Decision Support System for Trucking Break-Bulk Operations

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ABSTRACT

Motor carriers have had to make profound changes in their method of operations with the advent of deregulation. Before deregulation, operating inefficiencies could be passed on to the consumer through negotiated rate hikes with the Interstate Commerce Commission. However, in today's competitive environment improvements in productivity are a necessity. A survey of the needs of the industry was conducted and it was determined that one such improvement would be the use of a decision support system (DSS) in the day-to-day operational planning of a motor carrier break-bulk. A break-bulk facility is for the consolidation of less-than-truckload freight. A DSS was designed and developed in conjunction with a large motor carrier. The DSS was designed to use a personal computer at the break-bulk operation in conjunction with a data base maintained at a remote main frame. The data base consists of a file of labor used and productivity achieved as well as data from a tracking system. The DSS on a daily basis determines the best allocation of men, equipment, and facilities for various costs and service situations; it also determines a weekly forecast of manpower required. The DSS developed has been demonstrated at the motor carrier's facility and is to be implemented systemwide.

In July 1980 President Carter signed the Motor Carrier Act of 1980 that deregulated the trucking industry in the United States. The law provided for (a) easier entry into the industry, (b) easier access for new routes and elimination of inefficient route restriction, (c) increased pricing freedom, and (d) limits on rate bureau activities. The immediate result of this deregulation has been a scramble by common carriers for new route awards. Many large carriers picked up expanded authority. There has also been an increase in the number of carriers; for example, from 17,000 in 1979 to more than 25,000 in 1982. The new entrants were for the most part independent owner-operators who concentrated on truckload (TL) freight. The TL sector does not require capital investments in terminals, break-bulks, and sophisticated management information systems whereas the less-than-truckload (LTL) market does. As a result the existing companies saw a significant reduction in their TL share of the market. They have therefore been forced to concentrate on the LTL market where success depends primarily on two factors. First, the carrier must provide the service (fast delivery) that is required to attract and maintain customers and, second, the carrier must minimize costs. Unfortunately, the two conflict, which requires some form of trade-off.

Further compounding the problems of deregulation was the recession. In 1981 prices for TL shipments had fallen 26 percent, and LTL had fallen 15 percent by 1982. Under these circumstances there should have been a self-correcting situation in which the less-efficient carriers would have gone out of business. This was not the case, however, because of the Multi-Employer Pension Plan Amendment Act (MEPPA), which created a barrier to liquidations or mergers. MEPPA requires that a firm pay its unfunded vested share of the pension plan before going out of business. In many cases, this unfunded liability exceeded the net worth of the company; thus any liquidation was forestalled.

To survive under these conditions, increased efficiencies in operations are required. Before deregulation, inefficiencies in operations could be passed on to the consumer via negotiated rate hikes with the Interstate Commerce Commission (ICC); competition was based primarily on service rather than costs. As a result, the trucking industry has lagged far behind other industrial sectors in applying modern productivity practices. In the January 1982 TRB special committee report (1) to the TRB Executive Committee on Research Needs of the Motor Carrier Industry, productivity headed the five priority areas identified in which research was needed immediately.

The improvement of efficiencies in LTL operations is of course vital for the existing carriers, given the loss of their TL markets. Once such area that has great potential payoff for LTL operations is the break-bulk.

A break-bulk is a consolidation point for LTL freight and is part of a hub and spoke system as shown in Figure 1. Each hub acts as a consolidation point and distribution center for a specific territory. The terminals at the ends of the spokes are pickup and delivery points for specific localities. Connections between adjacent hubs are on a periodic basis. Thus a shipment of freight would be picked up at an outlying terminal and be forwarded to a break-bulk facility for consolidation with other shipments and be moved from hub to hub until the shipment reached the break-bulk facility servicing the territory of its destination. At that point it would be dispatched to the nearest terminal servicing the final destination. Efforts are made to minimize the breaking of freight at intervening hubs by consolidating shipments into TL shipments that can be forwarded directly to the final break-bulk facility or terminal. It is estimated to cost on the average $250 to consolidate one TL shipment (2).

Break-bulk facilities are characterized by being operated in a labor-intensive mode rather than being

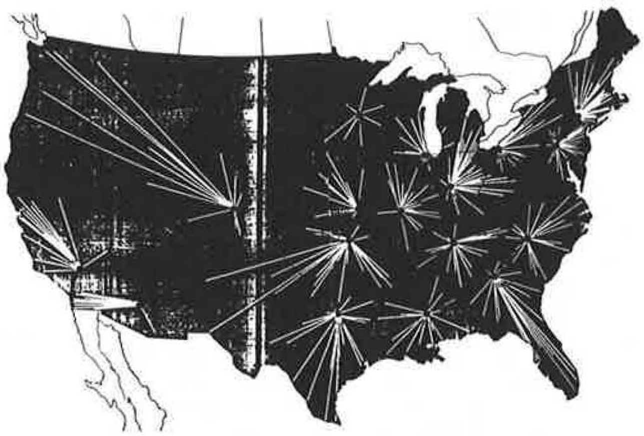

FIGURE 1 Break-bulk hub and spoke systems.

automated. This is true for two reasons: first, general freight is nonhomogeneous and, second, the labor force has not been cooperative in establishing automated systems. The labor force, which is dominated by the Teamsters Union, has some of the most stringent work rules in the American industrial sector and their average hourly wage including benefits has risen to $19 an hour. As a result, labor makes up 65 percent of the average motor carrier's operating costs.

The typical break-bulk facility is shown in Figure 2. Such a facility can have more than 150 doors for loading and unloading freight and can employ more than 50 dockhands per shift. Because service to the customer was the key competitive factor before deregulation, operations at a break-bulk facility have been such as to emphasize that factor to the detriment of efficiency. Thus, instead of trying to minimize the weight-distance through the terminal, the operations have focused on minimizing the mishandling or misrouting of freight. This has resulted in the establishment of specified doors and areas for loading and unloading and of traffic patterns that are normally across and lateral within the facility. Unloading is done on one side or area of the dock; quite often this involves the use of a dragline that then delivers the freight around the dock to the specified loading door. Unloading doors for specified locations tend to remain fixed.

The research being reported was based on apparent needs of the trucking industry with respect to increased productivity and quality of service. The study is limited to Class I general freight motor carriers.

The approach taken to accomplish the research was as follows: a literature survey was conducted to determine existing research on productivity in the transportation industry with emphasis on the motor carrier segment. It turned out that the amount of research documented in the literature was quite limited.

A written survey was conducted of the general freight motor carriers, and specific productivity needs were identified. These needs were further defined through telephone interviews and visits to several motor carriers.

From the information gained by a review of the literature, the written survey, and the visits it was concluded that a decision support system for break-bulk operations was desirable and would be developed. The decision support system would be designed and developed using the techniques and principles documented in existing literature. The rationale is then developed for the specific application of those principles to the decision support system that was created.

LITERATURE REVIEW

There are numerous articles and books concerning the economics of the trucking industry, the impact of deregulation on the industry and its customers, and operations research applications to specific transportation problems such as optimum pickup and delivery, location of fixed facilities in distribution systems, least-cost shipping patterns, and network analysis and design.

For instance, Perl (3) has an exhaustive summary of the applications of various operations research techniques to the transportation problems mentioned previously. Rakowski (4) and Muskin (5) have excellent summaries of the issues, importance, and impact of deregulation on the industry. An article by Stock (6) in 1979, which examined the role of motor carriers in forming new regulatory legislation, emphasized the necessity of using operations management methods to increase efficiency and profitability in the new deregulated environment. Barker, Sharon, and Sen (7) in a 1981 article discussed efforts to improve profitability through an understanding of factors contributing to LTL and TL costing. Decision-making rules were established for the routing of freight and trucks to replace traditional rules of

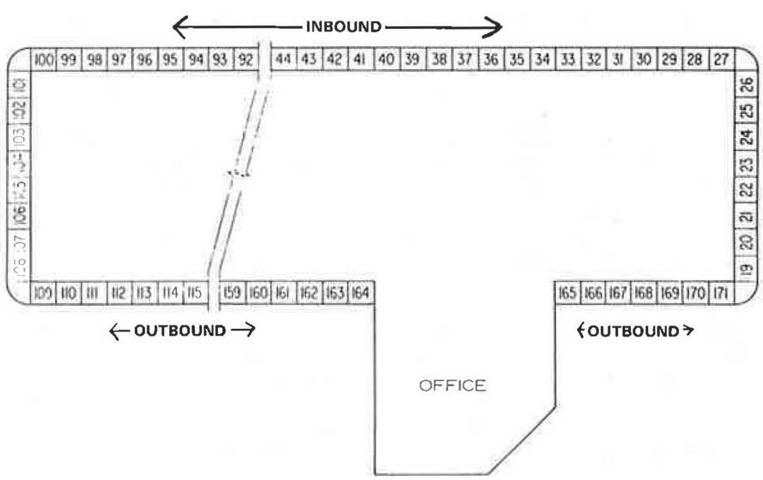

FIGURE 2 Typical break-bulk facility.

thumb for both TL and LTL shipments. A computer approach was developed and implemented with an estimated savings of $9 million annually.

Powell and Sheffi (2) in 1983 developed a heuristic approach to improving the load planning of LTL motor carriers. A trade-off of service versus costs was accomplished with the aim of gaining more direct shipments that bypass intermediate break-bulks. Starting with the existing network between terminals and break-bulks, the approach does the following: finds the best break-bulk to which an end-of-line terminal will be connected, adds links from an end-of-line to other break-bulks, and deletes links between break-bulks. One of the things noted was that the break-bulk closest to a terminal is not necessarily the best approach to linking a terminal to a break-bulk. None of the previously mentioned studies directly addressed the needs and wants of the motor carrier in day-to-day operational planning for the break-bulk facility.

Ferguson (8) came closest to a discussion of the problem in 1981 when he conducted an investigation of the use of operations management principles in the motor carrier industry. The objective was to determine the degree to which sophisticated computerized planning and control systems were used in the operations area and to determine how operations management principles were being applied in the motor carrier industry. Because of the dearth of recent academic or practitioner literature, he conducted a survey of more than 2,000 motor carriers of various sizes. He found that the larger carriers made extensive use of the computer but that the smaller carriers did not. He concluded that the area of computer applications needed to be thoroughly studied, particularly in day-to-day operational planning. He also identified the minicomputer as having potential application in the industry. (It should be noted that with the developments of the microcomputer since Ferguson's article, its impact should be studied as well.) He concluded that there was much to be done in the industry to improve operations management. Questions about the needs for forecasting, identifying facility bottlenecks, manpower allocation, "spotting" trailers in the unloading queue and at the dock to minimize the weight distance through the facility, optimum pickup and delivery, and the use of tracking systems in day-to-day planning were not addressed.

NEEDS SURVEY

To determine the needs of motor carriers with respect to improved productivity and to assess the use of operations management techniques in day-to-day LTL operations, a mail survey was conducted in April 1983. Figure 3 shows a copy of the survey form. The survey was limited to the top 141 Class I general freight carriers as listed in the American Trucking Associations' Financial and Operating Statistics (9).

There were 78 responses within 3 weeks of the mailing from 20 firms with revenues greater than $100 million and 58 firms with revenues less than $100 million as shown in Table 1. The survey revealed that more than 97 percent of the firms used computers in their operations with the primary use in the financial area, tractor and trailer control, and customer service. It also indicated the use of operations management principles in day-to-day planning. In those firms with annual revenues greater than $100 million a significant use was made of operations research in the areas of optimum routing for pickup and delivery, break-bulk operations, and forecasting workloads. Firms with less than $100 million in revenues were much more limited in their use.

The survey was limited in that it was impossible to determine how effective the firms were in their use of the techniques. To evaluate this effectiveness, eight firms were visited and numerous firms were contacted by telephone.

It was found that in most cases, although the importance of better use of operations management techniques was recognized, little was being done effectively because of a shortage of personnel with the required skills. Before deregulation most trucking firms did not even have industrial engineers or similar staff concerned with productivity improvements in their operations.

As a result of the survey, follow-up visits, and telephone interviews it was found that although many of the firms were using operations management techniques and the computer in day-to-day operations of their break-bulks, such use was at a primitive level. The largest use of the computer in break-bulk operations revolved around the use of the data in tracking systems. A tracking system provides customers with status information on their shipments. The information available in these tracking systems usually consists of the bill of lading number, the number of pieces, the weight, the final destination, the current location of the shipment in the system (on a trailer or at a facility), and the time of the next action (departure from or arrival at a facility). For the larger carrier, the system could identify the status of more than 100,000 shipments at any one time. Although this information is available to the break-bulk managers, there is no systematic use of it in a rapid manner or on a daily basis to aid in the improved allocation of manpower, equipment, and facilities.

DECISION SUPPORT SYSTEM DESIGN AND DEVELOPMENT

A decision support system (DSS) consists of a person and a computer working together in an interactive manner to arrive at a decision to a semistructured problem. The system has a model that develops alternatives allowing the person with his judgment to arrive at a more effective solution. Decision support systems are characterized by a large data base, the facility for the manipulation of that data base (the model), the importance of timeliness in arriving at a decision, and, finally a person in the loop to provide judgment in evaluating alternative solutions. The design, development, and implementation of a particular DSS is a function of the decision maker and the situation. Each must be carefully considered.

Role of Computer in Decision Support Systems

The role of the computer in the decision-making process may be described as

1. Assisting managers in their decision processes in semistructured tasks;
2. Supporting, not replacing, managerial judgment; and
3. Improving the effectiveness of decision making rather than its efficiency.

A semistructured task can be defined in terms of a structured or unstructured task. A structured task is one that can be completely defined and one for which a computer would arrive at a definitive solution; an unstructured task is one that cannot be defined analytically and the solution to which depends entirely on the judgment of an individual. Semistructured tasks are those tasks that fall in between the structured and the unstructured. Here,

SURVEY OF CLASS 1 COMMON CARRIERS OF GENERAL FREIGHT

Please complete the survey of current uses of computer aided decisions in the general freight motor carrier industry. Mail the results to Madison M. Daily, Transportation Institute, Univ of MO-Rolla, Rolla, MO 65401.

Are your annual intercity freight revenues: (check one)
- less than 10 million dollars annually ____
- greater than 10 million dollars but less than 100 million ____
- greater than 100 million dollars ____

Do you utilize automated data processing equipment: Yes___, No___.

Do you do your own software programming: Yes___, No___.

Do you use now or do you plan in the future to use the computer in day-to-day operational planning: Yes___, No___.

If yes, is it used for:

	NOW	FUTURE
Financial Purposes (accounting, billing, etc.)	___	___
Electronic billing rather than mail (computer to computer)	___	___
Customer Service (status of shipments)	___	___
Direct access by your customers to shipment status information in your computer data base	___	___
Optimum routing for pickup and delivery	___	___
Routing of shipments for intercity freight (consolidate shipments to minimize breakbulk operations)	___	___
Tractor and trailer control (assign drivers, shipments and routes)	___	___
Breakbulk or terminal operations (minimize handling of shipments and queues for loading and unloading)	___	___
Forecast work load to optimize allocation of labor and equipment	___	___
Other________________________________	___	___

FIGURE 3 Survey form.

TABLE 1 Results of Survey

	> $100 Million		< $100 Million	
	Yes	Future	Yes	Future
Do you use ADP	100		96	
Do you do your own programming	94		95	
Use in operational planning				
Financial purposes	100		98	
Electronic billing	39	61	11	68
Customer service (shipment status)	94	6	51	42
Direct access by customers	72	22	6	66
Optimum routing (pickup and delivery)	28	55	8	66
Consolidate shipments	50	33	11	57
Tractor and trailer control	94	6	23	58
Break-bulk operations	61	28	9	62
Forecast workload	50	44	17	58

Note: All number are percentages.

although some aspects can be modeled, the problem as a whole cannot be defined in an optimum closed form.

Role of Manager in Decision Support Systems

When the output of the computerized models is combined with the judgment of an individual the combination can often lead to a more effective decision. A point should be made regarding the difference between effectiveness and efficiency in decision making. Efficiency is a quality of a task done well as determined by comparison to some predefined standard, whereas an effort's effectiveness is determined by its success in dealing with all the identified relevant criteria. The DSS under the control of the manager is used as a supportive tool to augment decision-making capability (10). Use of a DSS does not ensure more effective decisions; a manager who exhibited poor judgment would continue to make poor decisions when using a DSS although his decision-making efficiency might be increased.

Elements of a Decision Support System

Sprague and Carlson (11) describe a DSS in terms of its technological characteristics; that is, a DSS is aimed at solving a semistructured problem and requires a large data base, the manipulation of that data base by means of a model, and a system that is user friendly so that man and computer can operate in an interactive mode to evaluate alternatives. The components of the DSS are defined as the dialog subsystem that provides the interaction between the system and the user; the data subsystem that provides for the entry, storage, and retrieval of data; and the model subsystem that manipulates the data to arrive at various alternatives.

Decision Support System Development Methodology

The investigation of motor carrier needs indicated that all of the DSS elements were evident in break-bulk operations. First, the tracking system was a large data base containing all the essential information required for day-to-day effective planning, and there generally existed a historical record of manpower used and productivity achieved that could be used as a basis for forecasting. Second, there was certainly a need to manipulate that data in such a manner as to arrive at decisions that would lead to more effective use of men, equipment, and facilities. Third, timeliness was crucial in that, in order to be competitive, a firm must deliver freight with a minimum of delay; this constraint requires break-bulk personnel to unload, reload, and dispatch all inbound freight in less than 24 hr. Finally, the many variables involved, such as the daily variation in the amount of freight, the weather, the destination door loadings, and the requirements to handle hazardous and priority freight, necessitate that a person be in the loop to exercise judgment. This is an excellent example of a semistructured problem. It is one in which it is impossible to completely mathematically define an algorithm to arrive at an exact solution.

SELECTION OF A DESIGN AND IMPLEMENTATION STRATEGY

The implementation strategy selected for the design of the DSS was the evolutionary approach described by Boland (12) and Alavi and Henderson (13). That is, the user was to play an active role in the design and development.

The design and development were initiated by a meeting with the motor carrier's break-bulk managers and operation managers. At this first meeting a briefing was given about what a DSS is, what it can do, what it cannot do, and what the author hoped to accomplish. The break-bulk manager in turn presented what he thought to be his major problems. These were (a) forecasting his workload so as to be able to make an accurate weekly manpower bid, (b) a system that on a daily basis would identify where bottlenecks within the facility were going to occur, (c) the number and type of trailers required for each loading door, and (d) the number of personnel required for each shift.

At the conclusion of this meeting, it was agreed to observe the operation of the break-bulk in order to become better acquainted with the day-to-day decisions made by the break-bulk management staff. This was arranged and a day was spent observing the operations and shift managers as they carried out their various duties. Particular emphasis was placed on their decision-making processes.

Following this, the key decisions made by the break-bulk manager and his staff were to be identified and a series of questions was to be developed that needed to be answered in order to make those decisions. Based on the observations, there were two different time periods involved in the decision process. One occurred every Friday and involved the determination of the amount of manpower required for the next week. It was necessary to determine the manpower required for each shift in order to arrive at a bid. The bid was made to the local union and bound the motor carrier to guarantee the union work for at least 90 percent of the manpower bid. If the manpower required exceeded the bid, cost penalties would be applied to those hours worked beyond the bid.

The second time period occurred each morning before the start of the first shift. At this time the manager was faced with the task of determining the actual manpower that would be required for the day on the basis of the information in the tracking system about inbound freight and the freight already being unloaded at the dock. He then compared the required manpower with the bid for the day. If the required manpower fell outside the flexibility of the bid, he was then faced with the decision about a trade-off of costs versus service. The manager also needed to determine for the day how many and what type of trailers were required for the various freight destinations, the areas of congestion that might occur within the break-bulk, and how he could "spot" trailers at the dock to minimize his workload.

When this decision analysis had been done the author returned to the break-bulk where he and the management staff, using the decision analysis as a guide, arrived at the following agreed-on basis for the design of the DSS.

The key decision to be made by the break-bulk manager was how to make the best use of resources that consist of men, equipment, and facilities. The trade-off was service versus costs. The specific questions to be answered were:

1. How much manpower do I need for each shift?
2. How much manpower do I have bid?
3. How can I arrive at a good weekly bid?
4. How many and what type of trailers do I need for the various loading doors?
5. Where are my facility bottlenecks?
6. Where is my facility flexibility?
7. How can I spot my trailers in the arrival queue to minimize handling?
8. How can I assign unloading doors to minimize handling of freight?
9. Can I consolidate shipments to make a direct shipment to a final destination bypassing intermediate break-bulks?

It was also determined that because there was no local computing capability at a break-bulk the DSS would be developed on a personal computer. There are computer terminals (IBM 3278) available at the break-bulk that interact with the tracking system data base maintained at the corporate headquarters. However, these terminals are used in an edit mode only to keep the tracking system updated. The personal computer would be linked to the tracking system data via an existing communications network and the required data would be downloaded onto the personal computer storage disk as needed.

When a basis for the design had been determined, the next step was to arrive at a group of representations of what one would like to have appear on the computer CRT in either graphics or text form to answer the key questions. It was agreed that during preparation of these representations we would not be concerned with whether it would be actually possible to produce the representation on a computer but would rather concentrate on what was really required to arrive at a good decision.

This process was carried out over a period of about 2 months and was an interactive one in that the author would take sketches of the representations and have them made into finished drawings and then the managers would react to them with new or modified ideas of what would be helpful.

After the final representations, which were for the most part in graphical form, had been prepared they were taken to two other break-bulks in the motor carrier's system in order to test their applicability to the system as a whole. Again some new ideas were introduced and some modifications were incorporated, but for the most part they were minor, which indicated that the original ones were applicable systemwide. The next step was to actually develop the DSS.

SELECTION OF PERSONAL COMPUTER HARDWARE AND SOFTWARE

The first consideration was to decide which computer to use. There were several constraints to be considered. Most important, the only personal computers readily available to the research group were IBM PCs that ranged from a model with a 64K memory and one floppy disk drive to the IBM PC XT with a memory of 128K, one floppy disk drive, and a 10MB hard disk drive. Because the tracking data to be downloaded could be as much as two megabits; the historical manpower and productivity data one megabit; and the programs for the data base, model, and dialog system another megabit; the PC XT was selected. A description of the specific hardware is given in Table 2.

The next choice was that of the languages to be used. At first it was planned to use UCSD P code pascal because of its portability. Using the language would make the programs independent of the IBM PCs. However, because of the many commercial applications programs available under the IBM disk operating system (DOS 2.0) and their ease of use, the author selected DOS 2.0. Aston Tate's DBASE II was selected for the data base management system--it also has the capability of writing programs for mathematical manipulations. The slowness of the sort and file merging routines is offset by the fact that the PC is often more responsive to the user than is time sharing or batch processing on a large main frame. The graphics package chosen was Business & Professional Software, Inc.'s business graphics. This is an excellent interactive, user friendly software package. The menu-driven dialog system linked the user to the various models and was written in IBM BASICA.

The model system consisted of the routines to sort, merge, and manipulate the data. The most crucial effort was the selection and development of the forecasting technique to be used. This was because of its importance in reducing costs by limiting the cost penalties that occur when the manpower bid deviates by more than 10 percent from the required. Further complicating the forecasting task is the large random component in historical data. Simple exponential smoothing with decomposition and correction for trend was selected as the best technique for forecasting.

APPLICATION

In this section the DSS that was developed is presented. The DSS is menu driven; the user responds to the items listed. The DSS, when running a particular model, often requires an interactive response from the user. This allows the user to address "what if?" and "what was?" queries to the system.

Log-on Procedure

The first step is to enter the command "yellow" that will be followed by the logo and request for a password. Because the DSS is a management tool it should be protected by proper password identification.

Top-Level Menu

The top-level menu allows one to accomplish three different procedures. The first selection allows one to produce the forecast for the week. The forecast is done using exponential smoothing in an interactive manner. The interactive variables are the alpha parameter and the productivity. These can be varied and displayed in various combinations along with past actual and forecast data to allow the manager to use his judgment in arriving at a correct forecast.

The second selection deals with the break-bulk operations planning for the day. It determines the actual manpower required; the number and type of trailers for the various loading doors; and the doorloading for each door in terms of weight, pieces, and number of shipments and allows the manager to interactively vary costs versus the amount of freight dispatched for the day.

The third selection allows the IBM PC XT to function as an IBM 3278 terminal. This allows for the interface between the data maintained at corporate headquarters and the PC. One can also return to the DOS 2.0 operating environment if desired.

TABLE 2 Personal Computer Hardware and Software Used

Item	Vendor	Model
Hardware		
Personal computer	International Business Machines	XT (128K Memory)
Printer	International Business Machines	Dot Matrix
Plotter	Hewlett Packard	7470A
Software		
Data base system	Aston Tate	DBASE II
Graphics	Business & Professional Software, Inc.	DOS 2.0
Disk operating system	International Business Machines	2.0
Other	International Business Machines	BASICA

Forecasting Menu

The forecasting menu allows for the accomplishment of two procedures. The first procedure develops the weekly forecast through an interactive process with each day of the week forecast separately. First the alpha to use as the parameter in the exponential smoothing algorithm must be selected. Alpha would be selected on the basis of a judgment about what the current environment required. For example, in a period of rapid growth or decline, an alpha near one would be used whereas in a period of little change an alpha near zero would be used. To determine which alpha to use, one can use the second selection, the graphics mode. One can display past actual data along with the forecasts based on various alphas to determine which is appropriate.

When an alpha has been selected using the first procedure, a forecast is generated along with the average productivity achieved. The amount of past data to be averaged for the productivity is a function of the alpha and is related by the following formula:

$$N = (2 - \text{alpha})/\text{alpha}$$

where N represents the number of past weeks to be averaged. The formula is derived from equating the mean value of the age of a moving average to the mean value of the age of the exponentially smoothed data. This value is also used to determine how far back one should go in the actuals file before starting the forecasting process. Should the manager decide that another productivity standard would be more appropriate, he can revise the forecast using those figures. When the forecast has been developed for the week it can then be compared graphically with past weekly forecasts or actuals for any week in the historical file. Again the manager can use his judgment to determine if the forecast is appropriate. This feature is useful for weeks that have holidays that create transients in the orderly movement of freight.

Representations for this procedure consist of

1. Menu;
2. Command sequence;
3. Manpower used each day of the week in 1983 overlaid with the forecast for an alpha of 0.1 and 0.9;
4. A forecast for each day of the week based on a selected alpha; the productivity achieved for this period in bills per hour per person and pounds per hour per person is also indicated;
5. Command sequence to revise forecast based on a different productivity number; and
6. A forecast based on the standard productivity of 2.8 bills per hour per person versus the actual productivity achieved.

In the graphics mode, the manager has the option of calling up a historical file of information. Past data on manpower used and productivity achieved can be displayed in various graphic formats. This information can be used to decompose the data into seasonal and cyclical patterns, to fit various curves to the data to determine trends, and to compare the current weekly forecast to past actual data for the same week of the year. The capability exists to limit the data shown to a selected portion of the data for detailed analysis. This again allows the determination of specific seasonal patterns. In addition, one can overlay the labor used with the productivity achieved for the same period; this allows one not only to see how much labor was used but also to see how efficiently it was used.

The BPS graphics package has the capability of fitting the following curves to the data: linear, second order polynomial, exponential, log, and sine. The normalized standard error that is the ratio of the deviation of the points from the curve to the data's standard deviations is determined. A zero would indicate a perfect fit and a one would indicate no fit at all.

The representations for the forecasting graphics consist of the following:

1. Command sequence;
2. Current week's forecast overlaid with the same week for the past 2 years;
3. Average weekly manpower used in 1981, 1982, and the first 39 weeks of 1983 overlaid with the best curve fit to the data; a normalized standard error is indicated;
4. Average weekly manpower used for 1983 overlaid with the best curve fit to the data;
5. A plot of the average weekly labor used in 1983 overlaid with the average weekly productivity achieved in bills per hour per person and pounds per hour per person;
6. A plot of the actual weekly labor used overlaid with the bills and pounds moved across the dock;
7. A histogram of the productivity achieved in bills per hour per person for 1981, 1982, and the first 39 weeks of 1983;
8. A side-by-side bar chart of average weekly labor used for each quarter for the years 1981, 1982, and 1983;
9. A side-by-side bar chart of average productivity achieved in each quarter of 1981, 1982, and 1983 for both bills per hour per person and pounds per hour per person;
10. A plot of the average weekly labor used for the early shift as a percentage of the total average weekly labor used; and
11. A conversion from the specific number of the week of the year to an actual date for 1981, 1982, and 1983.

BREAK-BULK OPERATIONS PLANNING MENU

The break-bulk operations planning menu allows for the following procedures.

Coding of Bills

This procedure asks the operator to enter a trailer number from those trailers in an inbound or arrival status. The procedure then takes each shipment on the trailer and assigns it to the appropriate loading door for the shipment's next destination. A printout is provided that indicates the shipment number (pro number), the pieces, the weight, the final terminal for which the shipment is destined, the door through which the shipment will be dispatched, and an indication of whether the shipment is hazardous or hot (priority). This allows dock personnel to direct each shipment to the proper door for dispatching. A second printout is also provided that summarizes the weight and pieces for the various destinations and loading doors--the summary is sorted by weight. This allows the manager to spot the trailer at an unloading door nearest to the loading door through which the largest amount of freight is to be dispatched. This procedure, which uses a heuristic approach, attempts to minimize the weight distance of the freight across the dock.

Estimate Status of Trailers Unloading at Dock

The tracking system data do not reflect the correct status of those trailers unloading at the dock. The system reflects what the trailers contained when they arrived--as soon as they are unloaded the data are purged from the system. Some motor carriers are investigating the use of bar codes similar to those used in a grocery store check-out counter to keep an accurate account of freight within terminals. Without such a system one is forced to estimate the status of the trailers in order to be able to answer the questions posed by the DSS. This is accomplished by having the manager respond to a query on the CRT for each trailer in an unloading status. As each trailer is listed, a response is solicited about the percentage of the freight that remains on the trailer. The weight and shipments for each trailer are then adjusted by this percentage.

Weight for Next Destination and Final Destination

This procedure scans all the inbound trailers and the trailers that are in an arrival status plus the updated status of those trailers at the dock and combines all of the information into a single file. It then summarizes the data by the final destination terminal or break-bulk. This allows for the determination of any direct shipments to a terminal or break-bulk bypassing any intermediate break-bulks. It does this by listing any shipment of more than 10,000 lb destined for a terminal not directly serviced by the local break-bulk. Following this the file is then summarized by those destinations normally serviced on a daily basis by the local break-bulk. This gives the door loading by weight and pieces for each unloading door. Because of CRT size limitations only 13 destinations can be printed on the screen at any one time in graphic form. With this information the manager can reassign an extra door for a destination that is overloaded by deleting a door that has little freight scheduled. It also allows him to assign extra personnel to those areas where the need for immediate assistance is indicated. The information developed by this procedure is used in the trailer and manpower procedures that follow.

Trailer Needs

This procedure takes the door loading information gathered in the weight by destination and final destination procedure and uses it to estimate the number and type of trailers required for each door. It does this by using a table of weight versus trailers required. It also estimates the weight remaining that is not sufficient to fill a trailer.

Manpower Needs

This procedure determines the personnel required for the next 24 hr. To run this procedure, one must answer the following questions as prompted on the CRT:

- What productivity figure do you wish to use? Enter bills per hour______
- How many bills do you have to unload at the beginning of the period for those trailers now unloading at the dock? Enter bills______
- How many bills do you want to have to unload at the end of the period for those trailers unloading at the dock? Enter bills______
- What is your 90 percent bid for the day? Enter number of people bid______
- What is the average regular pay? Enter pay______
- What is the average premium pay? Enter pay______

The procedure then responds with the number of personnel required and any associated unplanned productivity costs. These productivity costs are computed whenever the manpower required falls outside the range of 90 to 100 percent of the bid for the day. If the number is below 90 percent the extra productivity costs are based on the regular pay times the number of hours the excess people would work. If the number is greater than 100 percent the extra productivity costs are based on the premium pay times the number of hours worked above 100 percent. These calculations are in accordance with the current union work rules. This procedure can be run with various combinations of entries to arrive at a best figure for productivity cost. The major tradeoff is the amount of bills one has on hand at the end of the period versus the number of people required--this relates to costs versus service.

DEMONSTRATION

The software package was demonstrated using data furnished by a large motor carrier. The data consisted of all the tracking system data for one of the break-bulks for September 7, 1983. In addition, historical data consisting of the number of people used and the productivity achieved in terms of shipments per hour per person and pounds per hour per person for each shift for the years 1981, 1982, and the first three quarters of 1983 were furnished in tabular form. This information was then manually entered into the PC XT's hard disk. It was then decided to furnish the data in tabular form instead of trying to establish a real-time temporary communication link between the campus and the corporate office tracking system. After the expected minor software glitches were corrected, the DSS was found to operate quite well. The software was then taken to the motor carrier's corporate headquarters where it was placed on the hard disk of an IBM PC XT. It was then demonstrated several times to break-bulk management and various corporate staff personnel.

The demonstration used the previously furnished tracking system and historical labor used and productivity achieved data bases. The reception was quite positive. The break-bulk managers were pleased with the speed and ease of displaying decision-making information and stated that they had gained new insights into the historical data. Several new areas of potential application for the DSS were explored; for example, the use of a DSS in the day-to-day planning of maintenance operations was suggested. It was also noted that the processed information in the various break-bulk DSS data bases could be off-loaded to the corporate main frame for consolidation to provide a daily systemwide report on break-bulk effectiveness. Other improvements to the DSS were also suggested; for example, it was suggested that the condition of the weather be indicated in the historical files.

SUMMARY

The productivity gains wanted and needed by motor carriers have been identified as forecasting workloads, planning break-bulk operations, establishing sound work standards, optimum pickup and delivery of freight, and techniques for more effective consolidation of LTL freight. A DSS was developed that dealt with short-term forecasting and break-bulk operations planning. The evaluation criteria selected to determine the effectiveness of the DSS were improvements associated with decision outputs, improved cost benefits, and a change in the decision process of the break-bulk managers.

It was shown that the DSS has great potential for improving the productivity of motor carrier break-bulks. The DSS represents the application of a new technology to an area that has not traditionally used operational management principles. The great interest shown by the motor carrier industry in responding to the survey and voiced during the author's visits clearly demonstrates the new importance motor carriers have placed on increasing productivity. They have recognized that to be competitive in today's deregulated environment they must apply sound operational management principles. The motor carriers are trying to rectify their past neglect either by hiring personnel with the required expertise or by seeking the expertise from outside the industry. This presents an excellent opportunity for the academic community to fulfill a substantiated need.

The management of Yellow Freight System, Inc., has recognized the potential benefits of the DSS and plans to implement the DSS at its break-bulks. After the DSS is placed in the field and the managers gain experience in its use there will undoubtedly be many improvements suggested. Because this need for improvement was recognized, a conscious effort was made during the design to keep the system simple and flexible to facilitate rapid and easy changes.

The following specific benefits were identified during the demonstration. First, the DSS allows the manager to organize and plan his day-to-day operations to make the best use of his men, equipment, and facilities. The DSS provides information that allows the manager to pinpoint potential problem areas. With this information the manager can then take corrective action to minimize the impact of the problems. For example, if a particular loading area of the break-bulk is a potential bottleneck, he can divert his resources to that area from areas that are underused. This benefit should be confirmed through increased productivity reflected in the bills per hour or pounds per hour numbers. The DSS also allows the manager to trade off service versus costs in those instances when his manpower needs do not match his manpower bid.

The second major benefit confirmed involved forecasting workloads. By means of the graphic representations, the managers were able to gain new insights into the importance of seasonal and random variations in the historical data. The managers who for the most part do not have a formal education in management science techniques were nevertheless able to quickly grasp the fundamentals of exponential smoothing. The importance of adjusting the smoothing constant and the fittings of curves to the data to determine trends were easily understood when several examples were demonstrated for various conditions. This benefit should be confirmed through reduced costs of penalties associated with incorrect bids.

The managers expressed great interest in the productivity achieved versus labor used for the different time frames. They were able to identify problems of which they had previously been unaware. For example, when overlaying productivity achieved (both bills per hour per person and pounds per hour per person) with labor used, it was determined that while the labor was going up the productivity was going down. Because the change was occurring so slowly over time the change did not become evident until it was presented graphically. Before the DSS managers did not have an easy method of generating the graphics for analysis.

One area that has great potential for the saving of money is that of coding the bills. The bills are now manually coded; if this were done by computer, it is estimated that more than $200,000 per break-bulk could be saved annually in reduced manpower costs.

A saving of only one manyear of effort will pay for the system at a break-bulk. It is estimated to cost approximately $25,000 for two PC XT 370s, peripherals, and software that will interface with the existing communications network.

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