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SIMULATION WITHIN THE RAILROAD ENVIRONMENT

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ABSTRACT

A panel of individuals with expertise in the railroad industry provides an overview of Simulation within the Railroad Environment. The panelists discuss their work and highlight the issues, challenges, and benefits associated with application of simulation models. Topics presented are;

- Model Development, the issues and challenges.
- Role of Dispatch Model in Mainline Capacity Studies.
- Benefits of Simulation tools in Train Dispatching.
- Usage of Simulation in Strategic Decision Making.
- Areas for Improvement and Increased Use.

1 INTRODUCTION

Simulation modeling has several key uses within the decision making process of a railroad operation. Applications for modeling all facets of railroad operations are now in use and will continue to grow as the demand for fast and reliable pre-expenditure analysis and justification keeps pace with a continually accelerating rate of change for the highly competitive freight market. This paper very briefly outlines the uses of various operations based simulation tools in strategic initiatives as well as outlines some of the common issues associated with their use.

2 ERIC VAILLANCOURT, CANAC Inc.

2.1 Model Development, The Issues and Challenges

The railway industry presents specific challenges to simulation software developers. Where some environments lend themselves to iterative resolution of mathematical formulae, and others can be well represented with applying standard queuing models, simulating various aspects of the railroad cannot be achieved in any satisfactory manner using either of these approaches.

A number of characteristics make the development of railroad simulations a particularly challenging endeavor. The following are some of the more unique characteristics of the railroad, which need to be incorporated into a railroad model, and which pose a number of idiosyncrasies and complexities:

- **Large territories modeled**, often span over hundreds of miles; perhaps more than a thousand;
- **Traffic dispatching decisions**, a human decision making process under dynamic conditions;
- **Distance between control (decision) points,** can be as little as a few hundredths or as great as a few dozen train lengths;
- **Dynamic train priorities,** which change depending on how late or early the train is;
- **Crew on duty times,** respect the legal requirements for maximum work time for the train crew;
- **Need for transient state information,** operations rarely reflect a steady state system;

Other important points in the development of a rail simulation model are related to the environment in which the model will be used. In the competitive market in which railroads operate today, results must be quick, and if possible, cheap. Capacity planning groups are becoming increasingly small and high-maintenance systems are less than ideal. The usage of a simulation package must be intuitive and interactive, in that the user must be able to influence dispatch logic at will. Furthermore, a single model needs to realistically represent a wide variety of operations, and the results must bear scrutiny both at a micro- and a macro-level, if they are to be used in the justification of high-cost capital projects, which rail projects typically are.

Railway operations can be decomposed into a number of different layers, all of which must be taken into consideration in a self-contained simulation package. These include:

1) The physical performance of the train over the specific topography with grades, curves, speed limits, rail conditions etc, given its make-up in terms of power, weight, length, wind and other resistances;
2) The movements allowed by the physical layout of tracks and interconnections;
3) The movements allowed by the traffic controller signaling system;
4) The characteristics of each train schedule, the preferred routings, mandatory stops, etc;
5) The interactions between mainline train movement and yard operations;
6) The rolling stock and crew cycling constraints.
7) The decision making process of the dispatcher who tries to optimize train movement through the system.

The typical approach used by most known simulation package vendors is to separate physical performance calculations from the other parts of the project. **Layer 1** is a pre-processing stage often referred to as the Train Performance Calculator when maximum speeds are calculated. This leaves only minor acceleration-deceleration calculations for the later stages.

The main part of a railroad simulation model encompasses **layer 2** through **layer 7**, and is typically referred to as the Dispatching Model. Each layer comprises specific challenges s follows;

Layer 2: Physical layout restrictions become a cumbersome problem when train lengths cannot be considered short when compared to the distance between control points, i.e. locations at which a decision is made regarding the movement of a train. Especially sensitive locations are interlockings, where connections between various tracks are concentrated, each connection conflicting with a number of others.

Layer 3: The signaling system model represents a dispatcher or an automatic train control system, which issues the authority to a train to use a stretch of track up to a defined location. The defined location is typically a decision point or a wayside signal. The signaling system, automated or not, acts as the communications device between the dispatcher and the train crew, relaying the directives to the train and protecting a train's authority to use a given stretch of track to the exclusion of all other trains.

Often, a simulation will encounter various different types of signaling systems in different areas of the simulation. More than one train control system can overlap on the same area causing different trains to be controlled by different systems, which presents an even higher degree of complexity. While most systems can be simulated by varying parameters related to response times based on a fixed block location approach, the advent of Positive Train Control systems, representing moving block control schemes, is a particular difficulty. In this case, distance based train separation is replaced with time based separation. The authority issued to the train in this case can be updated several times a minute, incrementally moving the other end of the authorized segment forward. The main challenge here is in the cohabitation of all these different train control schemes.

Layer 4: The program's architecture must be open and flexible enough to allow the input of a wide variety of operating characteristics onto subsets of the total traffic. This allows the simulator to reflect realistic train behaviors such as scheduled stops, routings for specific tracks, temporary track outages on portions of the infrastructure, and other specific events.

Layer 5: Where physical train characteristics can generally be considered fixed on the mainline, trains are broken and rebuilt inside yards. Even without accurately representing inner-yard operations, mainline train runs are often affected by yard operations, and these interactions need to be at least minimally represented in a line model.

Layer 6: Rolling stock and crew cycling management can be seen as another layer of constraints for the model. The model must have the ability to take these issues into consideration, or at least be able to monitor crews and fleets, when making dispatching decisions.

Layer 7: The dispatchers try to optimize train movement through the system under dynamic conditions. They have limited information regarding each train's present location and speed and less than perfect information on the train's future location and speed, and, obviously, no information regarding possible up-coming failures. They try to make allowances for unexpected events and minimize the risk of a failure impacting the traffic flow. The program logic needs to realistically replicate this human decision making process.

All of the previous items depict the environment in which the heart of the model, the dispatching logic, really needs to shine to realistically represent railroad operations. The dispatching logic is where alternatives are measured and "best" decisions are made. Historically, various approaches have been taken to achieve the desired result of producing a program logic which realistically replicates the human decision making process of the dispatcher, each with some advantage in given circumstances:

Priority based sequential slotting: This approach consists of inserting the full path of each train in order of train priority. It has not proven itself to be very reliable in most cases, but it has been used in some models due to its simplicity and speed, and to the high predictability of the results it generates.

Empirical Delay application: Without detailed train movement monitoring, this type of model attributes to each train a certain amount of delay based on the number and nature of adverse events occurring to it. For example, a train might be given 3 minutes delay for each meet with a lower priority train, 5 minutes for each meet with a higher priority train, 30 seconds for each track change, etc. While this approach does not attempt to produce exact results, it has often been used to produce and maintain service schedules with interesting results, as long as the timeframe involved allows for proper calibration of the attributed delays.

Parametric modeling: This approach depicts the track layout, traffic and operating characteristics in terms of a dozen or so parameters representing key information such as speed, meet/pass point spacing, number of different train priorities, proportion of single vs. multiple track segments, etc. Results from this approach can be used in preliminary assessments of capacity, but they lack the detail necessary to be used as justification for major capital projects.

Event based - optimizing algorithm: This approach is event based, so it realistically represents each movement of each train sequentially. It can be fast, and uses well-known optimizing algorithms. It follows a decision making pattern based on optimizing train movements which dispatchers try to do. Critics say that it relies on perfect knowledge of future events, which is information unavailable to the actual dispatcher, and that it therefore provides useful but not quite realistic results. Also, interacting with the algorithm to modify the behavior is usually considered cumbersome.

Event based - Boolean logic: This approach, while similar to the previous one in that it is based on discreet events, relies on user provided operating rules to decide train moves. The logic quantifies the desirability of specific events using a set of rules derived from experience that typically take into account the probability of events not unfolding in an optimal fashion.

We have found this last approach to be the most desirable for most railroad cases. Its great flexibility allows the user to influence each individual decision or, more generally, to modify decision patterns that do not accurately represent reality in the specific circumstance depicted in the simulation. The main limitation, which it shares with other event-based approaches, is the possibility that the main dispatching logic will decide on a train movement that will ultimately result in a physical impossibility (lock-up) later in the simulation. This will occur in event-based simulations because the logic is, by design, near-sighted.

Indeed, we are not trying to assess the repercussions of each move until the end of the simulation, but only within a typical dispatchers realistic decision making horizon. A move that seems optimal at the time of the decision will sometimes result in a lock-up later on. This difficulty can be overcome with the use of an *anti-lock-up logic*, which will analyze each decision only in terms of feasibility, avoiding any decision that results in an insolvable situation.

3 ANN M. DRUMMIE, CANAC Inc.

3.1 The Role of a Dispatching Model in a Railway Mainline Capacity Study

There are many stakeholders in a typical intercity railway operation. The continual interaction between stakeholders is hopefully smooth and efficient. Besides the infrastructure owner, which is usually a freight railway company, there can be companies such as passenger (AMTRAK), commuter, mine, port and other freight operations. The group is tied with interdependent contractual relationships based on rates, performance penalties, maintenance spending, and capital contributions.

3.2 Need for a Negotiating Tool

All players are continually making plans for expanding their own businesses. But the growth of one party, has an effect on the others, and could require changes to the formal relationships. An effective long-term plan for a particular railway corridor needs to incorporate individual forecasts to determine strategies to best meet overall expectations. All parties need to work from the same unbiased, credible data source to efficiently and professionally negotiate their interpretations, priorities and strategies for the corridor.

One common negotiating tool is a graph depicting changes in performance with increased traffic and changes in infrastructure. The graph needs to clearly identify the sensitivity of the corridor to various proposals. For example, adding ten commuter trains or ten freight trains may affect the performance of all trains to differing degrees. With performance thus being quantified, it is then up to the parties involved to interpret acceptability and/or appropriate compensation. An example is provided in Figure 1.

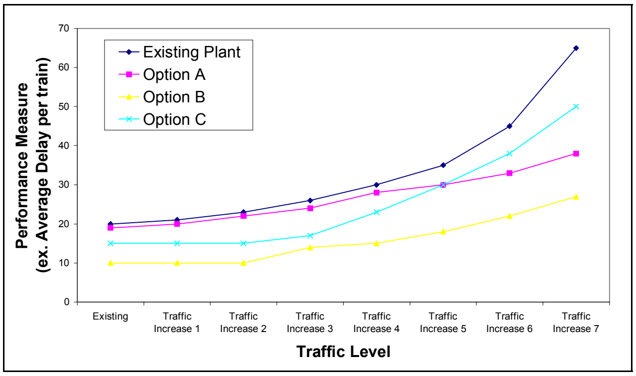

Figure 1: Effects of Increased Traffic and Plant Enhancements on Train Performance for Corridor A To B

3.3 Credibility of Performance Measure

The graph, to serve effectively, needs buy-in from all parties. The performance measure described needs to reflect one that is already being monitored. Examples are unscheduled delay per 100 train miles, percentage on-time arrival, annual gross ton-miles, and fleet utilization. The value for the measure needs to benchmark with reality. The changes in the value through the forecasts need to be founded in standard, accepted operating practices and policies.

Credibility is established at the start of a study, when the bulk of the project's schedule is dedicated to replicating a time interval of actual operations. Through automatic and manual records of locations and times, incidents, weight, horsepower, length, work programs, and schedules, a wealth of data is collected. A computer model is then tailored to match the events over the chosen time interval. The formatted data resulting from the simulation run, is filtered, and categorized, to define the specific measure required, to the accepted level of precision.

3.4 Required Detail on Traffic Impacts

At least three simulations through the computer model need to be run and analyzed to generate a reasonable curve. Each stakeholder may be forecasting new traffic, which may cause its own particular constraints on the infrastructure. Ex. Additional commuter traffic will increase density during rush hour and limit any other users from running during this time. Additional passenger traffic will increase the frequency of high-low speed interactions over the corridor. Additional and longer freight traffic will require longer sidings and passing tracks and highlight the effects of slowing down for crossovers.

If all stakeholders need to know their respective impacts on capacity in order to negotiate their role in contributing to improvements, then a number of simulations are required. Each would hold all things constant but one type of traffic. With more simulations, comes more information about the effects of combinations of traffic over the territory, and the resulting curve is better defined.

3.5 Required Detail on Plant Impacts

The more plant enhancement options that are being considered, the more curves required on the graph. Options usually involve a new crossover, track, siding, or platform, at a few possible locations. If it is hoped that decisions will be made about the order of implementing options, and if the cost of projects is to be split between participants, then each option likely needs to be simulated separately, controlling all other variables. For true long-term planning, combinations of options would also be required.

3.6 Advantages of Using a Computer Model

Each simulation is just a point on the graph. Certainly, the more points on the graph, the better the graph can help guide decision makers toward negotiating agreements. Without using a computer model, the task would be unacceptably time-consuming. Any graph produced within a few months would have minimal points per curve, and minimal curves. The credibility of the base case would be weak, as fewer details of actual operations could be incorporated. The precision in the reference measure would also be weak, and perhaps the desired measure may not even be possible to quantify through manual analysis.

With a computer model, however, in a reasonable time frame, a study team can generate the results required for various parties to negotiate new and renewed relationships. Such a reality-based study also provides the opportunity to review existing operations and raise awareness of the effects of interactions along the corridor. It also provides quantitative and qualitative support for individual departments and companies to submit feasibility, capital and operating plans through their respective funding channels. As well, it can support a cooperative effort for projects that may only be valid through a combined cost-benefit analysis.

3.7 Requirements of a Computer Model

The model chosen to forecast the effects of added traffic and added plant needs to accommodate:

- **Dynamic priorities:** as trains movements become fleeted, crews run out of time, and yards or silos become unavailable;
- **Varying density of traffic:** as volumes vary by day-of-week or corridor segments, such as commuter trains which are near the cities and create peak and off-peak hour densities;
- **Restricted flows:** as certain traffic requires specified routes, such as station platform access and yard entry/exits;
- **Recovery from incidents:** as events such as track washouts, silo failures, mechanical difficulties, and maintenance time periods, all hinder daily operations;
- **Multiple performance measures:** as commuter services focus on schedule arrival time performance, while freight services focus on tons hauled and train delays.

Actual dispatching practices need to be imitated in order to meet these interactive details of a transportation environment. The results need to be accessible and flexible to be defined in terms recognized by particular clients.

3.8 Conclusion

A dispatching model is an integral part of successfully completing a mainline railway capacity study. As such, it is critical for guiding the incremental performance and long-term planning of most corridors.

4 STEVE J. VUCKO, Canadian National Railway

4.1 Potential Benefits of Simulation Tools in Train Dispatching

Train dispatching is considered to be the “heart of the railroad” and any inefficiency found here can adversely affect the overall performance of the railroad. Since rail traffic has increased significantly over the last several years and as it continues to grow, it increases the workload of the train dispatchers, impacting their effectiveness.

The industry has recognized the need for dispatching planning models but none are yet in production. In anticipation of how these types of planning tools would function, and the potential benefits expected, this paper describes a manual evaluation to validate these benefits.

4.2 Dispatcher Workload

In order for dispatchers to control the movement of trains, they must mentally consider data from numerous sources, to determine when and how the trains will move across their respective territory, particularly in planning meets and passes. This data includes track topology, train make-up, schedule times, priorities, work on-line, slow orders, yard congestion and track work to name a few.

A dispatcher’s ability to plan effectively becomes strained as train levels increase. These increases usually translate into increased radio communications with train crews and track engineering forces. As well there is a tendency for exceptions to what was planned to occur more frequently. As exceptions occur, the dispatcher must mentally re-plan the train movements on an ever-increasing frequency, while at all times, attempting to maintain predefined schedules and service commitments.

The more frequently the dispatcher must re-plan the train movements and track work, the more difficult it becomes to make an optimal decision, given the amount of data that must be mentally processed. Since there is variability between dispatchers in how they perform their duties, there are inconsistencies in the way the plan is executed.

4.3 Evaluation

The objective was to determine that if a computer aided planning tool was used in dispatching trains during day-to-day operations, what the outcome could have been when compared to the actual events. Using one week of history from the Edmonton to Vancouver corridor on Canadian National's rail network, consisting of 5 subdivisions (approx. 1000 route miles), actual events were thoroughly analyzed to understand the decisions that were made by the dispatchers and what the results of those decisions were.

Then using a simple set of business rules, a portion of the corridor was manually re-dispatched as if the computer model was making the decisions. Given the length of time it takes to manually perform this type of simulation, one subdivision (about 140 miles) was re-dispatched for a 10-hour period.

4.4 Corridor Analysis

The historical data collected consisted of train delay reports, train sheets (written history of train movements), published train schedules and service commitments, work block information (track outages for maintenance), train crew statistics, track conditions (affecting train speeds) and actual train times at reporting points along the corridor.

Train run times and speeds were analyzed as well as yard departure times and dwell times, siding usage, crew on-duty times and train meets and passes. Conclusions from the analysis for the entire corridor were: trains generally gained time over a subdivision, trains were staged due to the slack in the schedule, train arrival and departure times varied between 3 hours ahead and 3 hours behind schedule, a significant percentage of the extended run trains was re-crewed, and, more than half of the train meets fell outside of the ideal meet/pass scenario (a train taking the siding is in the clear in sufficient time to allow the opposing train to pass at subdivision speed).

It was observed that prioritizing train movements was inconsistent from day-to-day for the same dispatcher and between dispatchers. A dispatcher generally planned for his/her territory without consideration of the consequences beyond and could only plan for 2 to 3 hours into the future.

4.5 Manual Re-Dispatch

The Clearwater Subdivision was selected to re-dispatch because it typified normal operations within the corridor during the sample week. It had no major exceptions (such as major work blocks). It had a minimum number of double track locations and operations were consistent from day-to-day. It was easy to analyze the entire run for each train.

The time-distance plot shown in Figure 2 depicts the train movements as they occurred during a 10-hour period.

During this period several instances of sub-optimal traffic flow occurred including: 1) double train meets including an instance when 3 trains were stopped, 2) trains were "bunched", 3) trains were not running on schedule (more than 1 hour behind or ahead) and 4) over-siding-length trains were stopped.

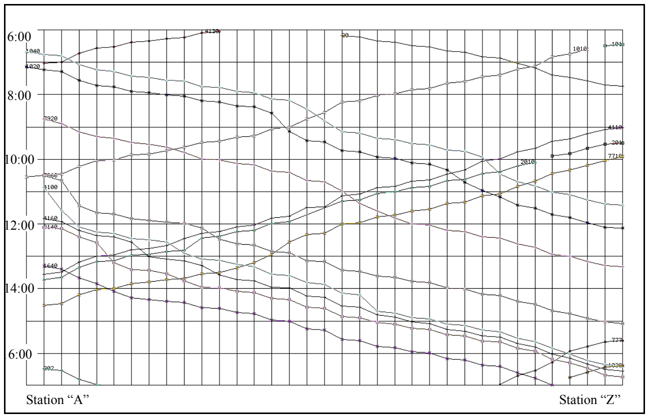

Figure 2: Historical Train Movements

A simple set of business rules were defined and used to manually re-dispatch the trains. The business rules were: 1) respect the priority of trains (i.e. 100 series trains have preferential track usage over 200 series), 2) avoid double meets to reduce congestion, 3) always hold over-siding-length trains on the main track, 4) respect crew on-duty times are to be respected to avoid re-crews, and 5) run trains on schedule.

Once the manual re-dispatch was completed the trains were re-plotted as shown in Figure 3. Review of the time-distance plot identified many improvements: 1) double meets were eliminated, 2) train congestion was eliminated, and 3) over-siding-length trains were not stopped. This resulted in corridor traffic being more fluid and the trains were more evenly spaced.

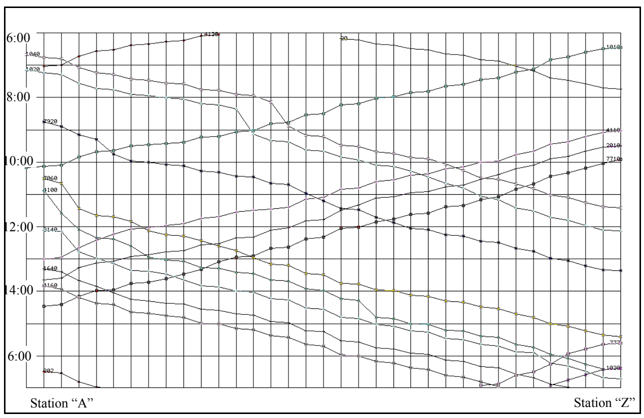

Figure 3: Re-dispatched Train Movements

By following the simple business rules, and especially by having the time to properly assess all the information, train meet time was decreased, the number of train meets and re-crews was reduced, corridor congestion was minimized and average train velocity was increased.

These results translate to improved asset utilization due to quicker turn-around times for the equipment and cost reduction in the form of reduced fuel consumption and reduced re-crews. Given the variations in the operations from one part of the network to another it is difficult to extrapolate these results to the entire CN network to determine what the overall benefits could be, however these results do indicate the potential.

4.6 Conclusion

The dispatchers that executed the plan during the sample week performed an admirable job in light of the tools and information that were available to them. However given enough time, some decisions could have been made differently (as was done in the manual re-dispatch) which would have improved the overall operations.

As traffic increases the amount of data which a dispatcher needs to consider in each decision also increases. Using a computer planning model to assist in dispatching the trains should not only reduce the variability between the dispatchers, but should also reduce the dispatcher's workload. This should enable the dispatcher to be better able to plan and respond more quickly using all available data. It would also allow for planning further into the future (hours) and to span across multiple dispatchers' territories.

To what degree these benefits will be realized will only be determined once such planning tools are placed into production.

5 JOE BEKAVAC, Canadian National Railway

5.1 Usage of Simulation in Strategic Decision Making

Simulation modeling has several major uses within the strategic decision making process of a railroad. Key elements for railroads are the most efficient design of the service offering, effective use of assets, and containment of cost, but without compromising safety.

5.2 Asset Based Simulation

Locomotive models are used by asset managers to establish optimal distribution routines for these assets. Locomotives are high cost assets for the railroad and as such every minute not spent pulling revenue is a liability to the company. Locomotive simulation tools use the base operating plan (i.e. schedules) of the railroad along with train powering parameters (i.e. customer requirements, tonnage hauled, route characteristics) to plan the train to train connection cycles of the locomotives. They also take into account the standards for planned maintenance, routine maintenance, fueling, inspection, etc. Presently such models are becoming real time with a direct data feed from railroad operating systems.

Car asset models are similar in nature to locomotive models. The key element of a car asset model is the match of equipment type to customer loading requirements and order volume. The idea is to reduce unproductive time of car assets and reduce the number of miles running empty through optimizing repositioning schedules and costs. One further factor with respect to car asset models is the need to predict the timing and volume of cars coming from foreign interchanges in order to rely more on the inbound pipeline and thereby reduce idle on hand counts at yards and customer sites. In this case AAR (American Association of Railroads) data is utilized along with historically based prediction models to set tactics of optimal asset distribution against a forward view of the customer order file.

Maintenance of way models are utilized to evaluate the impact of train traffic on effective lifecycles of right of way (the highways of a railroad). Such models also utilize field data of track geometry cars to provide basic status of the right of way structure along with historical data as a base and then apply tonnage and train characteristic data to forward extrapolate life cycle impact of rail, ties, subgrade and bridge structures. This is used to set capital and regular maintenance strategies for the planning horizon.

5.3 Train Operations Simulations

This area of simulations concentrates on gaining full quantification of track/train dynamics. Models typically use design consists over a simulated track bed based on actual track geometry. The parameters of throttle, brake, gradient, wind resistance, etc can be accurately modeled to give a profile of all in-train dynamic loading, engine parameters, speed, and stopping ability.

Train operations simulations are typically used to determine minimum run time standards (i.e. no train meets), evaluate the impact of zone speed adjustments vs. capital, forecast fuel consumption, and check braking distances relative to signal system capability.

Key results of such studies focus on the economical design of trains and provide decision factors relative to locomotive and car selection, as well as ensure safe operations based on track/train/signal parameters in the field.

5.4 Line and Terminal Capacity Simulations

Line and terminal simulation models provide a means to analyze the capacity and/or operating performance of the rail network under a variety of conditions. When speaking of line simulations, the track configuration complete with sidings, multiple track and signal configurations is overlaid on the network and coupled with a set of trains of specific design. These simulations test the capacity of a network by determining delay occurrences to trains.

This type of simulation study is extremely useful in determining and properly adjusting train schedules to reflect reality, assessing network bottlenecks so that plant/train schedules may be designed to avoid them, and proving the cost/benefit of plant (track and signals) addition or deletion relative to train schedules. Ultimately, when coupled with costing data, this type of study provides the ability to find the lowest cost plant/train configuration to move a set volume of traffic with consideration to the levels of service required.

The same holds true for terminal simulations, however in this case the study is focused on inflow/outflow requirements of a specific traffic terminal relative to the design of the physical plant. In this type of study the physical yard plant is modeled (i.e. track lengths etc) and a plan of switcher engines as well as arrival and departure of trains is input. Models then determine congestion, delay, and workload parameters, which then enable judgment on the need to vary fixed cost (plant structure), or variable cost (switching assignments, inbound/outbound train plan) relative to the operating plan.

In either line or terminal simulation the bottom line is that the study allows the user to determine the impact on service and profitability. These studies are often used in assessing major capital plans relative to up/downgrading lines and facilities, thereby shifting traffic to new routings and handling methodologies. This may involve the participation of a foreign carrier in the case of arrangements for haulage/trackage rights which may lead to mutual benefits to multiple carriers.

5.5 Traffic/Service Simulations

Railroads also use models that can simulate an entire rail network and operations. These simulations model the physical and operating characteristics of the network, plus the traffic handling decision logic that determines the routing for loaded and empty cars through the network. These models have built in algorithms specified by the user that look at generated traffic at each network node and apply logic rules which control train blocking, connections and routing. User specified service plan parameters are then applied to redefine traffic levels as specific trains that then are the basis of determining operating plan characteristics.

These tools provide a true 'what-if' design method that can determine optimal service/cost system operating plans, i.e. a change in blocking logic or service will drive train design, terminal workload, line tonnage density, and train management issues and ultimately provide metrics to assess cost/service trade-off decision points. These types of simulations are extremely beneficial in assessing cost/service optimization, however are extremely logic and data intensive.

Presently major railroads typically only rely on such studies to answer major issues of network restructuring and mergers, citing that although this type of tool would be the optimal for regular network enhancement the cost to maintain the system as an active tool may be prohibitive.

5.6 Rail/Non-Rail Interface Simulations

Railroads have also used other simulation models to determine the impacts of some non-rail activities. For example, queuing models at intermodal terminal gates are used to determine gate configuration and delay time based on in-gate truck activity. Time study simulation of lift equipment and chassis management is utilized to determine intermodal terminal processes and design.

Break-bulk facilities such as plastic pellet distribution transfer and distribution terminals also have benefited from such simulation analysis that is typically not core to railroad operations. Automotive distribution centers are another area where simulation models are used to design and test the efficiency of the combined auto compound, rail facilities and operating plan.

5.7 Bottom Line Benefits and Risks

Bottom line benefit from simulations of complex rail operations is clear – the ability to fully evaluate, plan and optimize plant / operating scenarios prior to implementation. The simulation is often used to justify capitalization of projects, determine downgrade/removal of network fixed plant, and/or assess strategic network options like major mergers.

Risks to utilization of simulation models rest largely within the corporate culture of the organization. In the past simulation methodology has been viewed as an onerous time and asset consuming process with models that required consultant or specialist operators and with a lack of base data that often lead to poor quality input (and hence results). Opportunities may be missed as a result of lack of support. Also, for the reason of expediency, quantification processes may be overridden, resulting in poor decisions based on 'gut feel' that may overlook spin-off impacts.

Clearly, data entry is key to legitimate results, as is process standardization for such analysis. It is fundamental that data and methodology standardization be absolute if the analysis is to be the anchor of the business case supporting an operational initiative.

6 JOE BEKAVAC, Canadian National Railway

6.1 Areas for Improvement and Increased Use

Moving forward, there are some areas that present opportunities to improve the use of modeling systems in strategic decision making.

6.2 Direct Downloading from Legacy and Operating Systems

Data entry is typically the most time consuming aspect of simulation modeling. Investing in this aspect is likely to give the greatest single boost to providing value from such analysis. Direct downloading from legacy and operating systems would cut data entry time and allow for less error in the input data stream.

6.3 Online Hook-up to Design/Asset Managers for 'What-if' Capability

As noted earlier many systems are only utilized on a project basis. With complex network models now capable of being loaded on desk top computers they can be a tool in the hands of the network service design officers and asset managers. Such applications however require considerable IT support and often a sophisticated user.

6.4 Link to Other Key Corporate Systems

Most simulation systems are stand-alone applications. Data must generally be exported to other systems to determine cross-functional impacts. In future, linking corporate systems will aid in decision making across functions. For example, a network flow modeling system could be linked to an asset modeling system to determine the impact on right of way and car/locomotive assets from a major service change. A link to a capacity modeling systems could assess line bottlenecks and terminal operating implications. Linking to costing systems could determine the bottom line impact of operating scenario changes.

Furthermore, marketing forecast systems could link into a network flow modeling system to drive Origin-Destination volume/line density and service plan requirements. Presently such forecasting data is typically manually imported into network flow systems and it is not easily revised as Market forecasts are changed.

6.5 Industry Standardization

As railroads look beyond their operating limits to find opportunities to cut cost and improve service, it is clear that pre-expenditure simulations can provide large benefits. This is evidenced in numerous merger/co-production opportunities that have thusly been evaluated. In these cases one major issue is the standardization of data and simulation applications between railroads. Optimally a protocol amongst major railroads would be of benefit to all for such analysis.

6.6 Conclusion

The use of simulations to evaluate operational changes of a strategic nature can be valuable to most large railroad operations. When managed correctly such studies provide a cost effective means to plan and support major initiatives to a high degree of accuracy. The key is good data quality and responsiveness to be able to digest and analyze complex operating scenarios to respond to opportunities. Looking forward, with more sophisticated computer applications and more effective data platforming, simulation modeling will become a larger part of an operations manager's tool kit and will allow for responsive and accurate decision making in the ever changing and increasingly competitive world of the railroads.

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