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THE CONCEPT OF SMART FREIGHT TRANSPORT SYSTEMS
- THE ROAD HAULIER’S PERSPECTIVE

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ABSTRACT

The context of transportation has changed significantly with the globalisation of supply chains, steeply rising fuel costs and further emphasis on environmental performance. Since transportation accounts for an ever larger share of costs, lead times and environmental impact, there are increased pressures for more efficient execution.

Major tools for improving efficiency are the use of information and communication systems to better plan, monitor and control the transport activities. This calls for reliable data capture, storage, processing and communication. Here, recent hardware and software advancements leading to technologies available at a reasonable price wait to be utilised for distributed decision-making.

Road hauliers are currently the subjects of significant pressure to incorporate the new applications into their operations from vehicle suppliers, the government and transport buyers; either directly or via their contracted logistics service providers. Hauliers are generally very small companies operating at a very small (if any) profit margin. They are often not able to employ or develop their own technical competence. Hence, they risk being forced to invest in several costly systems with overlapping functionality; each fulfilling certain needs of their strong counterparts rather than their own.

This article takes the road hauliers’ perspective, with the purpose of identifying their need for information and communication support, while analyzing how they are matched with the current supply of technologies. The concept of Smart Freight Transport Systems (SFTS) is developed in a case study setting as a departure from the truck and haulier level. The rendering also departs from what is currently available on the market and what is likely to be available within a five-year timeframe rather than trying to define a highly futuristic view.

Key words: Identification, Information system, Information technology, Logistics, Road haulier, Transportation.
1. INTRODUCTION

The context of transportation changes significantly with the globalisation of supply chains, rising fuel costs and further emphasis on environmental performance. Transport buyers (TBs) such as manufacturing and distribution firms now experience transport accounting for an ever larger share of their costs, lead times and environmental impacts. With this change follows an increased management attention, which in turn sharpens the demand for more efficient execution, and this implies certain challenges.

Transportation is also attracting further attention from policy makers and authorities. This relates in particular to the road freight transport sector accounting for a steeply rising share of overall CO₂ emissions, but it also adds to other emissions, noise, congestion and accidents. Since road infrastructure is not planned to be extended in proportion to the expected traffic growth in a business-as-usual scenario, the use of infrastructure must be more efficient, and new charging schemes must be developed.

Furthermore, the large road vehicle suppliers extend the service content of their products. They not only do this in order to stay competitive with attractive product offerings, but also in order to expand the volume of their business from intermittent truck sales, to generating more revenue during the full product life cycle.

As is similar with many other industries, information and communication technology (ICT) is regarded as a major facilitator for the improved planning and controlling of road transport activities. This calls for reliable data capture, storage, processing and communication. And recent hardware and software advancements have brought technologies to the market at a reasonable price. ICTs have been implemented for certain applications, but some technologies wait to be further exploited and technologies that are already implemented can be used in new ways.

However, ICT is not only applied to cope with changes in the transportation context, it also induces change. The implementation of the telegraph and the telephone in the late 19th century facilitated more efficient rail and sea transport, since information about the goods could be sent in advance (Knowles, 2006). In the 1950’s through the 1980’s vehicles were equipped with radio communication and mobile phones; this improved vehicle management, but the transport processes were not profoundly changed. New ICT applications implemented in the late 20th century, however, lead to spatial concentration of production and warehousing activities, which in turn created new types of transport networks. A particular effect of the new logistics systems is the increase of road freight transport (Banister and Stead, 2004).

ICT certainly creates utilities, but it does not come without headache for all acting categories. A particular case is the road hauliers (RHs), who are currently being pressured to incorporate the new ICTs into their operations from vehicle suppliers, the government as well as the TBs; either directly or via their contracted Logistics Service Providers (LSPs). RHs are generally very small companies. More than half of Swedish RHs for instance, are owner-operators with one truck (Swedish Association of Road Haulage Companies, 2006) operating at a very small (if any) profit margin. They are often not able to employ or develop their own technical competence. Hence, they risk being forced to invest in several costly systems with overlapping functionality; each fulfilling certain needs of their strong counterparts rather than their own. Here, the European Commission (2006) has identified that the SMEs are particularly vulnerable to closed systems, which raises thresholds to fully participate in the market.
Although RHs are at the heart of the current development of distributed data capture, processing and communication in supply chains, most literature in the field of logistics and ICT takes the perspective of TBs (e.g., Landers, et al., 2000 and Spekman and Sweeney II, 2006), LSPs (e.g., Dírr and Giannopoulos, 2003 and Stefansson, 2006) or government (e.g., McKinnon, 2006 and Tsai, 2006). Very few publications analyse the implementation of ICT from an RH perspective.

This article takes the perspective of the small RHs with the purpose of identifying their need for ICT support and analysing how these needs are matched with the current supply of technologies. Particular attention is given to the pressures that the business partners and authorities exert on road hauliers for implementing ICT technologies. The concept of Smart Freight Transport Systems (SFTS) is developed and described as a departure from the truck and haulier level. The rendering also departs from what is currently offered in the market and what is likely to be available within a five-year timeframe, rather than trying to define a highly futuristic view.

Smart is interpreted here as a stage after control system, but less advanced than artificial and human intelligence. Smartness shows some intelligent behaviour and it is associated with adjectives such as adaptive, autonomous, functional, learning, proactive, rationally responsive and interactive. A smart freight system can (Lumsden and Stefansson, 2006):

- process a unique identity
- communicate effectively with its environment
- retain or store some data about itself
- deploy a language to display its features
- participate in or make decisions relevant to its own identity

This is basically a desk research effort based on a general understanding of the RH situation from many years of research in the field, combined with thorough knowledge about the ICT applications currently coming into service. The work is empirically illustrated by a case study regarding long-distance consolidated cargo.

The next section describes the RH’s situation and their relation to business partners and authorities, including a conceptual model showing the relationships. Section three analyses the RHs’ need for ICT support along with the assets and relationships that need to be managed, while section four matches these needs with the supply of technologies. Section five is used for presenting a case study that is followed up in section six, where a vision of an SFTS concept is developed. The benefits and implications of the SFTS are finally elaborated on in section seven.

2. THE CONTEXT OF ROAD HAULIERS

Requirements for the functionality of ICT applications obviously differ depending on the character of the RH company, the networks it operates within, the size of consignments, and the type of goods. The efficacy of and need for certain applications then varies with different market segments. It is here claimed that the part of the road haulage industry that the scientific literature as well as the public debate circles around, accounts for only a fraction of the road haulage industry by severe overestimation in several dimensions.

The first dimension is the length of transport assignments, where the debate tends to overestimate haulage over long distances. The average road haulage distance increases - for Swedish RHs it increased from 75 kms in 1990 to 102 kms in 2005 – but still only 8% of road transport assignments were over 300 kms in 2005 (Swedish Association of Road Haulage Companies,
2006). Consequently, the absolute majority of transport assignments are not worth consolidation efforts and they are also without competitive reach for other traffic modes.

Another apprehension is that most freight transport is outsourced by manufacturing and trading firms. The truth, at least in Sweden, is that the vehicles used in own account, by far outnumber those used for hire or reward (i.e., by professional RHs), and they increase more rapidly. In fact, there are almost eight vehicles used in own account for each used for hire or reward; but for heavy trucks (above 3.5 tons gross weight), the relation is the opposite; 2.5 times more for hire and reward (Statistics Sweden, 2007). Compared to vans that are often also used for moving persons, (for instance, a plumber to a construction site) the professionally used trucks are used more intensely for downright freight transport.

Disproportionate attention is also given to the market segment of consolidated cargo; i.e. cargo larger than parcels that are consolidated in terminals, are also illustrated here by the situation in Sweden. The two largest operators share about 80% of the segment, and out of the 302 million tons transported domestically by Swedish trucks the same year (Statistics Sweden, 2006), the larger of the two handled 1.2 million tons in 2003 (Sommar and Woxenius, 2007). Hence, consolidated cargo actually accounts for about 1% of the Swedish road transport volume, but as the average transport distance is rather long, the share of transport work is higher. The share of the number of consignments, which clearly affects the need for ICT support, is obviously also significantly higher. For the Swedish market leader mentioned above, the 1.2 million tons of general cargo accounted for 11% of the transport volume in tons, but 73% of the number of consignments (Sommar and Woxenius, 2007). Nevertheless, part loads, i.e. several consignments transported together by routing the truck rather than using terminals, is a much larger segment as are full loads transported directly from consignor to consignee. It should be noted that from an RH perspective, the long-distance haulage of consolidated cargo between the forwarders’ terminals is treated as a full load.

Palletised freight also attracts more attention than its share of the transport flows. In all, only 10-12% of the total amount of tons and 21-26% of the tons kms performed in Swedish road transport are goods that are suitable for pallets (Arnäs, 2006) and only 44% of the heavy road vehicles are technically adapted to it (SIKA, 2006). Hence, the majority of trucks transport something other than pallets. Compared to palletised transport that is standardised and often of a repetitive character, transport with technically specialised vehicles are often engaged in short hauls, and the specifications of the transport assignments differ widely. The need for ICT support is then regarded as high, although the number of consignments are comparatively small.

Still, much literature is (explicitly or implicitly) limited to cover long-distance palletised goods in consolidation networks operated for hire and reward. A good exception is Golob and Regan, who divide the road haulage industry into several categories along different parameters in order to analyse their ability to adopt different information technologies (Golob and Regan, 2002); more specifically, routing and scheduling software (Golob and Regan, 2003). Andersson and Lindgren also (2005) analyse the ICT needs of RHs by acknowledging the differences between segments. Nevertheless, it is here emphasised that this article attempts to cover all types of road transport. Bodies forcing ICT applications onto the RHs, such as road charging technologies, must understand and acknowledge the wide variety of contexts in which RH firms operate.

Seen as a system, transportation is composed of a multitude of hierarchically and vertically connected actors. RHs are thus part of webs including providers of vehicles, fuel, infrastructure and ICT. And although they are often contracted by transport and logistics intermediaries, they coordinate the transport services with both consignors and consignees. Besides providing
infrastructure as a production means of road transport, authorities also regulate and enforce traffic and the external effects that stem from the latter. There is a certain potential for improving the efficiency of the many contact interfaces involving RHs (shown in figure 2.1) by using ICT applications. The model is generically designed for being valid for most segments of the road haulage industry.

Figure 2.1 The inter-organisational context of road hauliers.

The actors in the upper part of the figure represent suppliers to the RH, while those in the centre and bottom of the picture are customers. Authorities however, take on other roles besides supplying infrastructure. It should also be noted that logistics service providers are not always involved as intermediaries between shippers and the RH.

A common feature of the road haulage industry is that profit margins are very low. In the Netherlands (a rather typical example of Western Europe), RHs in domestic operations reported a profit margin of 0.1% in 2002-2003, while those internationally engaged lost 1.6% (Karis and Dinwoodie, 2005). As a collective, the Swedish RHs reported a profit margin of 4.1% in 2005, while the market segments of semi-trailer haulage and international transport reported meagre profit margins of 2.4 and 1.7% respectively (Swedish Association of Road Haulage Companies, 2006).

This means that resources for investments in non-mandatory ICT applications are scarce. RHs are also getting hardened by the fact that their customers tend to reap the benefits from any achieved productivity gain. Consequently, RHs have reasons for not being first in line to invest in spectacular ICT applications. One example is investment in routing and scheduling software, which is now rather mature and comparatively inexpensive. Golob and Regan (2003) found that despite 500 scientific journal articles with the key words “vehicle routing,” very few RHs actually used the software.

3. ROAD HAULIER ACTIVITIES REQUIRING ICT-SUPPORT

In this section, demands for ICT functionality and implementation are investigated from the perspective of an RH. One way of structuring the ICT applications for freight transport is suggested by Boushka, et al. (2002), who divides them into asset utilisation, operational efficiency, security, quality control, and customer service. The observation mentioned above states that the RHs are pressured by other actors, however this leads to structuring the section
along those resources or actor contacts that are managed by using the ICT applications. Managing vehicles and drivers are then regarded as activities mainly internal to the RH firm. Managing the freight flow and customer contacts regards the relations between the RH firm, the consignee, the consignor and any intermediary, while managing authority contacts relates to access, charging of infrastructure, conforming to regulations, (e.g. working hours and emissions) as well as various intermittent reporting obligations. A similar division is used by Clemetson, et al. (2006), however this includes the driver’s family and friends as users of communication with the truck.

3.1. Managing vehicles and drivers

This section focuses on the need for ICT applications and functionality used primarily within the RHs’ own operations. These applications are used for improving the use of the production resources in terms of vehicles, load units and drivers. The division suggested by Andersson and Lindgren (2005) – dispatcher, driver, management, administrative personnel, and vehicle maintenance personnel – is used for denoting the professional roles inside the RH.

As opposed to the one-directional and intermittent goods flow, trucks, trailers, unit loads, and drivers depart from a base to which they return regularly and the resource utilisation must be managed continuously. The ability of matching the one-way transport assignments with the two-way flow of the RH’s resources practically differ profits from losses. Typically, one third of the road transport distance is run empty (McKinnon, 1996). And better ICT support has been advocated for improving the balances. Imbalances are, however, accepted in technically specialised segments like petroleum distribution to petrol stations and timber transport from forest to mills, where the TB pays also for the empty backhaul.

In 2005, driver salaries most often constituted the highest individual cost for RHs – 33% for long-distance haulage and 44% for local distribution in Sweden. (Swedish Association of Road Haulage Companies, 2006). And consequently, much attention was given to maximise the use of this resource, especially during periods of driver scarcity. With the tight connection between driver and vehicle, maximising driver utilisation will also foster a good vehicle utilisation.

Planning the drivers’ schedules and optimising their delivery tasks is getting increasingly complex due to stricter working time legislation in the EU (see, e.g., Karis and Dinwoodie, 2005), implementation of time-dependent driving bans (see, e.g., Bekiaris, et al., 2007) and deliveries that follow stricter time windows. Longer opening hours for deliveries in manufacturing, construction and retailing also add to complexity of driver planning. Route distribution and long hauls are particularly sensitive since they involve rather protracted activities that are complicated to divide between drivers.

Simpler planning tasks are still handled manually, but the dispatchers face an increasing need for ICT support in the office for solving complex planning situations, such as being able to tell whether a certain driver is likely to be able to deliver within the allowed driving hours and the set time window, or if the driver can pass through a road section before a weekend driving ban applies. It can also be a tool in the driver cabin warning when the driver approaches the allowed driving time. Or as a planning tool for routing and re-routing after changes in transport assignments or in road conditions.

Data logged in the vehicle and transferred to the office is also useful for the administrative personnel for calculating driver salaries or consolidating it for reports to the authorities. Also, management will use the data for improving the firm’s general efficiency, and for deciding on market and capacity issues or changes in semi-fixed pick-up and delivery routes.
Furthermore, there is a need for more technical data for managing the vehicles themselves to control fuel consumption, emissions and maintenance/repairs. Drunk driving and driving behavioral concerns are other areas of technical surveillance. These applications have been taken up by RHs during the last years, since they often lead to a direct cut of the fuel costs or damage to property or image. This more technical data is also useful for management when deciding upon vehicle replacement.

3.2. Managing the freight flow and customer contacts

This section focuses on the interaction between the vehicle and the goods, and the related contacts between the RH and its customers. These are either TBs directly or for some segments other LSPs, such as forwarders, third party logistics providers and operators based in other traffic modes. In the latter case, the RH must coordinate with the LSP as well as the consignor and the consignee. From an RH perspective, the aim of the applications in this category is to improve the effectiveness of the vehicle operations in relation to its customers.

In traditional road haulage operations, the dispatcher instructs the truck driver to pick up goods at a consignee, but much of the data relating to the transport assignment is not available and has to be collected by the driver. Physical copies of the consignment note are later transferred to the administrative personnel and to the consignor. The data collected, including the proof of delivery signed on the consignment note, is then entered manually into different information systems, e.g., for invoicing of the goods and the transport service.

ICT applications obviously have a significant role in improving the operations, and many applications are in widespread commercial use. Related to the goods flow, the RHs’ need for ICT support can then be divided into:

- improve efficiency; for cutting costs in operations and administration;
- make data visible; for improving planning by the RH and the customers;
- improve safety; for reducing errors to improve the value for customers and reduce claims and error corrections; and
- improve security; for more secure work environment for drivers and less claims

By reducing the number of times the data is entered manually, administrative costs can be significantly reduced and much of the toilsome error correction can be avoided. This obviously also improves the competitiveness of the RH. RHs would also benefit from more accurate information about the physical properties of the goods to transport. If they Lack this information, they cannot pre-plan the loading very well, and they often need to use excessive resources to cope with any deviations from what is booked by the TB. If the status data is continuously made available to the actors in the supply chain, much of the verbal communication that consumes time for dispatchers and administrative personnel would be avoided.

The ICT applications must support a wide variety of road transport services. Special cases are the transport of hazardous material, international transport requiring customs clearance and transport of temperature sensitive products. For the latter category, logging and communicating temperature data during transport allows RHs to monitor and adjust their operations to ensure that the products are not obsolete in transit and thus reduce claims for replacements (Josefsson and Philipsson, 2004). By logging the temperature curve rather than just alerting that the maximum or minimum temperature has been violated, a reduction of the durability of the product can be calculated rather than treating the product as obsolete. This is however, not applicable if the temperature violation has lead to an irreversible change of physical features in the product.
Road is often the modal choice for transport of theft sensitive products. Since thieves get increasingly brutal, it is a correspondingly increasing problem for a driver’s work environment. RHs can use ICT applications for making the transport safer by sending alarms if the truck deviates from the planned transport pattern, referred to as geofencing, or if a seal is broken (Clemedtson and Jansson, 2006). The ultimate aim is to reduce the attractiveness to steal the goods.

Still, most of the improved ICT capabilities in the road transport industry benefit the LSPs or the TBs more than the RHs themselves. For RHs, investments in ICT applications are often seen as fulfilling demands qualifying for doing business with certain customers rather than a deliberate effort to improve the activities. According to Arnäs (2007), the customer demand for electronic invoicing is seen by the RHs as an incentive for further use of the data.

3.3. Managing authority contacts

The third category where ICT can play a significant role for RHs is contacts with authorities, primarily as providers of infrastructure but also in the roles of regulation and law enforcement. Road safety with inspection of the technical standard of the vehicle and the status and behaviour of the driver is obviously in the core, but driver safety, environment and security issues are attracting increasing attention by authorities. The market segment of hauling containers to and from seaports is particularly affected by the stricter legislation on security as investigated by Tsai (2006). The ICT applications in this field aim at smoother and more equitable charging, but also for more efficient administration of reports; e.g. statistics, working hours and salaries paid as basis for taxation.

Congestion is the external effect most costly to society. According to the European Commission (2006), road congestion incurs costs corresponding to 1% of the GNP in the EU, and RHs both contribute to and suffer from this problem. Allocating road slots to individual vehicles is currently only realistic for selective bottlenecks, such as bridges, tunnels and bus lanes. ICT solutions can then support the prioritisation of which trucks to use the scarce capacity. Rather detailed and dynamic data, like urgency of the goods delivery, current loading status and fuel used will be needed for a decision based on the highest benefits to society. RHs can also cooperate with authorities by reporting the congestion status from their vehicles. They can also get back aggregated data from many vehicles as basis for re-routing decisions (Arnäs, 2007). Road passage is important, but access to parking and loading docks in urban areas is also a common nuisance and cause of efficiency losses for RHs. Public ICT applications can here be used for more advanced slot allocation and for verifying the right of access and possibly charging.

There are also examples of private companies offering services corresponding to infrastructure for the RH; e.g. private toll roads, ferry and rolling highway operators are other modes used in infrastructure roles. For some of these services, slot allocation is the standard procedure.

Figure 2.1 can now be extended with the activities that the RH and its partners might improve with ICT support.
Figure 3.1 Activities benefiting from ICT support.

The intention is to show that these applications have basic overlapping functionalities exposing RHs to the risk of over-investing in technology, know-how and administrative adaptation.

4. A SUPPLY CHAIN CASE STUDY

The empirical evidence collected for this work is based on a transport setup study involving several participants in a flow of products from a production facility in Sweden to an automobile assembly plant in Belgium. This case is to act as a foundation for development of the SFTS as it includes the necessary participants for a requirement analysis in a transport solution including consignees and consignors, LSPs, RHs, as well as authorities. It reveals areas of potential improvements, especially where more advanced ICT solutions can support the activities that are to be carried out. The scope of the case study is from the time the transport operator is contacted and the product leaves the production facility until the product is put on a load unit that is driven on a RoRo vessel that will leave Port of Göteborg departing to Belgium.

The product is a fluid that has been filled on a 1000 litre Intermediate Bulk Container (IBC). The fluid is considered dangerous goods and is treated as such with all required documentation as stated by the authorities. The transport assignment is forwarded to the RH by a common dispatching unit which has many individual RHs associated. Which RH is allocated to the assignment is based on availability and type of assignment. The decision is taken by a dispatcher in collaboration with the available drivers. In this case, a driver must obtain permission to drive dangerous goods in order to be involved.

Prior to the RH’s truck arrival, the producer prepares the freight documents. These documents are to follow the product all the way to the receiver in Belgium. As the RH arrives to the producer facility, the IBCs are loaded onto the truck. Identification is done by labels with written text, and the truck driver verifies the shipment against the documentation manually. When loading is finished the truck leaves the facility heading towards a terminal operated by a LSP situated close to the port.
When the truck driver arrives to the LSPs terminal, he or she waits for permission to enter through the gate. To get permission, the documents have to be reviewed and processed. If entrance is granted the truck driver receives instructions of where to take the shipment and drives the truck to the assigned dock where the IBCs are unloaded. In most cases, the RH brings back empty IBCs to the production facility. And when unloading is finished, loading of the available empty IBCs begins. The RH returns back to the production facility, but that part of the transport setup has not been studied.

The full IBCs that have been unloaded are now loaded onto trailers and registered in the LSPs logistics information system. A list of trailers departing to Belgium is prepared and sent to the Port of Göteborg and to the shipping line. Freight documents are sent with express courier to a Belgian office of the LSP (that operator is only involved in the information flow, not in the physical flow). A second RH hauls the trailers from the LSPs terminal to the close by Port of Göteborg.

The Port and shipping line staff prepares a loading plan for the RoRo vessel. The route is Sweden-Belgium-Norway-Sweden. Hence, the loading plan has to take into account that due to the different destinations no trailers are loaded and unloaded twice. The Belgian office of the LSP prepares the freight documents of the trailers arriving from Sweden and forwards them to the Belgian port authorities. The RoRo vessel is finally loaded with the trailer, and the vessel departs from Göteborg to Gent, Belgium.

5. THE SMART FREIGHT TRANSPORT CONCEPT

In order to solve some of the identified problems, a framework for SFTS is put forward below. The framework consists of attributes that have been developed by studying literature and analysing empirical data from the involved case study.

In general collaborative logistics, the arrangement between the partners is a starting point for a transport solution based on SFTS. Contracts must be made that identify the mutual processes that are carried out. The technology for data exchange must be agreed upon and the data content or messages must be commonly determined. Standards for RFID tags have to be established for increased interoperability, not only in reading frequency and such, but on data contents. The case study revealed a lot of situations where information was missing, mainly due to lack of agreement on what specific information to exchange. This is addressed by the Mobile Stationary Interface group, organising ICT suppliers, LSPs, RHs and scientist, who develop a new standard for mobile data communication (Udikas, 2007 and MSI group, 2007).

5.1. Managing vehicles and drivers

The dispatch office assigns the consignment more or less manually to the truck or an RH that in turn sends an appropriate truck to the site. This is done with the help of telephone communication or by assigning the shipment to a truck that the driver has already notified as vacant. This is a task that can be supported with several ICT components, such as fleet and transport management systems; including a navigation system based on GPS technology with GIS applications. The GPS system gives input to a track and trace system, and in addition an identification system must be in place to link the freight to the vehicle. This is not done today but is necessary to track the location of the freight by monitoring the truck. The identification is preferably based on RFID technology to make the reading of the load units on and off the vehicle more efficient.
One of the issues in managing vehicles that is connected to the above issue of assigning freight to a vehicle is the driver’s status of working hours. When an assignment is allocated to a truck, the dispatcher needs to know the situation and if the driver in question can carry out the assignment within the hours left on duty. For this purpose the SFTS needs to keep track of the driving hours by monitoring specific drivers in an on-board vehicle management system.

Notifications of arrivals or delays in transportation assignment are linked to the vehicle management as well as to the freight management. There are two ways of solving this task, either by the vehicle management system or by the fleet management system. The latter will be discussed in the next section. By managing notifications and delays from the vehicle, the truck has to be equipped with a on-board management system that allows a route to be generated and an estimated arrival time to be calculated. This should then be communicated by the driver to the consignee as needed.

Obtaining permission to pass the gate turned out to take quite a long time in the case study, and needs to be improved by prior notification of arriving vehicle and associated goods. As with arrival time and delay notification, there are two alternatives here as well. Either to send from the vehicle a request of access based on the goods on board and the assignment information, or to send the information from the dispatcher directly to the consignee. If done by the truck driver, the vehicle needs to again be equipped with an on-board management system that has information on the load and a reference to the assignment.

When the truck has arrived to the place of delivery, information on exactly where to go in the area is needed. This could be done in advance by sending the appropriate location information to the driver through an on-board management system that displays a map or detailed instructions on where to go.

5.2. Managing the freight flow and customer contacts

The results from the case study revealed problems in data exchange. Physical paper document exchange was extensive and so was the manual keying into dedicated information systems. Information sharing between partners must be extended to increased electronic data exchange through EDI, Internet, email, etc. To some extent, not only allowing data and information to be exchanged by a common data server or message exchange but to include more data and information in RFID tags that follow the goods throughout the journey. This addition of data that is attached to the load unit and carries increased information on the good and its destination is a key issue in the SFTS design.

Identifying the goods is closely linked to management of the freight flow and as has been pointed out before; an identification system based on RFID technology is preferable. The RFID tags need to be effectively designed for reading and writing throughout the transport journey. The absence of technology for data sharing (as shown from the case study) shows the need for a more advanced system behind ordinary bar-codes. Actually, the applied bar codes are not sufficient as they are not used for goods identification throughout the chain nor validation of goods specifications.

The lack of information on deviations in the case study shows that it could have serious effects on the flow. Examples of missing IBCs or lack of information about the status, both location and maintenance needs of the containers were observed. For execution of various activities, planning and monitoring systems need to be in place and be able to give support for decision making in various instances in the supply chain. Any exceptions and deviations from schedule have to be notified to other partners in the chain to allow for changes in due time.
It is very important that link to the vehicle management system be capable of monitoring the movements of the goods. And in case of exceptions, it must react in an effective way. Communicating the whereabouts is important and for that purpose, a Track & Trace system must be in place. The same system can then be used for notification of arrivals or delays of particular shipments. In this case, routing is done by the dispatcher and not the driver. To make this possible, a Fleet Management system has to be installed with functions for routing through different areas.

5.3. Managing authority contact

Although the authorities are not involved in the case to a great extent, in many ways, the authorities need to be involved in the SFTS concept. Some important involvements are infrastructure situation, traffic situation, accident status (if any), temporary constrains, and much more.

As the studied case involves dangerous goods, the authorities are very strict on the handling processes and are committed to let truck drivers follow the rules. This goes for access to tunnels, transport on ferries and RoRo vessels, just to name a few. In the case, a problem was encountered that involved the location of the semi-trailer on board the vessel. In the case of a fire or similar disaster, the location must be known, as these trailers need to be removed as soon as possible.

Driving hours and input to infrastructure charging system in various countries based on weight, distance, fuel used, what road is driven, etc. are all natural steps in making the transportation system more sophisticated. Some specific countries have recently implemented road charging systems that are most easily done by the embedded vehicle management system, and not by insisting a certain technology is used. In years to come, this development would mean many small units in each vehicle carrying out international transport assignments. The technology for supporting information sharing needs to take into consideration interoperability and each participants’ capability of operating the specific technology.

The role of the shipping line and the port resembles that of an infrastructure provider, but it is not as evident as shipping lines where full trucks are accompanied by the drivers, and the drivers themselves drive onto the vessel. Still, the use of a RoRo ship implies that the traffic modes are used somewhat redundantly and both the port and the shipping line are significantly involved in the information flow analysed in the case study.

The transport assignment is within the EU, and hence not subject to customs clearance. Link to customs authorities is not established for this specific case study.

6. BENEFITS AND IMPLICATIONS

A growing number of participants in outsourced logistics operations has led to increasingly complex distribution solutions that need to be managed in a different manner in the future. This development calls for a framework that moves forward more efficient data and information exchange between parties partaking in supply chain setups, RHs, consignees and consignors as well as authorities and other relevant partners. Better visibility of freight movements and involved activities becomes necessary and the SFTS’s framework proposes numerous attributes that have to be specified to be able to increase precision, reliability and efficiency in transport execution and reporting.
6.1. Managerial implications

A Smart Freight Transport System architecture must be flexible and capable of being used for decision support in connection with a variety of services such as dynamic route planning, merge-in-transit, postponement, and exception management. It should be a high-level system solution that includes many different components such as:

- identification system based on RFID technology
- on-board information system that enables data and information processing
- embedded computer system that is integrated with many of the vehicle functions
- communication system based on advanced telecommunication solutions to secure reliable data exchange.

Although the services supported by the SFTS often require access to a central database, local data storage and processing capability facilitates distributed decision-making. Hence, much of the essential information is accessible in the RFID tags or the warehouse information system that can interact with the on-board information system. This allows local decision-making, although the central database is not accessible and increases the robustness of the transport service. The SFTS can contribute in various ways. The benefits are given below in separate categories.

Managing vehicles and drivers

- Reduce fuel consumption through monitoring vehicle operation.
- Reduce maintenance costs through better driving behaviour.
- Reduce unnecessary or off-route mileage by navigation applications.
- Improve overview and control of driving hours.
- Reduce overtime and night-out costs by improved visibility of vehicle and driver use.
- Provide data for comparison of the actual with the predicted scheduling.
- Provide on-board information about road congestion or other relevant information about the traffic situation ahead.
- Provide means to choose alternative routes for the journey, and make ad-hoc decisions.
- Reduce delays, particularly when communicating with on-board navigation systems.

Managing the freight flow and customer contacts

- Reduce waiting time by providing customers with notification of impending delivery.
- Reduce delivery and invoicing errors.
- Reduce delivery mistakes.
- Improve customer service.
- Improve order status information and consignment tracking.
- Improve customer service through “real time” visibility of arrival and departure and identification of problems en route.

Managing authority contact

- Reduce paperwork and administration costs.
- Improve driving hour reporting.
- Improve charging feasibility and common platform for charging policy.

The framework suggests improving information accessibility and capability of data retrieval from RFID tagged goods and load units. To enable such data retrieval, the RFID tags need to carry extensive data that allows each partner in a distribution setup to share data that is relevant for each decision that has to be made. This concept allows local decision making as a
complement to centralised planning and decision making. Therefore, the decision process will not be as dependent on access to central data and information retrieval as it is in most logistics management setups.

To make such a framework possible, a new infrastructure for data communication must be implemented, not only in warehouses and terminals, but even in vehicles that transport the goods. The vehicles and the goods or the load units have to be equipped with communication technologies that indicate position and status of the goods and vehicle. Such technology enables supply chain operators to react on deviations from schedules, and to change their plans accordingly. The technology implementation does not come free of charge, but cost savings in the form of more efficient transport execution, capability to react upon delays and exceptions, increase in resource utilisation due to more reliable operations, and many more factors will compensate somewhat for high costs of implementation. Other issues of relevance are possibilities to increase customer service as well as safety and security as in the case where dangerous goods are involved. The environmental performance of road haulage can also be performed by generally decreased mileage for accomplishing the transport tasks.

How to distribute the costs and benefits between the actors is however, a critical issue. Many investments are sound from an over all system perspective, but they are too often never realised since one actor is supposed to carry the costs while others reap the benefits. RHs in particular are expected to invest in sophisticated ICT systems for improving the operations of other actors. For each investment, the RH must obviously analyse the implications in terms of costs and benefits from its own perspective. Cost cutting applications close to the driver and the vehicle have thus been more successful than those for managing the goods flow and the authority contacts. The latter might not need that much investigation however, since these applications often qualify for doing business with certain partners, or they are sometimes even legally mandatory.

### 6.2. Analytical implications

The framework for the SFTS has been developed from findings in logistics and informatics literature, analysis of the RHs needs through a case study analysis and an examination of available technologies. An analytical contribution can be identified in terms of a systematic model and a structured terminology for the SFTS.

Systematic models support examination of complex systems. Such models are needed for analysis of various requirements in the RH industry, the information systems’ functions, and use among the existing actors. The model that has been developed in this work shows the inter-organisational context of the RHs, identifies the various actors that exist and need to be analyzed in addition to the relations that are between the various participants in the RHs surroundings.

In addition, apparent terminology for the field where advanced transport solutions are in focus for the RH industry is important. Research in the area has increased in recent years and will without doubt increase even further in coming years as specific fields are explored and analyzed. As researchers explore the various areas and present narratives on their results, a common understanding of the basic terminology simplifies the knowledge exchange between peers. Consequently, the knowledge generation of the RHs requirements and the support found in information systems suppliers’ solutions will be more effective. Dissemination of research results to industry people may not be underestimated, and is at the end of the day vital for further development of the field. For that purposes, a common terminology is essential.
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