Rail Applications Special Interest Group

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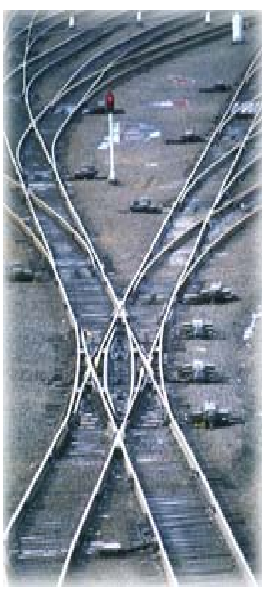
FROM THE EDITORS DESK

INSIDE:



Thanks for reading the Spring RASIG newsletter! The RASIG team continues to promote the application of Operations Research (OR) models and algorithms to the practical problems of the railroad industry practical problems. We had a successful year in 2004 with the INFORMS sessions, the student papers, the newsletter, and the workshop in December. In the October 2004 INFORMS National Meeting in Denver, CO, we organized five invited sessions, one student paper session, and a roundtable discussion on Interline Gateway Optimization. All the sessions attracted a large audience, with an average attendance of over 40 people. A couple of months later, in December 2004, we organized the workshop, "**Operations Research in Railroads: Challenges and Opportunities**," in Fort Worth, TX. Over 100 people from academia, industry, and consulting companies and representing North America, Europe, and South America attended this workshop. In the continuation of expanding our presence , we have included two articles in the current newsletter that focus on the European railroads. One of the most stimulating sessions at the workshop was the panel discussion, "Opportunities in Developing Next Generation Decision Support Systems in Railroads," in which several senior academics and railroad executives presented their ideas. We will now share with you some of the panel members' answers to our questions.

Question: What are the major decision problems in the railroad industry for which OR models can be used?

Answer: US Railroads are experiencing a major growth in freight transportation and are finding themselves close to capacity. Lines and yards are congested, but building tracks and yards is an expensive decision. All railroads require:

- Quantitative tools to better take advantage of the current capacity level.
- Tools to aid expansion plans: where to lay new tracks; where to increase capacity and by how much; where to invest for the greatest profit.
- Real-time locomotive management system: how to assign locomotives to trains and when to deadhead locomotives. This problem is difficult to solve due to unreliable train schedules and uncertainty of demand.
- Crew scheduling systems: how to assign crews to trains. Unreliable train schedules and complicated work-rest rules that differ from district to district make this a complex problem that is currently solved manually; it could greatly benefit from OR.
- Disruption management entails how to move traffic in case of track failure, train accidents, or bad weather.
- Pricing is another application area for OR models.

Question: What characteristics should these OR tools have?

Answers: All tools developed should possess the following characteristics:

- Models that produce implementable solutions, not necessarily optimal solutions. A solution close to the target is good enough.
- Human experience cannot be substituted by models; thus, we need to keep humans in the loop. Tools can direct us in the right direction, but people should be able to make adjustments.

Railroads are not deterministic. There is significant variability in demand from one day to another, from one week to another. OR tools must also satisfy the following three criteria: robustness, recoverability, and responsiveness. The tools should be robust enough to produce acceptable quality solutions in a satisfactory amount of time, should allow us to recover smoothly from disruptions, and should allow us to respond rapidly to changing demands or market conditions. Helpful Hint: Try a model on a small scale, and if it is promising, try it on the full-size problem.

Question: Are railroads open to using OR models and changing their business practices? Are they willing to fund research to develop OR models?

Answer: Yes! By all means! Railroads are open to changing business practices if the return on the investment justifies it. If solutions are implementable and promise significant benefits, they will be used. You should also be able to justify the solutions. Further, adopt a user-centric design and have user acceptance before the tool is commissioned. Discover how users make decisions. Spend time with them. Learn from them and use this learning to develop models. Railroads can also fund pilot projects or write a support letter for acquiring federal grants.

Ravi Ahuja, Innovative Scheduling
Pooja Dewan, BNSF Railway

WAGONLOAD RAIL FREIGHT SERVICES IN EUROPE

The North American carload freight business is challenging but profitable. While many would argue that it's the best run in the word, Europeans tell us that it's not quite good enough for them. Based on what we've learned in recent consulting engagements for certain major European railways, we believe that it is possible to profitably run a carload freight business in Europe given the proper tools and the political will. The European railways are starting to come to the same conclusion, and, as a result, they are reforming their organizations in order to plan and operate the freight side of the business.

As most of you know, European railways from a freight perspective are comparatively inefficient and have experienced a steady decline in market share. Over the last three decades, the railway's market share of tonnage has fallen from 20 percent to 8 percent, according to statistics from the European Commission. However, we believe that, in spite of the downturn, profitability *is* possible for carload rail freight in Europe if we focus on recent advancements in operational technology and take advantage of political reforms that reflect and support operational models.

Led by the European Commission, the European railways are undergoing a period of massive reform. According to Chris Nash and Cesar Rivera-Trujillo of the Institute for Transport Studies, University of Leeds, the five key areas for rail reform in Europe are:

1. Separation of infrastructure from operations (one party responsible for maintenance of the tracks, etc. and another responsible for the daily operations of a freight company)
2. Open access (lack of discrimination in the use of rails, rail yards, and equivalency of pricing between nations)
3. Passenger franchising (bidding out of passenger services to independent providers)
4. Contracting out (bidding out of infrastructure support or other non-core services)
5. Independent regulation (regulation by a third party or by a consortium of nations)

These reforms are shaking up the state-owned railways. As a private sector, independent operators grab market share through open access, and mandates are put in place to reduce subsidy levels; the traditional state-owned monopolies are therefore being forced to change. This change is coming slowly and in the face of great internal and external resistance. Nonetheless, the European railways are starting to focus on reducing their costs, increasing their efficiency, shedding unprofitable lines of business, and taking a more customer-centric view.

State of Freight Railways in Europe

Before addressing what is possible, it's important to consider the historical problems with European freight transport by rail.
Some of the challenges include:

- Restrictions on train size due to both train technology and infrastructure (poor economies of scale)
- Network congestion (bias towards passenger trains and lack of paths for freight trains)
- Poor commercial and operational organization (e.g., high costs due to over manning and poor locomotive utilization)
- Difficult interoperability across borders (inspections, international data transfer, different loading gauges, different power supplies, different running directions, etc.)

These inefficiencies reflect a lack of operational sophistication, political "sacred cows," or simply a divergence of historical technologies across European nations. Whatever their source, the cumulative effect of these challenges has often seemed overwhelming and therefore stymied a pursuit of viable solutions.

Despite the above, a railroader from North America would be familiar with many of the issues faced by the European railways. For example, 40 to 60 percent of most railway traffic is single carload traffic. Their lines of business break into traditional areas such as carload, unit train, intermodal, and automotive traffic. A large percentage of European rail traffic must be interchanged with other carriers (generally at international borders). They operate a traditional classification system with system hump yards and smaller flat yards handling regional and local traffic. When one carrier uses another carrier's cars, it must pay a per diem rental charge, and equipment leasing companies operate extensive private railcar fleets.

Despite these similarities, there are also significant differences. Trains are shorter, generally consisting of 15 to 30 cars; the average train consists of 20 to 25 cars. Most trains are single block trains, and the lengths of haul are shorter, with transit times that are generally much faster than in North America (measured both in train speeds and time spent in yards).

OR PAPERS DATABASE

RASIG, in collaboration with Innovative Scheduling, has developed an on-line database of papers related to Operations Research in railroads. This database contains references and abstracts of hundreds of papers in railroad OR published in the past fifty years. It will allow users to search for papers using key words or find papers on specific railroad decision problems. We hope that this database will assist in the literature survey and thus promote the use of operations research techniques in railroads. This database is available at the website: **www.InnovativeScheduling.com**.

—- RASIG Editorial Board

WAGONLOAD RAIL FREIGHT SERVICES IN EUROPE (CONTD.)

It is very complex to reserve slots or paths for operating the trains; in some cases, it requires over a year in planning. Unit trains do not often handle bulk traffic but instead are simply single customer trains. The use of single customer trains for loaded movements often results in the carload network repositioning a disproportionate number of empty cars.

Applying Modeling to European Freight Railways

While these differences are important, we have found that the similarities are even more noteworthy. It is indeed possible to use operations research tools to model European freight railway operations, to test out changes to these operations, and to identify ways to make the railways more efficient. Having applied these tools to several European railways, some of our findings include:

- Many of the European railways follow a strict classification hierarchy, moving cars from local yards to regional yards, and then to system yards, and back down to regional and local yards. This hierarchy results in an excessive number of handlings by North American standards, and modeling tools can help identify ways to improve the routing efficiency of the cars.

- Many of the trains are small by design. Often, by using a network-focused tool, one can identify pairs of trains that can be combined to increase the train size. This may require the operation of a multi-block train. In other cases, efficiencies require the combining of a carload train and a short "unit train" operated for a particular customer. These types of changes often encounter significant commercial and organizational resistance.

- Nominally, most European railways operate a highly planned, scheduled railway. This includes not only well specified trains to be operated, but the associated crew assignments and locomotive cycle plans. However, it appears that the railways often end up annulling 10 to 20 percent of these trains, in part because there are more trains scheduled than are needed. In addition, traffic is often "rolled" when trains become full. In some cases, trains are run outside of their designated time slot and in other situations extras are operated. Not only does this produce an inconsistent service product for the customer, it can also play havoc with the carefully designed crew and locomotive plans. Use of modeling tools allows the train designers to more carefully match train capacity to actual traffic levels; this improves train size and reduces the need for operational changes to the plan.

- It often seems as if a yard is never closed in Europe. As traffic has declined and as origin-destination patterns have shifted, the yard facilities have not kept up. As a result, there is often excess yard capacity as well as a need to rationalize the system of yards. Studying alternative sets of yards to maintain is a perfect application for modeling tools.

These are just a few examples of where practices at the European railways can be improved through the use of computer modeling and Operations Research tools. There are many others, including better local service design and improved interchange blocking and train design.

Summary

In response to seemingly insurmountable problems with European rail freight, several options have been considered and attempted, including rationalizing railway operations by cutting staff, improving equipment utilization, and cutting yards. At times, it seems as if very little methodology supports many of these actions. Technology improvements have been limited mostly to equipment utilization models and tracing and tracking systems. Currently, few European railways are addressing the heart of the problem by looking at traffic and customers in an effort to optimize the flow of freight. What we have seen is that despite their North American roots, operations research tools can be applied to examine these issues very effectively. We are starting to see the use of such tools in Europe, and we believe it is a trend that will accelerate in the coming years. The potential savings for European railways are undeniable.

Carl Van Dyke
MultiModal Applied Systems

QUICK QUOTE

"A railroad is like a lie you have to keep building to make it stand"

-Mark Twain

NEW PARADIGMS FOR OR IN RAIL: FROM CREATING EFFICIENCIES TO CREATING OPPORTUNITIES

We read about it in the trade publications: the transportation infrastructure is strained to its limits. Railroads, ports, borders, highways, and airports are all facing heavy congestion. Equipment, crew, and driver shortages crop up. With the double whammy of revived economic growth and continually increasing internationalization, it appears that the transportation sector is facing both the opportunity for growth and the threat of crippling shipper supply chains due to the inability to provide quality service for the ever-growing transportation demand. As the transportation infrastructure in nearly all modes and at all levels is stretched to the limit, we should now call on OR to do more than create efficiencies in existing operations. We need OR to both generate opportunities for expanded and improved service and to institute more creative approaches to solving today's problems.

As an illustrative example of this concept, consider rail's traditional "empty equipment allocation" problem, in which empty pieces of equipment (trailers, flatcars, boxcars, gondolas, etc.) are assigned to customer demands. These models typically minimize repositioning and other qualitative costs subject to the constraints that customers must be served and equipment must be available. This class of problem has been well-researched, widely implemented amongst railroads in various forms, and it has created millions of dollars in savings.

For this familiar OR problem to enter new paradigms in the current environment, we must rethink both its objective and its constraints. The objective transitions from cost minimization to profit maximization raise the question, "Which (combination of) customers should be served in order to maximize profits?" All business is not good business in an era of tight capacity; the opportunity cost of providing one service may be the lost capacity to provide quality service somewhere else.

In a sense, we may reconsider the constraint that customer demand must be satisfied. The customer current traffic mix may *not* be the best for profitability and network capacity. (The optimal service is less than demand.) Conversely, non-rail traffic may be ideal for improving network balance and yield. (The desired allocation may be greater than the current demand.)

In this view, each opportunity for new business must be assessed for how well it complements the existing network of equipment flows. More aggressively, marketing groups must seek out opportunities that best fit individual networks. The question is not one of "take it or leave it," but rather, "At what price is the new business worthwhile?" By expanding the scope of the questions under consideration, a wider realm of operations research tools and techniques need to be employed, including estimation of market potential demand and willingness to pay, network-based profitability estimation, and yield management techniques.

We might also reconsider the "subject to equipment availability" constraint and instead ask the question "Where might equipment capacity be created?" in order to create opportunities to better serve more customers with existing fleets. Partitioning the traffic network by service provider and equipment by ownership creates network imbalances with the sadly ironic result of both equipment shortages and network congestion. Additionally, equipment idle time at surplus locations contributes to hub and yard congestion, and empty repositioning consumes train space. OR models can help identify and evaluate such creative solutions as equipment risk pooling. Additionally, it can spot markets across networks and owners in order to break through the traditional equipment availability constraint and expand service opportunities.

In this illustration, finding the hidden opportunities in transportation networks is a function of identifying the right combination of complementary equipment sources and traffic flows. More generally, OR modelers in the rail industry should challenge traditional notions of constraints in this and other rail/OR problems in order to transition from an efficiency to an opportunity focus.

Michael F. Gorman,
University of Dayton

CALL FOR ARTICLES

We invite all RASIG members to contribute articles to the newsletter and share their experiences and insights with others. You may contribute your article on any aspect of railroad OR, be it theory, modeling, algorithm and/or practice. The main criterion for acceptance of your submission will be its readability, relevance, and usefulness to RASIG's members. Please limit your articles to 500-1,000 words and send them to:

Krishna C. Jha
krishna@InnovativeScheduling.com

APPLICATIONS OF OPERATIONS RESEARCH AT SWEDISH FREIGHT RAILWAYS

The Purpose of the OR Application

The main purpose of the operations research application at Green Cargo is to maximize resource utilization. Swedish railway companies have to adhere to timetables designed by the government authorities. Green Cargo and the passenger traffic operators bid for allocation slots in the track network based on information about traffic patterns and customer requirements. If no slot conflicts arise, the operators receive their bids. However, the service potential is in some sense beyond the control of the operators. Another important constraint is that train lengths cannot exceed 630 m (700 yds) due to infrastructure. Given the timetable and infrastructural constraints, Green Cargo provides services to destinations across Scandinavia and for export while maximizing the return on its scarce resources (locomotives, crew, and cars).

The Flow of Information

Even in a fully scheduled railway company, particularly a freight railway such as Green Cargo, there are many changes to the present timetable. To be able to optimize the resources, the timetable's information has to be timely and accurate. Furthermore, this information has to flow into the subsequent systems, i.e., the locomotive, crew, and railcar optimization systems. Therefore, Green Cargo has adopted a policy of keeping its own timetables up-to-date in a system called TrainPlan, which feeds the optimization systems. In the internal timetable, information about available train capacities as well as about crew and rolling stock is provided. Moreover, a reservation system makes it possible to book train cars well in advance.

Locomotive Optimization

The locomotive optimization process determines the turn-around plan for all locomotives. In the fleet assignment process, a sequence of timetable tasks is assigned to each locomotive. Furthermore, the process determines a number of locomotives, deadhead usage, and options for maintenance. Several rules or preconditions that the solutions have to comply with include: only specific points for switching locomotives exist; specific locomotives switching times are required; pulling power at specific lines are prespecified; and the type of locomotives that can be utilized depends on . The turn-around plan for the locomotives is transmitted to the crew optimization system since it contains information that is vital to the crew planning process.

Crew Optimization

Due to its inherent complexity, the crew planning process at Green Cargo is divided into a crew pairing and a crew rostering phase. First, anonymous pairings are formed out of the timetable tasks in such a way that the crew requirements of each task are fulfilled. A pairing is a sequence of tasks that are assigned to a driver. Then, in crew rostering, the pairings with other possible activities, such as stationary tasks, reserve duties, and off-duty blocks, are sequenced to rosters and assigned to individual drivers. Rostering is performed one month at a time and published two weeks ahead of execution. In both pairing and rostering, the solutions have to meet rules and regulations coming from legislation and contractual agreements.

Empty Car Optimization

In the operational system, empty freight cars have to be repositioned so that the transportation demand can be fulfilled. The empty freight car distribution process plans, optimizes, and implements the empty car movements. The objective of the operational planning of the empty freight car distribution at Green Cargo is to satisfy as many demands for empty cars of each car type as possible, while minimizing the distribution costs. When compared to transports of loaded cars, the planning of empty cars allows more freedom in carrying out the empty movements. An order for loaded cars has a fixed origin and a fixed destination and is often scheduled for a specific day, which implies that there are few alternatives for executing the order and the movement. To reposition empty cars, no demands have to be fulfilled for specific origin-destination pairs, and there is no specific time schedule for each empty transport.

When the demand for loaded transport becomes known, corresponding freight cars of the right type are booked on the trains. Most of the demand is known at least one day before the transport is to be performed, and transportation times are generally less than 24 hours, which enables empty cars to fulfil the loaded transport demand. The remaining train capacity after loaded cars are booked onto trains can be used for empty cars. The loaded transports cannot be changed to fulfil empty car requirements, which means that the train capacities for empty freight car transport are limited. The loaded transports thus generate a demand for empty freight cars.

Name to be added
Green Cargo

QUICK QUOTE

"The human brain is like a railroad freight car — guaranteed to have a certain capacity but often running empty" -Annonymous

RASIG CALL FOR PRESENTERS!
INFORMS 2005 -- NEW ORLEANS
NOVEMBER 13-16, 2005

This year's conference theme - Ecologies, Economies and OR - couldn't be more appropriate for the rail industry. What other industry is so critical to both the world economy and world ecology? Consider: U.S. freight rail transports 40% of the gross ton miles GTM's in the U.S., while garnering only 10% of the intercity freight revenue, and generating one-third of the pollutants of trucking? (Source: AAR)

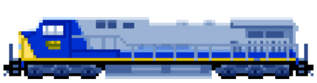
The time is now to start thinking about sharing your wisdom with the RASIG members...

- What have you been working on?
- What has the shift in the economy meant to your company's operating practices?
- What OR software products or hardware technologies are gaining ground in the rail industry? What are the implications for rail operations and OR models?
- Recent implementation successes? Lessons learned?
- What is the latest research in new techniques in rail?

RASIG will continue to create value for its members as members contribute their ideas and best thoughts. Please contribute yours. The deadline for submissions is fast approaching, so don't delay in your response! **Please send a 50-word abstract of the talk to Mike Gorman (michael.gorman@udayton.edu) if you are interested in presenting in the roundtable session or one of the technical paper sessions.**

ALREADY IN THE WORKS:

- **Roundtable Topic: Managing Tight Rail Capacity: More Hardware or Better Planning?** Coordinator: Michael Gorman
- **Student Paper Contest**; Chair: Pooja Dewan, BNSF Railway
- **Railway Optimized Equipment Distribution: Success or Failure?** Chair: Carl Van Dyke, Multimodal Applied Systems
- **Emerging Trends in Rail Optimization**; Chair: David Hunt, Cambridge Systematics
- **Yield Management and Railroads**; Chair: Michael F. Gorman, University of Dayton



Railroad Facts

- The world's highest railway is in Peru. The central railway climbs to 15, 694 feet in Galera Tunnel, 108 miles from Lima.
- The longest railway in the world is Trans-Siberian Railway of Trans-Siberian Railroad, built 1891-1916. It is 5787 miles and spans eight time zones.
- Indian Railways is the largest employer in the world with a staff of 1.6 million people.
- In 1761, the first iron rails laid at Bath, England.
- The world's first passenger railway was Mumbles Railway in 1804 from Rutland Street Station to the Pier at Mumbles.
- The first railroad in America was 16 miles long. It was built by Delaware and Hudson Co. in 1829 to haul coal.
- In 1887, the Interstate Commerce Commission was created in United States to regulate railroads to ensure fair prices.
- In 1990, world speed record for an electric train, was set in France by a TGV, which reaches a speed of 320 mph.
- In 1971, President Richard Nixon and Congress created Amtrak and eliminated several passenger routes.
- In 1987, world speed record for a diesel locomotive was set in Britain by British Rail's High Speed Train, which reached a speed of 148 mph.

Management Science in Railroad Applications

2005 STUDENT RESEARCH PAPER CONTEST

For papers demonstrating application of analytical techniques to railroad problems

RASIG (Rail Applications Special Interest Group), a subdivision of INFORMS (Institute for Operations Research and Management Science), and Railway Age are sponsoring a student research paper contest on Management Science in Railroad Applications.

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

Authors of First Place, Second Place, and Honorable Mention papers will be asked to present the papers at the INFORMS Annual Meeting November 13-16, 2005, in New Orleans, LA. RASIG will cover the conference registration fees for all primary authors who are asked to present their papers. Railway Age will publish summaries of the First Place and Second Place entries.

Rules:

- The paper must be written by a student or students enrolled in an academic institution during the 2004-2005 academic year.
- The paper must relate to an application of Management Science for the improvement or utilization of railroad transportation.
- The paper must represent original research (not literature reviews) and have not been published elsewhere.
- Use any approved reference style.
- Cover page must include the paper title, a single-spaced 75 word summary/abstract, primary author's name, summer address, phone & e-mail address, and the name of the institution where the student is enrolled.
- Second page should repeat title and abstract but contain no identifying names.

How to Enter:

- Submit an abstract of your proposed paper by July 1, 2005.
- The completed paper should be submitted by August 30, 2005.
- Submit abstracts and papers to: Pooja Dewan, email: Pooja.Dewan@BNSF.Com, or by mail to: 2400 Western Center Boulevard, BNSF Railway, Fort Worth, TX-76131. Electronic submissions are preferred.

RESULTS OF 2004 RASIG STUDENT PAPER COMPETITION

First Prize:

- **Heterogeneity and Reliability of Railway Services.** Michiel J.C.M. Vromans. Department of decision and Information Management, School of Management, Erasmus University Rotterdam, Netherlands, MVromans@fbk.eur.nl

Second Prize:

- **New Approaches for the Train Dispatching Problem.** Guvenc Sahin. Department of Industrial and Systems Engineering, University of Florida, Florida, United States, guvencs@ufl.edu

Honorable Mentions:

- **A Network Flow Approach for Railroad Crew Scheduling.** Balachandran Vaidyanathan. Department of Industrial and Systems Engineering, University of Florida, Florida, United States, vbala@ufl.edu
- **An Optimization Model for Assignment of Empty Cars in Railroad Networks.** Amar K. Narisetty. Purdue University, Indiana, United States, anariset@purdue.edu

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