

Marine Sector Technology Plan

**An overview of key
technologies and R&D
requirements for the
UK marine engineering
sector**

VERSION: 1

DRAFTED BY: Nick Heyes
DTI Marine Team
SEPTEMBER 2005

Index

1. Executive Summary
2. Introduction and background to the key technology themes
3. Efficient propulsion systems
4. Hydrodynamics and hull optimisation
5. Advanced materials
6. Manufacturing technologies
7. Navigation & traffic management
8. Autonomous vehicles
9. Sensors & control systems
10. Renewable marine energy
11. Cross cutting environmental themes
12. Appendix A Background to sectors
13. Appendix B The EU Waterborne Technology Platform

Executive Summary

- This report relates to the commercial and naval shipbuilding, leisure boat building, ship repair and marine equipment sectors. Its aim is to stimulate collaboration for R&D projects between these sectors and others where there may be common technology requirements as well as to provide an overview for potential funding organisations
- Key areas of technology include efficient propulsion systems, advanced materials, hydrodynamics and hull optimisation, navigation and traffic management, manufacturing technology, autonomous vehicles, sensors and control systems and renewable marine energy.
- Many areas of these themes have applications within other industries, which makes the marine sector an attractive collaborative partner. Key industries for collaboration include construction (similar one-off capital intensive projects to shipbuilding), automotive, rail and aerospace.
- Environmental technologies are cross cutting throughout all of these themes and increasing pressure is subjected by customers (eg: MOD) as well as through general regulation. Through life costs and disposal costs will be an important consideration for future product lines
- Investment in long term R&D continues to be difficult for a sector that has a large number of SMEs
- We need to retain and maximise the usage of national scientific assets which impact the sector
- Skills and a skills shortage of engineering operators, qualified ship's officers, designers and technicians continues to be an issue and acts as a barrier to technology innovation
- The sector as a whole seems open to the idea of shared resources and pooling of technology. The maritime nature of the sector leads itself to regional clusters of activity.

Introduction

This report relates to the commercial and naval shipbuilding, ship repair, leisure boatbuilding and marine equipment sectors. An overview on each of the three key sectors within this study is included in Appendix A

With national government and EU technology funding now concentrated on a collaborative, cross-sectoral basis, there is an advantage for industry & academia to have a clear set of technology and R&D priorities. This helps stimulate R&D collaboration as well as providing a catalyst for potential projects.

Whilst the UK Marine Sector has been innovative and a strong utiliser of technology, there has been no “national” technology strategy to date. Links between industry and academia have been strong in some areas and non-existent in others, which have created a fragmented approach to projects. The marine sector also has a lot to offer and take from other sectors like aerospace and automotive with strong common themes of technology such as composite materials, sensors, electronics, materials handling etc.

The DTI and Government views the marine sector as important and is keen to see the sector flourish. A “company neutral” technology plan will be essential for long term sector R&D and this document is designed to be dynamic and updatable as needs change.

To draw up this report, the DTI hosted a 1-day, Marine Technology Future Focus event in May 2005. It was attended by technology and business experts (both academic and industrial) from the maritime sector and the ideas and themes gathered from that event form the basis of this plan. The key themes for discussion were:

- Efficient propulsion systems
- Advanced materials
- Hull optimisation and design
- Navigation & traffic management
- Sensors and control systems
- Manufacturing Technology
- Autonomous vehicles
- Renewable marine energy
- Cross cutting environmental themes

“Thank you for at last giving the disparate but very committed marine sector a feeling that DTI is no longer sea blind! Hopefully the enthusiasm shown by the attendees can be built on. If the marine sector (which is a greater proportion of GDP than aerospace) got just a proportion of the support and commitment from politicians, Whitehall and the media we would greatly help the nation’s wealth and sustainability. In the end we must sustain our expertise (it’s our greatest asset) and get young people of talent to come into the field.”

The DTI has a dedicated unit (Energy Group), which leads on the renewable marine energy topic. However, we included this important theme within this report as it has opportunities and ramifications for the marine engineering sector that we are considering. This report does not have the breadth to look at the renewable energy sector in detail.

In addition, there are emerging activities that may require technologies specific to the sector such as economic and environmentally friendly disposal of ships.

The event also highlighted the breadth of the industry and the wide range of Government departments that impact on the sector. This represents a challenge for a better “joined up” government approach and one which the DTI will prioritise to embrace

There are also significant opportunities for potential EU collaboration under the current Framework Program. Work is already underway to produce a maritime Strategic Research Agenda under the Waterborne Technology Platform - based on a vision of the maritime sector in 2020. This work will be completed by the end of 2005 and will undoubtedly influence future EU R&D initiatives. Information on this is included in Appendix B

This report is not designed to be a set of technical references but to act as a catalyst for potential collaboration and to provide an overview about the sector for R&D funding institutions – both government and private.

Technology is a dynamic subject and we will continue to add to this report over time.

For more information please contact the DTI Marine Team:

Nick Heyes
nick.heyas@dti.gsi.gov.uk
Tel 0207 215 1083

Efficient Propulsion Systems

Propulsion systems are a vital part of any modern vessel with most customers and operators looking for a combination of enhanced power, reduced weight, minimised acoustic noise and vibration, lower capital costs and efficiency. Cost and technology barriers exist but in many instances there is reluctance from potential clients to accept new ideas. There will also undoubtedly be increased environmental considerations. Key areas of technology which require development have been identified as follows:

- Alternatives to traditional propeller drive systems – podded drives, water jets, rim driven propellers and advanced materials for traditional shafts and propellers (eg: composites) to minimise noise and vibration
- On going technology transfer (and marinisation) of turbine development from aerospace sectors
- Biomechanical propulsion
- Fuel cells – with a requirement for lighter and cheaper systems
- Improved design integration – with special consideration for electrical systems
- High Temperature Superconductivity - development of semiconductors to suit high power electrical drive systems
- Phase change cooling and new technologies in power electronics and machines.
- Alternative fuel sources – eg: biomass fuel, nuclear and also renewable energy systems – eg: photo voltaic (PV) power, wind/wing sails etc
- Improved remote conditioning systems, diagnostic data and control systems – essential for future “power by the hour” type contracts
- Hi efficiency electric motors and generators
- Development of LNG model
- Offshore fuel cell refuelling schemes
- RJC Engine development for lower power applications

Notes:

Fuel prices have a mixed impact on the sector. Some of the companies derive income from offshore oil companies and see increasing fuel prices as a benefit for their economic activity but the majority see a necessity to deliver more efficient systems for the future. Most experts see technology in traditional fossil fuel products not keeping pace with fuel price rises

There are also concerns about availability of qualified personnel for postgraduate research. Skills within the sector continue to be a concern

“We tend to be very conservative and need to have change forced on us”

Increased regulation for leisure users especially on inland waterways may force users to look at alternative fuel arrangements

Continuing worries are expressed at protecting IPR and the costs and complexity of implementing suitable protection

Hydrodynamics & Hull Optimisation

Hull design is a product of many variables ranging from complex fluid dynamics calculations through to practical testing of models. It also impacts on propulsor design and development. The UK has potentially strong capability in this area but national assets are under-utilised. Key technology barriers and areas for development include:

- The science of hydrodynamics continues to be challenging and there is still a requirement for practical testing of models. Skills within this technology area continue to be in demand and we must ensure we have sufficient resource for the future
- Alternative propulsors (see also section on efficient propulsion systems)
- Foil and multi hull development
- Increasing safety standards dictate better manoeuvrability and better understanding of hull performance will help in this arena
- Better understanding of a marine structure's wave handling capability
- Sea keeping and comfort, powering and speed prediction, manoeuvring and propulsor design are the key aspects of this technology
- Drag reduction coatings and hull resistance minimisation
- Underwater turbines & wave energy generation devices need specific hydrodynamic analysis and development
- Advanced adaptive and learning control system where control is varied depending upon ambient conditions
- Customer is risk adverse to new designs and the ship building industry is reliant on selling its prototype. Therefore a more risk accepting customer prepared to try new designs is required or, inverting this paradox, there is a requirement for better risk analysis from the sector.

Notes:

The Hydrodynamic's National Advisory Committee has developed a simple plan showing the state of technology within the UK and areas where technology requires enhancement. For a copy e-mail mrrenilson@qinetiq.com

"The UK needs a modern test facility. I would like to add my voice to request for cheaper access to existing test facilities in the UK. Work and experience is being lost to those countries that have sensible policies"

Advanced Materials

The marine sector using an interesting mixture of structural materials and coatings. Improved fuel efficiencies can be obtained through better antifouls and coatings and ships can be made safer through the use of new construction materials. Key areas of technology interest include:

- Biocomposite and non-food crop reinforced structures – in particular:
 - ◆ Non food crop composites. Eg: Flax, hemp plus other biologically grown reinforcements and non oil derived resins
 - ◆ Using bio sources (renewable source/sustainable source/recyclable)
- Smart biomaterials
- Thermoplastics
- Resin infused mouldings
- Carbon fibre pre pregs
- Hybrid sandwich construction
- Demand for low density, lightweight, high performance materials with known structural qualities
- Self cleaning materials for hull construction
- High temperature resistant adhesives
- Formable sandwich construction
- Steel to alternative material bonding
- Embedded monitoring systems not just for structures but also for coatings
- Recycling of existing materials and disposal of redundant composite materials – see also cross cutting environmental themes
- Improved manufacturing processes for material handling, production systems and disposal of industrial consumables
- Improvements in gasketing and sealing technology
- So called smart materials with self monitoring and repairing properties
- De materialisation of structures
- Priorities still need to be attached to developing and working with steel and other traditional materials

Notes:

Whilst composites form just a part of the materials program, the National Composites Network has been set up to specifically deal with technology dissemination and advice. View their website at www.ncn-uk.co.uk. Practical help is available for all businesses who need consultancy in the area of composites technology.

Some parts of the leisure marine sector still use traditional craftsmanship and skills. There will continue to be a niche market for these traditionally crafted products.

Manufacturing Technology

Manufacturing lies at the very heart of the marine sector but production volumes are extremely limited and a large amount of customisation is required even within the leisure sector where small volume production runs may exist. Investment in appropriate plant seems to be the biggest barrier as opposed to technological innovation or lack of machine/plant capability. However, much can be done within the sector to improve existing processes and practices and small changes here can make step changes to productivity improvements. Key issues are areas for development include:

- Access to rapid prototyping technology
- General engineering skill shortage of suitably qualified technical operators
- Better integration of CAD/Manufacturing processes
- Improvements within the supply chain in terms of lean manufacture, just in time, best practice etc
- Improved use of advanced moulding techniques
- Shared local facilities so that advanced plant and manufacturing expertise can be shared amongst innovative SMEs
- Knowledge based engineering appears to have applications within the marine sector and its infancy within the sector should be promoted
- Better, environmentally friendly processes
- A cleaner brighter workplace – learning from high performance work places in other sectors
- Automation of lamination of complex shapes which are currently laid up by hand
- Modularisation techniques for leisure boat production
- Outsourcing to lower wage economies continues to be an option and possible threat

Notes:

The sector sites cost and investment as being a major factor in the development of manufacturing technology. With a specialised product line and small production volumes, investment in automation poses problems. There are some calls from industry for more access to shared facilities

“MOD (Navy) have now taken a vigorous approach to environmental issues from concept to disposal.”

Rapid prototyping has made some inroads into the sector helped by industry partnerships with universities. There are also concerns that not enough emphasis is placed on design for manufacture and a more integrated approach.

“Manufacturing research is simply not high profile in most universities and there is very little credit and reputation to be obtained from it.”

Knowledge Based Engineering (KBE) is a technology that deals with the capture of knowledge for engineering processes within a software environment. It has been used extensively in the aerospace industry in many areas of component design and analysis. It is also widely implemented as a solution to the automation of engineering and manufacturing data.

Navigation & Traffic Management

Notes:

Labour & crew costs continue to be a significant part of a ship's operating cost so there are desires to totally automate a ship – see also our section on Autonomous Vehicles. There are also significant fuel savings to be obtained through more accurate ship's course holding. There are perception and technology barriers and the need for a step change in port operations to be implemented for this to be implemented. Key areas for development include:

- Cost reductions in defence/aerospace technology to allow commercial and consumer integration
- Security and tracking devices have broad applications
- Concept of Motorways of the Sea and marine spatial planning needs consideration
- Requirements for a more advanced common interface standard allowing non-proprietary equipment to share data.
- Lower cost world “satellite” footprint of internet access for high speed transfer of at-sea data
- Improved weather data and transfer of shipborne real time metrological data
- Improved digital techniques for ship steering and autopilot systems
- Automatic docking systems – both leisure and commercial
- Development of radar technology
- Concerns over navigation impacts of wind turbine farms

Autonomous Vehicles

The profile of autonomous marine vehicles cover both unmanned surface ships and remotely controlled sub-sea exploration equipment. Public perception, security, a risk adverse ship owning and insurance industry and port facilities act as barriers to development in this field with technology and cost only a small limiting factor. Key underpinning issues for development include:

- Enhanced security and safety systems – protection against hijack, theft, terrorism, small craft etc
- Improvement in long term reliability of ship board systems
- Upgraded sensors and control systems
- Inadequate regulation of the spatial sea area – in particular lack of control of leisure vessels
- Enhanced ship-shore data links
- Redefined port strategy and mechanical handling – improved technologies in port security, implementation of tracking and RF tagging for cargoes
- Advanced docking systems and ship stabilisation systems
- Niche unmanned vehicle sector dealing with hazardous waste or cargoes where human intervention may be difficult
- Development of marine control centres/traffic control systems
- Ship recovery systems

Notes:

Manning costs of a modern commercial ship are put at 10% of the overall total but capital costs are saved with reductions in crew living space and the associated systems. For the future, regulation may demand increased crew costs and numbers. There are demands for a prototype ship to be constructed to ascertain the true economic viability. There is also a shortage of trained ship's officers

Sensors & Control Systems

Improved sensors and control systems will be the heart of a more sophisticated ship and future improvements in power by the hour type supply contracts. Sensors and control systems are embedded into every aspect of marine engineering and their advancement is essential for long-term technology improvements. Key areas for development include:

- Improvements in environmental sensing techniques and technology
- Use of bio-sensors
- Embedded sensing technology for structures with better feedback systems
- Lower cost sensors to allow embedding into cheaper composite structures
- Improved performance of in water sensors – notably with respect to bio fouling and long term accuracy
- Potential integration of a range of existing standards to make a “marine protocol” allowing a more open interchange of information between non proprietary systems
- Potential for a “marine xml” type web standard for distribution of data
- Improved sensor technology notably in high temperature and high-pressure radioactive environments, oil in water measurement, water quality, metallic deformation (cracks/fatigue etc), composite delamination and moisture content.
- Enhanced EMI/ENC techniques for reduced interference

Notes:

“There is massive potential for developing more open data standards. Differences in standards between the likes of BV and Lloyds will never be resolved. Therefore, there is a need for a higher standard of data handling, rather than content.”

Renewable Marine Energy

Notes:

This is a wide topic and this report is not able to consider it in full. The marine engineering sector has huge offerings for this market. Key issues for this sector include:

- The proven robustness of systems, environmental impact (underwater noise, impact on ecology, etc), cost (currently not viable without subsidy), performance standards for comparison of different devices, marine spatial planning, transmission at reasonable cost and control of grid when source is uncertain
- Energy conversion techniques – there needs to be a more open approach to the energy media as it's not necessarily going to be electricity
- Need to set up a “yard” or test centre for wave devices to develop and implement new manufacturing technologies, to helping with the reduction of costs and leading to mass production,
- Strong possibilities of regional centres of expertise in SW and N where environmental conditions allow for renewable energy generation

Cross Cutting Environmental Themes

To simplify this broad area, key themes which impact across all technologies include waste management, emission control, carbon abatement, hazard reduction and environmental management. All of these themes impact on the key technologies for the sector. Key areas for technology development include:

- Light and noise pollution – improvements in measurement techniques
- Disposal of consumables such as filters, paint and coatings from ship yards and dry-docks,
- Disposal of composites and FRPs
- Disposal of ships
- Integrated design for more fuel efficient systems
- Alternative fuels – ongoing development of PV and wind power and electrical power for leisure vessels
- Improvements in sealing technologies to minimise accidental spills
- Membrane bio technology to clean water
- Desalination technology
- Improvements in ship and leisure vessel exhaust systems for minimised acoustic and environmental impact
- Power storage systems for non material/fossil fuels
- Design for minimised waste in manufacturing processes
- Need to develop poly-interfaced power connection for wave technologies (“wave hub”).

Notes:

There is acceptance that environmental issues are important and need to be addressed by industry. However, concerns exist over the “pace” of regulation and the changes that need to be implemented.

“There is enormous money and IPR to be made out of marine equipment and components dedicated to W&T.”

“Need to “recycle” power technologies from the oil and gas community and set-up virtual teams to “migrate” with solutions into standard, low cost, industrialised components for the W&T industry – there is potential here for government coordination”

“There are concerns too about public support – more education in schools and communities is required”

Appendix A

Marine Equipment Sector - An Overview

Information Provided By Society Of Maritime Industries – the trade body which represents this sector.
Further information - www.maritimeindustries.org.uk or tel 0207 928 9199 for further information

The commercial and naval marine equipment sector is a substantial business in the UK turning over nearly £2 billion per annum of which nearly two thirds is exported. Our maritime companies are market leaders, selling their products and services in the Far East, USA and in our European partner countries, particularly in the areas of propulsion systems; power generation; electronic controls and instrumentation; navigation and communication; deck machinery and cargo handling equipment; and coatings. Indeed, many companies enjoy the technological synergies which come from links with the aerospace and electronics industries thereby ensuring innovative solutions are available to the sector's customers to meet the evermore stringent environmental and safety regime in which the modern shipping industry operates.

The commercial marine sector has seen strong growth over the last two years particularly from the Far East shipyards and a substantial naval programme is in prospect both here in the UK and in selected export markets. Maintaining a technological edge over competitors is of paramount importance to UK based companies and, therefore, further investment in the underpinning research and development and the innovative flair which is the industry's hallmark is essential for future growth.

Appendix A

Commercial/Naval Shipbuilding & Ship Repair - An Overview

For information contact Shipbuilders & Ship Repairers Association – the trade body that represents this sector
www.ssa.org.uk TEL 01784 223770

The United Kingdom has a long and distinguished history of Warship Construction, carried forward today in worldwide sales of innovative designs of fighting and support craft.

- UK remains pre-eminent in the design of all types of ships and has extensive expertise in product and process technology, as well as comprehensive consultancy capabilities.
- Also world class academic institutions in naval architecture, underwater systems and oceanography
- Naval shipbuilding industry able to design and build the most complex surface and submarine vessels for global operations; good export performance in patrol and coastal warships
- Equal to best in world in design and manufacture of ultra-luxury large yachts (“super-yachts”)
- Competitive merchant ship repair companies around whole length of UK coastline able to handle virtually all classes of ships

On the repair and conversion side, the UK has gained a solid reputation in this sector and purely in terms of turnover is now second only to Germany having seen an increasing trend year-on-year from for the past five years. From 2000 to 2003, turnover increased by 25% to Euro 420 million.

Shipyard Employees = 22,000
Turnover = £2bn

Appendix A

Leisure Boatbuilding & Leisure Marine Equipment - An Overview

Information provided by the British Marine Federation – the trade body that represents this sector
Further information www.britishmarine.co.uk TEL 01784 473377

The British leisure marine industry is a successful sector of the UK economy. It is almost wholly comprised of small and medium sized enterprises (SME's) who provide the boats, equipment, facilities and services that enables up to 4 million British people to enjoy boating and watersports on our coast and inland waterways. Many companies in this industry are leading exporters and the sector contributes significantly to UK tourism.

Boatbuilding in the UK has developed significantly since the 1960's when composite manufacturing materials were introduced which has led to a sophisticated production boatbuilding industry. Many leading boatbuilding companies are British including four of the world's largest luxury powerboat builders. These boatbuilders sustain a supply chain of engineering companies that manufacture marine equipment, marine electronics, boat fittings and accessories.

UK boatbuilders and marine equipment manufacturers have built a worldwide reputation for good design, innovation and quality that has enabled them to succeed in very competitive global markets. The UK leisure marine sector exports 42% of its production.

Inland hire fleet operators and coastal yacht charter companies together with inland and coastal marinas contributes significantly to UK tourism. Research published by the British Marine Federation in 2005 estimates that the UK leisure marine industry delivers an added value contribution of £700 million to the UK economy and generates an additional £2 billion tourism spend.

The British Marine Federation 2004 Annual Statistics report quantifies the UK leisure marine industry as follows:-

Revenues	-	£1.994 million
Employment	-	30,000 people
Exports	-	£839 million

The UK leisure marine industry has grown at an average annual rate of 8% per annum since 1997.