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Electronics Design & Consultancy

# Transport Project - Sea Transport Scenario Descriptions

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# 1 Introduction

This transport study is being undertaken by Plextek and Quotient on behalf of Ofcom. The objective is to identify how the use of wireless is likely to develop within the transport sector over the next 20 years, and to determine any significant additional requirements for spectrum.

The project initially developed a high level vision as to how transport, air, sea, road, and rail will develop. This view was derived largely from industry and government views in the public domain and from UK Government and European Commission policy papers, and from examination of current research work. This view is summarised in Chapter 2 for maritime transport.

Based on this vision, developments where new wireless applications would arise (or existing ones would expand) potentially requiring significant new spectrum were identified. For each a most likely story or scenario was then developed in more detail and tested to see if::

- It would be technologically possible;
- There would be demand for the service or application;
- It was likely to be commercially viable.

In addition, each story is to be presented to stakeholders in the sector to seek feedback and if possible agreement with the overall view. This document presents the stories developed for the maritime transport sector in Chapters 3 to 6, which are to be discussed at the Stakeholders meeting being held on March 13th.

Those developments that are agreed likely to occur and to potentially require additional spectrum will then be further evaluated in order to derive estimates as to how much additional spectrum might be required and what its basic characteristics will need to be.

The four potential developments are given in the table below.

| Development | Summary |
|---|---|
| Broadband connectivity at sea | Covers use of wireless for passenger and operational broadband communications both ship to shore (including approach to and in port) and within a vessel. Includes onboard monitoring of freight and equipment. |
| Automation of port container handling | Use of wireless to automate and improve container handling. Includes electronic tagging of containers and remote control and monitoring of container handling equipment. |
| Port security | Use of wireless to track and monitor personnel and vehicles within port areas for the purposes of security. |
| Navigation | Covers the expanded use of wireless based navigation aids (GPS, eLORAN, AIS, LRIT, etc.) including VTMS in ports and crowded waters. Includes automatic berthing radars. |

**Table 1.1: Summary of developments in the use of wireless in sea transport.**

Note that the developments described in the stories may not always quite align with the original vision (Chapter 2) as our understanding and views moved on during the project.

# 2 A future view of maritime transport

Around 430M tonnes of international freight, some 95% of the total, enters or leaves the UK by sea each year, and the ports handle another 130M tonnes of domestic freight per annum. Although port capacity is concentrated in the south and south east of the country, all parts of the country are served by major ports including Sullom Voe, Forth, Liverpool, Milford Haven, Tees & Hartlepool, Grimsby & Immingham, Southampton, London, Dover, and Felixstowe.

The total tonnage has shown steady growth over many years and is expected to grow at around 1% per annum. As illustrated in Figure 2.1, however, this growth is expected to differ significantly between sectors. Roll-on, roll-off (ro-ro) and lift-on, lift-off (lo-lo) traffic is expected to grow by 112% between 2005 and 2030 whereas liquid and dry bulk freight and general freight is forecast to grow by just 7% over the same period.

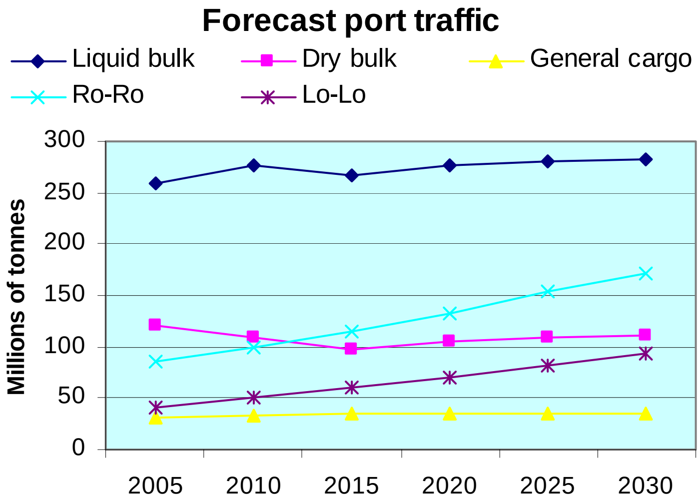


**Figure 2.1: Forecast annual port traffic by freight type. (Source: MDS Transmodal. "Update of UK port demand forecasts to 2030". Final report to the Department of Transport. July 2007.)**

Expansion plans, recently approved at Felixstowe, Harwich, London and Liverpool, are expected to accommodate this growth up to around 2020 with a need for further expansion thereafter[1].

## 2.1 Policy objectives

With 95% of freight entering and leaving the UK by sea, the smooth and efficient operation of shipping and ports is clearly essential to the UK economy. Shipping is also a relatively fuel efficient and low carbon means of moving large amounts of freight[2]. The prime objective of Government policy is therefore to contribute to national and regional prosperity by facilitating the free movement of goods and people through UK ports and, at the same time, minimise the impact on local people and the environment. The thrust of policy is to achieve this by making best use of existing facilities and ensuring that any new developments are environmentally sustainable. The three key aspects of UK policy are[3]:

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[1] Department for Transport. "Ports policy review Interim report". July 2007.

[2] Department for Transport. "Low carbon transport innovation strategy". May 2007.

[3] Department for Transport. "The future of transport: A network for 2030". July 2004.

- To work with the IMO and the European Union on improved regulation in support of the global and UK shipping industry, and pressing for the highest standards of security and safety;
- To facilitate the use of electronic aids to navigation (in line with the General Lighthouse Authorities[4] vision for 2020);
- To encourage the greater exploitation of short-sea shipping to reduce the need for long road and rail journeys through active involvement in European short-sea programmes.

In July 2007 the Department for Transport issued its Ports Policy Review Interim Report. Although the ports policy review is not yet complete, and consideration of the Eddington Study and further consultation has yet to be completed, likely conclusions are already clear. In summary, demand for port capacity is expected to grow at 3% to 4% per annum in the container and roll-on roll-off sectors. This will result in demand exceeding capacity in around 2020 when the recently approved expansion plans for ports are taken into account. However, Government expects that the market will be ready and able to fund any necessary further expansion, and that port operators will be best-placed to determine the timing, location and scale of any investments. Therefore, no substantive changes to the regulatory or operating framework for ports are proposed.

In 2006, the European Commission published a mid-term review of its 2001 Transport White Paper[5]. This proposes the development of an integrated maritime transport strategy within the future EU maritime policy currently being developed. Maritime transport policy was further detailed in “Improving the competitiveness, safety and security of European shipping” under five themes[6]:

- Ensuring a level playing field for EU shipping in the global market place;
- Increasing the use of multimodal logistics in Europe through greater use of short and long sea journeys in place of road and rail transport;
- Increasing and modernising port facilities to enhance their capability to handle inter-modal traffic and make them more competitive;
- Enhancing security within ports and along the whole logistics chain;
- Ensuring high safety standards.

The Commission also plans to remove obstacles to maritime trade within the European Union (through the operation of a single market). The Commission is also running the Marco Polo II programme in support of its policy to encourage the switch of road traffic to other modes. This programme provides financial support to operators establishing non-road based transport and logistic services, and runs from 2007 to 2013 with a budget of EUR 400 million. Funding is available under this programme to support Short Sea Shipping and the establishment of Motorways of the Sea.

Short Sea Shipping[7] refers to transport of freight and passengers by sea within Europe. The Commission has supported short sea shipping since 1995 through promotion centres, simplified

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[4] General Lighthouse Authorities. “2020 The vision: Marine aids to navigation”. August 2004.

[5] European Commission. “Keep Europe moving – Sustainable mobility for our continent”. COM(2006) 314. June 2006.

[6] European Commission. “Maritime transport policy: Improving the competitiveness, safety and security of European shipping”. October 2006.

[7] See http://ec.europa.eu/transport/maritime/sss/index_en.htm. September 2007.

administration and targeted investment. Motorways of the Sea[8] is an initiative to support the establishment of frequent and high quality maritime based logistic services between member states. By making maritime based transport chains competitive with road transport, both initiatives are expected to enhance the shift of traffic away from roads. The UK specifically supports short sea shipping through, for example, Freight Facilities and Water Freight grants.

## 2.2 Commercial and other pressures

Shipping is a highly competitive, global industry and future trends will be driven by future developments in world trade. Overall continuing deregulation is expected to lead to greater competition and an increase in world trade. Patterns of trade are likely to become more complex over the coming years. In particular, the next 5 years will see the impact of China's expansion with both its imports and exports growing rapidly. India and developing countries in Asia and possibly Latin America may emerge as major manufacturing centres, leading to further changes in trade patterns. In the longer term, as oil use declines, the volume of Middle-East shipping is likely to reduce.

Over the last 10 years the movement of freight has become an increasingly integrated activity both across different modes of transport and with manufacturing. Many of the major freight transporters are now third party logistics providers (3PLs). 3PLs take responsibility for the whole logistics chain, and integration between the logistics company and their client can be very close with the 3PL reacting directly to the client's production schedule. 3PLs therefore have to provide, and demand from their suppliers, a highly reliable and predictable, cost efficient service.

Encouraged by government initiatives, short sea shipping is expected to grow, both between UK ports and between the UK and other EU countries[9]. And, as road transport takes on its environmental costs, it is expected to become an increasingly viable alternative.

UK ports compete with European ports for international traffic. As the European Commission works to make EU ports more efficient and competitive[10], the level of competition is likely to increase. And, as noted above, there will be strong pressure for lower costs, faster cargo handling and good links with the inland transport infrastructure.

Taken together, both shipping and port operations will continue to be under strong competitive pressures to provide fast, reliable and cost effective services well integrated with the land side transport network. Key challenges will be the expansion of inland connections and later to manage further expansion without detriment to the environment. On top of this, environmental, safety and security regulations are likely to become ever more stringent.

## 2.3 Use of wireless within the maritime transport sector

The maritime sector makes extensive use of wireless both to aid the safe passage and operation of vessels at sea and in the operation of ports. The majority of wireless use at sea operates in the maritime bands which are subject to international agreement (through ITU-R and IMO). Onshore wireless usage within ports largely operate on nationally assigned frequencies, mostly in bands allocated to mobile services.

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[8] European Commission. "Motorways of the Sea: Modernising European short sea shipping links". May 2006.

[9] Across the EU short sea shipping grew at a similar rate to road freight transport over the 10 years to 2004. Professor K Cullinane, Napier University. Private communication. July 2007.

[10] The recent Ports Services Directive seeks to open up the market for port services, and the European Commission is now considering the issue of port pricing and nationally owned ports.

The maritime radio services can be divided into three main categories of use.

- Surveillance – onboard radars are used to detect and avoid other vessels and navigational hazards. Onshore radars, operated by the Maritime and Coastguard Agency or port authorities are used to monitor vessels in coastal waters;
- Communications – voice and data channels are used in several bands for ship to shore and ship to ship communications, and for broadcasting weather and navigational information;
- Navigation – terrestrial and satellite based radio location systems are increasingly being used in addition to the traditional methods.

The Automatic Identification System (AIS) is worth a separate mention. AIS is a means for ships to wirelessly exchange data on their identity, location and course with other suitably equipped ships within a range of a few tens of miles. Thus nearby AIS equipped ships can monitor each other and determine if there is any risk of collision. AIS equipment is also increasingly being used in conjunction with traditional aids to navigation (such as lighthouses and buoys) so that the aids can be located electronically. In addition, it used by shore based stations to monitor the location of coastal shipping.

Table 2.1 summarises current maritime radio use.

| **Service** | **Description** |
|---|---|
| ***Surveillance*** | |
| Onboard radar | Are used to locate and track other vessels (for collision avoidance), navigational hazards and position fixing. |
| Onshore radar | Are used by the Maritime and Coastguard Agency and port authorities to track vessels in coastal and inland waters / harbours for vessel traffic management. |
| ***Communications*** | |
| MF, HF, VHF & UHF bands | Voice and data ship to shore communications are used for weather and navigational broadcasts, for distress, search and rescue, for operational traffic between ships and their offices, and for ship to ship communications. The VHF bands are also used for shipping communications within ports, and the UHF frequencies for onboard communications. Passenger ship to shore telephony no longer operates in these bands in the UK. |
| Satellite | Satellite links are widely used for operational traffic and also for passenger communications. |
| ***Navigation*** | |
| LORAN-C | A LORAN-C system operates in northern European waters, and there are plans to upgrade it to eLORAN. |
| GPS | This satellite based system is increasingly being used to provide position information. Differential GPS signals are broadcast in UK waters to enable greater positional accuracy. |

| Service | Description |
|---|---|
| AIS | AIS enables vessels to locate the position of other ships and of aids to navigation, and AIS receivers are used by shore stations to locate vessels in coastal waters. |

**Table 2.1: Summary of the current use of maritime radio services.**

Wireless is important to the efficient operation of modern ports. As with airports the main use is for communication with staff whose work requires them to be contactable as they move around the port. Private business radio is used for much of this communication (one to many communication is often required for safety reasons) along with mobile phones. Some of the largest ports, such as Rotterdam, make use of trunked private mobile systems.

Wireless data systems are also used extensively in support of the increasing use of IT in port operations. For example, instructions on the loading and unloading of containers are sent wirelessly to crane and gantry operators, and movement instructions to tug drivers[11]. GPRS and 802.11 equipment (the latter in the 2.4 and 5 GHz bands) have both been successfully used for this purpose. Further automation of freight handling and remote control of equipment are expected increase the use of wireless.

Electronic seals, based on short range devices, are also used to identify containers although not widely at present. The key obstacles to greater use are the current cost, and the lack of widely agreed standards.

## 2.4 Expected developments

Over the past few decades there has been a general increase in the size of vessels on international trade routes. This trend is expected to continue particularly for container ships, liquefied natural gas (LNG) carriers and cruise ships. In contrast the largest vessels, oil tankers, have settled at a maximum of 300,000 DWT for some years and are not expected to see an increase in size[12]. There is also interest in higher speed container vessels and passenger craft, the latter likely to make use of new, lighter materials and ride control to increase passenger comfort.

A more recent trend within the shipping industry has been the adoption of information and communications technology, as evidenced by the widespread use of GPS, electronic charts and integrated bridge systems. As a result visual aids to navigation are being relied on less, their place being taken by electronic aids. Over the next few years the European GNSS (global navigation satellite system) Galileo is expected to become operational[13], and it is proposed to enhance the existing LORAN-C system through the implementation of Eurofix[14].

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[11] Tugs in this context refer to the vehicles which are used to move containers within the port marshalling areas.

[12] Professor Torgeir Moan. "Marine structures for the future". Inaugural Keppel Lecture. National University of Singapore. July 2003.

[13] There is currently some doubt over the funding of Galileo. As of September 2007 the European Commission was pressing for 100% funding by the EU, see "Galileo: The Commission proposes practical measures to ensure the programmes's future", European Commission press release, IP/07/1358, 19 September 2007, http://ec.europa.eu/dgs/energy_transport/galileo/whatsnew/index-en.html, 25 September 2007.

[14] Eurofix is a system for transmitting differential satellite navigation data, differential Loran-C data, Coordinated Universal Time and other data over Loran-C signals. There is also an alternative U.S. proposal, see "The case for eLORAN" by the General Lighthouse Authorities of the UK and Ireland, May 2006.

### 2.4.1 Developments within IMO

From 31st December 2008 the majority of commercial vessels will be required (under the IMO SOLAS regulations) to transmit long range identification and tracking (LRIT) information. The information (essentially the identity and position of the vessel) will be transmitted to secure LRIT data management centres via satellite links and will be available only to government administrations and search and rescue services. The prime objective is to enhance maritime security by enabling states to monitor vessels within 1000 miles of their coast.

The IMO also has a work programme to develop a strategic vision for E-Navigation. The objective is to integrate existing and new navigational tools into an all embracing system to enhance berth to berth navigation and related services to maximise safety and security at sea and protect the environment. The work is in its early stages and it will be several years before a final solution is mandated. Nevertheless we can expect that it will be based on the integration of radio position fixing equipment (satellite and eLORAN) and data from wireless aids to navigation with electronic charts and hydrographic and environmental data to provide a reliable and standardised navigation display[15]. AIS and radar information may well be incorporated to aid collision avoidance, and marine safety information broadcasts may be automatically received and displayed. Links to vessel traffic systems (VTS) may be standardised to aid navigation and manoeuvering in ports and coastal areas. LRIT and the Global Maritime Distress and Safety System (GMDSS) would likely be incorporated. E-Navigation will, therefore, make greater use of automated data exchange between ships and shore stations as well as between ships.

### 2.4.2 Research activities

Further insight into likely future developments was obtained from examination of research projects funded by the European Commission. Two significant projects are MarNIS and MARUSE[16].

MARUSE is focused on the future requirements for maritime navigation systems and the application of Galileo and the European Geostationary Navigation Overlay Service (EGNOS[17]). EGNOS will utilise geostationary satellites to transmit correction signals to GPS and GLONAS receivers which are used to increase positional accuracy from about 20m to 2m.

The objective of MarNIS is to identify how modern navigation and communication systems can be used to bring about improvements in maritime safety, security, efficiency and reliability. It foresees the use of Galileo, AIS and automated ship to ship and ship to shore communications to:

- Track and monitor vessels with high risk or dangerous cargoes both to improve security and safety;
- Track and monitor vessels to allow better scheduling of port arrivals and coordination with onward transport systems;
- Improve traffic flow in confined waters (such as through the Channel and in ports and inland waterways) through the use of AIS and vessel traffic systems (VTS);
- Track cargoes and automate much of the associated administration so that goods can be handled more rapidly (particularly for intra-Community trade).

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[15] Mitropoulos E E. “Aids to navigation in a digital world”. Keynote address by at the 16th IALA / AISM Conference. May 2006 (at www.imo.org) and “The E-Navigation revolution”. *The Coastguard Proceedings*. Summer 2007 (available at www.uscg.mil/proceedings).

[16] See www.marnis.org and www.maruse.org. September 2007.

[17] EGNOS uses geostationary satellites to transmit correction signals which are used to increase the accuracy of GPS and GLONAS signals from about 20m to 2m.

These projects are consistent with the IMO E-Navigation objectives but go further to use information and communications technology to enhance the efficiency and reliability of maritime transport.

Other maritime research projects funded by the European Commission cover advanced vessel design, clean propulsion systems, the safety of high speed vessels, port operations and inter-modal transport. Examples are given in Table 2.2.

| Project | Description |
|---|---|
| HERCULES | The objective is to develop optimally efficient, clean and reliable marine power plants through the implementation of advanced concepts such as extreme parameter engines, intelligent turbochargers, energy recovery and compounding, and adaptive control. |
| CLEANENGINE | Development of clean internal combustion engines based on biofuels. |
| CREATE3S | The objective is to realise a new generation of short sea shipping vessels. Based on a ship platform module and an inter-changeable cargo module, this design is expected to reduce construction costs and to speed loading and unloading. |
| CHINOS | The application of IT and automatic identification to improve the efficiency and security of container handling at ports and throughout the entire logistics chain. |
| SMOOTH | SMOOTH is investigating the improvement in ship hull efficiencies that could be achieved through the use of air lubricated hulls (savings of up to 20% are predicted). |
| VISIONS | Develops future scenarios and operates a pre-competitive process to generate new concepts for vessels and floating structures. |
| EFFORTS | The objective is to identify ways to achieve more effective, safe and environmentally friendly operations within ports. |
| FREIGHTWISE | Freightwise aims to support inter-modal transport by facilitating the development of transport management tools which are inter-operable between all players in the logistics chain, cargo owners, transport operators, inter-modal integrating services, customs and coastguards. |
| TRIMOTRANS | The objective is to develop large standardised containers suited to carriage by and transfer between road, rail and sea transport. |

**Table 2.2: Examples of maritime research projects funded by the European Commission[18].**

[18] Project summaries can be found in "Sustainable surface transport – Research technological development and integration" published by the European Commission, 2006.

## 2.5 A future vision for maritime transport

This vision is based on the policies and developments described above, the GLA Radio Navigation Plan[19], and the vision for maritime transport in 2020 developed by the Waterborne Technology Platform[20].

In 2025 the great bulk of goods and freight will still enter and leave the United Kingdom by sea. The overall tonnage of non-containerised traffic (coal, crude oil and oil products, liquefied gas, steel, ores and vehicles) will have remained fairly static although the imports of LNG will have grown by 300% over the period. Containerised traffic will have doubled over the same period[21]. Ports, in particular those specialising in container traffic, will have become highly automated and tightly integrated with the inland transport system.

There will still be a thriving ferry industry carrying lorries and cars to and from Europe. However, with the shift in freight traffic from road to rail that has occurred over the past decade, a significant proportion of these “lorries” will be special purpose trailers that simply carry containers between the ferries and the port side rail terminals. In addition, there will have been further growth in the amount of domestic freight carried by ship and more freight will be delivered to ports closer to the final destination (diverting some traffic away from the major ports in the south east to more northern ports). With the exception of cruise ships, the number of passengers travelling by sea will have continued to decline.

In 2005 the short sea shipping fleet was relatively old (40% of vessels more than 25 years old). This and the significant growth in European short sea shipping means that by 2025 the short sea shipping fleet is largely new[22]. The new fleet includes new ship designs allowing higher cruising speeds, greater efficiency, lower emissions and highly automated handling of goods. The oil tanker fleet is also relatively new as a result of the phasing out of single hull oil tankers between 2003 and 2015 to meet environmental standards. Other deep sea cargo ships will have been replaced more slowly as they come to the end of their useful lives, but there will have been some growth in both the size and speed of the newer vessels.

The biggest changes to have taken place since the turn of the century will, however, be hidden within the ship. Diesel propulsion systems will be cleaner and more efficient, emitting lower levels of greenhouse gases and particulates. And some vessels will be using alternative fuels (LNG or possibly hydrogen). Ships will no longer discharge waste directly into the sea but will either process it or return it to land for disposal. Similarly, ballast water will be processed before discharge. On the bridge, information and communications technology will have integrated and transformed the control and management of ship operations. Many aspects of navigation, cargo handling and the associated commercial and customs administration will have been automated.

### 2.5.1 Operation at sea

By 2025 the IMO will have mandated e-Navigation capability on all SOLAS vessels. Navigation will be based almost entirely on the use of satellite navigation systems with enhanced Loran

[19] See “GLA radio navigation plan” and “2020 The vision”, published by the General Lighthouse Authorities of the United Kingdom and Republic of Ireland, in February 2007 and August 2004 respectively.

[20] See “Strategic research agenda” and “Vision 2020” by the Waterborne Technology Platform, http://www.waterborne-tp.org/, 17 September 2007.

[21] These forecasts are taken from MDS Transmodal. “Update of UK port demand forecasts to 2030”. Final report to the Department of Transport. July 2007.

[22] See project CREATE3S in “Sustainable surface transport, Research technological development and integration”, European Commission, 2006.

available as a back up across the seas around Europe. Galileo will be operational, GPS and GLONASS will have been modernised[23], and AIS based aids to navigation will have been extensively deployed in the approaches to ports and other high risk locations. As a result berth to berth navigation will be almost entirely based on electronic aids.

Continuing concerns over safety and protection of the environment, and particularly over security (led by the U.S.A.), will have led to the mandatory tracking of all commercial shipping within European waters and of all shipping destined for European ports. On the high seas this is based on the IMO standardised Long Range Tracking and Identification system enhanced with additional facilities developed through European research projects. Closer to shore, it relies on the exchange of data via a supplementary AIS data service.

Ship to shore communications have also expanded significantly over the past two decades. Nearly all passenger ships are now equipped with onboard mobile networks enabling most 3G, 4G and 5G mobile subscribers to use their handsets even in the middle of the ocean. Many of the more enlightened cargo ship operators have installed onboard mobile phone networks for the benefit of their employees. Ship to shore links have also expanded in support of other services, including web access for passengers and crew, real time updating of electronic charts and other navigation information, cargo status monitoring and “at sea” customs facilities. Some of these services are provided by the relevant authorities but others are offered by commercial service providers.

### 2.5.2 Onboard use of wireless

The almost ubiquitous use of wireless to provide local connectivity on land has been mirrored onboard ship. Although the metal structure of vessels remains a major limitation on propagation within vessels, this has been offset to a large extent by the very low cost of wireless equipment. Onboard wireless is used to provide WLAN, cordless telephony and links to CCTV cameras (often installed in the interest of greater security). In addition, on the latest cruise liners passenger e-tickets also act as cabin keys and their pass to the facilities to which they are entitled. On container ships, the container e-tags can be interrogated remotely allowing continuous monitoring of valuable or high risk cargo.

### 2.5.3 Port operations

With the growth in the size of vessels, particularly container and cruise ships, safe and accurate manoeuvering of ships into and out of port has become even more critical and major ports have adopted sophisticated vessel traffic management and information systems (VTMIS). In order to maximise compatibility with the international shipping fleet, these systems have been built around the facilities mandated by e-Navigation. These enable the traffic control centre to identify all vessels within the area of interest, their position, heading and speed. Combining this information with that on the weather, local tides and currents, channel depths and available berths the management system will identify the optimum route for each vessel to follow. Indeed, the route into port will normally have been transmitted to each vessel well before it reaches the port although the ability to change it in real time is maintained so that unforeseen incidents and changes can be accommodated. A continuous data link between the VTMIS and a vessel means that the shore based controller and the ship’s captain (or the pilot) both see the vessel’s track and intended route plotted on the same chart. The same system also provides the necessary information for coordination with tugs and pilots where these are required. A number of ports handling the largest vessels will have installed radar based automatic berthing systems to minimise the chance of damage to vessels and quays.

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[23] They will still rely on correction signals broadcast over the IALA radiobeacon DGNSS service and via geo-stationary satellites (the EGNOS system in Europe).

Security will be a major concern within ports and all craft operating within waters defined as under the control of the port authorities will, by 2025, be required to carry a minimum set of e-Navigation equipment so that they can at all times be identified and tracked by the harbour authorities. In response to the financial incentives to reduce greenhouse gas emissions and to improve efficiency, many of these same craft will have shifted to the use of alternative fuels. For the same reason, many of the shore side vehicles and equipment will be electrically powered.

Again for security reasons, all personnel and vehicles operating within the port confines will be equipped with RFID devices allowing their movements to be tracked and monitored, and causing alarms should they enter any areas prohibited to them.

### 2.5.4 Freight handling

The handling of bulk cargoes will have been improved to minimise spillage and improve safety but the biggest changes will have been to the handling of containerised cargoes. All containers entering or leaving a European Union port will be required to be e-tagged. Container e-tags will contain all the information required in the transport of the container and its contents. As containers are off loaded, the quay side systems will automatically route it to right place for onward transport. Similarly, containers will be loaded automatically in the right order[24]. This high degree of automation will extend to the loading and unloading of containers on and off trains and, to a lesser extent, lorries. Multi-lift gantries and automatically guided vehicles will further contribute to greater handling efficiency. Thus containers will typically move from ship to land transport without any human intervention, and in a much shorter time than taken today.

The e-tags will carry all the necessary administrative information involved in their transport. Thus containers will pass through customs (or not in some cases) on the basis of a scan of the e-tag. In a similar way, bills of lading and other documentation will be automatically generated from scanning of the e-tags and forwarded to the appropriate organisation.

### 2.5.5 Passenger and luggage handling

Passenger handling, including vehicle drivers and their passengers, will be handled in a very similar way to air travellers. Again, their e-tickets will be swiped to complete check-in and customs formalities. Vehicles and luggage will be e-tagged.

### 2.5.6 Land side access to ports

The biggest change to be seen in access to ports will be the expansion and upgrading of rail links. These improvements will have been made very largely to minimise the time difference between road and rail transport for freight, encouraged by obligations made on port operators when obtaining planning permission for port expansions and alterations.

### 2.5.7 Electronic marine highways

To enhance the safety of shipping the UK and France will, by 2025, have cooperated to introduce a vessel traffic management system in the Straits of Dover. It will use radar and AIS to track vessels and data messaging backed up by voice communications to warn vessels of any potentially dangerous situations. However, the additional wireless traffic will be accommodated within the existing maritime and satellite bands.

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[24] Modern container ports are already close to this situation with IT systems determining loading, unloading and routing instructions which are automatically sent (wirelessly) to crane and gantry operators.

### 2.5.8 The Global Maritime Distress and Safety System

By 2025 GMDSS will have been more closely integrated with electronic navigation aids and will make greater use of data transmission. The use of data in place of speech for some communications and the use of more efficient data formats means that the updated system continues to use the same frequencies.

### 2.5.9 Key assumptions and wider issues

The key assumptions underlying our future view of maritime transport is that the uptake of ICT and electronic navigation aids will occur more quickly than changes have traditionally taken within the maritime community, and that commercial pressures will lead to greater automation of cargo handling. Assumptions which relate more specifically to the use of wireless are that:

- The increase in wireless traffic resulting from the increased use of electronic navigation aids can be accommodated within the existing maritime bands;
- Concerns over security increase to the extent that continuous tracking of personnel and vehicles within port areas is considered very important and possibly encouraged by legislation;
- Wide enough agreement on the use and standardisation of e-tags can be achieved within the freight transportation industry as a whole for them to become the universal standard method of identifying and tracking the majority of cargoes;
- There is a real demand for broadband connectivity at sea for both passenger and operational communications.

# 3 Broadband connectivity at sea

## 3.1 The Vision

On shore we are moving towards the information society in which communications, information and entertainment are available to almost everyone at all times wherever they happen to be. The pivotal device in this transformation is the mobile phone as it takes on more and more functionality. Already a communications, information and entertainment device it will become an electronic purse, travel ticket, navigation device and more. As such ubiquitous communications become standard ashore people will expect similar facilities to be available when travelling at sea.

By 2025 we envisage that virtually all ferries and cruise ships in the developed world will be equipped with onboard mobile networks enabling 3G and 4G (and possibly 5G on this time scale) mobile subscribers to use their handsets even in the middle of the ocean. Many of the more enlightened cargo ship operators will have installed onboard mobile phone networks for the benefit of their employees. Ship to shore links will have expanded in support of these and other services, including web access for passengers and crew, real time updating of electronic charts and other navigation information, cargo status monitoring and “at sea” customs facilities.

The almost ubiquitous use of wireless to provide local connectivity on land will also be mirrored onboard ship. Although the metal structure of vessels will remain a major limitation on propagation within vessels, this will have been offset to a large extent by the very low cost of wireless equipment. Onboard wireless will be used to provide WLAN, cordless telephony and links to CCTV cameras (often installed in the interest of greater security). In addition, on the latest cruise liners passenger mobile phones will also act as cabin keys and their pass to the facilities to which they are entitled. On container ships, smart container RFID tags can be interrogated remotely allowing continuous monitoring of valuable or high risk cargo.

## 3.2 Background and current issues

Over the past three to four years deployment of GSM and cdma2000[25] systems onboard ships has grown significantly albeit from a very small base. The great majority if not all of these installations have been on cruise ships and, to a lesser extent, ferries[26] whose passengers are able and willing to spend several US$ per minute for their calls. That this service is currently serving the luxury end of the market is also indicated by the fact that the total addressable market has been estimated at around 350 vessels out of a total of approximately 6000 passenger ships world-wide. “Broadband” access to the internet is also available on some of these ships but prices can be high, for example $25 per hour[27], and the service is more akin to terrestrial dial up connections. Tracking developments ashore, some cruise ships also provide Wi-Fi access for passengers in lounges and hotspots.

These systems rely on satellite links for connection back to terrestrial public networks which makes them more expensive to operate than their terrestrial counterparts. Nevertheless, several companies are now promoting onboard mobile phone and email systems for crew as well as operational use on merchant ships[28] targeting the 1.2M seafarers on 44,000 merchant ships world-wide.

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[25] These are the two major mobile phone standards deployed around the world.

[26] A quick internet survey found only one out of 6 European ferries operators offering onboard Wi-Fi access.

[27] See www.royalcarribean.com..

[28] See www.wiredocean.com, www.blueoceanwireless.com, and www.stratosglobal.com.

### 3.2.1 Key decisions, drivers and barriers

The key driver for the installation of onboard mobile phone and internet connectivity on passenger ships comes from passengers who wish to keep in touch with family and friends or business while at sea, and the convenience that comes with the ability to use their normal phone or laptop. The main barrier to take up is price to the end user, and the capital outlay required by the ship owner. However, the latter are expected to reduce as equipment for terrestrial indoor systems becomes more widely available.

Drivers for the use of similar systems onboard merchant vessels are crew retention[29] and, to a lesser extent, for operational traffic. Email, which is also available over traditional maritime wireless, is widely used for operational purposes and, as the internet becomes increasingly used across the logistics chain, internet access will become an integral part of a ship's communications suite. In both cases the main barriers are the cost of the service.

### 3.2.2 Wider issues

For regulatory reasons, onboard mobile phone networks have to switched off once the vessel is within range of a licensed terrestrial network, which limits the opportunity to sell the service on short sea crossings (across the Dover Straits or the Irish Sea for example).

Given the recent European Commission actions to control GSM roaming charges there is the possibility that similar action could be taken in respect of onboard calling charges. However, in this case the cost structure is quite different and such a move is considered unlikely.

## 3.3 The story

### 3.3.1 Ferries and cruise ships

Back in 2007 onboard mobile phone and internet access had been limited to cruise ships at the high end of the market and to first class passengers on a very small proportion of ferries. During 2008 one ferry company, operating in northern European waters, began to offer a mobile phone service in all onboard public spaces across its fleet. Prices were somewhat higher than European roaming charges nevertheless use of the service grew steadily if unspectacularly. Initially, the other ferry operators found that peoples' choice of ferry was not much influenced by the availability of the service, and on short voyages mobile phones remained connected to the terrestrial networks for much of the trip anyway. As a result take up across the ferry industry was slow. One or two companies installed onboard Wi-Fi hotspots but the speeds offered were low and charges higher than people were used to ashore. With plenty of other distractions onboard, take up was very limited and where it was offered the service remained largely confined to first class passengers.

Around 2012, the availability of onboard mobile telephony began to have a noticeable effect on ferry bookings and there was a scramble to outfit the majority of longer distance ferries. At the same time, the cost of broadband provision to ships came down as some satellite operators upgraded to the DVB-S2/DVB-RCS standard which provided them with greater capacity. As a result, some ferry companies revamped their onboard internet service, expanding the areas in which Wi-Fi access was available, and began to use it as an onboard information, entertainment and marketing tool. This proved more successful than the earlier internet offerings, in part because by this time most mobile phones included Wi-Fi connectivity so that many of the services could be accessed without the bother of opening up a laptop. As Wi-Fi connectivity became more common it

[29] Wallem Shipmanagment now provides free email to all crew on more than 100 merchant vessels, although phone call and SMS messages are charged for. See Case Studies at www.stratosglobal.com.

also became used for operational purposes, enabling crew members to access the ship's IT system more easily and the higher capacity of the associated satellite link also provided a cost effective ship to shore link for other operational uses such as automated chart and weather updates.

By 2015, onboard mobile phone services were almost universally available on western European ferries. Onboard internet connectivity spread more slowly as prices remained noticeably higher than their terrestrial equivalents but it too was almost universal by 2018. Over the following years, the onboard system capabilities were steadily upgraded inline with terrestrial developments albeit with a lag of one to two years.

These developments were paralleled within the cruise ship industry where onboard mobile phone and Wi-Fi connectivity became almost universal on a similar time scale.

### 3.3.2 Merchant vessels

In the mid-2000s, crew recruitment and retention was a major concern to ship owners and operators and one of the key facilities that seafarers wanted was improved access to ship to shore communications[30]. At the time facilities were typically limited to expensive satellite phones and special purpose email terminals located at a fixed position with little privacy. Around 2005, a number of vendors began to offer onboard mobile phone networks as a means of providing crew with a more attractive means of calling friends and family. These proved popular with crews and were increasingly installed on merchant ships in the following years, quite often in conjunction with an email service, and in a significant proportion of cases the ship operator subsidised the service – free SMS or free emails being the most common. Nevertheless, it was not until 2020 that onboard mobile phone systems became common on merchant ships.

A subsidiary use that developed alongside crew communications was container monitoring[31]. In this case particularly valuable containers were fitted with monitoring devices which incorporated a mobile phone and could thus be interrogated remotely or automatically call should anything untoward be detected. Although this did not work as easily as it sounds[32], the additional carriage charges that could be levied for the facility did help to offset the cost of the crew subsidy.

Onboard use of Wi-Fi networks developed more slowly, in part because few seafarers possessed laptops or could afford the charges. However, as its operational benefits were demonstrated on ferries and cruise ships, it began to be taken up slowly by the rest of merchant shipping where its uses included flexible access to the onboard IT system, links to temporary CCTV cameras and container monitoring.

[30] "Port Based Welfare Services for Seafarers", by the Seafarers' International Research Centre available from www.itfglobal.org/seafarers-trust/welfarerpt.cfm.

[31] "Blue Ocean Wireless launches the world's first GSM network for merchant maritime vessels". Blue Ocean Wireless press release. 28 March 2007.

[32] The stacks of containers made it difficult to guarantee coverage of all containers and typically those of interest had to be placed within a limited area in order to ensure reliable connection to the onboard mobile phone network.

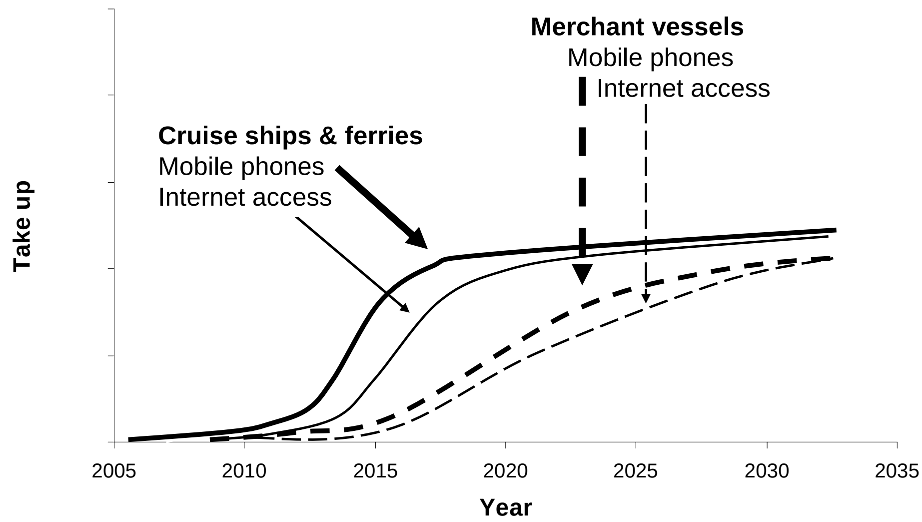


**Figure 3.1: Illustration of the provision of mobile phone and internet access on passenger ships and merchant vessels.**

### 3.3.3 Onboard IT systems

In parallel with these developments onboard IT systems were increasingly being used and increasingly being linked back to onshore IT systems. Although the great majority of this operational traffic was text based and undemanding of bandwidth, the volume of traffic grew steadily from the late 2000s. In addition, more capacity hungry services were incorporated over time, including the downloading of chart updates and weather maps.

## 3.4 Technology issues

Today's offerings use a variety of satellite systems operating in a number of bands with L, C and Ku band systems being the most common. Many of the satellite operators have plans to expand capacity and offer higher speed connections[33] and this is thought likely to provide adequate capacity for the expansion of maritime operational services. Passenger services could require significantly greater capacity and further study is needed to determine if there a risk that this could exceed supply within 20 years.

The continuing extension of terrestrial mobile phone networks into indoor situations and the on-going development of UMA[34] femto cells can be expected to lead to lower cost equipment and thus to lower costs for onboard mobile phone networks. The UMA technology also enables subscribers to access mobile phone networks via Wi-Fi devices which may also provide an attractive low cost route for onboard phone systems.

## 3.5 Evidence for development time scales

The following pointers were used in developing the scenario time scales.

- In the UK the migration from dial up to broadband internet access for residential customers occurred largely between 2000 and 2006. Onboard systems will be more constrained by the

[33] SES, Iridium, Globalstar and Eutelsat all have plans to launch new satellites between 2009 and 2016.

[34] Unlicensed Mobile Access is a 3GPP standard enabling the services of a mobile network to be accessed via any IP-based access network such as Wi-Fi.

technology and price than terrestrial DSL systems were, so their take up is likely to be somewhat slower.

- A brief search of the internet revealed no more than a few hundred onboard mobile phone networks installations for merchant ship crews in one year. With over 40,000 cargo ships in the world fleet (and around 10,000 in Europe) it will clearly take some time to fit out a significant proportion.

## 3.6 Indicators for tracking developments

The key indicator will be the obvious one of the take up of mobile phone and internet access on both passenger and cargo vessels. In addition, promotional campaigns by ferry and cruise companies which emphasise onboard connectivity will indicate that the companies see the facility as being important in peoples' decision making, suggesting that there is real demand from passengers.

## 3.7 Summary

Clearly the technology to duplicate the communication facilities that people take for granted ashore is available. And, given the use of these facilities in an increasingly wide variety of terrestrial situations (on the move, in public transport, in hotels, hotspots and airports, etc.) there is good reason to suppose that people will use the same facilities while onboard ship provided the price is deemed reasonable.

Costs can be expected to fall with time both as the onboard wireless systems fall in price (driven by the expansion of terrestrial in-building systems) and as competition and satellite capacity grows. Given that the high price of roaming calls was accepted by the paying subscriber for many years it is likely that users will be prepared to pay noticeably higher prices for calls at sea. Given also that those roaming charges were not that different to onboard GSM call costs today and that cost reductions are to be expected, it is likely that a sound business case for connectivity at sea will emerge.

In the case of the crew communications, the situation is different with the subsidy paid by the ship operator having to be justified in terms of crew recruitment and retention costs.

As these ship to shore communication facilities become established and provide the convenience of direct access into the world telecommunication network and the world-wide web it is likely that its use for operational purposes will expand, further improving the business rationale.

# 4 Automation of port container handling

## 4.1 The Vision

Within 20 years all containers entering or leaving a European Union port will be required to carry an e-Custom compatible RFID tag enabling fast automated import and export formalities. The same tags will also be an integral part of the global shipping management systems used to track and manage the shipment of containers from start to finish, providing real time information on their location and condition.

The physical handling of containers will also be highly automated. As containers are off loaded, the quay side systems will automatically route them to right place for onward transport. Similarly, containers will be automatically loaded onboard in the right order. This high degree of automation will extend to the loading and unloading of containers on and off trains and, to a lesser extent, lorries. Multi-lift gantries and automatically guided vehicles will further contribute to greater handling efficiency. Thus containers will typically move from ship to land transport with almost no human intervention, and in a much shorter time than taken today.

The automation of administration and handling will have led to a small but continual decline in transport costs, as well as to an increase in reliability.

## 4.2 Background and current issues

A modern container port already makes significant use of IT radio communication systems to control the loading, unloading and marshalling of containers. Typically, the IT system will identify containers as they arrive at the port by train or lorry and then determine a) where they should be stored prior to loading and b) the correct onboard position and the appropriate loading order. Instructions are generated automatically and sent, often wirelessly, to the appropriate tractors, straddle carriers, and stacking and dockside cranes. A similar process is used for incoming containers. The radio communication systems also provide general communications around the port and often use a mix of technologies including private mobile radio, Wi-Fi and cellular with varying degrees of integration between them.

Operator positioning of vehicles and containers is often assisted by position determining systems. These typically use differential GPS combined with laser distance measurements, odometers or fixed RFID tags to achieve positioning accuracies of a few centimetres. Automatic identification of containers is often based on optical character recognition and, more recently, on RFID tags.

The strong commercial pressures on UK ports to provide a fast, reliable and cost effective service means that they continue to look to IT and automation to make further improvements in productivity and reliability. The way in which this is likely to develop is indicated by the products now coming onto the market and from research and development projects. Automated (unmanned) stacking cranes have been operated in the port of Antwerp[35] and automatic straddle carriers have been used in the port of Brisbane[36] since 2005, and remote control of container lorry loading and unloading is commercially available. Current research includes work on the remote control of

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[35] See http://www.gottwald.com/gottwald/site/gottwald/en/products/automatedstacking.html. 10 January 2007.

[36] “Kalmar leads the way in terminal automation with new test facility launch”. Kalmar press release. 14 May 2007. www.gottwald.com.

dockside cranes[37] and closer integration of port, rail and road operations[38]. Standardisation of electronic documentation is also on-going both across Europe and more globally.

Fast and accurate identification of containers (and freight in general) is clearly important to greater use of IT and automation. Whilst optical character recognition is the most widely used automated system today, commercial use of RFID tagging of containers is now beginning[39]. Suitable RFID tags can also monitor the status of containers and report, for example, if the doors have been opened. Global ISO standards for RFID tags for containers have been developed but proprietary systems are also used.

### *4.2.1* Key decisions, drivers and barriers

The key driver for port automation is to increase productivity through faster and more reliable handling of freight. However, the advantages are only realised when other associated activities, such as customs clearance, documentation handling and payment of port dues, are improved in parallel. Typically, this involves integration of all involved parties into a common IT and communications infrastructure. Thus automation of container handling is part of a wider programme of port automation and process improvement, and different ports will have different priorities and investment plans. In addition, it has yet to be shown that automation can be economically introduced into smaller ports[40].

Ports are only one link in the overall supply chain and on-going work towards global standards (particularly in respect of electronic documentation and identification) is essential to improve the overall flow of goods[41]. Achieving international agreement takes time and can throw up new challenges. For example, the regulations applying to the use of RFID devices and, in some cases the available frequency bands, vary from country to country.

### 4.2.2 Wider issues

Security and environmental concerns are leading to the introduction of new requirements on the way port operations are conducted and may in future impact on the way in which automation is implemented.

## 4.3 The story

This story focuses on the automation of container handling but port automation includes the use of ICT systems to handle and automate the associated administrative processes.

This story describes the development of a large and successful modern container port which, in 2008, used a comprehensive port management IT system linking all the port functions together and automatically issuing instructions to tractor, straddle carrier and crane operators around the port. The instructions were transferred over a Wi-Fi network and the vehicles were all fitted with position determining systems that ensured that the containers were accurately placed. Other mobile staff typically used private mobile radio systems or mobile phones to keep in touch with their office

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[37] "Securcrane". EC 6th Framework project. www.securcrane.info.

[38] "Freightwise". EC 6th Framework project. www.freightwise.info.

[39] "Eastern US's fourth busiest port embraces RFID". RFID Journal. http://www.rfidjournal.com/article/articleview/3103/1/1/.

[40] "Strategic Research Agenda – Overview". Waterborne. Available from www.waterborne-tp.org.

[41] The industry group EPCglobal is leading the drive towards global electronic product code standards to support the use of RFID (see www.epcglobalinc.org/home/).

or controller. The port's policy was to enhance its IT systems and to use automation where it reduced costs or allowed them to offer value added services to their customers.

In 2008, the port undertook a major upgrade of its IT and internal communication systems with the objective of giving all its mobile staff direct access to the IT system. This was achieved by providing Wi-Fi coverage over the greater part of the site. Over time this facility became used by more and more staff. The new system also enabled the private mobile radio systems to be integrated into the overall port communications network, and this integration occurred over the next few years.

In 2009, the port began the phased deployment of RFID readers on its container handling vehicles and at other strategic locations in the port[42]. This allowed it to offer its customers a container tracking and condition monitoring service, and provided a back up to the optical system used to read container ID numbers. Shippers wanted the same tag to work across the whole of their logistics chain and, for compatibility with several US ports, the port therefore adopted a proprietary system using the 433 MHz band. A number took up the tracking service but rather fewer took up the condition monitoring service. However, the container tags were still fairly expensive and not all shippers used the same system with the result that take up was relatively slow but steady. In 2010, the two container RFID standards, ISO 10374 (essentially container identification only) and ISO 17363 (capable of carrying information on the contents and of updating as it moved through the supply chain) were finally brought up to date. It was relatively inexpensive and simple to upgrade the RFID readers to accommodate the ISO 17363 standard so the port was quickly able to handle both standard ISO 17363 and the original proprietary tags.

At this point, the shipping industry began to move away from proprietary systems to the ISO standards, a move that was reinforced when in 2011 the US, Chinese and European Union authorities all announced their intention to mandate electronic seals based on the ISO 18185 RFID standard (although it would take a few years before this came to fruition – see the port and container security scenario). Over the next few years the proportion of containers equipped with tags increased significantly as prices continued to drop. Nevertheless, a small proportion of shippers continued to use their original proprietary systems. By 2013 it was clear that RFID tags were more reliable than the optical character readers, leading to fewer corrective container movements and fewer manual interventions, as well as less costly to maintain. Shortly thereafter the port introduced a surcharge on any containers not conforming to the ISO RFID standards and by 2017 all containers passing through the port conformed to the standard.

In 2018, in response to demands from shippers who were beginning to use the new ISO compliant electronic seals on valuable or high risk cargoes, the port upgraded its RFID infrastructure to support the new standard. This was implemented under a cost-sharing agreement with Customs and Excise and fully integrated with the customs clearance IT system. Thus, in 2020 when electronic seals became mandatory both the port and customs were able to carry out their standard security checks on containers remotely and automatically.

The electronic seals were capable of all the functions that the other ISO standard tags supported with the result that over the following years, electronic seals became the default tag for containers, and the other tags largely disappeared.

In 2010, the port had begun the introduction of remotely controlled loading and unloading of lorries and trains as this allowed the same throughput but with fewer operatives. In 2011, the first fully automated (unmanned) shuttle carriers were introduced. These proved to work well and reduced

[42] Other ports took the approach of using the services of RFID tracking service providers (for example SaviTrak) which avoided the need for the initial capital investment. However, the port discussed here believed RFID would become a fundamental element of its port operations and therefore decided to keep direct control of its RFID infrastructure.

labour costs, so they were phased in across the whole port over the following 15 years as the older vehicles came to the end of their useful lives. Over the same period, the smaller number of stacking cranes were converted to unmanned operation and the dockside cranes were converted to remote operation.

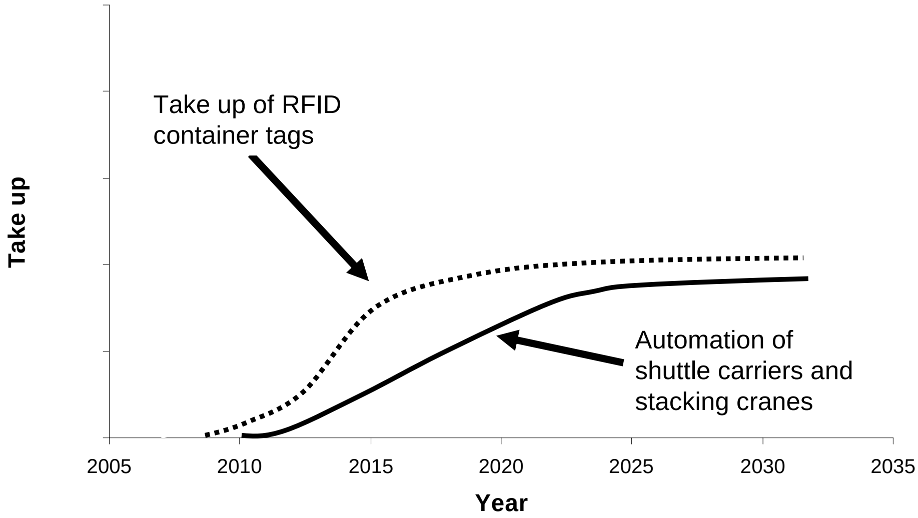


**Figure 4.1: Take up of automated container handling equipment and RFID container tags.**

Although the automation reduced the likelihood of damage to containers it also made it more difficult to produce evidence when damage claims were made. In 2015 the port therefore introduced a system which photographed containers as they were loaded onto or unloaded from ship or lorry. The images were automatically transferred by wireless to the dock's IT system for archiving.

Thus, by 2026 the port was highly automated both in the handling of containers and in the administration of the associated custom and shipping formalities although it was not until 2025 that the first unmanned quayside crane was introduced. Other ports around the UK followed a similar path although time scales varied from port to port.

## 4.4 Technology issues

RFID tags and the electronic seals which are assumed to largely replace them will be read at short range when passing a reader (for example when off-loading from a ship or lorry) or at longer distances to check the status of containers stacked in a parking area. As discussed elsewhere under Port and Container Security, existing RFID spectrum allocations are expected to be adequate and links between the readers and the IT system are not expected to place any significant demand on a port's wireless infrastructure.

The remote and automatic operation of equipment (straddle carriers, etc.) will require telemetry between the equipment and the controllers (whether man or computer) and accurate onboard positioning determining systems. In addition video links will be essential both for remote control (so that the controller can see what he is doing) and for automated operations (so that controllers can monitor and intervene as necessary).

Neither the positioning systems nor the telemetry requirements are expected to result in significant spectrum requirements. The video links, however, which have to be real time and mobile, may place a significant demand on a port's wireless infrastructure. Additional capacity will be required for the transmission of container photographs although these could be uploaded during quiet periods.

A port's wireless infrastructure will support several other functions including mobile IT applications, office to ship communications, port and container security systems, and perimeter surveillance systems. These will be considered together in assessing the total spectrum that a future port might require.

## 4.5 Evidence for development time scales

The following time scale information was used in the development of this scenario:

- The 2007 Draft Communication from the Commission, the Freight Transport Logistics Action Plan[43], which foresees an all electronic flow of information associated with the transport of goods, envisages the development of a standard for information flows by 2010 and the establishment of "one stop administration" for intra-EU freight by 2012. However, we note that the related European consultation on European Maritime Transport Space Without Barriers only closed for comments on January 20th, 2008.
- The EC funded research project Securcrane aims to demonstrate remote control of quayside cranes by April 2009 and the project Freightwise aims to demonstrate a generic system architecture for inter-modal and multi-modal transport management information systems by April 2010.

In addition, published forecasts[44] of take up rates for active RFID were also used as a guide to the rate at which container RFID would expand.

## 4.6 Indicators for tracking developments

Both RFID and automated container handling equipment are in use today thus key indicators for the development of the scenario presented above will be the on-going take up of these systems as the users obtain a better understanding of the benefits achieved in practice.

From the point of view of potential spectrum requirements it should be noted that developments across several areas of port operations will effect the requirements for and on port wireless systems.

## 4.7 Summary

RFID tracking and monitoring offers to improve the efficiency of container handling by providing more timely, accurate and reliable information on the whereabouts and condition of containers. Automated handling also offers to improve efficiency by enabling more reliable and safer movement of containers and to give productivity gains, and commercial pressures ensure that these are gains that port operators actively seek out. Furthermore, the technology needed is clearly practical and available today.

This suggests that a key barrier to faster take is one of cost. In the case of RFID tags very large numbers will be required which means the return on investment is strongly affected by the cost of tags. With active tags suitable for use with containers costing tens of US$ today, and around 250M containers moved annually, the cost can be seen to be substantial. However, the cost of tags is expected to fall substantially as volumes grow. The other barrier to the take up of RFID tags is the need for commonality across the whole transport chain. The moves towards standardisation are, however, reducing this barrier. The growing adoption of container tags suggests that the business

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[43] http://ec.europa.eu/transport/logistics/freight_logistics_action_plan/doc/action_plan/2007_com_logistics_action_plan_en.pdf. Accessed on 16 January 2008.

[44] "Active RFID and sensor networks, 2007 – 2017. P. Harrop and R. Das. IDTechEx. ISBN 0-9545362-2-3.

case is already positive in at least some situations and, as prices fall, it will become so for increasingly wide sections of the industry.

In the case of automated container handling the automation components (computers and positioning, video and wireless systems), although falling in price, are only a fraction of the (large) total cost of the handling equipment (straddle carriers, etc.). Furthermore with container ports already operating at high levels of efficiency the savings from further automation will take time to generate a return and deployment will often be tied in to equipment replacement cycles.

# 5 Port security

## 5.1 The Vision

Security is a major concern across all transport sectors and particularly so at international gateways. Tracking and monitoring activities across a large port is a major, labour intensive effort and we therefore expect that ways will be sought to automate and maximize security without disrupting the efficient working of ports.

Passes of various sorts are already widely used to control access by staff and vehicles. These rely on protected entry points and fences and barriers. However, gates and fences within a port to protect particularly high risk cargoes can impede normal operations. The ideal would be a system capable of continuously tracking all individuals and vehicles within a port, and automatically raising an alarm should unauthorised entry into an area or any unexpected activity be detected. Such systems could increase security, minimize the impact on normal operations and reduce the need for security personnel to continuously monitor CCTV images. The vision is that the integration of video surveillance systems and accurate wireless location will become practical and reliable, and achieve this ideal, within the next 20 years.

## 5.2 Background and current issues

Since the terrorist attacks of 2001 there has been a strong focus on security for international transport. In the case of maritime transport the IMO introduced the International Ship and Port Security Code (ISPS code). This requires that ports and ships take both procedural and physical measures to protect facilities against terrorist attack including the development of security plans, controlling access, and monitoring the activities of people and cargo. The code was transposed into European law in 2004 and implemented within the UK's National Maritime Security Programme[45] under the auspices of TRANSEC[46] and the Maritime and Coastguard Agency. As a result, security in UK ports has been significantly upgraded over the past few years with, for example, access control systems in sensitive areas, perimeter surveillance and photographing of all visitors.

In addition, the US Department of Homeland Security has introduced four main security enhancing programmes, listed below, and announced its intention to mandate the use of mechanical seals on all containers entering the USA from October 2008.

- The Container Security Initiative – includes the pre-screening of containers at their port of departure by US customs officials (with reciprocal arrangements available), imaging of containers, and smart tamper detecting containers.
- The Customs Trade Partnership against Terrorism (C-TPAT) – in return for voluntarily implementing certain security measures, members of C-TPAT receive priority entry and clearance at US ports.
- The Smart Box programme – promotes technologies which will enhance container security.
- The Advanced Trade Initiative – requires that shippers send manifests to the US Customs and Border Patrol bureau in advance of the shipments arrival.

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[45] This programme combines European and international security initiatives with the UK's maritime security measures into a single regime.

[46] The Directorate of Transport Security and Contigencies (TRANSEC) within the Department for Transport is responsible for devising and enforcing security standards within the transport sector.

Proprietary electronic container seals, which can remotely report attempts at unauthorised opening of containers, have been commercially available for a few years and, in 2007, an ISO standard[47] for active RFID based electronic container seals was released (using either the 433 MHz or 2.4 GHz bands). However, lower cost passive RFID seals are also being developed[48] (using the 800/900 MHz bands) whilst others are developing yet more capable seals[49].

Security is an on-going process and new measures, initiated by TRANSEC, the European Union or the USA, can be expected over the coming years. The challenge is to maximise security without imposing overly burdensome requirements on the transport chain. Intelligent surveillance systems offer the prospect of enhanced levels of security with minimal interference to the on-going operations at ports. Research in the public domain can provide an indication of likely future developments. It includes:

- The use of RFID for security and tracking of containers[50];
- The tracking of personnel and vehicles, automated video surveillance of crowds and the detection of suspicious behaviour[51];
- The use of data fusion to integrate multiple tracking and surveillance solutions into a single automated protection system[52],

Future intelligent surveillance systems are likely to use a combination of technologies (video, infra-red, biometrics and RFID) but may be 10 years away from realization[53].

### 5.2.1 Key decisions, drivers and barriers

The key decision maker for the UK is TRANSEC but maritime transport is a global activity and actions and regulations from the USA and the European Union can be expected to be influential. The key driver will be on-going concerns over security and the potential use of sea transport as a means of achieving illicit entry for goods and individuals into the country.

The efficient flow of goods is key to the economy and the cost of security measures is borne directly by industry. There is therefore strong pressure for the development of processes and systems which improve security but have minimal negative impact on operations. Furthermore, the need for compatibility between different countries and across the multiple parties typically involved in the transport chain requires coordination and common standards which can take time to achieve.

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[47] ISO 18185.

[48] "RFID enabled container seals employ technology affordably". Bulk Transporter. 1 December 2007. http://bulktransporter.com/.

[49] See GateKeeper USA, Inc.. www.gatekeeperusainc.com.

[50] EC Project SECCONDD, "Secure Container Data Device Standardisation". See http://ec.europa.eu/enterprise/security/articles/article_2007-02-23_en.htm.

[51] See projects Avitrack, REASON, ISCAPS, ETISEO, VBL and ViTAB at www.cvg.rdg.ac.uk/projects/.

[52] EC project SOBCAH, "Surveillance of Border Coastlines and Harbours. See http://ec.europa.eu/enterprise/security/articles/article_2007-02-23_en.htm.

[53] "Intelligent surveillance in Europe: Where do research efforts stand?". Paul Kellett. Machine Vision Online. 22 May 2007. http://www.machinevisiononline.org/public/articles/details.cfm?id=3169.

### 5.2.2 Wider issues

Although security is not a new concept in maritime operations, some of the more intrusive potential security procedures which could continuously track individuals could be delayed by privacy concerns.

## 5.3 The story

This story focuses on two key aspects of container transport security where wireless is likely to play a significant part: that of ensuring that container ports themselves are secure (through intelligent surveillance) and the ability to monitor unauthorized attempts to open containers (through the use of electronic seals).

### 5.3.1 Intelligent surveillance

By the 2008, the new Port Facility and Ship security plans (developed under the UK's National Maritime Security Programme) were in place and operating smoothly. These consisted largely of secure perimeters, access control on all persons and vehicles entering ports, and extensive CCTV monitoring of sensitive port operations. In 2010, TRANSEC decided that equipment costs had reduced enough for it to mandate the use of biometric access controls at both sea ports and airports, and to increase the requirements for CCTV monitoring. Industry was given two years to meet the new requirements.

Meanwhile, research on intelligent surveillance systems had been moving forward and in 2012 trials were carried out at Heathrow and Schiphol airports. These trials showed that performance was not yet good enough to replace human CCTV surveillance, and the European Commission continued to fund research in this area. However, the trials had shown that combined wireless tracking and video monitoring did enable "safe" people and vehicles to be reliably identified in real time and marked as such on screen. This enabled security personnel to concentrate their attention on the remaining individuals and vehicles. The highly automated nature of operations in container ports meant that the actions of the majority of vehicles were known (to the scheduling computer) and a few vendors introduced smart CCTV systems which used this information to identify and mark safe vehicles[54]. A small number of container port operators installed these systems and found that although they had little effect on the number security personnel required, the reliability of their surveillance was improved.

By 2015 intelligent surveillance systems had advanced sufficiently for two vendors to announce products based on advanced video analysis combined with long distance RFID location and tracking[55]. By comparing the CCTV video with movement and location information from the positioning systems and with the expected and allowed movements, these systems could identify any irregular or prohibited activity.

These systems were targeted at surveillance of aircraft while parked at airport gates. Following successful trials TRANSEC decided to mandate their use at all international airports within 3 years. The application of similar systems within ports was also considered at this time but the large areas involved and the great variation in port operations with cargo type led TRANSEC to conclude that deployment in ports would be too expensive. Four years later, the cost of RFID tracking systems

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[54] The research projects ViTAB (Video based threat assessment and biometrics network) and VBL (Video Surveillance for efficient CCTV analysis) are currently investigating means to improve the efficiency of CCTV monitoring. See www.cvg.rdg.ac.uk/projects/.

[55] Long range (150m) real time location systems based on UWB tags are available today although still expensive at around £40, see www.ubisense.net.

had fallen substantially. Furthermore, in both airports and ports virtually all airside and portside operatives and vehicles were equipped with GPS enabled radios or wireless PDAs[56], and by this time these wireless systems were all integrated into the port's communication systems[57], making wide area tracking straightforward and inexpensive. As a result TRANSEC judged that intelligent surveillance of all portside operations was practicable and affordable, and in 2019 announced that all major cargo and ferry ports would have to implement the new systems.

A four year grace period was given to allow for the development of systems to match the variety of port operations. The high levels of automation in container ports meant that these systems were the simplest to implement and, since lower insurance rates were available to ports using intelligent surveillance, some container ports had implemented their systems within 3 years. In most other ports, the systems were brought into operation during 2023. There were some teething problems including one infamous case in which a visiting dignitary was given the wrong security clearance causing a major alert to occur part way through the visit. But by 2025 these had been largely overcome, and the port operators were finding that they were benefitting from reduced insurance premiums and from improved productivity as CCTV staff were redeployed to other duties.

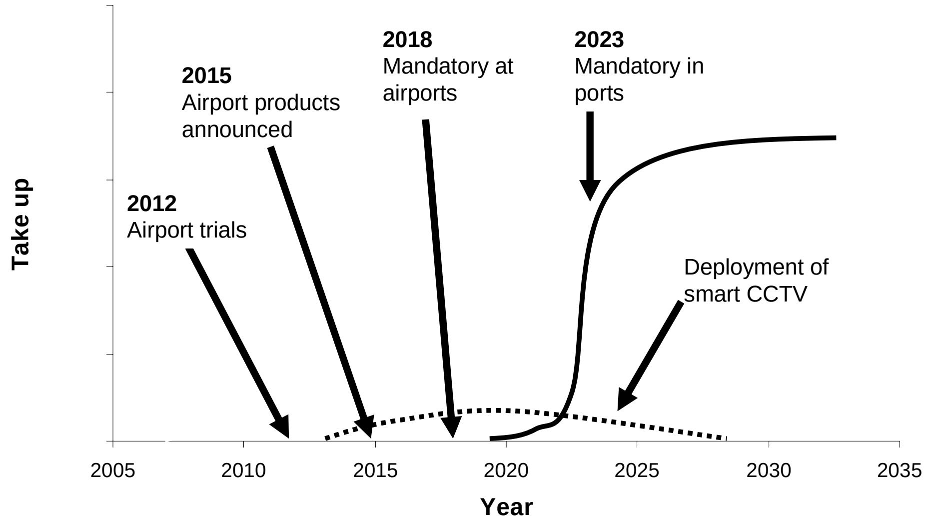


**Figure 5.1: This figure illustrates the key events leading up to the mandatory introduction of intelligent surveillance systems in UK ports. Also shown is the interim deployment of smart CCTV systems in a small number of ports.**

### 5.3.2 Container security

It was in 2008 that the USA mandated the use of standard mechanical seals on all containers entering the country. In the same year the first electronic seals meeting the ISO 18185 standard appeared on the market. These seals used active RFID tags operating at either 433 MHz or 2.4 GHz, and were therefore usable in almost all parts of the globe, and met the US standard for mechanical seals.

The prime advantage of the e-seals was that they enabled automated, remote checking of containers

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[56] The type of radio employed varied from port to port but included private mobile radio, mobile phones and Wi-Fi. By this time, many GPS receivers made use of the EGNOS augmentation system to achieve accuracies of 2m or less.

[57] This capability had been available since 2005, see "Cisco Brings IP Networking to World of Two-Way Radios". http://newsroom.cisco.com/dlls/2005/ts_102405.html. October 24, 2005.

for tampering. In addition, they could record the time of tampering as well as holding identity and other information about the container, and some thought that these advantages would see it quickly taken up by the shipping industry. However, the seals were quite expensive (at around $20 in 2008 dollars) and other RFID enabled e-seals were also on the market. These included both less expensive passive RFID based e-seals, and proprietary systems with a richer set of functionalities. As a result, take up over the next few years was relatively slow, with different shippers opting for different systems and prices not falling as rapidly as had been expected.

In 2011, the European Union's Maritime Transport Space Without Barriers programme proposed that RFID enabled e-seals be used to improve the security of intra-EU container transport. This was sensibly to be based on the ISO 18185 standard but required a read/write as well as read only capability. By this time, both the US, Asian and the newly assertive Chinese customs authorities were developing their own requirements for RFID enabled customs clearance. Indeed, all three had already separately announced their intention to mandate the e-seals. The new requirements included a low cost, passive RFID option as well as higher levels of security and mandatory data for customs clearance purposes, and it took a protracted series of negotiations before a revised ISO 18185 standard was finally agreed in 2014.

By this time, a variety of e-seals were used on a significant proportion of high value containers and integrated into the IT systems of shippers and some of the major third party logistic providers. A phase in period had therefore to be allowed for and in an unprecedented joint move the USA, China and the EU all announced in 2015 that the new standard e-seal would be mandatory at all their ports in 2020. Within a year, almost all other customs authorities had announced essentially the same move.

By 2020, the vast majority of sea containers carried ISO 18185 standard e-seals and all the world's major container ports had installed the necessary infrastructure of readers and were operating automated customs clearance systems. The functionality of these e-seals was such that they largely made other (sea) container tags redundant.

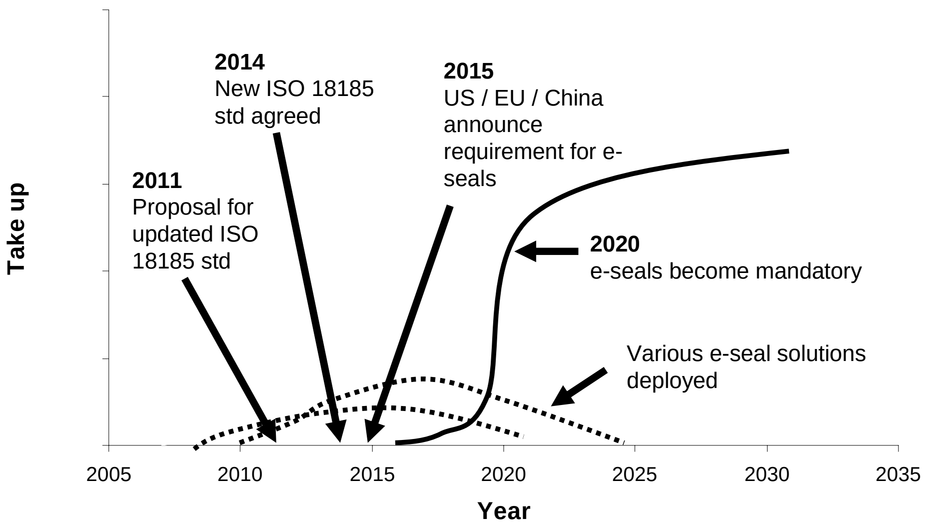


**Figure 5.2: The events leading up electronic container seals becoming mandatory at most of world's ports in 2020. Also illustrated is the take up of various earlier e-seal solutions which are superseded by the new, mandatory standard.**

Although industry had to bear the costs of the security measures mandated by the Customs authorities there were some compensating advantages; insurance charges on high risk cargoes came down and with 100% use of e-seals the time taken for security checks was reduced.

## 5.4 Technology issues

### 5.4.1 Intelligent surveillance systems

A number of real time location technologies could be developed to provide the accurate position data needed by the intelligent surveillance systems in the areas of highest activity. The Ubisense[58] tags referred to above are ultra wide band devices that operate at low power in the 6 – 10 GHz band. Location is determined from the angle of arrival and the time of arrival of the UWB pulses and ranges of up to 150m with an accuracy of 15cm are claimed. Another approach works with any standard Wi-Fi network using signal strength measurements[59]. An alternative approach being developed within the TINA[60] project will use a low power chirp signal spread across the whole of the 2.4 GHz licence exempt band, and are expected to not interfere with other users of the same spectrum[61]. A further potential technique based on measurement of the E and H fields in the near field region of an antenna promises to operate at frequencies around 1 MHz[62] and at extremely low power levels that should not interfere with existing users. Location data over the wider area of a port is easily provided through the use of enhanced satellite navigation systems. Thus the location systems themselves can be expected to be accommodated within existing spectrum allocations. It will be necessary to transmit the location information over wireless to the intelligent surveillance computer. This will amount to a small volume of data (10's of bytes) sent regularly by all operatives, vehicles and movable machinery and is unlikely to put a significant load on the ports overall wireless network.

The video cameras monitoring the areas of interest will need to be linked back to the analysis computer. Links over a local Wi-Fi network could be convenient but with multiple cameras such links might exhaust the available capacity. Cabling is an alternative or wireless links could use the CCTV band (at 31 GHz) or the point to point broadband fixed wireless bands at 70 and 80 GHz. The latter have very high capacities.

### 5.4.2 Electronic seals

Electronic seals are expected to be read at short range when passing a reader (for example when off-loading from a ship or lorry) or at longer distances to check the status of containers stacked in a parking area. In the former case, only a small number of e-seals will be read at one time. In the latter case the limiting factor will be the difficult RF environment created by multiple rows of stacked metal containers so that the number that can be seen by a single reader will be relatively small. In both cases the existing spectrum allocations are expected to be adequate.

As with video cameras the e-seal readers will need to be linked back to the port IT systems, and Wi-Fi would be a convenient way to achieve this especially for mobile and portable readers. The amount of data that will need to be transmitted in this way is small (perhaps a few hundred bytes per container) and the required transmission capacity will be a fraction of the total available. Data over PMR or public cellular networks are alternatives, as are cabled systems. Thus the operation of e-seals is not expected to place a significant demand on a port's wireless infrastructure.

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[58] See www.ubisense.net.

[59] See www.ekahau.com.

[60] See http://intelligentairport.org.uk/.

[61] Each chirp signal will of course add to the noise and cause a small reduction in the capacity of a Wi-Fi network.

[62] See www.q-track.com.

However, a port's wireless infrastructure will support several other functions including mobile IT applications, office to ship communications, automation of container movement, and perimeter surveillance systems. These will need to be taken into account in assessing the total spectrum a future port might require.

## 5.5 Evidence for development time scales

The following were taken into consideration in developing the scenario time scales.

- Achieving final agreement on international standards can take a significant amount of time. The ISO 18185 standard was thought to be almost complete in 2004 but in the event was not released until April 2007.
- The 2007 Draft Communication from the Commission, the Freight Transport Logistics Action Plan[63], which foresees an all electronic flow of information associated with the transport of goods, envisages the development of a standard for information flows by 2010 and the establishment of "one stop administration" for intra-EU freight by 2012. However, we note that the related European consultation on European Maritime Transport Space Without Barriers only closed for comments on January 20th, 2008.
- Funded research projects of the type considered in development of intelligent surveillance systems typically last 2 to 3 years.

## 5.6 Indicators for tracking developments

With regard to the introduction of intelligent surveillance systems decisions by TRANSEC will be key, and these in turn will depend upon assessments of threat levels and other security measures, and on the development of the appropriate technology. In addition to changes in the perceived level of threat, indicators will include:

- Improvements in video tracking and scene understanding over the next few years;
- Developments in intelligent surveillance systems based on video analysis and real time location systems (including in other situations such as airports);
- The commercial success of longer range RFID location systems and substantial cost reductions in the cost of the corresponding tags.

With regard to electronic seals decisions by major trading nations and international standardisation will play a determining role so indicators will be:

- The development of government programmes to further increase security in maritime transport or encourage the use of electronic customs procedures;
- The development of effective and low cost alternatives such as automated scanning of container contents;
- Proposals within ISO to enhance the ISO 18185 standard;
- The commercial development of e-seals, prices and market take up.

## 5.7 Summary

Security is expected to remain high on the national and international agenda for several years to

[63] http://ec.europa.eu/transport/logistics/freight_logistics_action_plan/doc/action_plan/2007_com_logistics_action_plan_en.pdf. Accessed on 16 January 2008.

come, and the UK and other governments can be expected to continue to mandate improvements in security systems such as the intelligent surveillance system and electronic container seal described here.

### 5.7.1 Intelligent surveillance systems

The key benefit of intelligent surveillance systems is their potential to improve security without hindering the normal operations of a port, and taking less manpower to do so. The technology is not available today but improvements rather than fundamental advances in the technology of video scene analysis and tracking are required to make these systems practical.

The cost of these systems will be driven by the cost of computing power and the cost of RFID location systems. The former continues to fall every year while the latter is expected to fall significantly over the next few years as it is taken up across other industries. Thus cost is unlikely to be a major handicap per se. Rather, decisions on whether or not to implement intelligent surveillance systems will depend upon a wider view of security encompassing the assessed effectiveness of other aspects of security and the priority areas for improvement.

Spectrum constraints are considered unlikely to be a limiting factor in their deployment.

### 5.7.2 Electronic seals

Mechanical container seals will be mandatory on all containers entering the USA from October 2008 and other countries may well follow suit. These seals will improve the security but require physical checking which takes time and increases shipping costs. E-seals which can be checked rapidly, remotely and automatically would therefore have a clear benefit. The technology is available today but it is relatively expensive and multiple solutions are on offer. Thus the two remaining barriers to the take up of e-seals are cost and the lack of a widely accepted standard. Costs will reduce as RFID technology is used more widely across the transport and other industries and there is a clear move towards common standards through the ISO process.

The final decision by government agencies to mandate their use will of course depend upon the wider security picture and the costs and benefits of other security measures. But only a small amount of time and effort needs to be saved per container to justify the cost of the seals (a few US$ per container early in the next decade) and we conclude that this development is likely to come about.

The requirements for spectrum to support the use of e-seals will not be a constraint.

# 6 Navigation

## 6.1 The Vision

By 2025 navigation will be based almost entirely on the use of satellite navigation systems with enhanced Loran available as a back up across the seas around Europe. Galileo will be operational, GPS and GLONASS will have been modernised[64], and AIS based aids to navigation will have been extensively deployed in the approaches to ports and other high risk locations. As a result berth to berth navigation will be almost entirely based on electronic aids.

Continuing concerns over safety and protection of the environment, and particularly over security (led by the U.S.A.), will have led to the mandatory tracking of all commercial shipping within European waters and of all shipping destined for European ports. On the high seas this is based on the IMO standardised Long Range Tracking and Identification system enhanced with additional facilities developed through European research projects. Closer to shore, it relies on the exchange of data via a supplementary AIS data service.

With the growth in the size of vessels, particularly container and cruise ships, safe and accurate manoeuvring of ships into and out of port has become even more critical and major ports have adopted sophisticated vessel traffic management and information systems (VTMIS). In order to maximise compatibility with the international shipping fleet, these systems have been built around the facilities mandated by e-Navigation. These enable the traffic control centre to identify all vessels within the area of interest, their position, heading and speed. Combining this information with that on the weather, local tides and currents, channel depths and available berths the management system will identify the optimum route for each vessel to follow. Indeed, the route into port will normally have been transmitted to each vessel well before it reaches the port although the ability to change it in real time is maintained so that unforeseen incidents and changes can be accommodated. A data link between the VTMIS and a vessel means that the shore based controller and the ship's captain (or the pilot) both see the vessel's track and intended route plotted on the same chart. The same system also provides the necessary information for coordination with tugs and pilots where these are required. A number of ports handling the largest vessels will have installed radar based automatic berthing systems to minimise the chance of damage to vessels and quays.

## 6.2 Summary

The move to much greater use of electronic navigation aids described above is already well underway although it will take many years for the world's fleets to make the change. Although the changes are significant from an equipment and operational point of view their impact on the use of wireless is much less since any number of users can make simultaneous use of radio navigation signals whether from satellites or ground stations. Some aspects of maritime wireless usage will be impacted but to a small extent as discussed below.

### 6.2.1 Long range identification and tracking

LRIT becomes mandatory with effect from 31st December 2008 and requires that ships transmit their identity and position at intervals when within 1000 miles of a coast. Satellite is used. The amount of information per ship is small (10's of bytes) thus even with regular reporting by many

[64] They will still rely on correction signals broadcast over the IALA radiobeacon DGNSS service and via geo-stationary satellites (the EGNOS system in Europe).

ships at regular intervals the demands on satellite capacity will be small[65].

### 6.2.2 The VHF band

The VHF band is used for ship to ship communications, port operations (including vessel traffic management systems), safety broadcasts and the automatic identification system. The use of VHF wireless for port operations and safety broadcasts will be little affected by the move to electronic navigation aids. The other uses are considered below.

**Automatic identification system** - With AIS, which is mandatory on all vessels exceeding 300 gross tonnes, each ship transmits its position and course at regular intervals so that all other equipped vessels can determine the position and track of nearby vessels[66]. At present it operates in two channels in the VHF band. We understand that this provides adequate capacity for commercial shipping but could become inadequate if a large proportion of leisure boats were to be equipped.

**Vessel traffic management systems** – The vision above envisages greater interaction between port operators and approaching ships and greater use of vessel traffic management systems in busy waters. The major additional traffic in this vision is the data link between ship and VTMS control. However, this requires only identity, position and course information at intervals and will therefore generate only small amounts of additional traffic easily supported on a single VHF data channel.

Taken together the additional usage identified above could lead to the need for a few additional channels which, with the current 25 kHz spacing, would amount to around 100 kHz. There is no technical bar67 to moving to smaller channel spacings (12.5, 8.33 or 6.25 kHz) which would provide more than enough additional capacity and allow for growth in usage.

### 6.2.3 Chart uploading

With the move to electronic navigation equipment charts have to be updated electronically, potentially while at sea. Whilst the amount of data in a chart is large, updates would normally apply to only a limited number of features suggesting that update file sizes would be quite moderate. Furthermore this is an application that could well run alongside the ship to shore (satellite) links that we expect for onboard mobile phone and internet connectivity. In port, chart updates could be accessed over standard public terrestrial networks.

### 6.2.4 Docking radars

Docking radars need operate only over very short distances (a few hundred metres) and only during the relatively short period while berthing. Thus no major spectrum requirement is foreseen as coming from this application.

Our overall conclusion is that the changes in maritime navigation expected over the next 20 years will lead to a relatively small expansion in wireless traffic, largely over satellite or in the VHF band, and lead to no major new requirement for spectrum.

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[65] We estimate that the entire European fleet of cargo vessels, cruise ships and ferries could be served by a single 10 kbps channel.

[66] Aids to navigation such as buoys are also being equipped with AIS so that they will be visible on the same display as other vessels.

[67] Migration to a new channel plan would of course need to handled carefully, especially in the case of AIS.