APPROACH FOR HANDLING THE INCREASED COMPLEXITY OF EUROPEAN INTERMODAL FREIGHT FLOWS

Johan WOXENIUS, Ph. D.
Per Olof ARNÄS, Lic. Eng.
Sofia OHNELL (former WALLIN), M. Sc.

Department of Transportation and Logistics
Chalmers University of Technology
SE-412 96 Göteborg, Sweden
1 INTRODUCTION

There is a clear trend that logistics service providers such as Maersk, Deutsche Post, DB Cargo, KLM and Schenker acquire, merge, start joint ventures or form alliances with other logistics service providers to form true mega-carriers. They grow both in scale and scope, the latter in terms of geographical coverage, size of consignments as well as the traffic modes employed. This is necessary in order to meet the demands for a wide logistics service portfolio when their main customers, who likewise have grown in size and geographical scope, out-source their logistics activities or require “one-stop-shopping”.

Pressured by decreasing transport prices, the mega-carriers look for economies of scale and enhanced resource utilisation. The fact that the size of vehicles and vessels increases at the same time as the size of each individual consignment decreases implies that a larger number of consignments have to be consolidated in each moving container, ship, train, lorry or aeroplane. It also necessitates further efforts to unitise the goods flow in order to transship quickly and cheaply between traffic modes.

In order to manage their increasingly complex operations, the mega-carriers implement rigid information systems and internal regulations that diminish the role of the flexible transport planner, the so-called “fixing forwarder”. This implies that all consignments that are regarded as somewhat awkward have less chance to be transported smoothly within the logistics systems. The increasing number of consignments in each unit then implies a certain risk that a large share of the units require special attention or that the awkward goods must be transported in separate transport systems.

In this article, it is shown that European intermodal transport of goods requiring consolidation gets increasingly complex and certainly more complicated1. It is also shown that goods requiring special attention cause severe and growing problems, not least due to the induced complexity. The main purpose of the article is, however, to outline approaches for dealing with these problems.

The article focuses logistics markets requiring consolidation of parcels, general cargo and part loads, thus excluding mail and full loads. Although taking a perspective of European production systems involving more than one traffic mode, most of the presented facts and ideas can be generalised to single-mode transport as well as to other parts of the world.

In the next section, theories on goods requiring special attention, logistics complexity and the equalizing role of terminals developed at the department, are presented. With facts and logical deduction, the section following after the theoretical framework, enters deeply in the changing logistics environment briefly presented above and what affects it has on the European transport system. Then a number of approaches for handling the problems are presented followed by an illustrating case. Finally, some general conclusions from the study are drawn.

---

1 A complex system is here understood as one that cannot be intuitively understood, contrary to a complicated system that has a lot of interrelated components but is still possible to understand and describe.
2 THEORETICAL FRAMEWORK
The three theories presented in this section are all developed at Department of Transportation and Logistics at Chalmers University of Technology.

2.1 Goods Requiring Special Attention
Goods Requiring Special Attention (GRSA) and Goods Requiring Normal Attention (GRNA) are relative groupings of goods based on risk analysis theory. The grouping is situation-specific and depends on the three factors goods type, systems design and system response. Depending on these factors, the disturbance potential in a given situation can be represented using a traditional FN-diagram found throughout risk analysis literature (see, e.g., Kaplan and Garrick, 1981, Stallen et al., 1996, Fischhoff et al., 1984). FN stands for Frequency and Number of fatalities, originally used when assessing societal risk of, for instance, a nuclear power plant. The disturbance potential is a multi-dimensional measuring tool for describing likelihood as well as consequences of all disturbances possible in a given situation. Disturbance means here "(…) an unplanned event causing negative consequences " (Arnäs, 1999, p.iii).

Figure 1. The FN-diagram shows normal goods (GRNA) and three assumptions of GRSA. Note that the “GRSA perceived high”-curve results in more attention than is actually needed (Arnäs and Sjöst-edt, 1999).

The figure above is an FN diagram showing that the definition of GRSA is not an absolute. In the FN-diagram, the consequence of an event is plotted against the cumulative probability to form a curve. The curve represents the disturbance potential in the system in a given situation (what can go wrong and what would the consequences be). The diagram is always divided into a tolerable and an intolerable region. If the curve crosses into the intolerable area, the disturbance potential is too high and must be reduced. This reduction of either probability or consequence requires special attention. Different actors can perceive different curves in the same situation. Therefore, depending on what the system perceives as difficult, the goods are classified differently. This implies that some systems (or actors within systems) accepts goods that other systems or actors will not, simply because they perceive a lower disturbance potential. It also implies that the classification can change from time to time in a physically identical system and from link to link in a transport chain.
Since the same consignment can be perceived differently by all the actors in the system, a generalisation must be made with extreme caution. The attention requirements can be classified into three classes as shown in the figure below.

**Figure 2. Classes of attention requirements (Arnäs, 1999).**

![Diagram of classes of attention requirements](image)

Factual attention requirements are measurable and can indicate whether goods are GRSA or GRNA, as long as the intolerable level is known. The unknown modifier is the perceived requirements that can push the curve either way, depending on the individual operator’s assessment of the situation. It is quite safe to assume, however, that when goods due to measurable properties (physical dimensions etc.) deviate from the system norm in such a way that they become impossible to handle using the standard resources they can be regarded as GRSA. Typical examples of GRSA are goods with any of the characteristics (1) Hazardous, (2) Climate sensitive, (3) Fragile, (4) Over-sized or (5) Theft attractive. Goods can also be regarded as GRSA only if transported together with another kind of goods, for example toxics in combination with foodstuff.

2.2 **Logistics Complexity**

Lumsden (1998) describes a logistics network, Figure 3, as a set of links and nodes used for moving goods from a set of producers to a set of consumers. The producer side of the network can be any kind of physical location where the products are produced or stored. On the consumer side of the network, is again a physical location where the products are used or stored. Thus, a consumer can also be a producer, depending on the relation studied, and vice versa. The physical movement of the goods, i.e. the links that connect the producers with the consumers, can be carried out in a number of different ways, both regarding the traffic mode and the links and nodes used.

**Figure 3. The logistics network (Lumsden, 1998).**

![Diagram of logistics network](image)
As can be understood from Figure 3, a logistics network becomes increasingly complex very quickly as the number of producers and consumers increases. This is especially true for intermodal transport mixing different traffic modes and further complexity is added if consignments are consolidated in nodes for achieving efficiency in the links. Lumsden et al. (1998) identify two strategies to deal with this complexity in logistics systems, see Figure 4. Depending on the strategies, different consequences arise and different systems are obtained by use of different tools.

Figure 4. A model for logistics complexity (Lumsden et al., 1998, amended with segregation instead of disintegration)

Lumsden et al. (1998) state a couple of assumptions lying behind their model. Number one is that all considered logistics systems are believed to be complex in one way or another. It is also presumed that there is a trade-off between complexity and information, i.e. if we are fed with information we can understand the system and it is no longer complex. The authors further assume that relations exist between, for instance, over capacity and over transport, between simplicity and complexity, and that trade-offs exist between different parts of the model.

One manner of handling the logistics complexity is segregation\(^2\), which leads to simplicity. Simplicity in a system can be achieved in two ways, by introducing either over capacity or over transport. Depending on which system that is chosen, different tools are used. Over capacity can be attained by having a larger number of vehicles, slots or standardised units, than is necessary for fulfilling the transport tasks. Over transport on the other hand, is based on hub- and spoke-systems, in which the vehicles travel longer distances than necessary.

The other way to manage logistics complexity is integration. This strategy does not avoid the complexity, but rather finds means of controlling the complexity. The control is based on information in the system, either vertical or horizontal information. If the information flow in a transport system is perceived as a tube, then vertical information can be compared to taking a snapshot or a cross-section of that tube at a certain instant. The information that is obtained then, is real-time information, such as where the vehicles are at that exact instant. Still regarding information in the system as a tube, horizontal information is then the information that is memorised in each vehicle or package and accompanies the same throughout the system. Horizontal information is static and does not change as the

\(^2\) Lumsden et al. prefer to denote it disintegration.
vehicle or package is transported in the system, as opposed to vertical information, which does change as the units move.

2.3 Terminals and their role as equalizers
Hultén (1997, pp 65-66) states that “(...) the terminal must not only provide connectivity in terms of appropriate handling equipment but also bridge the gap between the means of transport in terms of frequency, capacity and time (...)”. One extreme is here that of a seaport where lorries carrying one to three TEUs are coordinated with ships carrying up to 7000 TEUs. On the other side of the scale is cross-docking in a hub-and-spoke system where lorries or airplanes of similar sizes are coordinated without intermediate goods storage.

Figure 5 The function of the terminal is to bridge the gap between two processes (redrawn from Hultén, 1997, p. 66).

When GRSA is identified, bridging the gap gets more difficult, or at least more risky since the disturbance potential increases. If, for instance, the capacity in Process 2 is not sufficient (i.e. lesser than required by the goods) the gap gets difficult to bridge unless the capacity changes or another process is utilised.

This model ties the two concepts of GRSA (Section 2.1) and Logistics Complexity (Section 2.2) together in the sense that the complexity of the supply chain determines the parameters \( f, C \) and \( t \), i.e. the “size” of the gap) for all nodes and links, and the concept of disturbance potential indicates whether the goods will transfer across the gap without difficulty.

3 A CHANGING LOGISTICS ENVIRONMENT
The aim of this section is to show that both the complexity and the share of GRSA increase in the European transport system and, in turn, that this induces problems to the logistics service providers (LSPs). First some general logistics trends are identified and analysed. Then the effects of these trends are analysed in a little more narrow transportation sense in the perspective of GRSA and complexity. The focus is on European logistics markets requiring consolidation of parcels, general cargo and part loads. Transportation of mail and full loads is thus not treated here.

The trends and their effects are verified by data, illustrating examples and logical deduction. However, it is not intended to fully prove that the whole European logistics industry is changing in a certain direction, that would anyway be just a limited snap-shot combined with speculations concerning a rapidly changing and multi-faceted industry. It is also

---

3 TEU = Twenty foot Equivalent Unit.
tempting to analyse interactions between the different trends and their effects for the transport industry. Here this is done by caution since such interrelations are very complex and that it is a delicate task to determine the action-response pattern between the supply and demand sides.

3.1 General trends in logistics and supply chain management

Over the years, shippers have been much more particular about their demand and the development seems to be towards even more advanced logistics services. The almost naïve exchange of stock levels for expensive Just-In-Time services in the 1980ies and early 1990ies has certainly halted in line with lower interest levels and cost consciousness, but phenomena such as out-sourcing of logistics activities, delivery time windows, increased frequencies, globalisation, demand for tracking-and-tracing and ICT-support indicates that the transport companies have to offer much more than just place utility.

A part of the project TRILOG-Europe financed by the European Commission, regarded trends in supply chain management. Using a mixture of research methods, of which the Delphi survey, case research, analysis of statistics, workshops and desk research are the most important, the project partners arrived at the list of trends shown in Table 1.

<table>
<thead>
<tr>
<th>Level of logistical decision making</th>
<th>Trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Restructuring of logistics systems</td>
<td>Spatial concentration of production and inventory</td>
</tr>
<tr>
<td></td>
<td>Development of break-bulk / transhipment systems</td>
</tr>
<tr>
<td></td>
<td>Creation of hub-satellite networks</td>
</tr>
<tr>
<td>Realignment of supply chains</td>
<td>Concentration of international trade on hub ports</td>
</tr>
<tr>
<td></td>
<td>Rationalisation of the supply base</td>
</tr>
<tr>
<td></td>
<td>Vertical disintegration of production</td>
</tr>
<tr>
<td></td>
<td>Wider geographical sourcing of supplies</td>
</tr>
<tr>
<td></td>
<td>Wider distribution of finished products</td>
</tr>
<tr>
<td></td>
<td>Postponement / local customisation</td>
</tr>
<tr>
<td></td>
<td>Increased direct delivery</td>
</tr>
<tr>
<td>Rescheduling of product flows</td>
<td>Time-compression principles applied in retail and manufacturing</td>
</tr>
<tr>
<td></td>
<td>Increase in retailers' control over supply chain</td>
</tr>
<tr>
<td></td>
<td>Growth of 'nominated day' deliveries and timed delivery systems</td>
</tr>
<tr>
<td>Management of distribution</td>
<td>Changes in freight modal split</td>
</tr>
<tr>
<td></td>
<td>Reduction in international transport costs</td>
</tr>
<tr>
<td></td>
<td>Impact of legislation and regulation</td>
</tr>
<tr>
<td></td>
<td>Increased use of information and communications technology</td>
</tr>
<tr>
<td></td>
<td>Developments in vehicle and handling technology</td>
</tr>
<tr>
<td>Changes in product design</td>
<td>Complexity, Packaging, Modularity</td>
</tr>
<tr>
<td></td>
<td>De-materialisation</td>
</tr>
</tbody>
</table>

In this section a number of the identified trends will be selected and presented, however under new headers, using own data and examples.

3.1.1 Demand for more advanced logistics services

The change in demand towards more advanced services is here motivated by three examples. The first one regards merge in transit. Behind this term lies a trend that LSPs take over the function of coordinating and preparing shipments for delivery to end customers from distribution warehouses and retail shops. A typical example is when Danzas-ASG

---

4 The part of the project studying global trends in Supply Chain Management was lead by Heriot-Watt University (GB) with the partners TNO Inro (NL), Chalmers University of Technology (SE), NEI (NL), Cranfield University (GB), Baker Rose (GB) and Latts-ENPC (FR).
coordinates deliveries from the PC manufacturer Dell’s plant in Ireland as well as from several suppliers in other parts of Europe and delivers full computer systems to Swedish consumers. The alternatives for Dell would have been to establish an own coordination warehouse in Sweden or link all the components such as monitors and loudspeakers via Ireland. The alternative of delivering the different items separately is not accepted by the consumer and also requires several stops for the distribution lorry. Merging in transit adds significantly to the complexity of the transport system and it has certainly been regarded as GRSA by Danzas-ASG who treats Dell shipments separately in the consolidation terminals, but not on the lorries.

The second example is that some shippers want to maintain a possibility of redirecting consignments in transit. Traditionally shippers have bought rather simple transport services connecting their distribution networks with hierarchical warehouses. There is, however, a large savings potential in instead letting the LSP redirect consignments in transit.

For instance, shippers in Portugal serving customers in the Benelux region can send a consignment to a customer or a warehouse according to long-time delivery plans. Once and a while, however, there will be an urgent demand from another customer. The shipper then has the option to send an emergency shipment by a fast but expensive express service, but also to redirect shipments in transit to a customer with less urgent needs.

The third example is a phenomenon commonly denoted postponement. Here, the LSP assists in making the final adjustment to customer orders. The idea behind is to postpone the point where products are made customer specific and thus keep storage levels at a lower level. Hence, LSPs add to the form utility and not only to place utility.

3.1.2 More but smaller consignments

Another identified trend is that the magnitude of freight flows increases while the average size of each consignment decreases, meaning that the number of individual consignments increases significantly. The first part of the statement is easy to show with trade and transport statistics and it is so obvious that it is not further motivated.

It is harder to show that the average consignment size decreases. Interviews with operators and numerous articles in business magazines support the statement, but these are rarely supported by statistics and often refer only to parts of the market. It could, of course, be that each transport company sees a decrease but this might also stem from over-leak between segments. The scope of this article excluding mail and full loads here comes in handy since it is the number of letters and volume of crude oil that really influence this statistical measure if the whole industry was to be accounted for.

The discussion is often confused by the fact that the size of consignments varies between the actors in a transport chain. In intermodal transport, for instance, the forwarder might stuff a semi-trailer with hundreds of consignments while the semi-trailer as such is the consignment for the intermodal operator. For the railway operator performing the haul between terminals, the wagon set constitutes the consignment. Sub-consignments, consignments and super-consignments can thus be defined in consolidation networks for describing the Russian Doll effect (Woxenius, 1997).

One reason behind the decreased consignment size is believed to be that more goods are sent directly from the producer to the retailer or the consumer, without passing through any
kind of central warehouse. For instance, it used to be that a car spare part was sent from the producer to the car brand’s warehouse, and then from the warehouse to the car repair shop. Today, however, the spare part is commonly sent straight from the producer to the repair shop.

The conclusions arrived at in this article neither depend upon the magnitude of the two parts of the stated trend nor if they are really true, so it has not been motivated with a deeper empirical study. Nevertheless, those who have studied it in detail, e.g., the partners of the mentioned TRILOG-Europe project, have come to the same conclusion (Demkes, 1999 p. 132):

“A shift from material density towards information density ... has led and will continue to lead to major shifts in distribution patterns: the number of shipments will increase and at the same time their size decreases.”

3.2 Effects for European intermodal transport and GRSA

The LSPs are prevented from fulfilling the new demand by just adding transport resources to the system by the economic and environmental restrictions set by customers and society. Hence, they must constantly find and implement new structural and operational patterns, of which most of them have in common that they add to the complexity of the systems and that they narrow the spectrum of consignments they can handle. Here, some of these patterns are presented and analysed in the perspective of complexity and GRSA.

3.2.1 Larger logistics service providers

One new structural pattern that is fairly easy to show is that the LSPs grow in size and scope. It should be noted, though, that this trend applies to the relatively small number of already quite large transport companies. The majority of transport companies are still small road hauliers, but these driver-operators are either active in the full-truck-load (FTL) segment or as tightly connected suppliers to the large forwarders in an FTL manner.

Beside the national railways, the largest transport companies have served the markets for the smallest and the largest consignments. Mail delivery demands networks with substantial geographical coverage implying extensive economies of scale. The mail segment has also been a concentrated market due to national monopolies. Transport of the largest consignments – crude oil – requires significant supply of capital for investments in transport vessels and pipelines, which also deters small entrants.

Nevertheless, mail and full loads are outside the scope of this article. But it is very clearly so that transport markets requiring consolidation of parcels, general cargo and part loads are served by ever-larger enterprises. The key to this development is that the shippers demand that the forwarders follow them in their geographical expansion but also a strive to utilise the economies of scale that occur in consolidation networks.

In Europe, this development is expressed in a fight for being one of, say, ten mega-carriers operating extensive networks selling their services directly to major shippers. Those who

5 Earlier research (Woxenius, 1995) has shown that the small hauliers face sincere problems to survive in the changing logistics environment if they want to maintain independence from the forwarders. They are then limited to serve local or niche markets.
cannot make it to the top are believed to be stuck in the unpleasant position as supplier of different movement and transhipment services to the mega-carriers or remain small serving niche markets. This has caused a situation where companies are bought, earlier competitors merge or form joint ventures or alliances while others try to grow organically – all in a giant carousel-fashion.

It is not only the traditional forwarders that fight for being a mega-carrier. Also mode specific transport companies widen their geographical coverage and service portfolios. No one seems to offer transportation anymore, all offer logistics solutions, acknowledging that it is the more advanced services and the value added that are to account for the profits. The simultaneous vertical and horizontal integration is also a fruit of anti-trust legislation – many of the transport companies are now so dominant within their respective mode that expansion must be made outside the core business. It is also difficult and expensive to capture the last market shares in the own market and rarely appreciated by the customers.

On such example is Maersk that has incorporated the shipping lines Sea-Land, Safmarine and Norfolk Line. Substantial growth in the core business container shipping is no more an option and the company already owns the industries supplying equipment such as ships and containers. Maersk-Sealnd now goes ashore developing a multitude of logistics services marketed to shippers.

The rail mode has traditionally been dominated by very large companies but after a long period of very significant lay-offs, the European freight railways now merge in order to form larger units. The most obvious one is Railion with Dutch NS, German DB Cargo and Danish DSB Cargo as partners. DB Cargo is clearly dominating with 92% of the shares and the head office is neither situated in Utrecht nor in Copenhagen (DSB, 2000). DB Cargo has also formed joint ventures with non-rail based transport companies for developing logistics services, e.g. Railog with the forwarder Schenker (DB Cargo, 2000-11-28). This situation is also present in the USA where a decade of mergers has resulted in only four remaining Class 1 railroads.

There is also a trend that the markets earlier defined by the size of consignment is losing significance. One clear example is that the express delivery companies such as TNT, UPS and FedEx leave their well defined market of transporting parcels not needing mechanical handling equipment, normally below 35 kg. Under the category integrator they now compete more head-to-head with the airlines for a little larger consignments, but also with forwarders and third party logistics providers. For instance, TNT’s offer now ranges from warehousing, transportation and distribution to total supply chain solutions.

Also the post offices expand. Especially Deutsche Post in Germany has realized a first-class shopping spree for companies including DHL (51%), Van Gend & Loos (The Netherlands) and the forwarders Danzas (Switzerland), which in turn has bought ASG (Sweden) and Nedlloyd Logistikbereich (The Netherlands) (Deutsche Post, 2001).

Also the former niche operators grow in size. A recent example is that the chemical manufacturer BASF has teamed up with three transport companies Bertschi AG, Hoyer GmbH  

---

6 Indian Railways (IR), for instance, is the largest employer in the world with a staff exceeding 1,5 million in 1997, however also for producing passenger transportation (Indian Railways, 2001).
and VTG-Lehnkering forming the rail operating company rail4chem (World Cargo News, 2001/b and rail4chem, 2001).

3.2.2 Larger vehicles and vessels
It is not only the LSPs that grow larger, also the vehicles and vessels they employ are getting larger. This primarily concerns the biggest units, but there are strong tendencies that also the average size for each mode increases. However, due to the modal split towards road transport, the average size of all vehicles and vessels are rather decreasing.

Vehicle sizes are obviously mode-dependent. For road that is strictly limited by the parameters set by the infrastructure, the expansion mostly refers to the length of articulated lorries and semi-trailer combinations. After a period of harmonisation within the EU implying increases in most countries, the vehicle length are now believed to stay at 18,75 m for several years, although 25,25 m is allowed in Sweden and Finland. Height and width will probably be slightly adjusted upwards. Increases not resulting in more pallet places are less important.

On rail there is a trend towards longer and heavier trains for transportation of commodities in order to better utilise economies of scale. Here signalling systems, weight capacity of the tracks and length of meeting tracks limit the sizes. The fact that intermodal transport with inferior load factor increases its importance at the expense of conventional wagon load transport, however, points in a direction of less payload of trains.

Container vessels have grown significantly in recent years after leaving the panamax era. Post-panamax ships now count in up to 7,000 TEUs. Maersk-Sealand leads the development with 21 post-panamax vessels between 6000 and 6600 TEUs, although rumour says they can take 1500 more empties. The future promises even larger vessels, but ports’ fairways and handling equipment must be enlarged accordingly. Hence, twin-lift of containers is rather common and the design for a 4 TEU spreader has been shown (World Cargo News, 2001/a).

Also aeroplane sizes increase. Most significant on the freight side is that FedEx has ordered ten of Airbus’ A-388-800F (freight version), however not for delivery until 2008 (FedEx, 2001). Also DHL has renewed their fleet with big Boeing 757s.

3.2.3 More consolidation
All the above trends clearly point in a direction of more consolidation. Instead of following one vehicle between consignor and consignee, each consignment passes several nodes in consolidation networks. Much effort should then be spend on making the consignments conform to the standard parameters set by the forwarders in order to avoid resource consuming treatment of GRSA. However, the physical parameters of some consignments inevitably classify them as GRSA. Then GRSA has to be mixed with GRNA in order to operate the consolidation networks efficiently yet fulfilling the customers’ requirements for high transport quality. The outcome of that is spelled complexity.

Nevertheless, consolidation in unit loads such as containers, swap bodies and semi-trailers does not automatically add to complexity. If all goods in a container are GRNA, it actually does not matter to the intermodal operator if there are two or a thousand consignments in a unit load. Hierarchical consolidation has then made these to sub-consignments, while the
unit load is the new consignment that, in turn, is consolidated into ships or wagon sets as super-consignments.

Also when GRSA is concerned this consolidation can act in either way. A long consignment might be experienced as GRSA by the forwarder since he must plan the stuffing in detail or perhaps even use a 40-foot container instead of regular 20-footers. Once the container is stuffed it is not regarded as GRSA by the intermodal operator since the system is designed for both units. If, instead, the GRSA is hazardous cargo, one small consignment in one container might give the full container status as GRSA and then accordingly a full train or ship.

3.2.4 More intermodality
Global sourcing and more trade over longer distances in combination with LSPs that grow in size and scope means that the transport chains are increasingly designed as combinations of traffic modes, i.e. intermodality. This results in a decreasing rate of flow generalisation implying specific problems for intermodal transport operators since the mix of traffic modes with the consecutive interfaces between actors, activities and resources adds further to the complexity. The mix of traffic modes with different operational characteristics also implies that more goods will be regarded as GRSA somewhere in the transport chains.

Moreover, what is regarded as a full load in one traffic mode in an intermodal transport chain can be only a fraction of the capacity of another mode. As shown in section 2.3, the terminals must then bridge these capacity gaps, referring to the example of a port.

3.2.5 More rigid systems
In order to cope with the increased complexity, it is a postulate that the mega-carriers employ very strict systems in order to control their flows. This applies to the parameters of the consignments as well as the administrative systems. In the process, “the fixing forwarder” is sacrificed and flexibility and tolerance in goods parameters must yield for standardisation. The result of these rigid systems are that transport of GRSA is much more resource consuming, if possible at all.

A problem when defining the disturbance potential is that consignments can change status from GRNA to GRSA and vice versa in transit and that the definition is dependant on the control system itself. If the consignment in the example of demand for redirecting consignments in transit described in section 3.1.1 is shipped according to the original plan, it will be experienced and treated as GRNA, but if it is redirected it becomes GRSA for a while, but once redirected it is treated as GRNA again. If the control system is not designed for tracking consignments in transit this demand could either be impossible to fulfil or the consignment will be treated as GRSA all the way, although no redirection occurs.

4 APPROACHES FOR HANDLING COMPLEXITY IN INTERMODAL FREIGHT SYSTEMS
One outcome of the changing logistics environment identified in the former section is that a larger percentage of the goods will be considered as GRSA and that without countermeasures this implies that a larger share of the transport units will need special attention. This increases complexity in the sense that all goods and units cannot be treated equally and
there is less chance for the employees of the forwarders to understand the full transport system.

When too large a difference between two processes (i.e. links) occur, there are a number of strategies that can be used to “bridge the gap” as described by Hultén (1997). In this section a set of such strategies for handling the complexity induced by GRSA is presented.

4.1 Approaches for handling complexity caused by GRSA
The options for dealing with GRSA in intermodal transport of consolidated cargo can be summed up in six different approaches. In the figure below, the first case illustrates the different elements that are used to describe the approaches. Two goods types, GRNA (cylinder) and GRSA (cube), are to pass through three links (in this case three traffic modes). The GRSA cube represents a consignment that is regarded as GRSA in link 2, but not in link 1 and 3. In the model, there are two gaps to be bridged, Link 1 - Link 2 and Link 2 - Link 3. There are six distinctly different approaches for handling the situation in bridging the gap between the links 1 and 2 (or more accurately, solving the problem). In reality, some of the approaches can be combined, but in many cases they are implemented separately.

**Figure 6 Approaches for handling GRSA in intermodal transport systems.**

There are six principally different approaches to handle GRSA as shown in the figure. The white cylinder represents normal goods and the cube represents GRSA.

1: **Deny transport.** Do not permit goods regarded as GRSA to enter system.

2: **Apply brute force.** The forwarder or consignor does not take into account future problems in the supply chain (SEP – Somebody Else’s Problem).

3: **Postpone goods.** This approach is sometimes necessary when physical, capacity or regulatory restrictions limit the transport of GRSA to certain departures.

4: **Divert goods.** Accept the goods and change to different system when problem arises.

5: **Use alternate link.** Substitute the link where the problem is identified.

6: **Transform goods.** Change the properties of the goods so that it will not be regarded as GRSA by the system.

4.1.1 **Deny transport**
The first approach for dealing with GRSA simply means that the forwarder does not allow such goods to be transported in the channel. This could be done directly by applying strict rules for acceptable consignment parameters or indirectly by pricing transport of GRSA in order to deter orders.

This approach represents a very uncomplicated way of dealing with GRSA, but could entail a loss of customers if carried out in its entirety. Therefore, it is believed that this approach is not applied very often, since it seems unlikely that a mega-carrier would deny a
customer, especially any of the larger customers, an occasional GRSA-consignment. A customer, who has been denied a transport, would have to turn to a niche operator in order to have his GRSA transported.

There is a certain risk that this approach results in a lower resource utilisation or customer service since separate transport systems have to be established, thus loosing economies of scale.

**Example:** An ordinary mailbox at the post office is designed for denying consignments that are considered too large for the regular mail handling system. If a customer needs to send an over-sized item (i.e. regarded as GRSA somewhere in the chain), he needs to visit a post office for manual service. The customer also pays an extra fee due to the extra attention the goods requires or, depending on the design of the mail system, for sending it in a totally separated channel. As an alternative the customer can contact an express delivery service. The same occurs when the consignment is either theft sensitive or extra urgent, yet complying with the regular mail size, and thus forwarded as registered post and express mail respectively. In all these cases the consignments are denied as regular mail.

### 4.1.2 Apply brute force

Also in this case the decision of sending the GRSA, although it does not fit the transport channel completely, is made by either the consignor or the forwarder. In other words, it is one of these two parties that turn over the difficulties in fitting the goods in the link to someone else, i.e. make it Someone Else’s Problem, SEP. In intermodal road-rail transport, for instance, it is very common that the consignor reports a lower container weight than the actual hoping that it will not be noticed. This is usually only a problem for the road legs since less weight is accepted than on rail.

Just like approach one, this one is not very sophisticated, but relies heavily on the creativity, initiative and good will of the individuals involved in operating the bottleneck link. This approach will be less likely to work out in the future, since the “fixing forwarder” disappears due to the standardisation of the channels.

The problem is aggravated by the fact that many international transport chains involve nodes with different availability and relative factor prices for machinery and labour. A problem seen as minor in one country with low man-hour costs can thus lie in the intolerable region of the FN-diagram in another country.
Example: A third party operator in Hamburg, Germany, runs a large warehouse/distribution centre. One of their customers is a large furniture retailer. The operator handles goods originating from India, and acts as a distribution hub for the European market. Shown in the picture below is a pallet (one of about 40 in total) containing 24 fibreboard boxes. The pallets are not loaded very well, hence the tilt. Due to the tilt, this pallet cannot be loaded in their normal warehouse (using shelves), therefore a special area of the facility is used.

The consignor did not know (or care) about this problem (SEP). According to the manager, handling goods in this manner costs about 30% more than using the standardised shelving system (from a study visit in November, 2000).

Figure 7 This pallet was poorly loaded by the consignor in India. It was therefore put in a special area in the forwarder’s terminal since it would not fit into the shelves. The consignor did not know or care about the forwarder’s problem (picture from a study visit in Hamburg).

4.1.3 Postpone goods

Postpone goods, like the name says, means delaying the transport of the goods. This can be while waiting until there is enough compatible GRSA to fill one transport unit, waiting for available capacity or for certain departures dedicated for, say, hazardous cargo. In the model by Hultén (1997), this approach can be described as overcoming large differences in both time and capacity by letting the bridge “do all the work”.

Neither is this approach very refined, but it does require some kind of scheme for dealing with GRSA, unlike the previous two. When the goods finally is transported through the channel, it can be done in one of two ways, either the entire transport channel transforms into one appropriate for GRSA, or only the most problematic link is changed. Thus, at certain times, the characteristics of the channel change to accommodate the goods. This is common in ferry shipping, in which certain types of hazardous cargo cannot be transported together with passengers. During night time with fewer passengers, certain departures are allocated to hazardous cargo. Hence, the link is physically the same, but taking the measure of postponing the hazardous consignment the mix with passengers can be avoided.

This approach is probably, among the ones requiring planning on some level, the easiest one to coordinate since separate channels, with no interactions, are used.

Example: In container shipping, there is normally a limited number of container positions equipped with electrical power supply for reefer engines. Once these are filled, remaining reefer containers have to wait for the next departure offering spare reefer slots. Vice versa is not a problem since dry freight containers can use the refer slots without restrictions.
4.1.4 **Divert goods**  
If the bottleneck link is unable to accept the goods classified as GRSA, another route through the network can be chosen. When the nonconforming link is passed, the goods continue in separate channels. Again, this approach requires more planning from the forwarder than the previous one.

**Example:** In summer 2000, Sweden and Denmark finally fulfilled a dream from centuries past and opened the land connection between the two countries across the strait Öresund. The link between Malmö and Copenhagen consists of a bridge followed by a tunnel. According to safety regulations, the road transport of dangerous goods across the link is prohibited between 06:00 and 23:00. A Swedish forwarder that normally uses the link to drive through Denmark to the continent must reconsider, should his vehicle be loaded with dangerous goods. A shipping line operates from the port of Malmö with connection to Travemünde in Germany. This would be a probable alternative for the forwarder carrying dangerous goods.

4.1.5 **Use alternate link**  
This is very similar to diverting the goods, but after the problematic link is passed, the two goods flows converge, indicating that a good deal of planning is required of the forwarder. As a matter of fact, this approach leads to the most complex system of all six. In order to manage such a system, a very good planning and information system is needed.

**Example:** The Swiss road regulations concerning gross weight of lorries are much stricter than those of the neighboring countries. This is not a problem for lorries transporting voluminous goods, but well for those transporting heavy goods. A forwarder serving the cross-Alpine market for general cargo transport might find that they only occasionally exceed the Swiss weight limits and thus normally send their lorries on road through Switzerland. On occasions when the composition of consignments result in over-weight, the forwarder can choose to use a Rolling Highway service\(^7\) through Switzerland and yet comply to the regulations in Germany and Italy. Hence they can avoid using two just more than half-full lorries. With larger flows they can plan their loading operations in such a way that some lighter lorries on road are combined with a heavy one on the Rolling Highway service.

4.1.6 **Transform goods**  
In this case, the decision is with the consignor, who transforms his goods in order for it to conform to the standard of the transport channel. The transformation can be done through changing the package or possibly the actual goods. Like approach 1, deny transport, this one defers all the difficulty in sending the GRSA to the consignor.

The more odd, but yet frequently sent, the GRSA is, the higher the probability that this approach will be utilised. It is today common to consider logistics consequences already when designing new products, although packaging is a powerful tool for implementing a standardised interface between product and transport system. From a transport system perspective it is the consignment, i.e. the goods in its package, and not the product itself that is of importance when discussing GRSA.

\(^7\) In a Rolling Highway service, full lorries are driven onto low-built rail wagons and are then transported by rail. It is a rather common way of relieving Alpine crossings from lorries.
Example: The classic example of transforming goods is that of the flagpole. When the transport system did not accept the dimensions of the flagpole the only long-term solution was to change the flagpole by cutting it to pieces (or make a telescopic construction) so that the entire pole could fit in one container. The consignee could then assemble the pole on site.

4.2 Comparison between the approaches
In approaches 1-5, the decision of whether and how to send the GRSA through the transport channel is made by the forwarder (with possible exception of approach 2). It is only in approach 6, that the decision is placed at the consignor’s, however demanding input from the LSP.

The degree of planning required from the forwarder, in order to carry out the haulage, increases as one moves from approach 1 to approach 5. This means that the later the planning of the transport is made, the fewer options for putting the GRSA through, exist. In the end, only the approaches of denying transport or to use brute force, remain.

Another difference between the approaches is that in approach 2, the links that classify the goods as GRSA, are forced to handle the goods regardless of the increased disturbance potential, while in approach 3-5, the links are replaced or subjected to planned changes. For using approaches 1 and 6, no alterations to the channels are necessary, in the former one, the goods have to be sent with a forwarder applying a different approach, and in the latter one, the goods itself is transformed.

When analysing the approaches using the model in Figure 5 created by Hultén (1997), a number of interesting points can be made:

- Strategy 2 (brute force) does not take into account the difference in capacity when changing link.
- Strategy 3 relies heavily on the process of bridging the gap.
- The strategies 4 and 5 do not bridge the gap, but instead change to a target process more in sync with the source process. In strategy 5 the system then redirects the goods to the original chain, thereby demanding that the next process (link number 3) will be able to handle the differences in $f$, $C$ and $t$.
- Strategy number 6 is pre-emptive in such a way that the goods themselves do not instigate a widening of the gap in the supply chain.

4.3 An illustrative case
In this section, a real world case is used for illustrating how the approaches for handling GRSA can be evaluated. The data are gathered in an interview with the CEO of the company acting as customer.

A Swedish importer of health products had in January 2001 launched a massive campaign promoting a certain substance. In the campaign deal, the vendors received display material as well as large discounts on the product. The product, which was manufactured in southern Germany, was extremely sensitive to cold temperatures. When the product was to be shipped to Sweden, southern Germany had its coldest winter since 1939 resulting in acute shortage of heated trailers.
The immediate response from the forwarder was to *deny transport* referring to *force majeure*. This was not accepted by the importer, who referred to the contract that guaranteed a climate controlled transport since that was required for the northern part of the transport chain. The problem was that the forwarder did not book a heated trailer well in advance since there is usually no shortage. To *apply brute force* was no option since that would inevitably have lead to destroyed goods. The forwarder then wanted to *postpone goods* waiting for better weather conditions. Since the campaign was under way, the importer deemed it critical that the product was delivered on time and refused also this solution. Neither the option to *divert goods* was applicable since it should be distributed to a large number of functional food stores using the pre-booked services of a Swedish forwarder.

The decision taken was to *use an alternate link* by sending the shipment by air freight at a cost far surpassing the budgeted freight costs. Once in Sweden the product was distributed by the Swedish forwarder according to the original plans.

To *transform goods*, for instance by sending it in insulated or heated packages, thus integrating the climate control into the consignment, could not be arranged with guaranteed success with such a short notice and would have induced extra costs for wrapping and for getting the equipment back.

### 5 CONCLUSIONS

The European LSPs face a future, in which the customers’ demand evolves towards more advanced services and for transport of more but smaller consignments. Their willingness to pay for these premium services is not unlimited, however, so the LSPs need to change their structural and operational patterns. Also environmental constraints will give incentives for the LSPs to develop more efficient services.

Among the responses to these trends on the demand side is the formation of very large mega-carriers with a wide range of services. In these large networks, the degree of consolidation increases and so does the number of consignments in each transport unit. The larger networks also implies that a larger part of the transport chains involves different traffic modes. As a result, the logistics system display a rapidly increasing complexity and also that the share of consignments and transport units require special attention increases.

The LSPs’ measure for handling the complexity is to implement rigid regulations and control systems in order to standardise the flows. The “fixing forwarder” disappears in that process. This, in turn, results in a situation where an even larger share of the consignments requires special attention.

The mega-carriers can handle the increasing fraction of GRSA (Goods Requiring Special Attention) using the following strategies:

- Deny transport. This option is not very attractive for the carriers and will rarely be used. The consignors will instead be forced to pay increased rates.
- Apply brute force. In this strategy, the carrier relies on others (links further down the supply chain) to handle the goods. This strategy will not be possible on a larger scale without large investments in flexibility.
- Postpone goods. By acknowledging limited capacity, the carrier lets the consignment wait until sufficient capacity exists in regular or dedicated departures. The
consignors will not be satisfied with this solution if applied frequently in an unplanned manner.

- Divert goods. The consignment is switched to an alternative channel for the duration of the transport. By changing channel, the carrier will have difficulty maintaining the original schedule and if the consignment consists of more than one load unit, synchronization will be difficult if they are not all diverted.

- Use alternate link. The link where the disturbance potential is too large is substituted for an alternative link. The flows converge at a later stage. This strategy puts great demands on the carrier concerning coordination. The vertical information flow will thus be considerable. It is even possible that the substitution itself causes larger disturbances than the ones the carrier tries to avoid.

- Transform goods. The goods itself is changed to fit the system. This solution generates large costs with the consigner, whereas the carrier will not experience any cost increase at all. It is likely that this is the strategy that most mega-carriers will pursue, thereby putting the responsibility with the consignors.

Mega-carriers will move towards a high degree of standardization to be able to run their networks on a continent-wide scale. Since the consignors are relatively unorganized and have virtually no freedom of action, they will comply with the requirements posed by the carriers stating that the consignments must be standardized. The costs will therefore ultimately be paid by the mega-carriers’ customers.

This is quite in line with the development of the Supply Chain Management concept, in which product development, production, logistics planning and marketing are integrated using a systems approach. Hence, it is the joint purpose of all actors in the supply chain to minimize costs and maximize customer satisfaction, which in return should give all actors a better financial outturn. In that environment it is obviously nothing peculiar about designing products and production systems that are in line with standardized logistics systems. By doing that, the supply chain can enjoy the better logistics service and lower prices offered as part of a standardized service than if it had to demand dedicated ones. Transforming the goods is thus believed to be the most applied approach to limit the share of GRSA.

REFERENCES

Note: The dates in references to web pages mark the date of the press release

Arnäs, P. O. (1999) GRSA - Goods requiring special attention and their effects on intermodal transportation systems, Department of Transportation and Logistics, Chalmers University of Technology, Göteborg, Sweden.


Hultén, L. (1997) Container logistics and its management, Department of Transportation and Logistics, Chalmers University of Technology, Göteborg.


