Welcome to the 2009 issue of the RAS (Railway Applications Section) Newsletter. The past year has been a tough year for all railroads worldwide and, in particular, in North America. Railroads have seen their volumes drop dramatically (15% - 30%) in a matter of months. This drop is unprecedented for an industry which has witnessed annual volume changes by no more than 5% year after year. The volume drop shocked the railroad world, and executives scrambled to cut costs wherever they could. Hundreds of locomotives and thousands of railcars were put into storage, thousands of crews put on furlough, and capital projects were cancelled or put on hold. Service planning teams significantly reduced train starts to counter the drop in shipment volumes. Several austerity measures were adopted – no trips to the INFORMS meeting! Most railroads have done an incredible job of cutting costs while maintaining similar levels of profitability as previous years and need to be congratulated for a commendable job. Congratulations!

We expect (or hope) the economy will recover, and traffic volumes will pick up soon. Railroads must begin to think creatively about how to prepare for increased volumes. What can we do now so that we can accommodate a future increase in traffic volumes using fewer assets and improve profitability? What is the next big thing from the Operations Research world that can help railroads achieve new levels of profitability when the volumes return? Many of us conjecture, or believe, that Dynamic Car Scheduling will be one of things that can contribute significantly to railroads’ bottom-line. Let me first describe dynamic car scheduling. Currently, most railroads utilize Static Car Scheduling, meaning each railcar has a fixed blocking sequence from its origin to its destination. For example, a shipment from Miami to Chicago will have the following blocking sequence: Miami → Waycross → Atlanta → Chicago; that is, the shipment will first take the Miami → Waycross block, followed by the Waycross → Atlanta block, followed by the Atlanta → Chicago block. In dynamic car scheduling, we will specify several blocking sequences for the Miami to Chicago shipment, such as Miami → Waycross → Atlanta → Chicago and Miami → Waycross → Selkirk → Chicago. Thus, when the Miami shipment reaches Waycross, it will have two options: either go in the Atlanta block or go in the Selkirk block. Depending upon the capacity of trains which will carry these blocks or other network conditions, it can be dynamically decided on which block the shipment should be placed.

Dynamic car scheduling can be very useful in practice. We all know that shipment volumes vary significantly from one week day to another week day and from one week to another week. Railroads have traditionally countered the impact of traffic volume variations by leaving some spare capacities at yards and on trains. If a yard can handle 1,500 cars/day, then railroads plan for 1,300 cars/day; if a train can carry 150 cars, railroads plan for 130 cars. Railroads also run extra trains, called Second Sections, on certain days when scheduled trains are at full capacity. Thus, static car scheduling results in lower capacity utilization on some days (when volumes are low) while running second sections of trains on other days (when volumes are high).

Dynamic car scheduling can smooth the effect of variations in daily volumes and redirect traffic depending upon yard and train volumes/capacities. If the Miami-Chicago shipment at Waycross sees that the Atlanta block is full, it takes the Selkirk block, or vice-versa. It gives the car scheduling algorithm some flexibility in routing the shipment to its final destination depending upon the train volumes on a specific day or other network conditions, and trains can be loaded more to their capacity. Dynamic car scheduling, if done well, offers the following benefits to railroads:

1. Smooth train and yard volumes and improve network fluidity
2. Reduce the number of train second sections
3. Reduce car dwell times at terminals
4. Improved committed time of arrivals of shipments

Dynamic car scheduling has been talked about among different railroads for several years, but has not been implemented for various reasons. Now, however, momentum is picking up among railroad executives, and they have started thinking about it seriously. The forthcoming INFORMS meeting has a 3-hour round-table session, organized by Dr. Dharma Acharya (CSX Transportation), to discuss several aspects of dynamic car scheduling. Several railroad executives will also give talks in this session outlining their perspectives. Details of this round-table are described in this Newsletter. Please come to the INFORMS meeting and to the round-table session to learn and to share. See you there.
Cutting Through the Gordian Knot of Fleet Planning

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For passenger railways and many freight operators, rudimentary fleet planning is completed at the same time that the timetable is established. This is done mainly to ensure that the timetable is balanced in terms of the equipment that will be used on train services, and that it can be covered with the existing rolling stock. A reserve of units can be used as a guarantee that the timetable can be covered, and then the detailed planning is pushed closer to the actual operation. Although this method is effective for the most part, greater savings are possible by creating an optimized plan of the entire fleet operation that takes all pertinent details into account. Obviously this does not come as a surprise, so why is it that more railways do not use this cost saving approach?

The main reason is that it is an incredibly difficult optimization problem to solve. When the Danish State Railways (DSB) approached Jeppesen in 2005 to build such a product, they had already explored the marketplace and found that no programs existed that would solve their planning situation. DSB have now accepted the first release of Jeppesen’s Resource Management Solution for Fleet (RMS – R Fleet). They are using it in live production, which will provide them with immediate operational cost savings due to reduced rolling stock usage and maintenance costs. Long-term savings attributed to reduced capital investments for rolling stock are also expected.

Modeling a Railway’s Track and Rolling Stock Complexity

To solve the problem of fleet planning for either a freight or passenger railway traffic, an essential first step is to create a consistent model of the network and determine the rules by which rolling stock are assigned to run on it. The model must take into consideration issues, such as the following.

1. The topology of the track in terms of switches, depots, stations (either drive-through or last-in-first-out).
2. Which units are best suited for the different trains, considering passenger quality-of-service demands at different times of the day.
3. Rules governing the use of different unit types, such as which units can and cannot be coupled together.
4. Restrictions on where units can and cannot be run (i.e., diesel units can run on electrified track, but electric units cannot run on non-electrified track).
5. Room available to park trains in depots, and their arrangement so that the trains are correctly sequenced for use the next day.
6. Maintenance demands which require that trains be routed to a maintenance depot in time for mandatory service, plus projected downtime prior to redeployment.

One of the most important objectives of a fleet planning exercise is to determine the minimum amount of rolling stock needed (including allowances for equipment failure) to guarantee the level of service required by the operator to meet its commitment to the government regulatory body. This is an especially important issue in certain areas of Europe where rail operators bid for the rights to run traffic, both on their home networks and on foreign networks. Franchise rights are awarded to the operator who can tender the most favorable bid in relation to its rivals. Accordingly, being able to correctly assess the minimum level of resources required to run an operation becomes critical to an operator’s ability to win rights to run a franchise.

Specific to the Danish rail operation is a greater-than-usual need for train splits and merges. Since Denmark is spread across a peninsula and two large islands—Jutland, Zealand (on which the capital Copenhagen is situated), and Funen—the connecting rail bridges are subjected to a very high traffic density. For outward journeys from the capital, one way of increasing bridge capacity is to compose long trains that can then be split into various destinations once the bottleneck areas are passed. For journeys inbound to Copenhagen, trains from outlying areas have a corresponding need to be concatenated prior to passing the bottleneck areas. Therefore, a requirement of the solution is that it should allow the modeling and optimal placement of both train split and join operations.

Modeling, in Relation to the Fleet Planning Process

Simply put, the fleet planning process can be divided into three main steps: fleet consist assignment, fleet equipment rotations, and depot parking. There is also a fourth step, individual unit assignment, although this is most commonly handled as an operational issue. The impact of unplanned maintenance makes it less essential to plan the movement of individual units from a long-term perspective. In the assignment of rolling stock, the decision is made regarding which locomotives, coaches and/or multiple units should be used to cover each train in the timetable. Each timetabled task is assigned a consist, an ordered sequence of units, to ensure the following.

1. The technical constraints related to infrastructure and equipment are respected, such as electrification, platform lengths, the capacity of storage tracks at yards, and feasible consist changes between services.
2. Constraints related to business policies, such as safety and crewing are respected. For instance, the solution must use the appropriate equipment types, with the expected capacity, as required by the service policy of the operator. Furthermore, it must be possible for the trains to be staffed in a practical, legal and safe manner.
3. Utilization of the equipment is optimized, taking into account the cost of the equipment, the cost per unit kilometer, the cost of various local or preparation activities, the crew cost, the correct level of capacity on the trips, and other robustness measures.

The consist problem cannot be properly solved without also considering how to connect units between the trips. The number of units stored at every station is dynamically calculated so that the balance at each storage yard can be controlled and compared to the available yard track capacity. If the problem is difficult to balance in terms of incoming and outgoing units at different stations, it may be necessary to create new trains for positioning purposes. In RMS – R Fleet, the optimizer will suggest routes where new trains could be added in a cost-efficient way. It will then be up to the railway to request the appropriate slots from the national railway network authority.

With all consists synthesized, it is necessary to construct the rotation of each vehicle unit. Rotations are anonymous per se (i.e. they do not name specific units, but they are created for a specific vehicle type) and are often cyclic. In a weekly plan, based on a typical week in the timetab-
In these two RAS Roundtable Sessions, we will be discussing freight railways current and future Car Scheduling Systems (CSS). CSS drive the routing and scheduling of loaded and empty railcar shipments. Efficiency of a CSS could impact various railroad operating costs associated with car miles, intermediate car handlings, shipment transit times, crew and locomotives. This could translate into potentials for saving hundreds of millions of dollars in operating costs.

With a few exceptions, majority of the North American freight railroad’s CSS were developed in 1970s and 1980s and are mainframe based. Vast advancements have been made on computer hardware systems and information technology over the past 30+ years. Railroad’s CSS have not yet been able to fully capitalize on these advancements.

What are the limitations of the current CSS? What are the desired functionalities and features of the new CSS system? What are the potential areas for cost savings from a new CSS? Extensive discussions will be held on these areas. Speakers represent railroad practitioners (CSS owners), academicians, and consultants with extensive experience and knowledge in this area. At the end of these two sessions, we hope to summarize strengths and shortcomings of the current CSS systems and come to a consensus on the desired overall framework and functionalities of the next generation CSS.

Next Generation Car Schedule System at Norfolk Southern, Dan Plonk, Dan.Plonk@nscorp.com
In this presentation, I’ll start with an overview of our existing car scheduling system, Algorithmic Blocking & Classification or ABC. I’ll describe what ABC is and how it works. Then, I’ll focus on the next generation ABC which extends the current ABC algorithms to incorporate shipment delivery time and individual train capacity. The new system will allow us to improve customer service and better utilize capacity. Lastly, I’ll outline the next steps.

Current and Future Car Scheduling System at CSX, Cary Helton, Cary_Helton@csx.com
In this presentation, we will describe the features and short comings of the existing car scheduling system. We will then describe the desired features/functionalities of the future car scheduling system.

Capacitated Car Scheduling on a Time/Space Network, Chip Kraft, ckraft@temsinc.com
Capacitated Car Scheduling on a Time/Space Network provides an opportunity for railroads to boost capacity by utilizing train capacity that might otherwise go to waste. In an era of rising fuel prices, it may also provide an opportunity to introduce a "Time Definite" service offering into the railroad product mix. We will describe a real-time process control algorithm, based on a revenue management "Bid Price" framework, that has been implemented to make this possible.

Design of Next Generation Car Scheduling Systems – Lessons Learned from Prior Systems, Carl Van Dyke, Carl.VanDyke@oliverwyman.com
The very first car scheduling systems were created almost 40 years ago. The fundamental capabilities of these systems has not changed significantly over this time period. At the same time, the industry has changed dramatically, with the rise of unit train and intermodal services, which are unsupported by these existing systems. As railways create the next generation of such systems, it is time to look at the lessons of the past 40 years, and factor them into the design of the new systems.

Current and Future Car Scheduling System at BNSF, John Orrison, John.Orrison@bnsf.com
In this presentation, we will describe the features of the existing car scheduling system at BNSF. We will also discuss the desired features/functionalities of a future-state car scheduling system.

Computational Results of Several Dynamic Trip Planning Approaches, Ravindra Ahuja, Ravi@innovativescheduling.com
We believe that dynamic trip planning for railcars can increase a railroad's network capacity significantly without much capital investments. In this presentation, we will present comparative computational results of a dynamic trip planning algorithm where a railcar has multiple car-block sequences.

Cutting Through... (contd.)
ble period, a cyclic rotation which is ten weeks long will be covered by ten units. The construction of rotations and consists are naturally tightly integrated. One cannot be done without affecting the other. The objectives when constructing the rotations are:
1. To fulfill constraints related to time or distance traveled by each unit.
2. To take into consideration local activities such as fueling, cleaning, and inspections in the rotations.

When a unit following a rotation is directed into a depot, it is necessary to address the non-trivial problem of parking. The storage planning problem involves selecting storage tracks for equipment, and scheduling shunting movements between storage locations and stations in such a way that units do not block each other more than necessary. Often it is not possible to reach all storage tracks from all platforms, which makes it even more important to be careful when deciding where the units are parked. It is common to have dedicated depot drivers manning the depots. During rush hours it is most effective to have the storage tracks nearest the platforms free, so that it does not take too much time for the depot drivers to return to park the next incoming train.

We are well on the way to cutting through the Gordian Knot of fleet planning. Our first release of the RMS – R Fleet system has passed acceptance at DSB. DSB is anticipating the cost reductions they require in order to remain competitive in Europe. When bidding for new franchises, the means to correctly calculate the amount of rolling stock required for running traffic outside of their domestic network will be an important advantage for DSB.

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Scheduling Unscheduled Trains
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Introduction
Incorporating operations research tools into railroad scheduling is the key to improve the operating ratio, while maintaining the quality of service. In recent years, railroads have adopted optimization-based tools for scheduling train services. However, the unscheduled train services that constitute 40-50% of all rail transportation have remained untouched. Unscheduled services consist of point-to-point unit train operations carrying bulk commodities such as coal, food products, rock, phosphate, fertilizer, etc. The major constituents of bulk commodities are coal and food products (see figure, source: AAR).

Basic Operations
Most of the unit trains are operated on demand between a loading facility (i.e., coal mines) and an unloading facility (i.e., power plant). The basic steps involved in operating a unit train are shown in the figure below. Unit train operations are considered unscheduled service, because there is no repetitive schedule of demand from customers. As a result, the railroads are not able to schedule the resources (i.e., yard, locomotives, crews, and railcars) well in advance. All decisions are made at the tactical level, which often leads to inefficiency in both resource utilizations and the overall cost of transporting the commodities. For example, the total cost of a train load of coal increases on average from $50,000 to $300,000 as it reaches a power plant in Chicago from a mine in Wyoming (source: University of Wyoming). This demonstrates the significance of the transportation cost of bulk commodities.

Requirement of a Decision Support System
Although, the demands for unit trains are unscheduled, a pattern can be observed in the operations of these trains. For example, in coal transportation, the following information can be derived for few weeks with high confidence: (i) Number of trains to be loaded at a coal mine; (ii) Number of trains to be unloaded at a power plant; (iii) Number of trains originating or terminating at a yard; (iv) Curfew corridors in the network; and (v) Number of locomotives and crews required at a yard. These observations can lead to the development of a system, in which major resources can be planned for a few weeks in advance. However, as tactical changes are imminent in unit train operations, the system should also have the capability to efficiently readjust the plan as real-time operations deviate from the plan. Another critical factor for a decision support system is to consider the interplay of the resources with the scheduled train services. Generally, railroads maintain a dedicated fleet of locomotives and railcars for the unit train operation, however, crews, yards, and tracks are shared among scheduled and unscheduled train services.

In past, the size of the unit train network and the mathematical complexities involved in tactical decision making have precluded the development of an optimization based decision support tool. Currently, manual decisions are made by railroad personnel, who can consider only the limited number of factors and options while decision making. The decisions are made using some basic heuristics and the experience of decision makers. This approach results into unit train operations with either underutilized resources or unmet demand.

However, with the recent advancements in the fields of Operations Research and in the Information Technology, a decision support system can be developed which optimizes resources and helps railroad personnel in making efficient decisions in the real-time. The decision support system should create and schedule trains in such a way that revenue generated through meeting the client’s demand is maximized while maintaining the level of service provided to the customer. The decision support system should also be equipped with components to communicate a plan effectively to all personnel involved so that recommendations can be efficiently implemented. To succeed, the decision support system must have following characteristics:

1. Model all business rules related to yards, tracks, locomotives, crews, and cars.
2. Consider system-wide impact of any recommendation.
3. Optimize integrated cost of all important resources in the railroad.
4. Easy to use and adaptive to the changing business needs.
5. Available to all personnel involved, and provide customized information to the users.
6. Have real-time information of railroad operations.

Conclusion
A considerable amount of effort has been made in optimizing the scheduled train operations. However, the unscheduled train operations have been untouched and a big potential lies in developing the decision support system for these operations. The new system can adopt similar approach as that in scheduled train operations, however, it must consider the relatively high dynamic nature of the unscheduled train operations. Two main characteristics which are desired in an efficient system are: (i) the ability to generate a master schedule for a few weeks in advance, and (ii) the ability to revise it with minimal changes in the master schedule when new requirements are provided. Having an effective decision support system can make significant impact in the unscheduled service operations costs and in the unit trains revenue. A railroad can generate over a hundred thousand dollars in revenue by transporting an additional unit train and can save tens of millions of dollars per year by making even one percent improvement in the operational cost.
RAS Student Paper Awards
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Rail Applications Section (RAS), a section of Institute for Operations Research and Management Science (INFORMS), sponsored a student research paper contest on Management Science in Railroad Applications. This contest offers the following awards:

- Cash Awards: $500 First Place, $250 Second Place
- Honorable Mention recognition for other top papers

Authors of the First Place and Second Place are asked to present their papers at the Student Paper Award Session of the INFORMS Annual Meeting in San Diego, CA. RAS covers the conference registration fees for all primary authors who are asked to present their papers.

To qualify, the paper must be written by a student or students enrolled in an academic institution during the 2008-2009 academic year. The paper must relate to the application of Management Science for the improvement or utilization of railroad transportation, and it must represent original research that has not been published elsewhere. More details on eligibility criteria, the application procedure, and deadlines for submission are available at RAS’s website: www.informs-ras.org.

We expect that these award-winning papers will be presented in the Student Paper Contest session at the INFORMS 2009 Meeting in San Diego. We provide below the abstracts of these papers. We encourage all RAS members to attend this session and motivate our young researchers to continue to make great strides in building new models for railroad planning and scheduling problems. This year we had received submissions from around the world on a variety of topics.

First Prize:

- Integrated Service Network Design for Freight Rail Transportation. Endong Zhu, University of Montreal; Co-authors: Teodor Gabriel Crainic and Michel Gendreau, University of Montreal

  Abstract: The research aims to produce a good operating plan at the tactical level for freight rail transportation. The service network design problem is studied, as we consider the scheduled service selection, blocking policy, train make-up policy and car distribution together. A 2-layer time-space network is proposed to model the car flow as well as the decisions on both blocks and services. The mixed-integer programming model is difficult and a tabu search heuristic is developed to provide good feasible solutions within reasonable solving effort. Numerical results show the proposed method is robust, and capable to provide near-optimal solutions for rather large instances.

Second Prize:

- Exact and Heuristic Algorithms for the Curfew Planning Problem. Ashish K. Nemani, University of Florida; aknemani@ufl.edu. Co-author: Suat Bog, University of Florida, sbog@ufl.edu

  Abstract: In this paper, we study the Curfew Planning Problem (CPP) encountered by railroads for the maintenance of their railway tracks. The CPP is to design an optimal annual timetable to complete a given set of repairs and replacement jobs (rail-work and tie-work) on the railway tracks for a set of crews specialized in rail-work (rail-crew) or tie-work (tie-crew). We develop the work schedule for each crew such that the disruptions in train routes due to subdivision curfews are minimized. A subdivision is said to be under curfew if any crew is working in it. The solution to the problem must also satisfy several operational and regulatory requirements such as the crew continuity, time windows, the maximum inter-project distance travelled by crews, etc. Our paper presents several solution approaches for the CPP: (i) time-space network model, (ii) duty-generation model, (iii) column-generation model, (iv) decomposition-based heuristics, and (v) optimization-based iterative algorithms. We solve each model using CPLEX and present the computational results based on real-life instances.

Honorable Mention:


  Abstract: We present a new approach called SAPI (Statistical Analysis of Propagation of Incidents) to repair a disturbed railway timetable after incidents. The method estimates the probability of propagation of incidents to reduce the search space defined by a MIP formulation, obtaining very good solutions in a short time. We tested several versions of this method in two different networks located in France and Chile, showing that our procedure is viable in practice.
Operations Research Tools at CSX Corporation
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CSX Corporation, based in Jacksonville, FL, is one of the nation’s leading transportation companies providing rail-based transportation services. CSX uses Operations Research (OR) tools to make strategic, tactical and real-time decisions in various departments across the company. The following is a brief description of the OR tools currently used at CSX.

**Dynamic Car Planning:** Each day, railways allocate hundreds of empty railcars among hundreds of customer car orders. In 1997, CSX implemented the U.S. rail industry’s first real-time, fully integrated equipment distribution optimization system, Dynamic Car Planning (DCP). DCP's optimization engine finds the best set of car-to-order assignments, and provides a car and a destination to operations to create a trip plan for each individual car. The optimization engine is based on a straight-forward transportation problem.

In 2009, DCP earned CSX the position of finalist for the Franz Edelman Award for Achievement in Operations Research and the Management Sciences.

**Railway Traffic Controller (RTC):** RTC is a simulation model for dispatching trains. Some examples of its use at CSX are:

1. Finding bottlenecks for traffic congestion and evaluating various capital improvement scenarios.
2. Evaluating the train schedules.
3. Conducting what-if analysis of network structure and traffic changes on both train operations and performance.
4. Evaluating the impact of track conditions (slow order, out of service, etc.).

**Algorithmic Class Tracking (ACT):** ACT is an operating plan analysis tool designed to create and maintain blocking and train plans. In ACT car routes are determined based on the least overall car miles and handlings, while also satisfying the user-defined constraints and rules. The system provides what-if capability to analyze potential plan changes, and uses weighted shortest-path algorithms.

**Strategic and Real-Time Crew Scheduling:** Railway crew scheduling is dependent on territory configurations such as single/doubly-ended, split, triangle, and short/long pools. At CSX, we have implemented an array of network flow models to address these configurations from both strategic and real-time perspectives. These models assist in performing what-if analysis, such as train profile change, labor rules change, territory set-up change, etc.

**Ballast Sourcing:** Ballast sourcing for track construction in the face of limited ballast availability and alternative sources can be a challenge. A sourcing plan includes purchasing and transporting ballast at the lowest total (delivered) cost. We use an LP-based model to create the sourcing plan. The model allows scenario analysis by varying constraints and cost inputs. Examples of this include adding or removing capacity at quarries, changing prices, or creating minimum purchase requirements.

**Fuel Truck Simulation:** Every day thousands of locomotives are assigned to shipment trips, and along the way they are fueled at one or more of many fueling locations. These fueling locations can be either fixed facilities (e.g., mainline, service center) or movable facilities (e.g., fuel trucks). In the case of movable facilities, one of the challenges is to decide how many fuel trucks are needed in order to satisfy the fueling demand. We use an ARENA-based simulation model, which for a given scenario shows the fuel truck utilization and incurred train delay.

**Curfew Grid Scheduling:** Railroads perform hundreds of scheduled track maintenance projects each year throughout its network. Different types of work are performed by various maintenance teams. A project-team schedule should be created before the year starts. There is also a need to be able to change the schedule incrementally throughout the year. We use network flow and a heuristics-based model to develop a project-team schedule which minimizes the total distance traveled between projects.

**Locomotive Shop Router:** Each locomotive must be sent to a shop for quarterly (Q) maintenance every 92 days. If it cannot reach a shop within that time period, it becomes past-due-Q and cannot be used. The challenge that locomotive managers face is how to best direct locomotives to shops just-in-time and consistent with the shop’s capacity.

The Shop Router Model assists locomotive managers in this complex decision-making process. It receives periodic data from live systems regarding its trains and locomotives, and then generates the route of locomotives to shops over the current set of scheduled trains.

**Locomotive Planning:** CSX uses a locomotive plan as a basis of real-time locomotive assignments. The locomotive plan consists of assigning a set of locomotives to every train in the scheduled train network so that each train has the required pulling power. It also ensures that the terminals are balanced in terms of locomotive type and count.

The Locomotive Planning Model helps us create and maintain this plan. It utilizes decomposition and mixed-integer programming techniques.

**Locomotive Simulation Optimizer:** This simulation model helps in what-if analysis related to locomotives. Some examples include the following:

1. Assessing the impact of locomotive fleet size on network performance.
2. Determining the impact of shop locations and shop capacities on locomotive utilization.
3. Identifying terminals with frequent shortages of locomotives and determining potential solutions.
4. Understanding the impact of strategy or policy changes on the system’s performance.

**Hazmat Route Risk Analysis:** Railroads are required to conduct annual route analysis for all routes used to transport hazmat materials covered under the regulation. They should evaluate safety and security risks of the route, as well as facilities along the route.

The Hazmat Route Risk Analysis Model helps to generate up to six distinct alternate routes for each of the hazmat shipments. It scores each route based on safety and security risks, which allows us to choose the best route for the shipment.
The last year has sent the U.S. and world economies tumbling. As railroads and other businesses scramble and retreat to adjust to these changing conditions, the Operations Research models that rely on cost numbers are also put to the test and may require some fine tuning.

OR models often allocate scarce resources to competing uses in an optimal manner. Railcars, locomotives, crews, track space, yard space all must be carefully managed to maximize throughput with minimal delay. During economic downturns such as the one experienced in 2009, the bedrock assumptions about resource scarcity are tested. Suddenly, fixed and quasi-fixed capital resources are in excess. How does this affect OR model accuracy and usefulness?

Consider, for example, yield management software that is designed to maximize revenues from some fixed capacity. In high times, these models may reject a tendered load to reserve scarce capacity. Pricing tools recommend where to increase prices in order to maximize returns on the fixed physical plant. When pricing is an option and capacity is in excess, such models might recommend price reductions that may not produce the desired volume increases.

Another example of a system whose performance is affected by shifts in demand is the equipment distribution system. With a tight supply, cars are allocated directly to orders with some of the orders being rolled to future dates when insufficient capacity exists. When demand falters the strategy changes and model decisions might focus more on what to do with excess supply rather than excess demand. For example, rail cars can be sent to storage locations until orders are received. As asset velocity naturally slows, models must place a greater focus on cost reduction rather than the speed at which cars are delivered.

The simple rules that fail in times of scarcity are suddenly more effective. Heuristics, such as using the closest car for an order, the most fuel efficient locomotive, or most direct route less often, results in the domino effect of cascading increasing downstream future costs that globally oriented OR models try to avoid. As a result, OR models deliver less value, or in the worst case scenario, generate recommendations that are oriented OR models try to avoid. As a result, OR models deliver less value, or in the worst case scenario, generate recommendations that are inferior to those of simpler methods. Forward looking OR models that reserve capacity for future use are difficult to defend if they create near-term costs. In this relatively unstable and high-pressure, cost-centric environment, OR model recommendations will be viewed with greater scrutiny. Recommendations that are out of line with managerial objectives might result in a loss of confidence in OR models.

What should be done to counteract this situation? When it is not business as usual for the railroads, it is not business as usual for OR models and decision support systems either. First, managers and OR analysts should revalidate input data and assumptions that OR models run on. Expectations for capacity availability, demand forecasts, interchange flow patterns, etc. must be carefully evaluated. If this unusual downturn causes history not to be a good indicator of the future, manual adjustments to forecasts are in order. As train schedules change, so will the natural ebb and flow of crews, cars and locomotives. Accordingly, the input data of the OR models must be updated to reflect these changes.

Second, the models’ parameters should be revisited and recalibrated. Changes in managerial objectives and focus might create inconsistencies with model recommendations and managerial mandates. For example, with a tight car supply the fastest possible delivery is paramount for service and equipment turns. With an ample supply, however, opting for closer and less expensive cars may be in order. It may become necessary to reduce idle equipment penalties, because equipment is naturally less utilized; idle equipment is less costly, and less avoidable.

Finally, the positive reasons that OR models are created and implemented still exist in economic downturns, even if they are somewhat muted by excess capacity. OR practitioners and model users must remain confident that models remain valuable for managing complex networks and not lose confidence in their ability to help manage assets. As the economic conditions improve, OR tools will be critical to maximizing the returns on rail assets.

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**Operations Research... (contd.)**

**Locations of Railroad Wayside Defect Detection Installations:** Railroads constantly check the health of railcars for a variety of defects, which helps to identify in advance potential problems that if unresolved could cause accidents. The placement of these expensive detection systems plays a critical role in taking pro-active measures to identify defects. In this Lagrangian relaxation-based optimization model, we attempt to identify the minimum number of required installations that can inspect the maximum number of cars in a given time period based on the traffic flow patterns.

**Intermodal Yard Simulation Optimizer:** The Yard Simulation Optimizer helps us to study the yard dynamics before we actually build the yard. Some of the dynamics are:
1. Determining blocking and car-handling capacities of a yard.
2. Assessing the impact of train schedule changes on car dwell time and track occupancy in the yard.
3. Evaluating the impact of modifying yard layout (adding and removing tracks) on yard congestion.
4. Determining a yard’s operational efficiency as a function of yard resources (crews, locomotives and cranes).

**Employee Shift Scheduling:** Departments with 24/7 operations need to design schedules for each shift by taking into account the following: the number of employees required, maximum consecutive work days, minimum rest period between shifts, and scheduled vacation.

To solve this problem, a linear optimization model is used which is implemented in Excel using the Frontline Systems Solver Optimization engine.

**Forecasting:** Forecasting network traffic is an important part of the function of planning and managing resources.

Market demand is used to forecast traffic demand at the OD level, which is run through the Operating Planning Tools. Based on the output, one can determine train volumes and adjust train plans accordingly, determining resource requirements as well as developing revenue and price impact estimates.

* * *
### RAS Sessions at 2009 INFORMS Annual Meeting, San Diego, CA

**Sunday (October 11): C-Room 32A**

**SA75: Student Rail Research Paper Contest**  
Chair: Michael Gorman, University of Dayton  
- Network Design for Freight Rail Transportation (Endong Zhu)  
- Exact and Heuristic Algorithms for the Curfew Planning Problem (Ashish K. Nemani)  

**SB75: Planning Models for Rail Transportation**  
Chair: Theodore Crainic, University of Montreal  
- Scheduled Service Network Design for Rail Carriers (Endong Zhu)  
- Minimizing Greenhouse Gas Emissions in Intermodal Freight Transport: An Application to Rail (Tolga Bektas)  
- Blocking Studies at CSX Transportation (Cary Helton)  
- Managing Locomotives in Freight Rail Transportation Systems (Mervat Chouman)  

**SC75: Next Generation Car Scheduling Systems I**  
Chair: Dharma Acharya, CSX Transportation  
- Next Generation Car Scheduling System at Norfolk Southern (Dan Plonk)  
- Current and Future Car Scheduling System at CSX (Cary Helton)  
- Capacitated Car Scheduling on a Time/Space Network (Chip Kraft)  

**SD75: Next Generation Car Scheduling Systems II**  
Chair: Dharma Acharya, CSX Transportation  
- Design of Next Generation Car Scheduling Systems - Lessons Learned from Prior System (Carl Van Dyke)  
- Current and Future Car Scheduling System at BNSF (John Orrison)  
- Computational Results of Dynamic Car Scheduling Algorithms (Ravindra Ahuja)  

**18:00 – 18:30 PM**  
Refreshment Break.  

**18:30 – 19:15 PM**  
RAS Business Meeting.  

**19:30 – 21:30 PM**  
RAS dinner, Harbor House Restaurant, Seaport Village, 831 West Harbor Drive, San Diego, CA (just west of the San Diego Convention Center); Telephone: (619) 232-1141.

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**Monday (October 12): C-Room 32A**

**MA75: Practical Application of OR in Rail Industry**  
Chair: April Kuo, BNSF Railway  
- Risk-Based Railroad Tank Car Safety Design Optimization (Rapik Saat)  
- Optimizing the Routing of Trains with Heterogeneous Traffic (Yung-Cheng Lai)  
- Effectively Solving Production Gang Scheduling Problem for Railway Track Maintenance Projects (Gang Li)  
- Ballast Procurement and Delivery Optimization (Xiajun (Amy) Pan)  
- Freight Tariff Design for Multi-product Multimodal Networks: An MPEC Approach (Hani Mahmassani)  

**MB75: Railway Crew Scheduling**  
Chair: Kamalesh Somani, CSX Transportation  
- A Decision Support System for Railroad Crew Planning (Krishna Jha)  
- A Simulation-based Crew Planning Model to Improve Crew Utilization and Train Performance (Yudi Pranoto)  
- Strategic and Real-time Crew Scheduling Models at CSX Transportation (Kamalesh Somani)
Monday (October 12): C-Room 32A

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| 13:30 – 15:00 AM | TB75: Railroad Capacity Planning Session I  
Chair: Clark Cheng, Norfolk Southern Corp.  
- LineMAX: Line Capacity Analyzer at Norfolk Southern (Vinay Mehendiratta)  
- Capacity Planning and the Total Service Integration Process at CSX (Cary Helton)  
- Dispatching System Developments at BNSF Railway (Roger Baugher) |
| 16:30 – 18:00 PM | TB75: Train Scheduling  
Chair: Krishna Jha, Innovative Scheduling  
- A Multi-stage, Hybrid Model for Train Schedule Optimization (Clark Cheng)  
- Implementing A Comprehensive Train Planning Model Results (Cary Helton)  
- A Genetic Algorithm Procedure to Solve the Railway Routing and Scheduling Problem (Pavankumar Murali) |

Tuesday (October 13): C-Room 32A

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| 8:00 – 9:30 AM | TA75: Joint Session RAS/TAL: Recent Advances in Transportation Planning System  
Chair: Ravindra Ahuja, Innovative Scheduling  
- New Algorithmic Approaches to Solve Curfew Planning Problem (Ashish Nemani, Suat Bog)  
- A Simulation-based Decision Support System for Railroad Terminal Capacity Planning (Edward Lin)  
- Multi-year Installation Design of Railroad Wayside Defect Detection Installations (Fan Peng) |
| 11:00 – 12:30 PM | TB75: Railroad Capacity Planning Session II  
Chair: Clark Cheng, Norfolk Southern Corp.  
- Evaluation of the Impact of Advanced Railway Technologies on Line and Network Capacity (Yung-Cheng Lai)  
- Investigating the Impact of Train Type Heterogeneity on Railroad Capacity using Simulation Modeling (Mark Dingler)  
- Railway Dispatching with Perfect Delay Information (Steven Harrod)  
- Integrating Steady State and Dynamic Rolling Stock Models with Cyclical Demand (Michael Gorman) |

"Railway Records"

- The fastest train in the world is the TGV in France. It is a similar train to the Eurostar which runs in the UK and across to France and Belgium. It can run at 322 miles per hour. In test runs, the French TGV reached speeds of 363 miles per hour and when it braked it took 10 miles to stop.

- The steepest Cogwheel railway in the world is in Switzerland. It has a gradient of 48%.

- The longest straight stretch of railway is in Australia. The part without any curves is 478 kilometers (301 miles) long.

- The only railway to go to the top of a volcano was built on Mount Vesuvius in Italy, in 1880.

- The largest station in the world is Grand Central in New York. It has 44 platforms.

- There is 15,795 route kilometers (9815 miles) in Great Britain’s National Rail network, 14,353 km (8919 miles) of which are open to passenger trains.

- Indian Railways is the world’s largest commercial or utility employer with 1.65 million regular employees as of 2000. This state-owned company is one of the busiest in the world, transporting over six billion people and around 750 million tons of freight and cargo every year, covering the entire length and breadth of the country (Guinness World Records, 2008).
Knowledge of your network and experience used to be enough to plan and schedule trains, crews, and locomotives. Not anymore. Today, smart railroad executives use computer modeling from Innovative Scheduling to optimize:

- **Network Planning**
- **Block Planning**
- **Train Planning**
- **Locomotive Scheduling**
- **Crew Scheduling**
- **Yard Capacity Management**

Find out how you can reduce your operating costs through computer modeling and optimization.

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RAS Dinner at INFORMS

We would like to invite all RAS members for a dinner on Sunday (October 11) at the INFORMS Meeting. Please show your commitment to RAS by joining us at the dinner. This dinner will be free for all RAS members and spouses are welcome too. The dinner will take place at 7:30 PM at the Harbor House Restaurant located at Seaport Village, 831 West Harbor Drive, San Diego, CA, just west of the San Diego Convention Center; Telephone: (619) 232-1141. Another special attraction of the dinner will be a featured lecture by a distinguished speaker (yet to be decided). Sponsors: Innovative Scheduling, Jeppesen Rail, Logistics, & Terminals, and Oliver Wyman. Please RSVP to Howard.Rosen@jeppesen.com by October 8. We will try to accommodate you even if you have not done RSVP, but may not be able to guarantee it.