SECURE AND SUSTAINABLE SUPPLY CHAIN MANAGEMENT: INTEGRATED ICT-SYSTEMS FOR GREEN TRANSPORT CORRIDORS

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Abstract. In the EU White Paper on Transport 2011 the emphasis was laid on green transport corridors, i.e. transhipment routes with concentration of freight traffic between major hubs and by relatively long distances of transport marked by reduced environmental and climate impact while increasing safety and efficiency with application of sustainable logistics solutions. Green transport is based on inter-modality and advanced ICT-systems improving traffic management, increase efficiency and better integrate the logistics components of a corridor. Until today only the first steps have been realised in the implementation of green corridor concepts, so that concrete requirements and frame conditions for ICT-systems of green corridors are described on conceptual basis. Baltic Sea Region (BSR) enjoys a vanguard position in the development and realisation of green transport concepts in Europe and some research projects delivered already the first results for the requirements of ICT-systems supporting green transport corridors. Of special importance is the EU initiative "East-West Transport Corridor (EWTC II)" since for the first time a green corridor manual has been presented formulating recommendations and requirements of green transport corridors to European level. The authors took part in some important green transport corridor initiatives around the Baltic Sea, including EWTC project, and were involved in related research activities. This paper aims at pointing out the current status and the future direction of ICT-systems for green transport corridors, especially under the viewpoint of secure and sustainable green corridor management.

Keywords: sustainable supply chain management, green transport corridors, ICT- systems, secure inter-modal logistics

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1. Introduction

Despite recent economic turbulences the growth rates of economies and exporting economic sectors (e.g. Dudzevičiūtė 2013; Tvaronavičienė 2014) further increase of trade volumes is expected to continue in the future increasing the demands in the performance of logistics networks (Prause, Hunke 2014; Tvaronavičienė *et al.* 2013, Vasiliūnaitė 2014). The current estimations for Europe are predicting a 50% increase in passenger and freight transport within the next 20 years (Tetraplan 2009). The European Commission reacted on the development by presenting the White Paper on Transport 2011 setting the political framework for an EU Transport Policy Development in order to build for the next decades a competitive European transport system that will increase mobility and employment, remove major barriers in key areas and reduce fuel consumption. The emphasis in this approach is laid on green transport

corridors, i.e. European transhipment route with concentration of freight traffic between major hubs and by relatively long distances of transport marked by reduced environmental and climate impact while increasing safety and efficiency with application of sustainable logistics solutions, inter-modality, ICT-infrastructure, common and open legal regulations and strategically placed transhipment nodes (COM 2011).

So in a couple of international initiatives, concepts for green transportation corridors have been developed, partly implemented and tested in order to find a more practical approach to the issue. The Baltic Sea Region (BSR) is an important arena for sustainable transport projects since in several logistics projects on European and regional level aspects of green transportation have been studied in order to design more efficient and safe processes for multi-modal transport (BSR Transportcluster 2012). All these projects highlight the efficient use of the available transport infrastructure, inter-modality and high-performance ICT-solutions together with intelligent transport systems (ITS) as main pillars for green corridors.

The results of the most important green transport projects in BSR lead to clear requirements and a list of needed functionalities which have to be provided by ICT-systems for the management of green corridor performance. The paper will give an overview over existing ICT-solutions for the major green corridor projects in the BSR, whereas an inside view will be given for the East-West Transport Corridor project (EWTC II) implementing an inter-modal green transport corridor between the South Baltic Sea and the Black Sea Region.

The last part of the paper will be dedicated to a comparative analysis of ICT-systems for the most important green corridor projects in the BSR including Scandria, TransBaltic and North East Cargo Link II. The conclusion part will highlight common functionalities and features of the current ICT-systems as well as missing areas, which have to be filled in the future. Finally, the question of requirements for a future integrated green corridor ICT-system will be discussed.

2. Methodology

Since the appearance of the first Transport White Paper (COM (2001) 370 final) of the European Com-

mission (EC) in 2001 the necessity of shifting volumes of the dominant road traffic to other efficient transport modes is being expressed constantly. The goal was linked to the preparation of an environmental-friendly transport sector, and at the same time to provide securer and efficient transportation by reducing accidents, congestions and negative impacts through emissions, i.e. noise and pollution. After the revision of the EU Transport White paper (COM (2006) 314 final) in 2006, the concept of green corridors was introduced in the Freight Transport Logistics Action Plan (FTLAP 2007).

Since the EU enlargement in 2004 several initiatives were launched in BSR aiming at improving sustainable transportation in European Union. The first inside view in the logistics and ICT situation in BSR was given by the Interreg III project "LogOn Baltic – Developing Regions through Spatial Planning and Logistics & ICT Competence" during the years 2006 and 2007. The empirical activities of LogOn Baltic included a logistics survey, an ICT-survey and expert interviews, which were conducted in the project regions with a total of more than 1,200 participating companies (LogOn Baltic 2008; Kersten *et al.* 2007; Kron and Prause 2008).

Between 2008 and 2013 in a larger number of national and international projects about inter-modal and green transport concepts were developed and tested in BSR. Important initiatives like Green Corridor of the Swedish Logistics Forum, East-West Transport Corridor, TransBaltic or SuperGreen had different objectives but their results were based on expert interviews, surveys and case studies. Since the authors were involved in the empiric studies of some BSR projects or had access to relevant project results the methodology of the paper includes a literature review and analysis of theoretical material in the context of transport corridors and ICT application. Expert interviews and survey results which cover the whole BSR are tools for investigating the practical application of developed ICT systems. Furthermore, the paper uses a comparable analysis of the research outputs of relevant BSR projects to achieve research-based requirements for green corridor ICT-systems.

3. Conceptual background

In order to understand what a transport corridor means by theoretical backgrounds it can be helpful to see the corridor as a conglomeration of different

stakeholders which act along a defined geographical area in order to achieve different goals but with the same objective to reduce costs, increase efficiency, minimize environmental impact and create safe and sustainable logistics solutions. Realization of the increasing complexity of the interactions among acting organisations along their supply chains suggest that a network perspective may better explain the emergence of collaborative practices and integrative behaviours in logistics in general and supply chain management from organisation's point of view. Furthermore studies acknowledge the importance of a network structure for the effective diffusion of supply chain-related practices (Roy *et al.* 2006) and for the efficiency and the flexibility of responses of the supply chain to customer expectations (Wathne, Heide 2004). As the stakeholders act in a coherent sense and are located in a certain geographical area such a transport corridor can be described as a tubular service cluster. For the example for the EWTC green corridor, linking in its kernel Sweden, Lithuania, Belarus and Ukraine, the tubular cluster has the following shape (Figure 1).

Fig.1. Green transport corridor as
a tubular service cluster

Source: authors

Figure 1 highlights already a couple of interesting questions arising with green corridors. First topic is related to intercultural issues since different business cultures, different business models and different legal systems have to be harmonized. Another important issue is related to governance of green corridors since the heterogeneous set of stakeholders together with their own interests and agendas have to be unified in order to run and develop the whole green corridor.

Arising from the social network theory a transport corridor can be seen as a scale-free network, starting from dyadic relationships between two stakeholders and growing to a broader network. The behaviour of organisations in such systems as well as the impact on them has been studied and explained in resource dependence theory by Pfeffer and Salancik (1978) and by Meyer and Rowan (1977) in new institutionalism

theory. Specific characteristics of scale-free networks vary with the theories and analytical tools used to create them, however, in general, scale-free networks have some common characteristics. One notable characteristic is the relative high number of nodes with relations to other nodes which greatly exceeds the average. The nodes with most of the relations are called "hubs", and may serve specific purposes in their networks. It turns out that the major hubs are closely followed by smaller ones. These ones, in turn, are followed by other nodes with an even smaller number of degrees and so on. This hierarchy allows for a fault tolerant behaviour. If failures occur at random which, in the case of transport corridors, means the drop out of a stakeholder and the vast majority of nodes are those with small degree, the likelihood that a hub would be affected is almost negligible. Even if a hub-failure occurs, the network will generally not lose its connectedness, due to the remaining hubs. On the other hand, if a few major hubs are taken out of the network, the network is turned into a set of rather isolated graphs. Thus, hubs are both strength and weakness of scale-free networks. These properties have been studied analytically using percolation theory by Cohen *et al.* (2000) and by Callaway *et al.* (2000).

Rowley (1997) applied such a social network perspective to the stakeholder theory of the firm. Accordingly, research has started to address systems of dyadic interactions and stakeholder multiplicity, which can be also of importance for the understanding of a transport corridor concept. Opportunities for organizational resistance or adaptations to stakeholder expectations (Neville, Menguc 2006; Oliver 1991; Wolfe, Putler 2002) can be investigated. Vurro *et al.* (2009) investigated the predictors for stakeholder networks for value chains and identified two structural features of such stakeholder networks: Firstly, network density, defined as the degree of completeness of the ties between the actors in a network, has been identified as a likely determinant of corporate responsiveness in that it affects the ease of communication and efficiency of information flow across actors in the network. The second predictor, the degree of centrality in the network, that is, the extent to which an organization occupies a central position in the network, has been suggested as a further influence on the attentiveness of companies to stakeholder concerns and their willingness to accommodate their requests (Rowley 1997). When seeing the green corridor as network of supply chains with

the participation of various stakeholders it is necessary to understand how these stakeholders can communicate and cooperate. As the focus of this paper is laid on the role of ICT in these networks the theoretical background is given.

A literature review reveals an abundance of existing articles about the role of ICT in logistics and supply chain management covering a wide range of issues including enterprise resource planning (ERP), e-business as well as new technologies and other information systems for improving the supply chain management (Auramo *et al.* 2005; Ketikidis *et al.* 2008). By following the argumentation of Auramo *et al.* (2005) the commonly viewed functional roles of ICT in supply chain management can be classified into three categories:

- Transaction execution
- Collaboration and coordination
- Decision support.

A more concrete interpretation of the benefits of ICT in supply chain management has been formulated by Cross (2000) and Simchi-Levi *et al.* (2003):

- Reducing friction in transaction through cost-effective information flow
- Providing information, availability and visibility
- Enabling single point of contact for data

Empiric studies on ICT in supply chain management confirmed that the theoretical results described in the literature are in line with the perception of supply chain managers in companies since the involved practitioners stressed accordingly as the main benefits of ICT use in supply chain management (Grieger 2004; Auramo *et al.* 2005; Ketikidis *et al.* 2008):

- Improvement of information quality and quantity
- Improvement in operational efficiency
- Costs saving
- Reduction of lead time
- Enhancement of service level
- Higher flexibility.

Additionally it has to be emphasised the big differences between small and medium-sized enterprises (SMEs) and larger companies in ICT use in logistics and supply chain management due to large price differences among the existing information systems (Ketikidis *et al.* 2008). Consequently not every enterprise can afford sophisticated ERP or supply chain management systems making it complicated to integrate ICT-systems of the SME sector into supply chain management solutions.

The research results and corresponding literature is significantly reduced when it comes to ICT related topics in the context of inter-modality and even more limited in the context of the specific role of ICT in green corridors since these topics are part of on-going research activities (Bontekoning *et al.* 2004; Clausen *et al.* 2012). Since multi-modal transport corridors are built of networks of logistics companies and other corridor components their management depends on powerful ICT-systems (Daduna *et al.* 2012). Sander and Premus (2002) stressed the function of information in supply chain management referring to the glue that hold the collaborating business structures in the supply chain together whereas Evangelista (2002) stated that the role of ICT in supply chain management can be described as key integration element.

OSullivan and Patel (2004) pointed out that a lack of integration within and across different transport modes generate additional costs for the users so that Gustafsson (2008) proposed in order to make inter-modal transport as attractive as road based transport the integration between traffic and transport management is necessary. Oh (2011) was able to show that a modal-shift including supporting ICT-systems is a powerful measure towards green transportation since a reduction of 15% of greenhouse emissions can be achieved. But beside these special results the specific role and needed functionalities of ICT-systems in the context of green corridors is still part of recent research activities so that only a few number of publications exist (Clausen *et al.* 2012).

4. Network structures and ICT-systems

According to the Freight Transport Logistics Action Plan green corridors reflect an "integrated transport concept where short sea shipping, rail, inland waterways and road complement each other to enable the choice of environmentally friendly transport" stressing the multi-modal and green aspects (FTLAP 2007). In order to speed up the realisation of green corridor concepts in Europe in recent years an increasing number of initiatives have been started on national and transnational level to support the shift towards greener and more efficient logistic solutions. Main initiatives are East-West-Transport-Corridor (EWTC II), TransBaltic, Scandria and North-East-Cargo-Link (NECL II).

By taking into account the results of these initiatives the current situation shows that the main character-

istics of a green corridor and conditions that make a transport corridor actually green are varying but it is already visible that there are also common topics, which are recognised by all green corridor initiatives (Hunke, Prause 2012). Firstly, it is inter-modality, which enables the choice of environmental-friendly transport along the transport route, since reduced emissions is one of the obvious objectives of a greener transportation. Other important factors for green transport are adequate transhipment facilities, innovative transport units and vehicles, and advanced ITS-applications, which can be considered as requirements for green corridors, since the customers who chose to use a transport corridor expect not only environmental-friendly transport but would like to benefit from economic advantages and cost and time savings as well.

Therefore, economies of scale with bundled cargo together with high load factors are other factors for a green corridor, offered together with reliable time tables and adapted schedules for trains, ferries and other line traffic (Notteboom 2008; Daduna *et al.* 2012). The definition of the Commission covers also the fair and non-discriminatory access to corridors and transhipment facilities that make it possible for every customer to participate in the corridor and use the public available benefits. One approach to achieve these requirements for the implementation of green transport corridors is the development and establishment of an ICT-system.

4.1. Frame requirements for ICT-systems

The use of ICT-systems in the logistic networks depends heavily on the acceptance of the stakeholders. The technology acceptance model postulated by Davis *et al.* (1989) describes that the degree of user acceptance of technology has a positive effect on the usage of technology, which in turn also affects the performance of the network. According to DeLone and McLean (1992), the patterns and frequency of ICT-use are influential factors of individual impact such as quality, productivity and performance. Transferred from organizational theory the study of Igbaria and Tan (1997) of 625 employees in a large organization shows that user satisfaction on individual performance was actually related to ICT-use, therefore suggesting the ICT-use variable as an indicator of performance.

Vice versa, already the results of the research pro-

ject LogOn Baltic project revealed huge differences in the logistics competences around the BSR, which are still valid until recent times (LPI 2012). As a result of the comparison of regions with different levels of competence, the LogOn Baltic has brought to light that the BSR regions with higher logistics competence enjoyed a higher degree of ICT-use in logistics as well as a significant higher level of outsourced logistics ICT-services linked to an advanced level of sophistication of used logistics ICT-systems. Another important observation was that the focus in outsourcing of logistics ICT-solutions was laid on closed and company oriented systems (Kron, Prause 2008). Expert interviews revealed that the landscape of inter-company logistics ICT-systems is dominated by larger production companies and logistics service providers to safeguard the control of their individual supply chains and to realise dedicated platforms for sourcing of transport services mainly from regional SMEs (Prause *et al.* 2010).

The requirement for openness and harmonisation applies also to supporting ICT-systems of green corridors which is in line with the results about multimodal transport systems. The set targets are in conflict with the still dominating situation in BSR which can be characterised by a rather closed and dedicated ICT-landscape in logistics (OSullivan, Patel 2004; Gustafsson 2008; Kron, Prause 2008; Prause *et al.* 2010).

4.2. Functional range of ICT-systems

A way to increase effectiveness and to decrease cost of the business' activities in the supply chain is the optimization of activities in the supply chain on a cross company level within a network. While many existing IT-solutions offer effective means of managing business processes within companies, a cross-company management of the business processes requires different stakeholder's cooperation. An e-platform is a solution to facilitate such collaboration. "A digital information exchange is a key to facilitating transports, improving transport system efficiency, and reducing negative impacts on the environment because it allows corridor actors to plan better and react quicker and more appropriately" (EWTC 2012). The ideal e-platform is a virtual environment that facilitates business activities of logistic service providers and customers needing shipment. Integration of supply chain processes and companies increases the per-

formance and security of supply chain management. Key benefits, resulting from integration provided by an e-platform are:
- take advantage of new supply and distribution channels,
- reduce cost of distribution system,
- exchange knowledge via open partner systems,
- increase quality and range of added value services.
- shorten supply chain through elimination of intermediary companies,
- gain quick access to vast knowledge on companies and goods (data mining),
- simplify and reduce time of ordering and distribution,
- enable customers to track orders,
- expand activity area to global market (Baltic. Air-Cargo.Net 2012).

Geographical information plays also an important role for many business activity decisions. GIS service provides input to decision supporting tools and visual feedback to gain a better insight by tying geographical location information with relevant aspects of business activities. Spatial data and information about terrestrial transport modes are required so that the customer can view details of chosen infrastructure element. Visualization should include the position of all the relevant objects to supply chain management: goods, routes, facilities (warehouses, distribution centres, ports, rail stations etc.) and companies (e.g. material handling, customs, etc.). An e-platform provides opportunities to get valuable information for business intelligence. Gathered standardized statistical information on transactions is an input that allows performing various marketing analyses, developing business strategies and more accurately estimating demand for services traded on the platform. Implementation of semantic web technology will further increase analytical capabilities.

Platform usages itself provide wide range of information on demand, customers interest in available services, desired transport routes, destinations etc. Actual demand for a given service is more accurate information than interview results. This information is valuable for service providers planning their business and can be easily obtained by platform operator. (Baltic.AirCargo.Net 2012)

5. Application in practice

The EWTC II project plays in several senses a spe-

cific role among all green corridor projects in BSR since it aims to improve East-West trade routes between the Baltic Sea and the Black Sea Region by enhancing interoperability between different infrastructures, standards and systems, as well as removal of physical and operational bottlenecks, especially on the EU borders. But also on EU transport policy level EWTC II project has a vanguard position since for the first time a green corridor manual has been developed which will be used as a blue print for all future green transport initiatives and which has been forwarded to EU political level.

Special attention in the project was paid to co-modality, especially to rail transport including European and Russian gauge size together with short sea shipping in this corridor. The backbone of the project consists of the container train Viking, which shuttles between Klaipeda and Illichevsk via Minsk and Kiev. The Viking train is linked to Karlshamn in South Sweden by a ferry line and from Illichevsk via short sea shipping routes to destinations in the Black Sea. Due to these extensions, the EWTC II can be considered as a part of the Transport Corridor Europe-Caucasus-Asia (TRACECA) being able to attract new freight flows from Central Asia and China to Europe (Kusch *et al.* 2011).

The development of the ICT-system for the East-West Transport Corridor was influenced on theoretical considerations of Gustafsson (2008) and the results of "Green Corridor" initiative of the Swedish Logistics Forum (EWTC II 2012). Since the existing proposals were not practical enough to meet the needs of the East-West Transport Corridor, a special task 3C in the EWTC II was initiated for the development of a fitting ICT-system. On the base of expert interviews and surveys it was possible to specify 15 criterions for the ICT/ITS of the EWTC II, which have to be fulfilled in order to facilitate secure and sustainable transport, improve transport system efficiency, and reduce the negative impact of transports on the environment (Info Broker 2012):
1. Increase load factors from currently 30-50% to above 50% (EEA 2010; Notteboom 2008).
2. Usage of digital waybills will increase inter-modal transport efficiency.
3. Intelligent truck parking systems increase corridor efficiency by reducing up to 1h per driver and day for seeking safe parking areas (EWTC II 2012).
4. Better information at transfer nodes of the corridor by terminal service providers reduces waiting

times.

5. Up-to-date traffic information within the supply chain allows drivers and other operators to choose alternative routes.

6. Automatic Identification System data (AIS) about ship locations and estimated time of arrivals allow better resource management.

7. Access to up-to-date local weather data allows carriers to re-route or re-schedule transports.

8. Better matching of broadcasted transport information with the needs of logistics actors.

9. Standardisation and harmonisation of ICT-system interfaces and electronic documents for e-Freight enables more efficient multi-modal transports.

10. Easing of small cargo shipments by rail and sea in order to increase inter-modal operations related to rail and maritime transport since cur-rently small shipments are dominated by road transport causing big carbon foot-prints.

11. Reduce idle costs by sharing of transport units, since too many low-rated and utilized transport units are scattered around ports, terminals and transfer nodes.

12. More efficient management of transnational over-sized cargo transports by facilitating time-con-suming entry processes and reduction of related bureaucracy.

13. Intelligent Port Access Control by using open integrated ICT-systems for pre-registration according to the EU security and terrorist regulations as well as transnational transports for reduction of delays at the port gates.

14. Implementation of data exchange between major transport hubs in the corridor will increase transport efficiency.

15. Improved cargo tracking would facilitate resource planning for consignors, consignees and transport operators.

These 15 requirements set the frame for the development of the ICT-system of EWCT II corridor in order to facilitate the surface transport sector by offering simple means to reduce costs and problems associated with accessing and exchanging relevant information by stressing the specific needs related to secure inter-modality and sustainability. The transport and traffic information components shall safeguard high efficiency, increase safety and reduce the environmental impact on green corridors by sharing information among the actors of the inter-modal transport process including briefings about current situation of traffic, weather, cargo position and port access in the corridor. The emphasis of the parking information system was motivated to ensure high levels of security and quality and enhanced seamless traffic flows.

The contribution of the ICT-solution to the realisation of a green corridor concept can be assessed by Key Performance Indicators (KPI) being developed in order to benchmark considered green corridors (Clausen *et al.* 2012). The KPIs of the EWTC II green corridor concept, used the KPI system of the Super-Green (2010) project as a starting point, but their scope was enlarged by stressing social and economic aspects of the sustainability of the corridor (EWTC II 2012). As a result, the sustainable performance of the developed ICT-tool can be easily benchmarked when using these key performance indicators.

Furthermore, the TransBaltic project with its ICT-system "Logit 4SEE™" is another practical application. The ICT-system can be characterised as an ICT-tool for planning inter-modal chains giving the transport users the possibility to select the best alternative for door-to-door transports by delivering cost and time calculations to be able to find the optimal modal mix. "Logit 4SEE™" represents a multi-modal transport planning and monitoring system that allows a transparent supply chain management on the base of a web based application (TransBaltic 2012). Specific functionalities of "Logit 4SEE™" are:

• Description and registration of logistics offers of logistics service providers in the ICT-system including time schedules or duration of their transport services.

• Providing transport requests from registered customers for transport and logistics services containing transport instructions.

• Transport planning system calculating transit time, costs or CO_2 emission.

• Transport execution and monitoring of cargo along the transport chain including all kinds of cargo status information.

• Support of electronic inter-operability between actors involved in multi-modal transport chains using UBL standards for electronic documents in transport.

• Loads consolidation system from different transport orders going in the same direction for partial or whole transport chain.

The Scandria ICT-system can be regarded as an op-

timised version of the EcoTransIT tool for the Baltic Sea ferry transport inside the Scandria corridor. The Scandria ICT-system is a web-based online tool for inter-modal route planning, infrastructure information and for evaluating changes of inter-modal freight nodes and networks with a geographical focus on the area between the Adriatic Sea and Baltic Sea including road, rail, inland waterway, short sea shipping, and ferry networks. The main functionalities, covered by the Scandria ICT-system are (Scandria 2012):

• Inter-modal routing system offering alternative routes between inter-modal terminals.

• ICT-tool offering the usage of fixed relations in the routing process by taking under account already used inter-modal transport services by a transport operator and by offering different options for transport modes for routes in graphical form.

• Accessibility analysis tool analysing and optimising the accessibility of inter-modal terminals according to time, distance, energy consumption or costs.

• Terminal information tool providing information about terminal infrastructure, services and organisation.

• Scenario tool allowing the creation and comparison of different scenarios depending on the network and terminal parameters.

The NECL II system can be characterised as a logistic ICT-solution for transport matching. For the development of the ICT-tool, a full work package 5 of NECL II was dedicated in order to realise a fully operating transport matching system with a focus on the decrease of existing volumes of empty or partially loaded transports. The functionality of the NECL II system is laid on (NECL II 2012):

• Choice between alternative transport routes.

• Comparison of alternative transport routes.

• Possibility to optimise routes by cost, time, CO_2 emission

• Multi-criteria optimisation of transport routes.

6. Results of practical realization

It should be recalled that all considered green corridor projects accept the already discussed definitions and requirements of European Union about green transport corridors as well as the results of the "Green Corridor" initiative of Swedish Logistics Forum. All in all, by taking into account all discussed features of ICT-systems of the main green corridor projects in the BSR together with Northern understanding of a

green transport corridor, it can be concluded that an appropriate ICT-system for the support of green corridors should facilitate the following functionalities:

• Routes planning
• Open architecture
• Standardisation of interfaces
• Electronic data interchange
• Transport optimisation
• Real time data information systems
• Inter-modal route planning
• Loads bundling and consolidation
• Cost calculation
• CO_2 emissions calculation
• Purchase of transport services
• Transport monitoring.

Additionally, the comparable analysis reveals that there are specific topics representing crucial factors for the development of green transport corridors but the existing ICT-systems of the BSR green corridor projects are not supporting corresponding functionalities. The most important missing functionalities are related to contracting, finance, return logistics and logistics pricing (Info Broker 2012; TransBaltic 2012; Prause *et al.* 2010; Theofanis, Boile 2009):

• All analysed green corridor ICT-tools support and focus on technical and organisational aspects of inter-modal transport planning but business and contracting related aspects of transportation have been neglected. One reason is that transport service providers give special business conditions for different clients and cargo, and they are not eager to be transparent with this information (Prause *et al.* 2010).

• Invoicing and payment services are hardly mentioned in the existing ICT-systems (TransBaltic 2012).

• Return of logistics assets including containers and train platforms is not considered in existing ICT-systems although big traffic is related to empty containers. A software module dealing with empty logistics assets may reduce the cost of containerised traffic and make transport greener (Wolf *et al.* 2012; Theofanis, Boile 2009).

• All transport planning tools are based on transport tariffs stored in a database. But freight rates are rather flexible being comparable to spot market prices in road transport or being subject to volume discounts in case of railway and maritime carriers. Hence, the existing models in the ICT-systems are too rigid and simple to model the reality in green transportation (Info Broker 2012; TransBaltic 2012).

Since the development of green corridor together with their ICT-systems is still on-going inside and outside BSR it will be only a question of time until these missing functionalities will be tackled in upcoming green corridor projects. A special frame condition on green corridor ICT-systems is set by the key performance indicators which are until now individually developed by each green corridor project in BSR and which are still part of the on-going research activities. In the considered BSR cases these key performance indicators are also impacting the functionalities of the green corridor ICT-systems.

In the future, one important task will be the integration of the existing ICT-tools of the green transport projects around the BSR into one integrated ICT-system of extended functionality in order to be able to utilise the available capacities around the BSR more efficiently towards a greener logistics. Such an integrated transportation ICT-system can bring together the big market players in logistics and trade as well as SME sector in logistics to realise a cheaper and more environmental-friendly transport. By taking into account the discussed issues the advantages of integrated ICT-system can be expressed by the following point:
• Increased accessibility of inter-modal freight transport solutions, i.e. the gain of door-to-door co-modal solutions together with environmental and logistics performance attributes.
• Improved synchronisation of logistics processes and better utilisation of logistic resources.
• Enhanced reliability of inter-modal services and better adaptability of logistics solutions through dynamic updated information.
• Reduced costs and effort for the management of complex transport chains.
• Possibility to use standardised electronic logistics documents like waybills and customs information along the transport chains.
• Creation of an open transport spot market along the involved green corridors including the possibility of a fair participation of logistics SME sector.

Since a fully working integrated ICT-system for green corridors is still a topic of the future, it is recommendable to use an open architecture able to integrate and exchange information with already existing systems. Related to the issue of open architecture is the question of the definition and use of standards, since businesses using data standards like Global

Standards 1 (GS1), Universal Business Language (UBL), United Nations Electronic Data Interchange For Administration, Commerce and Transport (EDI-FACT) were not focussed on the modelling of transportation processes, so there exists still the need for the development of standards regarding the description of logistics service, logistics nodes and other logistics objects. The existing standardisations can offer solutions for regions or branches, but there is no appropriate general solution for general multi-modal transport sector until now.

The comparative analysis of the running green corridor projects in the BSR brought to light that up to now it is possible to formulate minimum requirements for the provided functionalities that an integrated logistics platform system has to offer:
• Generation of inter-modal door-to-door transport alternatives comprising the whole transport chain planning.
• Transport chain visualisation.
• Multi-criteria transport optimisation tool.
• Calculation and measurements of energy consumption and CO_2 emissions.
• Standardised electronic data interchange in order to be able to integrate corporate systems using different communication standards.
• Information about logistics nodes, available services and service booking.
• Parking information and booking parking places.
• Up-to-date information about traffic and weather conditions.
• Transport tracking and monitoring
• Negotiation, contracting and booking system.
• Financial settlements.

However, these necessary functionalities are representing the more technical part of the requirements that have to be fulfilled by an integrated ICT-system. The more challenging task is to realise the organisational and political framework for such system architecture. By summing up the results of green corridor initiatives from BSR together with the discussions of the paper it can be stated that integrated ICT-systems have to meet the following system requirements (Green Corridor 2010; Info Broker 2012; TransBaltic 2012):
• Open architecture.
• Oriented on standards.
• Focus on inter-operability and co-modality.
• Independent of technology.

- Endorsed and adopted by major freight ICT-systems providers and logistics operators.
- Support the European transport and logistics system to be more efficient and environmental-friendly.
- Creation of a fair and balanced transport spot market within the corridors enabling market leaders and SMEs to interact at a low cost.

Especially the realisation of the last point represents a task which is placed far beyond technical questions because it needs to convince the current logistics players to open their closed ICT-systems and to integrate them into a common logistics platform which is linked to loss of their influence and market power. In order to succeed with these tasks, more research on green corridor business models and the possible benefits of integral corridor management systems for all participants will be necessary.

Another strong barrier for the implementation of green corridor ICT-systems is related with the fact that creating open data bases comprising freight tariffs and contracting conditions in order to be able to build transparent spot markets is again a political sensitive topic, where more incentives than general arguments have to be developed in order to increase the will to participate among the main logistics players in a green corridor. In case of the acceptance of participation of a critical mass of logistics companies in such systems, it is still necessary to develop a communication system between these co-operating companies and to agree on underlying business models, standards of documents and messages. But an important constraint for successful future applications and solutions in BSR is to be open and affordable for the small and medium companies due to the dominance of SME sector in logistics.

Conclusions

Green transport corridors play a growing role as transhipment routes for long distance freight traffic based on multi-modality and supporting ICT-systems. When it comes to the realisation of green corridor concepts, only a few pilot projects exist until now giving the opportunity to develop and test green corridor solutions together with their ICT-systems (EWTC II 2012; Info Broker 2012; TransBaltic 2012). The management and monitoring of the performance of green corridors is based on key performance indicators which are until now individually developed by each green corridor project in BSR and

which are still part of the on-going research activities. These KPIs together with general demands on green corridors prove a high impact on the functionalities of supporting green corridor ICT systems (Green Corridor 2010).

The main future task will be the integration of the existing ICT tools of the BSR green transport projects into one overall integrated ICT-system of extended functionality facilitating and coordinating the available capacities around the BSR more efficiently towards a greener logistics. Such an overall integrated transportation ICT-system has to offer an ICT-platform for the different stakeholders of BSR logistics, to realise their cooperation according to the frame conditions and to improve the performance, safety and efficiency of green corridors.

Even if the final structure of such an overall system is still open, already now some cornerstones of such ICT-systems for green corridors are visible since they will rely on open architecture, use standards and realise green and democratic models for efficient multimodal logistics markets. Especially the realisation of the last point represents a task which is placed far beyond technical questions because it needs to convince the current logistics players of open their closed ICT-systems and to integrate them into an integrated logistics platform which is linked to the loss of their influence and market power. In order to succeed with these tasks, more research on green corridor business models and on potential benefits of integral corridor management systems for all participants is necessary.

But beside the discussed technical issues the results of the first implemented green corridors in BSR already revealed that political and cultural topics play also a crucial role for the acceptance and success of the green corridor concept. Important preconditions for the implementation of green corridor ICT-systems are related to transparency, cooperation and trust since the creation of open data bases comprising freight tariffs and contracting conditions are necessary to build transparent spot markets but at the same time these strategic and political sensitive topics represent main obstacles for the participation among the main logistics players in a green corridor.

So in order to safeguard the success of green corridor concepts the scope of research has to include cultural and political topics touching issues beyond ICT-systems so that the participation of a critical mass of

logistics companies in such systems can be realised. But the solutions of these questions need a lot of further research which is on the agenda in running and upcoming green corridor projects.

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