RECENT TRENDS IN LOGISTICS AND THE NEED FOR
REAL-TIME DECISION TOOLS IN THE TRUCKING INDUSTRY

Jacques Roy
Department of Management and Technology
Université du Québec à Montréal
C.P 6192, Succursale Centre-Ville
Montréal, (Québec) Canada H3C 4R2

Tel.: (514) 987-3000 ext. 3685
Fax: (514) 987-3343
E-Mail: roy.jacques@uqam.ca

Abstract

For the last ten years or so, the freight transportation industry has been facing new challenges such as time-sensitive industrial and commercial practices as well as the globalization of markets. In response to these changes, new information-related technologies have developed rapidly: Electronic Data Interchange (EDI) and the Internet, Global Positioning Systems via satellites (GPS) and Decision Support Systems (DSS). These technologies can greatly enhance the operations planning capability of freight carriers in as much as they make use of this information in order to optimise their operations. GPS, EDI and the internet can also provide the necessary information required to achieve real-time computer-based decision making using appropriate operations research techniques. Today’s decision support tools must therefore be designed to be used in a real-time environment. This paper describes this environment and proposes optimization tools that can be made available to motor carriers.

1. Introduction

During the last decade, the freight transportation industry had to face new challenges as a result of important changes affecting supply chains and logistical processes. The first change may be attributed to the impetus toward inventory reduction which led to “Just-In-Time” procurement practices and, more recently, to “Quick Response” or “Efficient Consumer Response”, that is the just-in-time replenishment of goods in the retail industry. The procurement and distribution of goods has also been significantly influenced by the recent trend toward the globalization and liberalization of markets. This has led to free trade agreements between countries over wide geographical regions such as the European Union and the North American Free Trade Agreement (NAFTA). These changes have resulted in increased demands for electronic trade and specialized logistical services such as “Third Party Providers”. And with the advent of electronic commerce, “Business-to-Business” and “Business-to-Consumers” practices are now very much part of the motor carriers environment.

As a result of these changes, the freight transportation industry has had to recognize the importance of information technologies in order to enhance its capability to respond to the needs and requirements of its customers. For the last ten years or so, new information-related technologies have developed rapidly: Electronic Data Interchange (EDI), Internet, and Global Positioning Systems via satellites (GPS) to name a few. These technologies can greatly enhance the planning capability of freight carriers in as much as they make use of this information in order to optimise their operations. GPS, EDI and the internet can provide the necessary information required to perform real-time dispatch using appropriate operations research techniques. With on-board computers, motor carriers can be informed of the content of pick-up vehicles before they reach the terminal. They can therefore decide what is the best door assignment rule for these trucks in order to minimise freight handling. They can also revise work scheduling and more importantly the load planning of highway vehicles on a daily basis, thus generating major savings while providing high levels of service to customers. Several of these tools were initially developed as tactical or
operational planning tools. Today’s decision support tools must be designed to be used in a real-time environment.

This paper provides a review of recent trends in logistics and of their impact on motor carriers. The next section describes the typical operations of a motor carrier. Then, the more “traditional” tactical and operational planning tools are quickly reviewed before we finally describe the set of real-time decision tools that are required in today’s trucking industry.

2. Recent trends in logistics and their impact on the trucking industry.

We now introduce some of the most important recent trends in logistics, or what is now more commonly named Supply Chain Management, and discuss their impact on the motor carrier industry.

2.1 The increased use of time-sensitive strategies in both manufacturing and commerce

This trend originated in the 1970’s with the advent of Just-In-Time (JIT) practices in the manufacturing sector as a reaction to the successes recorded in Japan by companies such as Toyota. Its philosophy rests on the elimination of waste and focuses on the reduction of production set-up times and inventories in the supply chain. Although JIT practices have been around for several years now, its application is still growing today and it is expected that as much as 60% of all shipments will be ordered Just-In-Time in the United States in year 2000 [1].

During the 1990’s, the JIT philosophy has extended to the physical distribution of finished goods from manufacturing facilities to retail outlets and through distribution centres. This has led to new practices known as Continuous Replenishment Programs (CRP), Quick Response (QR) and Efficient Consumer Response (ECR). CRP defines the practice of partnership between members of a distribution network that modifies the traditional approach of replenishment based on customer orders to a replenishment strategy based on both the actual demand at the point-of-sale (POS) and sales forecast. The sharing of POS information with suppliers is a critical aspect of these new practices. Other key elements include: shorter reaction times; more efficient logistics networks based on faster transportation means, cross-docking and more efficient in-store reception methods; using electronic data interchange (EDI) or internet in combination with bar coding; emphasis on Total Quality Management and Continuous Improvement practices; activity based costing and category management. QR is the name given to such practices in the textile and apparel industry. Major savings have been reported by well-known companies such as Benetton, Sears Roebuck, Levi’s, and so on. ECR is the grocery industry’s answer to QR and it is expected to reduce costs by about 10,8% in the Canadian food industry. These new practices are expected to spread to other sectors as well; we are for example referring to EHCR, the Efficient Healthcare Consumer Response.

The impact of these time-sensitive strategies on motor carriers is plain to see: they are increasingly replacing distributors in performing cross-docking and acting as partners in the distribution of goods between manufacturers and retailers. To do so, motor carriers must be linked to the real time information networks of their partners as we will see in the next section.

2.2 The development of electronic commerce

Electronic commerce is defined as conducting or enabling the buying and selling of goods or services through electronic networks, including the internet [2]. It makes use of a wide array of information technologies such as fax, E-mail, voice mail, electronic funds transfer (EFT), internet, intranet, image processing, barcode and electronic data interchange (EDI). The latter was certainly a pivotal point in the development of electronic commerce as pointed out by many authors [3, 4, 5]. They all have shown the importance of EDI to make logistics and physical distribution more efficient and faster. More recently though, internet has appeared to be a better and cheaper way to get the same results [6] because cost and a lack of critical mass of EDI users in the market were major barriers to EDI implementation, particularly for small carriers [7]. Moreover, investing in information technologies such as EDI may only be profitable when these technologies are fully integrated with other internal systems within the organization [8].

The use of those information and communication technologies thus appears to be determinant in achieving excellence in logistics. Nearly a decade ago, the results of a survey of over 200 top managers of logistics and transportation in the United States were already pointing out information and communication technologies as the most important success factor in their domain [5]. The World Class Logistics research completed at Michigan State University with its 3,693 respondents surveyed, came with information technology as one of the four crucial factors defining world class logistics capability. From a subset of respondents to this last research, the authors demonstrated more precisely the prevalence of this factor in determining logistics capability [9]. The last annual Deloitte and Touche consulting group’s survey of North American trends in supply chain management also finds, from a sample of nearly 200 manufacturers and distributors, that information technology is the key to supply chain success [10]. Among the benefits associated with use of these technologies we can underline the following: minimization of manual data entry, increased
transaction speed and accuracy, lower communication costs and promotion of simplification of procedures.

The use of electronic commerce also implies that all participants in a supply chain, including motor carriers, become essential to the process. It is the entire supply chain, from materials to finished goods, that is thus affected by the introduction of these technologies. In fact, electronic commerce acts both ways: as a response to a better supply chain performance and also as a source of pressure from the market to improve the performance of supply chains. QR and ECR are facets of what is now commonly called “Business to Business” or B2B, that is the application of e-commerce between businesses. When consumers are interacting directly with suppliers, we are in a “Business to Consumers” or B2C environment where not only the distributors are being eliminated but the retailers as well! The freight carriers’ importance is however increasing since the physical distribution of goods is the most important activity left in such an environment. Motor carriers are therefore under strong incentive to join the movement and integrate new information and communication technologies (NICT) into their day-to-day operations.

The number of motor carriers offering EDI services in USA and in Canada has thus increased significantly in recent years [11]. However, Canadian motor carriers have been slower to adopt EDI and electronic commerce as indicated in a survey of motor carriers using best practices conducted by KPMG in 1997. Moreover, many surveys have shown that carriers are more reactive than proactive in that matter. For instance, it was found that carriers adopt EDI mainly to satisfy customer requirements, and after to increase customer service and remain competitive [12].

We also see a growing number of carriers concluding partnerships or alliances with shippers and other carriers as well. These alliances are facilitated by the use of new information technologies that are part of the electronic commerce arsenal. This pattern may lead to virtual (or electronic) integration between carriers and shippers. However, carriers that elect not to invest in these new technologies will not be able to provide value added services to their customers and will therefore have to be satisfied with low yield traffic only.

2.3 The outsourcing of logistical services to third party providers

With the globalization of markets, companies are increasingly focusing on their core competencies, be it the manufacturing or assembly of goods (the car industry) or the design and marketing of products (Nike). Those core competencies seldom include the supply and distribution of goods and these activities are therefore increasingly outsourced to third party organizations that specialize in logistics. The U.S. market for third party logistics (3PL) services was estimated at $25 billion in 1996 and it could grow to close to $50 billion by year 2000 [13]. According to a survey of Fortune 500 manufacturers conducted in 1999, 65 % of the respondents indicated that their company uses 3PL services and that roughly one third of their logistics operating budgets will be given to 3PL within three years [14]. The same survey indicates that the most frequently used 3PL services are related to transportation and warehousing.

It is therefore not surprising to observe that a good number of 3PL services providers originate from the transportation industry, including Ryder, Schneider, UPS, FedEx, to name only a few of the larger ones. It seems like it is increasingly difficult for motor carriers, in North America as well as in Europe, to obtain satisfactory financial results by concentrating only on the transportation sector. An increasing number of trucking companies are finding it necessary to diversify their services in order to include some of the logistical services currently being offered by 3PL services providers. The trucking industry may well consist of three major segments: 1) those carriers who have chosen to diversify and compete with 3PL’s, 2) some carriers fortunate enough to exploit a niche (specialized equipment or focus on a specific product), and 3) the vast majority of remaining carriers who will have to reduce costs in order to survive in an increasingly competitive market. Even those who try to differentiate themselves from others by offering superior service levels will find it difficult to compete with other carriers who claim that they can offer the same service levels. In a recent survey of executives of trucking companies conducted in the Province of Quebec in 1998, it was found that those who reported the best financial performance, as measured by the return on investment, were motor carriers who concentrate their efforts in a niche and those who diversify the range of services offered [15]. It was also interesting to note that all respondents believed that their company was pursuing a differentiation strategy by providing superior service levels to their customers!

3. A description of motor carrier operations and planning levels

3.1 Motor carrier operations

Intercity trucking companies generally specialize in

(1) truckload (TL) freight;
(2) less-than-truckload (LTL) freight; or
(3) parcels.
Generally, shipments fill an entire trailer in TL freight transportation, therefore they do not require service routing decisions, sorting or handling. Consequently, TL trucking companies do not need to invest in terminals and in specialized city pick-up and delivery equipment. But, due to customer demand, TL carriers are also performing multiple pick-ups with the same destination or one pick-up with multiple deliveries or drops.

LTL carriers typically haul shipments weighing 100 to 10,000 pounds – 50 to 4,500 kg. Since trailers hold 30,000 to 50,000 pounds depending on the density of freight, carriers must consolidate many shipments to make economic use of their vehicles. They have established a large number of terminals to sort freight, both end-of-line terminals at points of origin and destination, and break-bulk terminals, which consolidate freight. End-of-line terminals maintain fleets of small trucks and trailers for handling pick-ups and deliveries in the city. In Canada the same terminal usually performs both functions.

Figure 1 shows the typical flow of shipments for LTL carriers [16]. The cycle starts with a demand for a pick-up. These are seldom known in advance and vary from day to day. Demand also varies by season and type of freight. For example, early spring and fall are peak periods in the garment industry. The carrier generally collects shipments in the afternoon and delivers them to the origin terminal, where they are unloaded and verified against the information appearing on the shippers’ documentation (bills of lading): weight, dimensions, number of pieces, type of freight, and so forth. The carrier determines tariffs and prepares a waybill. The waybill accompanies the freight and is used to verify it in subsequent handling operations. Next, freight is sorted according to its immediate destination and loaded into line-haul trailers or it is simply moved to the nearest break-bulk terminal if the origin terminal does not sort shipments. Freight addressed to other points in the origin city is transferred to loading zones for local delivery (normally the next morning).

Trailers cannot always be dispatched economically for each destination to which freight is addressed. Such freight is consolidated into trailers going to intermediate terminals where it is loaded with other traffic going to its final destination. In fact, freight may once again be unloaded, sorted, and reloaded at the transfer terminal. Sometimes such freight can be kept in the nose of the trailer and more freight added to it, which reduces the handling costs. Low-volume long-distance shipments may pass through several such intermediate terminals.

At the destination terminal, freight is unloaded, verified, sorted, coded, and moved to loading areas for local delivery to consignees. Line-haul movements occur mostly during the night, so that freight can be delivered in the morning.

Carriers that transport parcels and small shipments such as UPS have many characteristics in common with LTL carriers. They must also consolidate shipments and their terminal network is similar to that of an LTL carrier.

### 3.2 Levels of planning

The problems motor carriers face in managing their operations can be classed as strategic, tactical, operational or real-time. Several operations research models have been proposed in the scientific literature in order to solve these planning problems. These models have been reviewed in [17, 18, 19, 20].

Decisions at the strategic planning level usually concern a large part of the organization, have major financial impact, and may have long-term effects. In the
motor carrier industry, they typically concern the design of the transportation system:

1. the type and mix of transportation services offered (parcels, LTL or TL services);
2. the territory coverage and network configuration, including terminal location; and
3. the service policy, what service levels are offered to customers in terms of both speed and reliability.

Such decisions help determine the motor carrier’s strategic position in the market. They should be revised periodically to respond to changes in the environment. The choices carriers make at the strategic level constrain the decision variables at the tactical and operational levels. Facility location is one of the most important strategic decisions and it has thus received a lot of attention [21, 22].

**Tactical** planning concerns short- or medium-range activities, such as:

1. equipment acquisition or replacement;
2. capacity adjustments in response to demand forecasts and the firm’s financial situation; and
3. service network design, freight consolidation, and routing decisions (load plan).

The load plan consists of specifying how freight should be routed over the network. It should consider the following: 1) service network design, the selection of routes on which carrier services will be offered, 2) freight routing, the sequence of services and consolidation terminals to be used to move freight, and 3) the movement of empty vehicles, or how to balance the network. Two basic approaches have been proposed in the literature in order to solve the load planning problem: APOLLO (Advanced Planner Of LTL Operations) [23] and NETPLAN (NETwork PLANning) [24]. These optimization models have been experimented successfully with actual data from large Canadian and U.S. based LTL trucking companies.

In the motor carrier industry, tactical planning may be performed over a time horizon of a few years when replacing vehicles or purchasing freight-handling equipment, for example. Tactical planning also involves making seasonal adjustments to pick-up and delivery zones, work scheduling and assignments of trucks to the terminal doors in order to adapt to fluctuations in demand over a period of a few months.

Tactical planning generally influences decisions made at the operational level. Operational decisions concern very short-term day-to-day operations. At the operational level, carriers plan current and next day activities. First-line supervisors often make the decisions. Starting with transportation plans formulated at the tactical level, motor carriers assign drivers and equipment and update transportation schedules in response to short term forecasts and daily variations in demand and in equipment and labour availability. The day-to-day planning of delivery routes is one of these problems that has received a lot of attention in the scientific literature under the general designation of vehicle routing problems [25].

Finally, in real-time management, carriers combine operational planning and control to maintain the transportation system under equilibrium. This topic will be covered in the next section.

The hierarchical relationship of the these planning levels makes a single model impractical; different formulations are needed to address specific planning levels or problems. At each planning level, the various decisions relate horizontally. Strategies developed for one problem interact with those established for other problems and require that decisions be made globally, network-wide, in an integrated manner [26].

Table 1 provides a sample of the typical problems encountered in trucking companies according to various planning levels.

Table 1: A sample of typical planning problems in trucking companies

<table>
<thead>
<tr>
<th>Planning Levels</th>
<th>Pick-up &amp; Delivery</th>
<th>Terminal Activities</th>
<th>Long Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic</td>
<td>Outsourcing</td>
<td>- Fleet location</td>
<td>- Fleet mix</td>
</tr>
<tr>
<td></td>
<td>Fleet selection</td>
<td>- Terminal location</td>
<td>- Outsourcing</td>
</tr>
<tr>
<td>Tactical</td>
<td>P&amp;D zone design</td>
<td>- Load planning</td>
<td>- Seasonal transportation plan</td>
</tr>
<tr>
<td></td>
<td>Door assignment</td>
<td>- Work scheduling</td>
<td></td>
</tr>
<tr>
<td>Operational</td>
<td>Delivery routes</td>
<td>- Daily adjustments to plans and schedules</td>
<td>- Vehicle routing</td>
</tr>
<tr>
<td></td>
<td>Truck loading</td>
<td></td>
<td>- Week-end dispatch</td>
</tr>
<tr>
<td>Real-time</td>
<td>Pick-up assignments</td>
<td>- Hourly adjustments to plans and schedule</td>
<td>- Real-time dispatch</td>
</tr>
<tr>
<td></td>
<td>Door assignment</td>
<td></td>
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4. Real-time decision tools

4.1 LTL operations

Figure 2 proposes a description of the real-time planning environment of a LTL carrier. Customer requests for pick-ups are forwarded to the motor carrier, either by phone, fax, EDI or internet, and the information is registered in the carrier’s information system (CIS). Pick-up trucks are usually already on the road, in their respective zones, and the customer requests are dispatched to them according to several criteria: space available, type of equipment required, estimated time of arrival at the customer location, distance from the pick-up point, etc. Real-time optimization tools are
not extensively used in that context; most motor carriers generally rely on a human dispatcher to make the appropriate decisions on the basis of experience and, sometimes, with the assistance of information systems that display the location of trucks and loads to be picked-up on a map. Although some commercial software packages are becoming available to assist in that matter, very little work has been published thus far on this subject. One of the few papers found in the literature discusses the use of parallel computer processing and a tabu search heuristic to tackle the problem in the context of courier services [27]. For the LTL application, one should refer to [28]. For a more general review of relevant literature, see also [29] and [30].

In the more advanced companies, as the loads are picked-up during the day, the relevant information is registered in the on-board computers and forwarded to the terminal where it is fed to the CIS. Although the technology for such real-time information management is available, very few motor carriers are so equipped. Most carriers still have to wait until the pick-up trucks arrive at the terminal at the end of the day in order to find out what was actually picked-up during the day. It is then often too late to perform any kind of optimisation at the dock for freight handling and sorting.

To have the information available in real-time is fine but it is even better to use it wisely. To do so, optimisation tools can be used daily in order to solve the following problems: 1) assigning pick-up trucks and highway trailers to terminal doors in order to minimize the cost of moving freight across the dock [31]; scheduling the work of freight handling employees (especially part-time workers) according to the daily workload patterns [32]; and revising the load plan, i.e. deciding on how freight will be sorted and consolidated at each terminal depending on the actual volumes, per origin-destination pair, picked-up during the day [16]. Some of these models were initially designed to solve the same problems at the tactical level based on demand forecasts. With the major improvements experienced in computer technology in the last decade, the same models can now be solved very rapidly, in an operational environment, in order to provide daily optimal solutions to motor carrier managers. Using up-to-date information on actual demand, with very short advanced notice, motor carriers can use these static models to assist them in adjusting daily plans in a quasi real-time environment. But, once again, such benefits will be obtained in as much as motor carriers make full use of the information gathered at the pick-up points.

At the destination terminal, with advanced knowledge of the content of highway trailers, door assignment of trucks and trailers can be adjusted on a daily basis, delivery routes can be redesigned and delivery trucks loaded accordingly. The routing of delivery trucks is in fact an operational problem that has received a lot of attention in the literature as mentioned earlier. But, increasingly, in order to satisfy customer requirements for just-in-time deliveries, motor carriers have to comply with time windows within which deliveries have to be made, or worst, precise appointments that have to be met. Therefore, even though actual demand is known ahead of time, the design of delivery routes in an urban environment with backhauls (pick-ups) and time windows is a difficult problem to solve, but some recent heuristic solutions can be found [33, 34]. With the increased emphasis on cross-docking, advanced information on actual freight to be handled will allow motor carriers to improve customer service and reduce costs.

Figure 2. Real-time planning of LTL operations
4.2 TL operations

Real-time planning of truckload operations is centred around the dispatch of highway tractor-trailer assemblies, as illustrated in Figure 3. Customer requests for pick-ups and deliveries are transmitted to the motor carrier, either by phone, fax, EDI or internet, and the information is entered in the carrier’s information system. In North America, satellite communication has become the standard in the long distance trucking industry. Satellite positioning also allows the carriers to provide up-to-date information to customers with respect to the exact location of their shipments. For example, one of the major truckload companies in the USA, Schneider National, equipped its fleet with on-board computers and satellite communication devices. Its use of technology has reportedly resulted in cost reductions in the order of 24% and increased on-time performance from below 90% to about 99%. Using satellite communication, Schneider can track the location of each vehicle anywhere in the United States and dispatch it on a real-time basis to satisfy customer needs and adapt to unforeseen changes. This tracking ability has enabled the company to reduce empty mileage by 25% last year. The use of on-board computers also enables Schneider to monitor vehicle speed and drivers’ working hours in order to comply with laws and regulations. As a result, technology has helped reduce the company’s accident rate by 35% since 1987 [35].

Figure 3. Real time Planning of TL Operations

The dynamic allocation of customer requests to vehicles has been studied in [28] and in [36]. More recently, the stochastic aspect of the problem has also been considered [37, 38]. These approaches are exploratory and there are still difficulties in solving large-scale real life problems rapidly. But again, we know that some unpublished approaches are being commercialized to solve this very important problem. For example, Maddocks Systems Inc. has recently announced the release of a new version of its “TruckMate” software that will provide dispatchers with optimal assignments for their long distance drivers.

Real-time decision tools are also rapidly becoming available on the internet to assist motor carriers in planning their work in a real-time environment. E-Dispatch and E-Scheduling are now very much part of the transportation vocabulary. Also available through the internet is the possibility for both buyers and sellers of freight services to make electronic bids through electronic freight markets. They are of particular interest for back-hauls, thus improving the efficiency of carriers by minimizing waiting time and empty mileage.

5. Concluding remarks

This paper has reviewed some of the most important recent trends in supply chain management and examined their impact on motor carriers. It was found that the increased use of time-sensitive strategies such as JIT, QR and ECR, along with the development of electronic commerce and the outsourcing of logistical services, has and will continue to have a major impact on motor carriers. Indeed, carriers will have to adapt by forming partnerships with customers, providing logistical services, investing in new information and communication technologies, and using real-time decision tools.

Next, the typical operations of a motor carrier were described and some of the more “traditional” tactical and operational planning tools were quickly referenced to. The real-time planning environment of both LTL an TL carriers was then described. It was found that several of the tools developed for the tactical planning level could be adapted and used to address some of the operational and even real-time (short advance notice) issues such as assigning trucks and trailers to terminal doors, scheduling part-time freight handling employees and revising load plans. It was also found that a very small number of motor carriers actually make use of the information that can be gathered at the pick-up points through on-board computers and real-time information systems. We believe that using this information wisely in conjunction with real-time and operational decision tools will significantly improve the performance of motor carriers, just like it did in the case of courier
companies and just like new logistical practices rest on the use of point-of-sale information.

References


