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# The role of intelligent logistics centres in a multimodal and cost-effective transport system

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**Abstract**

This paper describes the role of logistics centres including intelligent solutions in a multimodal transport system. The background is related to the logistics infrastructure in global logistics focusing on various warehouses, distribution centres and logistics business parks. These logistics nodes form an essential part of the logistics network in order to gain cost-effective and sustainable global logistics system. This paper is based on a case study and presents potential business models and service entities for logistics area level automatic identification (AutoID) services, concentrating on RFID. As a result several potential AutoID services were identified and they can be classified into two clearly separate service entities: areal and company-specific services. The proposed services encourage using RFID by offering leased infrastructure and supporting services for example. According to the study the most suitable way to provide AutoID services in a logistics area is to establish an areal service company to be responsible for different services including AutoID services.



Keywords: Logistics centre; RFID; Intelligent logistics

## 1. Introduction

The global marketplace and procurement operations are reality in the present business environment and therefore globalization is one major trend in logistics. It provides companies operating in the worldwide market with many opportunities by generating more potential market areas and customers, and also widening the potential supplier network. Globalisation also makes many demands, e.g. the current global economy demands the highest quality products at the least cost regardless of where the product is

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manufactured. Operating in a global market may also increase the uncertainty in the company's operations, which may in turn lead to considerably increased inventories and longer lead-times through global supply chains. (Bhatnagar & Viswanathan 2000, Bhutta et al. 2003) Therefore the development of global logistics networks including logistics centres is also a significant success factor in global logistics operations.

Global operations demand global logistics networks in order to construct cost-efficient and customer-driven supply chains. Logistics centres are essential nodes in the global logistics system, which can increase the added value logistics services in the logistics value chain and especially produce effective terminal operations, thereby increasing the competitiveness of supply chains. Logistics centres may have different roles in a global logistics network. These can be specialized in the needs of certain products or business areas or alternatively focus on certain markets. Location and service level of logistics centres can also be focused on the network of logistics service providers. The position of the logistics centre in the customer's supply chains is the most significant approach when evaluating the significance of this kind of logistics structures in the global network. The evaluation of facilities and operation models including the selection of service supply is another approach. This research focuses on intelligent solutions in order to evaluate the role of logistics centres in global supply networks.

Responsiveness in the supply chain management has increased as a focal area due to the trend of many markets to become volatile and difficult to predict. (Christopher & Towill 2002, Baker 2008) However, cost is one major driving force in designing supply chain operations, but agility has raised its significance as an answer to market needs. In general, the minimisation of inventory and assisting the rapid flow of goods through the supply chain are two keys to achieve these dual objectives (Baker 2008). A distribution network with various profiles of distribution and logistics centres creates numerous opportunities to increase both the cost-efficiency and customer responsiveness of supply chain. Distribution is also seen as a key driver of the overall profitability of a firm because it impacts directly on both the supply chain cost and the customer experience (Chopra 2003). A logistics centre may include activities like final packaging, labelling, mass-customisation and customer configuration of products. The significance of logistics centres as decoupling points is becoming increasingly important with global sourcing, which tends to be associated with increased lead times.

The transport system is closely integrated in global supply networks and it is also one basic element of a cost-efficient and customer-responsive logistics system. Logistics and transportation systems as part of logistics need to be consistent with the products they support, because customers tend to make no distinction between a product and the distribution system that supplies it. Other main premises of present logistics systems and lean management principles are eliminating inventories and organizing materials supply strictly on demand at every stage in the logistic chain, replacing storage and stock keeping inventories. (Caputo et al. 2003, Hesse & Rodrigue 2004) Therefore delivery entities are diminished and frequencies are increased in today's supply chain management. Logistics centres thus also have an essential role in consolidating transport flows and further improving the cost-efficiency of transportation system operations. Logistics centres also have a key role as multimodal terminals combining different transport modes and transportation units.

RFID (Radio Frequency Identification) is an identification technology which is used for tracking and tracing products throughout supply chains (Michael & McCathie 2005). RFID tags enable item, pallet or container level tracking (Ustundag & Tanyas 2009). According to Singer (2003) the four benefit factors of RFID technology are operational efficiency, accuracy, visibility and security. Kapoor et al. (2009) have

listed several benefits for supply chain management provided by RFID tags including improved asset management, improved inventory control, shrinkage reduction, increased product availability and fulfilment rates, reduction in labour cost, decreased operational time, material handling efficiency, improved process throughput, improved customer service including returns and recall management as well as service and warranty authorizations, increased in-transit visibility, confirming regulatory compliance through chain-of-custody records and overall process improvement. According to Hu et al. (2011) in a terminal, the use of RFID can reduce queuing and the number of gates needed in a gate house which reduces infrastructure cost and improves operational efficiency.

RFID tags are expected to supplant barcodes in the very near future (Kapoor et al. 2009). The advantages of RFID tags compared to barcodes are that RFID does not require line of sight between tags and reader, multiple items can be read simultaneously, tags can be read through non-metallic materials, and are proof resistant to environmental temperature and other external factors such as moisture (Kärkkäinen 2003). RFID tags can also be read and reprogrammed numerous times (Kärkkäinen 2003). In addition, battery assisted RFID tags can monitor environmental forces like temperatures and bacteria levels (Michael & McCathie 2005).

End users are becoming aware of the benefits of RFID, but the cost of implementation and the availability of infrastructure pose challenges (Frost & Sullivan 2011). Technology, standard and patent challenges hamper the adoption of RFID (Wu et al. 2006). The cost of RFID applications in supply chains includes the cost of acquiring and tagging items, tag readers, as well as necessary back-end systems to gather, maintain and process the data including changes to existing Enterprise Resource Planning (ERP) and other related systems (Kapoor et al. 2009). However, the benefits of RFID implementations through reducing labour, out-of-stocks, shrinkage, etc. are expected to exceed the implementation costs (Ustundag & Tanyas 2009). In addition, advances in RFID technology have decreased the cost of tags, readers, middleware and software, which is expected to increase the demand of RFID applications (Frost & Sullivan 2011).

The ultra high-frequency (UHF) RFID system can read a huge number of tags simultaneously generating a large throughput of data. To collect and process all the data considerable computing power and system integration are required (Wu et al. 2006). Niederman et al. (2007) have anticipated four basic scenarios for integrating RFID with existing systems:

- organizations having relatively ad hoc business processes will generate flat files from RFID and sensor data and provide this data for manipulation by existing applications;
- organizations will build new relational databases, systems, and processes (manual and automated) to interact with existing enterprise systems;
- organizations will work with vendors to build capabilities into the enterprise systems in a way that they handle the data originating from the RFID sources;
- organizations with custom legacy systems will convert to enterprise systems and simultaneously address system integration and utilization of RFID capabilities.

System integration does not seem to be the biggest challenge in RFID systems and many users and system integrators (SI) assume that installing an RFID system is a simple task (Wu et al. 2006). Several vendors such as SAP, Oracle, Sun, Peoplesoft, IBM, and Microsoft are currently deploying various middleware approaches toward the integration of RFID with their existing product offerings (Niederman et al. 2007).

## 2. The research problem

The use of RFID has several benefits in a supply chain and it enables efficient terminal operations, including the use of cross-docking for example, in logistics centres. As the cost of implementation and the availability of infrastructure are hindering the use of RFID, this study was issued to see how an intelligent logistics centre can facilitate the use of RFID by offering common RFID services without obligatory user investments and taking infrastructure issues into account already in the planning phase. Also the logistics centre location decision-making process was studied and the influence of AutoID services in differentiating from other logistics centres was discussed.

The research question was to construct a service model where logistics operators of various sizes and representing various business models have an opportunity to connect their own ICT systems to the ICT systems of the chosen territorial RFID service provider. This research also forms and analyses various business concepts and earnings models for this kind of RFID service providers at the logistics area level. The second research question was to ascertain how such intelligent logistics centres affect the multimodal and effective transport system and what their role is in it.

## 3. The research work and results

### *3.1. Research projects and methods*

This paper is based on two separate research projects conducted 2010-2011. One project was based on the analysis of existing logistics centre projects in various development stages and approximately 200 logistics centres were analysed in southern Finland, where the main focus was on specifications, location, position in supply chains, development stage and infrastructure. Some logistics centres are in the planning and marketing process, some are already operational and some in-between. The research project sought to identify common characteristics and success factors in the development of logistics centres, which currently seems to be in some kind of high season. The investor perspective is a further key element in this research. This research serves as the background for the intelligent logistics area case study.

The other research project was a single case study of a logistics centre called “LogiCity” in the city of Turku in Southern Finland. LogiCity is very innovative in utilizing modern technologies and it is, for example, the first in Europe and probably in the world to focus on the needs and possibilities of RFID services already at the territorial level planning phase. This research examines the role of AutoID/RFID service provider in open access systems, which are aiming to increase the transparency, control and security of transport flows. The project also sought to analyse business and earning models of areal AutoID services.

According to Eisenhardt (1989) a case study focuses on understanding the dynamics present within single settings and can consist of single or multiple cases, several levels of analysis and can combine different methods of data collection. According to Yin (1994) a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. One result and strength of case study method is that it relies on multiple sources of evidence, which is valuable in a complex problem-setting. It also benefits from the prior development of theoretical propositions to guide data collection and analysis.

Regarding the location decision-making and the development of a logistics centre representatives (one each) from two logistics operators (LO), two logistics service providers (LSP), four facility investors/developers, five municipalities and four regions in southern Finland were interviewed. A survey was also conducted and the responses of wholesalers, LOs and LSPs having a logistics surface area exceeding 10,000 m2 were taken into account (n=10). Regarding the logistics area RFID case study seven RFID/IT service providers were interviewed. A workshop was also organized where IT and LSPs and other interest groups discussed the approach to the utilization of technological solutions to improve logistics performance within the logistics area. In addition, several work meetings of logistics researchers and consultants were organized to assess the interviews and workshop, and to make recommendations.

### *3.2. Logistics centre roles and location*

A classification and categorization model of logistics centres was developed to assist various stakeholders to analyse the role and development stage of logistics centre projects. The model is based on size, extent of logistics services, openness of the logistics centre, orderliness of the development process and regional planning perspectives.

Table 1. Logistics centre categorization model (Eckhardt & Rantala 2011).

| Category | Title | Description |
|---|---|---|
| C0 | Logistics zone | A zone along the main transport infrastructure formed by logistics concentration, areas and centres. |
| C1 | Logistics concentration | A spontaneously formed compact group of logistics centres and areas with several management organizations, operators and industries. |
| C2 | Logistics area | Organised area for logistics operations, freight village or business park, including several logistics centres, warehouses and terminals with logistics services. Several actors involved. |
| C3 | Logistics service centre | Open logistics centre. One specific management, possibly several actors. |
| C4 | Logistics centre | Closed logistics centre. Operations for specific trade or industrial companies' needs. |
| C5 | Warehouse, Terminal | Private warehouses and terminals, surface area under 10,000 m2. |

This new classification model of logistic centres can to some extent be seen as a development path and assists various stakeholders to analyse the role and development stage of logistics centre projects. Therefore this model forms also basis to describe potential organizing models in various size, role, service supply and characteristics. These logistics centre classes have different roles in global networks. Port connections are crucial for Finland's global and domestic supply network. The data analysed of 200 logistics centre projects showed that a connection to seaports is essential to the systematically organized logistics centre concept. Air cargo combined with a general cargo seaport increase volumes. Thus in Finland, the only logistics zone (C0), which is a site discernible on a map, and a concentration (C1), based on an interesting geographical location, is located along the airport-sea port axis in Helsinki. The second logistics zone in Finland will be formed in Turku. Turku and Helsinki are the only remarkable air freight locations in Finland. Logistics areas (C2) are usually based on a municipality or a facility

investor/developer initiative and are mainly located at ports and close to main road junctions. Classes C4, which are only for specific company use, and C3, which usually refers to LSPs, are based in Finland on national transport systems and its most significant market areas.

### *3.3. Intelligent logistics area case*

#### *3.3.1. Case description*

LogiCity is a multimodal logistics area in Turku in southern Finland. LogiCity is close to Turku Airport, a railway and the main road connections to Helsinki and to central Finland. It is also located in the vicinity of two seaports, Turku and Naantali. In addition, a logistics centre called Avanti-Tuulissuo in Turku is located close to LogiCity and these logistical nodes together with the seaports will form a significant logistics zone in the western part of southern Finland.

LogiCity is currently under construction and some LOs and LSPs are already operating there. LogiCity is strongly profiled in multimodality and air cargo, and a global LSP has chosen Turku airport as its only air cargo location in Finland. Turku is located along a transport corridor between Scandinavia and Russia (Figure 1), which are significant markets for industries in southern Finland. The network of logistics facilities along the transport corridor will form a basis for logistics services. Thus this logistics zone will be developed both regionally and on a transport corridor basis, and has considerable future potential and market driven background.


Figure 1. The location of multimodal LogiCity area in Turku (LogiCity).

The development of the LogiCity area is concentrated on innovative development models: labour concepts, the utilization of AutoID technologies, air freight models and logistical processes of the fast

turnaround assembly industry. This case study concentrated on AutoID, especially RFID, utilization in LogiCity area.

### *3.3.2. AutoID services*

The case study concentrated on finding which services could be included in an AutoID service covering a logistics area, and what kind of business concepts and earning models could be used for areal AutoID services. The basis for the case study was that the business concept has an on-demand based operation model with plug-and-play platform, where operators in LogiCity area can join the RFID network without preliminary investments. As there are no previous studies related to the topic and no similar intelligent logistics area exist, the results are based on the interviews of RFID/ IT service providers operating in Finland. The recommendations are based on the interviews, opinions of the project group, and on the workshop,

Automatic identification (AutoID) services can be classified into two clearly separate service entities: areal and company-specific services. Areal services are related to control/monitoring/surveillance and guidance in the LogiCity area. Company-specific services are related to the management of material flows inside the company or in its supply chain.

Areal AutoID may include the following services:

- Vehicle identification (RFID and Optical Character Recognition, OCR)
- Vehicle location
- Vehicle guidance (for example on a display panel)
- Train identification (RFID and OCR)
- Container identification (RFID and OCR)
- Person identification (RFID and OCR)
- Personnel controlling and allocation (for example work force can be located and the nearest free person allocated for a specific working place when needed)
- Machine identification (RFID)
- Machine supervision and allocation (RFID)
- Data transfer (for example to access control system)

Company specific services may, for example, include the following services (Figure 2):

- Product identification
- Status in the supply chain
- Data transfer from RFID server to different systems (for example to warehouse management system (WMS) or to enterprise resource planning (ERP) system)
- Provision of empty and programmed RFID tags
- Provision and leasing of RFID infrastructure (readers and antennas, mobile terminal devices, tagging devices)
- Tagging service (produce tags and tag the products)
- Helpdesk
- Consulting

Two possible ways to order AutoID services were identified according to the interviews with stakeholders. Customers can either order the service directly from a service provider, who invoices the

customers directly, or order the service from a service company, who invoices the customers and orders the services in a centralized way from an AutoID service provider.

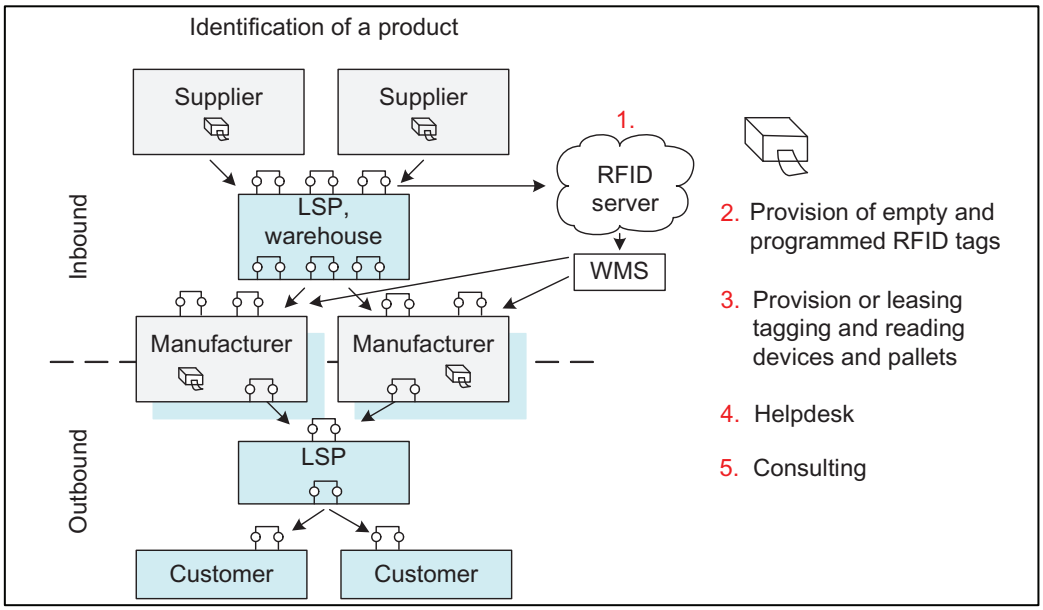


Figure 2. Company-specific RFID services.

Three principle ways for pricing/invoicing the AutoID service were found realistic according to the interviews:

1. The service is provided with a SaaS (Software as a Service) model, where licences and technologies related to the service are leased at a monthly charge. Companies are invoiced with a fixed charge based on the company size and the estimated use of the services. The server is located in the companies' premises.
2. The service is provided as a cloud service. According to Vaquero et al. (2009): "Clouds are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services). These resources can be dynamically reconfigured to adjust to a variable load (scale), allowing also for an optimum resource utilization. This pool of resources is typically exploited by a pay per-use model in which guarantees are offered by the Infrastructure Provider by means of customized SLAs (Service-Level Agreements)." As the charge is based on the use of the service it is more flexible than the previous SaaS model, but the amount charged may be difficult to predict.
3. The service is provided by combining the previous options, where charging is based on a fixed basic amount and a supplement based on the use.

For other services, such as for selling or leasing devices and tags, there would be separate pricelists.

As a result, according to the findings of the case study, the most suitable way to provide AutoID services in a logistics area is to establish an areal service company to be responsible for the various

service entities, including the areal and company-specific Auto ID services presented. The areal service company would make the decisions required regarding the system vendors. Customer companies (LOs, LSPs etc.) would order AutoID services from the areal service company, who would invoice customers. The pricing/invoicing principles would be decided upon specification of service content. Simplified invoicing model could be related to amount of operations/lines based on unit costs determined, but in large content this could include elements like division of benefits to customers. The possibility to procure RFID services without investments on infrastructure and with supporting services lowers the limen to start using RDIF which enables to achieve the generally known benefits of RFID: operational efficiency, accuracy, visibility and security.

## 4. Conclusion

Logistics centres have proved to be an essential part of global logistics networks in order to provide more effective terminal handling and cost-effective total logistics solutions for various transport flows. Logistics centres may have different business ideas, position in relation to markets, trade and industry, or systems of logistics service providers. These logistics elements are usually established on a market basis, but municipalities may also be active and even launch initiatives to establish logistics areas. The case study in this research indicates that such an idea launched by municipalities has been successful, although the construction processes itself is driven by operators and private companies. The role of municipalities as a driving force is therefore very valuable.

The service supply in logistics centres varies a lot from basic logistics services to business area or product specific solutions. The transport modes and opportunities for multimodality available can form a service supply and determine the role of the logistics centre in a global logistics network. This paper focused on intelligence and methods in order to increase operational efficiency in the logistics area. The capability for innovations is one key success factor to differentiate between logistics centres and areas offering basic logistics services and therefore increase the competitiveness and attractiveness of logistics concepts. The RFID infrastructure implemented in the LogiCity area and an AutoID service provider facilitates the utilization of RFID technology for different actors operating in the LogiCity area. These factors differentiate LogiCity positively from other logistics areas in Finland. From the customer perspective service acquisition needs to be concentrated as a one stop shop in order to facilitate contacting and decision making of companies.

The intelligent logistics centre, which in this case is based on RFID technology, has excellent operational preconditions to increase efficiency in its own operations and also to develop new service models for their customers. Tracking and tracing of material flows including effective handling processes is one significant approach to improving cost-efficiency throughout the supply chain, but it has also safety and security aspects. Both safety and security issues are increasingly important in the global business environment and in world trade. Therefore such intelligent logistics centres can strengthen their role in global supply networks.

Multimodal transport requires time consuming transfer between different modes and involves several actors. Issues impeding the breakthrough of multimodal supply chains include lack of transparency, missing information flows and missing services (Davydenko et al. 2007). Thus, easily integrated information systems and AutoID promote multimodal supply chains by making them a more effective, more secure and more appealing transportation arrangement.

As a need of future research this approach should be tested in greater detail at areal level in future research. These RFID technologies function as company and logistics centre solutions, but applying them at areal level calls for the piloting and expanding of present solutions in a wider perspective. RFID based solutions are only one approach and such examinations could also be performed innovatively on solution areas.

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