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Innovative Use of IT in Logistics: An Integrated Transport Tracking System Example

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Abstract

In the search for competitive advantage, organisations have recognized the potential significance of their logistics processes. They see improved customer orientation and the use of information technology (IT) as means of strengthening their market position. An example of this is a new logistics concept, 'efficient consumer response' (ECR), which covers both physical and information logistics, and which is being employed internationally as an element in attempts to respond effectively and efficiently to changing market conditions.

In the last five years, EURO-LOG has established itself as an inter-organizational logistics service provider focusing on information logistics. The company's success exemplifies a growing tendency towards specialised service providers covering small segments of newly evolving markets.

This paper describes the core principles of ECR and the resulting requirements for, and potential of, information logistics in transportation processes. This case study analyses the operation and contribution of the company's main product, TRANSPO-TRACK, an integrated transport tracking system that aims at more transparency and efficiency in the logistics chain. The potential of this type of service is discussed and the benefits identified. As an example of an inter-organisational system, the impacts on organisations at different points in the value chain of TRANSPO-

TRACK are identified and the need for appropriate planning processes highlighted. Lastly, the possibility of provision of information logistics services on the Internet is assessed.

Introduction

Increasing competition requires cost-optimized production, services and distribution as indispensable components of market success. The economic impact of logistics is increasing; transparent and efficient internal and external processes are seen as major success factors.[1] Hence, effectively and efficiently managed data and information exchanges - 'information logistics' - along the logistic chain are becoming crucial (Szyperski, 1990; Szyperski and Klein, 1993a and 1993b). In transportation, global integration and deregulation have increased competition and transport and logistics service providers[2] perceive a need to streamline their internal operations in order to remain competitive compared to in-house alternatives.

Efficient Consumer Response: Meeting Logistics Challenges

Following the success of electronic data interchange (EDI)3 -efficient consumer response (ERC) concept in the US, a group of large European wholesaling and retailing companies[4] founded the ECR Europe Executive Board in 1994, in order to sponsor research investigating the applicability of ECR and to co-ordinate the steps necessary to implement ECR in Europe[5].

ECR aims to offer increased customer service and cost reduction in the logistic chain. It streamlines internal operations, as well as enabling better co-operation of

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[1] About 70% of Europe-wide operating companies are currently in the process of reengineering their supply chain, and another 15% are in the planning stage, see Business Europe, ed. (1996).

[2] The term transport service providers refers to the physical transport of goods, while logistics service providers are related to information logistics.

[3] Electronic Data Interchange.

[4] Board members from industry include Cocal Cola, Johnson & Johnson, Kraft Jacobs Suchard, Mars, Nestlé, Procter & Gamble, members from wholesaling and retailing include Asko, Auchan, Alber Heijn, Promodes, Rewe, Safeway, Tesco. Their first ECR conference, held in Geneva at the beginning of 1996, attracted more than 1,200 participants and drew considerable attention.

[5] The study covered 20 companies in seven European countries.

independent supply chain partners and, thus, enhances an organisation's responsiveness to the changing needs of consumers (see, for instance, Gerstner, 1996; Huguet, 1994).

Streamlining addresses the primary difficulty in the transport sector: the logistic chain often consists of many independent partners that need to be co-ordinated. Thus, integrated transport systems exemplify the need for critical mass - true value-added can only be achieved when many partners are connected to the system. Hence, the success of ECR depends largely on the proportion of industry players engaged in ECR-related activities. So, the wide adoption of ECR is an important prerequisite for efficient supply chain redesign (Mathews, 1994).

Beyond increased transparency of transport processes, ECR comprises improved category management and seamless product replenishment. Category management refers to an organisation's response to customer needs, differentiated according to product categories that show similarities and thus may offer economies of scale when treated similarly. Logistics systems can provide the required transparent logistics processes by enabling the initiator of a shipment to find out where the merchandise is at any time. This demands comprehensive information acquisition and analytical instruments to access product-related transport information. Seamless *product replenishment* provides opportunities for increased efficiency in sub-processes of the logistic chain. It includes automated store ordering, continuous replenishment, cross docking, integrating suppliers by synchronizing production and actual demand, and increasing the reliability of operations (GERSTNER, 1996; GARRY, 1994).

Logistics Service Providers

At present, only a few German transport service providers and their clients use EDI. WECKER (1996) of transport and logistics service provider Dachser, estimates that, at most, 5% of their clients communicate via EDI. According to a 1995 study by the national logistics organization (BUNDESVERBAND SPEDITION UND LAGEREI, BSL) only half of logistics service providers use electronic data transmission facilities, and of these a mere 15% rely on the international standard, EDIFACT (ERNST, 1996). A COOPERS & LYBRAND (1995) study in the food industry supply chain concludes that the potential for cost reduction amounts annually to US$27bn. Further, the study foresees inventory reductions of more than 40% with the application of innovative logistics concepts.

Since the potential for cost reductions in handling physical products is often felt to be fully exploited, competitive advantage is mainly expected from information management and from uninterrupted flows of information between transport chain members - manufacturers, wholesalers, retailers, logistic services providers and customers (Venkatraman, 1991; Fawcett and Clinton, 1996). IT systems which address interface problems, support the efficient input of transport-related product information, and reliably transmit and provide information ready for customized analysis are available, but are still insufficiently implemented (Peel, 1995).

Research (for example, Malone and Rockart, 1991; Klein and Kronen, 1993; O'Callaghan and Turner, 1995) and detailed market studies (e.g. on-site investigations with Calberson, Dachser, Schenker, Thyssen Haniel Logistics, BMW, and Deutsche Lufthansa) identify, but do not limit, the information needs in the logistic chain as follows:

- a single data input,
- information arriving before the goods,
- information regarding delivery status accessible at any time,
- immediate notification of delays or other delivery problems,
- integrated communications services to all members of the logistic chain,
- integration of existing data processing and communication/data exchange systems,
- interfaces to other logistics networks such as air carriers or cargo community systems,
- communication/data exchange at least across Europe, ideally globally.

State-of-the-art IT for ECR

Efficiency enhancements in logistics require integrated planning across all members of the logistics chain on the basis of complete availability of transport-related product information (KLEIN, 1992). Highly detailed information about any single article at the level of the stock keeping unit has to be entered, stored and made accessible for analysis. A successful information logistics system includes:

- EDI providing for direct data exchange through electronic transmission
- Electronic Funds Transfer (EFT) allowing simplified payment procedures through data communications networks
- Activity based costing relating cost information to costs sources
- Article-numbering and bar-coding for identification and addressing of goods

- Databases to store, manage and analyse the collected information in an efficient manner

Installing such IT components without an integrated approach to change will not lead to the expected advantages (Galliers, Swatman and Swatman, 1993). Unless material handling systems, vehicle routing systems or other contemporary IT systems are integrated into the inventory management, order management, and manufacturing scheduling systems already in place, the supply chain will be more costly than necessary (Colabello, 1995).

Implementation of IT to support efficient product replenishment may lead to structural changes in the chain of specialized supply partners. With continuous replenishment, orders are no longer generated by the retailer, but by the manufacturer who is in constant information and data exchange with the retailers and takes responsibility for replenishment at the distribution centers of the retailers (Andel, 1996).

To provide a common basis for the information needs in the logistic chain, the EAN identification and bar-coding system[6] was developed. Now widely used, it comprises components to identify goods at the stock-keeping unit and provides complete transport information from sender to final addressee along all intermediate switching stations. EAN standards allow international identification of products, facilitate electronic data interchange and provide the basis for using bar coding and scanning technologies. The economic value of complying with these standards lies in the reduced need for multilateral co-ordination between manufacturers, logistics services providers and retailers within the logistic chain.

EURO-LOG: A Case Study

Overview

EURO-LOG B.V.7 headquartered near Amsterdam, was founded in 1992 as a subsidiary of EUCOM, a joint venture of Deutsche Telecom and France Télécom,

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[6] The EAN coding system was developed by the International EAN Organization (Article Number Association, 1996).

[7] Company with limited liability according to Dutch law.

together with Digital Equipment Corp.8 Other shareholders are TMG, a private consulting firm, and the Belgian and Dutch PTTs. About 120 employees work in EURO-LOG's subsidiaries in Germany, France and the Netherlands; 1995 turnover amounted to some DM 15 million.

EURO-LOG concentrates on the logistics and transport industry. It offers integrated communications and information services along the logistics chain. All members of the transport chain, i.e. suppliers, manufacturers, distributors and customers, can receive the information they require as shown in figure 1.

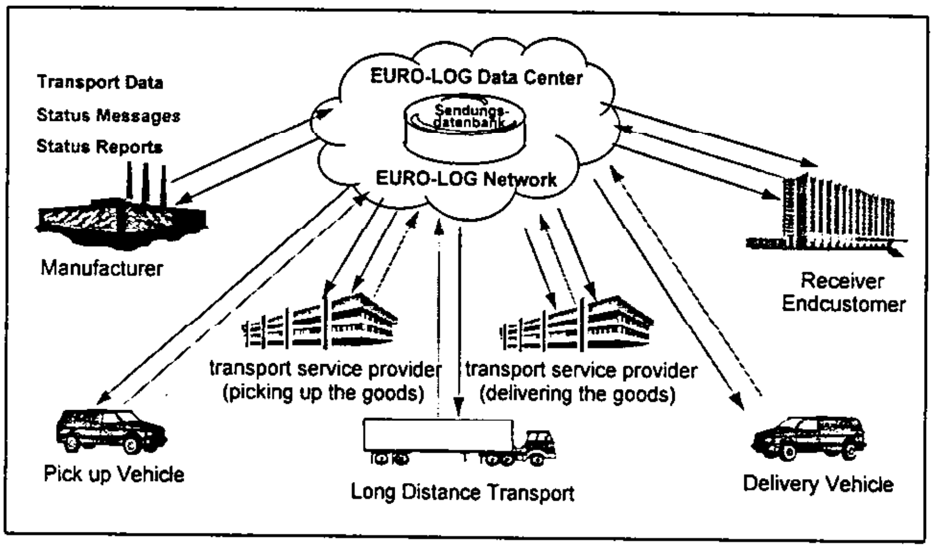

Figure 1: EURO-LOG data flows

EURO-LOG supplies all necessary hard- and software. The hardware includes furnishing trucks with scanners and on-board computers for processing voice and data, and providing at least one workstation for each member of the logistic chain. Any member of the chain is a potential customer - distributors interested in streamlining their internal operations, as well as manufacturers or their customers (e.g. retail chains) who need to access transportation information.

[8] EUCOM holds 85%, Digital 15% of the shares.

EURO-LOG plans to introduce integrated logistics service centres covering all Europe by the end of 1997, where customers will be served in their national language. Expansion into Eastern Europe is intended too.

The wholly-owned, German EURO-LOG subsidiary is headquartered near Cologne. It started operations in July 1993, since when the number of employees has increased three-fold to about 30. The following discussion focuses on EURO-LOG Germany as an example of the operation of such systems.

TRANSPO-TRACK

TRANSPO-TRACK is an integrated approach to overcoming technological and informational gaps at the interfaces of the logistic chain to provide seamless tracking and tracing of transport. Incompatibility between heterogeneous information systems of independent in-house solutions is overcome through data conversion to a common standard. TRANSPO-TRACK is based on EDI. A manufacturer who receives a request for merchandise from a customers sends the shipping order in its original data format via the EURO-LOG network to a selected logistic services provider. Any necessary data format conversion is undertaken by EURO-LOG (see Figure 2).

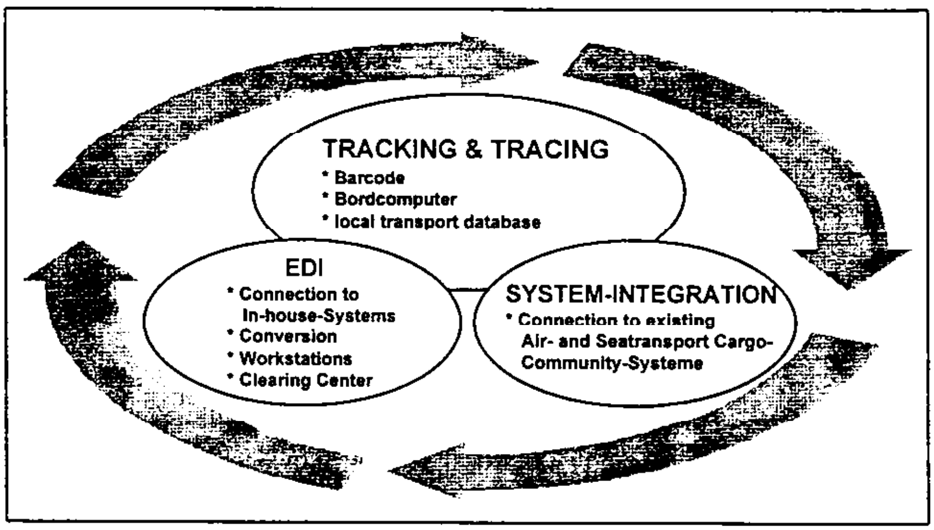

Figure 2: Integrated TRANSPO-TRACK approach

TRANSPO-TRACK enables information exchanges in the logistic chain. Information is made available at the shipment, parcel and article unit level. The integrated package comprises an electronic data interchange component converting data to and from any format, a gateway for the integration of 'island solutions' in combined transport,[9] and a system which enhances those already in place at the partners' sites by adding mobile communication facilities.

The integrated TRANSPO-TRACK system is built on six components:

- *EURO-LOG's computing centre* provides access to the complete logistics information for all members of the transport chain and maintains the central data processing and conversion facilities.
- *a data communications network* (ISDN and X.25) serves as the data transmission backbone for EURO-LOG services.
- different GSM mobile communications networks provide the infrastructure for the mobile data and voice communication service.
- *office workstations* provide interfaces between the clients' in-house systems and EURO-LOG's computing center. The workstations allow the maintenance of local data warehouses and the planning and co-ordination of transport orders.
- *warehouse workstations* at the switching stations along the transport route in combination with scanners receive, process and deliver freight status information.
- *mobile computing units* on board trucks serve as input devices for freight and transport information through bar code scanning and process this information for transmission of status control messages. For this, unique identification numbers and bar codes according to the EAN coding and identification system are provided.

Inter-Organizational Information Logistics

Load Preparation

The first step, before actual transportation, is the input of order information at the manufacturers', distributors', or logistics service providers' site. Here, the information needs of transport chain members' are selectively taken into account.

[9] 'Combined' transport refers to transports that combine more than one transport medium, e.g. a combination of truck and railway transportation. Combined transports often comprise several independent carriers to be coordinated by the logistics service provider.

The order information, which is the basis of the tracking system, may either be keyed in manually or imported and converted from electronic documents in in-house formats. Changes can be made manually and repeated processes enhanced through the use of templates.

The system assigns a unique transport identification number to each transport unit. The client can rely on a firm-specific bar code or switch to the EAN 128 standard. Transport information is then transmitted from the client to the central system from where it is distributed to all office workstations selected at the beginning of the process. The addressee data set can be adapted continuously to changing information needs.

Then, transport data is sent from the office workstation either to the computer on board the truck or to a warehouse workstation which can be locally connected to the on-board computer as soon as the truck arrives at the manufacturer's or shipper's site.

Information Regarding Load Status

Meanwhile, bar code labels are printed and the merchandise assembled for loading. The driver scans the bar code labels and loads. During data scanning, the mobile computing unit processes the information and controls for completeness of the shipment.[10] In the case of wrong or missing items, an alert, audio or visual, appears. During data sampling, criteria such as transport volume, transport unit (truck, rolling card, container), and sender or addressee are applied; they provide the basis for subsequent access to information at any level of detail from the warehouse workstation or from the mobile unit. Finally, load status information is transmitted to EURO-LOG's computing centre, either from the warehouse or directly from truck's on-board computer. Transport information is ready to be distributed to the selected transport chain participants - automatically or upon request.

Intermediate Delivery Status

At each switching or cross-docking point along the transport route, the shipment is scanned again, and updated status control information is transmitted. Thus, each switching of transport media, from first upload to final delivery, is accompanied by a status document generated by the agent responsible.

[10] Alternatively, if the truck has no on-board computer, the bar code labels are only scanned, with the data being transmitted to the warehouse workstation for status control when the scanning process is completed.

Transport and Error Status Information

Participants of the logistics chain are informed of the current status of their transport continuously or only in case of errors or delays, as they wish.[11] Error status can be accompanied by further information as to the cause, for example, completely or partially missing or broken contents. This information can be delivered as menu-defined standardized error messages or as more detailed descriptions that are supplied manually. In case of delays which lead to missing predefined time slots such as a fixed upload, switch or delivery date, the system automatically sends an error message to selected participants.

Obtaining Intermediate Status Information: Tracking and Tracing

Tracking and tracing can be done from the local office workstation through a request for transport status information directed to the computing centre. The information is based upon larger transport units such as a truck, container or parcel but can also be retrieved on a per item basis.

Mobile Voice Communication

The system also provides mobile voice communication facilities. All participants in the transport chain are always connected. Messages are stored in a mailbox for when a truck is temporarily out of reach of radio frequencies or is unconnected during scanning. Continuous connection is useful, for example, in case of traffic jams - the logistics service provider can contact the driver of the truck and provide redirection. Transport routes can be altered immediately. If the hardware fails at the computing centre, communication is not interrupted since the GSM system also allows voice communication.

Final Delivery Status

Upon arrival at the customer's site the driver downloads the shipment. In order to extract the final delivery receipt he scans the bar codes again. The data is automatically compared with the mobile unit's internal transport information. The final delivery status is sent via GSM directly or via fixed networks through the warehouse workstation and is forwarded to the other transport chain members. The companies' accounts receivable departments can invoice the customer immediately

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[11] In case of a hardware failure, fax delivery of information on a 'need-to-know'-basis is guaranteed.

upon delivery of merchandize, and logistics and transport service providers write their bills on the basis of proof-of-delivery status information.

All transport-related information remains available on-line for seven months and information is archived for an additional seven years on external storage media.

Cost-Benefit-Analysis

Analysing the benefits of IT systems, particularly when they are regarded as infrastructure, is very difficult (POWELL, 1991). Often this complexity is used as an excuse not to evaluate. While accepting that such calculations are approximate, this section provides the elements of a cost benefit analysis to show that it can, and should, be attempted.

Overview

Implementing the system requires an initial investment of about DM 5,000 for each mobile computing unit in the truck including telephone, software, scanner and modem, and a DM 50/month license fee. Initial investment for workstations amounts to about DM 3,000 each. A DM 100/month license fee per piece of equipment is also incurred. Each shipment costs an additional DM 1.0-2.0 depending on the level of transport information requested.. Table 1 shows the main benefits that the system delivers.

Manufacturers benefit from a reduction in the time span between delivery and invoicing. Further, in the case of delivery errors responsibilities can easily be assigned since the system allows trace back to the problem's first appearance (precise liability assignment[12]). Customer complaints and information requests can be processed and answered easily and immediately. In sum, the continuous flow of information leads to improved liquidity, better customer service, and reduced inventories (see also LOEBBECKE, 1996).

[12] Such limitation of liability accounts for considerable reductions in insurance payments in the medium term, thus further reducing costs.

Benefit	Manufacturer etc.	Transport Services Provider	End-Customer
Better information basis for dispositions		√	√
Increased staff productivity		√	√
Reduced inventories	√		√
Reliable and early invoicing	√	√	
Increased efficiency of data handling	√	√	√
Enhanced customer services	√	√	
Inexpensive and fast tracking of status	√	√	√
Easier communication along logistic chain	√	√	√

Table 1: Benefits to different partners in the logistic chain

The *transport service provider* improves internal operations and reduces paperwork. Freight data is entered only once, and in most cases this is automated by importing the information from the manufacturer's or the distributor's in-house system. Thus, input costs and sources of error are minimized. Improved route planning reduces idle periods in combined transport systems. Continuous communication with drivers leads to better use of transport facilities and higher load quotas as well as minimizing wrongly directed transports.

Timely and accurate information about delays or missing items enables end-*customers* to request additional delivery, find alternative sources for vital items, or even cancel a whole, erroneous order. Integrated international communication reduces preparation and post-delivery analysis of transports.

A transport tracking system that provides information according to a 'need to know'-principle helps all chain members react in a timely and flexible manner in case of delivery problems. [13]

[13] EURO-LOG initial investment to develop the TRANSPO-TRACK system amounted to approximately DM 200 million.

Cost Benefit Example[14]

This example takes the case of a large customer over a medium-term planning horizon of five years, assuming an annual transport volume of about 2.5 million units, increasing by 6% over five years. The company has 7,500 employees, likely to increase by 1.2% per year or 20% of the transport volume respectively in case of an in-house transport tracking solution (internal customer calculation). With the implementation of TRANSPO-TRACK, no additional personnel are required upto an increase to 3 million transports per year. Increases above that level require more personnel at the same rate as in-house solutions.

Initial investment for 100 stationary and 500 mobile computing units amounts to DM 2.8m, the license fees sum to about DM 2.52m over the five year period. Variable transport costs will reach an estimated DM 21m (see Table 2).

These numbers reveal a potential cost reduction during the five year period, which - based on an estimated total of 17.5 million transports - accounts for approximately DM 3.10 savings per transport. With average costs per employee of DM 65.000 per year, the system provides savings of more than DM 49.15m compared to an in-house system.

These figures do not account for competitive advantage through better customer service nor for additional monetary advantages through easier limitation of liability such as lower damage compensation payments and reduction in insurance payments. If these benefits are included, cost savings might average DM 5.20 per shipment.

Further Issues

Although the calculations in Table 2 look attractive, there are further issues which need attention. TRANSPO-TRACK is an example of an inter-organisational system and current work suggests that such systems may impact differently on the members of a value chain. Further, most organisations do not plan for IOS in a way which acknowledges these systems' inter-organisational consequences (Loebbecke, Powell, 1997).

[14] The following calculation has been developed in co-operation with a large EURO-LOG customer.

Basic Data (all figures in DM)							
Transport p.a. (units)	2,500,000						
Increase in transport p.a. (%)	6						
Employees (at beginning)	7,500						
Cost per employee p.a.	65,000						
Cost per order entry (IHS)	0.45						
Needed TT mobile units	500						
Needed TT stationary units	100						
Customers to be connected via EDP p.a. in % (max. 75%)	5						
Connected customers in % (Data entry cost = 0)		0	5	10	15	20	25
Licence fee p. TT mobile unit p.a.	600						
Licence fee p. TT stationary unit p.a.	1,200						
IHS: Employ. increase dep. on %-incr. in transport	20						
TT: Employ. incr. dep. on %-incr. in transport	(<=20% more transport = 0, >20% more transport like IHS)						
HW cost p. TT mobile unit	5,000						
HW cost p. TT stationary unit	3,000						

Example Calculation									
Year		0	1	2	3	4	5	Cost TT	Cost IHS
Transport units		2,500,000	2,650,000	2,809,000	2,977,540	3,156,192	3,345,564		
Employees	TT	7,500	7,500	7,500	7,500	7,590	768		
	IHS	7,500	7,590	7,680	7,773	7,867	7,961		
Employee cost	TT	437,500,000	487,500,000	487,500,000	487,500,000	493,350,000	499,270,200	2,942,620,200	
	IHS	437,500,000	493,350,000	499,270,200	505,261,442	511,324,580	517,460,475		3,014,166,69
Data entry cost	TT	1,125,000	1,132,875	1,137,645	1,138,909	1,136,229	1,129,128	6,799,786	
	IHS (0,45 p. unit)	1,125,000	1,192,500	1,264,050	1,339,893	1,420,287	1,505,504		7,347,23
Variable cost	TT (1,20 p. unit)*	3,000,000	3,180,000	3,370,800	3,573,048	3,787,431	4,014,677	20,925,956	
	IHS (unrealistic, but safe assumption)	0	0	0	0	0	0		(
Licence fee	TT	420,000	420,000	420,000	420,000	420,000	420,000	2,520,000	
Hardware cost	TT	2,800,000	0	0	0	0	0	2,800,000	
Total								2,972,865,942	3,022,013,930
* 3 status reports à 0,40 per unit									
				Cost difference in favor of TT:				-49,147,988	

Table 2: Exemplatory Cost Benefit Calculation:

Work by Finnegan et al (1996) suggest that there is general agreement among organisations as to their desired results from inter-organisational systems planning, and how they believe it should be conducted. However, the majority of organisations experience difficulties and the research illustrates the need for IOS planning guidelines. In general, Finnegan et al's study reveals an over-reliance on traditional IS planning approaches for IOS. This is a concern as IOS planning concepts are fundamentally different from their internal counterparts but predominance of internal planning approaches is likely to result in inadequate support for IOS planning. In the present context, the use of a services provider and the ability of the system to integrate disparate in-house solutions mitigates some of these problems. However, it is unlikely that all participants will benefit as fully as they might from this system.

Golden and Powell (1996) seek to measure the extent to which flexibility has been enabled within all those using IOS. They suggest that larger organisations are significantly more likely to achieve organisational flexibility than smaller ones. Organisations who initiate the adoption of IOS achieved significantly better levels of flexibility. These organisations are also more likely to succeed in integrating their IOS software with their existing software. The research shows that those who initiate the IOS are much more focused and have clear goals in mind. These goals are targeted at improving customer service, while decreasing costs and gaining a competitive advantage - just the benefits that TRANSPO-TRACK aims to deliver.

Golden and Powell also suggest that, while IOS are becoming a relatively mature technology, organisations are still experiencing problems in messaging standards and transmission methods. The messaging standards currently being used are believed by most organisations to be adaptable to foreseen circumstances. However, few organisations believe that messaging standards can be changed rapidly in response to unforeseen circumstances (LOEBBECKE, JELASSI, 1994). The standards used are seen to be flexible within the confines of what has been anticipated - outside the realms of what is expected they are seen as inflexible. One route forward which may allow flexibility and also mitigate some of the planning problems is use of the Internet.

Information Logistics via the Internet

Some industry experts (for example, Martin, 1996) predict the development of full-service logistics management companies that meet the demand for single-source services by integrating internet capabilities. The Internet offers logistic service providers opportunities to streamline intra- and inter-organizational processes and to increase customer satisfaction. Customers could access current information on freight rates, tariffs and schedules, find out about delivery time requirements and transport costs, and decide on the appropriate transport medium without a large investment.[15]

From the logistics service provider's perspective, critics claim the Internet to be useful only if customer contact is sporadic and transport volume low. Transport tracking systems require considerable initial investment, yet their full amortization and profit potential is realized only with a large installed customer base. If larger quantities of data are exchanged among logistics partners over an extended time period, traditional data transmission networks using modem or ISDN are still considered faster and more reliable. The intent to maintain long-term relationship between co-operating logistic partners has been widely discussed as an important variable in the EDI adoption process(see, for example, Bjřrn-Andersen and Krcmar, 1995; Walton, 1994; Emmelhainz, 1993; Swatman and Swatman, 1992).

However, integrating the Internet into the logistic chain may contribute to attaining critical mass by opening new market segments, that is, gaining numerous sporadic, low volume customers at low marginal cost.

Following the above, EURO-LOG is pursuing a parallel strategy. Large customers are served by providing direct transmission and communication connections to the logistics services provider's computer system, while customers with less intense information requirements may choose to be served via the Internet (KRUEGER, 1996a). EURO-LOG consequently provides conversion into a format transmittable across the Internet as well.[16] What role the Internet will play in the business in the medium term is yet to be assessed. However, soon, in the transport service sector, the current competitive advantage is likely to turn into a competitive necessity.

[15] Express transport services providers such as Federal Express (FedEx), United Parcel Service (UPS), or DHL Worldwide Express already use the Internet to provide their customers with access to status information regarding their transports. By submitting a particular transport identification number, customers can obtain information as to where a specific package is at a specific point in time or when it has been delivered to an intermediate post. To ensure data security, customer identification numbers and passwords are used. Customers value the service high - FedEx reports 12,000 daily requests worldwide for transport information (KRUEGER, 1996b)

[16] EURO-LOG also provides for security mechanisms such as authentification and data cryptography that protect the internal company network as well as the data to be transmitted.

Conclusion

The system described in this paper is an example of current state-of the-art logistics services, making information available on a 'per transport' as well as 'per unit' basis. Such systems are especially valuable in industries where accurate and timely delivery is crucial - the pharmaceutical and chemical industries or in automobile manufacturing (for, for example, just-in-time production). However, obtaining full benefit from such an IOS system requires appropriate planning and the benefits may fall differentially on the members of any logistics chain.

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