3.2 Marine Technology Research Programme

3.2.1 Introduction

Technology is a key enabler for the achievement of developmental and management objectives across the entire marine sector. It is also a sector in its own right, capable of generating high-value commercial products and services. To date, Ireland has largely been an importer of marine technologies (structures, equipment and instrumentation). This arises both from the historical under-development of the marine sector, including the traditional associated engineering industries, and from the absence of a high technology defence industry. The potential now exists to create a new, knowledge-intensive industry sector competing in the growing international market.

3.2.2 Sector Profile

The Irish marine technology sub-sector comprises approximately 50 companies with a combined turnover of €69m, employing nearly 500 people.

It is a very diverse sub-sector and most companies are small-to medium-sized enterprises. Despite its relatively small size, there are significant opportunities for growth in marine technology, particularly in niche technology areas where Ireland has, or can build, a strong international reputation.

3.2.3 Key Opportunities and Challenges

Market Opportunities

There is growing technology content in all marine sectors. Internationally, the Marine Technology sector, is characterised by many high-tech sub-sectors including software, underwater connectors, telemetry and communications and control systems. It is within these that the main opportunities for Irish SMEs exist. The market for marine technology products will continue to grow as development and management activity in the oceans increases. It will be characterised by increasingly sophisticated solutions involving the synthesis of a wide range of advanced technologies. The UK Greenwich Report[25] estimated that the marine information sector would grow from €3bn to €7bn by 2020, with the largest growth areas expected to be in monitoring, forecasting and information systems. This will entail the development of new techniques in observation and data analysis and management.

[25] Marine Foresight Task Force (1999). The Greenwich Project - A Marine Information Strategy for the United Kingdom.

Some of these activities, and the technologies to which they give rise and will employ, are outlined in Table 3.6.

Table 3.6 Advance Technologies Supporting Marine Activities

Activities	Technologies
Continuous monitoring of oceanic and atmospheric conditions	Networks of land-based, sea-based and satellite observatories
Measuring and monitoring ocean currents	3D and 4D models and computer simulations
Monitoring the dynamics of deep-water masses	Autonomous deep drifters and seabed observatories
Seafloor mapping and surveying	Multi-beam and other high performance sub-bottom profilers, ultrasound spectroscopy and deep-sea observatories
Expansion of ocean-drilling capabilities	Riser technology and down-hole logging tools
Marine environmental monitoring	Autonomous data acquisition systems incorporating novel, energy supply and bi-directional data transfer over long distances
Nutrient and pollution measurement, particularly biological and chemical parameters	Sensors incorporating innovations in nanotechnology, medicine and molecular biotechnology

Environmental Measurement and Monitoring

Increasing concerns for environmental quality and the use of satellite earth observation and other remote sensing technologies are opening up new opportunities in the area of smart sensors and dispersed observation systems. These will be linked to central computers with enhanced visualisation capabilities, to assist management and control decisions. There is a widely shared international vision, for 2015–2020, of globally connected systems for environmental monitoring. This is particularly applicable in freshwater and marine monitoring.

The application of remote sensing and information technologies for environmental measurement and monitoring represents an opportunity for Ireland to capitalise on the rapid evolution of technology in this area, and on the advanced capabilities developed in leading national technology research centres. These applications include aerial and *in-situ* sea surface, water column and seabed observatories for coastal zone and marine resource management in the context of the EU Global Monitoring for Environment & Security (GMES) Initiative and the EU Water Framework Directive. Technologies being developed globally to support these applications are illustrated in Figure 3.5.

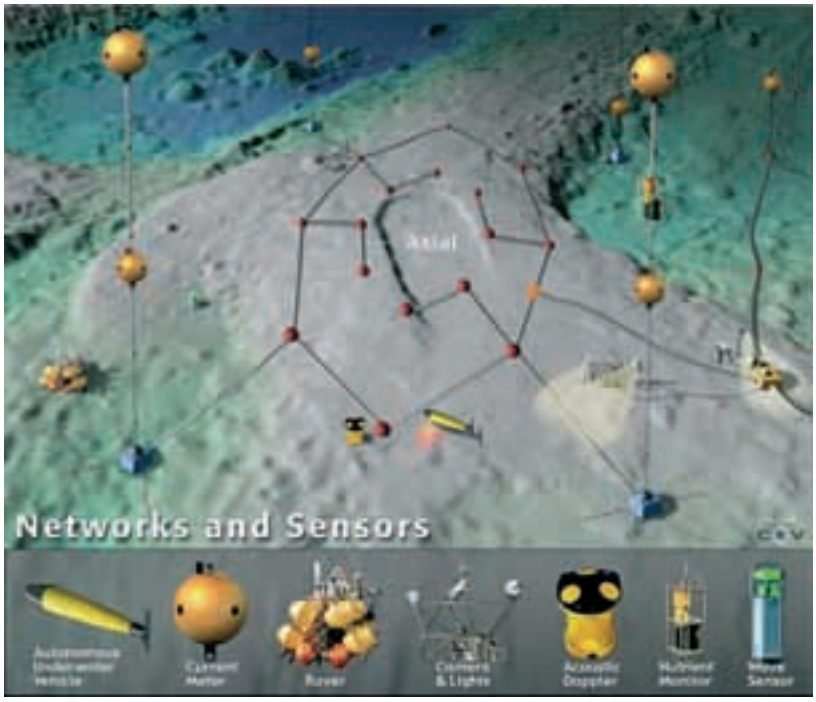

Figure 3.5 Environmental Sensor Networks (Monterey Bay Aquarium Research Institute)

Within this context, there is an accelerating development of extended observing systems involving co-ordination of new sensor technology with environmental cyber-infrastructure. Environmental cyber-infrastructure involves managing and enabling access to large databases and data arrays over extended periods. Together with the development of new, sophisticated models and advanced data assimilation techniques, these technologies will lead to powerful methods for understanding environmental dynamics and predicting spatial and temporal changes in environmental processes. Cyber-infrastructure also addresses the effective relaying of information in an appropriate form to various stakeholder groups, e.g. specialist researchers, agency engineers and scientists, public service providers, government committees and the public.

Offshore Aquaculture

Over the past 15–20 years, commercial aquaculture farms have been establishing in increasingly dynamic environments. Operators have been utilising improving technologies and methodologies, based almost entirely on the use of floating cages. Novel or alternative technologies are also being developed and there is a trend towards the use of submerged systems, particularly in open ocean situations. This technology will continue to develop. For example, a recent policy statement on aquaculture from the European Commission[26] states: *"Fish cages should be moved further from the coast, and more research and development of offshore cage technology must be promoted to this end. Experience from outside the aquaculture sector, e.g. with oil platforms, may well feed into the aquaculture equipment sector, allowing for savings in the development costs of technologies."* The continuing development of these systems will require the development, adaptation and application of a range of technological innovations in fields such as advanced materials for structural design; and sensors, robotics and telemetry for feeding, biomass and health monitoring.

[26] European Commission (2002). Communication from the Commission to the Council and the European Parliament - A Strategy for the Sustainable Development of European Aquaculture. COM/2002/0511 Final.

Ocean Energy

The rapid acceleration of international efforts to commercialise R&D in renewable ocean energy technologies provides opportunities for Ireland. These are considered in Section 3.4. The deployment and operation of large wave and tidal energy arrays will entail the use of a wide range of technologies for environmental monitoring and prediction, continuous monitoring of moorings and structural integrity, and real-time communications and control systems.

Challenges

The major challenges facing the marine technology sector in Ireland are:

> The lack of 'drivers' for technology development that exist in other countries, e.g. defence industry in Norway, the UK and the US;

> The lack of a large home market;

> No tradition of an 'Irish' brand in this sector, or of Ireland as a place where high quality RTDI in the marine sector takes place;

> Attracting 'flag ship' multinationals with strong potential marine tech focus to establish operations in Ireland;

> A general lack of understanding and appreciation of the potential impact of disruptive technologies; and

> The need to promote understanding of enabling technologies, e.g. Grid computing.

In essence, the challenges in realising opportunities and achieving objectives in this sector are also those that characterise the challenge for Ireland in creating a strong knowledge economy. It is, generally, not feasible for Ireland to compete in terms of scale with the large developed economies. Japan, the USA and other European countries are investing heavily in both the marine biotechnology and advanced technology fields. China and the larger emerging Asian economies are also investing. Ireland must compensate for the 'scale' factor by achieving a high degree of co-operation, agility and innovative creativity in implementing these programmes. These issues are addressed in the main Strategy document (Sea Change: A Marine Knowledge, Research and Innovation Strategy for Ireland 2007-2013).

3.2.4 2020 Vision

2020 VISION

By 2020, the marine technology sector will be a vibrant knowledge-based sector featuring:

> A globally-aware industry, with 75% of output exported;

> Annual turnover of €500m (up from €69m in 2003);

> Strong R&D infrastructure (third-level research centres with facilities and expertise relevant to the marine research priorities); and

> Strong linkages and synergies with companies in related and generic technology sectors; including communications, materials and process technology, and collaborations with high technology MNCs.

The sector will have achieved excellence in the development, manufacture and commercialisation of niche technology products and services in the areas of environmental monitoring, offshore aquaculture, ocean energy and seafood processing (Figure 3.6). It will have a strong focus on the application of information and communication technologies to the marine environment. Technology developments will support marine resource development through the creation of an industry leadership capability in intelligent systems for marine monitoring and management.

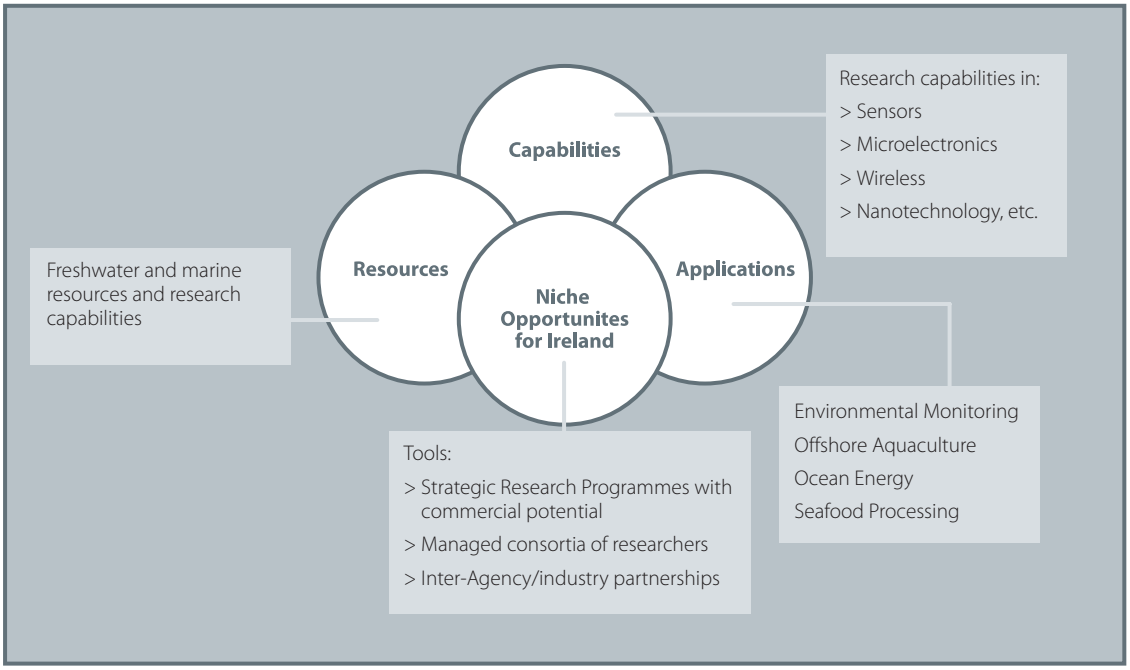

Figure 3.6 Niche Opportunities for Ireland in Marine Technology

3.2.5 2013 Objectives

The following objectives have been identified as critical milestones to be achieved by 2013:

2013 OBJECTIVES

1 Create a critical mass, multi-disciplinary and industry-oriented research grouping in the field of sensors, intelligent systems and sensor platforms.

2 Create a focused capability in the application of information and communication technologies to the marine sector.

3 Harness the synergies between the above to deliver innovative technology solutions to targeted sectors (aquaculture, seafood processing, environmental monitoring, and ocean energy).

3.2.6 RTDI Requirements/Key Outputs

The identified RTDI requirements and key outputs for delivering on the 2013 Objectives of the research programme are presented below.

Table 3.7 Research Requirements & Key Outputs for Marine Technology to 2013

Objectives 2013	RTDI Requirements	Key Outputs
1 Create a critical mass, multi-disciplinary and industry-oriented research grouping in the field of sensors, intelligent systems and sensor platforms.	Some of the key RTDI requirements, which are closely linked with those in the ICT area (see objectives), and which constitute the elements of a programme to develop intelligent systems, include: > Sensitivity for low levels of trace chemical concentrations; > Fouling of sensors; > Selectivity limitations; > Limited stability of sensor chemistry and material; > Correlation of pressure and depth sensors data to allow in-situ instruments to match satellite altimeter data; > Interfacing of sensor systems with networks and communication and data infrastructure mechanisms; > Instrument capabilities and functions in respect to data acquisition and analysis; > Design and operation of sensor platforms; and > Integration of fibre-optic technology with sensors, communication and power sources.	> A multi-disciplinary, industry-oriented research grouping in the field of sensors, intelligent systems and sensor platforms > A portfolio of IP and of novel and innovative products > A number of new companies and stronger existing companies, both from within the sector and in related sectors > Active joint development projects with a number of MNCs and with international partners

continued

Table 3.7 Research Requirements & Key Outputs for Marine Technology to 2013

Objectives 2013	RTDI Requirements	Key Outputs
2 Create a focused capability in the application of information and communication technologies to the marine sector.	Some of the key RTDI requirements in Marine ICT, include: > Automatic identification and tagging of events in sensor data streams; > Wireless technologies for use offshore and their integration with on-shore communications networks; > Underwater communications - acoustics, distance, reliability, speed, power and their integration with on-shore communications networks; > Web service workflow tools allowing users to bind processes together for particular applications; > Integration of instruments and sensors into a grid computing environment with web services interfaces; > Techniques for simulation and visualization of complex data sets; > Automatic linking of instruments and metadata production; and > Development of methodology for 'grid enabling' instruments.	> A leading capability in the application of information and communication technologies to the marine sector > A critical mass of research and technical capability virtually networked in national centres of expertise > Active collaborative partners with MNCs and other companies from outside the 'marine' sector
3 Harness the synergies between the above to deliver innovative technology solutions to targeted sectors (aquaculture, seafood processing, environmental monitoring, and ocean energy).	A fundamental RTDI requirement is for the creation and maintenance of an overlapping series of dynamically networked groups with multi-disciplinary capabilities, organised around strategic technology projects, in partnership with industry. **Offshore Aquaculture Systems** > Sensor systems for feeding, biomass and health monitoring > Feed control > Telemetry and communications > Cage design, materials, structural testing and modelling **Environmental Monitoring** > Housings for instrument packages > Visualisation > Nano-biomaterials for component manufacture > Biofouling prevention **Seafood Processing** > Microbe Sensors > Traceability systems **Ocean Energy** > Telemetry/Monitoring Technologies > Modelling > Storage technologies	> Rapid development and prototyping of new products and services > Competitive advantage to Irish companies operating in these sectors > New start-up SMEs and new niche products for established technology companies > Participation in internationally funded programmes and bi-lateral international collaborations

3.2.7 RTDI Capacity/Capabilities

Current Research Capacity

Third-level Sector

Marine technology research and innovation encompasses a wide range of disciplines, many of which are not focused purely, or at all, on marine technology research. Five research groups are currently actively involved in marine technology research. Together these research groups comprise approximately 28 researchers in marine technology research (Table 3.8). The research focus of these groups covers areas such as advanced sensors and sensor platforms, ocean optics and marine robotics. Of particular relevance to the 2013 Objectives are three research groups in DCU and UCC that are involved in a suite of strategic advanced marine technology projects in the area of advanced sensors for water quality monitoring.

A further 10 research groups and a number of individual researchers (approximately 50-75 researchers in total) have relevant skills and research interests that, although not currently marine-orientated, could be applied to the future RTDI requirements for marine technology. The expertise in these groups covers areas such as sensors (including fibre-optic sensors), composite materials, biosensors, telemetry and communications, smart packaging and labelling systems, food traceability (using RFIDs—Radio Frequency Identification Devices) and control and instrumentation systems.

Table 3.8 Overview of Current Marine Technology Research in the Third-level Sector

Institutes	No. Research Groups	No. Researchers*	Research Focus
UCC UCD DCU UL	4 Large Groups 1 Small Group	28	> Advanced water quality sensors > Sensor platforms > Microelectronics > Photonics > Nanotechnology > Optical-based sensor systems > Wireless autonomous sensing > Microbe sensors > Spectrophotometry/radiometry > Satellite calibration/validation > Airborne remote sensing > Ocean optics > Robotics > Control & instrumentation systems

Large: >10 researchers; Medium: 5–10 researchers; Small: <5 researchers

* In some cases, research groups may focus on more than one theme and the total number of researchers in these groups is greater than indicated here. The total number of researchers in the groups identified is approximately 40-50.

State Sector

Although the Marine Institute has no staff actively participating in marine technology research, it provides strategic direction and financial and technical support to third-level and private sector researchers. Enterprise Ireland and Shannon Development provide other funding, technical and commercialisation support.

Industry

Many of the 50 companies in the marine technology sub-sector conduct in-house research/innovation into the development/adaptation of new technologies. It is however, difficult, to quantify the research effort in the private sector. Furthermore, a number of companies participate in collaborative research with third-level institutes and state agencies. For example, three SMEs, together with two third-level institutes and two state sector bodies, are involved in a cluster of advanced marine technology projects funded under the National Development Plan Marine RTDI Measure. The focus of these projects is on the development of advanced water quality monitoring technologies.

Identification of Research Skills/Competencies to Meet Future RTDI Requirements

A summary, based on the identified future RTDI requirements, of the competencies required to meet the 2013 Objectives is presented in Table 3.9. Also included in Table 3.9 is an assessment of whether there are current strengths (S), areas that require strengthening (R), or gap areas (G), in relation to the identified requirements, within the existing research community.

Table 3.9 Competencies Required to Meet Future Research & Innovation Requirements for Marine Technology

Objectives 2013	Competencies Required	Assessment
1 Create a critical mass, multi-disciplinary and industry-oriented research grouping in the field of sensors, intelligent systems and sensor platforms.	> Analytical chemistry	S
	> Advanced sensors and sensor-platform development	R
	> Advanced materials	R
	> Surface technology (coatings)	R
	> Communications/telemetry	S
	> Photonics	S
2 Create a focused capability in the application of information and communication technologies to the marine sector.	> Communications/telemetry	S
	> Data stream analysis	G
	> Underwater communications	G
	See also note 1 below	
3 Harness the synergies between the above to deliver innovative technology solutions to targeted sectors:		
Aquaculture	> Communications/telemetry	S
	> Cage design, modelling & testing	R
	> Development/adaptation of biomass sensors	G
Environmental Monitoring	> Data handling, analysis & visualisation	R
	> Surface technology (coatings)	R
	> Nano-biomaterials	G
Seafood Processing		
	> Traceability systems	R
	> Microbe sensors	R
Ocean Energy		
	> Communications/telemetry	S
	> Ocean energy modelling	S
	> Energy storage technologies	G

* **S** – Current Strength; **R** – Requires Strengthening; **G** – Gap Area.

[1] The ICT competencies required to achieve this objective are similar to those required to achieve the Knowledge and Information Management objectives (Policy Support Research Measure) and are dealt with in further detail in the relevant

The current capacity in marine technology research is relatively modest. However, marine technology development can draw on a large pool of research expertise in the wider technology area in both the third-level and industry sectors. Focusing this expertise on marine technology research will assist greatly in meeting the 2013 Objectives. Although some of the expertise required to achieve Objective 1 is available, much of it requires further strengthening and broadening.

Many of the competencies required in support of the application of information and communications technology to the marine sector (Objective 2) are similar to those required to achieve the Knowledge and Information Management objectives (Policy Support Research Programme) and are dealt with in further detail in the relevant section (4.2). Apart from these, gap areas exist in relation to (sensor) data stream analysis and underwater communications.

Delivering innovative technology solutions to targeted sectors (Objective 3) requires a broad range of competencies. Some research strengths already exist, e.g. in the area of communications/telemetry. Competencies that require strengthening include fish cage design, modelling and testing; coatings technology; seafood traceability systems; and microbe sensors. Gap areas include nano-biomaterials, energy storage technologies and biomass sensors.

Figure 3.7 Research Competencies Required to Meet 2013 Objectives for Marine Technology

Current Strengths	Require Strengthening	Gaps
> Analytical chemistry	> Advanced sensors and sensor-platform development	> Data stream analysis
> Communications/telemetry	> Advanced materials	> Underwater communications
> Ocean energy modelling	> Surface technologies (coatings)	> Development/adaptation of biomass sensors
> Photonics	> Cage design, modelling & testing	> Nano-biomaterials
	> Data handling, analysis & visualisation	> Energy storage technologies
	> Traceability systems	
	> Microbe sensors	

3.2.8 Prerequisites for Achieving Objectives

Foresight exercises in a number of countries have all shown that many important inventions, and the emerging technologies to underpin them, are characterised by the coming together of a number of disciplines. This creates the need for multi-disciplinary, multi-institutional, and even multi-national efforts and hence for networks, co-operation and partnerships. Furthermore, many of the policy issues, such as intellectual property rights and the commercialisation of new ideas, need effective links between research systems, on one hand, and financial and legal systems, on the other. The development of such links is critical for Ireland's future success in marine technology development and use.

There are a number of prerequisites for success in the development of a dynamic marine technology sector:

> Creating critical mass and greater continuity in funding support;

> Developing test and demonstration mechanisms;

> Developing effective networking mechanisms; and

> Establishing effective market research intelligence mechanisms.

Mechanisms that address the realities of high-tech micro SMEs must be established. R&I support must bridge the gap between development of 'laboratory demonstrators' from current applied research programmes and the delivery of near- or at-market products that need 2–4 additional years development, with scale-up and proper field trials. These support measures need not be large but must be fast and flexible.

The existence of industry development mechanisms, such as WiSen (the Wireless Sensor Network) and the Photonics Association are critical to the success of this programme.