

PORT TECHNOLOGY OF THE FUTURE

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Abstract

Most ports are competing with one another on a global scale and this has led the drive to improve port efficiency, lower cargo handling costs and integrate port services with other sectors of the global distribution network with regard to lowering emissions, safety and security. The maritime sector has considerable influence on the volumes and conditions of trade and the capacity for economic development. Developing new practices and technologies for ports has become vital for maintaining growth and generating trade. New port technology and capital investment in infrastructure is essential to maintaining economic growth and competitiveness. Global competition, intelligent transport systems (ITS) and communication technologies are continuously modifying the environment.

The future is bringing increasing demands for greater efficiency and for more sustainable designs in cargo handling technologies. Moreover, the scarcity of land is forcing port companies to realise higher area utilizations. Terminal operators have the same objectives but they are also looking for cost reduction through decreased life cycle costs, energy consumption, maintenance etc. This is forcing terminal operators to invest in more sustainable, environmentally friendly and cost effective cargo handling equipment. The challenge is how to balance service requirements, costs and demand for sustainability.

Ports play a vital role in economic growth by attracting and generating trade. A port that is not able to cope with rapidly advancing technologies will not be in a position to foster the development of the trade sector. Therefore the development of new cargo handling technology is of paramount importance if a port is to succeed in implementing its economic role.

The main problem in handling increasing levels of cargo is managing the internal traffic and optimizing space inside smaller and medium sized ports. A new generation of cargo handling technology has been designed in the form of an Intelligent Autonomous Vehicle (IAV). The IAV is a clean, safe, intelligent vehicle which will contribute to improving the traffic management and space optimization inside confined space by developing a clean, safe and intelligent transport system.

Keywords: Intelligent Autonomous Vehicle (IAV), Intelligent Transport Systems (ITS), Space Optimisation, Traffic Management, Globalisation.

1. Introduction.

In an ever changing global scene, the maritime sector has had to take on many challenges. Due to the revolution of container shipping the world economy has become more accessible with container throughput experiencing steady growth over the last fifth years. The international seaport business has changed radically within the space of several years. Globalisation has brought about changes in the structure of the world economy and the shipping and port industries have had to respond to the challenges.

New port technology is essential to maintain economic growth and competitiveness.

Developing new methods and technologies for ports has become an entirely separate economic activity. Until recently there was very little competition between ports and port related costs were relatively insignificant in comparison to the high cost of ocean and inland transport. There was little incentive to improve port efficiency and effectiveness.

Increasing global competition and continued development of emerging countries has forced changes in the way ports conduct their business. Most ports are competing with one another on a global scale and this has led the drive to improve port efficiency, lower cargo handling costs and integrate port services with other sectors of the global distribution network with regard to lowering emissions, safety and security [1].

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2. North West Europe Region

The coastal region of North West Europe (NWE) stretching from Ireland to Rotterdam is of huge importance but despite this fact few of its smaller and medium sized ports are able to keep pace with growth due to the immense pressure they are under. This pressure is due to increasing container traffic, the economic scarcity of land resources and escalating environmental concerns. These concerns are more referent to urban centre ports such as Dublin Port and other small ports for example Oostende in Belgium and Radicatel in France. The main problem in handling increasing levels of cargo is managing the internal traffic and optimizing space inside smaller and medium sized ports.

There is a constant increase in the freight passing through European ports. For example, the volume of containerised freight entering and leaving seaports has doubled within the space

of several years. Around 90% of the EU's trade with third countries passes through the ports of Europe, with some 3.2 billion tonnes of freight being loaded and unloaded annually [2]. The EU's seaports play a vital part in ensuring the competitiveness of both its internal and external trade, and they provide essential links to its islands and remote regions. Moreover, the ports generate more than half a million jobs either directly or indirectly, and they drive the dynamism and development of entire regions, including most of the EU's remote regions. Europe needs a network of accessible and efficient ports. It needs greater port capacity, and existing capacity has to be streamlined. EU ports must identify all the issues they must resolve if they are to meet the ever-growing demand for transport, cope with technology change (such as containerised freight, intelligent transport systems (ITS) and new information and communication technologies (ICT) and address the need to reduce emissions. Europe's main transport arteries need to become 'green', taking account of environmental concerns as well as the general need for safety and security. All ports must meet these challenges, develop their operations and become more competitive [2]

3. Dublin Port

Dublin is Ireland's biggest and busiest port and although volumes dropped in 2009 and in spite of the economic downturn, exports in 2010 increased by 6.1% and again by 2.8% in 2011. The 2.8% increase is expected to double over the next thirty years. The port is crucial to the Irish economy as its function is to facilitate the movement of goods and people, in an efficient and cost effective manner [3].

The port handles over €35 billion worth of trade every year and supports some 4,000 jobs locally. 90% of Ireland's GDP is exported with 42% being handled through Dublin Port. The port offers multi-modal services with connections to Rotterdam, Antwerp, Le Havre, Felixstowe, Hamburg, Southampton and Liverpool which are important strategic trading hubs. [3]

Table 1. Historical and Forecasted Throughput

Year	Throughput	AAGR*
1980	7.3m tonnes	3.2%
2010	28.9m tonnes	4.7%
2040	60.0 tonnes	2.5%

*Average Annual Growth Rate.

Table 2. Profile of Throughput to 2040

	2010 '000 tonnes	2040 '000 tonnes	AAGR
Ro/Ro	16,403	41,920	3.18%
Lo/Lo	6,317	10,480	1.70%
Bulk Liquid	4,009	4,000	-0.01%
Bulk Solid	2,054	3,500	1.79%
Break Bulk	96	100	0.12%
Total tonnes	28,879	60,000	2.47%

Table 3. Forecasted Traffic for Ro/Ro and Lo/Lo

	2010	2040
Ro/Ro (‘000 units)	701	1,791
Lo/Lo (‘000 units)	377	625
Total units	1,078	2,416

In line with the Port Company’s ambitions and growth forecasts, there is a need to optimise the use of Intelligent Transport System (ITS) in Dublin port. Container ships are now carrying more units per voyage, therefore safety, security and the need to put more environmentally-sustainable practices in place are putting more demand on the port [3].

There is a need to optimise the use of Intelligent Transport Systems (ITS) within international ports such as Dublin. Currently in Dublin Port, the movement of cargo is operated by shunter vehicles differing from AGV’s as in other international ports.

3.1 Current Technology used in Ports.



Figure 1. Shunter Vehicle



Figure 2. Automated Guided Vehicle AGV)

4. Intelligent Autonomous Vehicle (IAV)

A new generation of cargo handling technology has been designed in the framework of Intelligent Transport for Dynamic Environment (InTraDE) an EU funded project to which Dublin Institute of Technology (DIT) is a partner with Dublin Port Company as a sub partner. Participation in the project will contribute to improving the traffic management and space optimization inside confined space by developing a clean, safe and intelligent transport system such as an Intelligent Autonomous Vehicle (IAV).

The IAV is similar to the Automated Guided vehicle (AGV) but is technologically superior as it is battery operated making it more economically and environmentally efficient. In contrast to the AGV, the IAV does not have to follow designated routes embedded in the infrastructure to reach its destination.

The IAV is an individual unit which can also work in groups allowing it to form a platoon similar to a train with locomotives. The unit capacity of an IAV is one TEU (twenty foot equivalent unit). Two IAV's will be required to transport two TEU or one FEU (forty foot equivalent unit) [4].

All four wheels have actuators and a failure in any of the wheels individually does not stop the vehicle from operating. The unit is battery operated and the wheels offer 360 degrees movement allowing the vehicle to move in any direction within a confined space.

The IAV is a multi-input, multi-data (MIMD) system equipped with several sensors which will enable it to benefit from Geographical Positioning System (GPS), allowing it to move unmanned around port terminals, delivering containers to and from marshaling areas. Although the IAV is not exactly new, what makes it different is that it does not require a guidance system such as rails or transponders set into the ground [5]. Traffic management and space optimization is a problem with the future development of port terminals in NEW and in particular Dublin Port. The problem can be solved by having a remote 'traffic control centre' directing vehicles to marshaling areas where the containers are handled by IAV's [4]

Table 4. Battery Specification of IAV

Working Temperature	-10C, +40C
Storage Temperature	-20C, +50C

Table 5. Payload Volume of 20ft. Container

Length	6M
Width	2.4M
Height	2.6M
Volume	1360 CU FT

Table 6. Summary of Technical Specifications of IAV

Weight (without load)	3000KG
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Payload	7000KG
Wheels Diameter	760MM
Dimensions	L: 7M W: 2.5M
Height of Landing Try	1.2M

Table 7. Characteristics of IAV

4 Wheels	Double Drive & Steering
Mass of Vehicle	2225 Tons
Height	1300 MM
Width	2500 MM
Length	7000 MM
Wheel Diameter	760 MM
Height under the Try	1197 MM
Position of Center of Gravity	0MM, 809MM, 0MM

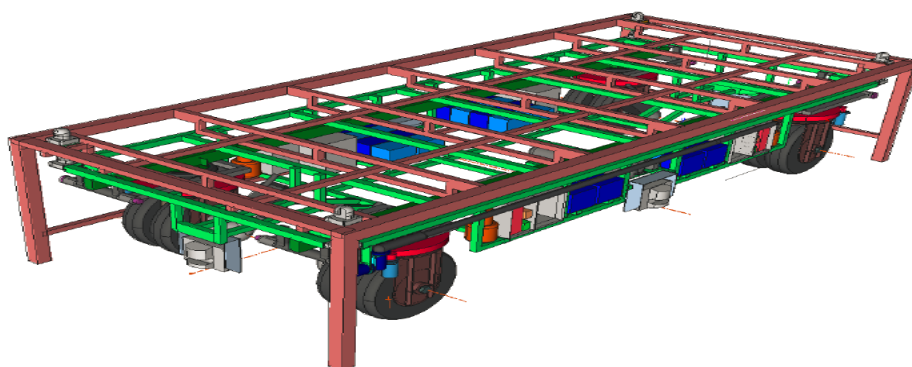


Figure 3. IAV Design

4.1 Suitability and Application of IAV in Dublin Port

If Dublin port is to grow and expand, there will be a need for some reconfiguration of the existing port with redevelopment as required. There is a limit to the volume of freight that can be handled in the ports existing estate and infrastructure. Therefore, the introduction of the IAV and the application of the virtual port simulator will be very valuable in forecasting the impact of changing traffic flows and the foreseen increase in efficiency and cost effectiveness of cargo handling in the port by designing a case study of Dublin Ferryport Terminal (DFT) layout using a virtual simulator.

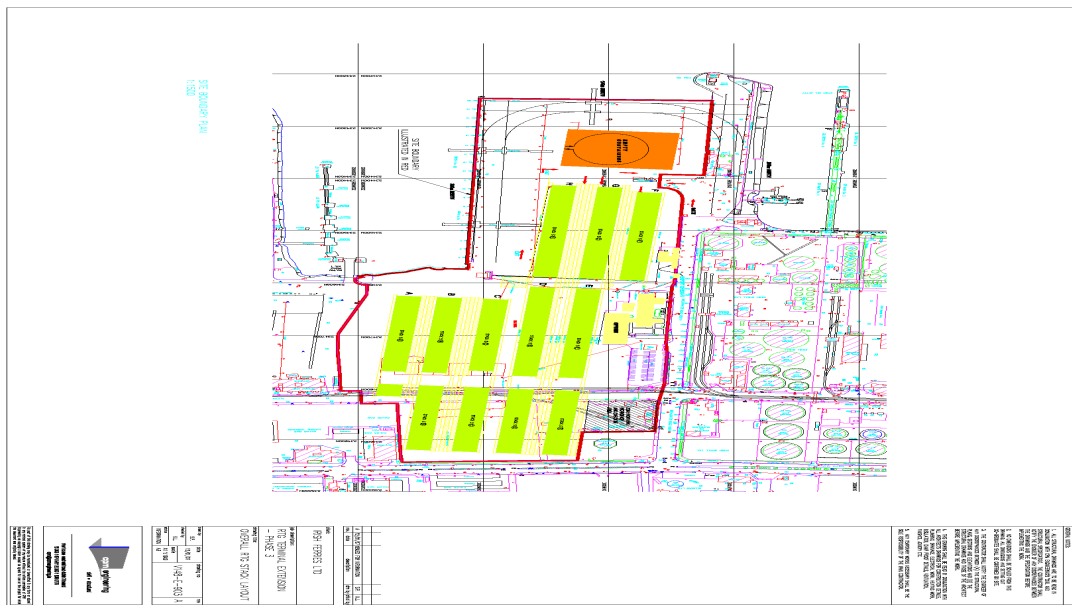


Figure 4. DFT Terminal in Dublin Port

IAVs will improve the traffic in Dublin port in terms of congestion, when the volume of vehicles is dense according to space motion. These vehicles will alter their speeds and trajectories according to the traffic status and the environmental changes such as pollution and noise. The auto-control will help significantly in decreasing the emission rate of pollution gases during the vehicles mission. In order to be efficient, cargo handling has to be situated close to the quay wall where vessels are operating, otherwise, valuable time will be lost moving the cargo from ship to storage area and vice versa. In turn, this will impact on the turn-around time of vessels, a crucial factor in vessel and port efficiency. The IAV will reduce the time lost in moving cargo from ship to storage area and vice versa by 10%. In addition, the environmental benefits will include a 20% reduction in air pollution [4].

The novel conception approach of the IAV will identify automatic navigation routes in order to overcome any infrastructural barrier in Dublin Port. It does not require fixed tracks (an inherent costly investment) commonly required for completely automated vehicles. A major consideration in the development of the IAV is its suitability for Dublin Port in terms of its payload capabilities and its capabilities to adapt to a varied range of environmental parameters which present themselves in the expansion of the Port.

4.2 Simulation of Dublin Port using IAV SCANer Studio Software

The simulation software used is called SCANer Studio simulation engine. It has adapted techniques to develop a real-time simulation for the study of traffic flows within Dublin port and other international ports. Data and information regarding Dublin Port was inputted in the

simulator in order to finalise a generic 3D dynamic simulator of the port. The tool employs an interactive approach between vehicles, traffic lights and roads that enables users to visualize a real port network and the vehicles that drive in it. The technique developed can be changed to different port layouts due to the flexible extensible method with which it has been implemented. The main study of the simulator is to set parameter values of the actual port system. Simulation is the perfect tool for evaluating system parameter values as it reduces the cost and time of a project by allowing the user to quickly evaluate the performance of different layouts, a process that is time consuming and extraordinarily expensive. The robustness of the system can be tested using different scenarios, allowing you to explore these scenarios without changing the values therefore any changes can be easily made [4]. The simulator will help significantly in the pre-analysis before experimental tests of the vehicle are carried out. With the different developed vehicles, infrastructure and environment, validation of the developed algorithms on control, monitoring, space optimisation and traffic management can be carried out before real integration begins. The software will identify potential obstacles and related problems and will reduce the number of obstacles in the port area by 3%. It will achieve a more effective method of moving cargo from ship to storage area and vice versa with a minimum efficiency improvement of 10%. Obtain a safe environment within the port area due to the simulators capabilities to locate the position of the goods at all times, a reduction in the loss or damage of cargo by 4% will be a target. Reduction in the level of accidents by 5% and it will also aim to increase the use of information and communication technology (ICT) within Dublin Port operations by 5% [4].

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