National Composites Network

Technology Roadmap for

Composites in the Marine Industry

March 2006

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National Composites Network

Materials

Knowledge Transfer Network

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1. EXECUTIVE SUMMARY

A team of experts adopted accepted procedures to form a roadmap for the use of composites in the Marine Industry. The following main actions / recommendations were forthcoming from the Technology Roadmap:

Awareness and Networking

- There is a great deal of scope for the Marine Industry to use technology that is already developed for the Automotive and Aerospace Industries, making use of the nanocomposite and nanocoating materials that are now available.
- It is suggested that NCN should provide a database of academic expertise in composites, which would be helpful to the Marine Industry.
- To find common interests with non-competitive businesses, NCN should provide information through suppliers and universities. Intellectual property needs to be safeguarded, and any partnerships need to be built on mutual benefits and trust.

Manufacturing

- Improved efficiencies within manufacturing are needed, looking at manufacturing in low cost centres, and moving to lean processing.
- Better communication is needed between engineers and purchasing, and engineers should have more contact with suppliers.

Skills

- More process engineers should be trained for the Marine Industry; there are insufficient skills within the workforce.
- Not enough data is available about relevant training for the Marine Industry. NCN are in a position to provide web-based information for the community.

Technology and Innovation

- Time availability and production pressures inhibit development of new technologies. More focused effort towards development should be undertaken. In this area, closer collaborations with academics and suppliers need to be explored.
- Time and effort are required to access funding for development projects, so help will be required to provide awareness of what is available. NCN is in a position to help here.

This is only the first stage of the roadmap. The NCN needs to develop this further, with input from those unable to attend the workshop. The main points will be picked up by the NCN, with a view to creating a vibrant and progressive community among the Marine Industry.

2. CONTRIBUTORS

The following people attended a meeting in the Tortworth Court Hotel on the 28th March 2006 to formulate the first phase of the National Composites Network's Roadmap in Metal-Matrix Composites:

Name	Affiliation	E-mail address
Alan Leong	Department of Materials, Queen Mary University of London	y.l.leong@qmul.ac.uk
Adam Brangan	Sunseeker	adam.brangan@sunseeker.com
George Kotsikos	Newcastle University	george.kotsikos@ncl.ac.uk
Darrell Cross	Amber Composites	darrell.cross@ambercomposites.co.uk
Tony Carroll	Milled Carbon	tony.carroll@milledcarbon.com
Adrian Waddams	British Marine Federation	awaddams@britishmarine.co.uk
Ian Dashwood	Formula Yacht Spars Ltd	ian.dashwood@formulaspars.com
Zhongyi Zhang	University of Portsmouth	zhongi.zhong@port.ac.uk
Oliver Winbolt	Fairline	oliverwinbolt@fairline.com
Duncan McRobbie	Lola	dmcrobbie@lolacars.com
Perry Cohn	Angle Consulting	perry@angleconsulting.com
Marion Meunier	White Young Green	marion.meunier@wyg.com
John Billings	SP Systems	john.billings@gurit.com
Alan Boswell	Oyster Marine	alan.boswell@oystermarine.com
Nick Partington	SP Systems / Gurit	nick.partington@gurit.com
Les Norwood	Scott Bader Co Ltd	les_norwood@scottbader.com
Richard Lawrence	Frazer-Nash	r.lawrence@fnc.co.uk
Marcus Warwick	NCN / TWI	marcus.warwick@twi.co.uk
Deborah Pullen	NCN / TWI	deborah.pullen@twi.co.uk
Alan Smith	Facilitator	SmithAZT@aol.com

3. METHODOLOGY

The methodology used for this roadmap is summarised in Appendix 8.1, following the procedures typically used for other roadmaps that have been produced.

Experts, in groups of around five, are asked to provide their thoughts and opinions for the four main stages of the roadmapping process:

- Where are we now?
- Where do we want to be?
- What is stopping us getting there?
- What needs to be done to overcome the barriers?

For each stage, large hexagon *Post-its* are used to gather each input. These are then clustered under common topics as a spokesman from each group presents their findings. This draws comments from the rest of the participants and generally arrives at a consensus of opinion.

Using adhesive stickers, priorities are given to what are considered the most important issues for the second stage of the roadmapping process, enabling a key priority list to be established for subsequent steps.

The final outcome is a list of priority items that need action in order to enable the industry to progress in a more dynamic and competitive manner.

As with other roadmaps, once this first edition is produced, comments are sought from others in the field, so that ownership comes from the entire community.

4. CURRENT SITUATION

A number of recent publications have considered the future trends related to composites for the Marine Industry. By way of introduction, these were summarised in Appendix 8.2.

With a group of experts from such a wide cross-section of interests in the Marine Industry (industrialists, academics, users and suppliers), the first stage of the roadmapping process, "Where are we now?", raised the points produced in Appendix 8.3 and tabulated in Figure 1.

The clustered topics covered, addressed issues regarding markets, skills, finance, technology and general industry items, in response to prompts such as:

- What are the current trends?
- What are the main drivers?
- What is the competition up to?
- Who are present leaders in the field?
- What is the UK really good at? – what are our niche areas?
- What are the gaps in technology?
- Do we have the right skills?
- Is capital investment sufficient?

Figure 1: Current situation	
Drivers	~ For performance, the drivers are weight saving, durability, and design (structure optimisation) ~ Industrial efficiency ~ For leisure, the drivers are cost, durability, legislation, and markets. ~ For all sectors, reduced emissions both in manufacture and use
Technology	~ Surface finish is crucial ~ UK tends to publish results of research rather than taking out patents ~ Current constraints are the carbon fibre supply chain and R&D investment
Trends	~ Cleaner processing ~ There is resistance to change at all levels ~ Low cost manufacturing sites ~ Performance trend is towards higher modulus materials ~ Style ~ There are moves to more joint ventures and technology transfer ~ Advanced composites are becoming more mainstream ~ The UK Marine Industry was started and is largely run by enthusiasts ~ Large scale Resin Infusion ~ Optimisation of structures ~ Low cost materials
Skills	~ A gap is understanding product reliability issues ~ There is a skills gap in manufacturing with composites
Gaps and needs	~ Fire insulation ~ Surface repairability ~ The expertise exists but it is not easy to access ~ Surface durability ~ Infusion and surface finish ~ Fire and noise insulation ~ Gaps in technology are analysis / correlation for leisure applications, along with predictive analysis and dynamic loading. This is throughout the world, not just in the UK ~ Rapid production of complex low cost volume mouldings
Markets / customers	~ Boat owner ~ Well developed supply chain (too much complacency) ~ Present customers are OEMs, MoD and RNLI ~ Customers have very different requirements in terms of performance, comfort, and cost ~ Semi-production motor yachts (40 to 120 feet)

	~ Generally the leading countries are Italy, France, USA, Scandinavia, and the Far East. For sail boats: UK, US, NZ. For power boats: UK, US, Italy. ~ Leading UK companies are Sunseeker, Fairline, Princess, Sealine, and Oyster ~ UK sports are important – racing teams, and other marine users (e.g. wind) ~ Supplier competition – other materials such as aluminium
Strengths	~ Design and innovation ~ Styling ~ It is a buoyant industry ~ For the UK the strengths are USPs, engineering, quality, technical excellence, island culture, and innovation
Environmental	~ Recycling waste
Financial	~ There is low capital investment because boards are risk averse ~ Premises are too expensive ~ The UK is good at specialist products, and not good at volume production (why?)

The current status for the use of composites in the Marine Industry was identified and is summarised in the following chart:

Trends and drivers for the use of Composites in the Marine Industry	
Trends and drivers	There is resistance to change at all levels. The UK Marine Industry was started and run by enthusiasts. For performance: the drivers are weight saving, durability, and design, with trends towards higher modulus materials. For leisure: the drivers are cost, durability, legislation, and more markets. General trends are for optimisation of structures; improved industrial efficiency, cleaner processing; lower cost materials; lower cost manufacturing sites. Demand for constantly improving style. There are moves to more joint ventures and technology transfer. Advanced composites are becoming more mainstream.

Current key strengths and weaknesses for the use of Composites by the Marine Industry	
Strengths	UK strong in design and innovation, and styling. The Industry is a buoyant. For the UK the strengths are engineering, quality, technical excellence, island culture, and innovation. The UK is good at specialist products and not good at volume production

Weaknesses	There is a gap in understanding product reliability issues. There is a skills gap in manufacturing with composites. There is low capital investment because boards are risk averse. Premises are too expensive. Expertise exists but it is not easy to access. Gaps in technology are analysis / correlation for leisure applications, along with predictive analysis and dynamic loading. This is throughout the world, not just in the UK

5. FUTURE DIRECTION

For the second stage of the roadmapping procedure, "Where do we want to be?", the technique was the same. During the first stage, looking at the current situation, some of the visions and aspirations of the participants were emerging.

To stimulate further thought, the following questions were posed:

- What is our vision for the future?
- What should we be doing to maximise benefit for the UK?
- Are we doing something now that we should put more effort into?
- Are we doing something currently that we should drop?
- What is going to make a real impact on our activities?
- What new areas should we be working in?
- Are there opportunities for creating spin-out companies?

The ideas from the participants are shown in Appendix 8.3, and are reproduced in the following diagram (Figure 2), with dots (●) indicating the level of priority judged by the team.

Figure 2: Future Direction
(● indicates priority level)

Vision	~ Seek stability by looking for opportunities outside the marine sector ●●●●●●● **(1)** ~ There is a need to be more competitive, with increased quality, improved productivity, and reducing costs to generate more profit ●●●●● **(2)** ~ The Marine Industry should find common interests with non-competitive businesses ●●●●● **(3)** ~ Aim for world leadership – quality, engineering, value for money, and increased market share ●●● ~ Robust engineering ● ~ Better design for the desirable product ~ Stop re-designing things – control bill of material
Funding / financial	~ More funding for R&D directed to service loads and durability, with the results being made widely available ●●●●●●●●● **(4)** ~ Need a profitable and sustainable business based in the UK ●●●● ~ Need cost control and optimisation at the component level ●●● ~ Need a stable business to make money ●● ~ Should have better tax write-offs
Environmental	~ Aim for cleaner technology for workers – for emissions, preferably more robotics ●●
Manufacture / production	~ Improved design for production (lean manufacture) ●●●●●●●●●●●● **(5)** ~ Need to optimise the use of suppliers at the design stage (with design for manufacture, and design for assembly) ●●●●●●●● **(6)** ~ Improve efficiency ~ More flexibility and customisation. There is a need to remain efficient to stay ahead
Skills	~ Invest in training – from the Board down to the shop floor ●●●●●● **(7)** ~ More technology transfer and skills sharing ●●●● ~ Have fun! ●●● ~ There is a need to harness the enthusiasm of enthusiastic owners without allowing them to stifle progress ●
Technology / innovation	~ Invest in R&D ●●●●●●●●●●●●●●●●● **(8)** ~ Innovation through collaboration with universities ●●●●●●●● **(9)** ~ Work with both suppliers and universities to prove new technologies ●●●●●●● **(10)** ~ Infusion will have an impact ●● ~ Promoting technologies ● ~ Share UK technology (Government funded?)

The main priorities raised are shown in the following diagram:

Main priorities for future direction for the Marine Industry's use of Composites	
Vision	Seek stability by looking for opportunities outside the marine sector. **(1)** There is a need to be more competitive, with increased quality, improved productivity, and reducing costs to generate more profit. **(2)** The Marine Industry should find common interests with non-competitive businesses. **(3)**
Funding / financial	More funding for R&D directed to service loads and durability, with the results being made widely available. **(4)**
Manufacture / production	Improved design for production (lean manufacture). **(5)** Need to optimise the use of suppliers at the design stage (with design for manufacture, and design for assembly). **(6)**
Skills	Invest in training – from the Board down to the shop floor. **(7)**
Technology / innovation	Invest in R&D. **(8)** Innovation through collaboration with universities. **(9)** Work with both suppliers and universities to prove new technologies. **(10)**

For the next phase of the roadmapping procedure, looking at the barriers to achieving the vision and what needs to be done to overcome the barriers, these top 10 priorities were discussed by the groups.

Priorities **(5)** and **(6)** were treated as being very similar, as were priority items **(4)**, **(8)**, **(9)**, and **(10)**.

6. BARRIERS TO PROGRESS AND POSSIBLE SOLUTIONS

Having arrived at a consensus of the future direction for composites in the Marine Industry, the next stage was to determine *"What is stopping us getting there?"* and deciding *"What needs to be done to overcome the barriers?"*.

Typical questions asked were:

- Do we have the skilled people we need?
- What are the gaps in our technology?
- Is funding likely to be adequate?
- Do we have the necessary infrastructure?
- What is inhibiting manufacture?
- Are patents inhibiting progress?

Actions needed to overcome the barriers (shown in blue) are also included in the following table (Figure 3), and are taken from the priorities shown in Appendix 8.3.

Figure 3: Barriers and Possible Solutions

Vision	**(1) Seek stability by looking for opportunities outside the marine sector.**
Barriers	• Market knowledge is needed
Next steps	• Research the market • Obtain market knowledge from sales and marketing

Vision	**(2) There is a need to be more competitive, with increased quality, improved productivity, and reducing costs to generate more profit.**
Barriers	• The industry is fragmented and no-cooperative • There is not enough time to improve efficiency (pressure on production) • Barriers are low volume; lack of efficiency; labour costs; lack of technology; privately owned companies
Next steps	• Outside funding needed to separate development from the pressures of production • Instigate: marketing strategy; lean processing; manufacture in a low cost centre; R&D collaborations; market research; clarify roles and responsibilities

Vision	**(3) The Marine Industry should find common interests with non-competitive businesses.**
Barriers	• Funding non-competitors with common interests • Time and resources not readily available • Who are they; more time needed. loss of Intellectual Property; secrecy; who benefits?
Next steps	• Need networking, information and better communications • Use consultancies, NCN, suppliers and universities more • Need appropriate forum; Investment / priorities; Find non-competitive partners, and create partnerships with mutual benefits and trust

Manufacture / production	**(5) Improved design for production (lean manufacture).** **(6) Need to optimise the use of suppliers at the design stage (with design for manufacture, and design for assembly).**
Barriers	• No time; lack of communication; lack of knowledge transfer • Need for additional investment in new processes • More process engineers are required, rather than designers • There is a lack of communication between engineering and purchasing.

	• There is a lack of engineering awareness of suppliers' capabilities
Next steps	• Money is needed to create time • Ensure improved communications from suppliers, and with experts and designers • Be pro-active and release funding • Employ and train more process engineers • Structure engineering and purchasing as one entity • Educate engineers to engage suppliers

Skills	**(7) Invest in training – from the Board down to the shop floor.**
Barriers	• Managing resistance to change • Management do not see the benefits upfront • Need a highly skilled workforce • Lack of money and time. • More visibility and availability of relevant training courses
Next steps	• Training organisations need better marketing • Improve design tools to reduce 'black art' approximations • Change company ethos towards research

Funding / financial **Technology / innovation**	**(4) More funding for R&D directed to service loads and durability, with the results being made widely available.** **(8) Invest in R&D.** **(9) Innovation through collaboration with universities.** **(10) Work with both suppliers and universities to prove new technologies.**
Barriers	• Money is tight • Lack of collaboration, with resistance to change, and no business case • No time for R&D, along with a lack of awareness of what it can offer • Time and effort is required to win funding, and find matching funding if it is needed • There is little knowledge about how to access funding • There is a lack of - awareness of collaborative opportunities; time; confidentiality
Next steps	• Demonstrate value for money • Create an industrial communications forum • Generate and provide business case • There is a need to prioritise workload to allow time for investment in the future • Overcome company ethos • Actively seek academic support • Use agencies, funding and networks • More effort through suppliers, universities, and users. Provide better links through NCN

7. ACTIONS / RECOMMENDATIONS

The following actions and recommendations were forthcoming from the Technology Roadmap Composites for the Marine Industry:

Awareness and Networking

- There is a great deal of scope for the Marine Industry to use technology that is already developed for the Automotive and Aerospace Industries, making use of the nanocomposite and nanocoating materials that are now available. *[Two of the participants in the roadmapping session have an automotive background and could be very useful for any subsequent meetings.]*

- It is suggested that NCN should provide a database of academic expertise in composites, which would be helpful to the Marine Industry.

- To find common interests with non-competitive businesses, NCN should provide information through suppliers and universities. Intellectual property needs to be safeguarded, and any partnerships need to be built on mutual benefits and trust.

Manufacturing

- Improved efficiencies within manufacturing are needed, looking at manufacturing in low cost centres, and moving to lean processing.

- Better communication is needed between engineers and purchasing, and engineers should have more contact with suppliers.

Skills

- More process engineers should be trained for the Marine Industry; there are insufficient skills within the workforce.

- Not enough data is available about relevant training for the Marine Industry. NCN are in a position to provide web-based information for the community.

Technology and Innovation

- Time availability and production pressures inhibit development of new technologies. More focused effort towards development should be undertaken. In this area, closer collaborations with academics and suppliers need to be explored.

- Time and effort are required to access funding for development projects, so help will be required to provide awareness of what is available. NCN is in a position to help here.

This is only the first stage of the roadmap. The NCN needs to develop this further, with input from those unable to attend the workshop. The main points will be picked up by the NCN, with a view to creating a vibrant and progressive community among the Marine Industry.

8. APPENDICES

8.1 Methodology

What is Roadmapping?

Based on a Foresight model, roadmapping is a high-level planning tool to help both project management and strategic planning in any technically-based establishment, whether in academia or industry.

Motorola first coined the word roadmapping in the seventies, but only recently has it been widely adopted by both individual companies and industry sectors as an essential part of their future growth. Figure (i) summarises the types of roadmaps that have already been produced. They can be for industries such as “glass” and “petroleum”, or for specific technologies such as nanomaterials, biocatalysis, etc. Some roadmaps have been produced just for single product areas.

How are the Roadmaps produced?

The process gathers together groups of commercial as well as technical experts, and takes them through the four stages that are shown in Figure (ii). The participants need to have sufficient information about the markets and the business to say where the topic under consideration is at the present time. The first step is to agree what the present situation is, and then to move on to provide a vision of where they see things going in the future - where they want to be during the next 20 years.

The third stage is to determine what the barriers to achieving the objectives and goals are. Finally decisions and proposals need to be made to enable the barriers to be overcome. These are arranged over a timescale, with short-term (0 to 3 years), medium-term (3 to 10 years), and long-term (> 10 years) goals.

Hexagon shaped *Post-its* (colour coded for each stage) are used to gather the participants’ thoughts for each step. These are then grouped into topics, and a typical example is shown in Figure (iii). When a consensus is reached regarding the conclusions, “dot” stickers are added to indicate the main priority items.

Such roadmaps provide a collective opinion about the future strategy, with agreed objectives.

As soon as the roadmap has been completed, it can be sent out to other interested parties for their additions and comments.

Roadmaps are “live” documents and should be updated on a regular basis.

8.2 Summary of publications related to Composites for the Marine Industry

BACKGROUND TO ROADMAPPING IN THE FIELD OF COMPOSITES FOR THE MARINE SECTOR

In connection with the National Composites Network’s activities to roadmap composites for the marine sector, there are a number of roadmaps and strategy documents relating generally to composites. The following summaries highlight the main issues relating to composites for the marine industry.

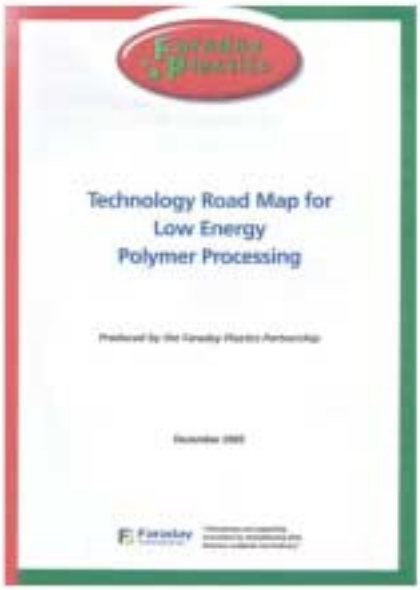
General Roadmaps on Composites

Figures from 2004 (http://europa.eu.int/comm/environment/waste/pdf/epec_report_05.pdf) indicate the main users of plastics by industry sector throughout Europe.

Technology Roadmap for Low Energy Polymer Processing by RAPRA

In December 2003, Faraday Plastics, one of the Faraday Partnerships, produced a roadmap on low energy polymer processing (http://www.faraday-plastics.com/techroadmap.htm). Nanotechnology, which is influencing many developments in composites, was not mentioned specifically.

Areas for research and development were identified and the main ones are listed below:



- Increased understanding of the energy balance in polymer processing
- Computer modelling of polymer processing
- Robust in-line melt temperature measurement
- Robust in-line energy measurement
- Supercritical fluid processing
- Single step processing
- Weight minimisation through micro-cellular foaming
- Fluid assisted processing.

Most of the above topics are now receiving attention, but a further 4 areas were identified as being worthy of R&D:

- Mixing technologies
- Process design for energy minimisation
- Intelligent processing additives
- In-line screw wear monitoring.

This particular roadmap resulted in over £3 million funding being obtained from the EU to progress certain aspects of the findings.

Thermoplastic Composites In Europe to 2025 by Coronet

Coronet, a European Research Infrastructures Network, produced in April 2004 a Foresight study into future research needs for thermoplastic composites (http://www.coronet.eu.com/DesktopDefault.aspx?tabindex=98&tabid=182).

A STEEP analysis identified Cost-effective Manufacturing as an important issue, with increases in productivity, lower part costs, reduced parts count, hybrids and advances in competing materials all falling into this category.

A trends analysis highlighted a number of key areas of research that will be needed to meet the expected trends in materials, processes and applications. In materials, these were:

- Natural fibre composites, including wood fibres
- Polymeric fibres such as PET, PP and PE
- Nano-reinforced fibres
- Self-reinforced polymers
- Reactive thermoplastics
- New commodity materials (e.g. PA, ABS, PBT, PET, and TPU)
- High performance materials (e.g. fluoropolymers, LCPs and PEKK)
- Bio-derived matrices
- Thermoplastic nanocomposites.

Modelling techniques and long-term performance characterisation of these materials is also needed. For processing technologies, the following were regarded as important research needs:

- Thermoplastic RTM

- New LFT injection processes
- Hybrid moulding processes (e.g. thermohydroforming) and structures
- Press and stamping processing routes
- Thermoplastic pultrusion and extrusion
- Diaphragm forming
- Filament winding
- Fibre placement and automated tape-laying.

Future needs in nanotechnology were identified below:

Materials	Research	Infrastructure
Self-reinforced polymers	Nano-reinforcement	Fibre spinning, continuous lamination lines, twin screw extruder
Nano-reinforced fibres	Self-reinforced polymers or other matrices, improved stiffness and temperature	Twin screw extruders, fibre-spinning
Nanocomposites	Enhanced fire properties; use with / without fibres, RTM with carbon nanotubes	Twin screw extruders, analytical equipment
Fire-testing	Fire retardance of nano-clays	Twin screw extruders, fire testing rigs

Towards Commercialisation of Nanocomposites And Hybrids, Faraday Plastics and Hybridnet

This roadmap (May 2004) focused on nanocomposites (http://www.faraday-plastics.com/techroadmap.htm). Processing was the first main point raised by the roadmap, stating that there is a lack of understanding of how polymers filled with nanoparticles or nano-clays behave under processing conditions.

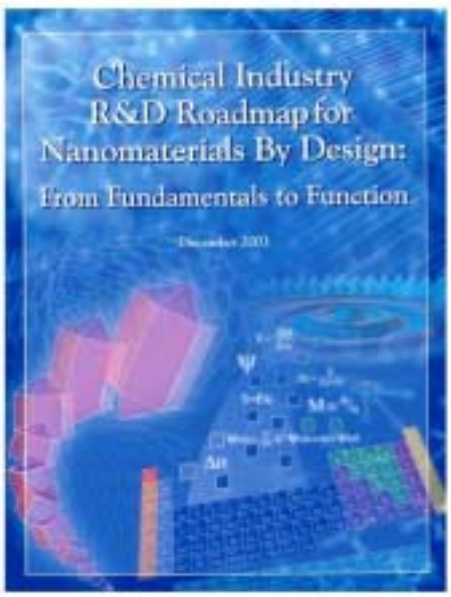
The report identified a real need to establish the processing behaviour for a range of nanocomposite materials especially when processed on traditional polymer processing equipment. Reproducibility is needed, and processing capabilities for nanocomposites should run parallel to product development and the development of reliable Quality Control techniques.

The full list of research needs for processing nanocomposites was:

- Development of processing technologies that will give reproducible products
- Develop in-line monitoring and control technologies
- Uniformity of exfoliation, dispersion and distribution on the nanoscale must be achievable
- Increased processing knowledge is required e.g. what factors affect material integrity, and how can these be controlled?
- Parallel manufacturing developments such as micromoulding need to be developed in-line with developments in nanocomposites technologies
- Presently there is a lack of knowledge of the processing characterisation of materials and how machinery design can be optimised
- Techniques must be developed that allow processing on traditional machinery
- Process induced structuring of nanomaterials must be more fully understood
- Processing technologies must be developed that are cost effective
- Quality control methods need to be developed.

Chemical Industry R&D Roadmap for Nanomaterials by Design

In the United States, the Chemical Industry Vision2020 Technology Partnership, in December 2003, produced their roadmap on nanomaterials. The 93 page report was called *Chemical Industry R&D Roadmap for Nanomaterials by Design: Fundamentals to Function*. It is well worth viewing at www.chemicalvision2020.org/pdfs/nano_roadmap.pdf.



It is very comprehensive; having taken a large number of people a great deal of time and effort to prepare. The emphasis is on getting nanotechnology based products to market as rapidly as possible.

The report begins by saying that Nanomaterials by Design will require concurrent development of:

- Nanoscale fundamentals and synthesis
- Methods of manufacturing
- Multi-probe measurement tools for the nanoscale
- Reliable models relating nanostructures to properties

Additional supporting activities must address:

- Environmental impacts
- Safety and health
- Standards
- Technology transfer
- Infrastructure
- Education

Manufacturing and processing are seen as being particularly important to the US community achieving its objectives in nanotechnology. The following diagram summarises the essential elements of the research pathway to Nanomaterials by Design.

Under Manufacturing and Processing, the following priority issues are highlighted, with timeframes and relative expenditure:

Priority	Task	Timeframe	Investment
Top	Unit operations and robust scale-up and scale-down methods	5 years	$$$$
Top	Manufacturing techniques for hierarchical assembly	20 years	$$$$
Top	Dispersion and surface modification processes that retain functionality	5 years	$$
High	Process monitoring and controls for consistency	20 years	$$$
High	Integrate engineered materials into devices while retaining nanoscale properties	20 years	$$$
Medium	Impurity removal from raw material precursors	5 years	$

Roadmaps for the Automotive Sector

In addition, there are a number of roadmaps that specifically cover the automotive industry, which have sections that could be relevant to the marine sector. Clearly they differ from marine practices in that mass production is a feature of the automotive sector, with recycling is becoming an increasing issue.

Plastics in Automotive Markets – Vision and Technology Roadmap

The American Plastics Council has carried out a roadmap on the future of plastics in the automotive industry which (www.plastics-car.com/roadmap/haveflash.htm). The web summary is set out as follows:

1. UNPRECIDENTED CHALLENGES

Today automakers are faced with formidable challenges:

- Consumers expect cars to perform better, have more features, and cost less
- Existing architectures are reaching their practical limit
- Globalisation and rapid manufacturing techniques are driving the industry to rapidly move innovative vehicles to market
- Design and assembly times must be compressed, and tooling and fabrication costs minimised
- Expectations for a clean environment and sustainable products are pushing automakers to be more responsible in the use of energy and materials

Automakers and designers have already embraced the versatility of plastics in such demanding applications as body parts, intake manifolds, safety devices, fuel systems and tanks, bumpers, structural applications and high performance racing cars.

While polymer use has increased dramatically, it has only just begun to use them to their full potential. The continuous drive to improve the bottom line will create even more opportunities for plastics in automotive applications.

2. A VISION FOR THE FUTURE OF AUTOMOBILES

The vision is that by 2020 the automotive industry will have established plastics as a material of choice in the design of all major automotive components and systems. To realise the vision, plastics producers and automakers will work to maximise the value of polymers throughout the supply chain and over the entire life cycle of the vehicle.

- Plastics will be the preferred material for enhancing component and system value
- Designing with plastics and composites will positively impact vehicle cost, environmental performance, and customer preferences
- Plastics will be the principal tool to produce safer, more affordable, stylish, durable, energy-efficient, and low emission vehicles in every market segment
- Rapid, cost-effective processing systems will provide automakers with the flexibility to respond to dynamic markets
- Polymer-based architectures will give automakers the freedom to create innovative vehicles that increase the value throughout the supply chain and for the driving public.

3. A STRATEGY FOR SUCCESS

To achieve the vision for the year 2020, a bold business strategy will be pursued, composed of 4 main elements:

- New applications for plastics – develop a portfolio of polymer-based tools that maximise the performance advantages of polymers and composites and allow the design and prototyping of new vehicle architectures
- Speed to market – shorten design and engineering cycles to fast-track polymer applications from concept to commercial product
- Enabling infrastructures – present automakers with a sound business case for plastics and built plastics
- Sustainable transportation – develop and use new plastics and composites to create sustainable vehicle.

4. TECHNICAL PRIORITIES

To achieve the strategic goals and vision a diverse portfolio of critical technologies will be pursued. Critical new technology development areas are:

- Advanced material systems
- Predictive engineering
- Automotive design

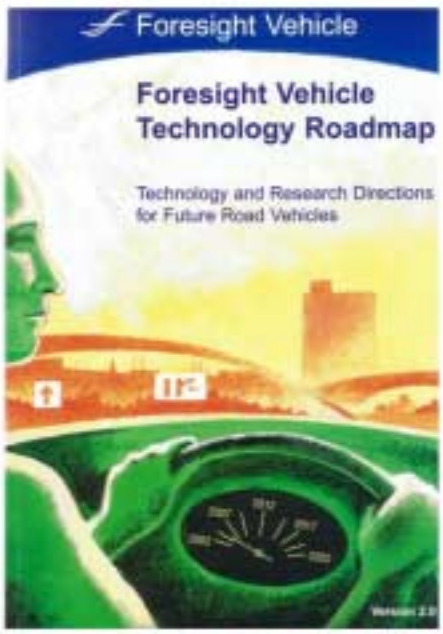
- Advanced manufacturing technology
- Business, market, and education infrastructure
- Environmental performance.

5. PARTNERSHIPS BRING VALUE

Achieving the vision will require resources beyond the practical reach of any single company. A coordinated strategy is essential, involving all stakeholders.

6. THE PATH FORWARD

In application after application, plastics have replaced conventional materials because they provide the functionality that engineers demand, the styling that designers seek, and the value that customers expect. Automobiles are no exception.



Foresight Vehicle Technology Roadmap

As part of the UK Government's Foresight exercise, the Society of Motor Manufacturers and Traders Limited produced, in 2004, a Foresight Vehicle Technology Roadmap (www.foresightvehicle.org.uk).

Technology targets are shown in the following table:

	0-5 years	5-10 years	10-20 years
Safety	• Selection of joining systems to match material performance capabilities	• Design/production and validation of 'smart' crash structures	
Product configurability and flexibility	• Component integration • Easier separation of materials for recycling or re-use • Effect of modular structures (and joining) on crash structures/NVH /stiffness • Robust engineering solutions for rapid modular reconfiguration	• Automotive industry relevant materials information database with all needs covered – one source • Management of customer customisation and effect on design process/homologation and supply chain	
Economics	• Reduce cost of moulded composites • Component performance beyond single vehicle life • Development costs • Re-processing of metal mixtures to give pure metals for re-use • A higher, safer and more environmentally sound vehicle development	• Disassembly techniques • Develop viable alternative to traditional paint finish for body panels	
Environment	• Establish standards of environmental friendliness • Development of polymer separation techniques • ELV compliant composite materials • Reduce vehicle weight • Attachment strategies for dismantling • Wider understanding of materials in the industry • Overcoming energy saving vs. recycling perceptions • National system for re-use of components • Low cost CFRP panels and structures	• New magnetic materials for hybrid/ fuel cell powertrain • Develop re-use mechanisms/ methodologies • Identify higher value markets for recovered materials • National systems for materials re-use and recycle	• Solve H_2 fuel infrastructure issues to enable widespread uptake and use • Hardwearing, low friction coatings to eliminate lubricants from powertrains
Manufacturing systems	• Joining hybrid structures • Surface quality thermoplastic composites • Develop low cost composite manufacturing process • Cost effective joining/dismantling of mixed material structures	• Coatings which survive production • Reduce time to manufacture for novel technologies • Materials that do not require paint protection • Convergence of business and technology research models	• Die-less forming

	• Cheap, environmentally friendly system to join steel, aluminium and magnesium without corrosion issues • Awareness of and access to process models and life cycle analysis • Establish central register of production routes to advise on potential facility sharing • Single piece structure development costs	• Flat pack/modularity requires ability to make cheaper, structural, sealed joints post-paint process	

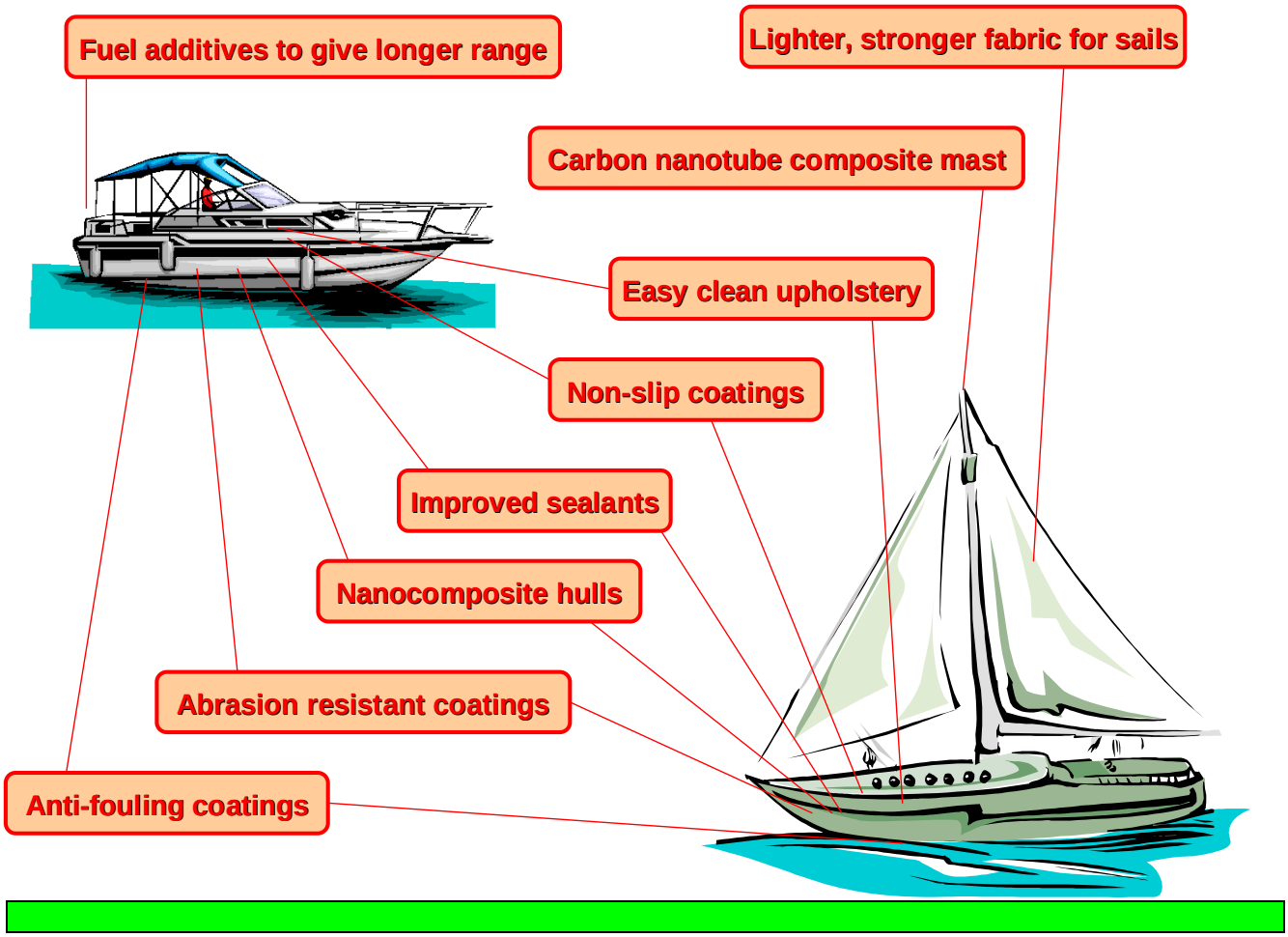
Monet Roadmap – Where does the future lead?

Monet is a European Centre of Excellence in 'artificial intelligence into industry', based at the University of Wales in Aberystwyth. It produced a report in June 2002 entitled *Model Based Systems in Automotive Domains: Applications and Trends* (http://monet.aber.ac.uk:8080/monet/docs/tg_minutes_and_reports/automotive/a1_report.pdf).

The approach taken has been through questionnaires to experts in the field. It claims that model-based reasoning has proved to be a very powerful technology for automotive applications for tasks such as diagnosis, design, and simulation. The general idea is that qualitative models can support several activities which are critical to the life cycle of vehicles: from analysis of the original design through on-board monitoring, diagnosis and recovery, to diagnosis and repair in the workshop.

Nanotechnology Developments

The following diagram summarises the potential of developments in nanotechnology, which are already impacting on markets:



IMPACT OF NANOTECHNOLOGY

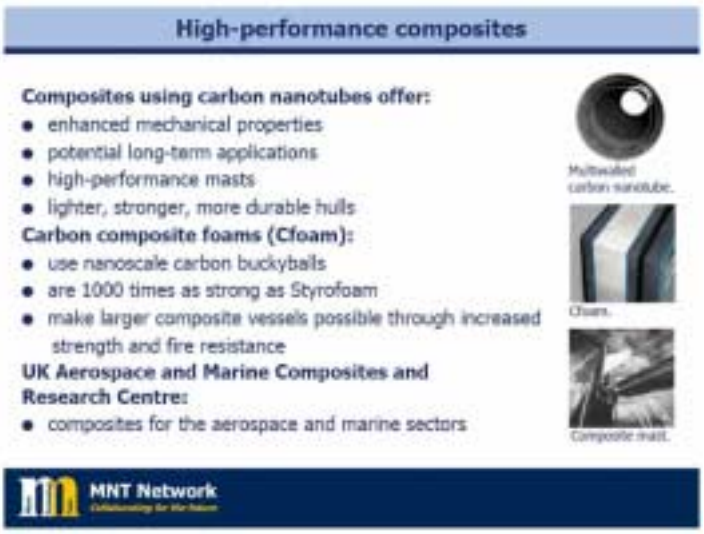
Nanotechnology is already having a considerable effect on the automotive industry, enabling lighter weight materials and additional properties leading to new products.

The diagram shows the possibilities, with respect to the marine sector.

Examples of use in automobiles are:

- *With 20% weight saving over conventional parts, the Toyota Camry's air intake cover and the Mitsubishi GDI models engine cover both has a nylon/nanocomposite material rather than a metal part. As well as light-weighting, this also makes use of the heat deflection properties of nanocomposite materials.*
- *The Chevrolet Impala uses 245 tonnes per annum of montmorillonite/polypropylene nanocomposite for its side body mouldings.*
- *The final lacquer on a number of Mercedes models is silica nanoparticle based and provides a durable anti-scratch surface. Other coatings developments in the field of nanotechnology are for textiles, where easy-clean coatings are now being used on Hugo Boss suits.*
- *Carbon nanotubes promise composites with 50-100 times the strength of steel and one sixth the weight! 60% of new cars in the US have plastic fuel lines incorporating carbon nanotubes to dissipate charges.*

The DTI's MNT Network, set up by the Government to coordinate the UK's activities in this rapidly developing area, has produced awareness packs which are designed to update specific sectors on the potential impact nanotechnology could have on their business. One has been produced for the marine sector with help from Marinetech South. The packs contain slides describing the opportunities, with notes on each slide, and case studies. Examples of some of the slides are shown below:



Textiles

Hydrophobic fabrics:

- dirt-deflecting and stain-resistant
- environmentally sound
- resistant to friction
- flexible and soft
- "nanowhiskers" increase surface tension so that liquid cannot soak through
- improved sail performance and durability
- dirt-repellent interior and exterior fabrics for boats

MNT Network

Self-cleaning, hydrophobic and scratch-resistant coatings

Scratch-resistant coatings:

- wearing surfaces (e.g. flooring and worktops)
- window and plastic glazing

Hydrophobic and self-cleaning coatings:

- coated marine antenna systems show rain attenuations of only 10% compared with 50% losses for uncoated systems
- self-cleaning glass

MNT Network

Fuel additives

Envirox diesel fuel additives:

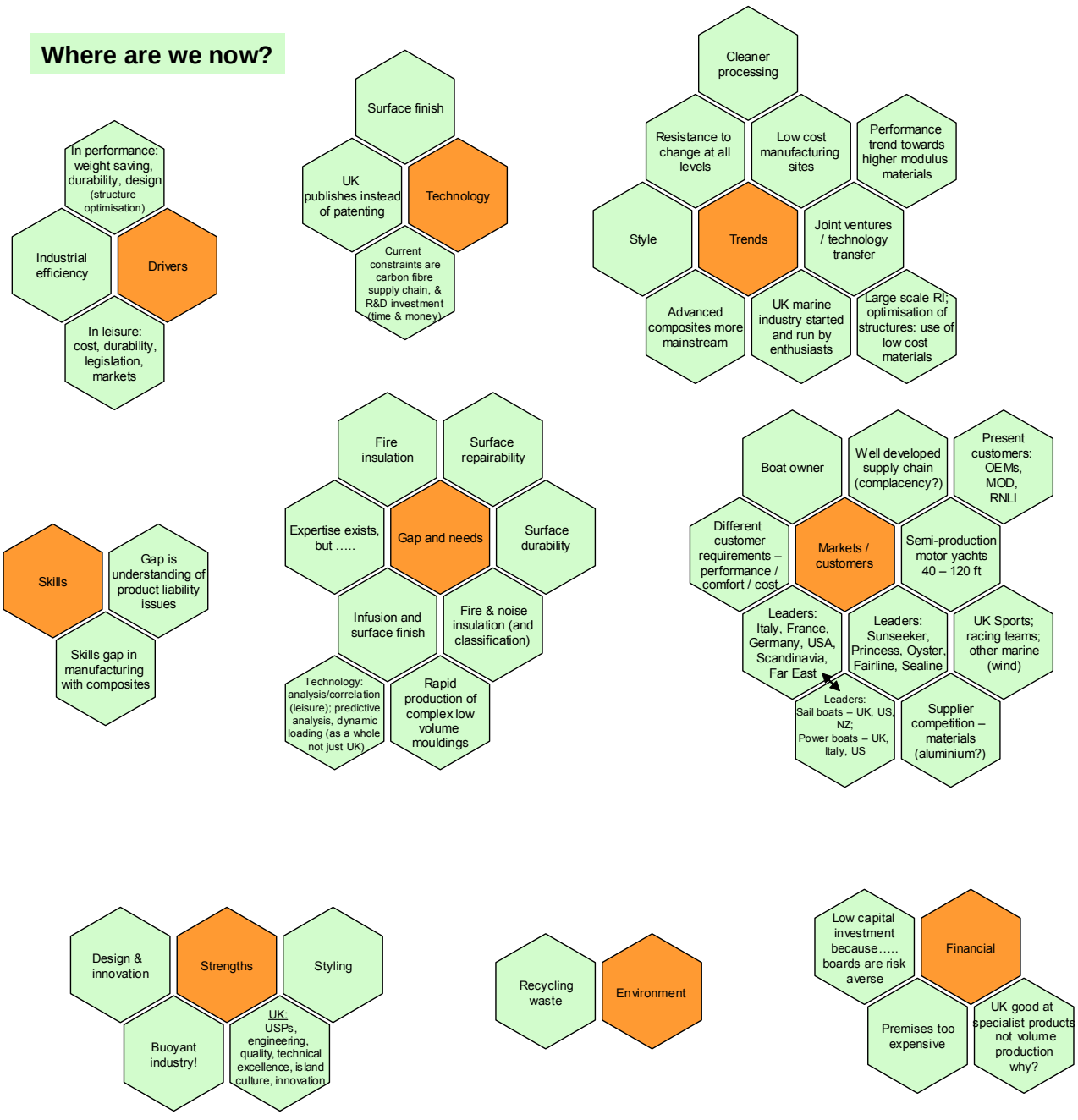
- are produced by Oxford-based company Oxonica
- are reported to:
  - promote longer and more complete combustion
  - significantly improve fuel economy in excess of 5%, verified in large-scale trials
  - reduce emissions
  - reduce carbon deposits
- can be added to bulk fuel storage or automatically dosed into a fuel line
- offer low application rates (5ppm)
- are classified as non-hazardous

Oxonica are seeking partners to conduct large-scale marine application trials.

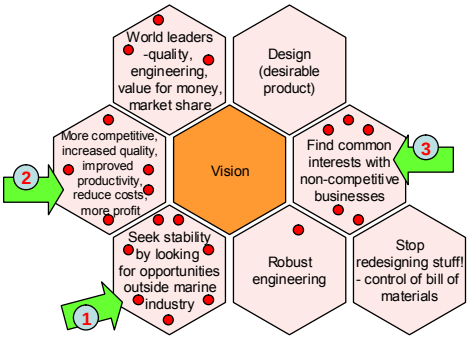
Images: Oxonica plc.

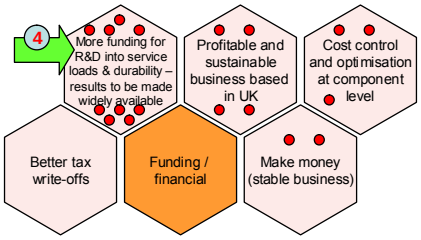
MNT Network

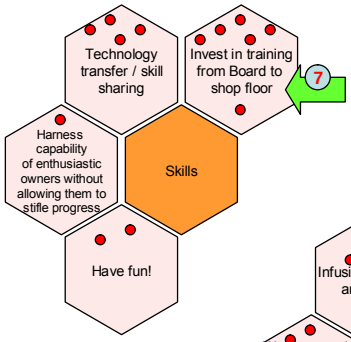
8.3 Results of the brainstorming with hexagons

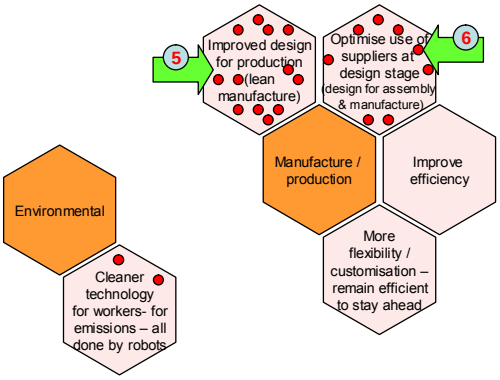


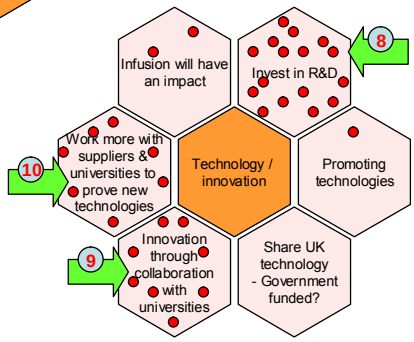
Where do we want to be?



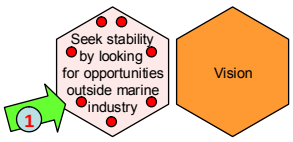




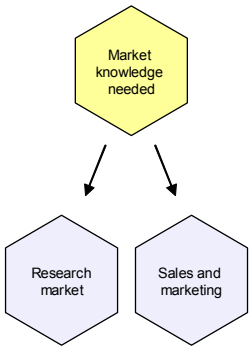




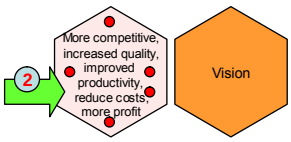
Priorities – Barriers and Actions:



What is stopping us getting there?



What do we do to overcome the barriers?



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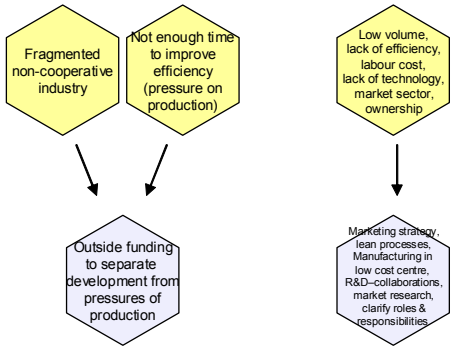

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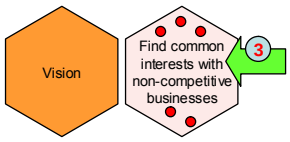

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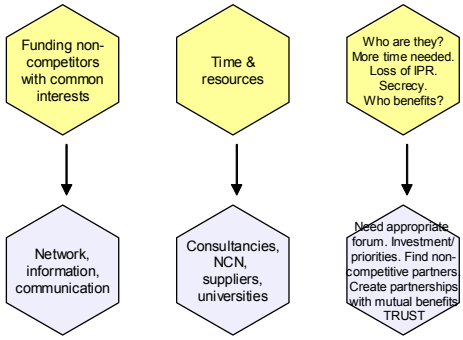
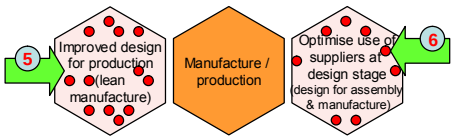
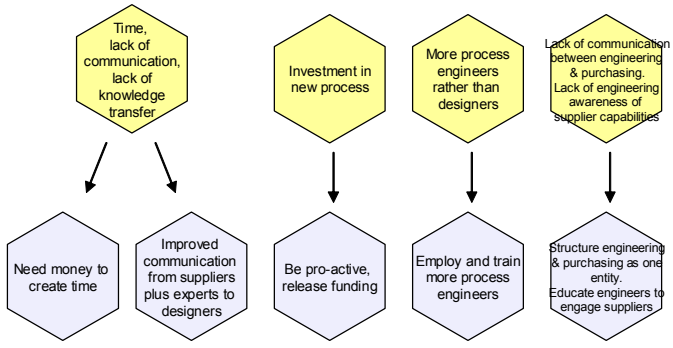


What do we do to overcome the barriers?



5 & 6 are very similar

What is stopping us getting there?



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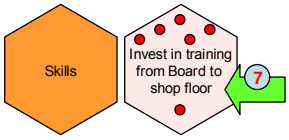

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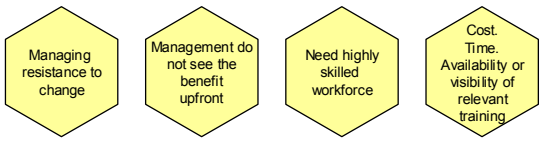
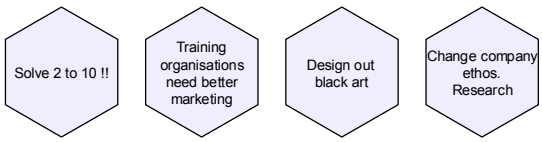
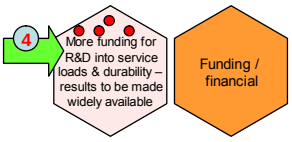
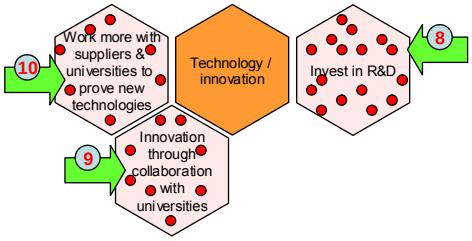


What do we do to overcome the barriers?

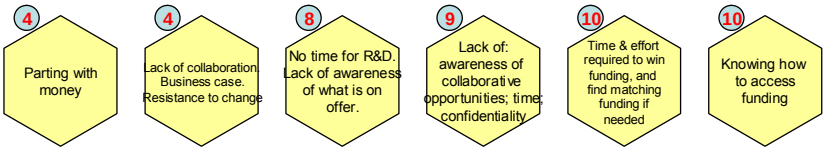






4, 8, 9, & 10 all connected

What is stopping us getting there?



What do we do to overcome the barriers?