DECISION SUPPORT MODELS IN RAILWAY OPERATIONS

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Introduction

We are seeing more and more decision support models appearing in control and day-to-day decision roles in transportation companies. The growing acceptability of these techniques and the arrival of new computer technology that helps in their delivery, are changing transportation operations. The author's experience is in the railway business and the examples given will be those in Canadian National Rail.

Before describing the examples it might first be advantageous to discuss the history of decision support models and systems and outline the current status of these techniques. Decision support models and systems come from the joint frustrations and resulting inventiveness of two professions: data processing and management science. The former had found trouble getting managers and decision-makers to use effectively the management information systems that were implemented in the late sixties and early seventies. Sure the information was there but it was often buried in mounds of irrelevant data in a long report. There was no man-machine interaction to allow the user to get exactly what he or she needed at that time to make the particular decisions.

New systems were required that allowed selected inquiries, evaluation of what-if scenarios and other user-directed requests. There resulted a significant development of decision support languages for the user to meet this need. The reductions in computer hardware costs allowed these languages which are much less efficient for the computer (although more amenable to the user), to be effectively used in many applications.

The Management Scientist had been more involved with more specific problem areas where he hoped to use more sophisticated modelling and optimization techniques. He found problems in getting large difficult-to-comprehend batch models widely accepted by management. There evolved a decision support methodology that allowed some optimization, prediction capabilities melded with a what-if capability built on user-accessible data bases.

Over the last 10 years the D.P. professional and the Management Scientist have developed, most fruitfully in concert, many applications involving decision support methods. Most of these applications have been in the planning area: short or long term. There were many reasons for this:

(a) Planning problems seemed the most complex and therefore needed computer support.

(b) Head offices always had analyst available to interact with the computer. The man-machine interface was and still is in need of a lot of perfection. Head offices handle more planning problems.

(c) Computer models and decision support systems were expensive and were not considered cost-justifiable at the lower levels of the organization.

(d) Trust had to be built up. Did the models do the job? Were users computer literate enough to use any system effectively?

(e) Real manager don't use models syndrome.

Recent development in microcomputers have changed peoples' attitudes and the level of computer literacy in companies. The successes of the past years have built up the trust in the model/system builder's capabilities and critical operational considerations where mistakes cannot be forgiven, such as train dispatching and crew dispatching, are being entrusted to the computer. Four other factors have helped the application of decision support at the operational level:

1) Massive reduction in hardware costs; emergence of inexpensive micros and super microcomputers.

2) More sophisticated interfaces such as high resolution graphics and the mouse.

3) Deregulation is requiring much more flexibility and quick responses at the operational level.

4) The recent high cost of capital has meant that buying excess capacity cannot be the automatic response to transportation operational problems. By speeding car classification, for example, we increase the effective capacity of a yard without an increase in real estate requirements.

I will describe some of the projects at Canadian National that illustrate this trend. Although there is not space to describe all of the details of the projects, I will try and highlight the decision environment and technology that made the project go.

The General Yardmaster Worksheet

In a hump yard (a yard where gravity pulls the cars down through remotely-switched classification tracks) there are critical decisions to be made by the person who decides which groups of cars are to be classified first, which trains are to be made up first and other hour to hour operating decisions. These decisions are made by the general yardmaster (G.Y.M.). Currently he is supplied with information through a computer terminal that lists which cars or trains are on which tracks and the current status of these cars.

To assist the prioritizing decision process an O.R. study suggested developing a spreadsheet, what-if type model that not only displayed the current situation but also allowed alternative decisions to be evaluated. The spreadsheet format where columns represent inbound trains and the rows the outbound trains is a natural one for the classification process. Each cell represented the number of cars, forming a block, that had to be transferred from the inbound train to the outbound. These cars are assigned to trains by a coding system, on our on-line database, called "tags".

Because of train delays, changes in traffic levels and other operating situations, it is preferable to re-assign some of these blocks of cars or re-assign temporarily the tags. Using financial spreadsheet type operations on the screen, blocks of cars can be moved around the screen. By pressing certain function keys on the intelligent terminal, while the cursor is on a certain block of cars or cell, one can throw up more detailed information about that block of cars on a super-imposed window on the screen.

This more detailed information can prove invaluable to the GYM when making the re-assignment decisions.

Through other inquiries he can get information on car types, the total tonnage in a block or the length of the block. The order of the columns or trains represents the humping or classification schedule for these trains.

If a train is getting full early (each train has maximum length) he can leave off some of the later arriving blocks and depart the train early. He would typically start building a new train which would depart a few hours later or keep the traffic for the next outbound train that carries traffic to that destination. Various simple manipulations of the spreadsheet re-assign the blocks of traffic to the later train. The way the spreadsheet lists the trains in classification and departure order helps the GYM vary traffic assignments to minimize the train delays and maximize train length. Hence both door-to-door service times are improved while costs are kept to the minimum by having trains fully loaded.

The intelligent terminal used in the prototype is a personal computer with a colour graphics screen. The PC allowed great flexibility in programming a sophisticated screen interface that had concepts such as windows and a fast response time. The minimum data necessary was stored in the PC which drew on an update from the main database on a regular basis. The PC had another advantage at the mock-up stage because of the speed in which simple interactive screen designs could be tried out for their effectiveness.

Development of the prototype required extensive skills both in the man-machine interface area but more importantly in understanding transportation operations. This kind of interface could not be designed from just logical principles but required a lot of field work observing how GYMs do operate. This knowledge of the environment and management style could then be married with some of the known principles on improving yard operations to maximize service and minimize overall transportation costs.

The prototype was finished but was considered too expensive for system-wide implementation at the time because of the total hardware cost involved. A subset of the system will be implemented on the minicomputer that currently contains the database.

Operations Management Centre Project

Here the idea is to enhance the decision capability of the regional operations centres by enhancing the information flow, improving the computer interface and the timeliness of incoming data. A major part of this project, which is currently in design stage only, is setting up intelligent graphics terminals to be the information interface for the regional operations controller.

Extensive use of graphics is expected, with use of windowed information on request as with the previous project. The information not only has to be available but readily available in any easy to use form without the requirement for a hard copy. The powerful intelligent terminal envisaged (a 32 bit machine) would also handle forecasting models.

At a later stage simple rule-based (expert) systems might be programmed to actively diagnose operational problems developing in terminals and over the network. Thus the controller's time could be spent more on resolving problems than trying to detect them. What-if simulation capability could also be programmed in to predict the effect on car siding to siding times of making certain decisions during the current eight hour shift. Again, in a railway network the total effects of decisions down-the-line are not always apparent and many resolutions of local problems might only succeed in passing a delay or cost to the next terminal.

Although costs of this system are high the number of required implementations is small and the potential savings on the large operating territories involved is enormous. What is not clear is whether the development of a sophisticated decision support system will indeed lead to substantially improved operating decisions. This will largely depend on the interface design and its effectiveness.

Again greater flexibility in the day-to-day operating decisions will be necessary as deregulation brings in greater competition. The trucking industry is physically a more flexible mode than rail and the latter must introduce flexible control system if it is to compete.

Rail Traffic Controller

For some time CN has been developing and implementing a computerized dispatching console that controls the signals and switches out in the field. There were two major objectives: put more, in fact most, of the logic in software rather than hardware thus reducing future maintenance costs; provide an enhanced man/machine interface so that a dispatcher could control a larger territory from his one panel and thus reduce manpower costs and obtain a more integrated dispatching system.

The Operations Research group has been involved in two projects associated with this RTC development project. One is to develop a graphics interface that would help the dispatcher better predict where trains would cross and to help monitor the speeds of trains. The other project for which a prototype has been completed was the development of an automatic dispatching algorithm which would provide an optimal meet plan for the train dispatcher. It should be noted that most of the CN main line is single track where trains must be put in a sidings for meets.

This advanced decision support system would give the dispatcher a suggested decision plan which he could then modify if he felt other factors were important.

Development of the algorithm was no easy task and required the use of a Unix based super-micro to reach optimal decisions in a reasonable amount of time. The algorithm has two major parts: one part determines feasible alternatives using a feasibility matrix technique; the other uses a branch and bound technique to find the optimal train meet plan. The prototype can currently handle a 5 train on 5 train meet situation. It is coupled to a track/signal simulation as a test bed. Substantial testing of the algorithm has shown it to be robust and efficient.

We are fortunate that before developing this algorithm we had done extensive work developing main line train simulations which embodied sophisticated dispatching logic.[1] Thus the level of expertise in understanding dispatching had already been established before development of the prototype on-line algorithm had commenced.

Oil Purchase System

With deregulation of the oil market, price variation from month to month and from place to place has become much greater. Purchasing were looking for an optimizing method which would help produce the best purchase and distribution plan. Although optimization was a cornerstone of the system a full database with decision support feathers was necessary to ensure all contract consideration were taken into account.

The online database and D.S.S. are on a PC although there is data transfer with the corporate purchasing database on the mainframe. The optimization uses integer linear programming on the mainframe. The prototype optimization has been used but the total system will not be in production mode until the summer.

In both the local database and the mainframe optimization, fourth generation languages have been used to speed up development time (to a few months). The languages were Dbase III on the microcomputer and SAS/OR on the mainframe. The reduced development time allows the development of commodity-specific purchasing models. These can be turned to the individual market environment and where large purchases are involved (over $100 m dollars) can easily be justified.

Directions

The reduced cost of hardware and software development, together with the success of previous projects lend support to the idea that these types of decision support systems will flourish in the transportation industry over the next few years. One other major factor that is helping this trend is the support from the actual users of the systems. In most cases the DSS is seen as a job enhancement process and receives enthusiastic support. Of course, users involvement in the design process is crucial for this to occur.

References

[1] Welch, N.; Gussow, J.; Interfaces 16:1 Jan-Feb, 1986.