A Shipment Information Centre

Yosef Sheffi, *Massachusetts Institute of Technology, U.S.A.*

The revolution in information processing and communication technology has transformed the logistics business and opened new opportunities. To capitalize on these opportunities one can imagine a computer system which can manage and provide decision support across all facets of the transportation and logistics function for today's complex worldwide business enterprises. This paper outlines such a system — the shipment information centre. It includes information gathering, processing and reporting from the point a shipment is ordered through its movement, delivery, the associated payment, and subsequent analysis based on its movement.

The world of transportation and logistics has gone through major changes in the last decade and the rate of change is accelerating. The transportation and logistics functions are continuously becoming more important in the basic mission of all manufacturing organizations - that of transforming raw materials and parts at suppliers' locations into finished goods delivered at the locations and times customers want them. In addition, industries such as retailing are critically dependent on their logistics capabilities to move, store, display and sell products in a timely fashion.

Logistics managers are faced both with an increased need for world class logistics systems and with more opportunities to create and manage such systems. The need stems from: (1) long supply and distribution channels, resulting from the globalization of sourcing and marketing; (2) the move to cut cycle times and improve customer service, resulting from the stiffening competition in every industry; (3) the requirement to feed as well as distribute the product of flexible manufacturing systems which adjust production mixes continuously; and (4) the pressure to rebuild integrated networks following corporate restructuring. The opportunities stem from two sources: (1) the continuing deregulation of the transportation industry throughout the world with trade barriers falling as part of agreements such as US/Canada/Mexico FTA and 'Europe 1992'; and (2) new information processing and communications technologies which open new possibilities for managing and controlling millions of moving items in real time all over the globe.

At the same time, many corporations are cutting costs and trimming their organizations, asking logistics managers to do more with less. One of the few viable ways to rise to the challenge is to rely to a greater extent on information and communication systems. The impact of such systems on transportation and logistics is significant since these technologies transform the logistics management process, which is spatially and temporally distributed, into a process that can be centrally controlled. In other words, modern computer and communications technology gives logistics managers the ability to control and manage transportation services which are 'produced' over time and space. Thus, logistics became an information management business.

The motivation for a global logistics information system is also apparent when one considers the focus on quality in today's business environment. To become world-class competitors successful companies have to engage in time-based competition. As argued by Stalk and Hout [1], and many others, the key to quality operations and profitability lies in reducing the cycle time for all processes in which a business is engaged. In the context of logistics this leads one to strive for shorter channel lead-times achieved through faster transportation and more frequent departures. Unfortunately, to achieve low transportation costs one needs to consolidate movements in time (by accumulating larger loads), geographically (by merging several shipments) and in vehicle tours. Consolidation typically implies using larger (and slower) conveyances and more circuitous miles. The competing needs to cut cycle times and reduce costs, can be achieved through the use of better logistics information technology.

This paper outlines the various components of a logistics information processing and communication centre which can help shippers obtain higher service levels, reduced costs, increased control, and streamlined management decision making [2]. Such a shipment information centre (SIC) can be developed and used by the central logistics staff of large shippers (manufacturers, retailers, distributors, etc.), contract logistics companies providing logistics management services, mega-carriers in their value-added function, or by stand-alone information providers.

The operational functions offered by the shipment information centre described here can be divided into three groups:

- pre-shipment systems;
- in-transit systems; and
- post-shipment systems.

These three groups, shown in Figure 1, are each made up of many sub-systems which are all connected and feed each other continuously.

Note that both this grouping and the various sub-systems described here are logical entities which may reside in a single computer, separate computers, a network, or whatever.

This article itself includes three major sections each dealing with one of the logical components mentioned above. While these three components are focused on three time frames relative to a shipments movement, one should remember that the systems themselves are not applied sequentially but interact throughout the movement of each shipment. Each one of these sections describes the various sub-systems involved, the inputs required and how the output can be used. The fourth section discuses some implementation issues.

A full logistics information system would include order processing, warehouse management, purchasing, and inventory management. The SIC described here interacts with such systems but they are not described here, only the interface with them is mentioned.

Pre-shipment Systems

Pre-shipment systems help manage the freight before a shipment is actually moved. Thus the input to any pre-shipment system should include the following information regarding a pending shipment:

- *What* - A description of the shipment including all relevant information such as weight, class, packaging, etc.;
- *Who* - Shipper, consignee, brokers, forwarders and other third parties involved in a given shipment;
- *Where* - Shipment origin and destination location;
- *How* - Handling requirements and delivery instructions;
- *When* - Release dates, need dates and applicable pick-up and delivery time windows.

For inbound shipments this information can be obtained from purchasing control systems, material requirement planning (MRP) systems, and material releases, while for outbound shipments it is usually obtained from order entry systems. In many cases the information may be entered directly into the system by the location initiating the movement. In addition, certain functions of such pre-shipment systems will be supported by data bases which are not shipment-specific and therefore do not change frequently. (This is mentioned later in conjunction with the description of the motor carrier load control centre.)

The basic purpose of pre-shipment systems is to generate a plan for the movement of each shipment, including a detailed route and time line. Once such a plan is generated,

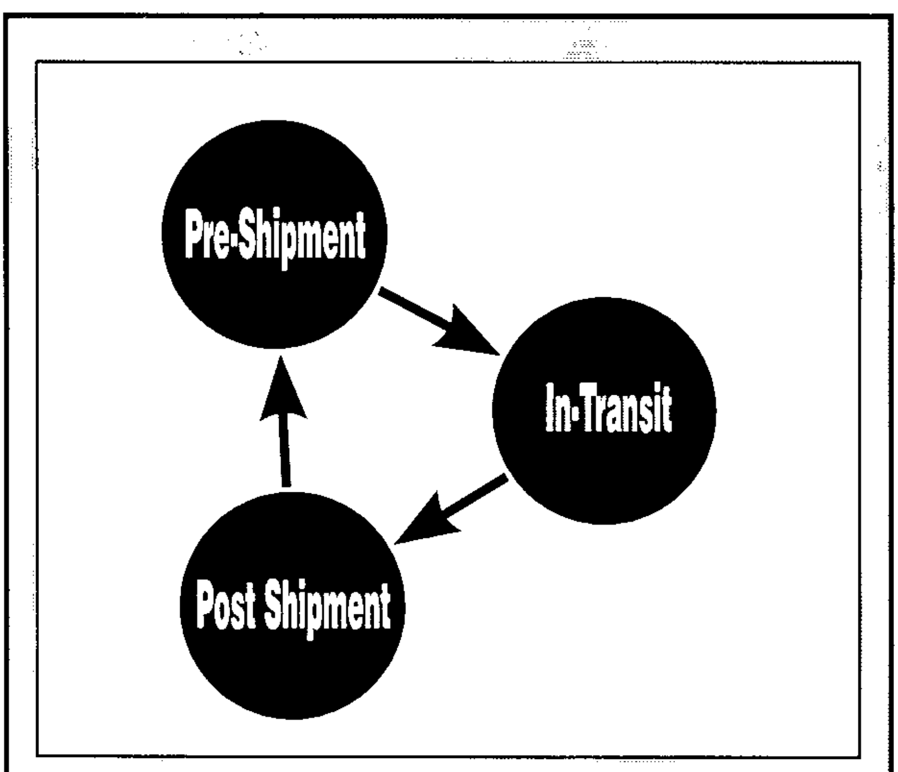

Figure 1

System Categories

control of the shipment is transferred to an in-transit shipment management system. Note that in addition to generating the plan, the pre-shipment system should notify shippers and consignees of the plan's elements, schedule pick-up and delivery appointments, notify participating carrier(s), and communicate the details of the plan to other parties such as forwarders, custom brokers, etc.

As part of this plan, pre-shipment systems should generate all the documentation necessary for movement. For a simple origin-to-destination one-mode move (say a shipment by truck) the documentation may include only the bill of lading and, later, a freight bill. For more elaborate (e.g. international) movements, many other documents should be prepared. Such documents include (in addition to the bill of lading) commercial invoices, certificates of origin, letters of credit, dock receipts, export and import declarations, custom entries and invoices, delivery instructions, and others. It is important to realize, though, that the information necessary for all these documents is included in the items put into the pre-shipment system and in the plan generated by the system. Thus, a single record in a shipment database can be used to generate them all, given the appropriate formats.

In some cases of outbound shipments, the origin may not be given *a priori*. Instead, the pre-shipment system may have to decide which of several warehouses, plants or distribution centres the product should be drawn from. To this end, the pre-shipment system will have to interact with warehousing and inventory management software to determine product availability. This supply location decision should be made simultaneously with the routing decision for all shipments scheduled to depart in the near future. This will minimize total logistics costs and generate the best consolidation, cost, and level of service trade-offs.

To generate a good plan the pre-shipment system will have to use a short-term demand forecast of what will be available for movement in the near future. Such forecast will be used to consolidate various shipments in time, in space, or in the vehicles, to create more efficient movements. The short-term forecast can be obtained from the above-mentioned order entry and purchasing control systems - to the extent that they include future shipments; from the in-transit shipment tracking system - for shipments that will hit certain terminals in the near future and may offer consolidation opportunities there; and from statistical forecasting based on past movements and managed by the post-shipment system. In addition, the system will need a supply forecast. This is a forecast of equipment that may become available for loading in certain directions as explained further in the load control section below.

The pre-shipment system is a decision support tool which helps determine the mode(s), carriers(s), and route each shipment should follow as well as the schedule for the move. To achieve its objective the pre-shipment system has to be either an on-line procedure or a batch process which is run frequently (say, every hour). The general structure of a load control centre should probably involve geographical processing nodes handling moves in certain areas of the world and international load control centres for handling movements between each of these areas. Within each geographical load control centre one can expect to see an overall mode assignment module, where a shipment is assigned to a motor carrier load control centre, a rail load control centre, a barge load control centre, a small parcel load control centre, a premium transportation load control centre, or another modal load control centre. To understand the functionality and usage of such systems, consider two examples: a motor carrier load control centre and an international shipment control centre.

Motor Carrier Load Control Centre

As mentioned above, each component of the pre-shipment system, and in particular the Motor Carrier Load Control Centre (MCLCC) has to be run frequently in order to devise and update the plan for each shipment. The data input to MCLCC includes the following [3]:

- The particulars for every shipment pending. This data comes from the order entry system for pending outbound shipments, from releases and call-ins for scheduled inbound shipments, and from the in-transit shipment management system regarding rail or ocean moves which will require trucking. It also includes shipments previously input but not yet firmly assigned.
- Inventory level at each facility from which the shipment may be sent (this is particularly relevant for outbound shipments).
- A short-term statistical forecast of shipments. This forecast should be updated by shipments already booked to create a complete picture of the most likely near-term shipping pattern.
- A supply forecast, including incoming truckload moves, which can be reloaded to create continuous TL movements. Parts of the supply forecast can come directly from carriers informing the MCLCC of short-term opportunities due to their equipment positioning and directional loading needs.
- A supply forecast for the location of private fleet trucks, if a private fleet is an option.
- Geographical information systems (GIS) which spell out location information (such as zip codes and co-ordinates) as well as distances and accessibility.
- Prices and contract files which include all applicable tariffs, carrier contract provisions, applicable discounts and relevant charges.

The MCLCC takes over once the pre-shipment system has determined that a particular shipment or a set of shipments should be moved by a motor carrier. It has to determine how shipments will be routed, looking at many motor carriers options including the following:

- A continuous truckload (TL) move.
- A straight truckload move.
- Pick-up and drop-off as part of a truckload move with stop offs ('a milk-run').
- Filling a less-than-truckload (LTL) 'pup' trailer with several shipments all destined to the same area. Such a trailer can move quickly (bypassing breakbulk terminals) through an LTL system and have its contents distributed from the terminal in the destination area.
- An LTL 'headload', which is a shipment (or a set of shipments destined to the same area) which is large enough to move on the same LTL trailer saving unloading and loading activities in breakbulk terminals.
- Combination of several small shipments into a larger LTL move.
- A straight LTL shipment.

Some of these options may be handled by a private fleet if one is available. The private fleet option should typically be looked at for before a common carrier is considered unless it is charged on a fully allocated basis. (In that case it can simply be looked at as another common carrier.)

As part of determining the applicable mode of trucking the MCLCC has to take into account the possibility of delaying some shipments' departures in order to consolidate them with forecasted movements into larger shipments. Such considerations have to take into account shipment need dates and carrier transit time standards in order to ensure on-time delivery.

As mentioned above, the MCLCC has to run frequently in order to process incoming information continuously. Once the data are acquired they have to be transmitted to a central processor even if the system is based on a distributed architecture. The reason is that the central processor has all the information necessary to optimize simultaneously all the shipping options across all locations and time frames. Alternatively, parts of the solution which are locally obvious (such as full TL moves) can be determined by a local processor and transmitted as such to the central one.

The MCLCC program can perform the optimization using a combination of heuristics and network-simplex algorithms. Elements of such an optimization set exist today for performing individual MCLCC tasks such as routing a TL fleet [4], creating continuous TL moves [5], multiple pick-up/delivery operations [6], private fleet routing [7] and many others.

This process can be run on-line with adjustments to the optimal solution made every time one or several data items are acquired or changed. The advantage of this software solution over a complete optimization-from-scratch every so often, is that re-optimization due to small data additions or changes is typically fast, requiring an order of magnitude less computation resources.

The optimization procedure itself should probably be tailored around a hierarchical heuristic looking at shipping options in the order listed above. Naturally, geographical locations of shipping and receiving points figure heavily in the calculations as shipments get consolidated as part of a multiple pick-up/delivery TL moves, or as part of a single pup trailer going to a set of destinations served by a single terminal on the LTL network.

Once an element of the plan (a TL move, a tour, a combined LTL shipment, or whatever) has been finalized for a shipment or a group of shipments, a plan for all items included is filed electronically and sent to the in-transit shipment management system. At the same time, pick-up instructions are sent to the carrier responsible for the move and to the origin locations, for verification. The destination is alerted of the impending shipment and given an estimated time of delivery based on the mode, carrier and applicable service standard.

The interaction which takes place between the MCLCC and the carrier once the shipments are assigned depends on the type of carrier. For first tier carriers with good electronic data interchange (EDI) capabilities the process can be paperless. Given the carrier and pick-up times, the MCLCC may generate a manifest to be used as a verification for shipment pick-up (if necessary). Beyond the manifest no paper is necessary and thus no bill of lading should be generated. Instead, the MCLCC can rate each move (since it has a data base of all carrier contracts [8]) and file the move and the rate with the central data base. The shipment record will also include account codes and all other relevant information. Once the 'shipment status' EDI message from the carrier to the central data base indicates a delivery, the shipment can be posted for payment (via electronic funds transfer) within an agreed time frame.

For second-tier carriers who are not EDI-compatible, the MCLCC can generate a standard bill of lading. Since the shipment will be rated by the MCLCC, the freight bill sent later will be used only as an indication of delivery rather than for audit and request for payment.

A Real Time Bid Process. A variant of the process described above includes a real time bid and award process. This process is applicable mainly to truckload moves and TL moves with stop-offs (tours).

In this variant, the carrier and the shipper set appropriate EDI links with routines for notifying system operators at both ends. Once the MCLCC settles on a move, it bids the move out electronically to a predetermined set of participating carriers. The information sent to these carriers includes origin, destination, pick-up time windows and need date/time at the destination. (Intermediate pick-up and delivery information should also be sent if the move includes stop-offs.) The carriers' computers take this information in. Given the current and anticipated location of their equipment and given their future (a few days ahead) needs for customer service, equipment maintenance, vectoring drivers home, etc., the carriers bid on each move within an hour or two of receipt of the data. The MCLCC then evaluates all the bids and awards the move *electronically* to the most competitive carrier [9]. Once the winning carrier acknowledges the award, the MCLCC continues as before, filing the plan and notifying all parties of the pick-up time, the awarded carrier, and the estimated time of arrival (ETA).

The overall process followed by the MCLCC may include the following:

- *Determination of supply location* - where each shipment should be supplied from.
- *Motor carrier mode choice* - as outlined above (TL, TL with stop-offs, LTL pup, etc.).
- *Optimization of capacity utilization* - generating multi-stop trucking tours, geographical consolidations, etc. The last three processes (supply location, mode choice, and capacity utilization) may have to be iterated to get optimal results.
- *Award business* - the shipment may be awarded to specific carriers based on a simple 'prime/alternate' designation on specific lanes or based on an electronic bid process.

In addition, the system can perform yield management computation. In this capacity it can look at future moves and assign forecasted shipments into future transportation slots based on available low rates. This process may result in 'half filled' moves which are then input to the iterative load control centre optimization process.

As mentioned before, the MCLCC is only part of the pre-shipment load control system. To perform a full mode choice analysis the output of the MCLCC may have to be fed back to the overall mode assignment module in an iterative manner, while the main assignment module interacts with other modal load control centres.

International Load Control Centre

International shipping is different from domestic shipping only in that the movements are longer and involve more participants, more documentation, and further complexity in the transaction/payment terms. This is not applicable to most air moves which, by nature, involve point-to-point activity and therefore are relatively simple. Consequently the focus here is on movements involving ocean shipping.

The basic function of the international pre-shipment system is the same as a domestic one – to generate a plan for the shipment movement so it can be tracked by an in-transit system. The data input to an international load control centre (ILCC) is similar to that required for a domestic one and includes the following:

- Particulars of each pending shipment (including terms of purchase);
- Statistical forecast of upcoming shipments;
- Supply forecast including shipping schedules for ocean carriers and anticipated in-land movement;
- Geographical information systems (GIS) which include location of terminals, warehouses, and port facilities;
- Price and contract files.

Given the need dates for each pending and forecasted shipment, the ILCC has to create consolidation opportunities for containerized freight, less-than-container-load (LCL) freight, and breakbulk freight. Opportunities for efficiency arise mainly through time consolidation and geographical consolidation. Time consolidation is typically driven by vessel schedules - realizing, for example, that small shifts in pick-up times can cause a shipment to make or miss certain vessels. Geographical consolidation is based on collection of separate LCL items into container loads, assembly of several containers to make a single shipment and even the use of chartered vessels to consolidate shipments and cut overall costs.

As part of the process of identifying shipping routes and consolidation opportunities for a set of shipments emanating from the same geographical area, the pre-shipment system can be used to actually bid the freight and book it with carriers. This process is now carried out, for the most part manually, by forwarders, brokers and other agents negotiating with carriers. These negotiations typically involved back-and-forth document processing which can easily be accomplished on-line. The booking itself is typically accomplished in stages with the ocean portion booked first and then all other legs pegged to a specific vessel departure time. The inland movements from the origin get optimized to meet this vessel departure while the inland movement from the destination port to the consignee is scheduled only tentatively. During the ocean voyage these port-to-consignee inland moves show up as future trucking, rail or barge movements for the MCLCC or a similar rail or barge load control centre. They can then be integrated, in the computer, with other domestic moves for maximum efficiency and best service.

The international load control centre differs from a domestic centre (such as the MCLCC described before) in several aspects.

1. *Geographically Distributed Process.* Each land mass should be handled independently. Thus a European ILCC should not see Pacific, Latin-American, or domestic movement. In fact, depending on port location and prevailing flows, further partitioning of the processing may be warranted. Thus each centre should handle all moves originating from the geographical area it covers, including the ocean portion of such moves. It should also handle all incoming international shipments from the water's edge. (Thus, for example, a North European ILCC will handle all shipments outbound from Northern Europe, including the ocean portion and all movements to North European consignees from the European port of entry.)

2. *Detailed Plan.* The movement plan set by the ILCC should include several 'milestones' which should be fed to the in-transit shipment system together with the movement plan. The use of these 'milestones' is explained in the connection with the in-transit system.

3. *Documentation.* All documents necessary for each move can be generated by the system once the movement plan has been forged. Nowadays many of these documents still have to be actually generated on paper since international EDI standards and practices lag behind domestic ones and because of government involvement in international transactions. The documents themselves can, naturally, be created from one data base since they all contain the same information, as mentioned before.

Note that any load control centre would benefit from having the largest possible number of shipments to draw from when making the shipping plans (e.g. for filling backhaul, geographical consolidation, making up tours, holding freight for full loads, etc.). Thus an important activity associated with the installation of a load control centre may be the renegotiation of payment terms. To control a large volume of shipments, all inbound freight to an organization operating a load centre should be moved 'collect' and all outbound freight on 'prepaid' terms. This will let the load control centre consider the maximum number of shipments. If both a vendor and a client operate a load control centre, those should be set to communicate with each other for even greater efficiency.

In-transit Freight Control System

The purposes of the in-transit shipment control system (ITS) are to:

- allow all participants in moving a shipment to plan their work;
- allow consignees to plan production/ sales activities;
- manage service failures;
- manage changing requirements;
- feed the post-shipment system.

To accomplish its mission an ITS has to keep a data base of all purchase orders, releases and order entries, or have access to a system that includes such information. The main data base of an ITS includes the shipping plans for all shipments in transit, and the location of these shipments.

Basically, the ITS allows parties interested in the shipment of any item to connect to the system and find where the item is relative to its shipping plan. The interested parties here include entities in the shipper organization (traffic managers, division headquarters, warehouse managers, logistics staff), similar entities in the consignee organization, interlining carriers who need to plan their operations, and various third-party providers such as contract logistics managers, forwarders, and custom brokers.

The record for each item in this data base of moving shipments should include the following:

- *Shipment identifiers* such as the bill of lading number, the shipment pro number, or a similar identifier.
- *The shipping plan* - this is a schedule of all events which a shipment should follow.
- *Conveyance and sub-conveyance identifiers* such as name, number or other ID for the relevant vessel, train, container, trailer, railcar, palette, flight, 'igloo', etc.
- *Item identifier* such as part number, stock keeping unit (SKU), P.O. number, or a similar distinguishing ID.
- *Shipment information* - a pointer to a record in a shipment data base which includes all the information entered by the pre-shipment system described

earlier.

The basic task of the in-transit system is to inform a user where a shipment is. For this task to be accomplished the user has to give the system a shipment identifier and the system, in turn, has to report the location of the shipment. To give such a response, the system has to have two types of data:

- a feed from the carrier [10] regarding the location of the conveyance carrying the shipment in question;
- a software data structure which points out the conveyance and sub-conveyance relationships for each shipment. For example, which shipments are on what palettes, which container houses these palettes, and what vessel are these containers loaded on.

To accomplish this basic location task, the in-transit shipment management system should include only the shipment and conveyance identifiers. Inclusion of part numbers or SKU identifiers can enhance the usability of the system since the participants may not be aware of tranportation-type identifiers such as the bill of lading or a shipment pro number.

The other information which is included on each shipment's record can be used to enhance the capability of the in-transit system and add to its functionality. Added features of the ITS can include the following:

- *Management by Exception*.. To be able to pay attention only to shipments which require it, the system has to include schedule milestones for every anticipated event in the shipment's plan. When a shipment misses a milestone (i.e. when the actual date is later than the plan date) the system notifies the appropriate participants - the consignee, any logistics management company involved, and any carriers or logistics vendors who are yet to handle that shipment and may consequently be impacted. The system can also provide a 'to do' list every day by communicating things to watch for (i.e. scheduled events/ ETAs coming up). The type of events in such a list can be pre-programmed based on anticipated problems or opportunities in certain locations.
- *In-transit Profile*. When a traffic manager at a consignee location is interested in a particular shipment, this interest stems, for the most part, from the need to have a certain part inbound to a plant or a certain SKU outbound to a selling location. In many cases the interested party is not a traffic manager but a production or a procurement manager who may not know the pro number or a bill of lading number. Similarly on the outbound side, a marketing executive may be interested in the movement of the product. In many cases such individuals need to get a *profile* of the incoming part number or outbound SKU. This is the main role of the item identifier records. In other words, given the information on all moving parts, the response to a query regarding a particular part number can be a profile of incoming flow such as the one shown in Figure 2.

Such a profile gives the consignee a picture of what is coming in and when it can be expected. The consignee can also access a particular shipment given the pro (or bill of lading) number and find more information regarding that shipment. Note that the last two entries (in Figure 2) include material which is only on order and not shipped yet. The information for these data comes from the shipment information record or from a special data base which includes P.O. and release information.

On the outbound side the interested party may be the client or a marketing executive. The profile of SKUs moving in transit will be similar while the 'on order' position may be replaced by a 'backlog' situation or schedule release information, similar to that shown in Figure 2.

The in-transit shipment management system should be able to deal with the realities of changing needs as well as with service failures. To this end it has to be able to interact with the pre-shipment system (the load control centre) in order to find an alternative plan for a shipment whose need date is suddenly earlier than previously expected or in case the carrier is late. In such situations the load control centre or some of its functions should be invoked to generate a new shipment plan

Part Number: 123456789 ABC

Inbound to: Plant A

Amount	Units	Last Verified Location	Date There	Location Type	Vendor	Next Activity	Expected Date	ETA Consignee	Pro Number	P.O. Number
5	bbl.	Atlanta	Now	Terminal	ABC Trucking	Arrival	2 days	2 days	1234	567
30	bbl.	Baltimore	Now	Customs	Broker, Inc.	Rail	1 day	5 days	2345	567
20	bbl.	Antwerp	2 Days Ago	Vessel	Steamship Lines, Inc.	Port Arrival	7 days	13 days	3456	678
30	bbl.	Frankfurt	On Order	Factory	Manufacturer, Inc.	Shipping	1 day	19 days	N/A	678
30	bbl.	Frankfurt	On Order	Factory	Manufacturer, Inc.	Shipping	9 days	27 days	N/A	678

Figure 2

Shipment Profile Example

that will meet the new requirements.

Note that in many cases only a small part of a shipment may be needed earlier. For example, a single palette from a whole container may have to be flown to a consignee to meet unexpected production need. To this end the in-transit system has to be able to split the shipment record and create immediately a new plan for the expedited part of the shipment. Both plans will be checked from that point on until final delivery of all items. For book-keeping purposes the records of both shipments have to relate to each other so that all material is accounted for.

In some cases it is advantageous to invoke the load control centre when a shipment need date is pushed back. Such situations may give rise to the use of a slower (and less expensive) mode of transportation (e.g. rail instead of trucking or barge instead of rail). Having extra time in hand may also open consolidation opportunities which may call for holding a shipment at an intermediate point until it can be combined with other shipments destined to the same location.

The ITS comprises three basic structural components:

- information collection links;
- data network;
- data disbursement links with front end processing.

The information collection links include two basic components: initial data entry and subsequent updating. The initial data entry involves all shipment identifiers, shipment information and the shipping plan, as mentioned at the beginning of this section. This information may be entered by either the shipper, the consignee or a participating third party (a logistics management company or a forwarder), depending on who manages (and pays for) the movement. Subsequent updating regarding location information can be entered by the carriers and other transportation/logistics vendors involved (e.g. custom brokers, warehousemen, etc.). The information coming in from the carriers will also have to include the initial relationships and subsequent updates regarding conveyance/sub-conveyance relationships. These will have to be transmitted at every terminal and other point where a shipment changes its mode of transportation. In most cases this information will come in from carriers and other logistics vendors via direct computer-to-computer EDI. Thus, the system will have to conform to several existing EDI standards.

The data network is an element that will typically be provided by a network carrier such as GEISCO, SPRINT, or other. These carriers have the physical lines and satellites in place, and the worldwide coverage and support necessary to operate such a network. The data disbursement links are where the users get their functionality from the system. Dialing in on a PC, a workstation, or a terminal hooked into a central computer, the user can download data, get reports, query the system, request plan changes, or whatever.

By the time the shipment is delivered, the in-transit system has basically accomplished its task. It should hold the shipment information in its data base for a few more days in a 'delivered' status but it should also update a history file. The shipment information history files serve as the basic data base for the post-shipment system which is described next.

Post Shipment System

The post shipment system (PSS) comprises a set of independent and sometimes related systems performing various functions. All these systems are similar in one aspect - they all use the same data base, namely the basic shipment history data base (SHDB). One should think about this data base in a relational sense, comprising some of the following files (or tables):

- ❒ *Basic files* (including one record for each shipment);
- ❒ *shipment information* - where each record includes all the information originally generated for a shipment;
- ❒ *shipment movement* - where each record includes the plan and the actual performance of the shipment relative to that plan;
- ❒ *shipment financial* - where each record includes carrier charges, amounts paid, dates of payment, payment records, etc.;
- ❒ *auxiliary files:*
- ❒ *transportation and economic indices files* - including historical point-to-point rates, expected market rates, anticipated price increases due to increase in elements of the transportation cost (e.g. fuel, labour, etc.);
- ❒ *geographical information system* - including level of service standards by mode for all carriers;
- ❒ *transportation dictionary files* - including standard carrier accounting code (SCAC) tables, vendor/customer code tables, part number/SKU tables with product description, various international codes, etc.

The basic functions of the PSS are to:

1. Complete the transactions involved with each shipment.
2. Prepare management reports for the on-going business.
3. Serve all logistics analysis needs.

These functions are discussed in this section.

Completing Transactions

To complete the transactions involved with each shipment, the following activities have to take place:

- audit of carrier freight bills;
- client billing (plants, divisions, accounts, etc.) and carrier payment;
- reconciliation of premium transportation;
- damages and claims handling.

Auditing, naturally, does not have to take place if bills are pre-rated. In any case, pre-rating or audit has to be based on price quotes from the carriers involved. Such price quotes may take two basic forms:

- tariff-based quotes;
- point-to-point quotes.

In a tariff-based quote the carrier typically agrees to provide a certain level of discount for a group of potential movements. For example, an interstate LTL carrier may quote a discount (off the house tariff) for movements between two states including all points in these states [11]. Point-to-point quotes are typically provided by TL carriers. Even these carriers, however, may provide per-mile rates from all points in one state to all points in another (in particular states that are not adjacent to each other so the fixed cost of the move does not come into play). Other carriers who basically provide point-to-point rates include the railroad, where most traffic, for big shippers, now moves under simplified contracts (based, for the most part, on carload rates); point-to-point barge moves, and small parcel/air moves. Segments of international moves are also quoted, for the most part, on a point-to-point per container-load basis or per-ton for specific breakbulk commodities.

In any event, in order to either pre-rate or audit shipments, the system needs a price file which is based on the way the carrier quoted its business - an interstate LTL tariff; a bureau tariff for intrastate LTL moves in still-regulated states; a per-mile table for TL moves; or a point-to-point quote for each leg of an international move, a rail move or a similar shipment.

To automate the rating or audit process, the system has to have the plan which the shipment followed in addition to the price quote for each leg of the plan. In many cases the plan is simply a point-to-point move with only one leg, as is the case with LTL, TL, small package, air, or when a third party handles the shipment door-to-door. In other cases, particularly with international shipments, the system can audit only against a detailed plan, checking each leg (e.g. inland trucking, stevedoring, ocean voyage, customs, port activities, rail, drayage) in turn. For each of these legs there should be a contract, a tariff in force, or a price quote so the bill from the carrier can be pre-rated or audited.

Once a freight bill is audited, the carriers can get paid. Naturally, however, in a full EDI implementation there is no reason to wait for a submission of the freight bill or an audit. If a bill is prerated it can go into a payable data base once the notice of delivery has been checked by the in-transit shipment control system. Given appropriate data links, an electronic fund transfer can be scheduled to take effect at a prescribed date. EFTs can also be batched to pay each carrier, say weekly, all due amounts. Carriers with whom EDI links have not been established can still be paid by a system-generated check.

Note that it is more difficult to follow such a process for inbound moves than for outbound shipments due to the complications associated with controlling multiple vendor shipments. Note also that the system has to be able to cope with many additions to and deletions from the vendor's data base as procurement requirements and agreements change frequently. While these vendors can get routing instructions, it may be difficult to control the vendor's actual shipping process. The first notice of an inbound shipment may come from the carrier's tracing system through the in-transit shipment control system. Once such notice is received, the system can rate the shipment, notify the carrier of the rate that will be paid, and pay (following the arrival notice) within the prescribed period as before. Again, this process can only work with EDI-compatible carriers.

In many cases the paying agency may be other than the company itself. It may be a bank or other freight bill audit and payment firm, a contract logistics company, or a carrier's logistics group. In these cases this third party will have to charge its clients (plants, divisions, etc.) the freight costs before it can pay the carriers. The process of client billing can take place once the shipment is dispatched, based on the same system used to pre-rate the shipment. This is particularly relevant for international shipments which may take a long time to complete while the initial legs are concluded. If the third party and its clients are properly tied through EDI and EFT links, the billing and payment process can be virtually instantaneous.

In many cases the path actually followed by a shipment may be different from the one planned for it. This happens, for example, when a shipment has to be accelerated due to a moved-up need date, or when a vendor sending inbound to a plant has used the wrong carrier. In these cases some reconciliation of charges may be necessary. For example, if a shipper was charged according to a given plan but the shipment (or part of it) was expedited, the variance has to be charged by the system to the plant, division, or company responsible for the change in the plan.

Similarly, when vendors ship inbound using the wrong mode, the wrong carrier, or the wrong shipping plan, the cost of transportation may be higher than expected. By comparing the charges submitted by the carrier to the approved contract rates by the approved carriers, the system can flag instances where the vendor should be charged with the incremental premium transportation costs.

Lastly, there may be cases of damages and shortages which are reported after a shipment has been delivered. The post-shipment system needs to track the claims and help follow them up until they are resolved. Once a resolution is reached all debit and credit operations need to be accomplished by the system and the basic history file updated.

Management Reports

As part of managing and controlling the worldwide movement of freight, various elements in every shipper organization need to be aware of statistics regarding the shipments moved. It is in this capacity that the post-shipment system acts as a basic MIS. The reports are basically generated as queries against a data base containing the basic and auxiliary files mentioned at the introduction of this section. These reports should be available to each activity centre (e.g. a plant, a warehouse, a terminal, a customer zone, etc.) covering the activities of that centre. In addition, it should be available at a divisional level (covering several activity centres) and at corporate-wide headquarters level. The reports can be divided into several groups:

- shipment-specific reports;
- activity summary reports;
- logistics vendor reports; and
- logistics performance reports.

Shipment-specific reports include queries regarding any event related to a specific shipment. Interesting points of information may be the date it was delivered; the date the carrier was paid (including proof of payment such as a cheque number or a wire transaction reference number) for the shipment; the parties handling it; the date it cleared customs; the shipment allocated cost (when it was a part of a consolidation operation), and so on. Of particular interest may be information related to the resolution of claims resulting from damage or theft in connection with a given shipment. This type of report should be available through a query of the basic files in the shipment history data base.

Activity summary reports review all logistics activities for any combination of time period and locations. Thus, a report here may include all movement over the last week inbound to a given plant; all containerized shipments entering the U.S. from Europe through a given port in the last quarter; a profile of all shipments of a given part number from a given vendor in a given period; a histogram of LTL shipment weights going into a given customer zone over a given period; total shipments moved between a given plant and a given warehouse, by week for a quarter; all intra-company shipments by mode for a given time period, and so on. Frequently-used reports can be pre-programmed and even pre-run. More unique reports can be programmed by users given simply query screens.

Logistics and transportation vendor activity reports give a picture of shipments handled by each vendor. Such reports can be used for tracking vendor performance and in contract negotiations. Reports in this category may include volume of business carried by each vendor including payment history for a given period; vendor performance reports such as carrier transit time performance vs. established or agreed-upon standards; carrier awarded vs. actually performed business; carrier error rate in shipment rating; carrier response time to claims; warehouseman cycle time in responding to orders; volume of shipments cleared by a custom broker by location; time from ordering equipment (rail cars, trailers, etc.) until the equipment shows up, by vendor, by location; condition and operability of carrier equipment, by location, by period, and so on.

Logistics performance reports depict how well an activity centre (plant, warehouse, division, company, etc.) is doing relative to its past performance, other centres in the system, industry-wide performance, or standard shipping methods. The dimensions of these comparisons involve both cost and level-of-service parameters. Examples of reports in this category include cost comparisons (total to move a product in a lane, or dollars per ton-mile in/out of a given facility, etc.) between a recent period and the same period a year ago; company-wide and/or plant by plant calculation of transportation as a percentage of each part price (for inbound shipments) and each product's cost (for outbound shipments); savings due to consolidation of LTL shipments into a 'milk run' (this involves a comparison of allocated costs in a milk run with individual LTL costs); savings due to geographical consolidation in a terminal or a pool vs. LTL cost for the same shipments (this also involves a comparison of allocated costs with LTL costs); report on savings resulting from the audit process, the premium freight charge-back, and the claims handling; transportation vs. inventory trade-off analysis by lane for a given period; list of opportunities to utilize more cube or weight in conveyances with less-than-full utilization, as well as better use of tariff weight breaks; 'effective cost' by mode for given lanes and a time period; comparison of ratios over a quarter or a year to industry standard indices; and so on. Many of these reports are designed to show the value of the system itself and the logistics staff who manage it, and through it the transportation and logistics activities of the company.

Logistics Analysis

An important part of the shipment information centre is to serve the analytical needs of the logistics organization. These needs include, first, on-going planning of logistics activities and operations and second, logistics input into purchasing, manufacturing, and marketing decisions.

In support of these two missions, the information centre can include systems to provide, for example, the following analyses.

Tactical Forecasting. As part of a continuous improvement process logistics professionals have to keep looking forward at what the requirements are going to be like in the next month or the next quarter. Given past shipments, as recorded in the shipment history data base, a set of forecasting procedures can be developed. Such forecasts are typically based on exponential smoothing, Box-Jenkins, ARIMA or similar time series methods [12]. The prediction of origin-to-destination flows may also require matrix estimation techniques such as those suggested by Van Zuylen and Willumsen [13] in the context of urban planning. The estimated flow should naturally be augmented by available information regarding upcoming changes in plant utilization, sourcing or marketing channels. The output of this system is a set of origin-to-destination flows including weight and class profiles of the shipments. The forecasting model should be run frequently on a scheduled basis (e.g. once a week) and when an exogenous change is scheduled to take place. The forecast generated by this system should drive many of the other analytical systems described here.

Strategic Forecasting. Many logistics analyses and on-going activities require a forecast of the business one to five years into the future. Such forecasts are naturally less reliable than tactical forecasting since the results are influenced by many factors which are not apparent at the time, such as the general economic climate and the composition of the business. Nevertheless, such forecasts should be generated to support analyses in connection with certain business issues assuming that all other factors remain within reasonable parameters. The forecasting methodology here may rely more on econometric models or commercial econometric forecasts than time series methods.

Setting Normal Shipping Patterns. Given a tactical forecast describing the anticipated freight flows for the next few months, one should be able to set default options for moving those shipments. Those default options would provide a base plan, determining what is the most economical way of moving the freight given the contracts and prices in place.

In the same way that standard MIS can look at past movement and identify lost opportunities, the system described here should be run frequently to identify upcoming opportunities in the forecasted flows. These include all types of consolidation, changes of mode, change of routing, etc. The resulting plans can then be used as a basis for the load control centre when it performs its operational optimization.

Market Test and Award of Business. To decide which carriers should handle their business many corporations conduct a market test. Such tests are typically massive undertakings and are carried out no more frequently than bi-annually.

Given that many carriers who may participate in such a market test may not be fully EDI compatible, the system should generate PC diskettes with the forecasted information (a profile of annual volume by lane, as generated by the strategic forecast and augmented by setting the anticipated normal shipping patterns). Such diskettes should also include the necessary software for bringing the information to the screen, editing it and then storing it on the diskette. The carriers should record their quotes on the diskette and the central computer system should be able to read such diskettes and store all quotes in a data base [14]. This data base can then be processed and the results displayed for decision-making. This process will involve, in many cases, the local logistics centres (plants, warehouses, terminals, etc.) so they should be able to provide their input on line.

Once the awards are decided upon and carriers have been chosen, a final set of negotiations may take place since the total volume of business each carrier may be awarded is approximately known. To this end the system may generate a compendium of the carrier performance reports over recent history. Such reports are part of the management reporting system mentioned above. Once the awards are made the system should issue routing instructions, including the right mode and primary/alternate carriers for every anticipated move. Furthermore, the system should be flexible enough to handle changes on a continuous basis as new vendors and customers are added to or dropped from the system.

New Lane Information. Given the amount of information the shipment history data base holds it is possible to estimate the expected price in a new lane. Such estimates are important for a local activity centre when it needs to ship to or from a new location. It is easy to derive these estimates when using a carrier with a nationwide tariff such as a national LTL carrier (the same discount or other tariff-related formula may apply). For a TL carrier and for other moves where tariffs covering all points are not published, however, a statistical analysis of existing moves augmented by some regional balance information can provide the range of expected prices. Such analysis can be based on multiple regression models using inputs such as mileage, class of shipment, type of origin, type of destination, and other relevant parameters.

The new lane information can also be made available on-line to procurement and marketing managers to help in part sourcing comparisons and product pricing decisions, as explained below.

Product Costing. Expected logistics outlays are important for product costing, both inbound and outbound. Information on inbound logistics costs can be used by procurement managers for product sourcing decisions and in negotiating terms of payments with suppliers. Similarly information on outbound logistics costs is important for product pricing and, again, for setting the terms of payments. To this end the system should be able to analyse total costs for moving products including all elements, as well as in-transit inventory costs. Managers should be able to derive from the system the cost FOB origin, loading port, unloading port, or destination as well as landed costs and average cost by zone of service. For example, the system should be able to recommend a uniform shipping charge for all points if the product is marketed this way.

Facility Location. One of the most important considerations in locating a facility such as a plant, a warehouse, or a distribution centre is logistics. Furthermore, unlike issues such as labour rate, taxes, cost of land and other factors, the logistics impact cannot be analysed in isolation – it is a *system* impact.

Using various operation research methodologies several optimization and simulation models have been developed to help in such facility location decisions [15]. All these models require a strategic forecast of freight flows (or a history from which a forecast can be generated, such as the one kept in the shipment history data base). Facility location models can be incorporated in the system so they can be fed directly from the strategic forecast and then used by logistics managers to provide input into corporate decisions.

The examples of logistics analyses given above are only a small subset of the possible analytical uses of the shipment history data base. Having such a data base ready for queries by the central logistics staff and by field logistics personnel will enable such users to answer many questions and analyse more issues. These include timing adjustments for DRP and MRP systems, shipment size decisions based on transportation/inventory cost tradeoffs, and many others.

Review and Conclusions

The shipment information centre outlined in this paper includes information gathering, processing and reporting from the time a shipment is ordered, through its movement, and until the transaction is completed. This information is also used for subsequent analysis based on all movements. The system described here requires significant information and communications technology resources as well as changes in the management and the organization of the logistics function. It may be somewhat different from the generic management information and decision support systems described in the logistics literature. The first part of this concluding section places the paper in that context. The second part mentions some system architecture issues, followed by a word about implementation and finally some concluding comments.

Link to the Literature

The logistics literature includes many attempts to classify logistics information systems along various dimensions. For example, Sprague and Carlson [16] distinguish between decision support systems (DSS) and management information systems (MIS), suggesting that DSS are an advance beyond MIS. They argue that information systems should support Simon's [17] three elements of decision-making – intelligence, design, and choice: MIS assists in the intelligence stage, management science helps choice, and DSS supports the design stage. Closs and Helferich [18] adopt this view and outline problem characteristics where decision support systems are likely to be useful. Bowersox, Closs and Helferich [19] classify logistics management information applications into *transaction systems* which support daily logistical operations, *decision support systems,* which aim to improve management decision making, and *assessment and control systems* which track performance.

The view taken in this paper is that all MIS functions support management decisions, and thus they were not classified according to any of the schemes mentioned above. This general view is close to that adopted by LeMay and Wood [20] based on Keen's [21] observation that DSS do not represent a distinct system type but are a means for implementing systems. LeMay and Wood further distinguish between operational, tactical and strategic decision levels. While these classifications are helpful, note that they do not imply the use of certain levels of system complexity, sophistication and methodology.

Operational or transaction systems do not necessarily use only simple data base queries. Many operational systems (e.g. freight bill audit, credit on data entry, etc.) may benefit from expert system methodology *because* decisions have to be made quickly. Similarly some dispatching systems and order entry/shipping assignment systems involve real-time mathematical programming software coupled with sophisticated on-line forecasting.

Today's environment of time-based competition calls for quick and accurate response to changing conditions, requiring better and more efficient *operational* decision-making. This article has looked at the functionality of a shipment information centre rather than at the algorithms necessary to process, store and retrieve the data or at how objects should relate to each other. It has also emphasized operational over tactical and strategic decisions support. Note however that this latter decision can be supported only with the data collected through operations. In the system described above the freight bill history file, augmented with other real time information, was the main data source for the statistical forecasting from which all tactical and strategic decision support can be derived.

Architectural Issues

The spatial nature of logistics information systems leads naturally to a distributed processing architecture. Many of the activities described in the proceeding sections can be handled by queries, reports, and documents generated at a local processor which is periodically updated. Local processing and storage power can also be used to consolidate updates of the central data base. Some operations, such as the load control centre optimization can be done only centrally since they involve multiple locations. Also certain functions (such as payments) are typically controlled centrally and thus the data driving them has to be uploaded to a central processing and storage facility. Furthermore, since many tactical and most strategic decisions may involve division-wide or company-wide data, the central facility should be the repository of the history files.

Another architectural feature of the Shipment Information Centre described in this paper is that it involves more than interactions among its three components: the pre-shipment, in-transit, and past shipment systems. The SIC also has to interact with the company's own purchasing systems, order entry, warehousing, material requirements and other systems, as well as with customers', vendors', and carriers' systems. A specification of architecture is beyond the scope of this paper but the interested reader may start with Madnick [22] who suggested specification of a flexible information technology architecture, including a sample configuration which can be developed into an SIC architecture.

Management Structure

As mentioned in the introduction, logistics is an information management business. Good information processing and communication capability can let logistics managers contribute to the company's bottom line by freeing them to pursue innovative logistics solutions rather than manage the information flows manually.

It seems, then, that the case for building and using systems such as the shipment information centre described in this paper is open and shut, and it would lead to great increases in productivity. One should not forget, however, that while the American investment in information technology has been enormous, there is a clear consensus that this investment did not, by and large, improve productivity and profitability. As Thurow [23] points out, all the explanations to this phenomenon of declining productivity despite investment in information technology can be summed up in the fact that organizations have not learned to change as fast as the technology does. Thus instead of *automating* existing logistics and transportation functions and processes, the system's designers must develop new ways of conducting logistics business. Some examples of such new ways of doing business, derived from the capability of the information systems are mentioned in this paper. They include paperless rating and payment, the electronic shipment marketplace, viewing the transportation system as an electronic warehouse, and so on. Surely many other innovations can be implemented if one questions the need for the existing procedures and experiments with new organizations and new ways in which organizations can relate to each other. A full implementation of the SIC will have to involve changes along all these dimensions. It will also have to overcome individual resistance to change, the lack of management's capacity to understand information technology, and the American corporate and legal culture. It is the latter which requires the excessive documentation and verification procedures which go hand-in-hand with many logistics transactions.

Conclusions

This article describes an extensive information processing and communication system. The objectives of this system are twofold: (i) to help manage the logistics process from the point that a shipment is ordered or requested until it is delivered and paid for, and (ii) to help provide input into purchasing, manufacturing and marketing decisions. To reach the first objective, the post-shipment part of the system supports tactical and strategic logistics decisions such as location of distribution centres and carrier market testing. On the operational level the pre-shipment and in-transit part of the system raise the point of view of the logistics manager to where complete supply and distribution channels are visible. In fact the entire network is visible, not only as current events take place, but also with respect to near-term events which the logistics manager should anticipate. To satisfy its second objective, the system helps logistics managers provide input into any decisions involving where to buy/make/store/sell parts, materials, and product, when to conduct such activities, how to price, or negotiate pricing and terms of purchase or sale, and related issues.

The system described here can help organizations reduce the cost of the logistics channel *and* speed up the network flows, thereby helping the organizations who use it to become both time-based and cost-based competitors. It accomplishes this by letting time-based competitors perform consolidations quickly and efficiently with a very wide scope. Such consolidations reduce transportation cost. The basic point here is that if the system knows where every item is *the computer is the warehouse*. It does not matter where items are physically located - on a barge, train or in a distribution centre, as long as the logistics manager can get at them, when unexpected needs arise, and expedite them in a controlled fashion. Thus not all items have to move fast if those that do, can.

The logistics management process implied by the use of the SIC described here is virtually paperless, and involves different ways of doing business between carriers and shippers. For example, the electronic marketplace concept implies that traditional market tests be replaced by a set of carriers which is prequalified annually (or once every several years) to do business and some default prices are set. A real-time bid and award process then takes place every day on a load by load basis. This, in turn, implies different contracts and entirely different procedures. It should free logistics managers to concentrate on the more forward-looking parts of the business. The process also embodies continuous measurement of every element involved in logistics. By itself such a process should lead to higher quality and better performance by all participants.

Finally, the tie between shippers and carriers – with the latter continuously transmitting conveyance location and preferred direction information, and with the load control centre taking advantage of this information – can lead to a more efficient use of resources. Carriers with fewer empty miles are more productive and can offer better rates and better service, reducing total logistics costs.

Notes

1. Stalk, G., Jr. and Hout, Thomas M., *Competing Against Time - How Time-Based Competition is Reshaping Global Markets*, The Free Press, 1990.

2. The emphasis here is on the transportation function takinig order entry, warehousing control and various other logistics information systems as given. Many of the functions which are commonly found in such systems and relate to transportation are included in the system described in this article.

3. To simplify the discussion, we assume here that the location where each shipment is going out of or coming from is fixed and known.

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6. Bodin, L., Golden, B. and Ball, M., 'Routing and Scheduling of Vehicles and Crews: The State of the Art', *Computers and Operations Research*, vol. 10, no. 2, 1983.

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8. Many corporations (e.g. Westinghouse, Goodyear, Pfizer and others) keep a house LTL tariff, against which all LTL carriers bid. This tariff is then used to rate all outgoing shipments, and for audit and payment purposes. TL rates can be quoted on a distance-based fixed and variables cost formula, a distance-based table or a point-to-point table.

9. Note that this does not necessarily mean the lowest bidder. The bid can be qualified by past service history tables which the MCLCC can keep and update periodically.

10. A 'carrier' in this case refers to any provider of logistics services such as a warehouseman, a custom broker, or a consolidator, in addition to a shipping company, a motor carrier, a railroad, an airline or a barge company.

11. In many cases the class is also part of the pricing mechanism used by the carrier and thus the quote may include both a discount and a class of freight.

12. A review of such methods can be found in many logistics texts such as Ballou [24] who gives many references to the original works.

13. Van Zuylen, H.J. and Willumsen, L.G., 'The Most Likely Trip Matrix Estimated from Traffic Counts', *Transportation Research 14B*, 1980, pp 281-93.

14. Some carriers may have no computer facility and may require a paper process with written quotes sent in and entered manually to the system.

15. An optimization methodology for facility locations is described in the classical work of Geoffrion and Graves [25]. Commercial models include the SAILS model which is a full optimization/data base product marketed by INSIGHT Inc., The optimization/heuristics LOCATE model used by Cleveland Consultants Associates Inc., and several others. The need for rigorous optimization methodologies in this context is described by Powers, Karrenbauer and Doolittle [26].

16. Sprague, Ralph D. and Carlson, Eric D., *Building Effective Decision Support Systems*, Prentice Hall, 1982.

17. Simon, H.A., *Administrative Behavior*, MacMillan Co., New York, 1976.

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Professor Yosef Sheffi, Center for Transportation Studies, Massachusetts Institute of Technology, Cambridge MA 02139, USA