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Multiple Case Study of Transport Chains of Dangerous Goods in the Baltic Sea Region

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Abstract

This multiple case study of 14 multimodal transport chains provides an insight on how international supply chains of Dangerous Goods (DG) work with an overview of problems which the actors are faced.

The data covers border-crossing transport chains in the Baltic Sea Region, which means that all movements involve a maritime transport leg in one form or another.

The main emphasis is on operations rather than costs in finding out how effective, efficient and professional the operations are in the various phases of the operations.

The empirical case-data was collected by interviewing managerial level employees from the participating companies in late 2006.

In the interviews it came up that the general public is interested in transport of DG, because of the risks that they present to the environment and people. However, shippers and transport companies tend to think that giving information to the public might increase people's awareness about the DG issues and might also tighten the regulations in the future. Thus, firms prefer to give as little information as possible on DG transports.

Requirements in DG transports stretch far beyond what is required in non-DG shipments. This calls for system-controlled operations, up-to-date equipment and well-trained personnel. In most of the studied cases DG cargo was transported in temperature regulated and specially built cargo units. The availability of such special equipment is often limited, which may affect the transport frequency. Special equipment also raises the cost of transport.

A major identified problem was differing regulations across transport modes (such as IMDG vs. ADR vs. RID), which complicates supply chain operations.

The study gives information on dangerous goods transport in the BSR, which has been very little studied. It gives important information regarding safety, security and environmental protection.

Keywords

Dangerous goods; transportation; Baltic Sea region; supply chain.

1. Introduction

In 2003 trade in the Baltic Sea Region (BSR)[1] totalled 1 788 million tonnes; imports 744 and exports 1 044 M tonnes. The total volume of maritime transport in 2003 amounted to 731 million tonnes, of which 178 million tonnes (25 per cent) was within the Baltic Sea countries, and the rest (75 per cent) extra-BSR trade (Fig.1; Baltic Maritime Outlook 2006).

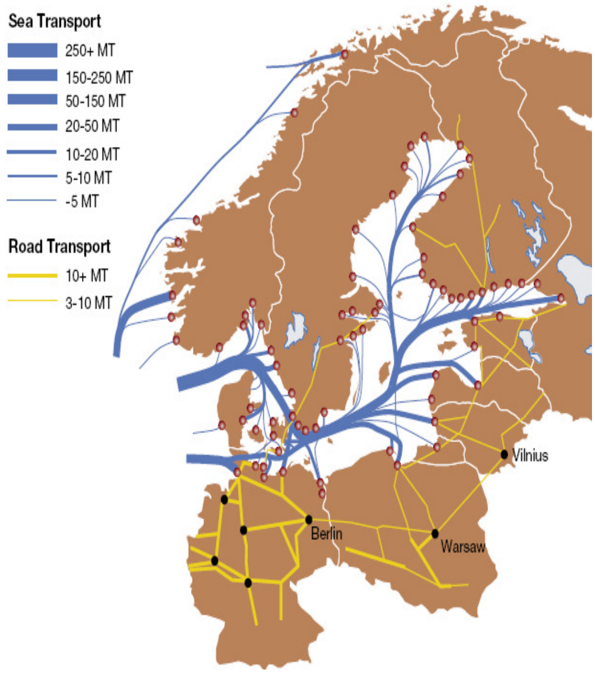

Fig.1 Illustration on key maritime and road transport routes in the Baltic Sea Region. Source: Baltic Maritime Outlook 2006; op. cit. TEN-A Ports, 2003

The European trade pattern shows significantly larger east-west trade volumes than north-south volumes, and the strongest growth in the intra regional trade is expected to take place between the north-eastern and the

[1] Denmark, Estonia, Finland, Germany, Poland, Latvia, Lithuania, Russia and Sweden.

south-western parts of the BSR. Oil and oil products will dominate the growth. Their share of total exports is expected to increase, while their share of imports is expected to decrease. (Baltic Maritime Outlook 2006)

Apart from Russia, all other littoral states to the Baltic Sea are members of the EU, after Estonia, Latvia, Lithuania and Poland joined the union in 2004 (see e.g. Naula and Ojala 2007).

More than 300 million tonnes of dangerous goods are transported in the Baltic Sea Region (BSR) annually. In spite of formal implementation, there are substantial differences in operational practices between authorities involved in DG transport. There is a vast need to improve the exchange of information between DG authorities and commercial actors, and to coordinate DG processes in the whole Baltic Sea Region.

This study was made as part of the DaGoB project (www.dagob.info). DaGoB is an abbreviation for "Safe and Reliable Transport Chain of Dangerous Goods in the Baltic Sea Region". It is part-financed by EU's European Regional Development Fund within the BSR INTERREG III B Neighbourhood Programme.

The DaGoB project aims at improving the co-operation between public and private stakeholders related to DG transport in the BSR, by connecting the stakeholders on different levels, providing up-to-date information on cargo flows, supply chain efficiency and risks related to DG transport.

1.1 Objectives of the study

The overall objective of this multiple case study is to analyse international multimodal DG supply chains in order to identify key bottlenecks in the process.

The empirical data comprises detailed information on 14 separate transport chains. The concrete object of analysis was the actual transport chain in long-term supply chains of the medium-sized or large chemical firms involved in the study.

Data was collected in personal interviews in autumn 2006 from seven medium-sized or large chemical industry firms and their logistics providers. Some firms provided data for more than one transport chain.

The initial selection of cases was made by type of goods (liquid and dry bulk, unitised and general cargo), the most important DG classes, different transport modes (road, rail, maritime) and transport units (container, semi-trailer, road vehicles, rail wagon).

The data is analysed to identify possible problems in physical cargo movements, inspections, documentation and related information exchange between authorities, between commercial operators and between other parties.

A detailed process description of each selected DG transport chain is presented in Suominen et al. (2007).

1.2 Multiple Case Study Methodology

The study is inductive, starting with observations followed by patterns (Fig. 1). Inductive reasoning will continue with tentative hypotheses leading to a theory.

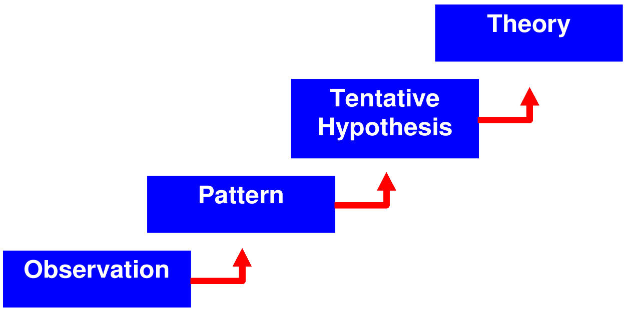

Fig. 1: Inductive reasoning (Trochim, 2006)

As is common in multiple case studies, both quantitative and qualitative data is used in a descriptive manner.

The theoretical framework of the study, its design and classification of DG is found in chapters 1 and 2. Single case descriptions are presented in chapter 3. Cross-case analysis is in chapter 4.

Multiple case study methodology shown in Fig.2 was generally followed. The work order also followed the theory – observation – methodology path discussed by Arbnor and Bjerke (1997), with the emphasis on observations.

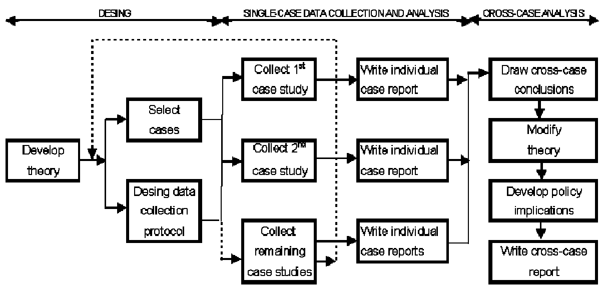

Fig. 2 Multiple case study methodology (Yin, 1994)

1.4 Analytical framework of the study

In this paper, the entire supply chain from supplier's supplier to the end user was not covered. Instead, the object of analysis was the physical distribution part of the shippers. The studied transport chain is initiated by a consignor and ends up with a consignee.

A number of transport- and terminal-related service providers are involved in the process. The nodes in between the commercial actors are called interfaces. The number of interfaces varies from case to case. These interfaces are addressed from 1 to 4, where 2 and 3 have sub-addresses from 1 to n. (Fig. 3)

The interest areas of the study are:

A Communication process,

B Authority involvement,

C Documentation process,

D Liability process, and

E Time consumption.

The nodes in between the interfaces and the interest areas are thus addressed in matrix. Questions in every addressed node shall be directed both upstream and downstream of the supply chain, in order to get measurable deviations in between actors.

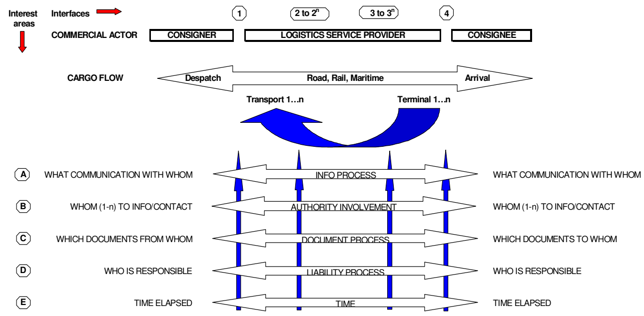

Fig. 3 Analytical frame of the study

1.5. Previous Research on the issue

An extensive literature search on multiple electronic archives[2] of research literature using all combinations of search words for "transport chain", "supply chain "dangerous goods", "authorities", "ADR", "RID", "IMDG", "IMO", "Baltic", "Finland", "Sweden", "Germany", "Estonia" provided only a handful of hits, none of which was directly applicable to the theme of this paper. (Cf. Fabiano et al. (2005))

2. Context of the study

2.1 The classification of dangerous goods

The classification of Dangerous Goods follows the standard international UN-based code. (Recommendations on the Transport of Dangerous Goods, 2005).

Class 1 - Explosives
Class 2 - Gases
Class 3 - Flammable Liquids
Class 4 - Flammable Solids
Class 5 - Oxidising Substances and Organic Peroxides
Class 6 - Toxic and Infectious Substances
Class 7 – Radioactive Material
Class 8 – Corrosive Substances
Class 9 – Misc. Dangerous Substances and Articles

2.2 The regulations involved in the transport of dangerous goods

Like in transport law in general, the carriage of dangerous goods in various modes of transport is often governed by separate legal acts, and the scope of the provisions has to be studied each time to verify their application in the context of multimodal transport (Railas 2006).

The multitude of legal regimes applicable to the transport of dangerous goods is, however, alleviated by the fact that the United Nations issues substance-specific Recommendations on the Transport of Dangerous Goods, which set the basic requirements for all modes of transport. Known as the Orange Book, this directory provides an extensive list of dangerous goods and their control in transport by air, rail, road, sea and inland waterways. It covers classification and definitions of all dangerous substances; packaging, labelling and relevant shipping documentation; and the training of transport workers.

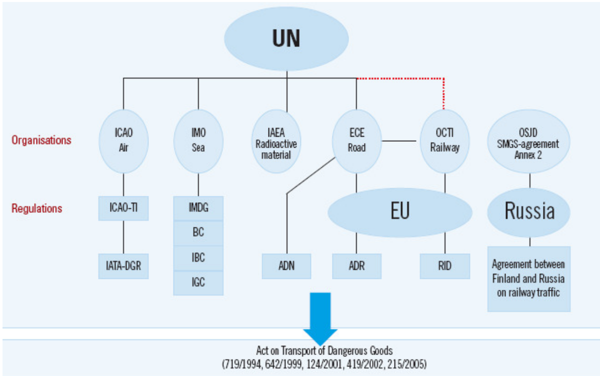

Fig. 4: International organisations and agreements for DG transport (Transport of Dangerous Goods in Finland (2006))

2.2.1. Road transport

All European Union countries except Ireland are parties to the European agreement concerning the international carriage of dangerous goods by road. The ADR Agreement applies to international carriage of dangerous goods by road, and its provisions do not usually differ much from domestic regulations. Pursuant to the Agreement, it is possible to conclude multilateral agreements on particular issues between individual parties to the agreement.

According to section 1.9 of the Agreement, the Competent Authority of an adherent state has to notify its domestic restrictions on the transportation of dangerous goods to the UNECE Secretariat in situations specified in the above section. The Secretariat then has to inform other parties to the Agreement of these restrictions.

The European Union has also regulated the carriage of dangerous goods by road through a directive that is based on the ADR Agreement. This Directive was followed by another directive regarding uniform procedures for checks on the transport of dangerous goods by road. The Directives have given the European Commission the right to make regular changes to the technical provisions, or to grant exceptions.

2.2.2. Rail transport

In the international carriage of dangerous goods by rail, the international RID provisions are applicable. As a

[2] ABI/Inform (ProQuest), Business Source Elite (EBSCO), JSTOR Business, Science Direct (Elsevier), Emerald Fulltext (Emerald), SocIndex with Fulltext, EJS: Electronic Journals Service (EBSCO), Blackwell Synergy

rule, these provisions do not differ from domestic regulations. Russia and Estonia do not apply the RID provisions. The carriage of dangerous goods by rail has also been regulated by the European Union, and the European Commission has likewise been vested the right to amend the technical provisions and grant certain exceptions.

2.2.3. Air transport

In air transport, the ICAO-TI, namely the Technical Instructions for the Safe Transport of Dangerous Goods by Air (2005-2006 Edition), (Doc 9284-AN/905) as well as the IATA-DGR, namely IATA Dangerous Goods Regulations) are applicable.

The cases studied here did not involve air transport.

2.2.4. Maritime transport

The main conventions in maritime transport involve bulk transport of oil, gas and packaged goods (IMDG). These are all governed by IMO.

The carriage of dangerous cargo in bulk is governed by Chapter VII of the SOLAS Convention and there are codes specifying requirements for the construction and equipment of ships involved in the transport of dangerous liquid and gas cargoes in bulk.

The SOLAS Convention has been amended by the INF Code relating to radioactive cargo. The entire name of the INF Code is the International Code for the Safe Carriage of Packaged Irradiated Nuclear Fuel, Plutonium and High-Level Radioactive Wastes on Board Ships.

For recent reports on chemical and oil shipments in the Baltic Sea, see Hänninen and Rytkönen 2004 and 2006.

2.2.4. Memorandum of Understanding on Transport of Packaged General Goods in the Baltic Sea

Eight countries surrounding the Baltic Sea have concluded a Memorandum of Understanding within the IMO framework regarding the transportation of packed general goods on board roll on-roll off (ro-ro) vessels in the Baltic Sea. (Fig. 5)

This is a unique arrangement, which simplifies the procedure of especially road-based transport units that use ro-ro or passenger vessels for short passages.

The ship owner can apply the rules of the Memorandum in the Baltic Sea including the Gulf of Bothnia, the Gulf of Finland and the entry to the Baltic Sea in short-sea ro-ro traffic, where the requirement established in the Memorandum regarding such matters as the training of the crew and personnel are satisfied. The Memorandum contains special provisions relating to the carriage of dangerous goods within the scope of the ADR Agreement and the RID provisions. The Memorandum allows the carriage of dangerous goods on designated routes.

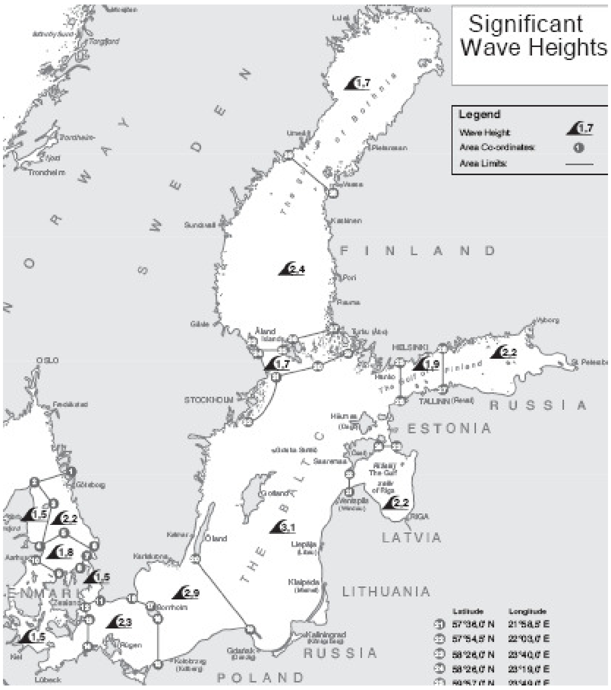

Fig. 5. The Map of Significant Wave Heights in the Baltic Sea indicating the areas, where MoU is applicable. (Finnish Maritime Administration)

The Memorandum has been subject to yearly amendments, all of which have entered into force on January of the subsequent year. The updated MoU text is available in webpages of signatory countries Maritime Administrations (See e.g. Finnish Maritime administration)

2.2.5. EU Involvement in DG regulation

Apart from the report "Evaluation of EU Policy on the Transport of Dangerous Goods since 1994" (2003; Sections 1 and 2), little research or surveys have been prepared for or by the European Commission (EC)[3]. This may reflect the situation where the EC has no competence on international conventions described above.

An integral part of the legislation of the EU countries relating to the carriage of dangerous goods is the function of the safety adviser. The relevant Directive provides that undertakings, the activities of which include the transport, or the related loading or unloading, of dangerous goods by road, rail or inland waterway, each appoint one or more safety advisers for the transport of dangerous goods, responsible for helping to prevent the risks inherent in such activities with regard to persons, property and the environment.

The EU has also regulated transportable pressure equipment by a Directive. The purpose of this Directive is to enhance safety with regard to transportable pres-

[3] Transport of DG has not received much attention in EU's Research Framework Programme, either. In FP6, one ongoing project is identified. DAGOT project deals with mostly land-based transport of Dangerous Goods in Central Europe. No website is currently available of this project, however.

sure equipment approved for inland transport by road and rail, and to ensure the free movement of such equipment within the Community, including its placing on the market, repeated putting into service and repeated use aspects.

Transportable pressure equipment envisaged in the Directive shall bear a phi-mark as proof that the equipment meets the requirements put forward by the rules applicable to the carriage of dangerous goods by road or rail. The recognition and verification issued in one Member State shall be recognised reciprocally in all EU and EEA states.

3. Single Case Descriptions

This chapter introduces the 14 transport cases. The cases are divided according to the transport modes and the transportation routes used, as well as according to the DG classes involved.

3.1 Case 1, Hydrogen by multimodal transport from Finland to Estonia

A full six-meter container load (equal to 180 bottles) of hydrogen is filled by the lorry driver at the production site, approximately 200 km inland from the Port of Hanko, Finland. Drivers are trained by the supplier to fill the containers themselves. The supplier utilises three logistics providers.

The order from Estonia has been received by the company's traffic office on the south coast of Finland. After the filling, the lorry drives to the Port of Hanko, where the load must arrive one hour prior to the ship's departure. The voyage from Hanko to Paldiski (46 nm) takes approximately four hours.

At the Port of Paldiski, there is an empty hydrogen container lorry docking with the filled lorry exiting the ship. The containers are changed in the port area. This is because the ship is staying in port for only two hours. The timetable does not permit the trailer to be driven straight to the client. Thus instead of having just one lorry on the move, the company needs separate lorries in Finland and Estonia. The empty lorry then returns to Finland by the same vessel.

Annual deliveries of hydrogen comprise some 15 containers. The supplier has not utilised a documented and signed process for monitoring the quality of the service, but the information system allows full reporting of supply chain operations. The supplier also systematically audits operators in the supply chain. In addition, meetings are organised, where efficiency, targets and development programmes are discussed. These meetings are also attended by management.

3.2 Case 2, Methane by multimodal transport from Finland to Sweden

The case company's Swedish organisation, or its Swedish client, places an order to the Finnish organisation on the south coast of Finland. The order is then passed to the supplier's traffic office. The filling takes place at the same supply site from where the orders are sent. Trailer tanks are filled by the drivers working for the logistics provider. They are trained to load and unload the cargo by the Finnish organisation of the supplier.

The lorry drives some 200 km to the Port of Naantali. There the logistics provider organises the ship's position. The distance from there to Kapellskär, Sweden, is 113 nm. After arrival at Kapellskär, the trailer continues to the client in Sweden. The driver unloads the cargo at its destination.

Table 1 Dangerous Goods transported in the selected cases

Case	Name	IMDG Class	UN no.	Packing group
1	Hydrogen	2.1	1049	-
2	Methane	2.1	1972	-
3	Argon	2.2	1951	-
	Nitrogen	2.2	1977	-
	Oxygen	2.2 (5.1)	1073	-
4	Cereclor	3 (6.1)	1993	III
5	Paratoluen sulphonic acid	8	2586	III
6	Mixed cargo	--	--	--
7	Printing ink	3	1210	II
8	Printing ink	3	1210	II
9	Paint	3	1263	II
	Paint	3	1263	III
	Tripropyleneglycol diacrylate	9	3082	III
10	Paint	3	1263	II
	Paint	3	1263	III
	Zinc oxide	9	3082	III
11	Paint	3	1263	II
	Paint	3	1263	III
	Isophoronediamine	8	2289	III
	Epoxy resin (mw < 700)	9	3082	III
12	Ammonia, anhydrous	2.3 (8)	1005	-
13	Fluorosilicic acid	8	1778	II
14	Ammonium nitrate based fertiliser	9	2071	III

Clients in Sweden are situated (with one exception) between 300 and 400 km from the Port of Kapellskär. This means that the same driver is capable of returning on the same day within working hours. This is possible when there are three ships rotating between the ports of Naantali and Kapellskär. It would be an advantage to the company, if it could transport the trailer without a driver. However, this is not possible as the Port of Naantali has cancelled the service.

3.3 Case 3, Oxygen, nitrogen and argon by road from Finland to Russia

The case company's Russian organisation informs the Finnish supply site, on the south coast, of a pick-up loading. It is the responsibility of the Russians with hauling equipment to handle the pick-up. This means that the consignee is in charge of naming the logistics provider. The Russian organisation of the case company then informs the traffic office of its Finnish counterpart. The driving planner arranges the Finnish documents, but all Russian documents are arranged by a freight forwarding company. The documents arrive at the driving centre by Post. These documents are then stamped by the lorry drivers on behalf of the company's Russian and Finnish organisations. The drivers handle the filling of the containers as well. All Russian and Finnish drivers are trained to load and unload the cargo properly.

The transportation distance from the filling centre to Vaalimaa, Finland is approximately 150 km. The lorry has the right to bypass other vehicles at the border, and then it will wait for customs in the customs area. After Finnish customs involvement, the lorry continues to the border, where the requested Russian payments take place. The lorry then drives on 61 km to Vyborg, Russia, where the Russian customs are based. The lorry has the right to wait in the customs area. After Russian customs involvement, the lorry drives either 150 km to St. Petersburg or 650 km to Moscow.

The quantity of air gases transported was approximately 10,000 tonnes in 2006. This quantity is expected to double in 2007.

3.4 Case 4, Cereclor by multimodal transport from France to Finland

Cereclor is a class 3 flammable liquid, which is not considered as an extremely dangerous substance. This substance is being exported from France to Finland by an industry chemical company, located in Helsinki. The annual amount imported is approximately 35,000 kg. Cereclor is loaded into trailers in Verdun, north-east France, and the trailers are then transported to the Port of Lübeck by road. From Lübeck, the goods are bound for the Port of Helsinki, and from there transported by road to their final destination – the case company's warehouse in the Port of Kotka, south-east Finland.

The case company utilises a single lead logistics partner (LLP), which is responsible for all Cereclor transportation throughout the supply chain. The case company's warehouse in Kotka is also outsourced to a specialised Finnish logistics service provider. The case company has not utilised a documented and signed process for monitoring the quality of the service, and the information system does not allow full reporting of different supply chain operations. However, the importing case company systematically audits the supply chain operators, utilising a database of errors and reclamations. In addition, meetings are organised, where efficiency, targets and development programmes are discussed. These meetings are also attended by company managers.

3.5 Case 5, Paratoluen sulphonic acid by multimodal transport from France to Finland

This case company is a Finnish-based chemical group operating mainly in northern Europe with a wide range of products. The transported substance in this case is a class 8 corrosive acid. The transport route begins from the consignor in northern France and ends up at the case company's facilities in central Finland. The goods are first transported from France to a port in the Netherlands in a tank container on a lorry. After that, the tank container is put on a ship from the Netherlands to a port in Finland, where it is again transported by lorry to Central Finland.

The distances en route are as follows: from the origin in France to the port in Netherlands approximately 400 km, from the port in Netherlands to the Port of Helsinki 1,300 nautical miles, and from the Port of Helsinki to central Finland approximately 200 km. The estimated quantity of dangerous goods annually transported on this route is 350 tonnes.

The major problem on the route is, without doubt, the availability of suitable heated tank containers needed to transport such a dangerous cargo. Apparently, it is not known exactly how many heated tank containers are available at any one time in the warehouse of the logistics provider, in France or Netherlands. Delays of many days may occur due to poor tank container situations. This can make it difficult for the case company to manage its stock levels.

3.6 Case 6, mixed cargo by multimodal transport from Finland to Estonia

This case company is a Finnish-based chemical group operating mainly in northern Europe with a wide range of products. The transported goods on this route comprise a variety of substances. Approximately one-third of these substances are a variety of different dangerous goods and two-thirds are not classified as dangerous goods.

The transport route begins from the case company's warehouse in central Finland. The cargo is first transported by road to the Port of Helsinki where the lorry continues by ro-ro ferry to Tallinn, Estonia. The goods eventually end up at the premises of the case company's subsidiary in Estonia.

The distances of the route are as follows: from the case company's premises to the Port of Helsinki approximately 200 km, and from the Port of Helsinki to the Port of Tallinn approximately 50 nautical miles. The final destination point is within the close proximity of Tallinn. The estimated amount of dangerous goods annually transported on this route is 1,000 tonnes, and of non-dangerous goods, 2,000 tonnes.

The major problem in the transport chain has been the late decision on whether the ro-ro ship should be labelled as a cargo or passenger vessel, as it also transports people. If it is eventually labelled as a passenger vessel, there will be delays in the transport chain and the goods might even have to spend the night at the seaport.

3.7 Case 7, printing ink by road transport from Finland to Russia

This case company is a Finnish subsidiary of an international chemical corporation, specialised in certain types of chemicals. The transported substance is a class 3 flammable liquid.

The transport route begins at the case company's premises in central Finland, where the cargo is transported to Russia by road via one of the three Finnish-Russian customs entry points. Freight-forwarder activities and some customs activity are conducted in central Finland, before the cargo is transported to Russia. The cargo ends up either at the premises of the same international group, or sometimes at a selected Russian consignee.

The distances en route are as follows: from the consignor to the border of Russia approximately 400 km, and from the border of Russia to Moscow approximately 700 km. The estimated amount of dangerous goods annually transported on this route is 700 tonnes. For crossing the border, the case company tends to use Imatra rather than Nuijamaa. Vaalimaa is rarely used due to long lorry queues.

Finnish logistics providers are usually utilised on the route. However, when the consignee doesn't belong to the same corporation, it is quite common to utilise a Russian logistics provider, hired and arranged by the Russian consignee. There may occur some problems with the Russian logistics providers. On some occasions, these providers notified their customers only at the last minute of a delay in the arrival time of their lorry of anything from a few days to a week. In these cases, the goods required unscheduled space in the warehouse of the case company.

3.8 Case 8, flammable liquid by multimodal transport from Finland to Ukraine

This case company is a Finnish subsidiary of an international chemical corporation specialised in certain types of chemicals. The transported substance is a class 3 flammable liquid.

The transport route begins at the case company's premises in central Finland, where the cargo is transported to the Port of Helsinki. The cargo and the original vehicle are transported to Tallinn, Estonia in a ro-ro ferry. The cargo is then transported in the same lorry to Kiev, Ukraine via Latvia, Lithuania and Poland.

The distances en route are as follows: from the consignor in central to the Port of Helsinki approximately 200 km, from the Port of Helsinki to the Port of Tallinn 50 nautical miles, and from Tallinn to Kiev approximately 1,200 km. The estimated amount of cargo annually transported on the route is 450 tonnes, of which the amount of dangerous goods is in the minority.

3.9 Case 9, mixed cargo by multimodal transport from Finland to Estonia

This case concerns a mixed cargo of 17 tonnes, of which 6 tonnes are dangerous goods and the rest are non-dangerous goods. It is a multimodal transport (road-sea-road) from Vantaa (FI) to Tallinn (EE). The consignor is a manufacturing company and the consignee its subsidiary. The table below shows the IMDG classes, UN numbers and packing groups of the cargo.

The sales office of the manufacturing company, i.e. the consignor, receives an order from its subsidiary through the information system. The consignor in Finland and the consignee in Estonia both use the same information system and therefore, the order (called a transfer order) can be viewed directly through the system. After the order has been confirmed by the sales office, the goods are collected, packed and labelled by the warehouse staff. All the necessary documents are issued and sent to the logistics provider, i.e. the carrier (FI). A total of 5 or 6 persons are involved in the case on behalf of the consignor.

The carrier contacts the shipping company and books the appropriate (ordinary/thermo transport) shipping space. A subsidiary of the carrier in Tallinn also receives this information through the same information system. The subsidiary then arranges the follow-on transportation from Tallinn. Three persons are involved in this process, both on behalf of the carrier and of the carrier's subsidiary. The carrier then sends a lorry to collect the goods from the manufacturing site in Vantaa. The consignor loads the trailer while the driver supervises the work. After receiving the cargo and the documents, the lorry drives approximately 30 km from Vantaa to the Port of Helsinki. The driver leaves the documents and the trailer with the shipping company for loading on board ship. The trailer is then transported from Helsinki to Tallinn. The carrier in Tallinn has arranged for a driver to wait for the trailer and the documents after maritime transportation. Because the ship arrives at night, the driver waits until the morning before transporting the goods to the consignee, about 5 km from the port.

The consignor always attempts to ship a full lorry load (FTL), i.e. 33 Euro pallets. If the load is less than full (LTL), there is a possibility of receiving an additional load from another business unit or from the carrier's terminal.

In this case, the approximate annual net volumes of dangerous goods are as follows: UN No. 1263, 3 III - 1.970 tonnes, UN No. 1263, 3 II - 270 tonnes and No. 3082, 9 III - 58 tonnes. These three classes make up about 99.9% of the total DG volume. There are DG shipments to this particular consignee several times a week.

The consignor does not apply a documented process to control the service from the loading point to the delivery, and the IT system does not allow it either. Nor does the case company apply a documented process for the evaluation and performance-monitoring of all its supply chain partners. The consignor does evaluate the partners while they are bidding, but no systematic evaluation is done during the contract period. Meetings are arranged with the partners to review objectives and performance, but top management is not involved in these meetings.

The carrier is in the same situation concerning the evaluation and monitoring of its partners. Deviations, for example complaints about drivers, are monitored. Because of the flat organisation, even top management may attend the review meetings. There exists a considerable amount of competition in the business, which is very cost-sensitive too. Therefore, the carrier co-operates closely with its customers.

The consignor did not identify any particular problems or bottlenecks in the transport chain, nor did the carrier. The cases are not very complex and the transport chain functions effectively.

3.10 Case 10, mixed cargo by multimodal transport from Finland to Latvia

This case concerns a mixed cargo of 10 tonnes, of which 6 tonnes are dangerous goods and the rest are non-dangerous goods. It is a multimodal transport (road-sea-road) from Vantaa (FI) to Riga (LV). The consignor is a manufacturing company and the consignee is its subsidiary. The table below shows the IMDG classes, UN numbers and packing groups of the cargo.

The sales office of the consignor receives an order from the consignee in Riga (LV) by e-mail. The order is confirmed by the sales office, after which the goods are collected, packed and labelled by the warehouse staff. The necessary documents are issued and then sent to the logistics provider, i.e. the carrier. A total of 5 or 6 persons are involved on behalf of the consignor.

The carrier contacts the shipping company and books the appropriate (ordinary/thermo transport) shipping space. The subsidiaries of the carrier in Tallinn and in Riga, both utilising the same information system, receive the information through the system. The Tallinn subsidiary then arranges the follow-on transportation from the Port of Tallinn to Riga. Three persons are involved in this process, on behalf of the carrier and of its subsidiary in Tallinn. After that, the carrier sends a lorry to collect the goods from the manufacturing site in Vantaa. The consignor loads the trailer while the driver supervises the work. After receiving the cargo and the documents, the lorry drives approximately 30 km from Vantaa to the Port of Helsinki. The driver leaves the documents and the trailer with the shipping company for loading on board ship.

The trailer is transported from Helsinki to Tallinn. The carrier in Tallinn has arranged for a driver to wait for the trailer and the documents after the maritime transportation. The same driver takes over the whole transportation process from Tallinn to Riga (approximately 350 km) because the carrier always attempts to move the actual DG cargo as little as possible. The Baltic customers are also very precise and do not accept any unnecessary delays.

The consignor always attempts to ship a full lorry load (FTL), i.e. 33 Euro pallets. In case of a less than full lorry load (LTL), there is a possibility of receiving an additional load from another business unit or from the carrier's terminal.

In this case, the approximate annual net volumes of the dangerous goods are as follows: UN No. 1263, 3 III - 558 tonnes, UN No. 1263, 3 II - 70 tonnes and No. 3082, 9 III - 21 tonnes. These three classes comprise about 99.8% of the total DG volume. There are DG shipments to this particular consignee several times a week.

The consignor does not apply a documented process to control the service from the loading point to the delivery; neither does the IT system allow it to do so. The case-company does not apply a documented process for evaluation and performance-monitoring of all its supply chain partners. The consignor does evaluate the partners while they are bidding, but no systematic evaluation is done during the contract period. Meetings are arranged with the partners to review objectives and performance, but top management is not involved in these meetings.

The carrier is in the same situation, concerning the evaluation and monitoring of its partners. Deviations, for example complaints about drivers, are monitored. Because of the flat organisation, even top management may attend the review meetings. There exists a considerable amount of competition in the business, which is very cost-sensitive too. Therefore, the carrier co-operates closely with its customers.

The consignor did not identify any particular problems or bottlenecks in the supply chain, neither did the carrier. The cases are not very complex and the supply chain functions effectively.

3.11 Case 11, mixed cargo by multimodal transport from Finland to Lithuania

This case refers to a mixed cargo of 10 tonnes, of which 6.3 tonnes are dangerous goods while the rest of the cargo comprises non-dangerous goods. It is a multimodal transport (road-sea-road) from Vantaa (FI) to Kaunas (LT). The consignor is a manufacturing company and the consignee its subsidiary. The table below shows the IMDG classes, UN numbers and packing groups of the cargo.

The sales office of the consignor receives an order from the consignee in Kaunas (LT) by e-mail. The order is confirmed by the sales office, after which the goods are collected, packed and labelled by the warehouse staff. The necessary documents are issued and then sent to the logistics provider, i.e. the carrier. A total of 5 or 6 persons are involved on behalf of the consignor.

The carrier contacts the shipping and books the appropriate (ordinary/thermo transport) shipping space. The subsidiaries of the carrier in Tallinn, Riga and Kaunas, all utilising the same information system, receive the information through the system. The Tallinn subsidiary then arranges the follow-on transportation from the Port of Tallinn to Kaunas. Three persons are involved in this process, on behalf of the carrier and of its subsidiary in Tallinn. After that, the carrier sends a lorry to collect the goods from the manufacturing site in Vantaa. The consignor loads the trailer while the driver supervises the work. After receiving the cargo and the documents, the lorry drives approximately 30 km from Vantaa to the Port of Helsinki. The driver leaves the documents and the trailer with the shipping company for loading on board ship.

The trailer is transported from Helsinki to Tallinn. The carrier in Tallinn has arranged for a driver to wait for the trailer and the documents after maritime transportation. The same driver takes over the whole transportation from Tallinn to Kaunas (approximately 700 km) because the carrier always attempts to move the actual DG cargo as little as possible. The Baltic customers are also very precise and do not accept any unnecessary delays.

The consignor always attempts to ship a full lorry load (FTL), i.e. 33 Euro pallets. In case of a less than full lorry load (LTL), there is a possibility of receiving an additional load from another business unit or from the carrier's terminal.

In this case, the approximate annual net volumes of the dangerous goods classes are as follows: UN No. 1263, 3 III - 298 tonnes, UN No. 1263, 3 II - 72 tonnes, UN No. 3082, 9 III - 5 tonnes, and .UN No. 2289, 8 III 0,5 tonnes. These three classes make up 100% of the total DG volume. There are DG shipments to this particular consignee once a week.

The consignor does not apply a documented process to control the service from the loading point to delivery, neither does the IT system allow it. The case company does not apply a documented process for the evaluation and performance-monitoring of all its supply chain partners. The consignor does evaluate the partners while they are bidding, but no systematic evaluation is done during the contract period. Meetings are arranged with the partners to review objectives and performance, but top management is not involved in these meetings.

The carrier is in the same situation as for the evaluation and monitoring of its partners. Deviations, for example complaints about drivers, are monitored. Because of the flat organisation, even top management may attend the review meetings. There exists a considerable amount of competition in the business, which is very cost-sensitive too. Therefore, the carrier co-operates closely with its customers.

The consignor did not identify any particular problems or bottlenecks in the supply chain, nor did the carrier. The cases are not very complex and the supply chain functions effectively.

3.12 Case 12, Anhydrous ammonia by rail and sea transport from Russia to Finland

This transport case gives a chain description of anhydrous ammonia transported by rail and sea transport modes from a chemical plant in north-west Russia to the case company's production facilities in south-west Finland. The case company is a supplier of agricultural fertiliser products, and is operating in several European countries. The table below shows the IMDG class, UN number and packing group of the cargo.

The substance is first packed onto railway wagons at a chemical plant in Russia, and transported about 750 km to a port in western Latvia. There the cargo is unloaded into a storage tank. When the required amount of the substance is ready to be shipped, the tanker arrives in port. The tanker for liquefied gas is loaded in the Latvian port, and sails about 270 nautical miles (500 km) to its port of destination in south-western Finland. There the cargo is discharged into a storage tank, where it stays until it goes to production. The total amount of anhydrous ammonia transported yearly through this transport chain is about 24,000 m^3.

3.13 Case 13, Fluorosilicic acid by rail and sea transport from Finland to Sweden

This transport case gives a chain description of fluorosilicic acid transported by rail and sea transport modes from the case company's chemical plant in eastern Finland to production facilities in south-west Sweden, which belong to the same concern as the case company. The case company is a supplier of agricultural fertiliser products. It is operating in several European countries. The table below shows the IMDG class, UN number and packing group of the cargo.

The substance is first loaded onto railway wagons at a plant in Finland, where the consignment continues to a port in south-west Finland. There the substance is loaded onto a chemical tanker, which sails to the south-western port of Sweden. The substance is used at these production facilities. The distances en route are: from the production facilities in eastern Finland to the port in south-western Finland approximately 600 km, and from the port in Finland to the port in Sweden 560 nautical miles (1040 km).

3.14 Case 14, Ammonium nitrate fertiliser by rail, sea and road transport from Finland to Estonia

This transport case gives a chain description of ammonium nitrate fertiliser transported by rail, sea and road transport modes from the case company's chemical plant in eastern Finland to a distribution storage in eastern Estonia. The ammonium nitrate-based fertiliser transported in this case contains less than 70% ammonium nitrate and less than 0.4% total combustible/organic material calculated as carbon or with less than 45% ammonium nitrate and unrestricted combustible material. This fertiliser is dangerous according to IMDG Code, but classified as harmless by ADR and RID.

The case company is a supplier of agricultural fertiliser products. It operates in several European countries. The transported substance in this case is a class 9 ammonium nitrate fertiliser transported in big bags. The table below shows the IMDG classes, UN numbers and packing groups of the cargo.

The transport route begins from the case company's production facilities in eastern Finland and ends at the consignee in Estonia. The cargo is first transported to the case company's own south-western port in Finland by rail. The cargo is then unloaded at a warehouse, where it waits for the ship to arrive. After that, it is put on a dry bulk ship sailing from Finland to a port in north Estonia, where it is transported by lorry to a distribution storage in eastern Estonia. The customer picks up the cargo from there itself.

The distances en route are: from the production facilities in eastern Finland to the port in south-western Finland approximately 600 km, from the port in Finland to the port in Estonia 280 nautical miles (550 km), and from port to the warehouse in eastern Estonia approximately 200 km. The estimation of dangerous goods annually transported on the route is 4,000 tonnes.

The problem in this transport chain is differences in regulation. The transported substance is dangerous according to the IMDG Code, but not according to ADR and RID. This presents a problem in the labelling of the big bag. Normally the labels are firmly printed on the bag, but then a problem may occur with the traffic police, who may think that the cargo is dangerous, because of the DG labels on it.

4. Key findings of single case analysis

4.1 Key findings from cases 1, 2 & 3

4.1.1 Communication process

A lack of language skills creates a problem to a certain extent, because the Russian drivers communicate only in Russian. In one of the cases (case 3), the only English-speaking person in the Russian organisation is in Moscow. If something complex, such as a change of loading point, needs to be explained, it may cause problems if the personnel at the Finnish loading site do not speak Russian.

4.1.2 Authority involvement

In case 1, transport chain design, it should be taken into consideration that municipal decision-makers have a role in granting special permits. This may have an influence on routing and the locations of supply sites.

The City of Helsinki allows 10,000 gross tonnes of hydrogen in the Helsinki area. Port authorities have a right to grant exceptional permits after hearing from the municipal environmental- and rescue committees. TUKES – the safety technology authority – is also involved in the process. The Environmental Committee of City of Helsinki would like to forbid entry of all DG goods into the Helsinki area. It was not in favour of the case, not even with the return transportation of loose 2-5 bar containers. Because of this, the port authorities denied the issuing of an exceptional permit. This begs the question: what will be the attitude of the Environmental Committee of the City of Helsinki to DG transportations when the new port of Helsinki is opened in 2008?

The denial of an exceptional permit had a great impact on the transport chain. Instead of having one trailer with one driver circulating through the Port of Helsinki, the case company had to use two trailers with two drivers – one in Finland through the Port of Hanko to the Port of Paldiski, where the other one was waiting with an empty container. The exchange of the containers was necessary because the transporting ship stayed in port for only two hours. There was no time to deliver the trailer straight to the client. The Finnish trailer then returned to Hanko on the same ship.

In case 2, passengers have more demand for sea travel during summer periods than winter periods. This affects the supply of transport capacity. One of the findings was that there were a total of three ships from Finland transporting methane during the winter, two of which two took more passengers during the summer. The remaining one was out of service for several days.

4.1.3 Document process

The ADR permission process seems to be different between Russia and Finland. According to the Finnish Ministry of Traffic and Communications, there in no need separately to apply for ADR traffic authorisation for every trip to Russia. However, it has emerged that the trailers cannot pass the border without doing so. In addition, there is a charge made for every application. This difference in processes may have an impact on the fact that today companies are use an excessive quantity of Russian trailers.

4.1.4 Liability process

The transport chain of hydrogen from Finland to Russia is well designed. Russian drivers are trained by the Finnish case company to load the air gases and stamp the documents on behalf of the Russian and Finnish organisations. The export documents are arranged by the freight forwarder and posted to the case company‘s driving planning centre.

4.1.4 Time

It might be expected that DG consignments across the border would require more time than normal consignments. However, this is not the case at the Vaalimaa border station. All DG trailers have a right to pass the queuing line and then wait in the customs area.

4.2 Key findings from case 4

The described transport chain seems to be functioning very well. There were no actual bottlenecks or problems perceived in any of the five processes described. The case company defined only the actual ordering process as slightly laborious. The smooth functionality is a result of a systematical and long-lasting development of the supply chain by all parties. The transparency of supply chain information is apparent because of the single lead logistics partner responsible for all logistics operations.

Another finding was that the goods were being transported first to the Port of Helsinki and from there to the Port of Kotka by road, instead of transporting them straight to Kotka by ship. This is done because the Port of Kotka does not use handling equipment suitable for unloading loads of less than one container. All substances imported by the case company – in full container loads – are delivered directly to the Port of Kotka by ship.

4.3 Key findings from cases 5, 6, 7 & 8

4.3.1 Communication process

In case 6, the major problem was the late decision on whether the ro-ro ship should be labelled as a cargo- or passenger vessel. If the ship is eventually labelled as a passenger ship, there may be delays in the transport chain and the goods might even have to spend the night at the seaport. A poor flow of information on the new DG maritime packing regulations has also caused major problems lately. On some occasions, the information on how to pack the dangerous goods cargo did not reach the consignor, which then caused difficulties and re-packing in the Port of Helsinki. Therefore, delays occurred throughout the process.

In case 7, if a Russian logistics provider is utilised on the route, problems may occur problems in trying to contact them. A few members of staff of the case company can communicate in Russian, but apparently it is difficult to contact the drivers, or/and the transport company itself, in order to receive the required information.

Finally in case 8, some problems may occur with Russian logistics providers. On some occasions, these providers notified their customers only at the last minute of a delay in the arrival time of their lorry of a few days up to a week. In these cases, the goods required unscheduled space in the warehouse of the case company.

4.3.2 Authority involvement

It appears from case 5, that in France, less weight is allowed on a lorry than is allowed in other Member States. In Poland, no dangerous goods may be transported by road on Sundays, which was revealed in case 8.

In case 7, the major problem seems to be the disorganised activity of the border customs, which sometimes seems indiscriminate. It is not unusual for drivers to be asked to change the tariff headings on their customs clearance. The Russian customs change the list of tariffs quite often. The creation of a standard list of tariffs could decrease some problems at the border.

4.3.3 Document process

In case 8, the transportation sometimes got stuck at the border between Poland and Ukraine due to partially missing customs codes, which were supposed to have been delivered to the border customs by the customs operating in Kiev.

4.3.4 Liability process

No perceived problems occurred.

4.3.5 Time

The major problem in case 5 was the availability of suitable heated tank containers needed for transporting dangerous goods. Apparently, it is not known exactly how many heated tank containers are available at any one time in the warehouse of the logistics provider, in France or the Netherlands. Delays of many days may occur due to poor tank container situations. This can make it difficult for the case company to manage its stock levels.

In case 8, when considering the total time the cargo is in transit, there is usually a small time benefit of a couple of hours for DG-goods in comparison to non-DG cargo. This is because the passage of dangerous goods is prioritised at the Poland – Ukraine border.

4.4 Key findings from cases 9, 10 & 11

4.4.1 Communication process

Neither the consignor nor the carrier reported any problems in the communication process. Both of them are content with the situation and consider that the supply chain functions effectively. There is a long-term partnership between the parties involved, therefore everyone knows their role in the supply chains of the cases presented.

4.4.2 Authority involvement

According to the interviewees, there is no key authority involvement in addition to the advance notice of dangerous goods provided to the Port of Helsinki. Random problems have emerged because of a missing or damaged technical portion from the registration certificate of the trailer. This has to accompany the trailer at all times, otherwise the lorry is not allowed to continue the transportation with that particular trailer. However, the cargo can be loaded onto another trailer. There sometimes appears to be difficulties with the exchangeable trailers: the documents are left in the trailer, where they may get wet or be stolen. In such cases, the driver informs the contact person in his own country and also the carrier in Finland. The Finnish Vehicle Administration (AKE) is then asked for a new registration certificate. In urgent cases during the summertime, the document has occasionally been sent by fast catamaran ferry from Finland to the driver.

4.4.3 Document process

The parties do not identify any problems with documents either. Both of them point out that everything is clear and functional on these routes in Estonia, Latvia and Lithuania. However, the consignor may face problems elsewhere. The practice between shipping companies varies: not all companies accept electronic signatures and insist on a signature in written by hand. Sometimes the consignor also has to correct automated documents manually with correction fluid, to meet the requirements.

The consignor recently sent a consignment to Hungary. In Poland, the lorry was not allowed to proceed, because the police stopped it and asked to see the DG markings and descriptions on the packing list. The consignor emphasised that all the required documents conformed to regulations, and had always been accepted in Poland before. In this case, the lorry had to stay in Poland for two days until the consignor paid the set penalty.

4.4.4 Liability process

No problems occur with liability issues. The consignor hands over the consignment to the carrier, who is then responsible for the case. The consignor is not aware of any accidents that have occurred, nor of any special incidents or near-misses. The carrier knows its liabilities and cannot pinpoint any problems.

4.4.5 Time

According to the carrier, Baltic customers are precise and therefore do not accept any unnecessary delays in transportation. All roles and responsibilities have to be clarified in the supply chain to ensure functionality. All parties normally succeed in this and no difficulties arise. In addition, it can be noted that the involvement of DG material has no effect on the transportation time in these selected cases.

4.5 Key findings from cases 12, 13 & 14

4.5.1 Communication process

There are no major problems in the communication process. Both the consignee and the consignor are content with the situation and consider that the supply chain functions effectively. In all of the cases, there is a long-term partnership between the parties involved, and therefore everyone knows their roles in the chain.

In case 14, some problems exist with the lorry drivers, because they want to extra salary, because they think they are transporting a dangerous cargo. When they see the DG labelling, they may not believe that the cargo is not dangerous according to ADR.

4.5.2 Authority involvement

According to the interviewees, there is no key authority involvement in addition to the advance notice of dangerous goods provided to the ports involved. Random problems have emerged in case 14, because of differences in dangerous goods regulations, especially between ADR and IMDG.

In case 14, some problems may occur with the Estonian Traffic police, when transporting this type of ammonium nitrate-based fertiliser. The substance is not subject to ADR, but is subject to IMDG, which means that it has to be labelled according to IMDG for the sea transport. It is normally transported in big bags, which means that the labelling is printed on the bags. Traffic police may not believe that the fertiliser is not a dangerous good according to ADR, as it has DG labels on it.

4.5.3 Document process

Neither do the parties identify any problems with documents. Everything is clear and functional on these routes between Finland, Estonia, Latvia, Sweden and Russia. However, the consignor in case 14 has some problems with labelling.

4.5.4 Liability process

No problems occur in questions of liability. In each case, the consignor hands over the consignment to the carrier, who is responsible after that. Then at the very end of the chain, the consignee is normally responsible for discharging the cargo. Liabilities are mentioned in INCOTERMS, and are followed accordingly. The case company is not aware of any accidents that have occurred, nor of any special incidents or near-misses. The carrier is also aware of its liabilities.

4.5.5 Time

According to the case company, no unnecessary delays in the transportation are accepted. The throughput time of the transportation chain might, however, vary greatly between the cases, because warehousing exists in the transport chains.

All roles and responsibilities have to be clarified in the supply chain to ensure functionality. All parties normally succeed in this and no difficulties arise. In addition, it can be noted that the involvement of DG material has no effect on the transportation time in these above-mentioned cases.

5. Cross-case analysis

This chapter reports the findings of the cross-case analysis. The empirical case data was collected from seven participating commercial actors between September and November 2006. Altogether, 14 cases were presented in this study, involving dangerous goods classes 2, 3, 8 and 9. All the cases included dangerous goods cargo either imported or exported to/from Finland.

This cross-case analysis draws together conclusions from the single cases' key findings. The analysis of each DG supply chain is divided into five different processes, which are *communication process*, *authority involvement*, *document process*, *liability process* and *time*.

5.1 Communication process

Regarding communication, the lack of a common language has caused some problems with drivers from the Eastern countries, for example Russia. This can cause deficiencies in communication between the consignor and the foreign logistics provider. For example, information on problems or proper instructions may not reach the partners effectively. In Finland, these negative effects have not been so severe, because it is relatively easy to find people who can speak and/or understand Russian. However, that may not be the case in other European countries.

It has also proved to be difficult to contact Russian drivers on the road. In the case of a delay, this is a significant problem, because Russian logistics providers do not seem promptly to inform their supply chain partners of delays. Furthermore, the revised arrival time for a Russian lorry may be as much as one week later. These types of problems could be related to differences between business cultures.

In cases where Finnish companies utilised Finnish logistics providers, there appeared to be no major problems. There usually exists a long-term relationship between the parties involved, therefore communication is fluent, and there is mutual trust between the partners.

However, the following issue has been regarded as a problem: at least when transporting from Helsinki to Estonia, the decision on whether a ro-ro ferry should be specified as a cargo- or passenger vessel, as it also carries people, is made very late. If it is specified as a passenger vessel just before departure, there can be delays in delivery, which causes problems in the effective planning of the transport chain.

Poor information flow on the new maritime regulations concerning the packing of dangerous goods has also caused problems. On some occasions, information on the proper packing of dangerous goods cargo did not reach the inland consignor, so repacking was required, which caused delays in the whole supply chain.

5.2 Authority involvement

When transporting dangerous goods, the involvement of the authority is normally more active than in the transport of other types of goods. The reason for this is the greater risk to transport system users, the public and the environment.

The carriage of dangerous goods is a heavily regulated field, and the legal provisions are subject to regular changes and amendments. There are international conventions and agreements in this field. Some of them apply to international carriage, some also to domestic carriage. The carriage of dangerous goods has been the subject of comprehensive EU legislation as well.

However, during actual transportation in the presented cases, the level of authority involvement appeared to be similar to that in the transport of normal goods. The only difference was that Customs collected the information on dangerous goods in advance, well before the ship arrived at its port of destination. In Finland, this information is collected via the PortNet system, a database used by the ports and other related authorities.

It emerged in interviews that some problems might occur with traffic police, because of differences in dangerous goods regulations for different transport modes. For example, when transporting a certain type of fertiliser, which is not subject to ADR, these kinds of problem might appear. The problem is that this fertiliser is subject to IMDG, which means that it has to be labelled accordingly for the sea transport. It is normally transported in big bags, which means that the labelling is printed on the bag. At roadside checks, traffic police might not believe that the fertiliser is not dangerous, as it has DG labelling all over it. So a problem exists in differences between regulations.

In some cases, especially when transporting high-consequence dangerous goods, the occupational health authorities might supervise the situation. The supplier must also guarantee that the containers, in which the DG cargo is transported, are inspected and accepted by the national security authorities. It should also be taken into consideration that municipal decision-makers have a role in granting special permits. This may influence the routing and locations of supply sites. However, when considering the cases presented above, no evident problems relating to authority involvement emerged in any of the cases.

5.3 Document process

The document process mainly runs smoothly in all the cases. Document practice seems to be well-established and stable, and no major difficulties arise. The companies studied send regular shipments, for example on a weekly basis, on the same routes. They usually rely on the same logistics providers who know the routes, rules and regulations. In a long-term relationship, the practices have been developed to be fluent, and the parties involved know their roles. All this contributes to the functionality, and issuing documents is considered to be a routine operation.

One of the companies interviewed said that it has to apply for an ADR traffic licence separately for each consignment to Russia. This causes extra costs for the company, but has to be done to enable the consignment to cross the border. According to the Ministry of Transport and Communications of Finland, this type of practice is not necessary. The difference between the two practices may contribute to the growing use of Russian trailers in these consignments, ordered by Finnish companies.

Otherwise the problems reported seem to be sporadic and may not relate to these particular transport chains. One shipping company did not accept an electronic signature, although others did. A Polish policeman deviated from normal practice and demanded DG descriptions on the packing list of the shipment. The lorry was held up for two days until the required penalty had been paid. Traffic occasionally got stuck at the border between Ukraine and Poland, because customs in Kiev had not sent the customs codes for the cargo. Nonetheless, no clear pattern emerges as concerning such problems.

5.4 Liability process

When considering the cases presented above, no evident liability problems emerged in any of these cases. Each of the supply chain partners appeared to be well aware of the issues involved. This conclusion is to some extent expected, considering the fact that liability issues directly affect company image. The utilisation of Incoterms in DG transport chains also seems to clarify substantially all liability issues.

In problematic situations, the party responsible for the problem is identified and the proper reclamations are made. It appears that the utilisation of logistics providers has delegated a major part of responsibilities from consignors and consignees to these logistics providers. The responsibilities of a consignor largely involve packaging, attachment of required documents and proper labelling of the DG cargo. In some cases, a consignor is also responsible for the training of the personnel involved in loading and unloading the DG cargo. Correspondingly, a consignee rarely has any responsibilities in DG supply chains, according to these selected cases.

The transparency of liability information is being optimised in cases where a single logistics partner, responsible for all the logistics in the DG supply chain, is used. Therefore, this approach is recommended.

5.5 Time

These selected cases give reason to conclude, that the overall transportation time for dangerous goods is less than the overall transportation time for non-dangerous goods, when transporting to areas outside the EU. This appears to be a result of DG prioritisation at the borders. However, the question of supply chain time is not as clear within the EU area. The following question may be asked here: what role do land border formalities and road transportation regulations play in this conclusion? In addition, maritime DG transportations from Finland to the south and west are strongly dependent upon maritime traffic schedules.

A factor that might affect the difference in transportation times between transportation of dangerous goods and non-dangerous goods is the availability of heated tank containers. Lack of such a container can sometimes cause a delay of up to one week.

Variations in throughput times cause deficiencies in customer service. A growing problem for commercial operators and authorities is how to balance the DG flow, especially with increasing volumes. These throughput time variations become essential when dealing with specialised transportation equipment. A supplier does not necessarily know when these types of specialised equipment are available. In cases with the longest throughput time, investments in the improvement of supply chain information transparency are required, otherwise lead times will grow longer.

5.6 Other findings

People are especially interested in the transport of dangerous goods, because of the risks that they present to the environment and public. At the same time, DG companies are afraid that, if accidents occur, their reputation will suffer. That is also why producers and companies involved in DG transportation tend to keep their knowledge to themselves. They think that giving information to the public might increase their awareness of these issues, and so lead to a tightening of the regulations in the future. That is also why they think that giving as little information as possible is the best solution in most of the cases.

Probably the most obvious difference between the transport of dangerous and non-dangerous goods is the need for special equipment. Tanks need to be temperature-regulated and specially built in most cases. The availability of this special equipment is often limited. This lack of proper transport units may set some limitations to the transport frequency. If suitable equipment is not available, the only solution might be to postpone the shipment.

6. Conclusion

The objective of this multiple case study was to provide an insight into how DG supply chains work, with main emphasis on the efficiency of operations.

Regulatory implications

Dangerous goods transport is a highly regulated field where different transport modes have their own regulations. Transport chains include many different transport modes, and keeping track of their differing requirements is often difficult.

One of the major problems in DG transport seems to be the differences between the regulations of different transport modes. Some goods may be classified as dangerous according to one regulation and harmless according to another. This makes the supply chain much more complex.

Each of the states around the Baltic Sea has its own Transport Act and related Decrees, based on the international legal framework. The high volume of legislation is a result of legislators´ concern regarding public safety in the transportation of dangerous goods.

Regulation that limits the amount of DG transported on a passenger ship has a significant impact on DG transport in the BSR, because such a large amount of DG is transported on passenger ferries.

In the summertime the ro-ro and ro-pax ferries carry so many passengers that the amount of DG cargo has to be decreased compared to during the winter. This limits transport chain planning. The amount of the DG on passenger-carrying vessels seems to be constantly decreasing because of such limitations.

There are also some local regulations or special permits made by municipal decision-makers, which may affect the routing of dangerous goods transport. For instance, some transport routes may be prohibited for DG transport, or at least the amount of cargo may be limited.

Here are a few suggestions for remedial actions, based on this study:

Decision-makers should be actively supplied with accurate information on dangerous goods transport.

Coordination between different authorities is needed in the field of safety.

Regulations must be adapted to the Baltic Sea Region conditions whenever possible.

Managerial implications

It emerged that the general public is especially interested in the transport of DG, because of the risks that it presents. However, the companies involved in DG transport tend to think that giving information to the public might increase their awareness of DG issues too much, resulting in a future tightening of regulations. That is why companies seem to think that giving as little information as possible is the best solution in most cases.

The companies also emphasised that, when transporting DG, requirements stretch far beyond those of a “normal”, i.e. non-DG shipment. Requirements in DG transports stretch far beyond what is required in non-DG shipments. This calls for system-controlled operations, up-to-date equipment and well-trained personnel. In most of the studied cases DG cargo was transported in temperature regulated and specially built cargo units. The availability of such special equipment is often limited, which may affect the transport frequency. Special equipment also raises the cost of transport.

However, the most important factor in DG transportation is the human factor. Attitudes must be right and training sufficient.

The studied cases were all ongoing business relationships, and no *ad hoc* or spot transactions were included. This contributed to the fact that no insurmountable problems were found in this study. Furthermore, shippers used familiar logistics providers and the trading partners are already well-known. The setting also means that if something unexpected happens, it can easily be clarified.

DG transport is a specialised business with a limited amount of actors up to the required standard of the trade in the marketplace. The same familiar logistics providers are used in many cases, which makes the transport chain more efficient.

Based on the above, we can suggest a few remedial actions for the future:

The human factor can be affected only by high-quality education and training, practice, up-to-date knowledge and the use of modern equipment.

Work to improve the safety of dangerous goods transportation must be actively continued. Emphasis should be placed on transport safety measures that prevent accidents from happening.

The public needs to be better informed about the research conducted in the field.

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