Transportation of Dangerous Goods: A Multiple Stakeholder Analysis for Improved Efficiency and Safety through Information Sharing

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TRANSPORTATION OF DANGEROUS GOODS:

A MULTIPLE STAKEHOLDER ANALYSIS FOR IMPROVED EFFICIENCY AND SAFETY THROUGH INFORMATION SHARING

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ABSTRACT

Purpose

The purpose of this study is to increase the understanding of multiple stakeholders' needs, benefits and challenges, with a focus on information sharing, to improve efficiency and safety in the transportation of dangerous goods by road, rail, and sea.

Design/methodology/approach

Inspired by grounded theory, this study is based on 21 semi-structured interviews with stakeholders representing authorities and consignor to consignee in transportation of dangerous goods in Sweden.

Findings

The study identifies the need for information sharing in connection with enforcement controls, digital dangerous goods declarations and operational support regarding regulations. However, several stakeholders seem to lack incentives to recognise these needs, which is a challenge as it leads to an absence of investment interest and a lack of adoption of ICT (information and communications technology) solutions.

Research limitations/implications

Although many stakeholders have an international perspective, this study is limited to a Swedish context. Further research needs to cover international authorities and add a legal perspective to information sharing.

Practical implications

The outcome of this study can serve as input into the development of ICT solutions and associated incentive models to improve the management of transportation of dangerous goods.

Social implications

Discussions are ongoing at the UN level about introducing requirements for telematics in dangerous goods regulations for road and rail. This study provides a structured overview of needs and challenges which could provide input into policy discussions.

Original/value

This study complements previous research by providing new empirical findings from multiple stakeholders on needs, benefits, challenges and incentives regarding information sharing in the transportation of dangerous goods.

Keywords: transportation, dangerous goods, efficiency, safety, multiple stakeholder, information sharing, information and communications technology, ICT, incentive.

1. INTRODUCTION

Continuous global increases in the transportation of dangerous goods (Laarabi et al., 2014), transportation set-ups with a growing number of parties, and increasingly complex information flows (Stefansson, 2006) result in growing complexity for each stakeholder to handle. Transportation of goods in general, and dangerous goods in particular, involves several parties including consignors, logistics service providers (LSPs), small transport companies, multi-modal transport operators, rail carriers, port and inter-modal terminals, consignees, governments, and emergency responders (Erkut et al., 2007; Perego et al., 2011). Moreover, the market is increasingly fragmented and research shows that single stakeholders' control over transports is decreasing (Sternberg et al., 2013). The transportation of dangerous goods is a multi-objective problem with multiple stakeholders (Erkut et al., 2007). Different organisations have different cost and revenue structures as well as differing incentives. A stakeholder's main interest in information sharing is based on the utility of information rather than the information itself (Simatupang and Sridharan, 2005).

Information and communications technology (ICT) solutions are recognised as a primary enabling tool for safe, effective, and efficient operations. The use of ICT could result in such benefits as improved planning and better supply chain management (Perego et al., 2011; Marchet et al., 2012). However, previous research shows that although the number of available ICT applications has increased and the pace of adoption has accelerated, the current level of penetration of ICT solutions and intelligent transportation systems (ITS) in the transportation industry is low and beneath its potential (Perego et al., 2011; Arnäs et al., 2013). Additionally, the majority of ICT transportation solutions were developed in the 1990s and 2000s (Harris et al., 2015). Nyquist and Sternberg (2013) identified some reasons for the lack of development of dangerous goods ITS relative to that of logistics and ITS in general; (i) a lack of incentive models for the stakeholders, (ii) a lack of standards to improve existing information sharing and (iii) a lack of collaboration to improve the sharing of dangerous goods documents.

To meet the need for further development of dangerous goods ITS, a comprehensive view of the needs of all involved stakeholders is required. Benefits and challenges for the different stakeholders need to be identified to make attractive incentive models and successful collaboration possible. Hence, the purpose of this study is to increase the understanding of multiple stakeholders' needs, benefits and challenges with a focus on information sharing to improve efficiency and safety in the transportation of dangerous goods by road, rail and sea.

The paper is organised as follows: section 2 describes the transportation of dangerous goods in Sweden followed by the methodology; section 4 presents findings focusing on identified needs, benefits and challenges; and section 5 discusses conclusions and suggests further research.

2. TRANSPORTATION OF DANGEROUS GOODS IN SWEDEN

Dangerous goods (DG) are associated with few, yet high-risk, transports in Sweden. Transportation of DG in Sweden decreased steadily since 2002. In 2010, DG represented 3% of the total transported goods and 5% of all transport work; of this the largest part (69%) was class 3 flammable liquids (Trafikanalys, 2012). DG transports pose high safety risks with severe consequences of an accident. DG transports that pose a security risk are easily identified due to the regulated use of orange placards, (Erkut et al., 2007). Conversely, exceptions such as limited quantities do not require orange placards.

2.1.1. Rules and regulations

Several organisations are responsible for DG regulations; however, the regulations hold many similarities, such as the classification of goods, packaging, labelling and document requirements (Nyquist and Rydberg, 2012). The UNECE (United Nations Economic Commission of Europe) is responsible for the treaty for transports of DG by road (ADR), while the Intergovernmental Organisation for International Carriage by Rail (OTIF) is responsible for the treaty for transports of DG by rail (RID). The Swedish Civil Contingencies Agency (MSB) takes an active part in the development of both treaties and is also the authority that issues the national regulations ADR-S and RID-S (Swedish Civil Contingencies Agency, 2015a). The International Maritime Organisation (IMO) is responsible for the treaty for transports of DG by sea (IMDG). The Swedish Transport Agency represents Sweden in the development of IMDG, port recommendations and the 'Memorandum of Understanding for the Transport of DG on Ro-Ro Ships in the Baltic' (Baltic MoU), applicable on certain routes in the Baltic Sea. The purpose of the Baltic MoU is to facilitate short-sea shipping of DG by applying ADR regulations instead (Swedish Civil Contingencies Agency, 2015a).

The Swedish act (2006:263) and the Swedish regulation (2006:311) regarding the transportation of DG constitute the Swedish legal framework and are applicable for all transport modes (Swedish Civil Contingencies Agency, 2015b). According to regulation 2006:311, the Swedish Civil Contingencies Agency is the transport authority for transports on land, while the Swedish Transport Agency is the transport authority for transports by sea and air. The enforcement of act 2006:263 is divided among the following authorities for road, rail, and sea:

- The Swedish Police, under the Ministry of Justice, supervises transports by road.
- The Swedish Transport Agency, under the Ministry of Enterprise and Innovation, supervises transports by rail and at sea.
- The Swedish Coast Guard, under the Ministry of Justice, supervises goods in the land area of ports that are destined for further transport, and on request supports the Swedish Transport Agency in transports at sea.
- The Swedish Civil Contingencies Agency, under the Ministry of Justice, supervises safety advisers for all transport modes, transportation security and ADR training of drivers, among other things (Swedish Government Offices, 2015).

In Sweden, the county administrative boards are authorised to (i) issue local traffic regulations to prohibit DG transports from using certain roads, (ii) recommend suitable routes for transportation, and (iii) indicate parking areas for resting (Nyquist and Rydberg, 2012).

2.1.2. Enforcement of DG transports

Up to 40% of the DG transports in Sweden [I] involve infringements of the above regulations; still, the DG regulations are enforced under diverse conditions with insufficient resources. Infringements on DG road transports are estimated at 20-30%. The Swedish haulage industry consists of 10,000 transport companies [II]. In relation to this, the Swedish police are only required to perform 7,000 controls annually, however, the fulfilment of this quota varies between counties. One reason is limited resources, as traffic policing has a low priority. Monetary penalties are issued for infringements at enforcement controls, which are primarily conducted on the roadside and take from 20 minutes up to several hours. The majority of penalties are issued to the consignor or the driver. The maximum fine for a driver, who is

personally liable, is SEK 10,000 at a single control. The police compile limited statistics of infringements, focusing on personal penalties rather than the involved vehicle.

The Swedish Transport Agency's Rail Division considers the enforcement process on railways more rigorous than the one on roads. The Rail Division performs annual risk-based controls of each railway company based on their safety management system. Sweden has 101 operating rail companies, of which 30 transport DG. The Rail Division performs 50 physical controls of DG waggons annually. Rail companies are also required to carry out their own controls. Infringements of DG rail transports are estimated at 10-20%. No monetary penalties are issued for DG transports by rail; instead the consignor or rail company is given an injunction to correct the violation. The enforcement system for rail is based on the rule that every rail company pays an annual enforcement fee ranging from SEK 186,500 to SEK 523,200 depending on the volume transported and the distance (Swedish Transport Agency, 2014).

Infringements of DG transports at sea are estimated at 20-30%, of which 15% are considered serious. The Swedish Transport Agency's Sea Division performs no spot checks of DG at sea; due to a limited budget they focus on annual vessel controls. Council Directive 95/50/EC and the European Commission require that one unit per thousand of the goods flow should be controlled. Due to a conflicting use of resources the Swedish Coast Guard only performs controls at a level of 0.2-0.3 per thousand of all transports on land, resulting in little risk of detection. When an infringement is found, a prohibition, injunction or summary penalty is issued. Further prosecution is also an option; however, Swedish law enforcement currently has difficulty prosecuting international stakeholders, resulting in unfair competition. The Swedish Coast Guard compiles extensive statistics; ADR statistics are sent to the Swedish Civil Contingencies Agency and IMDG statistics are sent to the Swedish Transport Agency's Sea Division. The Swedish Transport Agency's Sea Division does not compile any statistics of their own, nor do they forward any to the IMO as required since 2011.

2.1.3. Regulatory requirements on information sharing

Currently, the requirements for digital and paper-based transport documentation are unclear. According to the ADR and RID regulations, electronic data interchange (EDI) and electronic data processing are permitted as a complement to, or instead of, written transport documentation. However, the information must be easily accessible in the event of an accident or enforcement control, which requires a reliable internet connection. The consignor and transporting company are legally required to keep a copy of the transport documentation such as the DG declaration (DGD) for at least three months (Nyquist and Rydberg, 2012).

A working group was appointed in 2007 to investigate the possibility of introducing requirements for the use of telematics systems in the ADR and RID regulations. 'The Working Group on the use of telematics for the carriage of DG' was initiated by the European Commission and commissioned by the Joint Meeting of UNECE and OTIF (UNECE, 2007). Sweden is represented by the Swedish Civil Contingencies Agency. The working group meets regularly and discusses organisational and regulatory needs as well as solutions for information sharing. The main need is to provide emergency responders with digital information about the vehicle and goods when a DG accident occurs. As a step towards this, the working group has mapped such data as the information to be shared, receiving stakeholders, and usage in the future telematics application (OTIF, 2010). However, no benefits or incentive model are provided for the stakeholder that is expected to provide the information.

In conclusion, the theoretical perspective of the problem is international, but the social and practical perspectives require a national view, which is currently lacking. Therefore, the focus in this study is on Swedish stakeholders and conditions.

3. METHODOLOGY

This study was inspired by grounded theory in order to achieve better grounded empirical data and to more deeply understand the complex social interaction in the transportation of DG (Mello and Flint, 2009; Miles et al., 2014). Grounded theory is considered an appropriate method when collecting qualitative data through semi-structured interviews (Turner, 1981), especially for the area of "intra- and inter-firm information sharing and its impact on logistics performance" (Mello and Flint, 2009, p. 115). Advantages of using grounded theory include; (i) developing concepts based on theoretical similarities and differences in the data, (ii) likely usability of the concepts for practitioners, (iii) encouragement of creativity in the research process and (iv) inclusion of extant research into the concept development (Turner, 1981; Cutcliffe, 2000; Mello and Flint, 2009).

3.1. Research design

This is an interview study based on 21 semi-structured interviews with 17 organisations representing authorities as well as consignor to consignee in the transportation of DG in Sweden. As shown in Figure 3.1, the stakeholders are divided into two categories: logistics flow and governance. By interviewing more than one organisation for most of the parties, the author aimed to widen the empirical grounds and increase generalisability (Miles et al., 2014).

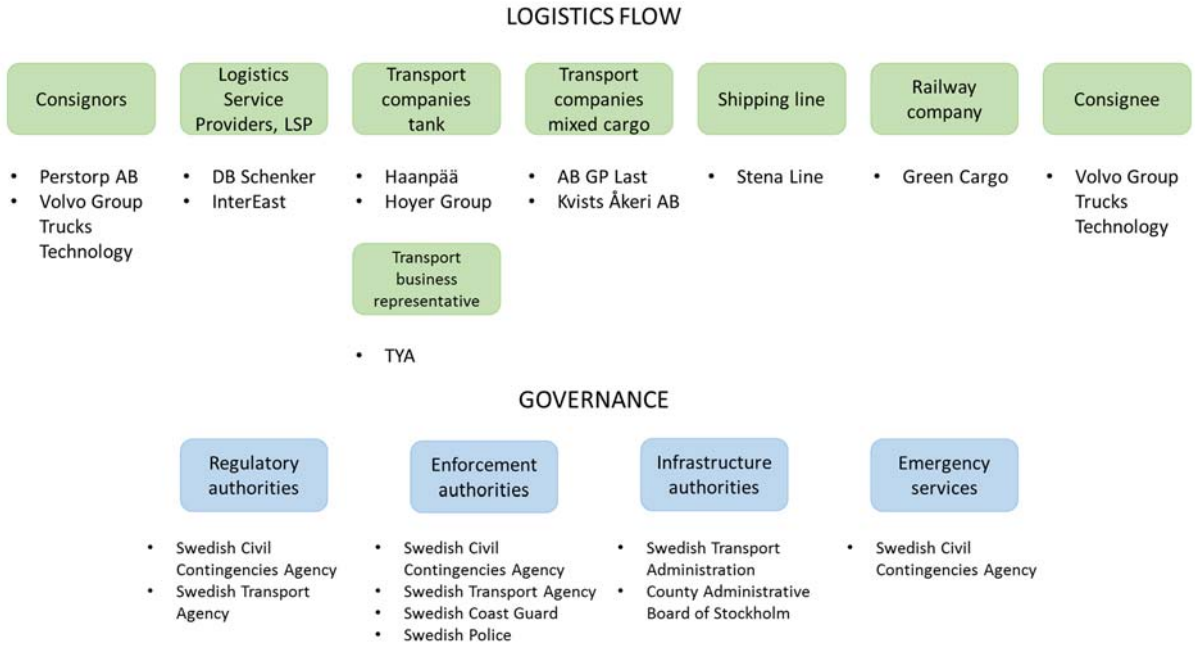

Figure 3.1 Categorisation of interviewed stakeholders.

Participant sampling within governance was mainly based on regulatory and enforcement authorities stipulated in DG rules and regulations. In line with Cutcliffe (2000), sampling evolved over time and the author explicitly asked for imperfect representatives to improve the credibility of the study. The author intended to focus the sample on companies from the same transport chains; Perstorp AB employs the tank transport companies Haanpää and Hoyer Group, DB Schenker sub-contracts AB GP Last and Kvists Åkeri AB; and finally, both InterEast and Hoyer Group contract Stena Line. The interviewees are presented in Table 3.1. The average DG experience accessed by the study is 18 years. In interviews 11 and 19, the organisations had double representation in order to better answer the questions.

Table 3.1 List of interviewees in the study.

No.	Organisation	Interviewee	Role	Experience of DG
1	InterEast	Oscar Törnqvist	Chief Operating Officer	6 years
2	Swedish Coast Guard	Jimmy Leijonfalk	National specialist DG and cargo securing	24 years
3	Swedish Civil Contingencies Agency	Brita Skärdin	Expert in ADR and RID and negotiator at UN	19 years
4	Swedish Transport Administration, Road	Martin Ström	Infrastructure project manager for DG	3 years
5	Perstorp AB	Per Derwik	Global Transport Manager	15 years
6	TYA – the Vocational Training and Working Environment Council (Transport Trades)	Stefan Reimers	Training and spokesperson for the transportation industry within DG	20 years
7	Swedish Police	Thomas Danielsson	Traffic police and ADR expert	5 years
8	Haanpää	Sven-Åke Sleth	Key account manager & ADR teacher	34 years
9	Hoyer Group	Bengt Johansson	Safety adviser & ADR teacher	37 years
10	Swedish Transport Agency, Sea Division	Pekka Piirainen	Supervision coordinator IMDG	25 years
11	County Administrative Board of Stockholm	Anna Bofjäll	Fire protection engineer	2.5 years
11	County Administrative Board of Stockholm	Olof Paulin	Risk manager	6 years
12	DB Schenker Sweden	Hans Carlheim	Safety adviser & ADR teacher	32 years
13	Swedish Transport Agency, Rail Division	Lars Pettersson	Supervision RID	10 years
14	Swedish Civil Contingencies Agency	Brita Skärdin	As above	As above
15	Green Cargo	Jan Pettersson	Safety adviser & ADR teacher	15 years
16	Stena Line	Magnus Weghammar	Freight business controller & booking manager	18 years
17	Swedish Transport Administration, Rail	Erik Lindberg	Safety adviser RID	25 years
18	AB GP Last	Mikael Nilsson	Chief Operating Officer, & safety adviser	16 years
19	Volvo Group Trucks Technology	Ulrika Andersson	Safety adviser	16 years
19	Volvo Group Trucks Technology	Åsa Nordström	Safety adviser	13 years
20	Kvists Åkeri AB	Mikael Kvist	Chief Executive Officer	25 years
21	Swedish Civil Contingencies Agency	Bo Andersson	Expert in emergency response development	30 years

3.2. Data collection

The semi-structured interviews were based on 15-20 questions that evolved over time to improve the subsequent data collection. The questions were adapted to each stakeholder and covered areas such as role and responsibilities, DG, logistics process, incentives and information systems. The interviews were 1 hour and 27 minutes long on average and were conducted between September 2014 and February 2015. All but one interview were audio recorded and then transcribed from dictation by the author. This was done on a detailed level including incomplete sentences indicating an incoherent speaker; however, word emphasis and pauses were omitted in the transcript. The respondents were given the opportunity to comment on the transcription of the interview; 14 out of 20 respondents returned comments. This was done before the transcripts were coded to achieve participant validation and to ensure that the respondent's thinking was represented accurately (Burnard et al., 2008). Some of the interviewees requested that the shared information be treated confidentially.

Literature was reviewed after conducting the interviews so emergent concepts could be grounded in data as far as possible (Cutcliffe, 2000). Secondary sources used are regulations, project reports, guidelines and meeting reports from organisations and authorities such as the Swedish Government Offices, UNECE, OTIF and the Swedish Civil Contingencies Agency.

3.3. Data analysis

All collected data were thoroughly analysed and coded, primarily from a descriptive approach (Miles et al., 2014), for a systematic and rigorous analysis (Burnard et al., 2008). The codebook, a critical tool in the analysis process (MacQueen et al., 1998; Fereday and Muir-Cochrane, 2006), consisted of an Excel file and was used to iteratively identify and define the constructs 'needs', 'benefits' and 'challenges', consisting of one matrix for each construct. The comment function in Excel was used for further definition or quotes from a specific interviewee to ensure consistency from the beginning of the analysis. The focus was on 'what'; the author distinguished between needs for information sharing and needs for specific solutions or system integration. The purpose was to keep a general, objective perspective and not to evaluate different solutions. For the two constructs 'benefits' and 'challenges', the focus was set on 'why'. In some cases the constructs were related to more than one specific need, which was indicated in the code book. As the author gained clearer insight into the data, definitions of some constructs were revised for better fit. The author also sought to identify any unique or contrary constructs as well as constructs of which the stakeholder was unaware. To distinguish and not overemphasise these implicit constructs in the analysis, the comment 'not expressed' was added to the code book.

Second-cycle coding was used to identify pattern codes mainly by identifying categories and themes, causes and explanations, as well as relationships between stakeholders (Miles et al., 2014). In this study the second-cycle coding focused on categorisation as well as comparisons between governance and logistics-flow stakeholders, different modes of transport, and mixed-cargo and tank transport companies in order to identify important patterns.

4. FINDINGS

Analysing the interviews from different perspectives resulted in the identification of 30 needs, 26 benefits and 56 challenges with reference to information sharing.

4.1. Needs and benefits for improved information sharing

The 30 needs presented in Table 4.1 were clustered into eight categories based on their similarities. Furthermore, a framework for categorisation of ICT applications and solutions, Marchet et al. (2012), was applied based on the area of application: (i) document management, (ii) operations management and (iii) safety and security management.

Table 4.1. Needs divided into categories and areas of application.

Area of application	Categories	Needs
Document management	Digital dangerous goods declaration	(i) Digital information to emergency services at DG accidents, (ii) Digital DG information, (iii) Facilitated DG document management and (iv) Support for creating DGDs.
Operations management	General transparency and digitalization	(i) Transparency, (ii) Non-confidential statistics available to companies, (iii) Record of approved vehicles and packages for DG on roads and railways, (iv) Digital bookings and transfer of DGD, (v) Facilitated and digital access to product information, (vi) Information on companies with recurring lack of compliance and (vii) Information earlier in the transport chain.
	Operational support	(i) Digital guide to DG regulations, (ii) Digitised written instructions adapted to work order, (iii) Application for DG loading and signage (iv) Digital information about local traffic regulations and (v) Information about parking lots.
	Applications and Information systems, IS	(i) Simple design of new solutions, (ii) Solutions supported by the IS of several LSPs, (iii) IS support to weigh containers and (iv) IS support for the Baltic MoU.
Safety and security management	Regulations	(i) Harmonised DG regulations, (ii) Earlier updates of DG regulations and (iii) NHM codes are only required on railway.
	Enforcement controls	(i) Control follow-up, (ii) Control statistics and (iii) Information sharing and collaboration between authorities.
	Statistics	(i) Goods flow statistics and (ii) Accident/incident statistics.
	Track and trace	(i) Track and trace of DG transports in general and (ii) Real time track and trace of DG transport in tunnels.

Each need has one or more associated benefits; more benefits enhance the possibility of developing a successful incentive model resulting in the adoption of a future ICT solution. Inspired by the main motivations for adopting ICT solutions as defined by Perego et al. (2011), the benefit categories used in this study are: (i) operational efficiency (e.g. resource efficiency, process control and cost reduction), (ii) safety improvement, (iii) compliance with DG regulations and (iv) explicit customer requests. The eight categories of needs along with their associated benefits, are presented in the following sub-sections.

4.1.1. Digital dangerous goods declaration

There are two benefits associated with the need for digital DGDs – safety and operational efficiency. As stated in section 2.1.3, the main reason for initiating the working group was to make rescue operations at accidents safer and more efficient, mainly by introducing digital DGD and associated documents. This need is confirmed primarily by governance stakeholders, especially the emergency services. Furthermore, several governance and logistics-flow

stakeholders for all transport modes see operational needs for digitising DGDs in order to streamline administrative procedures. As an example, Stena Line spends a considerable amount of time on information reproduction; having the correct, updated information digitally could make bookings of sea transports more efficient for both Stena Line and their customers. For rail transports the information is partly available today, however, the Swedish Transport Administration's Rail Division would like to see the information following the consignment at modal changes, as this sometimes causes problems. Several stakeholders seem unaware of the advantages of digital information and DGDs. If, for instance, the authorities could access digital DGDs, enforcement controls would be more intelligent and efficient.

Within one transport chain there are contradictory views of the need for digital DGDs. Kvists Åkeri states that it works well today with paper based DGDs and that a digitisation would require investments. Furthermore, the transport company is hesitant due to inspectors preferring to read information on a screen instead of on a paper. Conversely, their transport customer, DB Schenker, suggests further digitisation through, e.g. a bar code system for each DG consignment from consignor to consignee.

Regardless of digitisation, three logistics-flow stakeholders need facilitated handling of DG documents, particularly if the regulation is not better adapted to the transportation industry. One problem is the plethora of DGD formats, making it difficult for a driver to be certain that all information is provided. A standardised format or a publicly available application for creating DGDs is suggested, perhaps on some authority's website.

4.1.2. General transparency and digitalization

The stakeholders view transparency in numerous ways, however, these needs are expressed mainly by logistics-flow stakeholders with the associated benefits of safety and operational efficiency. The transport business representative, TYA, wants transparency so transport companies that follow regulations and have the necessary certificates and training can stand out and thereby achieve fairer competition. The Swedish Coast Guard sees transparency between Swedish enforcement authorities on control results and penalties as central, currently it is insufficient. The LSP InterEast agrees but points to the potential risk of increased transparency: "Who is the transparency for? For what purpose?"

Four out of seven needs are expressed by one single stakeholder each, showing variance in the experienced needs. In addition, three of these four needs could be categorised as information access instead of a need for information sharing (i.e. no stakeholder request the information). The Swedish Coast Guard, for example, suggests to making non-confidential statistics of enforcement controls publicly available so companies can identify system failures and improve safety; however, no stakeholder has identified this need. If asked, most stakeholders would agree with Kvists Åkeri: "the sooner the information enters the transport chain, the better and more correct actions can be taken by transport companies and LSPs."

4.1.3. Operational support

According to a majority of the interviewees, the DG regulations are extensive, complex and hard to understand, leading to insecurity. To increase safety, operational efficiency and compliance with DG regulations, both inspectors and logistics-flow stakeholders express a need for operational support, such as digital guides to the DG regulations, or the digitisation and adaptation of written instructions to a specific work order.

The extent to which DG are transported without placards is unknown; the interviewed police officer encounters 1-2 transports per year without placards. One of the logistics-flow stakeholders believes that using placards attracts the enforcement authorities, increasing the number of controls for the company. Thus, no one wants placards unless absolutely necessary.

As an operational support to save time and comply with regulations, a logistics-flow stakeholder suggests an application for the planner and the driver at loading and signage of DG transports where the UN number and consignment weight result in suggested placards.

There is a need for operational support in route planning of DG transports, despite inadequate enforcement of local traffic regulations and recommended routes. Available applications include ADR-Pro [III] and Serpac's ADR Tunnels and Services [IV], but the applicability is unknown as most transport companies are uninformed. Today Swedish local traffic regulations and recommended routes are only available as printed or online maps [V], which is not user-friendly. This does not pose a problem for drivers that frequently drive a certain stretch. However, several logistics-flow stakeholders point to problems for drivers from other regions and countries. Non-existent enforcement of local traffic regulations leads to an unknown level of compliance. It is noteworthy that the only governance stakeholder that seems to be aware of the problem is the Swedish Civil Contingencies Agency. Moreover, transport companies tend to prioritise minimising fuel costs and travel times over adhering to local traffic regulations (Erkut et al., 2007). Hence, if information about local traffic regulations is not easily accessible, a change in this behaviour is even farther away.

According to Kvists Åkeri and the TYA there is a need for more parking areas that are secure and/or adapted to DG and there is a need to share information about them – a responsibility of the Swedish county administrative boards. Benefits are unclear, however; the Swedish Civil Contingencies Agency anticipates that transparency of a larger selection of parking areas will facilitate route planning and thereby increase compliance with regulations for driving time and rest periods.

4.1.4. Applications and information systems, IS

Four of the logistics-flow stakeholders declare a need for new solutions to be simple, which will enhance safety and efficiency through better coupling between theory and practice for DG transports. The TYA states that: "the problem with today's solutions is that the enforcement authorities' exert too much influence on the design so that it becomes complicated for the drivers. (…) This affects some 150,000 employees in Sweden; 1,000 of these are inspectors and 149,000 are drivers, terminal personnel and others involved in DG transportation." Moreover, an overly complicated solution will lead to a low adoption rate.

The other three needs are expressed by one stakeholder each, indicating that they are unique. However, no direct benefits have been associated with these needs. They are: (i) Perstorp thinks that successful adoption of a new solution is dependent on support from the ISs of several LSPs; (ii) the Swedish Transport Agency's Sea Division points to potential future weighing of each container in a port, requiring technical equipment and support by ISs; and (iii) Stena Line states that there is no IS available supporting the Baltic MoU.

4.1.5. Regulations

A majority of the logistics-flow stakeholders propose increased harmonisation, or a full merger of ADR, RID and IMDG. However, the need is not recognised by the governance authorities. Examples of experienced problems are: (i) several transport companies have inadequate knowledge of differences between ADR and IMDG at modal change; (ii) differing product classification between ADR and IMDG; and (iii) confusion and mixed opinions of the utility of the Baltic MoU. Harmonisation would lead to increased safety and regulation compliance due to greater knowledge. This would lead to greater efficiency, as companies such as Stena Line could reduce their customer support.

The biannual update of DG regulations can be complicated and time-consuming for logistics-flow stakeholders to incorporate into their procedures. The Swedish Civil Contingencies

Agency announces changes in May, while other authorities don't provide any information at all. One logistics-flow stakeholder believes they could save time and money if they were provided with updates as soon as they are finalised; this is more important for companies adhering to more than one DG regulation. Finally, there are differences between DG regulations for rail and road; one example is the NHM codes (i.e. Harmonised Commodity Code), which cause problems at modal changes as they only apply to railways.

4.1.6. Enforcement controls

There is a significant opportunity to increase safety by improving the operational efficiency of enforcement controls. As described in section 2.1.2, enforcement resources are scarce and the lack of compliance is evident. According to Belzer (2000) there is a causal effect between few enforcement controls and lack of compliance in DG road transports. Improved IS support could enhance operational efficiency in the Swedish police's enforcement controls, which would also be benefit the transport companies. At first glance, the Swedish police's enforcement control system appears to work well. However, this is mainly due to the capabilities of individual police officers rather than a robust, coherent, systematic approach. The Swedish Transport Agency's Rail Division and the Swedish Coast Guard are well supported by ISs for reporting and follow-up of enforcement controls. Nonetheless, the Swedish Coast Guard points to the need for digital DGDs to improve controls. By comparison, the Swedish police simply have an IS for reporting penalties, resulting in random full controls every time since they cannot be based on previous controls. Improved reporting and follow-up of controls enables a risk-analysis-based approach resulting in smarter, more efficient, targeted controls.

Visions and needs for information sharing and enforcement collaboration differ between authorities. For instance, the Swedish Transport Agency's Rail Division is content with collaborating nationally and internationally in six to seven controls per year. The Swedish police have good collaboration on roads, but would like to increase it with the railways as serious infringements occur at intermodal freight terminals. However, sharing of statistics is limited due to legal reasons that hinder collaboration even between counties within the Swedish police jurisdictions. On the other hand, the Swedish Civil Contingencies Agency believes that increased information sharing between authorities regarding control results could lead to increased precision in controls by other enforcement authorities. Ultimately, the Swedish Coast Guard proposes a common IS for all enforcement authorities in the EU to considerably facilitate the tracking of companies lacking compliance.

4.1.7. Statistics

Access to statistics might improve safety; however, the information is challenging to compile and often confidential due to transportation security or competitive reasons (Trafikanalys, 2015). Municipalities and county administrative boards are responsible for safety of buildings, roads and tunnels. In addition, the emergency services have an interest in knowing which types of transports pass through their organisational area. Today these decisions are mainly based on inadequate goods-flow statistics from 2006. Such statistics should consist of yearly data on DG class, volume and frequency related to specific transport routes. Most logistics-flow stakeholders understand the need, but obtaining the data requires extensive work and the information is sensitive for competitive reasons. Access to goods-flow statistics would save time for municipalities in compiling better reports, as well as increasing safety by improving risk management in community planning as well as emergency response.

The Swedish Civil Contingencies Agency states that access to accident and incident statistics might further improve risk management in municipalities and county administrative boards.

But the need and benefits are unconfirmed. Yet information on accidents and incidents is more easily accessible as most logistics-flow stakeholders keep statistics for their annual reports.

4.1.8. Track and trace

There are three benefits associated with the need for track and trace: safety, operational efficiency and customer request. The needs for track and trace are only expressed by governance stakeholders; the logistics-flow stakeholders seem to lack incentives to share this information. If the Swedish police had track and trace of transports, including access to DGDs, problems such as transports without placards might be reduced. Furthermore, the location of a DG vehicle in an accident and access to the DGD would make rescue operations more efficient. In a railway accident, this information should be provided by the Swedish Transport Administration's Rail Division. Thus, they express a need for track and trace of each unit and its contents, preferably in real time. The railway company Green Cargo, transporting about 80 % of all DG on railway in Sweden, has track and trace of their units. However, during shunting the information is not transferred in real time. In general, the development of track and trace has come further on railways than on roads.

To create incentives for the logistics-flow stakeholders, the Swedish Transport Administration's Road Division suggests that transport companies that provide track and trace information in real time should gain access to otherwise restricted tunnels and road sections. The purpose is to enhance safety by improving incident verification and rescue operations. Track and trace of DG transports would allow the identification of what happens on the roads and in tunnels. Three of the transport representatives responded positively to this as long as sharing the information provides an appreciable advantage.

4.1.9. Relationships between benefits and stakeholders

According to the Swedish Coast Guard, there is a general interest in the transportation industry in achieving a high degree of safety; still problems occur in individual transport companies when LSPs set logistical requirements that are impossible to achieve while adhering to regulation. The primary focus of mixed-cargo transport companies is operational efficiency and profitability. This differs from tank transport companies, which have a more balanced perspective of efficiency and safety. Suggested causes for this difference are tougher regulation for tank transports, the safety risk posed by large volumes of DG, and the influence on companies transporting mixed-cargo from sub-contracting LSPs.

To realise the potential of several of the needs identified in the study, some interviewed stakeholders say the focus on the consignor's role needs to increase. In many cases the consignor is the source of information; thus, in order to minimise reproduction of information, the information should be caught as early as possible in the information chain. Furthermore, the consignor is advised to impose explicit customer requests on transport companies. This is in line with one logistics-flow stakeholder's statement that needs can be stipulated in order to drive development in a certain direction, since the needs often are fully incorporated. One reason for this is probably the heavy competition in the transportation industry.

4.2. Challenges for information sharing

Challenges for information sharing and ICT adoption vary between the transportation modes, and can be divided into three categories based on their area of impact: (i) user-related, (ii) technology-related and (iii) policy-related (Harris et al., 2015). Of the 56 identified challenges, 30 are user-related, eight are technology-related and 18 are policy-related.

4.2.1. User-related challenges

User-related challenges have economic, operational and managerial aspects, such as enterprise size and incentives (Harris et al., 2015). Examples of user-related challenges identified in this study are that too few, and the wrong, enforcement controls are conducted. However, the interviewees welcome an increase in controls, if they are conducted in a better way. Some drivers are reluctant to have equipment in the truck as they feel supervised. Furthermore, there is a significant variation in DG regulation knowledge between tank truck and mixed-cargo drivers. Finally, there is a lack of DG competence in both drivers and inspectors.

This study reveals unclear incentives for investments and lack of matching incentive models. Incentives can be defined as relevant and applicable benefits, also known as 'carrots'. Conversely, there are disincentives that have a discouraging effect, also known as 'sticks'. Disincentives are often used to achieve compliance in rules and regulations, for example reputation risk, enforcement controls and penalties. The Swedish Coast Guard states that: "…we can accomplish more with suitable carrots than with sticks – the stick can only influence the things you come across".

Based on sections 2.1.2 and 4.1.6, a lack of both incentives and disincentives to comply with DG regulations for road transports has been identified. To increase safety and achieve fair competition, the Swedish Coast Guard points to the need to develop disincentives such as ensuring prosecution of international companies or introducing sanctions, as was done with regulations for driving time and rest periods. A complete lack of incentives leads to absence of interest in investments. Thus, the challenge is to develop an incentive model that is a combination of incentives and disincentives for the involved stakeholders, as the benefits in succeeding in this task are potentially great.

A logistics-flow stakeholder declares that their most important incentive for investments is economic opportunities. This is based on the fact that safety is considered to be satisfactory for DG transports today, an opinion that is shared by several interviewed logistics-flow stakeholders. However, it is not explicitly expressed in all cases, perhaps due to the interviewee's role. Governance stakeholders put safety first, stating that companies' interests cannot be considered; their mission is to work for greater societal safety – e.g. by spreading the DG regulations. However, this might change as authorities become more service minded.

4.2.2. Technology-related challenges

Technology-related challenges include compatibility and interoperability of systems, ICT integration and standardisation, and information confidentiality (Harris et al., 2015). Technology-related challenges identified in this study are that existing technology and solutions are not up to standard with the needs that are expressed and that increased information sharing might result in information security risks. Furthermore, with increased information sharing, the needs for handling large amounts of data will grow. Finally, to achieve viability, ISs and solutions need to be harmonised with those for regular freight, something that is lacking today.

4.2.3. Policy-related challenges

Among the types of policy-related challenges are lack of related policies, coordination and harmonisation of related policies, and lack of standardisation supported by policies (Harris et al., 2015). Policy-related challenges identified in this study are legal restrictions for authorities to register and share information, as well as the DG regulations, which are considered confusing, impractical and slow to change. Additionally, there is a reluctance among the logistics-flow stakeholders to accept stricter regulations and added responsibility. Finally, railway stakeholders consider RID to be stricter than ADR, thus disrupting the neutral competition between the transport modes.

5. CONCLUSIONS

The contribution of this paper is threefold: (i) new empirical findings from multiple stakeholders on needs, benefits, and challenges regarding information sharing in transportation of DG; (ii) input into the development of ICT solutions and associated incentive models for improving the management of DG transportation; and (iii) a structured overview of needs and challenges that might be used as input into policy discussions.

According to the interviewed stakeholders, safety is improved through more enforcement controls and increased knowledge of DG. One proposed way to improve safety is to harmonise the ADR, RID, and IMDG regulations into one, which is particularly supported by the logistics-flow stakeholders. Furthermore, a majority of the interviewed governance and logistics-flow stakeholders agree that augmented enforcement controls would lead to greater compliance with DG regulations. The Swedish Coast Guard states: "research shows that 70% of the effect of greater compliance is achieved through greater risk of detection; that is, to conduct more enforcement controls". Conversely, some interviewed logistics-flow stakeholders claim that stricter regulations or solutions might pose a risk of decreased compliance. However, there is a lack of both incentives and disincentives to achieve this, since regulation enforcement is inadequate. There are, for example, DG truck drivers that have not been controlled once over the past 5 years. Moreover, there are clear differences between enforcement on roads and seas versus railways. The question is: which incentive model is the best for optimal transportation safety and efficiency?

Numerous interviewed stakeholders seem to lack incentives to realise identified needs. Safety is the main incentive for DG transportation today. However, for a majority of the logistics-flow stakeholders, economic incentives are central for operations and investments. It is noteworthy that none of the interviewees identified opportunities in information-driven business models. The complexity of information sharing together with the needs of economies of scale might be a barrier.

When developing solutions in the past, economic incentives were neglected, which resulted in a lack of adoption of ICT solutions (Nyquist and Sternberg, 2013). One way to obtain this is to develop adapted incentive models. There are on-going policy discussions on introducing regulations for use of telematics in ADR and RID. This study, however, questions how logistics-flow stakeholders benefit from investing in technical equipment and sharing this information (OTIF, 2010). Based on the findings of this study, it would be interesting to explore whether introducing regulatory requirements is necessary to reach the goal or whether market forces, such as an adapted and attractive incentive model, can achieve this. When a telematics policy for ADR and RID is suggested, this study proposes an impact assessment of the policy on stakeholders as well as on incentives and challenges to ICT adoption (Harris et al., 2015).

Suggested further research is to investigate the legal perspective on information sharing. The Swedish context of this study is proposed to be expanded to cover international authorities as well as more representatives for each stakeholder to reduce the effects of organisation-specific features.

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REFERENCES

Arnäs, P.O., Holmström, J. and Kalantari, J. (2013), ”In-transit services and hybrid shipment control: The use of smart goods in transportation networks”, *Transportation Research Part C: Emerging Technologies*, Vol. 36, pp. 231-244.

Belzer, M. H. (2000), *Sweatshops on Wheels: Winners and Losers in Trucking Deregulation*, Oxford University Press, New York, NY.

Burnard, P., Gill, P., Stewart, K., Treasure, E. and Chadwick, C. (2008), “Analysing and presenting qualitative data”, *British Dental Journal*, Vol. 204 No. 8, pp. 429-432.

Cutcliffe, J. R. (2000), “Methodological issues in grounded theory”, *Journal of Advanced Nursing*, Vol. 31 No. 6, pp. 1476-1484.

Erkut, E., Tjandra, S. and Verter, V. (2007), ”Hazardous materials transportation” Barnhart, C. and Laporte, G. (Eds.), *Handbook on Operations Research and Management Science, Transportation*, Vol. 14. North Holland, Amsterdam, pp. 539-622.

Fereday, J. and Muir-Cochrane, E. (2006), “Demonstrating rigor using thematic analysis: A hybrid approach of inductive and deductive coding and theme development”, *International Journal of Qualitative Methods*, Vol. 5 No. 1, pp. 80-92.

Harris, I., Wang, Y. and Wang H. (2015), “ICT in multimodal transport and technological trends: Unleashing potential for the future”, *International Journal of Production Economics*, Vol. 159, pp. 88-103.

Laarabi, M. H., Boulmakoul, A., Sacile, R. and Garbolino E. (2014), ”A scalable communication middleware for real-time data collection of dangerous goods vehicle activities”, *Transportation Research Part C*, Vol. 48, pp. 404-417.

MacQueen, K., McLellan, E., Kay, K. and Milstein, B. (1998), “Codebook development for team-based qualitative analysis”, *Cultural Anthropology Methods*, Vol. 10 No. 2, pp. 31-36.

Marchet, G., Perotti, S. and Mangiaracina, R. (2012), “Modelling the impacts of ICT adoption for inter-modal transportation”, *International Journal of Physical Distribution and Logistics Management*, Vol. 42 No. 2, pp. 110-127.

Mello, J. and Flint, D. J. (2009), “A refined view of grounded theory and its application to logistics research”, *Journal of Business Logistics*, Vol. 30 No. 1, pp. 107-125.

Miles, M. B., Huberman, A. M. and Saldaña, J. (2014), *Qualitative Data Analysis – A Methods Sourcebook (3rd ed.)*, Sage Publications, Thousand Oaks, CA.

Nyquist, C. and Rydberg, G. (2012), ” Intelligenta transportsystem för transport av farligt gods”, Swedish Civil Contingencies Agency, MSB, MSB501 – 2012 11, available at: https://www.msb.se/RibData/Filer/pdf/26592.pdf (accessed 9 March 2015).

Nyquist, C. and Sternberg, H. (2013), “Transport of Dangerous Goods: Review of Proposed IT Architecture – Logistical and information Focus”, Security Arena Lindholmen, available at: https://www.msb.se/Upload/English/Dangerous_goods/Transport_of_DG_Review_of_IT_architecture.pdf (accessed 9 March 2015).

OTIF (2010), “INF. 11”, RID/ADR/ADN Joint Meeting informal working group on telematics, available at: http://www.unece.org/fileadmin/DAM/trans/doc/2010/wp15ac1/INF.11%20(e).pdf (accessed 9 March 2015).

Perego, A., Perotti, S. and Mangiaracina, R. (2011), "ICT for logistics and freight transportation: a literature review and research agenda", *International Journal of Physical Distribution and Logistics Management*, Vol. 41 No. 5, pp. 457-483.

Simatupang, T. M., and Sridharan, R. (2005), "An integrative framework for supply chain collaboration", *The International Journal of Logistics Management*, Vol. 16 No. 2, pp. 257-274.

Stefansson, G. (2006), "Collaborative logistics management and the role of third-party service providers", *International Journal of Physical Distribution and Logistics Management*, Vol. 36 No. 2, pp. 76-92.

Sternberg, H., Germann, T. and Klaas-Wissing, T. (2013), "Who controls the fleet? Initial insights into the efficiency of road freight transport planning and control from an industrial network perspective", *International Journal of Logistics: Research and Applications*, Vol. 16 No. 6, pp. 493–505.

Swedish Civil Contingencies Agency, (2015a), "FN och OTIF och transport av farligt gods", available at: https://www.msb.se/sv/Forebyggande/Transport-av-farligt-gods/Internationellt-regelarbete/FN-och-OTIF/ (accessed 27 March 2015).

Swedish Civil Contingencies Agency, (2015b), "Lag och förordning", available at: https://www.msb.se/sv/Forebyggande/Transport-av-farligt-gods/Regler-vag-och-jarnvag/Lag-och-forordning/ (accessed 27 March 2015).

Swedish Government Offices (2015), "Förordning (2006:311) om transport av farligt gods", available at: http://www.riksdagen.se/sv/Dokument-Lagar/Lagar/Svenskforfattningssamling/Forordning-2006311-om-trans_sfs-2006-311/?bet=2006:311#overgang (accessed 27 March 2015).

Swedish Transport Agency (2014), "Transportstyrelsens föreskrifter om avgifter inom järnvägsområdet, TSFS 2014:53", available at: http://www.transportstyrelsen.se/TSFS/TSFS_2014_53.pdf (accessed 24 April 2015).

Trafikanalys (2012), "Godstransporter i Sverige: redovisning av ett regeringsuppdrag, Rapport 2012:7", available at: http://trafa.se/PageDocuments/Rapport_2012_7_Godstransporter_i_Sverige.pdf (accessed 29 March 2015).

Trafikanalys (2015), " Möjligheter att kartlägga flöden av farligt gods i Sverige – en förstudie, PM 2015:3", available at: http://trafa.se/PageDocuments/PM2015_3_Moejligheter_att_kartlaegga_floeden_av_farligt_gods_i_Sverige_-_en_foerstudie.pdf (accessed 29 March 2015).

Turner, B. A. (1981), "Some practical aspects of qualitative data analysis: One way of organising the cognitive processes associated with the generation of grounded theory", *Quality and Quantity*, Vol. 15 No. 3, pp. 225-247.

UNECE (2007), "Report of the Joint Meeting of the RID Committee of Experts and the Working Party on the Transport of Dangerous Goods on its Session", United Nations Economic and Social Council, available at: http://www.unece.org/fileadmin/DAM/trans/doc/2007/wp15ac1/ECE-TRANS-WP15-AC1-108a3e.pdf (accessed 23 March 2015).

I http://sverigesradio.se/sida/artikel.aspx?programid=83&artikel=5994042

II http://www.akeri.se/om-oss/akerinaringen

III https://www.beurtvaartadres.nl/en/dangerous-goods/app-adr-pro-2013

IV https://itunes.apple.com/us/app/adr-tunnels-and-services/id773259914?mt=8

V http://trafikinfo.trafikverket.se/LIT/#url=Yrkestrafik-vag/Karta