FACILITATING TRADE AND ADOPTION OF THE "INTRADE" IAV IN DUBLIN PORT IN 2040

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ABSTRACT

Dublin Port is the largest and busiest port on the island of Ireland. The port's main function is to facilitate the movement of goods and people which is crucial to the Irish economy, in an efficient and cost effective manner **[*Dublin Port Company, Materplan, (p.3)*]**. Dublin Port Company launched a new Master-plan for its long-term development in March 2011.

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 Automated Guided Vehicles (AGVs) as in other international ports.

Figure 1. Shunter Vehicle

Figure 2. Automated Guided vehicle (AGV)

The IAV will use a GPS guidance system to move unmanned around port terminals, delivering containers to and from marshalling areas. Although Intelligent Autonomous Vehicles (IAV's) are not a new concept, the different is, it does not require a guidance system such as rails or transponders.

KEYWORDS: Intelligent Autonomous Vehicle (IAV). Space optimisation. Traffic management. Intermodal transport.

1. INTRODUCTION

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. Opportunities have risen as a result of the structural changes which need to be exploited.

Most ports today are competing with one another on a global scale and, with the tremendous gains in productivity in ocean transport achieved over the past decades, ports are now perceived to be the remaining controllable component in improving the efficiency of ocean transport logistics. This has generated the drive to improve port efficiency, lower cargo handling costs and integrate port services with other components of the global distribution network with regard to lowering emissions, safety and security

Ports no longer operate in an insulated or isolated environment. They face the same competitive forces that companies in other industries experience. There is rivalry among existing competitors, continuing threat of new entrants, potential for global substitutes, presence of powerful customers and powerful supplies and regulative and legislative boundaries that must be adhered to. [***World Bank Port Reform Tool Kit*/module 2. *The Evolution of Ports in a Competitive World*. (p.1)]**

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 trades with third countries pass through the ports of Europe, with some 3.2 billion tonnes of freight being loaded and unloaded annually.

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 a high level of employment both 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 ICT technologies) and address the need to reduce emissions Europe's main transport routes need to become 'greener', taking account of environmental concerns as well as the general need for safety and security. EU ports must meet these challenges, develop their operations and become more competitive. **[*Maritime Transport without Barriers. Initiatives for Making European Ports more Efficient.* (p. 4, 5)]**

Globalisation, consumption needs and long term energy together with climate change have had dramatic effects on our environment and are at the forefront of the international maritime agenda. A feature of world trade is the increasing economic uniting of markets and as a result global cargo handling.

The operators of terminals and ports are obliged to take a more responsible stand with regard to the environment in view of the greater awareness for environmental issues and related laws and regulations. As a result, greater emphasis is being placed on the design and sustainable development of the technology that is used. These developments have brought the attention to bear on cargo-handling equipment using low-consumption, environmentally aware technologies to increase efficiencies, reduce emissions and to optimise the use of limited space. It is important that companies use equipment that is economical and environmentally compatible at the same time. The main problem in handling the increasing level of cargo in the terminals of international ports is managing the internal traffic management and space optimisation inside confined spaces.[***World Bank Port Reform Tool Kit/module2.The Evolution of Ports in a Competitive World*. (p.1)]**

2. DUBLIN PORT MASTERPLAN AND THE ROLE OF INTELLIGENT TRANPORT SYSTEMS

Dublin Port is the largest and busiest port on the island of Ireland. The port's main function is to facilitate the movement of goods and people which is crucial to the Irish economy, in an efficient and cost effective manner. Dublin Port Company launched a new Master-Plan; it's the long- term development, in March 2011. It handles over €35 billion worth of trade every year and supports some 4,000 jobs locally. 90 per cent of Irelands GDP is exported with 42 per cent being handled through Dublin Port. Growth in the container traffic was 1.1 per cent with an out-turn of 554,229 TEU (Twenty Foot Equivalent Unit) in 2010. 80 per cent of all exports and imports through the port are transported in containers. In 2010 the throughput was 28.711 million tonnes. Imports consisted of 6.933 million tonnes, an increase of 2.4 per cent. Exports increased to 11.184 million tonnes, an increase of 12.2 per cent. Dublin is the largest of the three base ports in Ireland, the others being Belfast and Cork. The base ports offer multi-modal services with connections to ports such as Rotterdam, Antwerp, Le Havre, Felixstowe, Hamburg, Southampton and Liverpool which are important strategic trading hubs. [***Dublin Port Company, Trade Statistics a, Facts and Figures b]***

The aim of the Master-plan is to chart the development of Dublin Port Company out to 2040 to allow for a doubling of trade volumes. It has already seen some evidence of a return to growth with a 6% rise in throughput in 2010. Given the depressed nature of the economy at present (2011), this may not seem feasible but with Irish exports thriving in the recession Dublin Port is one of the few companies in the country operating in a growth industry.

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

The Master-plan is based on the assumption that trade will grow to 60 million tonnes by 2040, this would be roughly twice the level of 2011 and imply an average annual growth rate of 2.5 per cent. If anything, this forecast might be too conservative. The volume of trade through Dublin Port in 2010 rose by 6.1 per cent to 28.9 million tonnes. Roughly three-quarters of that growth accounted for exports. While it is below the 2007 peak of 30.9 tonnes, it marked a turnaround for the port business after some difficult years affected by the recession in Ireland. [***Dublin Port Company – Masterplan Issues Paper*. (p. 7, 8)]**

In line with the ambitions and growth forecasts predicted by the Port Company, 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 Automated Guided Vehicles (AGVs) as in other international ports. The INTRADE project, in which Dublin Institute of Technology (Department of Transport Engineering) are Partners with Dublin Port Company as a sub-partner, has received European Regional Development Funding through InterReg IV B. Within North West Europe (NWE), few ports are able to keep pace with the activity similar to that experienced in Dublin port. The main problem in handling the increasing level of cargo in the terminals of international ports is managing the internal traffic management and space optimisation inside confined spaces. Participation in the InTraDE project will contribute to improving the traffic management and space optimization inside confined space by developing a clean and safe ITS such as a IAV (Intelligent Autonomous Vehicle).

3. INTELLIGENT AUTONOMOUS VEHICLE (IAV)

The InTraDE project is contributing to improving the traffic management and space optimization inside confined spaces by developing a clean and safe ITS (Intelligent Transport System) such as a IAV (Intelligent Autonomous Vehicle). The technology will operate in parallel with virtual simulation software of the automated site, allowing a robust and real-time supervision of the goods handling operation using virtual simulation software.

The IAV is the logical transition from mobile robotics to that of urban vehicles. The technology will have a specific design, with multi-actuated traction and steering systems. This configuration will allow the system to be redundant in control, so that different scenarios can be defined to run the vehicle on a segment of the road or particular pre-defined trajectory. Multi-decentralized inputs help find reconfigurable solutions, when an input fault is detected and isolated. In this case, the vehicle will avoid the stop situation, without obstructing the traffic operation

IAVs will improve the traffic in international ports 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 meet requirements of a changing industry and to service the needs of a rapidly developing economy in the long term, the IAV will reduce the time lost in moving cargo from ship to stacking areas and vice versa by 10%. In turn, this will impact on the turnaround time of vessels, a crucial factor in port and vessel efficiency, particularly in Dublin Port. In addition, the environmental benefits will include a 20% reduction in air pollution. [***INTRADE*. *Intelligent Transportation for Dynamic Environment*]**

The IAV will use a GPS guidance system 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. Traffic management is a problem with the future development of port terminals such as in Dublin Port. The problem can be solved by having a remote 'traffic control centre' directing vehicles to marshalling areas where the containers are handled by IAV's.

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 the vessels, a crucial factor in vessel and port efficiency. **[*Dublin Port Company – Masterplan Issues Paper. (p. 4)*]**

3.1. Suitability and Application of IAV in Dublin Port

If Dublin port is to reach 60 million tonnes by 2040, 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. The most accurate estimate is that the port will require in the order of 30 to 40 additional hectares to cater for the 60 million tonnes by 2040. Therefore, the introduction of the IAV (Intelligent Autonomous Vehicle) 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 good handling in the port in 2040 by

designing a case study of terminal layouts using the virtual simulator.

Figure 2. DFT Terminal in Dublin Port

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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 (and 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 redevelopment of the Port. [***INTRADE. Intelligent Transportation for Dynamic Environment.***]

This novel technology will adapt to the specific environment in Dublin port, which could then be transferred to different sizes of ports and terminals in the NWE region and beyond.

3.2. Technical Innovation of IAV

The IAV is novel in terms of its advancement of ITS designs with innovative features including:

- Autonomous platform totally operable by a remote control computing in virtual environment, semi automatic mode possible;
- Two degrees of mobility to command directly due to the 4 wheels steering with 360° mobility on all wheels;
- Totally modular design, intelligent “corners” with drive, steer and suspension;
- Electric hub motors (in-wheel), battery operated, associated with thermal generator according to the transport scenario;
- Low consumption and minimizing of CO2 and noise pollution;
- Carrying standard containers, with standard connections, stackable within weight limits;
- Position feed-back for the remote control by appropriate sensors (GPS, lasers, ultrasonic, …);
- Safety in freight transport and human-machine interaction: vehicles with low speed motion, two modes of driving ((manual and automatic)
- and using a real-time supervision of the overall system and soft system maintenance;
- Efficient traffic management inside an enclosed and in some cases, urban areas. The second innovation related to this project concerns the development of on-line virtual simulator for the port including all the traffic management and space optimisation. It can also simulate the external environment and accidental situations.

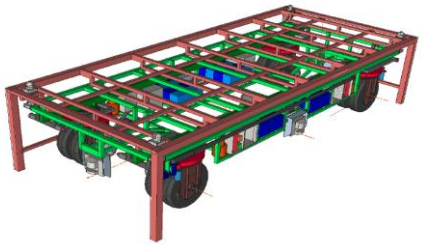

Figure 3. IAV Design

3.3. Specifications and Capabilities of the IAV

- The IAV will handle 20ft and 40ft containers;
- Two IAV’s coupled together will handle a 40ft container;
- A tow hook on the front will allow the vehicle to be towed incase of failure;
- Maximum velocity on horizontal flat floor forward and backward 25km per hour;
- Autonomy 10km for four hours continuously;
- Slope general of 3%;
- Transversal slope general of 3%;
- Noise level internal and external power supply by battery.

Table 4. Battery specifications 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

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Table 6. Summary of Technical Specifications of IAV

Weight (without load)	3000 kg
Payload	7000 kg
Wheels diameter	760 mm
Dimensions	L: 7m W: 2.5 m
Height of handling try	1.2 m

Table 7. Characteristics of IAV

4 wheels	Double drive & steering
Mass of vehicle	2225 Tons
Height	1300mm
Width	2500mm
Length	7000mm
Wheel diameter	760mm
Height under the try	1197mm
Position of centre of Gravity	0mm, 809mm, 0mm

3.4. 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 imputed 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 is 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.

The simulator will help significantly in the pre-analysis before experimental tests of the vehicle. 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%.

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Roisin Murray. DipEng, BEng, ME, CMILT

Roisin Murray graduated from ITT Dublin with a BSc in Manufacturing Engineering in 2002 and obtained a ME in Advanced Engineering from Dublin Institute of Technology (DIT) in 2004. She left the private sector to join the Department of Transport Engineering at DIT (2005) where she worked on transport research (2005-2010) and was appointed Assistant Head of Department in 2010.

She conducted research on behalf of DIT for Commission for Taxi Regulation and carried out a '*National Review of Vehicle Standards for Taxis, Hackneys and Limousines in Ireland'* (2005). Another area of interest has been deliveries at night in Dublin city centre with residents being affected by increasing noise levels, She managed an Innovation Partnership project to tackle unwanted noise generated by night deliveries. Funded by Enterprise Ireland and a consortium of Irish companies, *'Low Noise Solutions for Night Deliveries'* (2005 – 2007) developed new and innovative low noise, low cost products and materials for HGVs, ancillaries and delivery sites.

In terms of sustainable surface transport and international research, Roisin Murray has managed Irish participation in FP6 projects such as *SILENCE*, *BESTUFS (Best Urban Freight Solutions)* and *NICHES* (2005-2008).

Other research interests include: electric vehicles; light rail transit systems; transport policy, and impacts of behavioral and attitudinal changes in passenger transport and the freight industry. She is currently the Irish Principal Investigator on various national and European research projects (InterReg IVB) including INTRADE (Intelligent Transportation for the Dynamic Environment) which is co-funded by Dublin Port Company and ENEVATE (European Network on Electric Vehicles and Transferring Expertise, co-funded by Electricity Ireland (formerly ESB).

Kay McGinley. BA(Hons)MM

Kay McGinley graduated from The National College of Ireland (2007) with an honors degree in Maritime Management. She is currently doing an MPhil in the Dublin Institute of Technology, Department of Transport Engineering on the study of Intelligent Autonomous Vehicles in Dublin and International Ports.

Before joining the Dublin Institute of Technology (2010) to work as a researcher on the InTraDE (Intelligent Transport for Dynamic Environment) project which is co-funded by InterReg IVB North West Europe programme and Dublin Port, she worked in the shipping industry (1976-2009) where she was involved in a wide variety of roles and departments which involved shipping containers all over the world.

While in the shipping business she gained a wide knowledge of the maritime business. She also lectures in the Dublin Institute of Technology on maritime operations.