UK Marine Security Market Report

The Canadian Trade Commissioner Service

8th March 2013

Report for the Canadian Trade Commissioner Service

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"Nothing, nothing in the World, nothing that you may think of or dream of, or anyone else may tell you: no argument, however seductive, must lead you to abandon that Naval supremacy on which the life of our country depends."[1]

Winston S Churchill

First Lord of the Admiralty, 1918

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2. Table of Abbreviations

AIS	Automatic Identification System
AUV	Autonomous Underwater Vehicle
BMP	Best Management Practices – version 4
BODC	British Oceanographic Data Centre
C2	Command and Control
CCTV	Close Circuit Television
CDE	Centre for Defence Enterprise
CNIS	Channel Navigation Information Service
DECC	Department of Energy and Climate Change
DEFRA	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DRDC	Defence Research and Development Canada
Dstl	Defence Science & Technology Laboratory
ENC	Electronic Navigational Charts
ECD	Electronic Chart Displays
EN	Environment Agency
EEZ	Exclusive Economic Zone
ENISA	European Network and Information Agency
GLA	General Lighthouse Authority
GMDSS	Global Maritime Distress and Safety System
GOA	Gulf of Aden
HCSC	House of Commons Select Committee
IACMST	Inter-Agency Committee on Marine Science and Technology
IALA	International Association of Marine Aids to Navigation and Lighthouse Authorities
ISPS	International Ship and Port Facility Security Code
ISP	International and Strategic Partnerships Office [NOC]
JTAC	Joint Terrorism Analysis Centre
MARS	Marine Autonomous and Robotics Systems
MCA	Maritime and Coastguard Agency
MEDIN	Marine Environmental Data and Information Network
MFA	Marine and Fisheries Agency
MMO	Marine Management Organisation

MMWC	Merchant Maritime Warfare Centre
MOU	Memorandum of Understanding
MPA	Maritime Patrol Aircraft
MPP	Marine Programme Plan
MRA4	Maritime Reconnaissance Aircraft [Nimrod Mk 4]
MRCC	Maritime Rescue Coordination Centres
MSCHOA	Maritime Security Centre – Horn of Africa
MSI	Maritime Safety Information
MST	Marine Science and Technology
NAVTEX	Navigational Telex
NCAGS	Naval Cooperation and Guidance for Shipping
NMIC	National Maritime Information Centre
NERC	Natural Environment Research Council
OBP	Oceans Beyond Piracy
PJHQ	Permanent Joint Headquarters
RAPPICC	Regional Anti-Piracy Prosecutions and Intelligence Co-ordination Centre
RMP	Recognised Maritime Picture
RN	Royal Navy
RNLI	Royal National Lifeboat Institution
ROV	Remotely Operated Vehicle
SCADA	Supervisory Control and Data Acquisition
SOCA	Serious Organised Crime Agency
SDAC	Shipping Defence Advisory Committee
SIS	Secret Intelligence Service
SOLAS	Safety of Life at Sea Convention
SS	Security Service MI5
UKBA	United Kingdom Border Agency
UNCLOS	United Nations Convention on the Law of the Sea
UK NERC	(UK) Natural Environment Research Council
UK NOC	(UK) National Oceanography Centre
UAV	Unmanned Aerial Vehicle
VTS	Vessel Traffic System
WAG	Welsh Assembly Government

3. Introduction

While the informed reader will be well aware that the United Kingdom sees UK Maritime Security differently to when Winston Churchill made his famous comment on Naval supremacy, the words nevertheless give pause for thought and underline the importance of the Sea to the people of Britain, to their sovereignty and to their trade.

Times have changed and independence has given way to interdependence and the global nature of the country's role in the world is directly linked with the success and security of other nations. However, the UK remains an island nation, dependent for its survival upon the safe passage of energy, food and manufactured goods through British ports.

International shipping[2] carries over 80% of world trade and 92% of British trade, while UK ports move 582 million tonnes of cargo and over 5.38 million containers annually. The imperative of the Government therefore, across all departments, must be to maintain the safe and secure passage of British trade throughout the world in whatever form that might take.

Piracy in the Indian Ocean today is a real problem but at the same time other maritime threats to shipping from various illegal activities continue to proliferate and threaten UK trade, ships and seafarers around the world. In addition there is a growing raft of environmental concerns with longer term strategic defence consequences. Amidst all this the UK's high level dependence on seaborne imports and the resilience of British ports and associated infrastructure remains paramount.

4. Objective

The request from the Canadian Trade Commissioner Service asked for the report "to provide up-to-date and forward looking information to companies in the Canadian Ocean Technology sector, so that they may consider entering this market area or innovating to meet forecast market demand. The report will also make [Canadian] companies aware of the opportunities to enter global supply chains by partnering with or supplying multinational companies based in the UK".

The report will illustrate the organisations and issues currently affecting the UK Maritime domain and why they might be of interest to Canadian companies. Each sub-sector will cover the drivers likely to lead to highest growth in the medium term (defined as 2-10 years) with a focus on innovation, emerging technologies and their providers. Where possible details of supply chain structures indicating customers for ocean technology customers and multinational UK companies in the marine security sector who would see ocean technology companies in Canada as suppliers or innovation partners will be provided.

5. Executive Summary

Maritime security is essential to the UK. As a nation with a thriving maritime sector, dependent for its survival upon the safe passage of goods, people, food and raw materials Britain is wholly dependent on the sea. To assure its maritime security the UK employs a wide variety of government agencies working together at all levels, organised in such a way as to provide a comprehensive, interlocking approach to deal with a vast array of challenges and threats.

Challenges to UK Maritime Security range from piracy in international waters, to a multitude of threats closer to home including illegal activities such as people smuggling, terrorism and cyber-crime. Also, the UK coastline is evolving beyond recognition, with its growing dependence on offshore infrastructure, high volume inshore traffic and new environmentally friendly energy production at sea. This places security and budgetary demands on the many new agencies responsible for their success - in particular the Maritime and Coastguard Agency (MCA).

Long range maritime surveillance is currently an issue of great concern to the Government and there is an acknowledged capability gap. Steps are currently underway to resolve this shortfall but cutbacks have limited the options available. Updating closer in-shore surveillance is rapidly becoming a complex, technological task requiring a multitude of modern systems working together seamlessly under the control of different agencies.

Monitoring of vessels at close range is also becoming virtually automatic, especially for ships in high volume areas such as Dover Channel Navigation Information Service (CNIS) and this trend for automation is likely to spread around the UK as the MCA's transformation programme takes hold. Onboard systems also reflect the move to absorb these technological advances with the advent of E-navigation. However, important questions remain about software vulnerability and resistance to cyber attack. Nevertheless, the advantages provided by hi-tech simulation are providing increasingly realistic training for crews.

The Marine Science and Technology market is an area where the UK is moving forward with confidence and displaying considerable success by improving business processes and driving innovation. This is an area which is already of great interest to Canadian Universities, such as Victoria University, and Canadian SMEs because of the broadly similar approach to many of the environmental challenges and the drive to do 'more with less' which characterises a sector that champions innovation and shoe-string budget projects.

The protection of ports and their specialised infrastructure is a growing concern mainly due to their increasing size as well as the scale of the human and environmental risks they pose. A large scale maritime terrorist attack is currently seen more likely because Supervisory Control and Data Acquisition (SCADA) systems are not sufficiently secure and ports do not have adequate time and money to spend on investing in anything more than the minimum security.

Offshore infrastructure developments around the UK are flourishing but their demands for special status protection within a complex framework of coastal security requirements must be balanced by a raft of new agencies competing for limited funds. In the medium term there are likely to be conflicts of interest especially as offshore energy is brought online in restricted areas where fish stocks and other fragile resources are threatened and pollution is already a threat.

Maritime communications systems are in the process of being overhauled across the spectrum and around the UK. New systems will provide very much better reliability and connectivity.

Overseas the UK remains a key actor in all aspects of international shipping security and is involved in every aspect of military intervention to the mariner as well as assistance in providing intelligence and organisational support to pre-empt attacks at sea and prevent accidents. The UK has developed a very competitive industry in onboard anti-piracy technical solutions which are used by a wide range of vessels small and large.

The UK remains at the forefront of new developments. In the container world the London Gateway complex will be the largest port of its kind in Europe, greatly increasing the number of containers flowing through London but at the same time significantly reducing the environmental footprint. The UK Ministry of Defence (MoD) is linking with the commercial world to improve defence related research by allowing far greater civilian input into projects by spearheading imaginative initiatives to involve all aspects of academia, research institutes and the commercial world. MoD wants to encourage work that could improve the security of maritime operations by distinguishing between lawful and unlawful craft, developing graduated responses using non-lethal means and improving small arms accuracy at sea.

The UK offers a broad range of high-tech opportunities in mainstream and niche markets and the technological advances being made in the UK maritime security could have a very positive impact for Canadian SMEs.

6. Background

The landmass of the UK covers over a quarter of a million square miles and, at 7,723 miles, its coastline is the 13th longest in the world. (Canada is the longest with 125,566 km). Like many nations, the UK claims territorial seas out to 12 nautical miles (nm) and up to 200 nm for the Exclusive Economic Zone (EEZ); consequently, the UK is responsible for all maritime activities out to 1.2 million sq miles.

Over the centuries the UK has developed policies and systems to survey, monitor and patrol its boundaries and, where necessary, enforce its laws to maintain the integrity of security. To do this the UK has adopted a multi-agency approach which is based principally on the leadership of the Home Office.

It is worth noting that recent decisions about the future of UK maritime surveillance have preoccupied members of the UK Parliament and that, due to the cancellation of the Nimrod MRA 4, there is for the first time in many years a significant capability gap in long range, broad area surveillance[3]. There is also a desire to rationalise Government departments and agencies to ensure greater efficiency and value for money.

The UK marine industries include companies ranging from SMEs up to globally recognised names. Among the 5,000 companies across the UK, many serve a range of marine markets and share common technologies, skills and marine experience. Some of these companies are discussed in their strategy for growth[4].

7. UK Maritime Domain

The paragraphs below describe how the UK manages its Maritime Security and safety through Key and Supporting stakeholders.

7.1. Key Stakeholders

The Home Office has overall responsibility for all relevant maritime activity within the UK territory and adjoining sea areas. Specifically immigration, security, and law and order and as such is responsible for the Police, UK Border Agency (UKBA), and the Security Service (MI5). It is also in charge of government policy on security-related issues such as drugs and counter-terrorism.

The Department for Transport (DfT)[5] is responsible for the UK National Maritime Security Programme[6]. The National Maritime Security Programme covers all commercial maritime operations and, by regulation, the Department for Transport (DfT) applies the programme to passenger ships carrying more than twelve passengers and to cargo vessels (over 500 tonnes) as well as Mobile Offshore Drilling Units and their port facilities. This programme brings together the UK's maritime security regime and the various international and European initiatives to provide comprehensive protective security for UK ships and ports. In the area of UK Maritime Domain Awareness the Department of Transport has responsibility for security which is based on the SOLAS[7] Chapter XI-2 and the International Ship and Port Facility Security Code[8](ISPS). The European Union Regulations[9] on enhancing ship and port facility security transposes SOLAS XI-2 and the ISPS Code into UK law and requires EU member states to introduce effective sanctions for breaching provisions of the regulation.

The National Maritime Information Centre[10] (NMIC) is a newly formed cross government body located at the Northwood Headquarters in north London. The NMIC[11] is an information centre only but it draws together many of the main Government Departments responsible for safeguarding offshore installations including the Police, military units, the UKBA, the Intelligence Services and MCA amongst others. It is important to note that while NMIC is based at Northwood, the Chief of Joint Operations is not responsible for defence of the UK home base for the adjoining territorial waters and airspace.

The Police force is responsible for all law and order in the UK and on all offshore installations and in inland waterways. It is supported by the Serious Organised Crime Agency (SOCA). SOCA is currently in full evolution and by December 2013 will become the National Crime Agency (NCA). The aim is to have a more integrated operational crime fighting force and in addition to combating organised crime, it will strengthen the UK borders and deal with cybercrime. It marks a significant shift in the UK's approach to tackling serious, organised and complex crime and will have a major drive on greater collaboration between police forces, law enforcement agencies and other partners.

The UKBA is the country's main defence against illegal immigrants and works closely with SOCA to counter organised and dangerous criminals. It uses the latest technology to detect prohibited goods and people, in some cases well before they reach the UK border. It has a fleet of five cutters and together with the fishery protection units of the Royal Navy (RN) maintains a constant watch over UK waters working with SOCA to counter drugs and people smuggling.

The Joint Terrorism Analysis Centre (JTAC) provides an assessment of the threat to British maritime interests from international terrorism. The Security Levels set by

the DfT are determined in consultation with JTAC. It is worth noting the JTAC Threat Levels relate purely to the terrorist threat. The DfT considers other factors which affect the risk of a serious attack at sea when translating the Threat Level to a Security Level.

The MCA is an executive Agency of the DfT is primarily responsible for implementing the Government's Maritime Safety Policy. This includes coordinating the search and rescue (SAR) at sea and checking that ships meet UK and international safety standards. The MCA also takes the lead in pollution surveillance and its Counter Pollution and Response Branch organises a series of training courses for local authorities to prepare their personnel to respond to shoreline pollution. It provides a command and control structure for the decision making process in the event of a shipping incident which could cause pollution in UK waters.

The Royal Navy (RN) supports agencies in the maintenance of the integrity of UK waters, including protection of offshore installations, shipping routes, anchorages and the fishing fleet. Additionally it conducts explosive ordnance disposal, drug interdiction, anti-pollution enforcement and provides platforms to the Security Service and the Secret Intelligence Service's when required.

The UK Chamber of Shipping is the trade association and voice for the UK shipping industry with around 140 members from across the maritime sector. It works with Government, Parliament, international organisations and others to protect UK flagged ships and the whole shipping industry on behalf of its members.

The Chamber shares joint chairmanship of the Shipping Defence Advisory Committee (SDAC) with the Ministry of Defence. A priority for SDAC is to maintain support for the current European Security and Defence Policy (ESDP) counter-piracy Operation Atalanta. Current issues include piracy, both worldwide and specifically in the Indian Ocean. At recent meetings port interests and the Lloyd's Insurance Market have been represented.

The UK complies with International Maritime Organisation (IMO) Directives and Maritime security is now an integral part of IMO's responsibilities and is considered the authority on all aspects of Marine Data Exchange. The mandatory security measures for international shipping which came into force in 2004 include a number of amendments to the 1974 Safety of Life at Sea Convention (SOLAS), the most far-reaching of which enshrines the new International Ship and Port Facility Security Code (ISPS Code), which contains detailed security-related requirements for Governments, port authorities and shipping companies.

7.2. Maritime Surveillance and Vessel Monitoring

The Long Range Picture

Maritime Domain Awareness can have very broad connotations so is normally referred to in a practical way as the Recognised Maritime Picture (RMP). Improving this maritime picture in recent years has been a subject of an increasing interest from a variety of users including military, law enforcement, environmental agencies, sea freight carriers or offshore oil and gas industries.

The UK MoD openly regrets[12] the scrapping of the Nimrod MRA4 programme that would have provided our National RMP and the UK's principal means of maritime surveillance in the medium and long term. These aircraft no longer exist; a fact that has left a serious capability gap[13] which the UK Government is now trying to fill. The intention is to replace them with other military assets on a case by case

basis, but there still is currently no single asset or collection of assets that can offset the resulting capability gap.

Other existing platforms could only provide a reduced capability and divert resources from other tasks which would have wider implications for defence. Indeed in the MoD's own assessment there would be significant shortfalls without significant investment, and the coordination of such assets at the right place and the right time might prove very risky. Evidence on the possible future of the UK Maritime Surveillance is contained in a Defence Committee document[14] which concludes that, among a variety of options, an upgraded version of the P-3 maritime surveillance aircraft remains a popular choice while, contrary to popular perception, there are some significant disadvantages to the methods of employment and capabilities of currently available Unmanned Aerial Vehicles (UAV).

There is a variety of alternatives including space-based systems but ultimately the issue is one of cost and national security. Whereas on the one hand US or European launched satellites could be used far more extensively to provide similar or even better information the cost would be very high. Deploying terrestrial based UK assets would be cheaper and provide more mission flexibility while also ensuring greater national control of the product.

The debate inevitably returns to the UAV which, while expensive, will always be cheaper than its manned equivalent. It also has a performance which is constantly improving. Vast amounts of data collection and high speed fusion with sensors and decision makers will be of increasing importance in the Maritime field and for this the UAV is proving itself unbeatable. Despite the limitations in UAV capability outlined by the House of Commons Select Committee[15] (HCSC) it is reasonable to assume that UAV technology is suited to many of the routine tasks required to undertake maritime surveillance.

It is likely that the UK will wish to move forward rapidly with a replacement for its MPAs and it is becoming increasingly clear that maritime UAVs, by dint of their many advantages, will become an important part of the UK surveillance ‘umbrella’ in the short to medium term if for no other reason than cost.

On the commercial front there is a variety of companies that specialise in this field but Frequentis UK[16] is an interesting multi-national company which characterises its “all-encompassing objective and prime orientation” as “maritime domain awareness”. It is the main provider of communications to the Port of London Vessel Traffic System[17] and it considers that maritime authorities should be able to identify any potential hazards to life, goods, territorial integrity and the environment in a timely manner. It is also a global company and provides voice and data communications to the Canadian Coast Guard in 24 Command and Control Centres and around 198 Coastal Stations in Canada´s five maritime regions.

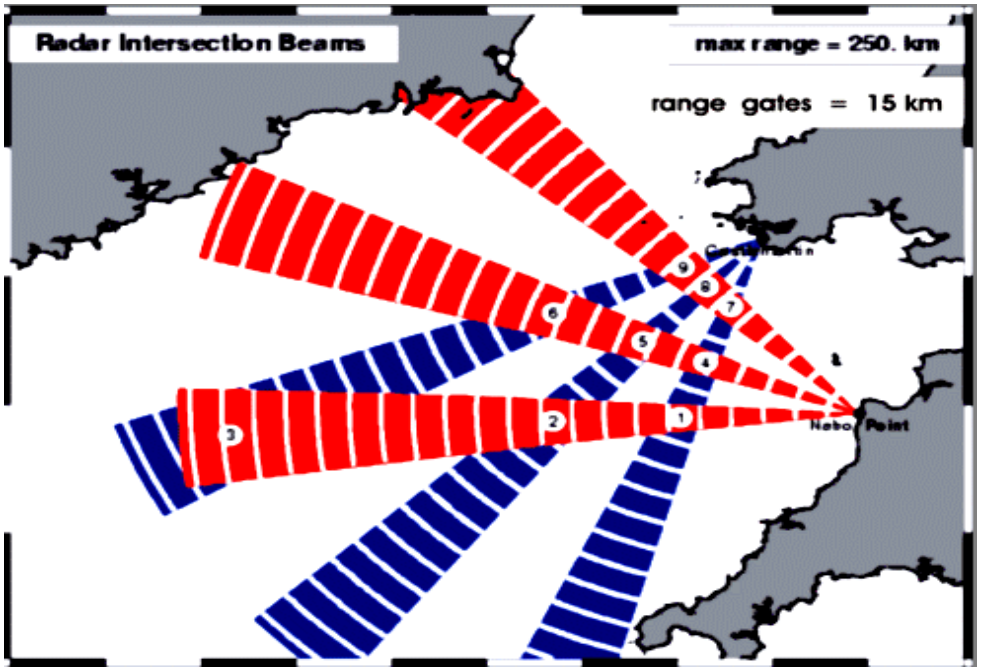
High frequency radar

High frequency (HF) radar is a long range system (up to 200nm) based on surface electromagnetic wave propagation and provides a unique capability to detect targets far beyond the conventional microwave radar coverage.

The UK is increasingly obliged to monitor its 200NM EEZ and regular maritime surveillance within this area is essential for national security. As a result HF radar systems could become an operational tool in coastal monitoring for many applications including ship detection, tracking, guidance, search & rescue, fishery

and research in oceanography. The disadvantage of HF radar is the size of the transmitter station which requires a large area for aerial installation.

Neptune Radar[18] is a UK company specialising in HF radar. It is known for work in the field of remote sensing of oceans by HF Surface-wave Radar and the analysis of data from HF Skywave Radar and Ionospheric Sounders. Neptune Radar has devoted much of its time to top level consultancy projects in support of HF Radar systems for both commercial and military use. As a result of its cooperation with the Universities of Birmingham and Sheffield, Neptune has been able to refine the emerging surface wave HF Radar technology and successfully establish its PISCES Sea State radar system, which has been in operation on the South-West Coast of the United Kingdom for nine years.



Maritime Surveillance - the medium range picture

Medium range systems cover approx 50-100 nm and attempt to satisfy two conflicting values – range and precision. Both are desirable but traditionally one must be sacrificed – one cannot have both. Modern day systems around the UK try to reconcile these differences. On a proprietary, off-the-shelf (OTS) level there is a range of modern, intelligent 'smart' surveillance systems marketed by UK based multi-national companies. SMARTBLUE is a Command and Control (C2) system developed by the UK based Raytheon Anschutz (RAn) Company. It provides the operator with 'full functionality' and control of a range of sensors to appreciate the maritime situation. It was designed as surveillance system and therefore fully IALA compliant for directing water traffic.

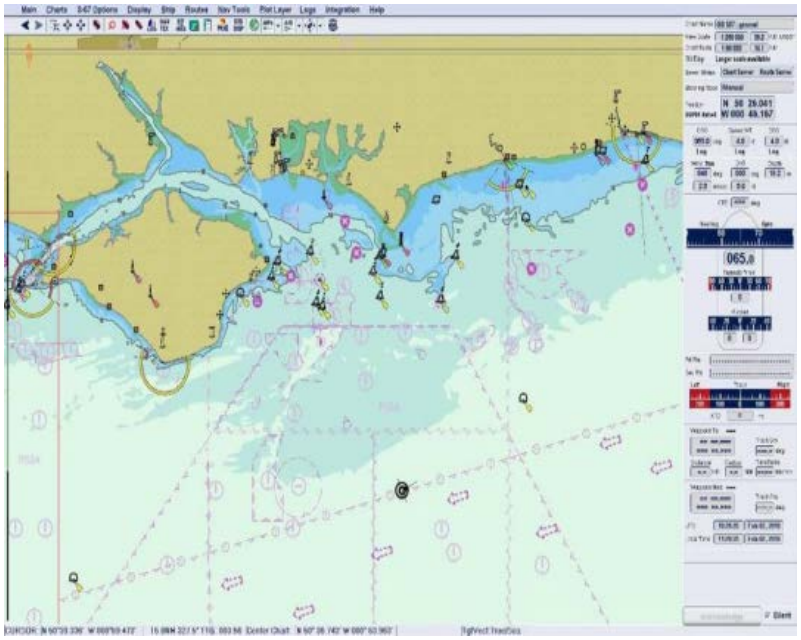


Figure 2. 'SMARTBLUE' computer generated image of the UK South Coast

A new product, it is nevertheless scalable (depending on area covered) and flexible (complexity of traffic situation) and can accept both Solid State and/or Standard Radar analogue inputs. Raytheon recommends the Kelvin Hughes 'Sharpeye[19]' Secondary Surveillance Radar (SSR) for this system. 'SMARTBLUE' can also link to any standard radar. It is able to integrate Automatic Identification Systems (AIS) as well as Close Circuit TV using proprietary Bosch systems right up to Electro Optical devices with laser range finders.

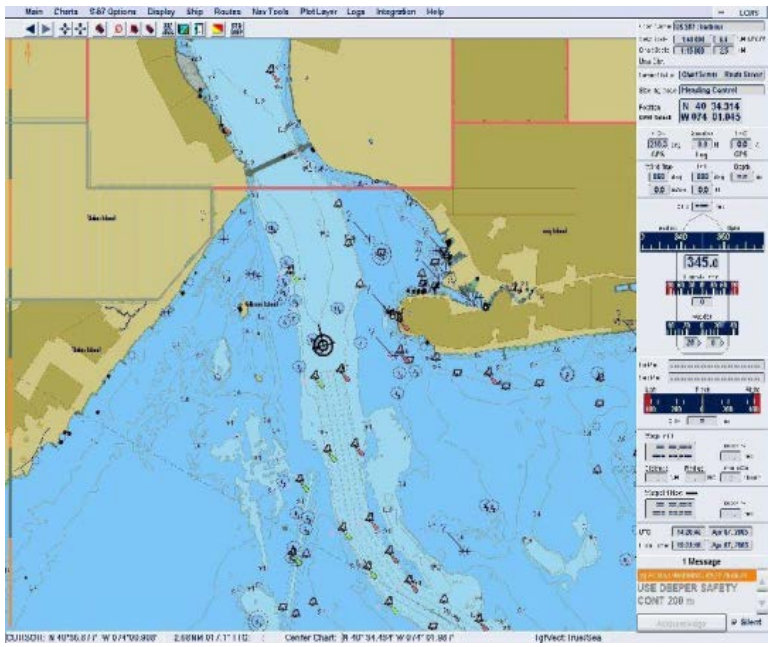


Figure 3. 'SMARTBLUE' showing the Lower Bay and the entrance to New York

Meteorological Sensor Input can also be connected and it is worth noting that Raytheon has a link with a Canadian company called Rutter[20] which provides Oil Spill Detection systems using the Rutter S6 Sigma processor fed by an 'X' Band radar system providing detection capability out to 3-5NM. (Note: The S6 Sigma processor changes the parameters of the radar to spot anomalies on the sea surface. It creates a polygon around this anomaly and then another sensor such as the CCTV system can verify the oil spill).

A diver detection system can be incorporated into SMARTBLUE in order to protect particular assets. However, while top of the range, it is considered expensive and has limited coverage unless multiple sensor systems are deployed. Linking SMARTBLUE with UAVs is possible, however transmitting video images can be expensive due to bandwidth requirements.

BlueFinger's SAFFIRE[21] product is also new but has a different development approach with lower costs and a more 'web portal' based concept. Bluefinger is part of a large mobile resource management and telematics company in Europe called Masternaut[22]. SAFFIRE is a flexible system which allows operators to monitor the tracking and telemetry feeds from vessels, people and specialist vehicles and plant, including airside vehicles and assets. These could include AIS, Inmarsat, Iridium, GSM/GPRS s well as others integrated into a single viewing and management platform.

The maritime surveillance capability of Bluefinger has been successfully adopted into the Anti Piracy and Counter Piracy surveillance sector supplying a number of leading Maritime Security organisations which in turn provide solutions to the Insurance market, ship owners, brokers and yacht owners.

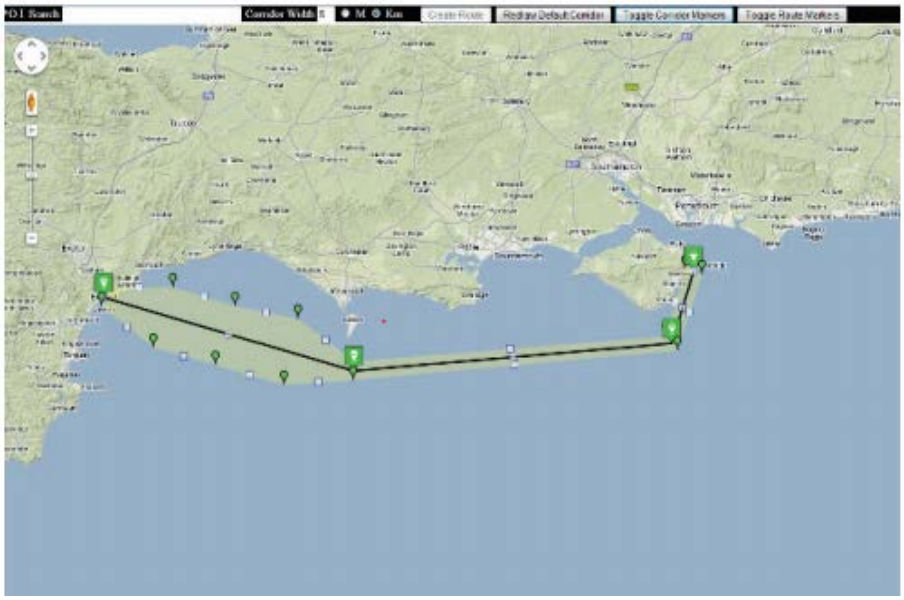
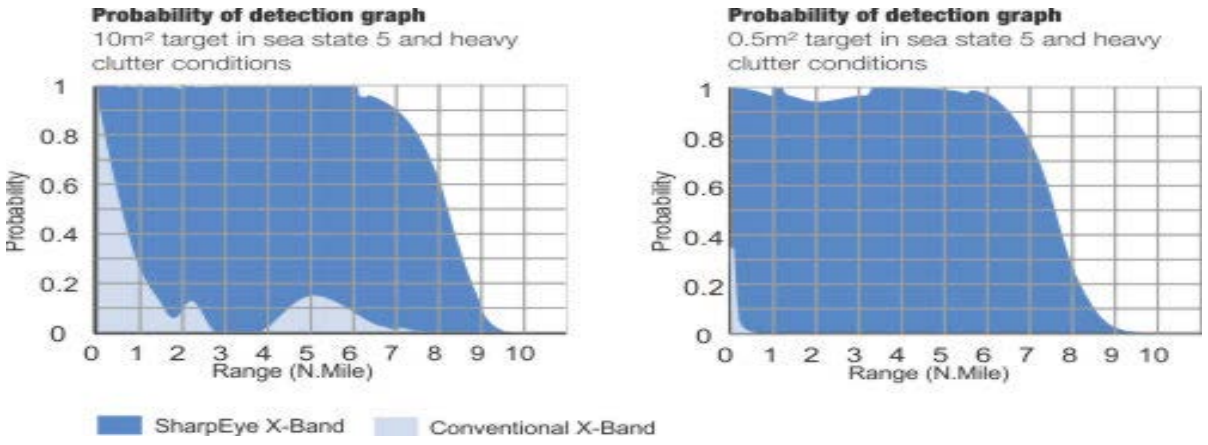


Figure 4. Vessel routes can be planned using the Saffire application. Route corridors or geofences can be automatically enabled, either at a fixed offset or tailored by the user for each leg, to monitor whether an assigned vessel deviates beyond the defined tolerance. Deviations will raise automatic system exception reports.

Bluefinger uses cooperative tracking, AIS, VHF/UHF radio and other surveillance systems to build up a comprehensive picture providing full EEZ surveillance. Consequently it has specialised in systems for the Fishery industry to many Governments around the world since 1995. BlueFinger also provides Precise Positioning products to some of the world's leading seismic exploration companies; providing timing and position data for Oil & Gas exploration operations. Currently Bluefinger is working to increase its penetration into on board vessels communications and in particular broadband services where the cost of using Broadband on a regular basis remains unacceptably high. Bluefinger is able to adapt to multiple data sources and has developed a data source integrator into a communications engine which manages all the external interfaces regardless of origin. As new sources are developed, they are added to the central data manager.

A UK company, Kelvin Hughes, markets the SharpEye digital radar technology which is available both in X and S band frequencies. It is a radical and innovative departure from current marine navigation radar technology in that it has no magnetron and uses a coherent transmission, which means that it is able to separate targets from clutter due to their differing radial velocity components. This extra dimension gives a significant performance advantage in detecting small targets in clutter resulting in safer ship operations.

SharpEye transmits relatively long pulses in order to illuminate targets with sufficient energy for detection while for the short range performance it transmits a patented sequence of pulses of differing length, with each pulse optimised to cover a specified but overlapping range scale.



Considered by many to be state of the art the graphs above compare the performance of conventional magnetron radar with that of SharpEye™ in S-Band indicating a significant performance advantage especially for a small 0.5m2 target.

Maritime Situational Awareness Systems

For many years now SELEX has pioneered a broad range of technologies within operationally deployed systems and integrated a range of sensors to deliver comprehensive situational awareness in a maritime environment. SELEX Galileo has developed the MSAS range of situational awareness systems which are able to combine crucial information from thermal imagery, radar, maritime charts and other data sources to provide comprehensive awareness to the operator in all

conditions day or night. SELEX has close links with naval applications and consequently many of its products are focussed on the specialised military market.

UK Vessel Monitoring - The Close Range Picture

Vessel monitoring moves the whole business of 'watching' the vessel one stage closer. If one thinks of 'awareness' as the basic whereabouts of a vessel i.e. "is it there?" and the 'surveillance' as the identification and occasional plotting of the vessel, the 'monitoring' of a ship or contact takes the process to a significantly higher degree. Whereas the previous two stages centred on the issue of national security and safety at sea (collision avoidance), the monitoring of a vessel requires much more care and attention and therefore demands vastly increased responsibility by both parties.

The best way to illustrate this is if one thinks of an Air Traffic Controller at Heathrow talking to an aircraft. Over the Atlantic the Controller is content just to worry about the side number of the aircraft but over the London Terminal Zone he will practically want to know the pilot's name. This is an over simplification but the comparison is relevant since in a sense the illustration is true for every aspect of security in and around the UK – whether it is surveillance in the London Underground or cameras in bus lanes. In the medium term it is likely that the UK coast will be one of the most monitored in the world.

As mentioned, the MCA is responsible for safety of life at sea and is currently modernising[23] to provide new, nationally networked coastguard coordinating rescues, running vessel traffic management arrangements where required and monitoring maritime activity around the UK coast. Once completed the network will be coordinated and managed from a new Maritime Operations Centre based at Southampton. Consequently, the whole UK network is in the process of being transformed for completion in 2015.

To achieve this conventional active radar is already widely used around the UK for marine surveillance both on shore and on vessels. Although performance of these systems is generally good there are currently both coverage and cost limitations. Coverage is limited by site and equipment availability as well as some technical limitations causing blind areas. Equipment procurement and deployment costs can be high and current spectrum management legislation may mean significant increases in licensing costs of active systems in the near future. However failure to provide anything less than the most advanced, most secure, and therefore the safest service in areas such as the Dover Straits would be the gravest of errors. In short, if this is currently true for CNIS, the MCA's Transformation programme is aiming to bring this level of service to other parts of the UK coast.

The improved capabilities offered by automated Vessel Traffic System (VTS) are most noticeable in some of the largest and busiest deepwater ports such as London[24] and Southampton[25]. It is worth highlighting that new technologies are allowing rapid progression towards semi-automatic and even fully automatic VTS. In the past this concept was reserved for air traffic control but with the advent of E-navigation and high definition CCTV and radar equipment being fitted as the norm both in vessels and in congested and high density waterways, VTS can automatically follow and in due course guide vessels throughout every point of a complex route.

Dover CNIS

A specific responsibility of the MCA is the CNIS at Dover. It is a Coastal Vessel Traffic Information Service (VTIS) principally concerned with the safe passage of traffic through the Straits ensuring essential information is made available in time for the mariner to make on-board navigational decisions. The information service provides broadcasts at fixed times and intervals, when deemed necessary by the VTIS or at the request of a vessel.

Figure 5. The CNIS in action

The equipment currently being used by CNIS Dover has recently been replaced and updated, arguably with the best equipment currently available. The radar transceivers are manufactured by TERMA, situated at strategic points along the UK to compliment equivalent equipment positions in France. They are fed by EASAT parabolic scanners which are then augmented with shipping information by AIS signals from SAAB Marine Electronics base stations before being displayed through Kongsberg Graphical User Interfaces. Notably the current MCA Transformation plan does not envisage changing any of this equipment in the medium term[26].

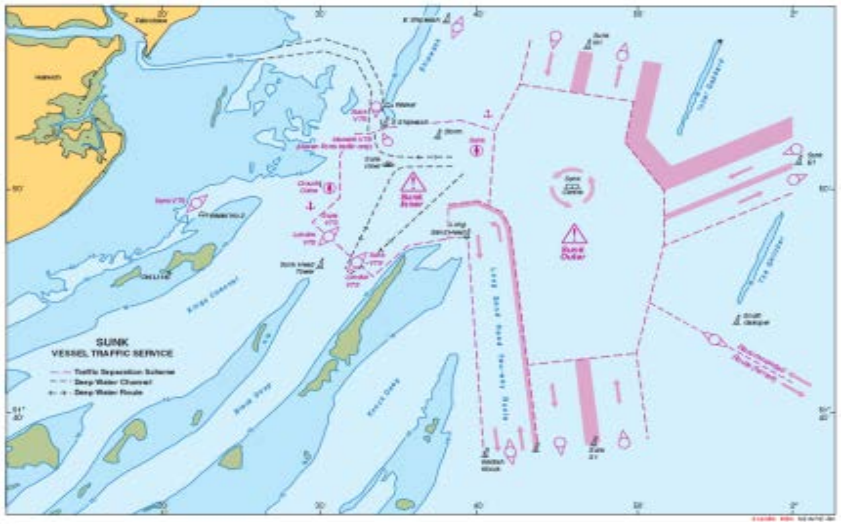


Figure 6. Traffic separation details in the vicinity of SUNK VTS

The MCA currently provides Traffic Information Services at Dover Strait TSS, Eastern Irish Sea VTS, and Sunk VTS and at other locations where VTS is established as a safety measure.

The MCA Transformation

The Technical requirements outlined in the MCA supporting documents[27]. The network will be controlled by the Maritime Operations Centre which will be the base from which all maritime functions are discharged, principally search and rescue coordination, counter pollution and vessel traffic monitoring. It has a distant horizon and is not limited geographically so is able to monitor a broad range of UK maritime interests extending to wherever national maritime interests exist. This will include UK territories and wherever a UK registered vessel is present. This is referred to as the UK Maritime Domain. A key deliverable for the future coastguard is maintaining knowledge of the current status of these areas.

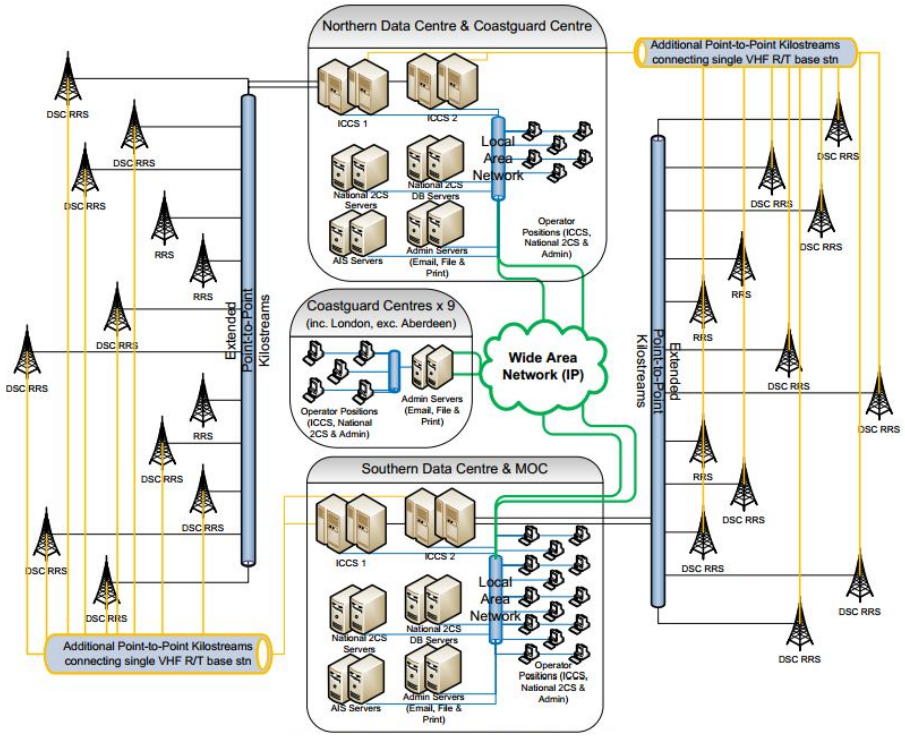


Figure 7. The new technical architecture is a 'hub and spoke' resilience design. If external networked communications fail, operational capability for the areas of work for which that Centre is responsible can be picked up from anywhere else in the network.

The design of the new system is compatible with the high level aims of data centre consolidation as outlined in the UK Government ICT Strategy[28]. While funding and suppliers have yet to be agreed the latest supported versions of key technology systems at Annex A of the supporting Document are worth noting by Canadian SMEs.

Passive Radar

Although not a mainstream product, passive radar is important because it offers a complementary radio frequency (RF) sensing technique which could expand coverage within the short and medium ranges while introducing significant cost savings. Passive radar can be defined as a sensor system relying on opportunistic transmissions to enable target detection using a receiver and appropriate signal processing software. This technique therefore eliminates costs associated with the transmitter licensing fees, and can be deployed in preference to active systems which are often insecure.

Passive radar technology is currently the subject of considerable research and there is growing interest in both civil and military fields. This is driven in part by the increasing availability of suitable transmitters of opportunity for such systems (especially AIS) and also by the potential cost/benefits of such a system compared to licensing and operating an active sensor system. Both THALES and EADS[29] are currently involved with research and development of passive radar and developed the Homeland Alerter 100 (HA 100) passive radar which was used in 2010 for air safety during the 14th July Bastille Day ceremonies in Paris.

Electronic Chart Displays (ECD)

The United Kingdom Hydrographic Office (UKHO) is the leading supplier of official Electronic Navigational Charts (ENCs) allowed under SOLAS Regulations. From 2012 Electronic Chart Displays (ECD) have become compulsory for certain vessels and the UKHO has produced a guide[30] to clarify the process that leads to adoption of ECDIS by shipping companies, in step with SOLAS Regulations.

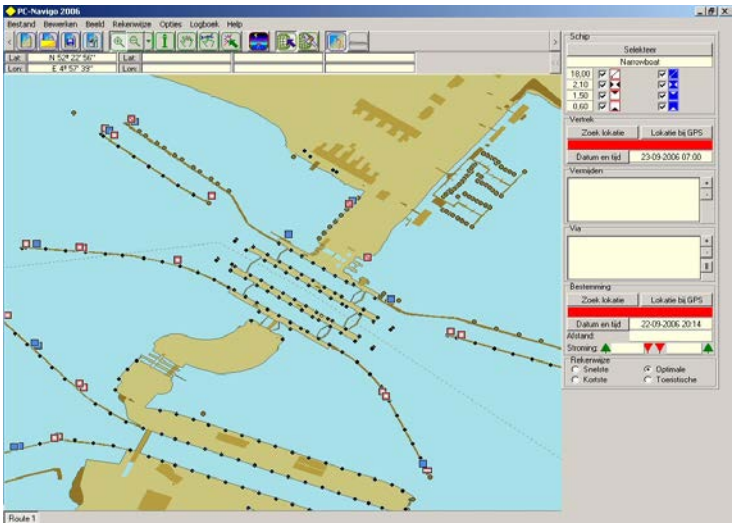


Figure 9. The locks of Schellingwoude, Amsterdam, displayed on an electronic chart display

ECDs are fitted widely in ships operating around the UK and IMO standards also require that vessels carry a backup to an ECD that can take over the chart-based navigation functions in event of system failure. The fitting of a second ECD or the carriage of paper charts are the two methods that are accepted as meeting the IMO requirements. The legislation is being phased in by vessel type and size to apply to all large merchant vessels and passenger ships.

Suppliers of ECD systems in the UK are mainly the principle suppliers of navigation equipment but, while the UKHO is unable to recommend vendors, it does produce a useful buyer's guide.[31]

Bridge Simulation Systems

This is a specialised area and, while a number of companies claim to offer integrated systems with service contracts, there is only a few which can be considered as offering comprehensive systems with full-life cycle support. Certain UK companies like Kelvin Hughes do offer bespoke simulation solutions but they tend to specialise in high performance radar designs orientated for mainly military purposes. One of the leaders in commercial bridge simulation is Kongsberg with its POLARIS system now in its 6th generation[32] . It is fitted as standard equipment in some of the leading maritime institutions in the UK including Warsash Maritime Academy[33]. VSTEP(ECDIS Ltd) markets the Nautis[34] which is fitted with a bespoke Kelvin Hughes radar simulation. SELEX also provides full mission simulation but it is tailored specifically for certain military platforms currently in service most notably in the UK and with allied navies, many of which are certified by the MCA.

E-Navigation

The prospects of E-Navigation[35] becoming a reality are now coming under very careful scrutiny as the e-navigation Strategy Implementation Plan (SIP),[36] under the control of the IMO, is coming into force.

The plan is already integrating existing and new navigational aids: in particular, electronic aids to navigation, in an all-embracing transparent, user-friendly, cost-effective and compatible system that will contribute to enhanced navigational safety while simultaneously reducing navigator workload. However, one of the gaps being identified is a possible lack of bandwidth and currently the IMO Sub-Committees have been tasked as the technical bodies to look into this. Also, there is concern that E-navigation does not sufficiently address the threat posed by cyber terrorism and that the systems currently being brought into service are not sufficiently robust or 'hardened' to cope with possible software attacks.

Figure 10. A schematic diagram of an E-Navigation concept

7.3. Maritime Observation and Science

The Information technology advances of recent years have revolutionised Maritime Science. The ability to observe, measure and analyse information thanks to relatively cheap technology using remote data collection and unmanned devices in real-time has allowed researchers to make a leap forward that would have been unthinkable just a few years ago.

Overall market confidence is high in the UK commercial Marine Science and Technology (MST) sector. The large majority of companies surveyed have experienced growth during 2011/12 and the reported turnover has increased to an estimated £1.35billion. Around 80% of companies expect to see an increase in overall market size and their individual company turnover over the next 12 months. The sector reported strong export revenue accounting for 37% of reported turnover amounting to £500m per annum.

A further sign of the confidence in MST is that employment has increased in the sector and 50% of companies expect to increase their headcount during 2012/13 although skill shortages continue to be a barrier to further employment. The difficulties in the Eurozone are reflected in the fact that companies do not see future growth in continental Europe as an export market with growth predicted as coming from the Middle East, Asia and South America. Offshore oil/gas remains a significant market for MST although renewable energy has an increasing influence on the marketplace.

The UK Natural Environment Research Council (NERC)[37] funds research in universities across the country and in six research centres around the UK. Several more centres around the country work in partnership with NERC to carry out research as it is needed. This ranges from rapid responses to urgent scientific requirements to strategic investment programmes and long-term surveys. NERC works with national and international partners including the UK Meteorological Office, the European Union and even NASA. As one of seven research councils funded by the Government they also collaborate with the other councils on issues of common concern under the banner of Research Councils UK[38].

NERC is particularly interested in improving business processes and driving innovation[39] as well as turning creative ideas into commercial opportunities. In particular it seeks to reduce financial risk in the innovation pipeline by boosting performance while reducing environmental impact. The NERC does this by matching business requirements to the right data and expertise, giving access to specialised facilities and research assets and channelling business requirements into future research.

The National Oceanography Centre (NOC),[40] which went live in 2010, is a national research organisation, delivering integrated marine science and technology from the coast to the deep ocean, working in partnership with the UK marine research community. It is owned by NERC and was formed by bringing together the NERC-managed activity at Liverpool's Proudman Oceanographic Laboratory and the National Oceanography Centre, Southampton, creating the UK's leading institution for sea-level science, coastal and deep-ocean research and technology development.

The NOC also welcomes foreign investment and works in close partnership with institutions across the UK marine science community and abroad addressing key science challenges including sea-level change, the oceans' role in climate change,

predicting and simulating the behaviour of the oceans through computer modelling, development, the future of the Arctic Ocean and long-term monitoring technologies.

To do this the International and Strategic Partnerships Office[41] (ISPO) is part of NERC's National Marine Capability. The ISPO is the NOC focus for international engagement and the development of international partnerships. It works with the UK and international marine science community and a variety of marine and maritime partners in the private and government sector to improve dialogue and sustained interaction in an inclusive, impartial way. ISPO provides the secretariat for Oceans 2025, the NERC marine centres' strategic research programme for 2007-2012, and also provides the NERC contribution to the secretariat for the UK Government's Marine Science Co-ordination Committee (MSCC). It also has an MOU with the University of Victoria, Canada.

Marine Robotics

An area of strong growth in Oceanography is marine robotics and investment in ROV research has recently been of considerable interest to the Canadian Government[42]. The UK has a strong track record in developing autonomous underwater vehicles and, over several decades, NERC - particularly through NOC - has led the world in the use of these technologies in exploring the world's oceans. The NOC has welcomed the news that its owning body, the NERC will receive £10 million over the next two years[43] for research and development of Marine Robotics. This area of technology development poses significant technical challenges, whilst offering enormous scientific opportunities. The development of sophisticated marine robotic systems builds on established expertise, enabling more cost effective routine mapping and monitoring of the oceans and seas. The UK's centre for autonomous underwater vehicles and robotics, Marine Autonomous and Robotics Systems[44] (MARS) is based at the NOC's waterfront campus and is the main centre for research and innovation in developing these submersibles – which include gliders and the highly successful family of Autosub AUVs and providing expertise to the UK marine science community.

Sea Gliders

Due to the advances being made in the Canadian Oceanographic sector the growth of the UK seaglider[45] technology is of considerable interest to SMEs. The NOC[46] has been using gliders to make innovative, advanced measurements of the ocean since 2006. The MARS facility was established In April 2012 to operate the NOC fleet of gliders. The sector has seen tremendous progress in vehicle technology in recent years and the Autonomous Underwater Vehicle (AUV) has become a technical reality. The NERC and consequently the NOC are particularly interested in developing this type of AUV that uses small changes in its buoyancy in conjunction with wings to convert vertical motion to horizontal, and thereby propel itself forward with extremely low power consumption. While clearly not as fast as conventional AUVs, their lack of speed can be used to great advantage by allowing the research to be conducted over a longer period of time which, in itself is a scientific consideration which previous technologies have not permitted.

Seagliders using buoyancy-based propulsion therefore represent a significant increase in range and duration compared to vehicles propelled by electric motor-driven propellers, extending ocean sampling missions from hours to weeks or months, and to thousands of kilometres of range. The Douglas Westwood report[47]

for the period 2011-2015 provides further reading on the growth prospects for the ROV Business which will be of specific interest to SMEs. It shows amongst other things that all of the fundamental market drivers for the ROV business are in a period of growth, which is likely to continue for the foreseeable future. Total annual market expenditure for ROV support of underwater operations is expected to grow from $891 million in 2010 to $1,692 million in 2015.

7.4. Communications, Data Exchange and Cybersecurity

Communications

Around the UK the MCA is responsible for the broadcast of Maritime Safety Information (MSI) on NAVTEX, VHF and MF and for providing the Radio Medical Advice Link Call (MEDILINK) Service[48]. However since current maritime systems are based on legacy analogue VHF radios and relatively low bandwidth digital satellite communications (SatCom) these services are set to evolve in the medium term as the MCS Transformation comes into place.

Unlike the terrestrial networks, advancement in maritime networks is severely lagging behind its land counterpart. The cost of bandwidth for SatCom networks is a key factor in persuading commercial traffic to modernise. It is expected to remain high due to the investment of launching satellites into orbit and also because of the technical requirement for the stabilizers for onboard antennas. On the other hand, outside the MCA Transformation programmed for the UK coast, it is worth noting that only MARINTEK (a Norwegian organisation), the main lead of the MarCom project,[49]is aiming at developing a novel digital communication system platform. It plans to introduce innovative mobile networks based on widely implemented land-based wireless systems and cheap, readily available broadband coverage. It is funded by the industry and The Norwegian Research Council's MAROFF programme.

Global Maritime Distress and Safety System (GMDSS)

Since 1999 GMDSS[50] has developed into an integrated communications system in use around the UK that uses satellite and terrestrial radio communications primarily for safety. It ensures that no matter where a ship is in distress, aid can be dispatched. GMDSS operation is strictly controlled and users are certified by the MCA[51]. Under the GMDSS, all passenger ships and all cargo ships over 300 gross tons on international voyages have to carry specified satellite and radio communications equipment for sending and receiving distress alerts and maritime safety information in addition to general communications.

Long-range identification and tracking (LRIT)

LRIT is an internationally regulated[52] system and a maritime domain awareness (MDA) initiative which allows Member States to receive a variety of reports from vessels[53] operating under their flag. The obligations of ships, Governments and rescue services to receive LRIT information are established in regulation V/19-1 of the 1974 SOLAS Convention.

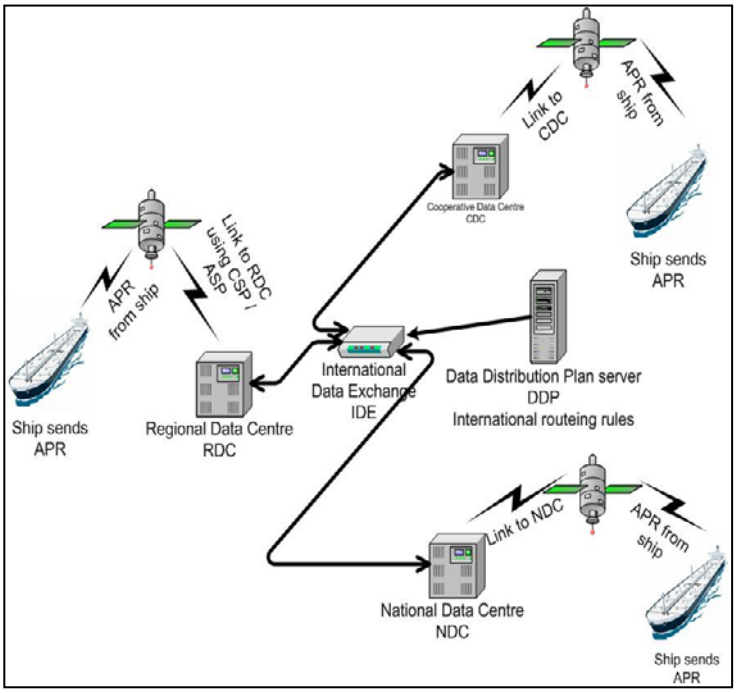


Figure 11. Simplified overview showing the process for linking the collection centres (data centres) operated by the Contracting Government to an exchange system known as the International Data Exchange (IDE)

Each Flag state is obliged to establish a National LRIT Data Centre or to join a Regional or Cooperative Data Centre. The Flag also has formally to appoint an Application Service Provider (ASP).

The LRIT system involves a request and response process, with various components linked together. Ship LRIT equipment must also be capable of being configured to transmit information as an Automatic Position Report (APR). This would include the identity of the ship, the position of the ship and the date and time of the position report. The equipment requirement is normally met through existing GMDSS INMARSAT equipment. The International Mobile Satellite Organization (IMSO) is the LRIT Coordinator who undertakes the audit and oversight functions.

Automatic Identification System (AIS)

It is important not to confuse the functions of LRIT with that of AIS since both systems are mandated by the IMO. AIS operates in the VHF radio band, with a range only slightly greater than line-of-sight. While AIS was originally designed for short-range operation as a collision avoidance and navigational aid, it has now been shown to be possible to receive AIS signals by satellite in many, but not all, parts of the world. This is becoming known as S-AIS but remains completely different from LRIT.

The only similarity is that AIS is also collected from space for determining location of vessels, but requires no action from the vessels themselves except they must have their AIS turned on. AIS transponders are currently only mandatory equipment for SOLAS vessels but increasingly VTS systems in the UK are using AIS in the transmit mode to direct water traffic which in turn is why the MCA is taking the lead to complete transformation of its operations by 2015.

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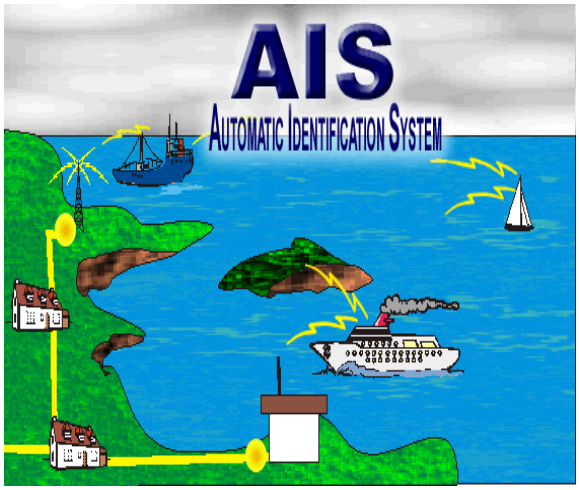

Figure 132. An AIS schematic displaying the essentially coastal nature of the system

LRIT and AIS

LRIT requires the active, willing participation of the vessel involved, which is a very useful indication as to whether the vessel in question is a lawful actor. However, the principle of AIS is to allow automatic exchange of shipboard information from the vessel's sensors - inputted, static and voyage related data - between one vessel and another and between a vessel and a shore station.

Thus the information collected from the two systems, S-AIS and LRIT, are mutually complementary. Co-channel interference near densely populated or congested sea areas satellites does cause problems.

In the UK the MCA coordinates the UK AIS service. However it should be noted that at the moment AIS coverage around the UK is neither complete nor continuous. There are gaps and not all areas are covered 24 hours a day.

Satellite Communications

INMARSAT, the British company, has a clear market lead in Satellite Communications. It uses a Geostationary Satellite system which is virtually unique and works by having satellites covering specific areas giving almost total coverage of the globe. The advantage of this over other systems is it normally has a clear line of sight to the satellite and there are no obstructions to affect the signal. Satellites are always located at points over the equator which means that the closer a ship is to the equator, the higher the satellite and therefore the more precise the signal. Conversely at the Poles the signal is lower and much reduced and therefore certain areas are considered blank spots.

To help overcome this INMARSAT is about to launch Global Xpress[54] which is supposed to provide full global coverage by late 2014. The Global Xpress satellites will carry 89 Ka-band beams and operate in geosynchronous orbit using a Ka-band network bringing higher speeds. INMARSAT believes the global demand for SAT-broadband services is set to expand rapidly as corporate and government users continually demand greater access and extend their networked activity. However, when questioned on coverage of the new GX system, INMARSAT stated that it will still use geostationary satellites which do not normally provide coverage at the

poles and that the extent of coverage will be confirmed nearer the launch of service.

The definition of 'broadband' is also evolving; throughput speeds that once seemed superfast can now be found routinely in the workplace or at home so Global Xpress will aim to satisfy this requirement. Boeing will build the three new Inmarsat-5 satellites that will offer downlink speeds of up to 50Mbps, and up to 5Mbps over the uplink from compact user terminals.

Iridium Telecommunications

An American multi-national corporation Iridium is the only serious rival to INMARSAT. The Iridium constellation is comprised of 66 Low Earth Orbit (LEO) satellites with additional in orbit spares. This unique network architecture of meshed, cross-linked satellites provides inherent advantages in performance and reliability.

Its system of LEO Satellites does cover the polar regions but because the satellites are moving rather than geo-stationary and their altitudes are relatively lower than those of INMARSAT there are some technical differences in the coverage.

INMARSAT and Iridium

inmarsat
Global Xpress™

At current rates INMARSAT is still cheaper than Iridium (hardware, monthly costs, and calls) and the UK based mariner could still be said to have a bias towards INMARSAT principally because it is a UK firm and they have been in the business longer. However it is important to consider the usage profile when comparing systems. Using Ka-band, Global Xpress will have rain fade/attenuation issues that will require L-band as a backup (used by Iridium) in order to ensure 100% connection. The Iridium system must be considered a growing competitor to INMARSAT particularly with its new Iridium Force concept coming on line by 2014 and in 2015, the Iridium NEXT system with speeds of up to 1.5Mbps.

8. UK Port Security and Safety

8.1. Port Security

The passage of people and goods of all sorts into UK Ports and Harbours has, over the last ten years, become an increasingly complex and expensive operation for those responsible for maintaining security and safety. The significant increase in global shipping and the exponential growth of the container business has brought its own security problems and to a large extent exposed their weakness against terrorist attack and organised crime.

On one hand, legislation requiring increased security, vigilance, checking, monitoring and safety has risen significantly and tended to encourage the authorities to monitor, suspect and restrict the flow of personnel and goods. On the other, the established technology for maintaining Port Security is under immense pressure to guarantee greater safety and even hasten the transfer of goods and personnel right across the supply chain.

Following the 2005 Terror attacks in London the EU has issued a directive[55] which requires Member States to ensure that port security plans are developed, maintained and updated. It adds that port security plans shall address the specificities of different sections of a port and integrate the security plans for port facilities within their boundaries.

The UK responded with Impact Assessments for certain ports[56] and it is worth adding that, since then, the UK Government has adopted a comprehensive approach to security and in particular to a major Terrorist Attack by undertaking a full re-organisation of the key security bodies resulting in the introduction of the National Crime Agency in late 2013.

Ports and ships are subject to a stringent inspection regime operated by Maritime and Land Transport Security[57], the Security arm of the DfT. It is part of the multi-agency threat and risk assessment groups which bring together all the agencies and organisations relevant to port security. UK Ports are constantly being consulted on new port security regulations which will be implemented by future EU Security Directives.

The threat of terrorist attack on naval bases, harbours, ports, oil platforms, terminals, underwater pipelines, shipping and coastal facilities is a growing problem for the UK.

Terrorist organisations are now training operatives in diving techniques, and the risk of attack on facilities from diver teams is now very real. Moreover systems, installations, infrastructure and ships are becoming larger and more complex so the result of any failure would be catastrophic.

Westminster International[58] provides a wide range of security and defence solutions for Ports which can be deployed to monitor, detect and respond to threats. Simple measures are often the most effective but the key test is the security and ruggedness of the systems integration which on the one hand must be comprehensive and efficient while also being resilient against false alarms, cyber attack and physical system failure. It is understood that Defence Research and Development Canada (DRDC) is very interested in the whole issue of underwater protection[59].

Underwater Security Net

Westminster's Underwater Security Net is perhaps an obvious solution for the physical protection of harbours, oil platforms and offshore infrastructure but its simple design will stop intruders both above and below the water from penetrating into sensitive areas. The fibre optic alarm net has a 100% effective detection capability and the cable running through the net module is connected to one optical transmitter and one optical receiver on the other side. As soon as the signal from the transmitter fails to reach the receiver, the alarm signals appear at the "Alarm Monitor" and the red flashlight in the middle part of the net will be activated.

Marine Barrier

The marine barrier is a simple, basic system but it would have provided significant protection to the USS COLE in 2000 had it been deployed. It is designed to prevent direct high speed ramming from small to medium sized marine craft and systems similar to this were used by the RN in the Port of London during the Olympic Games in 2012.

Diver Detection in Ports

Incursion by terrorists in civilian ports is now a reality. The Mumbai terrorist attacks have proved the inherent weakness of many high profile civilian and even military port defences. Unfolding events continue to confirm the sub-surface weakness of ports despite the lessons learned when navy frogmen first began to use them as points of attack in World War II. Consequently a considerable amount of effort is being expended by Industry to combat this threat well prepared. Kongsberg Mesotech Ltd, a leading maritime technology company in the field is developing a comprehensive diver detection system[60].

8.2. Maritime Management Systems

On a commercial basis there are important trends affecting the industry over the medium term. The ship owner today is faced with a multitude of onboard systems, each one developed for a specific purpose (e.g. a planned maintenance system, a crewing records system, a chart management system, a safety or security system etc). They are stand-alone insular systems and typically they have not been designed to operate beyond the local ship network. Very few have true two way data replication between ship and shore. Hence the end user has to work with a diverse disconnected collection of systems.

Convergence and economics are driving ship owners to have only one system comprising interrelated modules hosted on one technology platform. There are currently two options being developed. Companies such as Spectec[61] and Kelvin Hughes are attempting to develop one all-encompassing system with in-house developed modules. Other companies such as INMARSAT and Thomas Gunn[62] are attempting to create a platform or framework with standard IT protocols which allows third party experts to develop modules for their system.

Both solutions have advantages and disadvantages. The former (Spectec, Kelvin Hughes) will have consistent module integration but functionality will be limited. The latter (INMARSAT, Thomas Gunn) is likely to offer an evolutionary process which will result in good functionality but the dataflow between modules is likely to be restricted. Over the medium term the pressure will be on to see which companies succeed. However there are probably only going to be a handful of winners resulting in highly integrated systems capable of efficiently transmitting data between the vessel and ashore.

REG4SHIPS[63] is a UK company with a range of products and services that are designed to keep commercially operated vessels – container ships, bulk carriers, oil or chemical tankers, LNG or LPG carriers and super yachts – compliant with international maritime regulations, requirements and law. One of their core compliance solutions is a digital maritime regulations service. An important aspect for management systems is that shore authorities are able to track and monitor ships effectively using AIS for short range (VHF) monitoring and LRIT for longer range. These are now both statutory requirements but, in the future, there will be the need for a real-time monitoring system via satellite. This would benefit developing coastal states (particularly from a security perspective) and a greatly improved allocation of resources in piracy areas. It also resolves the political driver of "who guards the guards"?

8.3. Data and Cyber Security

The British Oceanographic Data Centre (BODC) is a national facility which hosts the Marine Environmental Data and Information Network (MEDIN) core team. MEDIN is a UK group working together in the UK and worldwide to improve access and stewardship of marine data. There are many European data and information initiatives in the marine domain currently being developed[64]. The group comprises over 30 partners representing the whole marine sector from the government departments, through research institutions to private value adding companies.

MEDIN is an open partnership that welcomes new members and provides a portal for access to marine data and information. MEDIN reports to the Marine Science Coordination Committee (MSCC)[65] formerly the Inter-Agency Committee on Marine Science and Technology (IACMST) and part of DEFRA. It is a government committee that develops and implements the UK Marine Science Strategy delivering the UK's Marine Objectives and other policy drivers.

Cyber Security

The issue of Cyber Security in the Maritime Domain is becoming increasingly important because of a lack of awareness within the industry. Put starkly, there is a capability gap between the enormous investment and reliance on IT in every sector of the shipping industry compared with the almost complete lack of security measures that are in use. The UK is no different from other countries and is perhaps more vulnerable than most being at the centre of one of the world's busiest sea-lanes (Dover Straits). There is genuine concern in the industry that not enough is being done to safeguard the value of maritime traffic which for the most part travels unseen and out of sight of 99% of the world's population.

Therefore the prospect of maritime terrorism on a 9/11 scale cannot be discounted and increasingly common hacking attacks on government and private computer networks are now being perpetrated on companies and organizations involved in the burgeoning private maritime security industry.[66] The EU has stated that Maritime cyber security awareness is currently low to non-existent. Member States are thus highly recommended to undertake targeted maritime sector awareness raising campaigns and cyber security training of shipping companies, port authorities and national cyber security offices. ENISA[67] has published the first EU report ever on cyber security and its challenges in the Maritime Sector. This principal analysis highlights essential key insights, as well as existing initiatives, as a baseline for cyber security.

While the IMO realises there is a developing problem with cyber terrorism it nevertheless mandated the transition from the primary use of paper charts to the Electronic Chart Displays (ECDs) beginning in 2012. This is a concern since sufficiently robust security systems have yet to be developed. There is currently little mention of security functionality for ECDs and neither has there been a significant move to combat cyber security in the maritime environment. The European Network and Information Agency (ENISA) exposed the problem in its report[68], but as yet many companies have yet to address the issue. This underlines a serious shortfall in security and a growing opportunity for maritime orientated cyber security companies.

Supervisory Control and Data Acquisition (SCADA)

SCADA systems are the unseen access and security networks which control large infrastructure installations, preventing unauthorised entry and ensuring safety through monitoring, surveillance and early warning sensors. They are discreet, protected and computerised but there are equally serious concerns about the security of SCADA systems currently in use. It is assessed that the move from proprietary technologies available before 9/11 to more standardized and open solutions available now has resulted in a large number of connections between SCADA systems and office networks and together with the Internet making them far more vulnerable to attack[69]. There is a perception that because SCADA systems are, by their nature, obscure, fire-walled and hidden from view behind physical walls and barriers they are more secure. This is not necessarily the case.

Security of SCADA systems is even more important because compromise or destruction of these systems would impact multiple areas of society far removed from the original compromise. Especially in the maritime sector which is hugely dependent on the security of vast infrastructure projects such as the new London Gateway with mega ships sailing close inshore by night etc.

The fact is that there are some unpleasant realities lurking closer than many would wish to believe. The STUXNET virus which for many remains a horror story reserved for the Sunday Newspapers has not gone away and has already re-surfaced in new forms called ‘Duqu’ and ‘Flame’. The Kongsberg company which supplies the radars for the Dover CNIS is taking it very seriously.[70]

The Port of London[71], the UK’s largest port, is arguably a market leader in operating a modern maritime SCADA systems. It handles over fifty million tonnes of cargo annually and is internationally acknowledged by shipping lines for its technical advances. It boasts the most sophisticated navigation systems and information technology in the industry so with over 28,000 vessel movements each year safety remains one of their prime objectives.

Biggleswade (UK) based Real-Time Software Systems Ltd was chosen by the Port of London to develop and install its new tidal telemetry system. It utilises a range of high performance ‘tele-control’ equipment and plays an important role in maintaining the safe movement of vessels along the 150km of water controlled by the Authority. The system consists of intelligent, programmable, radio-based outstations located around the Essex and Kent coastlines to monitor tidal depth. This data is reported to Real-Time Software’s Windows NT based client-server SCADA system at the Gravesend Control Room.

9. Security and Safety at Sea

9.1. Security Offshore

The growing interest in offshore installations for electrical power generation is driving a dynamic industry in wind farm production and inevitably an effective security infrastructure will be required to protect it[72]. Because of the nature of wind farm locations they are generally in new areas completely outside the established offshore business and as inaccessible to the authorities as they are vulnerable to attack form concerted groups of terrorists. Consequently, since more and more new offshore installations are being viewed as security targets, it is clear that they will require careful integration into the overall UK Security policy.

In addition, the Geographic location, economic importance and the exigencies of politics conspire to make offshore assets vulnerable, and these factors remain complicit in compounding the difficulties in protecting them. Moreover, the essentially hybrid nature of such installations means they retain most of the security downsides of both vessel and shore facilities.

The RN has always kept a close watch on offshore installation and permanently deploys groups of Royal Marines[73] in key locations to keep a careful watch on construction and operational activity in order to react quickly to any crisis. However the area of potential threat is vast and human resources are already stretched to the limit. In 2006, the attack on Shell's Benisede platform in the Niger Delta showed that even stationing soldiers aboard did not guarantee security and that protecting assets, lives and infrastructure from a deliberate asymmetric attack can never rely on military capability alone.

Offshore platforms have always enjoyed a special status in recognition of their position in the framework of critical infrastructure. However as un-manned wind farms become more prevalent there is a growing trend that sees responsibility for offshore counter-terrorism moving away from civil authorities and towards Defence forces. Safety of offshore installations is also the responsibility of the MCA[74] which is formal consultee in the consent process for any UK offshore renewable energy installation whether wind, tidal or wave powered. It is actively engaged in the offshore renewable energy application and consent process and its navigation and safety practitioner experience is valued by other Government Departments, developers and stakeholders alike.

In respect of security there is clearly common ground to be explored between national defence forces and energy production companies. Naval hardware is developing rapidly to meet the new dangers. Innovative technologies and systems including wide-area sensing and secure communications, coupled with the latest generation of agile littoral combat vessels providing an unparalleled first response to the potentially fast-evolving offshore threat.

Offshore security requires integrated systems to detect, deter and deny threats and, as has been shown for UK ports, much of the technology can be used for offshore as well – especially in the area of diver protection. The increase in 'intelligent' video that can monitor equipment and installations automatically is making it far easier to dissuade intruders from boarding a platform in the first place. Increasingly, electronic security systems are playing a more central part in this as the primary emphasis shifts away from night-time deck patrols and spotlights, particularly on larger facilities. Westminster International[75] offers a number of popular solutions as do US based, L-3 Klein[76].

The same wide-area sensing that characterises the advances made by military forces in mitigating the naval threat has been mirrored by systems designed for oil, gas and wind farm installations. The UK is currently coming to grips with an explosion of offshore wind technology and so the demand is growing despite the recession[77].

For example, infra-red illumination and thermal imaging overcome the inherent difficulties of video- in low light, while the latest developments in radar technology – and especially in the field of radar video surveillance (RVS) – have given offshore platforms a considerably longer detection reach. Operating within predefined extended boundaries, these systems can detect and notify personnel of vessel movements in the vicinity, escalating the response once an inner area of interest (AOI) has been breached.

Intelligent video systems have also made their way offshore, with the latest generations of analytical software classifying potential threats, helping crew make more informed decisions much faster. The problem of finally discerning the truly innocent approach from covert intrusion remains a human one, of course, but the early awareness helps reduce the likelihood of false alarm or mistaken intent on either side.

9.2. Security in UK Waters

The UK maritime services sector is responsible for well in excess of 260,000 jobs, a contribution of £13.8 billion to UK GDP and generation of £2.7 billion in tax receipts. The industry also supports diverse activity in other sectors. Although much of this comes from foreign trade outside of UK waters the UK maritime sector centred on the British Isles is considerable and together with maritime services and service providers from UK based suppliers the 'indirect' and induced contributions to the UK economy are enormous.

9.2.1. Specialised UK Maritime Stakeholders

It is worth mentioning some of the other stakeholders in addition to those already mentioned who play an important regional and local role in the Maritime Security of the United Kingdom.

The Marine Management Organisation (MMO)[78] is responsible for the new UK marine legislation which is a planning system based on principles of sustainable

development delivered in England by the MMO, and in Scotland by Marine Scotland. The MMO makes a significant contribution to sustainable development in the marine area promoting the UK government's vision for clean, healthy, safe, productive and biologically diverse oceans and seas. It has powers under the Marine and Coastal Access Act 2009 and brings together key marine decision-making powers and delivery mechanisms.

It has incorporated the Marine and Fisheries Agency (MFA) and acquired several important new roles, principally marine-related powers and specific functions previously associated with the Department of Energy and Climate Change (DECC) and the Department for Transport (DfT).

In the spirit of cross government responsibility the MMO marks a fundamental shift in planning, regulating and licensing activity in the marine area and exerts a strong emphasis on sustainable development. It is worth noting that, for political reasons, planning has a regional bias so that Marine Scotland is responsible for Scottish waters, the Welsh Government in Welsh waters, and the Department of Environment Northern Ireland and the Northern Ireland Environment Agency marine plan in Northern Irish waters. The UK is divided into marine areas - the map for England can be seen here[79].

The Environment Agency (EA)[80] is responsible for implementing the UK Government's Marine Plan[81]. This sets out high level objectives for the marine environment to be translated into more localised policies through marine plans. All decisions will be made in accordance with this Marine Plan and will provide greater certainty for developers and regulators alike. Marine plans will also be implemented through decisions of marine planning bodies, namely the MMO and Welsh Assembly Government (WAG), on licences/consents for development, as well as through decisions of other public bodies in relation to their planning / regulatory roles.

Most notably perhaps is the Scottish Government which has enacted its own marine legislation and, while broadly similar to the UK Act, allows Marine Scotland to take on overall planning responsibilities including sectoral plans for offshore energy as well as a decision-making role. Port development decisions are however taken by the Transport Scotland Agency.

The Department of the Environment, Food and Rural Affairs (DEFRA) sets policy and legislation to deliver in a variety of areas but specifically in the maritime sector in the marine and aquatic environment, biodiversity, sustainable development, the green economy, fisheries, environmental protection and pollution control. It works closely with the MMO on the development of the Marine Programme Plan (MPP).

The Maritime Rescue Coordination Centres (MRCC) are under the authority of the MCA which has responsibility for the entire network around the UK coast. The MRCC network[82] is currently being revised to deliver a more integrated search and rescue coordination service. It will be taking full advantage of modern communications technologies and centres will be able to support each other across the network during busy periods, thus sharing the work load. However it is unlikely to be operational before 2015.

Trinity House is the General Lighthouse Authority (GLA) for England, Wales, the Channel Islands and Gibraltar. Their remit is to provide Aids to Navigation to assist the safe passage of a large variety of vessels through some of the busiest sea-lanes in the world. To meet its obligations it deploys an array of more than 600 navigational aids, ranging from lighthouses to a satellite navigation service.

Responsibilities include the annual inspection and auditing of over 10,000 Aids to Navigation provided by local port and harbour authorities and those provided on offshore structures such as production platforms or wind farms. Trinity House is also responsible for marking, and dispersing wrecks which are a danger to navigation.

Royal National Lifeboat Institution (RNLI) is the charity that saves lives at sea. Composed solely of volunteers it provides a 24-hour search and rescue service in the United Kingdom and Republic of Ireland from 236 lifeboat stations, including four along the River Thames and inland lifeboat stations at Loch Ness, Lough Derg, Enniskillen and Lough Ree. Additionally the RNLI has more than 1,000 lifeguards on over 180 beaches around the UK and operates a specialist flood rescue team, which can respond anywhere across the UK and Ireland when inland flooding puts lives at risk.

The UK Met Office initiates all Weather Navigation Warnings and prepares routine forecasts for dissemination on behalf of the MCA which is responsible for the provision of Maritime Safety Information (MSI) to ships at sea. The UK Met Office acts as the Navigation Area I (NE Atlantic) coordinator for the IMO and International Hydrographic Organization (IHO), the Worldwide Navigational Warning Service (WWNWS) and also as the United Kingdom National Co-ordinator for issuing coastal navigational warnings. The approved method of receiving Maritime Safety Information (MSI) is via the appropriate IMO, Global Maritime Distress and Safety System (GMDSS) broadcast systems.

9.3. Security in International Waters

The security of UK flagged shipping outside of the country's EEZ is governed by the United Nations Convention on the Law of the Sea III (UNCLOS III) which came into force in 1994. It is considered the definitive 'international document of law' governing all aspects of shipping on the High Seas (areas in dark blue). It is important to remember that International Law governs the way countries deal with each other but not how a contravention or incident is dealt with by a specific country outside its EEZ. It is for this reason that the issue of 'International' piracy' and international terrorism remain so problematic for national governments and a significant obstacle for those under threat. Before looking at the technical aspects of UK shipping in international waters it is worth briefly summarising some of the additional stakeholders responsible for official activities. The UK Government and the UK maritime Industry are both active contributors to all these organisations.

The Foreign and Commonwealth Office[83] (FCO) and the Ministry of Defence[84] (MoD) together with the Special Intelligence Services[85] are the main defence organisations against threats to UK shipping outside of UK waters. The issue of piracy is not new but has risen in importance since 9/11 because of the increasing success rate of pirate operations off the coast of Somalia up to late 2011, the extortionate sums of money demanded and the possibility of a link with international terrorism. Consequently while Governments have been preoccupied with developing political and legal mechanisms by which piracy can be controlled and combated, armed forces and private contractors have seized on the opportunity to increase patrols and hit back at pirates as and when they attack.

The RN contributes considerable resources to the fight against piracy and continues to be the main defence of overseas territories ensuring safe navigation on the High Seas and enforcing International Law. Along with Allies it is involved

with a number of International Missions supporting both a NATO Mission, Operation Ocean Shield[86] and the European Union counterpart called Operation ATALANTA[87]. It also contributes to the US led Combined Maritime Force.

Operation OCEAN SHIELD

Aiming to stem the growth of piracy in the Gulf of Aden (GOA) and off the Horn of Africa and in accordance with UNSCRs, NATO has been helping to deter and disrupt pirate attacks, while protecting vessels and helping to increase the general level of security in the region since 2008. The RN has been closely involved with OCEAN SHIELD, which evolved from previous missions in the area providing food to Somalia. It now contributes to providing maritime security in the region and helping to reduce the overall pirate attack success rate.

The NATO Strategic Assessment of March 2012 highlighted the need to continue to erode the pirates' logistics and support base by, among other things, disabling pirate vessels or skiffs, attaching tracking beacons to mother ships and allowing the use of force to disable or destroy suspected pirate or armed robber vessels. In order to respond to new piracy tactics, NATO has developed its use of the NATO Shipping Centre[88] based at Northwood UK.

Operation ATALANTA

Like NATO, the European Union is concerned with the effect of Somali-based piracy and armed robbery at sea off the Horn of Africa and in the Western Indian Ocean. As a response and as part of a comprehensive approach agreed by Member States, the EU launched the European Union Naval Force (EU NAVFOR) Somalia in December 2008, also in accordance with UNSCRs.

Operation ATALANTA has many common objectives with Op OCEAN SHIELD and there is close cooperation. Similarly, EU NAVFOR operates in an Area of Operation covering the Southern Red Sea, the Gulf of Aden and a large part of the Indian Ocean, including the Seychelles. The Area of Operation also includes the Somali coastal territory as well as its territorial and internal waters.

NATO Shipping Centre

There are clear indications of an emerging willingness among the commercial shipping community to co-operate more with NATO especially when it is in its economic interest and recent anti-piracy operations have demonstrated the need for closer co-operation with commercial shipping.

The NATO Shipping Centre (NSC) was set up to be the key link between NATO naval forces and the merchant shipping community and the primary point of contact with NATO's military authorities. Importantly it is part of the Allied Maritime Command Headquarters Northwood in the UK and geographically close to the commands of other allied navies and in particular the activities with the EU Operation ATALANTA. The NSC is permanently manned by NATO staff who are the primary advisors to shipping regarding potential risks and possible interference with maritime operations.

In order to reduce both conflict of interest between military and merchant shipping, and to enhance safety and security at sea, NATO has developed and implemented the concept of Naval Cooperation and Guidance for Shipping (NCAGS)[89]. NCAGS provides the interface between military operations and merchant shipping assisting cooperation and providing guidance, advice, and at times naval supervision of merchant shipping. The UK Government and the RN is closely involved with all

aspects of the NCAGS capability and NATO has released a non-classified publication which covers the relationship with civilian shipping.

Maritime Security Centre – Horn of Africa (MSCHOA)

MSCHOA is an initiative established by EUNAVFOR with close co-operation from industry. MSCHOA provides 24 hour manned monitoring of vessels transiting through the Gulf of Aden (GoA) while the provision of an interactive website enables the Centre to communicate the latest anti-piracy guidance to industry and for Shipping Companies and operators to register vessel movements through the region.

It has also introduced Group Transits where vessels are co-ordinated to transit through high risk areas overnight to reduce attacks and this enables military forces to 'sanitise' the area ahead of the merchant ships. MSCHOA identifies particularly vulnerable shipping and coordinates appropriate protection arrangements, either from within EU NAVFOR or other forces in the region. MSCHOA is based at Northwood UK and works in close cooperation with the NATO Shipping Centre.

UK MTO Dubai

The UK Maritime Trade Operations (UKMTO)[90] office in Dubai is a contribution by the RN to help ensure that trade can transit safely in the area North of 10 degrees South and West of 78 degrees East. It acts as the primary point of contact for merchant vessels and liaison with military forces in the region.

UKMTO Dubai coordinates the management of all merchant ship and yacht movements in the GOA area. It also administers the Voluntary Reporting Scheme, under which merchant vessels are encouraged to send regular reports, providing their position/course/speed and estimated time of arrival at their next port. It is recommended that yachts give their position to UKMTO on a daily basis. All ships are strongly advised to read and implement the publication, Best Management Practice (BMP4)91 which is issued by the International Shipping Community and provides guidance to help self-protect against Somali pirates while transiting the High Risk Area.

Regional Anti-Piracy Prosecutions and Intelligence Co-ordination Centre (RAPPICC)

During the February 2012 London Conference on Piracy and Somalia, the United Kingdom agreed to establish a Regional Anti-Piracy Prosecutions and Intelligence Co-ordination Centre (RAPPICC) located at an old Seychellois Coast Guard base near Victoria. The UK has made an important contribution to RAPPICC in the form of its first Director and initial staff who were provided by the British Serious Organized Crime Agency[92].

RAPPICC is an information fusion centre and part of the Oceans beyond Piracy Project which is funded by the One Earth Future Foundation. RAPPICC facilitates the capture and prosecution of the financiers, investors and ringleaders of Somali piracy. In 2012 the US announced it was examining possible support to and participation in RAPPICC, along with Norway, Australia, the Netherlands, the Seychelles, Italy and Denmark. RAPPICC is engaging with the regional states of South Africa, Mauritius, Kenya and Tanzania. RAPPICC's philosophy is to separate the 'financiers, instigators and investors' of piracy from the 'foot soldiers'. RAPPICC will assemble prosecution packets for naval/flag state jurisdiction, which will include the accused, the complainant and the evidence to deliver to the chosen forum. RAPPICC will work with partners in determining the appropriate jurisdiction.

Anti-Piracy – Physical Defence

The principle aim of on-board anti-piracy technical solutions is to empower the master and crew to react swiftly and effectively against violent physical attack whilst underway at sea. For a variety of reasons the emphasis is on non-lethal means but mainly to limit the use of force to the minimum required to repel and attack.

There is a considerable range of equipment on the market involving a variety of technologies from the simple to highly complex. This is just a sample. The common theme among all devices is a broad adherence to the BMP 4 guidelines on Protection against Somalia based piracy and there is a strong recommendation for relevant crew training using simulated action which can be undertaken well in advance of a ship entering the High Risk Area.

Layered Defence

Merchant Maritime Warfare Centre (MMWC) is a UK based company advocating a multi-layered defence system which provides a suitable methodology to cover gaps in own-ship protective capabilities. It is considered an effective non-lethal approach to vessel security and is recommended for all merchant vessels. It provides early detection of a threat, allows sufficient time for coalition forces to render assistance as well as adequate time for the crew to find a safe area. It also prevents unauthorised boarding if the attack continues.

Propeller Arrestors

An interesting development of non-lethal protection is the MMWC Propeller Arresters™ which form a critical layer of physical defence between the vessel and potential pirate craft. Designed for easy and multiple deployment, the Propeller Arresters™ release 100 metre lines of buoyant polypropylene rope to create an impenetrable security perimeter around the vessel. Any attempt to cross these lines in a skiff will entangle the propeller and cause the engine to stop immediately, ultimately thwarting the attempted hijack. The Propeller Arresters™ are deployed on simple 10 metre booms either side of the hull, from the bow to the stern, running aft the full length of the vessel. Units are also placed around the stern creating a 'No Go' zone around the vessel with zero danger to own ship propulsion. They are designed to remain deployed for the duration of the transit meaning risk to the crew is significantly reduced during High Risk Area passage.

Nemesis 5000

The UK Dasic group[93] is an award winning company that offers a simple and relatively inexpensive device to keeping pirates from boarding a high sided vessel. The Nemesis 5000 is a comprehensive security solution to the ongoing piracy threat and works by implementing a high impact water jet curtain from the vessel's fire water system around the perimeter of the vessel.

Long Range Acoustic Device (LRAD)

The Long Range Acoustic Device (LRAD) produced by the LRAD Corporation is a non-lethal, directional acoustic array for the precise targeting of audio at an aggressor. It can be integrated with other solutions such as cameras and sensors together with a software control interface. The aiming and positioning system allows users to locate, communicate with and deter specific potential threats over extended distances.

In a maritime environment the LRAD fills the critical gap for vessels to hail, notify and warn approaching vessels at significant ranges, with audible voice or pre-

recorded messages in any required language. It extends the stand-off and perimeter and provides enhancement to force protection allowing communication at safe ranges to gain compliance, establishment, and change behaviour. Notably it has a “Stand-Off” capability in excess of 500m.

Protector

BAE Systems and the Israeli company Rafael have designed the Protector[94] as an Unmanned Surface Vehicle (USV) that responds to the demand for a pro-active ‘lethal’ solution to combat terrorism equipped with a stabilized mini-Typhoon weapon system, cameras, radar equipment and electro optics. BAE Systems admits that it was originally designed for military purposes; however it is clear that, if required, it could potentially be modified for commercial use. Highly autonomous, the Protector can successfully operate with broad guidance from a commander and operator in ports, rivers, harbours and coastal waterways making it an innovative solution for today's critical missions. These could include force protection, anti-terror, surveillance and reconnaissance and, if need be, simply to investigate a potential threat.

10. Developments and Innovations

10.1. London Gateway – Newest Port Development UK

The newest port development in the UK for 20 years will be the container handling development at the London Gateway[95]. It is a £1.5bn development covering 560 acres on a 'brownfield' site on the north bank of The Thames near the former Shellhaven refinery at Stanford Le Hope.

Opening in late 2013, it will transform the Rail-freight container business and directly challenge Southampton and Felixstowe docks.

When completed it will be the UK's first 21st Century major deep-sea container port and Europe's largest logistics park. It will offer a 2.7 kilometre-long berthing capacity on the River Thames frontage supporting over 12,000 new jobs.

For nearly twenty years Felixstowe[96] has been the UK's premier container port so, while London Gateway[97] will not take that mantle overnight, its existence will provide a competitive challenge. What prominent UK freight forwarders believe is that both London and Felixstowe should begin promoting the UK as an alternative distribution point for Europe as a whole, particularly in regards to imports from Asia.

This is based on three factors: the UK's deep-sea ports have traditionally been the first call on Asia-Northern Europe and the last call on Northern Europe-Asia routes; the change in value of Sterling against the Euro has given the UK significant operating cost advantages; and thirdly, the ongoing Eurozone crisis profoundly undermines any confidence cargo owners might have about investing in continental distribution hubs.

The company involved is Navis, a subsidiary of Cargotec98, which supplies the terminal operating solution (TOS) for the London Gateway. Cargotec was also contracted to supply 40 Kalmar automatic stacking cranes and 28 Kalmar shuttle carriers.

The Port of London Authority (PLA) provided services such as diving, salvage and hydrographic surveys, monitoring of licences, and tidal works approval for the project. The high energy impact compaction (HEIC) works are being carried out by LANDPAC[99]. The transportation and the environmental engineering services are being provided by AECOM[100]. The company also carried out the environmental impact assessment for the project. Part of the construction work of the terminal has been contracted to the joint venture of Laing O'Rourke and Dredging International. ZPMC will supply eight quay cranes for container operations at the rail terminal.

10.2. Improving the security of maritime operations

Currently the UK MoD is looking for ways to strengthen the security of maritime operations[101] so that it can be more effective at combating illegal activities such as gun-running, people-smuggling and piracy.

To do this MoD has invited the Defence Science & Technology Laboratory (Dstl)[102] to take the task forward and maximise the impact of science and technology. To involve the commercial world where possible and encourage freedom of thought Dstl believes that the work should be conducted by external suppliers (industry, universities and other research organisations) unless there is a clear reason for it to be done by Dstl.

Dstl operates by providing the government with a wide programme of research and scientific and technical support, delivered from internal and external resources.

Dstl's science and technology work covers a range of applications and disciplines including social science, mathematics and engineering and includes research, advice, consultancy, technical and systems risk management, and related activities.

Under Dstl, the MoD's Centre for Defence Enterprise (CDE)[103] is the first point of contact for anyone with a suitable 'disruptive' technology, new process or innovation that has a potential maritime security application. CDE funds research into novel high-risk, high-potential-benefit innovations sourced from the broadest possible range of science and technology providers, including academia and small companies, to enable development of cost-effective capability advantage for UK Armed Forces.

Specifically it is seeking proof-of-concept research proposals to improve the security of maritime operations. Areas of interest include:

- Methods to distinguish between lawful and unlawful craft, crew and operations on the High Seas
- Developing new technology that can provide a graduated range of responses particularly using non-lethal and non-destructive means.
- Improving small arms accuracy at sea by developing new tools and training aids representative of maritime platforms.

11. Conclusions

Maintaining the safe and secure passage of British sea trade around the UK coast and across the world in whatever form will remain an imperative of the UK Government. The UK maritime sector centred on the British Isles is considerable and together with maritime services and the UK based service providers makes an enormous contribution to the UK economy. Piracy in the Indian Ocean remains an immediate danger however new threats to shipping from diverse illegal activities are likely to proliferate and threaten UK businesses, ships and seafarers.

The future of UK maritime surveillance has recently pre-occupied members of the UK Parliament and the MoD now openly regrets scrapping the Nimrod MRA4 programme. UK maritime surveillance options include a variety of possibilities and an upgraded ORION P-3 remains a popular choice. However, the Unmanned Aerial Vehicle will always be an attractive, cheaper alternative and therefore will remain a serious contender as a future capability. In this respect Canadian SMEs may find interesting opportunities for development in UAV technologies.

Medium range surveillance around the UK coast still has to work hard to satisfy two conflicting values – range and precision. However, a combination of modern precision radar coupled with high speed automatic information systems will soon be able to provide a very accurate and reliable picture of UK coastal activity. The surveillance challenges around the Canadian coast are likely to be very similar as climate change opens up the North West Passage.

Constant close range monitoring of ships over extended areas is becoming a reality. As such the demands of responsibility by both parties - ship and shore - are increasing significantly. The role of the MCA is taking on a new and powerful dimension around the UK coast and is currently modernising to meet this challenge with new semi-automatic and even fully automatic technologies.

E-Navigation is now a reality and the IMO is gradually but systematically legitimising an increasingly broad range of electronic onboard systems while at the same time ensuring a minimal back-up option. There are significant questions about reliability in the event of failure or cyber attack but ashore the role of maritime simulation is growing and certain companies offer very realistic and highly developed systems which provide excellent training.

In the UK commercial Marine Science and Technology market confidence is high and the National Oceangraphic Centre backed by the Natural Environment Research Council is particularly interested in improving business processes and driving innovation. The aim is to reduce financial risk by boosting performance while reducing environmental impact. The University of Victoria, Canada, is already actively partnered with the International and Strategic Partnerships Office.

An area of strong growth in oceanography is marine robotics and investment in research continues to be of considerable interest to the Canadian Government. Due to the advances being made in the Canadian Oceanographic sector the growth of UK seaglider technology is likely to be of considerable interest to SMEs. There is great interest in the UK in developing this type of autonomous underwater vehicle.

This is a concern that sufficiently robust maritime security systems have yet to be developed both ashore and afloat. The European Network and Information Agency has expressed a strong concern about the lack of preparedness for a cyber attack highlighting a serious shortfall in security and a growing opportunity for improved

measure to enhance maritime cyber security. There are serious concerns about the security of SCADA systems protecting maritime security systems and IMO appreciates there is a developing problem with cyber terrorism in the maritime sector.

Offshore platforms retain a special status in the framework of critical infrastructure. There is a growing trend that sees responsibility for offshore counter-terrorism moving away from civil authorities and towards Defence forces. Naval hardware is developing rapidly to meet the new threats using automatic, wide-area, remote sensing systems. The UK Government has adopted a comprehensive approach to security and in particular to a possible major Terrorist Attack.

Current maritime communications systems are legacy analogue VHF radios and relatively low bandwidth digital satellite communications however the transformation of the MCA will change the order of business along the UK coastline significantly across the complete spectrum of frequencies from VHF up to SHF including LRIT including AIS and satellite systems. In data exchange convergence and economics are driving ship owners to have only one system comprising of interrelated modules hosted on a single technology platform.

International Law is the mainstay by which sovereign countries deal with each other but it does not cover how a contravention or incident is dealt with by a specific country in International Waters. This is the main reason why 'International' piracy at sea remains so problematic for national governments. The UK, along with allies like Canada, remains a key actor in a variety of international military forces, organisations and initiatives to counter this and other threats in International waters.

On-board anti-piracy technical solutions now go a long way to empower the master and crew to react swiftly and effectively against violent physical attack using multi-layered defence systems and innovative cost-effective solutions.

New maritime developments in the UK include the significant leap in the container handling capacity that will be afforded by the new London Gateway complex opening in 2013. It will receive the world's largest ships and transform the container handling capacity for the whole of the capital and the South East of England. Also, the UK MoD is spearheading imaginative initiatives to involve all aspects of academia, research, development and the commercial world to encourage work that could improve the security of maritime operations by distinguishing between lawful and unlawful craft, developing graduated responses using non-lethal means and improving small arms accuracy at sea.

In conclusion, the UK Maritime Security and Safety sector offers a broad range of high-tech opportunities in mainstream and niche markets supplying both the marine industry and research projects. Many of the building blocks for cooperation are already in place and, with the Canadian coastline significantly longer than the UK and bordering on some of the most environmentally challenging waters in the world, the technological advances being made in the UK maritime security sector offers significant potential for cooperation with Canadian maritime companies.

12. Reference Tables

12.1. UK Maritime Domain (para 6)

Sub-Sectors	Drivers	Growth trend in Medium Horizon	Possible Commercial Opportunities	Emerging Technology/Innovation opportunity	Who are the customers	Favourable to Canadian Industry
6.1 - Key Stakeholders	-UK Gov.wants to rationalise departments and agencies - embraces 'do more with less' concept	Medium - focussed on innovation	Software	More user-friendly but also more secure systems	UK Government departments	Yes
6.2 - Maritime Surveillance and Vessel Monitoring	-Anti-Terrorism, -Countering illegal-Immigration	Medium - looking to reduce manpower requirement	Automatic systems	UAVs, CCTV, remote sensing technology, HF radar, passive radar, E-Navigation	UK MoD, MCA , Raytheon UK, Bluefinger, Neptune Kelvin Hughes, SELEX-ES, Thales UK, UKHO, EASAT	Yes
6.3 - Maritime Observation and Science	-Environmental research esp. climate change	Significant – based on Low cost academic research	Autonomous systems	Underwater Vehicles	NERC, NOC, Southampton University, British Geological Survey, Scottish Assoc for Marine Science, Plymouth University,	Yes
6.4 - Communications	-Greater Satellite bandwidth -Improved VHF connectivity	Medium – Based on rationalising legacy systems	Applications favouring email and text comms.	Cyber security protection Improved SATCOM technologies for GMDSS equipment on board (INMARSAT-C) Satellite AIS	Raytheon UK, Selex-ES, Blue Finger, MEDIN, INMARSAT SAAB UK,	Yes

12.2. UK Port Security and Safety

Sub-Sectors	Drivers	Growth	Possible Commercial Opportunities	Emerging Technology/Innovation opportunity	Who are the customers	Favourable to Canadian Industry
7.1 - Port Security	-Countering a large scale Terrorist attack	High – Based on maintaining container through-put while ensuring security	Anti -Diver Security programmes possibility with DRDC Canada	Focussed on remote, autonomous underwater system s	All UK port authorities, Kongsberg Mesotech, Westminster Int.	Yes
7.2 - Maritime Management systems	-Systems convergence -Economics	Medium Based on evolutionary process	Management Software development	Enhanced applications based on XML format	INMARSAT Spectech, Thomas Gunn Kelvin Hughes Regs4Ships	Yes
7.3 - Data and Cyber Security	-Transparency -Fight against organised crime	High- based on inadequate IT systems	Security Software development	Improved firewalls Developing new SCADA concepts	BODC, MEDIN, IMO, Real-Time Software Ltd	Yes

12.3. Security and Safety at Sea

Sub-Sectors	Drivers	Growth	Emerging Technology/Innovation opportunity	Who are the customers	Favourable to Canadian Industry
8.1 - Security Offshore	-Environmental monitoring -Fishing monitoring -Pollution control -Anti-terrorism	High – based on growing demands for more output from UK offshore resources e.g. Wind, tidal, fish stocks,	Radar, AIS and sonar SCADA (supervisory control and data acquisition)	The Crown Estates, MCA, DfT, , DECC, Marine Scotland,	Yes
8.2 - Security in UK Waters	-Surveillance -Vessel Monitoring -Illegal Immigration	High- based on growing UK internal security concerns	Enhancing radar and AIS performance. Ruggedizing vessel monitoring systems against intrusion and system failure	MMO, MFA, EA, DEFRA ,Trinity House, RNLI, Westminster Int. L-3 Klein (US),	Yes
8.3 – Security in International Waters	-Technology -UK Politics -Int. Law	High – based on non-lethal, non-destructive engagement with adversaries	Vessel protection and vessel hardening systems Non-lethal weapons	MoD, FCO, SIS, dstl, NATO Shipping Centre, MSCHOA, UKMTO Dubai, OBP, MMWC Ltd, Dasic Group, LRAD Corp. BaeS	Yes

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