of competition (Global)	Strong / Established		2.0	
	Added Value in UK	30%	CFA contracts. Lower cost of ownership	2.0	
	Cross-sector opportunity	Large > £1bn	data monitoring. Synergies with all heavy industries - offshore, rail, renewables	3.0	
Triple bottom-line	Planet / Environmental	Modest		2.0	Knowledge Gaps (in team): Commercial & offshore. UK & overseas
	People / Societal	Major	Bringing work into UK regions	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	Babcock, BAE, A&P. System suppliers. Ship managers - Fishers ships. Offshore industry. LSC/IFS defence	Lack of holistic approach. Commercial shipping	2.0	Military arena. Well advanced in ship management but well in design for X. Commercial: strong ship management , weak in ship delivery. Enablers: probably lots more than we know about: materials, systems etc..
	University / Academic	None	Cranfield, Warwick, Exeter. Nano materials	Focussed research on marketing sector?	1.0	
	R&T Org. / Design	None	TWI?		1.0	
	Non-Marine / Other	Moderate / Emerging / Dispersed	Supply chain. International paints		2.0	
	Other UK resources	None		Commercial asset management	1.0	Knowledge Gaps (in team): Commercial & offshore: UK & overseas detailed knowledge of supply chain
Timeliness	UK Capability matches market need	Already "missed the boat"	Operators & maintainers		1.0	

Opportunity	H	New Submarines & U/W Systems		Team	PS DS
				Score	2.0

Value			Basis for Characterisation & Evidence	Score	This opportunity is attractive because:
Market Attractiveness:	Global Market Growth Opportunity	**V. Large > £5bn**	Military SSN, SSK(2) Brazil, Argentina, Canada? Platform/design. Special forces(SC).rescue (1). Commercial - long term (3) (deep sea, under ice) Accessibility. Market value $186bn to 2020	4.0	Worldwide opportunity established capability & facilities (des, build, support). Sustain/leverage skills. New market, far enough away
	Home (UK) Market Growth Opportunity	Small < £100m	Not world class	0.0	
	Strength of competition (Global)	Dominant / Entrenched	UK not an international competitor	1.0	
	Added Value in UK	**90%**	Consultancy (much lower for build)	3.5	
	Cross-sector opportunity	Small < £100m		0.0	
Triple bottom-line	Planet / Environmental	Modest	Access to scarce resource (commercial)	2.0	Knowledge Gaps (in team): Key user requirements. Market size/value
	People / Societal	None		0.0	

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	Plus MOD. Submarine enterprise & supply chain. Subsea operator (strong). Our design internal is still probably too large to sustain design capability long-term. Commercial appetite	Non military applications, no investment in new/radical technologies	3.0	Whole submarine from concept to build/delivery
	University / Academic	None	Multiple Universities in individual areas of research		1.0	
	R&T Org. / Design	None	Limited, unfocussed	What about AIP technology?	1.0	
	Non-Marine / Other	World-Leading OR significant scale	Offshore engineering		3.0	
	Other UK resources	None			1.0	Knowledge Gaps (in team): Requirement
Timeliness	UK Capability matches market need	Pace setting		Limited capacity/skilled resource. Ageing expertise	3.0	

Appendices

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

Appendix A: Workshop Participants

Name	Surname	Organisation
Paul	Critchley	L-3 Marine Systems UK
Tessa	Darley	Transport KTN
David	Dobson	Babcock
Ben	Evans	Blue Planet Hydrogen Ltd
Kevin	Forshaw	University of Southampton
Diane	Gilpin	B9 Shipping
Philip	Green	BMT Defence Services
Alan	Groves	DSTL
Stephen	Hart	Technology Strategy Board
Andy	Higgins	QinetiQ
Stuart	Hunt	BAE Systems
Paul	Karas	BAE Systems Surface Ships
John	Miles	Selex Communications LTd
Peter	MacLeod	Rolls Royce
Nik	Moss	Thales
Jeff	Owen	Babcock
Martin	Porter	L-3 Marine Systems UK Ltd
Pat	Salmon	Thales
Duncan	Scott	BAE Systems
James	Simpson	Selex Communications
Adrian	Waddams	British Marine Federation
Garry	Williams	E-Tech Group Ltd & Marine East
Simon	Wrigley	Ricardo
Paul	Wrobel	UCL
Dominic	Oughton	IfM
Jim	Trueman	IfM