Expert Support System for Modification of Railroad Car Service Rules

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The Association of American Railroads administers a series of policies called Car Service Rules. These rules govern the handling by one railroad of empty freight cars owned by another carrier. Among the Car Service Rules, the Special Car Orders indicate that cars of certain types will return to their owners through predetermined junctions ("outlets"). The selection of these outlets constitutes a difficult problem because it involves a tremendous amount of data and a great many discrete alternatives. These characteristics, plus many interacting factors and the conflicting objectives of equity and efficiency, preclude "optimization." Instead, the goal is to "satisfice"—to find satisfactory solutions. The Interactive Credit Balancing Machine (ICBM), a software "expert support system," provides an interactive environment for adjusting these outlets. It incorporates elements of artificial intelligence and operations research methods, but, most important, it puts a human expert directly into the decision process. ICBM automates the previous analytical approach, allowing Special Car Order outlet adjustments to be performed more quickly and in a more informed manner.

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CAR SERVICE RULES

Among many other functions, the AAR administers Car Service Rules for the freight railroads of North America (*1*). Through the authority of the AAR Committee on Car Service, these rules govern the use of a railroad's equipment by other carriers.

Because no North American railroad serves the entire continent, a shipment may travel over the networks of many railroads to reach its destination. In fact, about 60 percent of U.S. rail traffic involves multiple carriers (*2*). For obvious reasons of efficiency, such shipments stay in their original cars—transloading would cause great delays (*3*). Thus, cars belonging to load-originating railroads end up in the hands of terminating carriers. Sometimes, a terminating carrier reloads such a car and sends it to yet another railroad. In the end, elements of every railroad's fleet often disperse across the continent.

As can be imagined, the railroads need to govern this process. Having invested in freight equipment, railroads want those cars back for loading. Originally, then, terminating (and en route) carriers had to return all empty cars to their owners over the reverse ("mirror image") of their loaded routes. This, however, often led to inefficiency. Sometimes, owners do not need their equipment back immediately—for instance, if they are allowed to load equipment owned by other railroads ("foreign cars"). By allowing such reloads, empty car mileage—a nonproductive expense—can be reduced (and car use improved) industrywide (*4*). The railroad industry needed detailed policies on foreign car return and reloading, guaranteeing car supply and also promoting efficiency. Such policies evolved into today's Car Service Rules.

The present set of Car Service Rules governs when railroads can reload other railroads' cars and how they should return the cars they do not reload. Different rules govern different types of cars. Some equipment, still, always travels "home" by the "reverse route" of its loaded movement. Newer concepts, however, control the movements of other car types. In general, these concepts aim to promote efficiency (minimize empty mileage) while maintaining equity (forcing no carrier to accept more than its share of empty mileage) and assuring car supply.

SPECIAL CAR ORDERS

The present array of Car Service Rules includes the Special Car Orders, such as SCO90 and SCO100. These car orders govern the movements of several equipment types, including most boxcars and plain gondolas. In their present form, the orders specify that, if a car's last loaded route included handling by its owner, the car should return home by reverse route. Otherwise (i.e., if reloaded by a terminating carrier), the car will return home through a network of predetermined outlets. An outlet indicates a junction where one railroad agrees to take on empty cars of a certain type and ownership from another railroad. The receiving railroad, generally, car-

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ries such a car to another railroad at another designated outlet. If its network connects to the car owner's, however, a receiving road can bring the car to the owner at any junction.

Obviously, the selection of the outlets determines which railroads will carry how much empty mileage under the Special Car Orders. Ideally, railroads would bear empty mileage in proportion to the corresponding amounts of loaded mileage (a reasonable proxy for revenue). Toward this goal, the AAR Transportation Division (TD) uses a performance measure called the obligation adjustment to evaluate the Special Car Orders and their outlet selections (*5*). Thanks to the industrywide TRAIN II information system, TD can trace all car movements and create a movement data base (*6*). On a quarterly basis, TD identifies from this data base all movements of cars operating under Special Car Orders in nonreverse route mode (i.e., after reloading—owner not in last loaded route). The TD calculates time and distance costs for these movements, both loaded and empty. Car hire rates—the costs of "renting" a foreign car—contribute to both time and distance costs; distance costs also reflect the expenses of transportation (fuel, labor, etc.). As a first step, the TD's calculations sum the loaded and empty costs for each railroad and for the entire industry. Basically, each railroad's fraction of the industry loaded cost is multiplied by the industry empty cost, producing the railroad's "fair share" of SCO90/100 empty costs. Roughly, subtracting from this figure the railroad's actual empty costs yields the obligation adjustment. A negative obligation adjustment, then, indicates a railroad carrying more empty costs than it should.

Needless to say, the participating railroads demand adjustments when major imbalances occur. To address these concerns, the TD updates the SCO90/100 outlet sets every quarter. In doing so, TD tries to move all obligation adjustments toward zero without creating extra empty mileage resulting from longer return routes. The TD closes outlets onto railroads with negative adjustment sums, replacing them with outlets onto railroads with positive adjustments. Until the present, unfortunately, TD personnel lacked good tools to support this task; they used only hand calculators and huge computer printouts of movement data. To generate potential changes of outlets, TD staff had to shuffle through tremendous amounts of paper and make many tedious calculations. Once generated, such options could only be analyzed to a limited extent: Which carrier would the empty traffic be moved onto initially? By how much would its empty costs increase? By how much would the former carrier's costs decrease? It became difficult to project an empty route further than the first few carriers, to keep track of the cumulative effects of multiple changes, and to balance best the inherent efficiency-equity trade-off. Also, of course, this effort demanded a tremendous amount of time from busy personnel, whose workload had increased because of a large new project. Therefore, the TD sought an automated tool that would allow it to perform its quarterly analyses and adjustments more quickly and in a more informed manner. This situation inspired the work described herein.

PREVIOUS STUDIES

In the past, studies have examined the mechanisms that control interline freight car movements in North America. These mechanisms include temporary directives, as well as the standing Car Service Rules. To the present, almost all work on the standing rules has taken a long-run, strategic outlook. Such studies have compared various broad configurations of Car Service Rules (e.g., Special Car Orders versus reverse route). Some of the studies have analyzed empirical evidence (*4*, *7–9*); others have used predictive modeling (*10*, *11*).

Until the present, little work has addressed short-term or tactical issues in Car Service Rules. One computer algorithm currently in use by AAR generates outlets for Special Car Orders. Based on shortest routes over a network, it essentially creates new orders for cars of a specific ownership. To our knowledge, no previous research has dealt with the modification or fine tuning of particular Car Service Rules in use. The first attempt at an interactive methodology to modify standing Car Service Rules based on past performance is discussed in this paper.

ICBM

ICBM is an "expert support system" that guides its user through the quarterly analysis of the SCO90/100 system. ICBM automates the process of searching through, sorting, and manipulating the SCO movement data. In this way, it effects great time savings in the generation of possible outlet changes. Furthermore, ICBM's simulation capabilities allow thorough evaluation of the impacts of SCO outlet changes—including all downstream and cumulative effects. ICBM is a flexible, completely menu-driven tool that presents its outputs as clearly summarized tables and graphics. As such, it can work interactively to support decisions, incorporating human expertise directly into the process. Also, it can work in decision making mode, applying a small "knowledge base" of encoded expertise, to prepare a starting solution for interactive fine tuning.

ICBM mimics the methodology used by the human "experts" in the TD. Unlike an "expert system," however, ICBM uses only a simplification of the expert logic. An expert system uses a detailed codification of the expert's "knowledge base"—always extremely difficult to assemble properly—and makes decisions automatically. ICBM, on the other hand, incorporates the human element directly into the decision process. Where an expert system tries to be the expert, the expert support system supports the expert. ICBM's simplified logic intelligently filters and summarizes data before presenting them to the user. At each step, the user makes the final decision, applying subtle elements of his or her knowledge and experience that a computer model could never fully embrace. If desired, the user can essentially put ICBM on "autopilot," letting it make decisions based only on the simple logic. Before making these results final, however, the user reviews and attempts to improve upon them. Either way, the computer does the great volume of the work—the simple, repetitive tasks—leaving the human free to concentrate on the finer points. The following sections of this paper explain the program's operation in greater detail.

POSSIBLE OUTLET CHANGES

Generation

TD personnel generate possible outlet changes largely according to a few basic rules. These rules provide a series of steps to follow. First, the analyst identifies a railroad with a large negative obligation adjustment; he or she will work on making that value less negative. Then, the analyst finds an ownership ("mark") with cars that contribute heavily to the selected railroad's empty costs (i.e., those cars often travel empty over that railroad). Next, he or she identifies an outlet through which cars of the selected mark come onto the selected railroad—an outlet porting a large amount of empty costs onto that road. Finally, he or she considers the railroad delivering the cars through the outlet. The analyst selects an alternative outlet (junction and receiving railroad) at which that railroad might deliver the cars. Geographically, the new outlet should be relatively near the old one. A further outlet, drawing the car out of its way, may lengthen considerably the empty return route. The new receiving railroad, ideally, should have a positive obligation adjustment—or at least one more positive than that of the old receiving railroad. In other words, the new should not be bearing as much "unfair" empty mileage as the old. The "outlet change" generated consists of "closing" (deleting) the existing outlet picked in the third step and "opening" (adding) the new outlet from the last step. This will transfer empty costs from the old outlet's receiving railroad to the new receiving railroad.

At each of these steps, ICBM first ranks the alternative choices according to basic criteria. Then, the program presents the highest-ranked possibilities to the user with some supporting data. Figure 1, for example, shows a screen of hypothetical data, supporting selection of a railroad on which to work (the first step). Each railroad's abbreviation appears with its obligation adjustment value. Similar screens support later steps. The first screen leads to a screen listing car marks with the amounts of empty cost ("credit") they incur on the selected railroad (note that these positive amounts make the obligation adjustment more negative). Figure 2 shows such a screen. The third step consists of selecting an existing outlet. The corresponding screen displays such junctions with their delivering railroads and the amounts of credit they port onto the previously selected road (Figure 3 provides an example). Finally, a screen displays certain junctions of the delivering carrier of the selected outlet (Figure 4). Specifically, they are junctions close to the old outlet and where the delivering carrier connects to railroads having better (more positive) obligation adjustments than the old receiving carrier. ICBM shows these junctions as possible new outlets, with their corresponding receiving railroads and their obligation adjustment values. All of these screens show multiple alternatives preliminarily selected and ranked according to simple criteria; the user performs the final selection, using his or her expert knowledge of the decision's complexity.

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        RAILROADS WITH LARGEST NET CREDITS

            RAILROAD     OBLIGTN ADJT

            CR              -91720
            BM              -79479
            DH              -67066
            CNW             -12586
            CMNW             -4368
            DQE               -690

PLACE THE CURSOR ON THE RAILROAD YOU
WISH TO WORK ON AND HIT ENTER OR ...

      PF1 TO SEE MORE OF THE LIST
      PF2 TO GO BACK UP THE LIST
      PF3 TO RETURN TO MAIN MENU
```

FIGURE 1 Railroad selection screen.

```
CNW: OBLIGATION ADJUSTMENT -12586

     CARMARKS CONTRIBUTING THE MOST
          TO CNW'S NET CREDIT

          MARK        CREDIT

          COP           3312
          NLG           2180
          NDM            647
          NSL            540
          NOPB           170

PLACE THE CURSOR ON THE MARK YOU WISH
   TO WORK ON AND HIT ENTER OR ...

 PF1 TO SEE MORE OF THE LIST
 PF2 TO GO BACK UP THE LIST
 PF3 TO RETURN TO CARRIER SELECTION
```

FIGURE 2 Ownership selection screen.

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CNW: OBLIGATION ADJUSTMENT -12586
3312 CREDIT DUE TO COP CARS

 OUTLETS BRINGING THE MOST CREDIT FOR
 EMPTY CARRIAGE OF COP CARS ONTO CNW

JUNCTION          DELIVERING RR  CREDIT

CHICAGO     IL    GTW              3068
GREEN BAY   WI    GBW               244

  PLACE THE CURSOR ON THE OUTLET YOU
  WISH TO WORK ON AND HIT ENTER OR ...

      PF1 TO SEE MORE OF THE LIST
      PF2 TO GO BACK UP THE LIST
      PF3 TO RETURN TO MARK SELECTION
```

FIGURE 3 Old outlet selection screen.

Some enhancements to the screen mechanism provide additional support to the decision process. For instance, the user can move up and down within the displayed lists of ranked alternatives. As an example, by paging down from the railroads with the most negative obligation adjustment values (Step 1), the user can eventually see those with the most positive values. This allows exploration into the realm of possibilities. Also, at every point in the generation process, the upper left corner of the screen displays the choices made in previous steps (see Figure 4, for example). Along with the choices appear corresponding values of appropriate quantitative indicators. Finally, rather than working in a strictly stepwise fashion, ICBM offers flexibility. The user, if so desiring, can quickly and easily flip forward and backward among

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CNW:  OBLIGATION ADJUSTMENT -12586
3312 CREDIT DUE TO COP CARS
3068 DUE TO COP CARS DELIVERED BY GTW AT CHICAGO   IL

          SUGGESTED ALTERNATE OUTLETS FOR GTW

      JUNCTION          RECEIVING RR--OBLIG ADJT

      CHICAGO      IL       SOO           115369
      CHICAGO      IL       ATSF           22212
      CHICAGO      IL       CMNW           -4368

      PLACE THE CURSOR ON A SUGGESTION AND HIT
           ENTER TO EVALUATE IT   OR ...
           PF6   TO ADOPT IT      OR ...

           PF1 TO SEE MORE OF THE LIST
           PF2 TO GO BACK UP THE LIST
           PF3 TO RETURN TO PREVIOUS MENU
           PF4 TO PRINT THE SCREEN
```

FIGURE 4 New outlet selection screen.

steps. Once again, this permits extensive exploratory analysis. All in all, ICBM's ranking and selection approach combines strong points from the analytical abilities of both computers and humans. The machine processes the bulk of the tedious, mechanistic work; it leaves the subtleties to the interacting human.

Evaluation

To evaluate a possible outlet change, ICBM identifies those movements with routings that the change would affect and simulates the routings. The program then presents the results—predicted impacts on empty mileage and obligation adjustment values—in several formats.

It is easy to determine which movements the closing of an outlet affects: those that pass through the outlet. To determine the movements affected by a new outlet's opening, though, requires a bit more effort. ICBM examines all movements of empty cars of the appropriate mark across the outlet's delivering railroad. For each such movement, the program compares the "impedances" (a network distance-based measure of transportation cost) from the movement's origin to both the new outlet and the movement's destination (*12*). If the minimum network impedance to the present destination exceeds that to the new outlet, we predict the movement's diversion to the outlet. Using this paradigm, ICBM assembles data base records for the movements that potential outlet changes will affect.

To determine the impacts of a change, ICBM "places" an empty car at the origin point of every affected movement. The program then simulates the empty return path of each such car, both with and without the changes. Initially, ICBM considers the railroad holding one of the cars placed at an origin point (the delivering carrier of the outlet being opened or closed). What options does the carrier have for the disposition of a car there? Where does it have outlets to other railroads for equipment of this type and mark? Generally, the program picks the option (outlet) to which the path from the origin point has the lowest impedance. Similarly, ICBM emulates the decision of the receiving carrier at that outlet: Where can that railroad move the car with the least impedance? This cyclic process continues until the car reaches a railroad with a network that connects directly to that of the car owner. Such railroads can deliver the car "home" at any junction with its owner. Each such junction, then, constitutes an option for the carrier. The simulation routes the car to the junction reachable with minimum impedance. That movement completes the car's simulated empty return.

After predicting these movements, ICBM estimates their costs. To determine time-based car hire charges, ICBM uses the actual average car hire rate for each group of cars (those at the same origin point); it finds these data in the movement data base. To obtain the full time cost, the program multiplies this rate by the number of cars and an estimate of the transit time for the route segment. To estimate the transit time for a route segment, the evaluation package will try three different approaches, in order. First, it will search through the movement data. It will look for actual movements between the segment's origin and destination, carried by the segment's railroad. If the program finds such a movement, it captures the actual average transit time for the movement. If this method fails, ICBM will estimate the segment's travel time from the network distance and the carrier's average empty speed (averaged over all its movements in the data base). Finally, if the carrier has no movements in the data base, the program uses the network distance and the average empty speed for all railroads (averaged over the entire movement data base) to estimate a transit time. For distance cost, ICBM simply takes the average mileage rate (distance-based car hire plus 28 cents/mi transportation cost) for the car group and multiplies it by the number of cars and the movement's network distance. Adding this to the time cost creates the estimated overall empty movement cost.

Once ICBM has predicted the effects of a change, displaying the results presents a formidable challenge. Because of the multiple decision criteria involved—minimizing each railroad's empty costs while maintaining equity among them all—clear, simultaneous communication of all impacts has the utmost importance. To balance properly the many trade-offs inherent in outlet selection, the user must apply the finest points of his or her expert knowledge; this requires that he or she absorb all of the available information. Toward this goal, ICBM provides simulation results in two different table formats, as well as in graphical form.

Figure 5 shows the format of the first table, giving details of "before" and "after" empty return routes—routes simulated, respectively, without and with the change. Each line of the table represents one carrier's segment of an empty route. The record gives the carrier's abbreviation, the locations where it began carrying the cars and where it handed them over to the next carrier, and the corresponding empty mileage and cost data. The program can also show the two empty routes in graphical form, traced out on a map of North America. This allows the analyst to recognize immediately if one route is significantly longer or more circuitous than the other. To complete its presentation of the results, ICBM offers a table summarizing cost and mileage effects by railroad, as well as overall (Figure 6). For each affected railroad, this

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                    EMPTY ROUTES AFFECTED BY CHANGES

          RR   FROM               TO               CARMILES   CREDIT
          ----------------------------------------------------------
          GTW  KALAMAZOO   MI  CHICAGO       IL       295       105
BEFORE    CNW  CHICAGO     IL  DES MOINES    IA       837       294
CHANGES   IAIS DES MOINES  IA  COUNCIL BLUFIA         149        61
          UP   COUNCIL BLUFIA  PRINEVILLE JOR        3543      1157


          GTW  KALAMAZOO   MI  CHICAGO       IL       295       105
 AFTER    SOO  CHICAGO     IL  ST PAUL       MN       876       319
CHANGES   BN   ST PAUL     MN  PRINEVILLE JOR        3569      1299

                      (#2 OF 4 ROUTES AFFECTED)
                               2 CARS

PF1  ADOPT CHANGES                       PF7  SEE OTHER AFFECTED ROUTES
PF2  SEE SUMMARY OF EFFECTS BY RR
PF3  RETURN TO OUTLET SELECTION MENU
PF4  PRINT SCREEN
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FIGURE 5 Route display table.

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               EFFECTS OF CHANGES ON SCO90 RAILROADS

      ----OBLIGATION ADJUSTMENT---    CHANGE IN    CHANGE IN #
RR    BEFORE  AFTER  CHANGE (   %)   CARMILEAGE  CARS HANDLED
--------------------------------------------------------------
BN     11586  10187   -1394 ( 12%)      35692              8
CNW   -12586  -9942    2642 ( 21%)      -8374             -8
SOO   115369 109600   -5769 (  5%)        876              8
UP      -440    717    1157 (263%)     -27337             -8


SYSTEMWIDE EMPTY CARMILEAGE CHANGE:    -857  (INCL. NON-SCO90 RRS)
        (52978 --> 52121)               643  (SCO90 RRS ONLY)

                 PF1  ADOPT CHANGES
                 PF2  RETURN TO ROUTE DISPLAY
                 PF3  RETURN TO OUTLET SELECTION MENU
                 PF4  PRINT SCREEN
```

FIGURE 6 Railroad summary table.

chart indicates the values of the obligation adjustment both before and after the change, along with the absolute and percentage changes in that value. In addition, the table indicates the change in empty car mileage for each railroad. Finally, the table shows the changes in empty car mileage summed over all railroads and over those roads participating in the Special Car Order system. These tables and graphics, it appears, provide an effective way to inform the user of the impacts of a potential outlet change. The analyst, then, can evaluate the utility of the change.

Acceptance or Rejection

After examining the simulation's estimates of cost and mileage impacts, the user can apply his or her expertise to decide whether to adopt a change. Designed for maximum flexibility, ICBM also allows the user to adopt interactively generated changes without evaluation or to enter changes directly for evaluation or adoption.

When the user chooses to adopt a change, ICBM updates the working table of outlets and recalculates the obligation adjustments of all affected railroads. In addition, the program modifies the entire movement data base to reflect the routing changes uncovered by the simulation. Furthermore, the package maintains quick-reference lists of all changes adopted and of all changes evaluated but rejected. These facilities, along with utilities for quick rejection of previously adopted changes and quick adoption of previously rejected changes, afford great flexibility. The user can easily move backward and forward among the different steps of generating alternatives, evaluating them and observing their effects both independently and in concert.

Having passed judgment on a change, the user returns to the first step of the alternative-generating phase. Presented with the updated obligation adjustments, he or she may deem the modified results satisfactory and terminate the session. Alternatively, he or she may choose to repeat the generation-evaluation-judgment process one or more times, until reaching a final, satisfactory solution.

AUTOSELECT MODULE

If the user desires, he or she can instruct ICBM to operate independently. The program will then generate, evaluate, and accept or reject outlet changes by itself, without human interaction. To do this, the software will apply the simple criteria used to rank alternative choices in interactive mode. Now, however, the program will select the highest-ranked option at each step, rather than merely suggesting it. Additional simple criteria (quantitative and qualitative) applied to the simulation results determine whether changes enter the working solution. As it rejects potential changes, ICBM works lexicographically down the lists of options, from the last step up. To start, it takes the first choice from each step. If it rejects the change thus generated, it next tries the first choice at each of the first three steps but the second choice at the fourth step. After exhausting choices at the fourth step, ICBM generates an alternative with the first choices from Steps 1 and 2, the second from Step 3, and the first from Step 4. This process continues until discovery of a change that qualifies for adoption. Then, with the obligation adjustments and movement data updated, the process continues at the next carrier-carmark combination (the next choice at Step 2). After cycling through all of the choices at all four steps, the program reorders the choices and starts over (with first choices at each step). This loop continues until one of three events occurs. If new obligation adjustments ever satisfy a simple criterion (they are all reasonably close to zero), we have a satisfactory solution and stop seeking improvement. If, however, a full cycle (all combinations of first through last choices at every step) passes without the generation of any acceptable changes, the heuristic terminates without "satisficing" (obtaining a satisfactory solution). Finally, the user can intervene to stop the process at any time.

Because of the incomplete nature of this heuristic method, its working solution is never accepted by the user as final. The user always reviews the changes made automatically and discards any he or she considers unacceptable. The analyst will apply the finer points of his or her expertise here, perhaps generating desirable changes that the machine missed. Although the AUTOSELECT module does not provide complete results, it usually gives a good starting solution. Again, the system will preprocess the bulk of the work but leave the difficult fine tuning to human intelligence. Through this approach, the AUTOSELECT module can save even more of the user's time than can the interactive module alone. Use of the AUTOSELECT module, however, requires that the user carefully examine the machine's decisions before finally adopting them.

CONCLUSIONS

The adjustment of the Special Car Order outlet sets constitutes a difficult problem. Based on a tremendous volume of data, the AAR TD must select from among a huge number of alternatives. Because of the poor structure and discrete nature of the set of alternatives, even generating options is difficult. The many interacting factors and conflicting objectives involved add to the difficulty. In spite of these obstacles, the ICBM produces good solutions to the problem, requiring a fraction of the time needed by the existing methodology.

ICBM's approach incorporates elements of artificial intelligence (expert systems) and operations research (network models and simulation). By making the human element an integral part of the decision process, however, ICBM gains significant advantages over the other two approaches. The development of a detailed "knowledge base" or mathematical utility function always requires extensive, timely consultation with the users—in this case, very busy ones. By eliminating this need, ICBM's approach allowed faster development of the package and made it more palatable to the TD. In addition to demanding much time, the development of detailed models of complex decisions invariably includes imperfections. These cost yet more time and trouble and decrease the likelihood of a system's acceptance by its users. ICBM's user-friendly methodology, directly involving the user as it does, obviously lends itself to understanding by the user. As such, it engenders the user's trust. This, together with the program's flexibility and its ability to let the user make the actual decisions, greatly eases the system's implementation.

Serendipitously, ICBM has yielded some unexpected gains. Through automation, the system eases user access and queries into the huge, once-forbidding movement data base and the outlet tables. In this manner, the system has made previously unknown problems obvious. For example, inefficient, circuitous routes become striking when seen on a map. Broadly, ICBM is getting TD users involved in the computational modeling effort that supports their operations. Previously, the TD had remained somewhat removed from this work. By bringing users in, ICBM will deepen the TD staff's understanding of the process. Thus, the benefits of increased net effectiveness will extend from ICBM to other related projects.

Although the ICBM methodology has many advantages, it also has its weaknesses. These, however, carry over mostly from the nonautomated techniques that served as its model. For instance, ICBM uses historical data as a forecast of the future; this quarter's adjustments address last quarter's problems. The system does not explicitly consider seasonal variations, random fluctuations, or the like. We hope, however, that the human element—the user's expert knowledge—considers such factors. Another weakness is that ICBM assumes no changes in loaded movements because of the outlet adjustments. In reality, outlet changes can affect railroad behavior, particularly the reload-or-return decision. Political factors and the difficulty of modeling this decision, however, necessitate the assumption. In general, any "irrationalities" of the user will carry through to the results of ICBM.

Despite these weaknesses, we can surely say that ICBM works better than the existing methodology. ICBM's weaknesses all appear in the nonautomated techniques as well. ICBM, at least, gets the job done much faster and allows the user to make decisions in a much more informed manner. Based on such improvements and its relatively easy development, this decision support system would appear successful.

The actual benefits of ICBM will be difficult to quantify. Most obviously, it will save a great deal of valuable TD staff time. Whereas the manual quarterly analysis of the SCO90/100 system usually takes about 2 person-weeks, ICBM should allow its completion in a few days. This order-of-magnitude reduction will save more than 1 person-month every year. Beyond this, ICBM's results will be indirect or without a yardstick for comparison. For example, better equity among participating railroads can increase their satisfaction with the Special Car Order system. If this contributes to the longevity of the system, it could mean a lot; just for boxcars, SCO90 saves 15 to 30 million empty car mi/year (*11*). This equates to between $5 and $10 million annually, industrywide. Because it brings better choices of outlets, ICBM can help the system save even more empty miles. Overall, ICBM might bring great and varied benefits. At the very least, by automating and clarifying the decision process, it will help the TD fulfill its mission more efficiently and effectively.

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