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TRANSPORTATION RESEARCH FORUM

Mopac's Transportation Control System
A Systems Approach to Achieving Service Reliability

*by Guerdon Sines**

SUMMARY

MISSOURI PACIFIC is undertaking the development of a large on-line real-time information and control system identified as the Transportation Control System (TCS) whose paramount design objective is to improve service reliability. This objective will be achieved through the design and implementation of a subsystem called car scheduling. TCS is also a large comprehensive system embracing other significant design objectives that will strengthen MoPac's position in the rail transportation sector.

MoPAC'S TRANSPORTATION CONTROL SYSTEM

There is underway at Missouri Pacific a large comprehensive project which has service reliability as its paramount design objective. The effort is known throughout the Company as the Transportation Control System Project or simply TCS. It should be made clear that in order for Missouri Pacific really to deliver the project, more reliable rail freight transportation that can be economically sustained, that there are other design objectives which are of major importance. An examination of all the design objectives reveals that they cannot be satisfied successfully unilaterally. These design objectives are as follows:

- **Increase Service Reliability—Loads and Empties**

  For "loads" this means greater on-time consistency of movement from dock-to-dock. We do not regard this as deliberate thrust in accelerating the delivery schedule. It is rather an effort addressing on time consistency that will improve the quality of our customer's logistical operations.

  For "empties" this means providing the proper amount, type, and condition of empty freight car equipment on the date required. This is where our physical responsibility commences. In focusing upon the customer's logistical operation we visualize our role in his physical distribution starting by furnishing the number of cars he can load and the appropriate type of equipment required by his commodity and his materials handling operations placed at the proper spot at his loading dock in time for leading. We intend to protect what is dictated by the commodity in terms of protective devices, or equipment features condition. We intend to protect the numbers of cars for the dates required to the degree of sensitivity that the shipper can express.

**Director, Information & Control Systems, Missouri Pacific Railroad Company*

In both the loaded and empty portion of the service cycle we will be seeking to remove the surges that manifest themselves as either gluts or shortages. We are seeking to establish ourselves as an orderly and readily controlled link that is integrated in his logistics operation.

- **Reduce Transportation Resource Costs—Cars, Crews, Power, and Plant**

Concurrent, certainly of equal importance to securing or just maintaining sales of a superior product is our continued ability to produce it economically. At Missouri Pacific we accept the fact that we must reduce our costs of operation. Our approach will be one where we will consider the overall transportation cost, the cost of all the resources; cars, crews, power, and plant, throughout the entire freight car cycle. We will avoid focusing upon but one resource, at the expense of the others. We will address the total rail logistical system. At Missouri Pacific we have not only experienced improvements in our physical transportation process. We have also found out more about it. We have gained greater insight to its problems.

Whether it is the individual car with clear destination and handling instructions made available in a convenient manner to clerk, yardmaster, and engine foreman or an analysis of traffic moving through a terminal we find that both the operative and planning personnel seize the initiative exploiting opportunities presented. Such informational "opportunities" were not readily apparent or available before. Switch lists and advance consists would be late, incomplete, or erroneous. Analysis of a terminal's operations could be obtained only through an expensive survey of a manual clerical nature. On the one hand cars were mishandled or delayed. On the other hand improvements in operations were missed because they were not obvious, that is, not as "obvious" as had they been displayed in a computer collected and prepared analysis. It is with considerable confidence that we look forward to our line and staff management reacting appropriately to opportunities for greater efficiencies in car days, yard engine hours, and train miles. While we are of the opinion that this is a reasonable aspiration we are looking more to the outgrowth of our formalizing the planning, control, and evaluation cycle. We are not leaving it to chance, however. We are deliberately committed to reducing transportation costs by supporting planning, control, and evaluation with extensive computer and communication support. This is a reasoned commitment. In contrast to the approach where we could indeed improve service reliability for a short time with an inordinate assignment of resources to protect service commitment (this is sometimes referred to as "giving away the store") we concurrently will be addressing the objective of keeping the cost of our product under control and our pricing competitive.

- **Reduce Clerical Cost of Producing Information**

To achieve the first two objectives anyone with some exposure to railroad operations will tell you that the system will probably have to collect a lot of data, around the clock, from many remote locations, about numerous physical events covering location and status. These data will have to be captured on a fairly current basis in order to keep up with the changing transportation situation and quickly conveyed to some point where it can be sorted, collated, and summarized. Now to begin with we should recognize there has never really been a shortage of paper in railroad operations. By its very nature, that of being a business where two-thirds of the business is a commercial transaction involving two or more carriers, where the movement of the equipment requires reporting to any one of these carriers or possibly one not even sharing in the haul, where regulatory bodies at both the state and federal level and often other specialized political units require regular reportings of a highly structured and comprehensive nature and where there are a goodly number of labor contracts which seem to abound with complexities, rail transportation has generated paper. One of the first characteristics is that there is a lot of it. The second is that it is redundant.

To process these data from these paper based systems with state-of-the-art techniques of keystroking basic documents, then keypunching abstract information, shuffling punched cards in the PICL systems that support either train yard or industry zone operations, and transmitting with 150 word per minute devices would require a clerical force well in excess of those on hand. The sheer amount of data to be collected that it takes to drive a system that supports both service and cost objectives would overwhelm both the data collection techniques and the existing clerical force. The third objective of TCS, therefore, is to develop techniques of data generation, processing, and communication that are significantly more economical. The added task of accomplishing this in the railroad input environment is rather demanding. The physical transactions to be reported take place yards or miles away from data input points, at all hours, necessitating relaying of written or oral messages. The physical events may be taking place in inclement weather and at least half of the time under less than ideal lighting conditions approaching total darkness. Events take place at random. The unscheduled event is normal. Operations that require similar reporting in most respects yet uncompromisingly different in others occur concurrently at yard installations of any size. The impact that the customer "hours-of-daylight" and "end-of-day" oriented nature of billing, switching, handling, and spotting to make a "before-daylight-shift-spot" has upon schedules results in peaking of workload. The time-distance factors in rail logistics certainly stand out when the time expended for the paper shuffling and data generation that take place in the yard office represents distance that the cars could be moving. That is, the tendency for the physical system of rail operations, as opposed to the paper or data generation operations, to peak is also manifested in these other support systems. Even the receipt of but one train in interchange represents a critical peak if it is one 150 car train once a day moving on a tight connection. These are but some elements of a data input environment that has been characterized, possibly charitably, as hostile and error prone.

Whether one terms it "realistically" or "practically" no system supporting the first two objectives is going to get off the ground unless it achieves this one. If not achieved, the clerical cost will choke off the benefits of the first two objectives.

- **Improve Communication Between Shippers and MoPac**

  We are of the fixed opinion that if we make it less costly for shippers to transact business with MoPac we will have something that will sell. This transaction scope includes ordering cars, billing, requesting switching, tracing, diverting, and even the more internal process of planning. Specifically, we are talking about less keystroking, less paper work, less messenger service, and fewer phone calls. Therefore, a major design objective assigned to TCS has been that of relieving the shipper of the paper work tangle.

- **Improve the Quality of Management Reports**

  The railroad industry certainly has no shortage of management reports. The volume is overwhelming. Their negative qualities in terms of such shortcomings as incompleteness, approximations, over simplifications, inaccuracies, or sheer lack of relevance to the real rail process at least leave something to be desired. From one who has reluctantly muddled around with some of the "averages" in these reports and then later discovered some of the "innovative" techniques in which these "statistics" were produced, I have gotten uneasy at the thought of the management decisions made from them. I have become sympathetic with and admired the executive who instinctively knew the process well enough to make decisions in spite of them.

  If there are indeed regulatory bodies trying to measure and regulate us on the basis of what statistics have been furnished them the concern is the same and possibly more so. Current data collection techniques will not support management or regulatory requirements. These requirements particularly those of the regulatory bodies have largely ignored the data generation problem.

  Succinctly, the goal is to achieve a hierarchy of management reports for transportation, traffic, and accounting operations that present as complete a picture as possible with sufficient sensitivity to dispel the fog as to what is really taking place.

These five design objectives are being addressed concurrently in the development and implementation of TCS. From the discussion thus far one can possibly recognize that they conflict with each other. One cannot satisfy one and completely or largely ignore the others, or any one. We then perhaps can also make the second observation that there has to be a system of how to best satisfy these various objectives from an overall viewpoint, or what is euphemistically called the systems viewpoint, the systems approach, or systems analysis. We have not at this time attempted to reduce to a formal technique the analysis of the various trade offs of such relatively gross design objectives one versus the others. We have for the most part relied upon judgments, that is, rather wide in-depth experience with various systems of different generations on a number of different railroads over the past fifteen years; estimates of the rate of development of computer hardware, software, terminal and communications componentry; judgmental qualitative assessments of how much further we must progress on one objective in order to support another; and a final overall judgment that these are for the most part the major relevant objectives in the TCS system or the management equation of what is important in a major effort like TCS.

We have, however, quantified the benefits to the extent possible, developed the operational and one-time costs to support these design objectives, and rendered an overall economic analysis. This analysis included an examination of various alternative approaches of development and implementation. The strategy selected, first, had to be technically feasible. That is, the approach was within the realm of possibility from a technical sense as far as hardware, software, communications, etc. Secondly, it had to be operationally feasible. That is, the sequence of applications developed and implemented has to be logical from a step-by-step building block, mutual support viewpoint. In another facet of operational feasibility are such practical questions as to just how large a development or implementation force one can assemble and administer or how large a package of application be absorbed by the functional departments in one implementation thrust. Finally, it has to be the most attractive economically yielding the greatest return for the monies expended. It would probably not surprise anyone that we have to rework this strategy as problems or opportunities not anticipated present themselves. The major results of the analysis however have been the quantification of benefits of such a scale and of so attractive a rate of return that the effort, the TCS Project, commands resources of a large scale for a number of years. MoPac's TCS Project can certainly be characterized as a remarkable and uncommon commercial endeavor of a large scale addressing a broad range of design objectives.

The design objective which is vital to these proceedings is of course service reliability. We propose to achieve this objective by a TCS application subsystem called car scheduling. In discussing the details of this application I will address its aspects in the order as follows:

- The concept of the Trip Plan.
- Developing the "Best" Trip Plan.
- The Internal Functions of Car Scheduling.
- Car Scheduling Interface with –
  - Those Who Accomplish the Transportation Function
  - Those Who Plan and Monitor the Transportation Function

Trip Plan

The trip plan concept for TCS begins with the definition statement that "Every car to be moved on Missouri Pacific, loaded or empty will move from origin to destination according to a plan." This trip plan from a MoPac origin to a MoPac destination will identify all trains and yard engine assignments involved in the movement of a transfer or transit nature. This embraces thru trains, local trains, traveling switch engines, industry switch engines, yard transfer engines, and interchange transfer engines. On the other hand it does not include extra trains or yard classification engines. A MoPac origin is the location where a car is initially made available for movement which can be a customer's dock, an interchange track, or some location where the car is located upon being released from some "hold" status. The "hold" status can be for any number of either shipper or railroad reasons. A MoPac destination, the location to which the car is to proceed can be a customer's dock, an interchange track, a location where the car will reside in a prolonged "hold" status, a point where service is performed on the commodity or the car, or some location, though short of its ultimate destination, which can be developed with the information currently available. While it may be easy to accept and comprehend a trip plan for a car with customer dock on MoPac in one city, across our rail network to a customer dock in another city still on MoPac, the question may surface what about intermediate stops where the physical movement of the car is interrupted to part unload or complete loading, inspect, etc. In these cases, where the delay is beyond railroad transportation control, there will be more than one trip plan, two or more, as the interruptions in transit dictate. After each interruption a new trip plan will be developed when the car is made available for movement to "destination" which in some cases may be another preplanned intermediate stop.

The trip plan will be computer assigned. That is, when TCS is presented with a particular car as being available for movement and such information as destination, commodity, or condition, a trip plan will be developed by the computer from its files and tables and assigned to the car at that moment. This computer action will take place at any of the origins defined previously. There are of course certain exception situations where the car will not be so handled. Such would be of an unusual nature such as cars of livestock, cars whose loads were of excess dimensions (high/wide) and other cars whose handling may be restricted to speed or position on the train consist. There would also be that exception category where a special "manual" schedule was required because of any unusual service demand. All of these exception conditions will be handled by a manual scheduling activity in central transportation planning and control operation. This manual scheduling operation will be staffed by competent specialists on an around-the-clock basis as such exceptions are presented. Once such trip plans are developed, they too will be input to TCS and assigned to the car record.

Beyond this introduction to the trip plan basics here is a description of how the trip plan relates to what we now accept as normal transportation doctrine. A trip plan is made up of the block and train combinations that will move a car from origin to destination. Visualize the existing plan of scheduled train operations, the block of cars that are handled in these trains, the transfer of blocks from scheduled train to scheduled train at various nodes be they major terminals or remote junctions, and finally the transfer of cars down to the individual car from one block to another at such nodes. A trip plan is the linking of these planned connections, a car to a block and blocks to trains from origin to destination. By employing the word "existing" as the plan for train schedules, blocks, and connections at nodes, I wish to point out that car scheduling does not mean an immediate and complete restructuring of train and terminal operations. Rather, it is vitally and unavoidably dependent upon the existence of such a plan of operations. It is the formal definition of what this plan means in terms of the individual car. In all likelihood the well accepted concepts of scheduled symbol trains and blocks will remain for some time to come. Car scheduling as visualized at MoPac does not contemplate overtly, or covertly for that matter, a change in such practices. It is upon this working framework that we will implement car scheduling, exploiting and adding to it, rather than changing or reducing it.

What constitutes the development of a legitimate trip plan in TCS involves elements that are common in everyday rail transportation planning and operation. One of the more obvious ones is the geography of the railroad that is the network of main lines, branch lines, terminals and stations, which establishes where one point is in relationship to another and the physical route that is to be followed. Another is how we operate various trains and yard engine assignments which establishes what points are served by what operations, what provides the physical movement, and where connections take place. Yet another is the blocking policy. Besides establishing what blocks are handled by a train or engine assignment the blocking policy establishes the parameters that place a car in a block and the points where trains or engine assignments pick up and set out blocks. The normal parameters for a car being placed in a block are destination city, connecting line, commodity, and off-line destination city. In some cases equipment type and patron may become criteria.

The not so obvious elements are yard operations and restrictions of trains and blocks. Yard operations or yard processing capacity is a time dependent factor. It is often expressed as a "cut-off-time" that is the time by which a car must be at a yard or be released from a "hold" status at a yard in order to be available for movement on an outbound train or engine assignment. We have found that "cut-off-time" can vary according to commodity, patron, and operation, at the same terminal for different connections. That is, the connections that are planned between various inbound cuts and trains on the one hand and various outbound trains and cuts on the other can observe different rules. The rules that are developed are trade offs between what can be accomplished at the yard with the engines available at that time, in a yard processing capacity sense, on the one hand, and what is required to keep the business, in a marketing sense, on the other.

The other not so obvious elements are the restriction as to what car will not be handled on certain trains and engine assignments and blocks. These restrictions may be of a commodity, car type, or some requirement for special service nature.

In our analysis of these elements we have come to the conclusion that we can develop a simple system, that is, one that is relatively easy and straightforward to understand, develop, and operate that will employ these elements in creating legitimate trip plans. We have also come to the conclusion that there is a major task of collecting definitions of all of these elements. This is an immense task of data collection. Getting deliberate explicit definitions of some of these elements, particularly when it comes to the "cut-off-times" will require considerable skill and thoughtfulness. It certainly will require a major effort. It must also be well organized. The success we have experienced with a pilot operation on part of our railroad has given us confidence that we can bring the necessary resources to bear and accomplish the task.

Developing the "Best" Trip Plan

Anyone who has been associated with rail transportatio- will re that "published" schedules are often not the ones being followed. In some quarters the "published" schedule is referred to as the "paper" schedule as opposed to the real schedule. Trains have been fairly visible units of production. Anyone can see a train. It is large, almost inescapable. It is easy to keep track of. Even so there is often the ambivalence of the "published" versus the real schedule. To some extent the "published" schedules represent goals as much as they may be a marketing facade.

Going to greater detail in schedule performance, that is, the car schedule, the connection performance at nodes, that is, blocks moving from one train to another and cars moving from one block to another, is more obscure. Similarly, what constitutes a legitimate connection goal within the capabilities of a specific terminal node is more difficult to establish and monitor than train operations. The combinations of trains, blocks, cars, and terminal nodes suggest that the task of developing realistic tables for TCS car scheduling is one of immense dimensions. To address this task MoPac will employ a computer simulation program called Car Activity Regularizing Scheduler or CARS.

MoPac's operating plan with its geography, trains, blocking, policy, etc., will be defined and run in the CARS simulator with a representative traffic load tendered the network. The results of the run will display how the product will turn out if handled according to a particular service plan. A planned output will be the cars that moved according to the goals of the plan and those that did not. Another output would be the extra resources in terms of trains required if cars were to move according to plan but if train capacity restrictions maintained. Still another output would be under utilized resources (trains) that were operated. Such runs are visualized as being a means for the Transportation and Traffic Departments to address jointly in the development of an operating plan for the entire railroad, for all traffic. The product of such an effort will be an operating plan that we can realistically perform as well as one that is required in order to secure a certain share of the market.

It is anticipated that in the process of arriving at good schedules, that is, the good operating plan and achieving further improvement will be iterative and evolutionary. It is also anticipated that trials of new ideas will be undertaken both in the real world and by employing the CARS model.

Concurrently, MoPac is developing a simulator that addresses the operation of a terminal. The focus of this model is directed to the operations within the terminal. With this simulator one will have the ability to work in a conversational mode with a computer stepping through a yardmaster's decision process as work arrives in a yard. In this capacity as a yardmaster one can assign work to engines, in one sequence or another, yard trains on tracks, double over non-clearing trains, hold out trains, hold trains for connections, and run trains away from late connections or connections not switched. The model, identified by the acronym, YARDS, for Yard Activity Real time Decision Simulator, enables one with a fixed set of resources (yard engines, car inspectors, and yard plant) to see if he can process traffic through his facility and meet a new set of schedules for arrivals and departures. In doing it first with the old schedules and then with the new he will learn more about the problem and the relative effect of employing one solution alternative as opposed to another. It is also visualized that given a fixed traffic flow (without a schedule change) one can vary the resources, including the geometry of the yard plant, and acquire some insight as to the relative effect of cutting back or augmenting the resources.

With the use of such simulation tools we will develop the good and then the better operating plan. One additional but major feature of CARS is that it will serve the administrative function of organizing and passing to the on-line system, TCS, the files and tables representing the operating plan embracing all the elements of geography, trains and engine assignments, blocking policy, yard "cut-off-times," and train and block restrictions.

The Internal Functions of Car Scheduling

The car scheduling subsystem will be called upon to place upon all output documents in the yard office environment the next scheduled connection of a car being processed through that facility. As the switching is accomplished and the train or cut assembled the feedback of execution will be checked by the subsystem to see if the trip plan for each car is being protected. Failures will be noted and responsible yard personnel will be alerted by the system.

In these instances recovery may be achieved by either delaying the outbound connection or extra yard engine effort. On the other hand, recovery may not be reasonable. With the departure of the train the system will recognize those cars that have missed and go through a rescheduling process, outputting the new outbound connection on switch lists, inventories, etc.

One of the strong planning features of the car scheduling subsystem is its ability to project workload. The method employed will be the use of the anticipated (train) consist file. This file is in effect a reservation system for all cars scheduled to that train. By observing train limits the system can indicate when a particular schedule is "over-sold" or alternately a supervisor's review may yield a conclusion that the connection is light and some form of consolidation may be the reasonable economical alternative. Concurrently, the system will maintain a destination yard file which will give terminal personnel a greater opportunity to pick up changes in future traffic loads and make appropriate adjustments in engine assignments. There is in car scheduling the major control function of monitoring, that is, the ability of the system to recognize when things are not going according to the operating plan and calling this fact to the attention of both those who are executing the plan and those who made the plan and issued the instructions.

Car Scheduling Interface with—
Those Who Accomplish the Transportation Function

In terminal operations the lowest common denominator of execution is the yard engine crew responding to the planning efforts and instructions of a yardmaster. Car scheduling will penetrate this point of action by displaying the scheduled connection for each car on all switch lists. The goal for each car will be made available to both the yardmaster and the engine foreman.

The yardmaster's planning and monitoring will be supported by various inquiries he can make upon the system. Yard and track inventories will display connection information. Inquiries can also be made seeking the location of all cars that are scheduled to make a particular connection. When yardmasters advise the system that a train is set the system will respond with identification and location of those cars that failed to be made.

The reporting of accomplishment will embrace a technique of reporting back by "work order." This will reduce the detailed feedback reporting that is normally inherent in most of today's car/card oriented systems. Individual car feedback reporting will be restricted to exception reportings where cars are handled contrary to the instructions on the "work order."

Car Scheduling Interface with—
Those Who Plan and Monitor the Transportation Function

The best description of the roles of the general office transportation personnel is that of handling exceptions, responding to imbalances in the system when the load exceeds the processing capability (or limits) of a facility, yard or train, or the resources are out of balance with the workload and the opportunity for economy exists. The vital element is that such personnel will be able to make adjustments with overall system considerations in mind instead of sub-optimal local considerations. MoPac will be able to render a system response in implementing, executing, and adjusting the operating plan.

In conclusion it is proper to answer the question "why car scheduling?"

The answer is really a list of benefits.

- Improved consistency of service will mean more business.
- The plan down to the individual car loaded or empty is in the system.
- The individual plan or goal for every car is made visible to all responsible for its movement.
- Those responsible are made aware when a car misses its schedule.
- The system enables the plan to be reviewed, monitored, and adjusted.
- The predicting of empty car inventories and facility loading is greatly strengthened.
- Customer notification of failure on an exception basis becomes a reality.
- Input requirements of accomplishment are reduced.