



Intelligent transport systems in multimodal logistics: A case of role and contribution through wireless vehicular networks in a sea port location [☆]

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ABSTRACT

The growing complexity of logistics and its importance as a major economic activity has raised the profile of information and communication technology (ICT) as means to improve the levels of visibility, responsiveness and efficiency in supply chains relying in multimodal transport operations. With the use of wireless vehicular networks, Intelligent Transport Systems (ITS) have the potential to shape the future of multimodal logistics. In the absence of sophisticated ICT tools, the potential role and contribution of ITS and in particular wireless vehicular networks play in logistics is investigated in a multimodal case of a port terminal handling bulk material transported by sea, which is unloaded into haulage vehicles. Event flow mapping and network modelling analysis are used to determine the feasibility of ITS to support real-time data traffic related to the exchange of messages, which are representative of the flow of events taking place in multimodal logistics and which can be associated to high-impact capabilities with economic repercussions such as track and trace.

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1. Introduction

Logistics has become a major economic activity comprising the process of planning, implementing and controlling the efficient, effective flow and storage of goods, services and related information from point of origin to point of consumption for the purpose of conforming to customer requirements (Council of Logistics Management, 1998). Multimodal logistics has become an important component of logistics worldwide. Hence, in modern deep-sea and short-sea ports, access to other modes of transportation including road, rail, pipeline and air is available. The use of multimodal logistics has been encouraged by government directives and initiatives aiming at making operations more efficient and environmentally friendly. For example, in recent years the

European Commission has released a series of calls aiming at the development of short-sea shipping as a sustainable part of the logistics chain as European roads suffer from major congestion problems (DFT, 2007). In Northern Europe, the significance of multimodal logistics can be seen in the growing importance of short-sea shipping comprising regular liner services and ferries operating fast, reliable and flexible connections that carry a wide range of cargos in different types of vessels, including charter vessels for transport of bulk steel and construction materials, between terminals in the region as well as Roll On–Roll Off (Ro–Ro) operations including finished vehicle logistics (DFT, 2007). The efficient management of multimodal logistics would be difficult to achieve without the support of sophisticated information and communication technology (ICT). There is a need of developing electronic logistics management systems, and other applications that can be used to ensure and enhance safety and security and to simplify administrative and customs procedures (DFT, 2007).

In recent years, sea ports have consolidated their position as premier locations for complex logistics networks. For many countries with some of the most developed economies in the world, ports represent their main access gates for trade and commerce, hence ports are ideal transport nodes to investigate the use of innovative ICT to support multimodal logistics operations.

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The characteristic of ports to host different modes of transportation is of significant importance as the combination of specific modes may account for the majority of freight movements in a region. According to the European Commission, in 2005 the total volume of tonnage moved in short-sea shipping was of the order of 591 million tonnes. On the other hand, it is possible that the complexity of multimodal operations can result in serious inefficiencies in logistics. Some examples of inefficiencies associated to the use of road haulage and sea transportation include penalties of thousands of Euros when a vessel has to spend an extra day docked in order to get fully discharged, container lorries missing time slots due to delays for loading a container on a ship, haulage vehicles remaining idle or moving discharged goods to the wrong depot/warehouse within the port.

International logistics requires ICT systems that satisfy a diversity of needs as it has been agreed that international logistics is practically mostly multimodal and involves a number of different players that underline the challenge of implementing information services that work to serve the needs of the whole logistics chain (Leviäkangas et al., 2007). ICT has become an essential part of the rapid and accurate transfer and processing of enormous volumes of data by international transport firms and port organisations (Kia et al., 2000). Indeed, logistics and transportation are totally dependent on ICT as Stefansson (2002) indicates that the flow of information is essential for carrying out an effective and efficient movement of consignments and using more advanced technology and data sharing it is possible to increase the resource utilisation and thus reduce costs. Despite the wide recognition of the importance of ICT in logistics and transportation, Ngai et al. (2008) highlights that little empirical research has been conducted to study the use of information technology applications to support logistics operations. Furthermore, it is expected that emergent technologies may also have a significant impact on already complex multimodal logistics. This is particularly important as Kengpol and Tuominen (2006) highlight that new technologies have affected the practice and significance of logistics management. For example, Dullaert et al. (2009) work on multimodal transportation involving the combined use of road transport and inland navigation recognise the need for a communications platform to make possible the integration and sharing of operational information in the supply chain and to mitigate problems such as low reliability and quality of mobile data connections. The solution envisaged by them comprised a real-time decision support system in which intelligent software agents handle communicative tasks, exchange desired amounts of information among different users using common exchange protocols, which act as translators between different systems.

In order to cope with the strategic importance of ports, significant investments in ICT have been taking place in recent years. For example, ports are now becoming more technologically advanced with the adoption of ICT such as GPS systems aboard gantry cranes, ICT support for quay planning, routing of automated guided vehicles as well as equipment used for stacking of containers and invoicing (Neade, 2008). But the attention to ports using ICT is not recent. For example Kia et al. (2000) investigated the importance of information technology and its role in improving cargo handling operational systems. They used a simulation model to compare the productivity of a container terminal equipped with electronic devices against a terminal without such devices. The results of the simulation provided evidence that helped to explain why container tracking systems are given high priority among operational computer applications in ports.

ICT technologies including RFID, GPS-enabled devices, Cellular Networks, 3G and Wi-Fi have provided enhanced levels of visibility and connectivity for multimodal logistics. For example,

RFID has received significant attention by academics and practitioners and several studies on RFID applications can be found in the literature with particular emphasis on enhancing track and trace capabilities. The work from Zhou (2009) highlights that reasons why track and trace capabilities have become so important can be linked to the fact that for many organisations, it is becoming increasingly critical to know the status of an item instantaneously, as well as knowing the processes it has gone through and the history of transactions involved. The instantaneous status of an item includes identity, precise location, physical status and other key features. On the other hand the use of heterogeneous technologies can represent a burden to business applications relying on them mainly because of problems related to reliability, connectivity, limited range, scalability and security.

An element that has the potential to significantly shape the future of multimodal logistics and in particular sea port operations is Intelligent Transport Systems (ITS). In fact ITS have become the next big initiative for the management of transportation in Europe and other parts of the world. The ERTICO research project (2007) encapsulated the concept of ITS as the use of advanced ICT to achieve a reduction of congestion and accidents while making transport networks more secure by reducing their impact on the environment. Zomer and Anten (2008) highlight that ITS relate to important challenges for improved global supply chain design and operation, including real time control, based on real-time data, which ultimately affects risk and resiliency.

Among the various technologies used to support ITS, wireless vehicle networks represent a fundamental component, which will influence future transportation and logistics operations. Akaiwa (1997) states that the growing importance of wireless vehicular networks can be directly associated to the popularity and growth of mobile wireless communications, where advancements in wireless channel modelling techniques and the subsequent development of sophisticated digital transmission methods make possible to provide high data rate communications whilst adhering to stringent Quality of Service (QoS) requirements.

The growing complexity of multimodal logistics operations in ports and in particular the interdependencies between sea transportation and road haulage represents a strong case for exploring the efficient use of information and communication technology (ICT). In particular technologies, which are key components of ITS, such as wireless vehicular networks, which can impact the supply chain needs more attention.

In the following sections we review the developments of ITS, the nature of port operations and the potential effect of ITS on multimodal operations. The objectives and research methodology used are discussed followed by the analysis of an industrial case study used to illustrate the role and contribution of ITS to multimodal logistics through wireless vehicular networks in the form of Dedicated Short Range Communication (DSRC). The case addressed involves examining in detail tipping operations of bulk material in a port terminal using event flow, mapping and network simulation to demonstrate the feasibility of wireless vehicular networks to support data traffic, which is representative of track and trace capabilities needed in complex multimodal logistics operations such as those taking place in sea ports.

2. Intelligent transport systems (ITS), wireless vehicular networks and the potential to affect multimodal operations

In recent years, ITS have emerged as an initiative that will not only transform transportation by enabling Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications but

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