INTEGRATION OF TRACKING & TRACING SYSTEMS IN MULTIMODAL TRANSPORT CHAINS

Mrs. Jenni Eckhardt, Research Scientist, Technical Research Centre of Finland (VTT), Building and Transport, P.O. Box 18021, FIN-90571 Oulu, Finland, Tel: +358 8 551 2031, Fax: +358 8 551 2090, e-mail: jenni.eckhardt@vtt.fi

Mr. Antti Permala, Chief Research Scientist, Technical Research Centre of Finland (VTT), Building and Transport, P.O.BOX 1800, 02044, VTT, Finland, Tel: +358 9 4561, Fax +358 9 464 174, e-mail: Antti.Permala@vtt.fi

Mr. Johan Scholliers, Senior Research Scientist, Technical Research Centre of Finland (VTT), Industrial Systems, P.O.Box 1302, 33101 Tampere, Finland, Tel: +358 9 4561, Fax +358 3 316 3494, e-mail: Johan.Scholliers@vtt.fi

Mr. Pekka Leviäkangas, Senior Research Scientist, Technical Research Centre of Finland (VTT), Building and Transport, P.O. Box 18021, FIN-90571 Oulu, Finland, Tel: +358 8 551 2058, Fax: +358 8 551 2090, e-mail: pekka.leviakangas@vtt.fi

SUMMARY

The objective of this preliminary research was to look at the needs and possibilities of integrating tracking & tracing systems of different transportation modes and companies. The research covers identification along with the technical, economical and administrative factors that should be taken into account when considering the integration of tracking & tracing systems. As a result of the study, further research needs in the field of tracking & tracing in multimodal transport chains are defined.

INTRODUCTION

Logistics is the central competition factor of companies in supply chain networks. The efficient flexibility of electronic data transfer, information processing systems, data networks and identification and tracking technology holds a central position in the development of logistics. This development is driven by globalisation, the integration of Europe and by the development of information technology systems.

The Finnish freight transport telematics architecture (1) focuses on processes that are directly related to the transport of goods and on the information flows of these processes. The architecture covers different modes of transport including road, rail, water and air. It has been described independently of the transport mode so that process components can be collected in actual transport chains.

The architecture contains role definitions for the sender, receiver, logistics service providers and the public administration. The described process areas of freight transport are planning, management and control, supply chain operations and tracking & tracing (see
Figure *1*

The viewpoint of the architecture is that of freight and related information flowing through the logistics chain from sender to receiver. The information flows comprise management data, track and trace data and other data related to the goods order, transport agreement, transport order, dispatch note and load specification. The logical architecture contains the description of information objects and the information services that are based on these as well as the description of information system services.

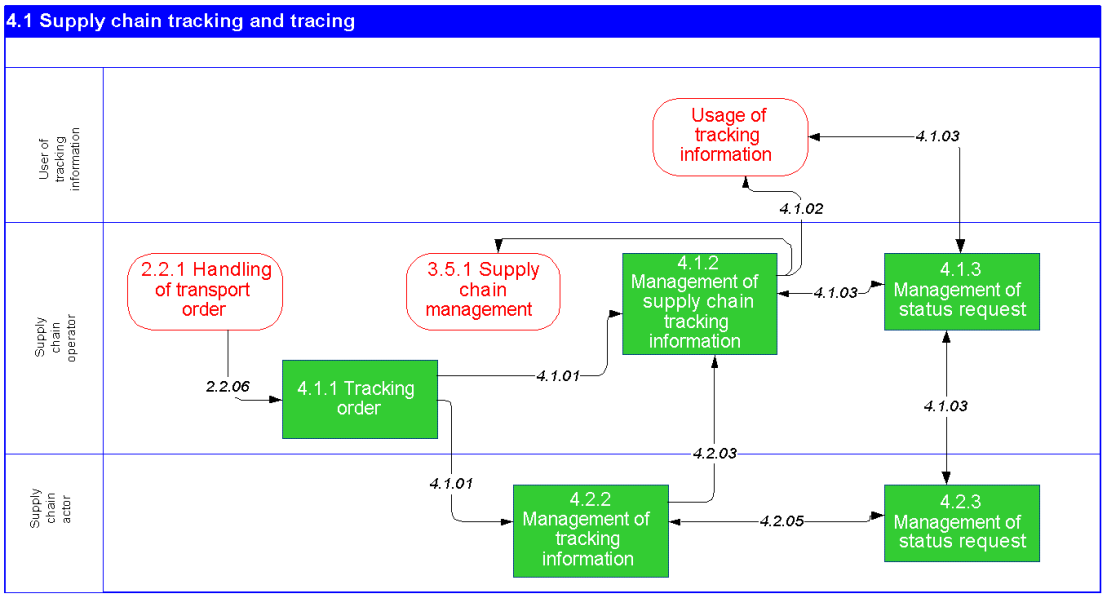


Figure 1. Process components and information flows of tracking and tracing in the supply chain.

A telematics (or information technology, IT) architecture is a tool for the integration of separate, company based information systems. This paper focuses on identification and tracking & tracing because development is moving fast in these fields at the moment.

OBJECTIVE AND METHODS

The objective is to clarify and analyse identification and tracking & tracing systems, which are in use or in development. Furthermore, interfaces to infrastructure and ways of operation are examined taking into account, among other things, the globalisation of trade and transports. The main purpose of the study is to propose themes for further research.

Explorative research was used in this preliminary study. Explorative research uses methods like literary research, interviews and observation (2).

Identification systems that include several commodity groups and parties examined in this paper require the acceptance and co-operation of all parties. Interviews with these parties have been carried out in this work with the purpose of specifying the wishes, demands and preconditions focused on by the different parties with regards to identification and tracking systems. The methods of companies in the tracking of packages have been analysed in workshops. The selected delivery chains were the food chain supply chain, uses standardised returnable boxes, and the delivery chain of technical wholesale. Furthermore, a third workshop, to which representatives from different branches were invited, was arranged. The aim was to discuss a common view to promote identification and tracking in the transport of goods.

The objective of the literature research in the project was to clarify the present state of the art of tracking and identification systems, and to look for information and experiences for the building of systems. An additional objective was to study the possibilities and obstacles in the development of tracking & tracing systems and the objectives and demands appointed by different parties to the systems.

The descriptions of current tracking & tracing systems in Finland were made on the basis of interviews and ready material. The interviews were performed using a prepared questionnaire in order to compare the answers. Between one and three experts per transport mode were interviewed.

The need for integration of the tracking & tracing systems of different transport modes and the needed circumstances for successful integration are defined according to two logistics experts' interviews. A prepared questionnaire was also used. These interviews were employed to define future research needs.

IDENTIFICATION

User needs

The users of tracking systems consider schedule information, which is when the goods are delivered, the most important. The real time location of the transport is less significant than schedule information. As the development of systems continues, versatile information about transportation circumstances (temperature, vibration, etc.) can be gathered in addition to location information. The objective of the tracking system is to improve service, create value added to the customer and to increase the efficiency of the company. Both data networks and mobile telephone networks are used for data transfer and transmission. Some pilot projects have utilised satellite communication. For both customers and the organisation the Internet is an interesting medium for data transfer due to its accessibility. The advantage of mobile telephone networks is the widely existing infrastructure and hardware.

On the basis of interest group interviews, the identification and tracking of handling units is uncommon nowadays and is mainly manually carried out. Only the biggest logistics service providers have advanced systems in use, which are mainly proprietary. However, the need for

intensifying the operation of supply chains requires the development of wide systems that contain several parties and commodity groups. However, opinions related to the scope and contents of identification and tracking systems vary. In its wider form, the system would cover the whole supply chain and all or nearly all commodity groups and supply chain actors. In addition to this information, the tracking system should also contain property data of goods information for the control of the supply chain operation. Only ID information would move with the handling unit, and other information would be in the background system.

The biggest obstacles in the development of the tracking system are the lack of operating models and shortcomings of the standards. Rapid technical developments also add uncertainty to the introduction of systems. In spite of these obstacles, the development of systems should be started.

Technology

The most important and used tracking and identification techniques are barcodes and RFID (Radio Frequency Identification). The barcode is the most widely used method but the use of RFID is increasing. The advantages of RFID are the reading/writing possibility and the fact that the system tolerates changes in environmental factors well and even damage. RFID is better suitable for automated identification than barcodes because the identification distance is longer, no visual contact is needed and the target can be in motion.

Cheap RFID tags with a long reading distance (over 2 meters) are not yet available in Europe. The lack of standards has hampered the introduction of RFID, especially in transport chains. If the methods used on the work floor can be changed so that the required reading distance is less than 1 meter, inductive systems can be used. In this case readers are embedded in the floor or hanging on the roof; and the handling units move either on a conveyor or pass through a narrow door.

In closed systems in which higher tag prices are allowed, active RFID tags can be used. Depending on the environment RTLS (Real Time Locating Systems) can be a better alternative to RFID. In RTLS the handling items are not identified by spot readers but through a local network of readers, covering the area of interest.

In Europe frequency regulations are tighter and the allowed transmission powers lower than in the USA. In the UHF frequency band, a reading distance of only one metre can be obtained in Europe, whereas in the USA 3-4 meter distances are obtained. The first practical applications can therefore be expected from the USA.

EAN.UCC (EAN International and the Uniform Code Council, Inc) and the RFID industry try to raise the UHF transmission power limit allowed in Europe. However, the first attempt did not succeed as there is hard competition with other applications in this frequency band. Passive UHF products that offer a longer reading distance (3-4 m) within the present regulations of Europe are appearing on the market. In the future flat and cheap batteries may also make disposable active tags possible and enable longer reading distances.

Recyclable boxes and roller cages belong to the most interesting targets for passive, long distance RFID systems. In the USA some pool companies already offer boxes and pallets with embedded RFID-transponders. With these they offer added value to their customers.

In the future the objective is to bring RFID to all consumption products (such as a barcode is nowadays). MIT's Auto ID Center has a vision of the "Internet of Things" in which to all objects an RFID-transponder is attached, which refers to an Internet address, which allows objects to discuss among themselves with a common language. This requires an extremely cheap tag. Nowadays the price of a tag is still about 30 cents but the objective is to get the price under 5 cents after 5 years.

Costs

The importance of the system costs and benefits has grown due to increased competition and risen transportation costs. Estimates of the costs of tags and systems vary quite much. Some experts have set a price objective of tags costing 5 cents within 5 years, but the feasibility of this objective is doubted by other experts. The RFID technique can be used to save time and costs, reduce risks and improve reliability.

The breakdown of investments in tracking systems, in which several parties are involved, have usually not been published. One can suppose that each actor is responsible for costs in so far as they are directly connected to their own infrastructure and equipment (the production plants, vehicles, etc.). However, the advantages obtained and the costs incurred are not necessarily directed to the same parties of the chain.

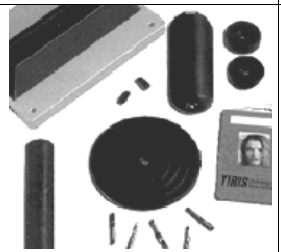
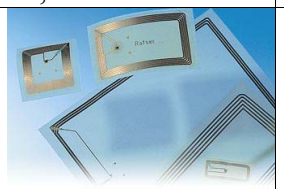
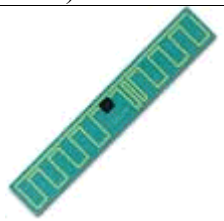
	Inductive 125 kHz, 134,2 kHz	Inductive smart label 13,56 MHz	UHF smart label 868 MHz (2,45 GHz)	UHF active tag 868 MHz (433 MHz)	Microwave active tag 2,45 GHz, 5,8 GHz	Chipless tags
Example tag	 Tiris tag www.tiris.com	 Rafsec smart label www.rafsec.com	 Intermec Intellitag smart label www.intermec.com	 Identec ILR tag www.identecsolutions.com	 Amtech tag www.amtech.com	 Checkpoint tag www.checkpointsystems.com
Passive / active	passive	passive	passive	active	active	passive
Reading distance	< 1 m	< 1,5 m (gate reader)	3-4 m (USA) 0,7 m (EU), 3-4 m (PALOMAR, EU)	4 - 100 m	8 - 20 m	
Price (example)	0,5 - 20 Euro	0,5 Euro	1 Euro 0,05 Euro (2005)	6 - 50 Euro	20 - 50 Euro	< 0,10 Euro
Multi-read	normally not	yes	yes	usually	sometimes	
Data transmission speed	slow				fast	
Reading through non-metallic materials	good	good	reasonably	reasonably	weak	
Example applications	access control animal identification	smart cards baggage identification, library, laundry returnable boxes	pallet identification	access control production control	container and vehicle identification toll collection (5,8 GHz)	restaurant tickets safe printing

Table 1: Properties of RFID–systems (3)

TRACKING AND TRACING

Main tracking & tracing systems currently used in Finland

In this study the following domestic systems are described:

- in railway traffic the RailTrace system of the Finnish Railways (VR),
- in air traffic the system of Finnair Cargo Ltd,
- in road traffic the systems of Kiitolinja/Schenker, SKAL (the Finnish Trucking Association) and the RoadNet system, and
- in waterborne traffic the PortNet system.

The descriptions are made mainly on the basis of interviews. The information also was obtained, for example from the Internet and brochures. A comparison of the tracking & tracing systems of these different transport modes is shown in Table 2. The PortNet system is not included in the comparison because a tracking & tracing service has not been developed for the system yet. PortNet is the only Finnish maritime information system, and tracking & tracing will be part of the system in the future. For that reason a short description is presented.

The following aspects were taken into account in the comparison of the tracking & tracing systems: geographical coverage, reference used in the system, method of identification, method of data transfer, the frequency of data transfer and the information given by the system.

	VR Cargo: RailTrace	Finnair Cargo	SKAL: SkalNet	Kiitolinja/ Schenker: Mobera	RoadNet
Geographical coverage	Finland, Part of Europe	World	Finland	Europe	Finland
Reference	Waybill number or other code	Waybill number or own keyword/figure	Own keyword/figure	Waybill number or other code or own keyword/figure	Waybill number or other code
Identification	Visual/manual	Barcode and/or RFID	Visual/manual	Visual/manual and/or barcode	Visual/manual
Data exchange	Internet, e-mail, EDI	Internet, Extranet, EDI, SMS	Internet, EDI, SMS	Internet	Internet
Data exchange frequency	Real-time, hour or day	Real-time	Real-time	Hour	Real-time
Given information	Location, time, status, estimated arrival time	Location, time, status	Time, status	Location, time, status	Location, time, status

Table 2. Comparison of tracking & tracing systems

The RoadNet and SkalNet systems cover only Finland geographically. In addition to Finland, the system of VR Cargo reaches some parts of Europe and in the future also to Russia. The Mobera system covers the transports of Kiitolinja and Schenker in Finland and the transports

of Schenker in Europe. Finnair is able to track its transports around the world by co-ordinating with its partners.

The waybill number is a very generally used reference. In the VR, Finnair, RoadNet and Mobera systems customers are able to follow transport information with the number of the waybill. In the SkalNet system the customer achieves tracking & tracing data on their own keyword/figure. Also in Finnair's Jetpak system the customer can follow the delivery by their own keyword/figure in addition to the waybill number. In the Mobera system different references can be used depending on the service used. The reference can be for example the sender's and the receiver's reference, or the address and the number of the declaration form or the reference of contract customers. In the RailTrace system the customer can use in addition to the waybill number the reservation number, wagon number or delivery number. The RoadNet system contains a customer number as an alternative to the waybill number.

The identification system of VR is partly visual/manual. RailTrace combines delivery and wagon information electronically but the wagon order checking takes place visually and the information is entered manually. The SkalNet system is mainly based on a visual inspection of the waybill and delivery. Barcode and other identification techniques are also possible to take into use if the customer wants. The tracing of the Mobera system is based on the barcodes of waybills but when they are missing, a visual inspection will be performed. The use of barcodes is partly manual because the necessary information about the delivery is written manually in the reading device. In the RoadNet system the deliveries are manually signed for the system with the help of a mobile device. Finnair uses RFID with a barcode for the identification.

In all the examined systems the tracking & tracing information is transmitted to customers and other users through the Internet, except in the Jetpak service of Finnair where the information is conveyed to customers through an extranet. In the SkalNet system an extranet can be used in addition to the Internet. The RailTrace system sends, if necessary, its customers a deviation report as e-mail. Information is transmitted to VR, Finnair, SkalNet and RoadNet systems using electronic data transfer. The information can be in EDI format for example. To the Jetpak service of Finnair and to the Mobera and SkalNet systems the information is transmitted with SMS (short message service) using the GSM network.

The Finnair, RailTrace (domestic transport information), RoadNet and SkalNet systems provide real-time information. In the Mobera system the information is updated at intervals of one hour. In the RailTrace system the information of foreign transports is updated with an hour or a day resolution.

All the systems give status and time information. The VR, Finnair, Mobera and RoadNet systems also give location information. The system of VR also reports the estimated time of arrival. None of the systems give environmental information such as temperature, humidity or pressure.

PortNet is a national maritime information system, which was developed for efficient and transparent information flow through the transport chain. The system is based on an extranet and information can be entered to the system on the web or by sending XML files or EDIFACT messages. PortNet serves different actors, such as ports, customs, shipping companies and maritime administrators. The system transmits information about maritime

transport, such as cargo and the shipper's manifest, arrival and departure times, and vessel information.

Integration of systems

The integration of tracking & tracing systems is still a relatively new matter, which is why empirical information about the operation of such systems is difficult to obtain. Interviews were utilised to clarify the need for integration, the benefits due to it and the technical, financial and administrative factors of integration. Two logistics experts were interviewed for the study. They were logistics manager Markku Henttinen from Indoor Group Oy, Finland, and project manager Joost Schafrat from ECORYS, the Netherlands. Also the experts interviewed related to the tracking & tracing systems presented their views.

Both in Schafrat's and Henttinen's opinion there is definitely a need for an integrated system. Henttinen sees the integration especially important when the merge-in-transit distribution model is used. Schafrat finds the integrated system important for door to door transport chains and first for transports delivering spoiling, high-value or time-critical goods. Both experts find the integrated tracking & tracing system needful for both customers and transport companies. Customers usually want information only about exceptions to the normal schedule, but when deviations occur the information given by the system can be important for customers. Lindholm (VR, EDI Management) and Voss (Finnair Cargo) also see a need for the development of an integrated tracking & tracing system.

In the opinion of Henttinen the benefits related to an integrated system are connected mainly to the reduction of logistics costs and to the improvement of service level. Schafrat finds the main advantage the fact that early notification of the parties involved about deviations will help to reduce the effects of delays further down the chain. Henttinen sees a risk also in the system: a lot of unnecessary information might be transferred, which creates unnecessary costs. Kullström (Kiitolinja) considers the fact that the real costs of the service have not been studied problematic.

Voss and Henttinen see the Internet as the only reasonable way to transfer information to customers in an integrated system. Henttinen sees the users of the system as its payers, but Schafrat sees the transport companies as payers. They might earn back some of the investment by including it in prices, and the rest should be earned back by efficiency. Standardisation is essential in Schafrat's opinion. He also thinks that a software or communication company would be the administrator of the system. Henttinen sees the users of the system as administrators. Schafrat finds it difficult to control the information flows to the satisfaction of all parties involved. Lindholm considers a common reference as a precondition for the integrated system.

CONCLUSIONS

It should be possible to read the handling unit IDs with more than one technology. The solution could be the combination of a barcode, RFID-tag and visual text. The data contents, data security and data protection of the system should be solved on the basis of needs that are defined in more detail by the parties involved. The activators of the introduction of such systems are probably big operators.

RFID–technology has already developed moderately far. Companies want affordable solutions, which do not impact the current work practices on the work floor. Pilot projects have shown that RFID-technology is not completely ready for large-scale practical applications in which low investment costs, reliability demands, faultless data transfer and sufficient reading distances are emphasised. The main question is the interoperability of tags as well as readers. The companies that operate in the area should indeed continue towards more practical solutions.

A central question at the moment is how it is worthwhile for the companies to proceed in their development of tracking systems. On the basis of the study one can state that there is no single identification system, which all the business branches could accept in Finland. The simple explanation is the considerably different technical needs and demands of the business branches at different stages of supply chains. As a recommendation to companies the branch-specific (or a few branches' common) initiatives, global standards and solutions are recommended. For example the GTAG-initiative seems to be, from the point of view of the retail business, an interesting and possible solution.

On the basis of the logistics experts' interviews it can be concluded that there is a need for an integrated tracking & tracing system. Some of the possible advantages could be the quick reaction to changes and minimisation of the drawbacks caused by changes. Also it might be possible to decrease logistics costs. Standardisation, common reference and easy connectability to other systems are the probable preconditions for an integrated system. In this study only two logistics expert interviews were carried out, which is why it is difficult to conclude the general definitions of the policy of an integrated tracking & tracing system. However, the results give good viewpoints for further studies.

According to the interviews there is a need for an integrated tracking & tracing system that covers all transport modes. There must be demand too for the reasonability of the system. To clarify the matter market research should be performed. The research would map the demand of the system users, the supply of service providers and the needs more extensively than in this preliminary study. The demand and supply must meet so that the service to be developed would be rational. The study should clarify what kind of information different parties need, for what kind of transportation and how they would like to have access to the information.

In a normal market economy system services and systems are developed if they are profitable and they increase shareholder value. For large-scale global players it is relatively easy to gain profits and win back the investments needed for integration. Real global integration requires however the participation of all actors. Thus, it would be essential to develop an operations model for an integrated tracking & tracing system, which would be cost-effective, even in

small geographical areas and with low volumes. The real costs of the integrated system should be estimated too.

Only Finnair's system of the studied tracking & tracing systems has world-wide coverage. This is due to co-operation with other airlines and an air cargo communication provider called Traxon. Several forwarders are also using Traxon's services (4). Railinc is a North American corporation that provides information technology systems and services for the railroad industry (5). Railinc for example performs tracking & tracing services on more than 330 railroads in the US, Canada and Mexico (5). CROBIT is an ongoing EU project, which concentrates on the development of a common information system for European railways. A lot of excellent information systems exist, but commercialisation seems to be problematic. Air traffic and rail traffic have currently the most developed systems regarding commercialised information integration. Thus, it would be essential to benchmark the connected airlines and forwarders, and the North American railroad industry in order to develop an integrated system for all transport modes globally.

REFERENCES

(1) Transport telematics-architecture. FITS publications 20/ 2003. Ministry of Transport and Communications, Finland.
(2) Järvenpää, E. & Kosonen. K. 2000. Johdatus tutkimusmenetelmiin ja tutkimuksen tekemiseen. Otamedia Oy. Espoo.
(3) Tracking and Tracing of Freight Transport. 2002. Technical Research Centre of Finland, Building and Transport, Transport and Logistics, Research Report RTE4059/02.
(4) Traxon. [online]. [Referred 16.08.2002]. Available: http://www.traxon.com.
(5) Railinc. [online]. [Referred 22.10.2002]. Available: http://www.railinc.com.

Interviews
Anttila, Mika. Finnish Trucking Association. 1.8.2002
Arkima, Antti. Finnish Maritime Administration. 30.9.2002
Henttinen, Markku. Indoor Group Oy. 8.10.2002
Kinnunen, Kati. Kiitolinja Oy. 12.8.2002
Kullström, Tom. Schenker Oy. 12.8.2002
Lindholm, Kimmo. Oy EDI Management Finland Ltd. 23.7.2002, 29.7.2002
Schafrat, Joost. ECORYS. 30.9.2002, 21.10.2002
Voss, Kristian. Finnair Cargo. 16.8.2002
Wahlström Juha-Pekka. Roadnet Finland. 23.9.2002