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OPTIMISATION OF LOGISTICS OPERATIONS USING GPS TECHNOLOGY SOLUTIONS: A CASE STUDY

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Abstract

Contemporary logistics are becoming more sophisticated. With increasing demands of responsive, agile, global integration of complex dispersed multi-tiered suppliers, subcontractors and manufacturers, logistics is facing the challenge of moving from straightforward transaction oriented to open/ collaborative supply management. This challenge is visibly demonstrated in distributed supply-networks where multiple providers, as shipping carriers; dock management; hauliers; manufacturers, are involved in collaboratively fulfilling transactions and providing a service. Cross-organisational connectivity with data visibility and real-time synchronisation across distributed providers is an ongoing challenge for many transport companies. Modern transportation face challenges as: congestion growth; lower costs; improved customer service; hightened terrorism/theft/security; information-sharing; regional multi-modal logistics growth; and proliferation of new complex tools to optimize/schedule routes.

The case study presented focuses on development of an integrated GPS/portal solution with an objective of enhancing control and visibility over inland transport thus improving customer service through the application of next generation information systems, utility computing and web-services.

Keywords: Contemporary logistics, real-time tracking, mobile technologies, road hauliage

1. Introduction

Over the past years Information and Communication Technologies (ICTs) have become well established in global supply chains as pivotal enablers of integration and alignment of dispersed suppliers, manufacturers and logistics providers (Manecke and Schoensleben, 2004). Coupled with the maturity of embeddedness of ICTs, a proliferation of mobile technologies is witnessed recently thus adding to the sophistication of technology solutions

provided to complex supply chains. Mobile technologies such as Global Positioning Systems (GPS), General Packet Radio Service (GPRS) and Geography Information Systems (GIS) coupled with advanced Internet solutions provide transparency and more specific information to supply chain collaborators in terms of instant localisation and traceability of shipments and delivery status. Several scholars (Tsai, 2005; Durr and Giannopoulos, 2003; Daugherty et al, 2005) have concluded that tracking physical goods at real-time greatly improves logistics performance, cost efficiency and customer satisfaction.

GPS are space-based radio positioning systems that provide 24-hour, 3-dimensional position, velocity and time information to suitably equipped users anywhere on the surface of the Earth (Malladi and Agrawal, 2002). The impact of these mobile technologies is more prevalent in contemporary sophisticated logistics which include multi-tiered suppliers, and manufacturers that are globally dispersed. It is apparent therefore that with an increase of global integration and complex business networks there is an imperative to develop network options beyond the boundaries of internal logistics. This brings new opportunities as risks inherent with implementing new logistics systems are lowered.

With particular reference to shipping lines there has been an enduring issue with part of the global supply chain called the first and the last mile. These terms refer to the stages of the delivery process where goods are collected from the shipper and delivered to the final customers in containers. Merchandise moved in containers include: electrical machinery and equipment, clothing and accessories, footwear, furniture, toys, games, sportswear, plastics, iron and steel products. In 2006, the total UK trade imports were valued at £325 Billion and exports valued at £244 Billion (Overseas Trade Statistics, HMRC, 2006). Many shipping-line companies successfully track cargo from manufacturing origin through to on-board loading into the port but persistently face the challenge of the last mile; when containers are collected from the port and delivered to the final destination.

This paper describes a scalable web-based tracking system, leveraging leading edge technologies and adopting best practice to provide real-time order status visibility to carriers, hauliers and their customers alike. Mobile real time tracking of individual trucks location along with real time status visibility is available using GPS (Global Positioning) and GPRS (General Packet Radio Service) to determine position of the shipments and transmit job status information via web services to the portal. According to Montragon et al (2009), mobile systems for vehicle tracking also known as telematics will represent an industry worth $41 billion USD by the end of the first decade of the 21st century (Bisdikian et al, 2002). The objective of this research has been to align operational and mobile information system models in a manner to meet the demands of transport companies. Road transport logistics is the primary transport mode in Europe with a market share of 45% of the total freight transport and above other modes such as sea (41%), rail (8%), inland waterways (4%) and pipeline (3%) (Montragon et al, 2009; Brown et al, 2006). The proposed solution incorporates many value-added processes such as: delivery controls such as updated estimated time of arrival (ETA) and issue of late running; statistic reporting including vehicle and job histories; digital imaging for damaged goods; vehicle defect reporting; driver time reporting; and highways agency data/warnings.

The paper contribution to the existing literature on logistics is the further understanding and refinement of mobile enabled tracking solutions in the transport industry. More specifically, the benefits of the new telematics solution are demonstrated on the container transport industry and how information transparency and sharing across the extended global supply chain is the new competitive basis for supply chains.

Distributed logistics supply networks are maturing and introducing a new complexity to the transport industry (Waters et al, 2006). This is due to the fact that multiple service providers are involved in any transaction including shipping/carriers, port and dock

management, import/export companies, retailers and manufacturers. Supply-chain synchronization breaks down traditional barriers and allows real-time collaboration through Web technologies for product design, procurement, manufacturing, supply-chain planning, and order fulfilment. A persistent challenge to the global supply chain synchronisation is a transport logistics process called the first-and-last mile. Shippers either send goods or receive goods in the supply chain. Their main aim is to maximize their profits by reducing lead-time from ordering to fulfilment, and decreasing operational costs resulting from an inability to adapt easily with changeable consumer needs. Some of the shippers have logistics functions in-house, because their logistics system makes their competitive power stronger.

Collaboration logistics service providers are trying to optimise transportation operations and to cut costs of less-than-truckload shipments and empty back hauls(where delivery vehicles find loads for their return journeys). Logistics service providers also seek to improve efficiencies by minimizing transportation cost with sharing truck capacity, reduce stock cost, shrink data processing costs and eliminate stock-outs that impact on customer service while meeting the requirements from the shippers. At the same time, client requirements have become sophisticated and costly, including time-window for delivery, temperature control, and tracking information services for valuable goods. In this context unreliable delivery schedules, time delays and increased traffic congestion have become a major issue in the transportation industry. Available survey evidence suggests that the probability of a delivery being delayed can be relatively high (McKinnock, 2006).

Unrealistic delivery schedules are only one factor of that impact on efficient vehicle use. McKinnon (2006) provided a classification of constraints of vehicle utilisation (Table 1). McKinnon and Ge (2004) conducted the 2002 transport KPI survey in the UK food supply chain, and deduced that roughly 29 per cent of the 15,600 journey legs monitored were suffered a delay with delays averaging around 45 minutes.

TABLE 1: Classification of the constraints on vehicle utilisation

Vehicle utilisation constraints	Classification of parameters
Demand fluctuations, Lack of knowledge of loading opportunities, Just-in-time delivery	Market Related
Health and Safety Regulations, Vehicle Size and weight restrictions, Goods handling requirements	Regulatory
Demand fluctuations, Lack of knowledge of loading opportunities, Just-in-time delivery, Goods handling requirements, Poor coordination of purchasing, sales and logistics	Inter-functional
Vehicle Size and weight restrictions, Unreliable delivery schedules, Limited capacity at facilities	Infrastructural
Goods handling requirements, Limited capacity at facilities, Incompatibility of vehicles and products	Equipment related

(Source: McKinnon, 2006)

Surprisingly only under a third of these delays were caused by traffic congestion on the road network. Interestingly, most delays occurred at distribution centres (DCs), reception bays of factories, and shops, indicating that "back-door congestion" increases the average length and variability of loading and off-loading times (McKinnock, 2006). In an effort to overcome challenges posed by unreliable delivery schedules, IT and vehicle tracking systems are making transport operations more optimised and 'visible'. Mobile tracking systems give both shippers and carriers greater confidence in delivery schedules, helping to overcome one of the traditional obstacles to backloading (Department for Transport, 2003). Advances in IT allow vehicle schedules and routes to be re-planned in real time while the vehicle is on the road. Operators are then able to exploit backloading and load consolidation opportunities that arise at short notice (Waters et al, 2006).

An example of vehicle tracking technologies are GPS devices used in logistics to track shipments and storage of products (Mintsis et al., 2004; Devlin et al., 2007). Currently, commercial use of the GPS tends to combine the GPS system with geographic information systems (GIS) in order to locate an object on a graphical map or with a more meaningful location name (e.g. an address). Vehicle tracking is now used in more than a quarter of vehicle fleets in the UK. Adoption is greatest among commercial vehicle fleets (30 per cent) and large fleet operators with more than 100 vehicles (31 per cent). An interesting finding is

that uptake is particularly high in the utilities (86 per cent), logistics and road transport (40 per cent) and service management (38 per cent) (m.logistics, 2008).

A recent survey of users of tracking systems, published in m.logistics (2008) reported benefits such as increased productivity; reduced costs and enhanced fleet performance. Other benefits mentioned include reductions in overtime claims, insurance premiums, fuel usage, communications costs and administration (m.logistics, 2008).

2. Research Problem and Aims

From the literature review, we can summarise a number of problem statements that underpin this study. Firstly, existing transport management systems have already adopted global positioning systems to track goods. This is prevalent in the transport and delivery of small, individual items such as parcels where the market leaders such as DHL and UPS have successfully used real-time goods tracking for many years (Malladi and Agrawal, 2002; m.logistics, 2007). However when it comes to tracking an aggregated bulk consignment of goods/raw materials transported within a container, visibility between the shipping customer and haulier becomes elusive.

Another interesting problem statement involves the use of GPS technology which is established in mobile communications but has yet to be proved in increasing visibility in extended global supply chains. The challenge therefore is not only to introduce a technical solution but to also establish a user-centric business model that involves all stakeholders such as the truck drivers as the key information initiators.

Finally, even though vehicle tracking systems have been available mostly in the small goods delivery service, GPS that seamlessly integrate with differing multi-format systems for information exchange across shipping and haulage companies are still rare.

Consequently, the research aim is to investigate the operations of a global shipping liner and a large haulage company operating from Liverpool, UK and to propose a mobile GPS tracking solution to optimise the logistics operation by overcoming inhibitors to visibility when it comes to bulk containerised goods. Some of the obstacles of successful facilitation are human acceptance factors as well as the very vulnerability of the mobile PDA solution installation.

3. Research Methodology

The research methodology employed here is case study based. This approach is based on collaboration between the researcher and the organisation, where the academic shareholders apply theoretical models and technological innovation to actual real-time problems, proposing, developing and applying solutions.

Case study research methodology is used extensively as it is: useful for exploration, theory building, theory testing and theory extension (Voss et al.,2002; Meredith, 1998); beneficial in both generating and testing hypotheses (Flyvbjerg, 2006) and constructive in exploring certain phenomena as well as understanding them within a particular context (Yin,1994).

Structured interviews and on-site observations were used as the primary data sources. Data were collected from shipping line managers, haulage company directors, truck drivers, port officials and container terminal managers. The initial data collection stage involved interviews aimed to provide an overview of the logistics service and to identify the information available in each the haulier and the shipping company thus providing a global view of the shipping-haulier supply chain. Specific data collected were service expectations, current model of operations, existing problems, challenges and trends in transport logistics.

The second stage involved on-field observations particularly in relation to container delivery and pick-up with haulier drivers. This is in line with the proposed observation of object in reality as put forward by Meredith et al (1989).

The final stage of the research methodology adopted in this work involved experimentation with the development of a prototype system. The prototype was used as a proof-of-concept to capture separate feedback from the field workers. Two drivers with different IT skills were selected to evaluate the prototype system with varying IT skills. One driver selected was IT experienced and the other was not.

4. Case description

Since the early 1990s, world container traffic has grown at almost three times the rate of world GDP and most growth is attributed to the increased trade with the Far East and India (Department for Transport, 2008). Growth in UK container movement has been in-line with the global trend as total port traffic has nearly trebled from about 3.5 million Twenty-foot Equivalent Units (TEU) in 1990 to nearly 9 million TEU in 2007(Department for Transport Maritime Statistics, 2007). In only one year, in 2007, UK ports have handled over five million containers.

The study case discussed here involves a logistics partnership between a large haulier company and a transatlantic shipping company. The haulier company has been established for 30 years and is based in Liverpool, which is one of the five largest lift-on and lift-off (lo-lo) container ports in the UK (Department for Transport Maritime Statistics, 2007). The other four largest lo-lo container ports in the UK are Felixstowe, Southampton, Tilbury and Thamesport (Figure 1).

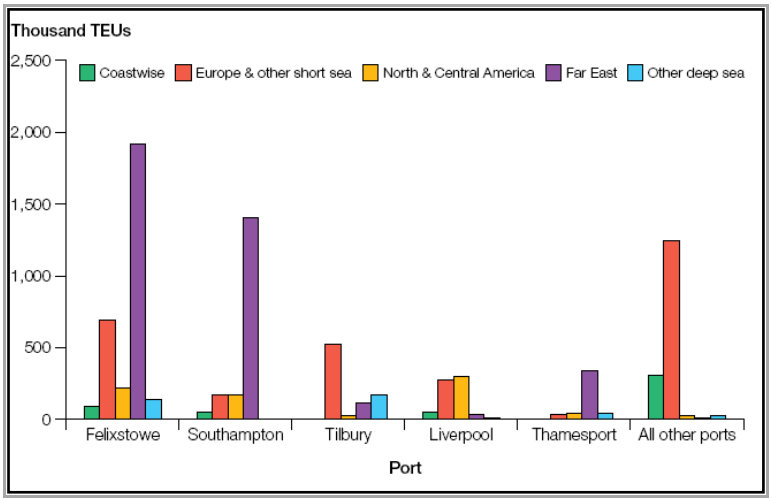

Figure 1: UK container ports by main trading area, 2007 TEUs
(Source: Department for Transport, Maritime Statistics, 2007).

The haulier company specializes in transport and storage of inbound and outbound containers covering destinations anywhere in the UK. The company has a committed culture of customer service and of long-term sustainable relationships with customers. In doing this they have sought to reduce costs, improve efficiency and most importantly to improve communication and process visibility with strategic customers such as the Container Shipping Line. The shipping line is one of the most respected companies in ocean transportation involved in movement of containers, oversize cargo and vehicles between North America and Europe.

The international logistics industry is increasingly competitive. There is growing pressure on hauliers to improve cost control and increase efficiencies, whilst at the same time improving customer service. Along with worsening port and road congestion and heavier security requirements, shipping lines and hauliers are looking to technology to provide solutions. The case haulage company had identified a growing problem with last mile tracking and connectivity. Improving the accuracy and availability of time estimates for the container reaching its destination, would permit more effective planning by their customers. In particular queries relating to delivery status, arrival and departure times and confirmations were time intensive as drivers and controllers were recording the container

delivery activity manually. Daily delivery jobs and driver instructions were paper based and all subsequent communication between the fleet control center and truck drivers was by phone. In an effort to enhance customer service, both case study companies had an urgent requirement for a simple and efficient way to track containers and to gain visibility to job status thus allowing vehicle schedules and routes to be re-planned in real time while the vehicle is on the road. According to Walters et al (2006) this way operators would be able to exploit backloading and load consolidation opportunities arising at short notice.

Real-time tracking Solution

A mobile GPS tracking telematics system and a webportal was developed to address the issues faced by haulier and shipping company. The system is based around mobile phone PDAs that can accept driver instructions from a central portal and transmit status updates and positional data back to the portal (Figure 2). The tracking issues are addressed by using GPS enabled handsets that transmit the co-ordinates of the vehicle back to the portal at fixed time intervals. The user can see the location of the vehicle on a map and because the tracking is linked to the order (and therefore the delivery location) the system can also provide the Estimated Time of Arrival (ETA) at the delivery location. Proof of Delivery (PoD) information, including the consignee's signature, is captured on the PDA and transmitted to the portal real-time. This makes the information available without the traditional delay of waiting for the driver to return to the depot. It also makes it available on-line across the whole supply chain and provides retrieval of historic PoDs for query resolution. Furthermore, the integration portal and inter-operability xml schema developed enables exchange of information with different company back-office systems. Thus the benefits of the tracking solution are extended from simple real-time visibility of location to complete integration with company order and payment systems thus providing a more holistic solution. Additional realized benefits include: cost saving by reduction of paper

copies; providing improved communication with drivers and automating the daily vehicle checks. The devices used in the cabs are also mobile phones with an integrated camera which can be used to record damage in support of any claims.

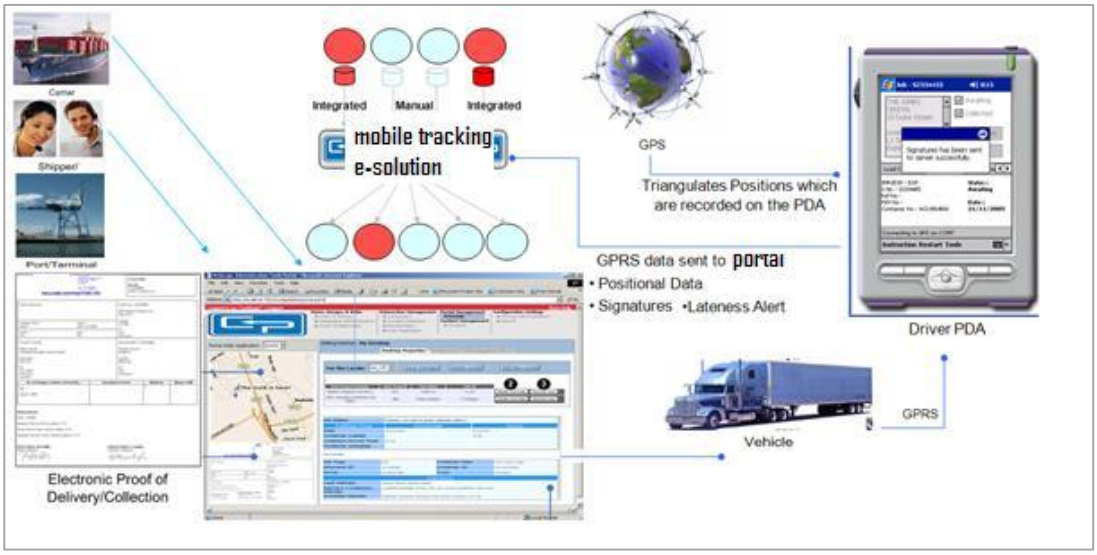

Figure 2: Real-time tracking management solution (Michaelides et al, 2008)

The mobile tracking e-solution as well as the web-portal is based on the SaaS concept (Software as a Service) which means that the application is hosted as a service provided to customers across the Internet (Figure 3)

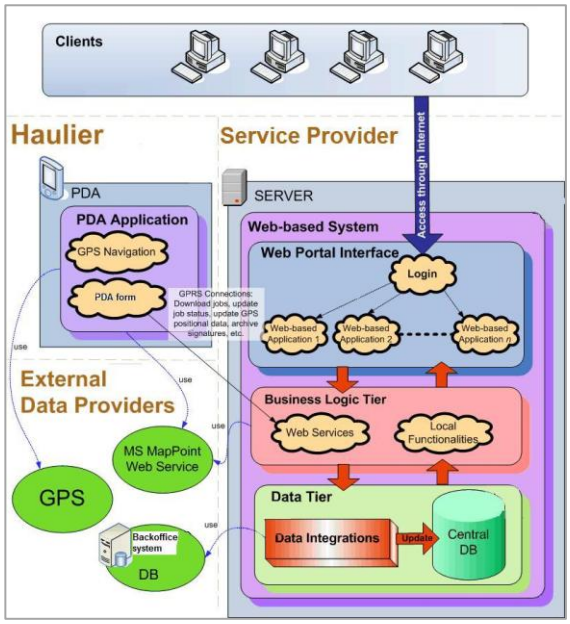

Figure 3. SaaS architecture

The advantage of using SaaS is that it eliminates customer effort of software maintenance, security updates and support as the actual application is installed on a service host. In addition to the above, the haulier company incurred no up-front cost and benefited from virtually unlimited computing power with a reasonable monthly service cost.

5. Findings

Trading in the haulage sector has become progressively tougher over the last two decades, and fierce competition is the key driver of falling margins. Efficiency gains therefore are imperative for hauliers in order to retain and win new business.The case study presented here suggests that it is possible to develop real time tracking e-solutions for the transport industry that not only improve internal operational efficiency but also extend visibility to supply chain partners and clients thus achieving an integrated solution. The specific e-solution has been operational for over three years in the case study company and the benefits realized are summarized in Table 2.

TABLE 2: Benefits of using the real-time tracking system

Benefit	Company
Web-enablement and GPS mobile tracking is key to consignment information sharing and delivery confirmation	Carrier and haulier
Connectivity enabled by XML interoperability utilities seamlessly aggregate information from customer-order processing systems with the haulier and the shipping line back-office system.	Carrier and haulier
Defect reporting improves the road worthiness standards of the vehicles as drivers could demonstrate their compliance through the wireless device during random enforcement road checks by the Vehicle and Operator Services Agency (VOSA).	Haulier
Cost savings by reducing empty miles travelling	Haulier
Automation of daily vehicle checks and improvement in efficiency. The automation of the scheduling process, results in far less management intervention, and far less chance for delays. The transport managers can focus on driver staff and business issues, such as individual performance, optimal procedures, and new customer services, rather than routinely calling drivers to manually establish their job location, status and schedule.	Haulier
Real time confirmation of proof of delivery leads to reduction of customer queries.	Carrier and haulier
The deployed portable in-cab solution is easily transferable to another truck which is inline with the transport industry trend of frequently replacing trucks.	Haulier
Improvement of customer / supplier relationship through competitive job pricing: The haulier job is priced on an assumption that the container will be unpacked and unloaded in 3 hours in a distribution centre or plant before more charges are	Haulier

incurred. However valuable customers may consistently unpack containers much quicker which means that with an accurate historical picture of the client jobs a better price plan can be put forward. This leads to the company transport managers running their supply chains more efficiently than competitors, or else they must find some service that competitors are not offering.

The last interesting finding in Table 2 is in line with Porter's (1985) two generic strategies of cost leadership (giving the same, or comparable, products at a lower price) and product differentiation (giving products that customers cannot find anywhere else).

6. Conclusions

The qualitative research case study employed in this study enabled the research team to gain an understanding of the challenges involved in a global logistics operation and to interpret these in a real-life setting. Furthermore, through this empirical study the benefits of using GPS vehicle tracking and integration portal technologies within the context of the transport container industry have been demonstrated. Transport practices are influenced by regulatory and global economic environments, available company infrastructure and competition with other supply chains (Srivastava, 2006). Sharing information such as container location through real-time vehicle tracking has enabled the case study haulier company as well as the shipping partners to quickly identify job status as well as establish appropriate control measures to overcome the uncertainty of the last mile. Increasing delivery visibility and reducing delays and errors helps organisations along a particular supply chain to share the same objective which Walters et al (2006) identify as satisfied end-customers. Meanwhile, in addition to the direct operational benefits of "quicker response" integration between the carriers and the haulier company, the Internet based container tracking system could generate considerable macro opportunities as a result of improved physical flows and trade security. For example new business contracts could be won from the client market that demand tracking systems to be in place for security as well as customer services purpose.

Future research will focus on enhancing vehicle tracking functionality with the introduction of fixed-cab tracking systems that integrate with the described here mobile GPS system to provide dwell and idling information as well as specific highways warnings. Proactive warnings help to inform customers of potential late arrivals in advance of the problem and reduce detention/demurrage by making customers aware that any free periods are about to expire. Idling reports will provide transport managers with an overview of driving behaviour and the ability to send a real-time alert to the idling driver. Finally a limitation of this study is that it is based on a single case study in a single industry.

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References:

Bisdikian, C., Boamah, I., Castro, P., Misra, A., Rubas, J., Villoutreix, N., Yeh, D., Rasin, V., Huang, H., Simonds, C., 2002. Intelligent pervasive middleware for context-based and localized telematics services. In: Proceedings WMC'02, Atlanta, GA, USA, September 28, pp. 15–24.

Brown, M., Allen, J., Woodburn, A., 2006. Developments in Western European Logistics Strategies in Global Logistics, New Directions in Supply Chain Management by Donald Waters. Kogan Page, London, pp. 353–373.

Daugherty, P.J., Richey, R.G., Genchev, S.E., Chen, H., (2005) 'Reverse logistics: superior performance through focused resource commitments to information technology', *Transportation Research Part E* 41 (2), 77–92.

Department for Transport (2008), [Online], http://www.dft.gov.uk/pgr/freight/

Department for Transport, Maritime Statistics, (2007)

[Online], http://www.skillsforlogistics.org/en/index/reports/dftfreight/

Department for Transport (2003), *Telematics Good Practice Guide:341*, StationeryOffice, London

Devlin, Ger J., McDonnella, K. and Warda, S. (2007) 'Timber haulage routing in Ireland: an analysis using GIS and GPS' *Journal of Transport Geography.*

Durr, G. and Giannopoulos, G.A. (2003) ' SITS: a system for uniform intermodal freight transport information exchange' *International Journal of Transport Management* 1 (3), pp 175–186.

Flyvbjerg, B. (2006) 'Five Misunderstandings About Case Study Research', *Qualitative Inquiry*, vol. 12, no. 2, April 2006, pp. 219-245.

m.logistics (2008), 'A quarter of fleets now using vehicle tracking', Issue 34, April/May 2008, http://www.mlogmag.com/magazine/34/A_quarter_of_fleets.shtml

Malladi R. and Agrawal D.P. (2002), 'Current and Future Applications of Mobile and Wireless Networks', *COMMUNICATIONS OF THE ACM*, October 2002/Vol. 45, No. 10

Manecke, N., Schoensleben, P. (2004) 'Cost and benefit of Internet-based support of business processes', *Int. Journal of Production Economics*, 87 pp 213–229

McKinnon A.C. (2006), 'Road transport optimization', Chapter in Book *Global Logistics 5edn editor, Walters D.* London, Kogan Page, Limited , GBR:

McKinnon, A.C. and Ge, Y. (2004), 'Use of a synchronised vehicle audit to determine opportunities for improving transport efficiency in a supply chain', *International Journal of Logistics: Research and applications*, 7 (3), pp 219- 38

Michaelides R., Liu K. and Jervis S. (2008), ' e-solutions enabling growth in the transport industry: Case study of a real- time Tracking Management System', LRN Annual conference, Liverpool, September 2008

Mintsis, G., Basbas, S., Papaioannou, P., Taxiltaris, C. and Tziavos, I. N. (2004) 'Applications of GPS technology in the land transportation system', *European Journal of Operational Research*, Volume 152, Issue 2, 16 January 2004,pp 399-409

Mondragon Coronado, AE, Lalwani C.S., Mondragon CoronadoE.S. and Mondragon Coronado C.E. (2009), 'Facilitating multimodal logistics and enabling information systems connectivity through wireless vehicular networks', *Int. J. Production Economics* 122 (2009) pp 229–240

Narasimhan, R., Carter, J.R. (1998). 'Linking business unit and material sourcing strategies', *Journal of Business Logistics* 19 (2), pp 155–171.

Overseas Trade Statistics, HMRC, (2006), [Online] http://customs.hmrc.gov.uk/

Porter, ME (1985), *Competitive Advantage*, Free Press, New York

Samir Srivastava, K. S. (2006), 'Logistics and supply chain practices in India', VISION, *The Journal of Business Perspective l* Vol. 10 l No. 3 l July.September 2006

Thomas, D.J., Grifin, P.J. (1996). 'Coordinated supply chain management', *European Journal of Operational Research* 94 (1), pp 1–15.

Tsai M-C. (2006) 'Constructing a logistics tracking system for preventing smuggling risk of transit containers' *Transportation Research Part A* 40 (2006) pp 526–536

Waters D., Richmond, Parkes and Wright (2006) Trends in the supply chain, chapter in book Waters D. *Global Logistics 5edn*, London, Kogan Page, Limited , GBR: