From the Editor’s Desk:

Xuesong Zhou, Arizona State University; xzhou74@asu.edu

Since 2004, Ravi Ahuja and Pooja Dewan have served as the co-editors for our RAS newsletter. We greatly appreciate their efforts in helping us build a strong community for applying operations research methods and tools for railroads. This year, a couple of RAS officers and members (including Jagadish Jampani and Krishna Jha) are working jointly to edit and publish this year’s newsletter.

The purpose of the RAS newsletter is to keep our members updated about recent activities, including the problem solving competition, student paper awards and various other reports from our RAS officers. By discussing the latest opportunities and challenges faced by OR departments in railroads, another goal of RAS newsletters is to encourage an active dialog for the upcoming meeting.

As a researcher of both railroad scheduling and urban transportation, I have had many discussions with faculty members in both areas and have been fortunate to actively work with many OR researchers from different companies to organize the two recent problem solving competitions. I would like to offer some observations on our future education and research needs based on my dialog with Dr. Steve Harrod and other RAS colleagues. I hope our thoughts will be interesting to you.

High Speed Rail Operations and Scheduling Applicable to North American requirements

In recent years, high-speed rail (HSR) has been offered as a sustainable (energy and environment) mass transit alternative to the overworked highways. Multiple economic and demographic indicators (such as population and fuel cost) project that high-speed rail will grow in importance in the United States and Canada for corridors of less than 300 miles. North America lags behind other nations in high speed rail operating mileage and, consequently, lags behind in education programs. Many universities in the United States — for example, the University of Illinois at Urbana-Champaign, Michigan Tech University and the University of Nevada at Las Vegas — have recognized the need to create an informed/skilled workforce that can aid policy makers on the role of HSR in the context of the current inter-city multimodal transportation system. Despite the proactive efforts of the above-mentioned universities, the challenge for our RAS community in supporting the education and training of HSR students in the United States is understanding and meeting North American requirements. We have to recognize that the majority of technical expertise in high speed rail originates in Europe and East Asia. Since the geography and rail freight traffic mix of North America differ significantly from that of these regions, many of these methods and assumptions need to be modified for North American applications.

Both Dr. Harrod and I have been working in the area of timetabling and train dispatching. We have found that there are very different objectives and constraints for North America when compared to those in Europe and Asia. Our research has indicated that it is critical to clearly define the related operations research problems specific to North America. While closely working with the existing rail companies in North America, our faculty members need to collect and distribute educational materials appropriate for the needs of high speed rail operations planning and management — for example, evaluating the capacity impact of running high-speed passenger trains on the existing freight-oriented facilities.
Better Defined Data-Driven and Market-Related Railroad OR Problems

From the perspective of many researchers in the urban transportation area, the operations research problems faced by freight rail companies are still quite "traditional." This is because their exposure to our field comes from our RAS problem solving competitions, which have focused on the problem formulation and solution algorithms from an optimization approach. This monotonous approach to the RAS problem solving competition might ignore other important aspects of our field. In comparison, some closely related highway transportation fields, such as intelligent transportation systems and urban traffic demand forecasting and planning, openly discuss their field from many angles including how to handle uncertainties associated with traveler behaviors. The highway transportation fields have much more complicated variables than rail operations, but experts have been successfully juggling these uncertainties while accounting for technological advances such as self-driving cars and connected vehicles.

Operations research and business departments in railroad companies need to work closely to predict both long-term and short-term ridership changes. This can be accomplished by using multiple historical and up-to-date data sources, including user survey data and other external economic factors, and eventually lead to a necessity to utilize advanced marketing analysis in a dynamic and uncertain environment. Researching this type of problem should easily be supported by high-level railroad executives due to the high impact of problem solutions/suggestions with the high return of investment by creating superior marketing strategies. In the future, it would be beneficial for us to collaborate with business teams and clearly define the market-related OR problems and include them in our problem solving competitions. This could further attract researchers from different disciplines to our exciting field, bringing with them interesting data mining, machine learning, transportation demand forecasting and predictive analytics tools to help solve our real-life market-related problems. Through a better integration with the forecasted volume and even predicted uncertainties of traffic origin-destination demand for different commodities, our core optimization problems of line planning, block plan optimization and train scheduling can receive stronger buy-in and acceptance from the ultimate users and decision makers of the rail system.
Annual Report by RAS Officers

Chair: Jagadish Jampani, CSX Transportation; Jagadish_Jampani@csx.com
Vice Chair: Krishna Jha, Innovative Scheduling; krishna.jha@innovativescheduling.com
Secretary: Shrikant Jarugumilli, BNSF Railway; Shrikant.Jarugumilli@bnsf.com
Treasurer: Fan Peng, CSX Transportation; Fan_Peng@csx.com
PR Officer: Xuesong Zhou, Arizona State University; zxhou74@asu.edu

RAS is proud to serve its members via activities that help advance the application of operations research to railroad problems. RAS competitions and activities are organized by volunteers who display a great sense of commitment and dedication. We are very thankful to our volunteers for taking the lead and spending a considerable amount of time to make RAS events a reality. In addition, these activities involve significant amount of money in the form of awards and other related expenses. We rely on financial support from our sponsors to continue these activities. This year we have been able to raise $6,000 with the generous support of our sponsors: BNSF Railway Company, CSX Transportation and Norfolk Southern. We mainly used these funds to sponsor the RAS Problem Solving Competition and the RAS Student Paper Award.

Continuing our past practice, we are hosting the RAS dinner on Sunday; however, this time we are combining the dinner with the RAS Business Meeting. Dinner is sponsored by Innovative Scheduling and Oliver Wyman. We thank our sponsors for continued support and generosity, and we hope to continue this relationship in the future.

RAS Distinguished Member Award

RAS is able to serve our profession through the contributions of volunteers. Although contributions from everyone are appreciated, some volunteers’ contributions have a far reaching impact. Their contributions have given RAS a new direction and continue to inspire others to follow their footsteps. The RAS Distinguished Member Award is given to recognize such individuals. This award was first given out last year. The award committee consists of the current officers, past award winners and past RAS Chairs/Presidents. This year, four past RAS chairs - Michael Gorman, Carl Van Dyke, Ravindra Ahuja and Pooja Dewan were nominated for the award. The award committee consisting of 14 members selected Dr. Ahuja as the recipient of the RAS Distinguished Member Award for 2013. We congratulate Dr. Ahuja for this award and RAS greatly appreciates his continued support over the years.

2013 Problem Solving Competition

This year, we released the competition problem on February 12 instead of our past practice of releasing the problem in April. We expected that two extra months of time would attract more participants and give the participating teams more time. But during the month of March, we only received two registrations. We were not sure if the problem was too difficult to attract participants or if there was another reason. We already knew that this year’s “Rail Road Yard Operational Plan” problem is significantly difficult and involves stochastic processes. The competition panel members decided not to take a chance that may result in fewer registrations. Hence, we modified the problem to a deterministic problem in addition to relaxing a few constraints, and we released the modified problem on April 3. Looking at the chart below, we do not see any correlation between releasing the problem early and receiving more registrations. That hypothesis is yet to be proven! Overall, we received about the same number of registrations and solution submissions as the previous year.
RAS Membership

RAS has a total of 121 members, 82 of whom are regular members and 33 of whom are students. In 2012, there were 79 regular members and 78 student members. As you might be aware, the number of registered students started to drop significantly starting in 2011 after INFORMS changed the policy to discourage free memberships to the sections. On the positive side, we are seeing a considerable number of people participating in the RAS Problem Solving Competition and the RAS Student Paper Award. A total of 99 people who are either students, academicians or from industry participated in the competitions. Further breaking it down, there are about 70 students out of 99 participants and almost all of them are not registered RAS members. We would like to keep RAS membership for the participants as voluntary but further reach out to students and encourage them to become RAS members. We welcome your thoughts about how to increase the registered student members. Please provide your thoughts during the RAS business meeting or send an email to incoming RAS chair Krishna Jha (krishna.jha@innovativescheduling.com).

RAS Sessions at 2013 INFORMS Annual Meeting

RAS sessions are filled with a wide range of interesting topics. We have a total of 12 sessions and 44 presentations. In addition, we have three joint sessions with TSL. Having joint sessions will expose new researchers to railroad research and help us learn from other transportation industries. We thank the cluster chair, Dr. Yanfeng Ouyang, and all of the session chairs for their hard work in organizing the sessions. The session lineup starts on the next page.

LinkedIn and Email List

RAS has a LinkedIn group (http://goo.gl/k3hF86) or simply search the Rail Applications Section of INFORMS). LinkedIn gives us a forum where people can post and discuss topics. The number of members in our group increased significantly from 181 in 2012 to 382 in 2013. If you are not already a member, please join the group to connect with the other 382 members from academia, railroads and consulting. This forum is also used as a form of communication during our RAS competitions.

We also have a mailing list of all RAS members (past and present) that allows us to communicate with RAS members. You can post job opportunities or reach out to other members for a specific question or discussion item.

Got News to Share?

Published a paper? Published a book? Hiring full-time employees or interns? If you have news that you would like to share with RAS members, please let us know. We can help spread the word. We look forward to seeing you in Minneapolis!
Annual National Meeting Sessions

Chair: Yanfeng Ouyang, University of Illinois at Urbana-Champaign; yfouyang@illinois.edu

This year we have 12 sessions lined up with diverse topics such as railroad predictive analytics, service planning and maintenance management, timetabling and routing, capacity analysis, high-speed rail and more. Three of the sessions are listed as joint sessions with the Transportation Science and Logistics (TSL) Society, which will help our section attract a wider audience. Our round table sessions will focus on capacity management, timetabling and planning for passenger train service. A panel of experts with intensive industry experience and profound OR background will explore various issues related to rail network capacity and passenger rail operations. As always, we are excited to see presentations from the winners of the Student Paper Award and finalists of the RAS Problem Solving Competition!

All sessions are scheduled in Room 211C, and those from MD to TD are in Auditorium 3, both in the Convention Center.

<table>
<thead>
<tr>
<th>Session</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SA33</strong>: Railway Applications Section (RAS) Student Paper Award</td>
<td>Chair: Juan Morales, BNSF Railway</td>
</tr>
<tr>
<td><strong>SB33</strong>: RAS Problem Solving Competition</td>
<td>Chair: Sandra Eksioglu, Mississippi State University</td>
</tr>
<tr>
<td><strong>SC33</strong>: Capacity Management for Passenger Train Service (RAS Roundtable Part 1)</td>
<td>Chair: Carl VanDyke, Oliver Wyman</td>
</tr>
<tr>
<td><strong>SD33</strong>: Passenger Railway Timetabling and Planning (RAS Roundtable Part 2)</td>
<td>Chair: Carl VanDyke, Oliver Wyman</td>
</tr>
</tbody>
</table>

**Sunday Oct 06, Room 211C (Convention Center)**

<table>
<thead>
<tr>
<th>Session</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>SA33</strong>: Railway Applications Section (RAS) Student Paper Award</td>
<td>Chair: Juan Morales, BNSF Railway</td>
</tr>
<tr>
<td><strong>SB33</strong>: RAS Problem Solving Competition</td>
<td>Chair: Sandra Eksioglu, Mississippi State University</td>
</tr>
<tr>
<td><strong>SC33</strong>: Capacity Management for Passenger Train Service (RAS Roundtable Part 1)</td>
<td>Chair: Carl VanDyke, Oliver Wyman</td>
</tr>
<tr>
<td><strong>SD33</strong>: Passenger Railway Timetabling and Planning (RAS Roundtable Part 2)</td>
<td>Chair: Carl VanDyke, Oliver Wyman</td>
</tr>
</tbody>
</table>
### Monday Oct 07 (211C except for MD39, which is in Auditorium 3)

**MA33: Business Analytics in Railroads**  
Chair: Krishna Jha, Innovative Scheduling

- 08:00 – 09:30
  1. Simultaneous Train Rerouting and Rescheduling on an N-track Network (Xuesong Zhou)
  2. Simulation-enabled Analytics at CSX (Jeremiah Dirnberger)
  3. Improving Railroad Service Design through Analytics (Todd Workman)

**MB33: Railroad Predictive Analytics**  
Chair: Aihong Wen, CSX Transportation

- 11:00 – 12:30
  1. Predictive Maintenance for Railroad MoW Vehicles (Aihong Wen)
  2. Prediction of Railcar Remaining Life by Multiple Data Source Fusion (Qing He)
  3. Predict Congestion Status of a Hump Yard using Data-mining (Yu Wang)

**MC33: National University Rail Center (NURail) Systems Research**  
Chair: Rapik Saat, University of Illinois at Urbana-Champaign

- 13:30 – 15:00
  1. Optimization of Rail Defect Inspection Frequency (Tyler Dick)
  2. Accident Analysis of Passenger Trains on Freight Rail Corridors (Chen-Yu Lin)
  3. Incremental Capacity of Single to Double Track with Variable and Sparse Siding Spacing (Ivan Atanassov)
  4. Train Scheduling on a Shared Passenger and Freight Corridor with Demand Considerations (Bo Zou)
  5. Review of Applying Hybrid Approach of Capacity Simulation on a Shared-use Rail Corridor (Hamed Pouryousef)

**MD39: Joint Session TSL/RAS: Rail Systems Management and Maintenance (Auditorium 3 in Convention Center)**  
Chair: Alejandro Toriello, University of Southern California

- 16:30 – 18:00
  1. Dynamic Headway in Positive Train Control (Lunce Fu)
  3. Optimal Investments, Divestments and Maintenance in Railroad Infrastructure under Uncertainty (Arnt-Gunnar Lium)

### Tuesday Oct 08, Auditorium 3 (Convention Center)

**TA39: Joint Session RAS/TSL: Railroad OR Models**  
Chair: Clark Cheng, Norfolk Southern Corporation

- 08:00 – 09:30
  1. Agent-based Traffic Optimization Model for Rail Terminal Management (Tie Shi)
  2. Meet-pass Planning Model for Rail Capacity Analyzer (Hyun-suk Yoon)
  3. Formulation and Solution Approach of Railcar Classification and Connection in Hump Yards (Mingzhou Jin)
  4. Next Generation Analytics Applications for Railroads (Ravindra Ahuja)
### TB39: Train Timetabling, Train Routing, and Railway Capacity Analysis
Chair: Matthew Petering, University of Wisconsin-Milwaukee

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
</tr>
</thead>
</table>
| 11:00  | 1. Scheduling and Recovering from Disruptions in Rapid Transit Networks (Luis Cadarso)  
2. Railway Network Train Pathing by Timed or Physical Block Headway (Steven Harrod)  
3. The Öresund High-capacity Rail Corridor Standards (Hans Boysen)  
4. Integer Programming for Cyclic Railway Timetabling and Routing on a Single Track Unidirectional Line (Matthew Petering) |
| 13:30  | 1. Strategies for Intermingling of High Speed and Legacy Railway Services (Steven Harrod)  
2. Capacity Assessment on a Rail Network: A Maximum Network Flow based Formulation (Xuesong Zhou)  
3. Optimal Siding Location Model for Mixed-use Rail Corridors (Mei-Cheng Shih)  
4. Freight Transportation In Turkish State Railways (TCDD) High-Speed Train System (Alp Ertem)  
5. Impact of High-Speed Passenger Trains on Freight Train Efficiency in Shared Railway Corridors (Kuilin Zhang) |
| 16:30  | 1. Composite Dispatching Rules to Schedule Passenger-coaches in Indian Railways (Balasubramanian Kanagasabapathi)  
2. Development of a Feasibility Model for a High Speed Rail Line (Reinaldo C. Garcia)  
3. A Heuristic for the Driver Scheduling Problem in Passenger Rail Transportation (Dung-Ying Lin)  
4. The Delay Distribution (Samuel Sogin) |

---

### INFORMS 2013 ANNUAL MEETING
MINNEAPOLIS, MINNESOTA
2013 RAS Problem Solving Competition

The 2013 Problem

This year the participants were asked to build a model which can be used to identify a plan that optimizes the operations of a railroad yard. The goal of an operations plan is to minimize the total waiting time of railcars in the yard and maximize the total number of railcars processed during a certain period. Building a classification yard operations plan is challenging as it covers many interrelated operations and decisions, such as the sequence of inbound trains’ disassembly, the sequence of outbound trains’ assembly, sorting plans at the hump, block-to-train assignment plan for classification tracks, etc. Optimizing the operations plan of a classification yard is very important for a railroad company as it helps fully utilize the limited resources of its rail network. Visit the competition website for additional details: [http://www.informs.org/Community/RAS/Problem-Solving-Competition](http://www.informs.org/Community/RAS/Problem-Solving-Competition)

Total cash award for this year’s competition is $3,750: First Place: $2000; Second Place: $1,000, Third Place: $750.

The Response

The competition was very well received internationally. We had a total of 45 teams registered. Members of these teams were from Chile, China (Mainland), France, India, Israel, Korea, Russia, Singapore, Taiwan and The United States. A total of 12 teams submitted their reports. We had a heavy exchange of questions and answers during the period in which the teams were working on solving the problem. Special thanks go to Xuesong Zhou (Arizona State University), one of the problem owners, for responding to questions in a timely manner. The teams proposed a number of innovative optimization and simulation models to solve the problem.

Finalists

We would like to thank all of the participating teams for their hard work and contribution to this competition. The judging panel went through a rigorous process in order to objectively rank and select the finalist teams. This was not an easy process since the quality of the work presented was high. Therefore this year, in addition to the three finalists listed below, we are listing three teams which deserve to be honorably mentioned in this competition.

These three finalists will make a presentation at the INFORMS Annual Meeting during the RAS Problem Solving Competition Session on Sunday, October 6, from 11:00 – 12:30 in the Minneapolis Convention Center, Room 211C. The three finalist team reports will be made available on our website ([www.informs.org/Community/RAS/](http://www.informs.org/Community/RAS/)) soon after. We invite you to come and support these bright minds.

Hai Wang, Maokai Lin, Massachusetts Institute of Technology, USA
Jiangang Jin, Shanghai Jiao Tong University, China

Wenliang Zhou, Lianbo Deng, Zhao Zhou, School of Traffic and Transportation, Central South University, China

Setareh Borjian, Krishna Selvam, Massachusetts Institute of Technology, Cambridge, MA, USA

Honorable Mention

The following are the three honorable mentioned teams for the 2013 RAS Problem Competition.

I-Lin Wang, Wei Lee, Chiao-Yu Liao, National Cheng Kung University, Taiwan
Yihuan Shao, Lunce Fu, Tianyi Pan, University of Southern California, USA
Tianyi Pan, University of Florida, USA
Natalie Simpson, Ryan Hauser, University at Buffalo, NY, USA

Recognition

We thank the sponsors BNSF Railway, CSX Transportation and Norfolk Southern, the problem owners Xuesong Zhou and Edward Lin and the judging panel chair Sandra D. Eksioglu. We also thank the organizing committee members — Behnam Behdani, Burak Eksioglu, Kevin Crook, Jagadish Jampani, Shrikant Jarugumili, Krishna Jha, Ilya Lavrik, Yudi Pranoto, Guvenc Sahin, Kamalesh Somani, Alper Uygur, Yu Wang and Bin Yu — for their guidance and suggestions.
2013 RAS Student Paper Awards

Chair: Juan C. Morales, BNSF Railway, Juan.Morales@BNSF.com

Rail Applications Section (RAS), a section of the Institute for Operations Research and Management Science (INFORMS), sponsored a student research paper contest on analytics and fact-base decision making in railway applications, with a total cash award of $1,750: First Place: $1,000, Second Place: $500, Third Place: $250.

To qualify, the paper must be written by a student or students enrolled in an academic institution during the 2012-2013 academic year. The paper must advance the application or theory of OR/MS for improvement of freight or passenger railway transportation, and it must represent original research that has not been published elsewhere by the time it is submitted. More details on the eligibility criteria, the application procedure and deadlines for submission are available at RAS’s website: http://www.informs.org/Community/RAS/Student-Paper-Award.

Eight students from around the world with a wide variety of topics registered for the competition. The quality of the submitted papers was in general quite outstanding. Authors of the First, Second, and Third Place award winning papers will present their papers at the Student Paper Award Session of the INFORMS Annual Meeting in Minneapolis, MN. 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. We provide below the abstracts of these papers. Extended abstracts of the awarded papers are available on the RAS website.

I had the honor of leading an elite paper reviewing committee made up of eleven members from different academic and industry backgrounds. In order to avoid any conflict of interest, members of the committee with any type of affinity with any of the authors or co-authors did not review the corresponding paper(s). Winners of this year’s paper competition can be found below. The First Place paper will be considered for publication in Networks. The paper still needs to go through the journal’s normal refereeing procedure; however, the paper will receive an expedited refereeing and publication.

Balanced Train Crew Assignment in Double-ended District
by Yutian Yang, University of Texas at Austin
Coauthors: Anantaram Balakrishnan and Brian Roth

Abstract: Crew scheduling problems in railways involve assigning crew members to scheduled trains at minimum cost while satisfying agreements with labor unions and particular operational policies in railroad companies. In this paper, we develop an optimization model and heuristic algorithms to solve crew assignment in double-ended districts with workload balance requirements which aim to evenly allocate workload across crew pools. We also study two rotation key policies which determine the dispatching order of crews in crew pools. We present the computational study on the real-life data arising from a major North American railroad company.

Smooth and Controlled Recovery Planning of Disruptions in Rapid Transit Networks
by Luis Cadarso, Technical University of Madrid.
Coauthors: Angel Marin and Gábor Maróti.

Abstract: This paper studies the integrated timetabling and rolling stock re-scheduling problem for disruption management in rapid transit rail networks. We consider passenger behavior while minimizing recovery time and schedule changes, which measure the quality of the recovery plan. We report computational tests on instances of the Spanish rail operator RENFE.

A macroscopic timetable rescheduling approach for large scale disruptions
by Lucas P. Vellenturf, Erasmus University, Rotterdam.
Coauthors: Martin P. Kidd, Valentina Cacchiani, Leo G. Kroon, and Paolo Toth.

Abstract: On a daily basis railway operations have to deal with disruptions in the network characterized by partial or complete blockages of open track sections. These disruptions often continue for some hours. Train services need to be cancelled and others need to be delayed in order to compensate for the loss of network capacity. In particular, such disruptions typically lead to infeasibilities in the planned timetable, the rolling stock allocations and the crew duties. This requires the railway operator and the infrastructure manager to reschedule the timetable, and the rolling stock and crew schedules. In this research we focus on the rescheduling of the timetable at a macroscopic level. The formulation minimizes the number of cancelled and delayed trains while adhering to capacity constraints on the tracks and within the stations. The model ensures that there is rolling stock available for all trains in the resulting timetable.
**Operations Research at Netherlands Railway**

Dennis Huisman, Joint Appointment at Erasmus University Rotterdam and Dept. of Process Quality & Innovation, Netherlands Railways; huisman@ese.eur.nl

In Europe, passenger railway transportation plays an important role in society. For instance, commuters travel by train to their work, professors and students take the train to travel to universities and families use the train to visit relatives. On an average working day, Netherlands Railways (Nederlandse Spoorwegen, or NS for short) transports more than one million railway passengers. To provide good and cost-efficient service to these passengers, NS uses many operations research methods in its operation. In addition, NS works closely with universities to develop new models and solution methods for several relevant problems.

In 2008, NS won the Franz Edelman Award for the development and application of its innovative tools for timetabling, rolling stock scheduling and crew scheduling. All these tools were used in the construction of a new nationwide timetable, which went into operation in December 2006. After the introduction of the new timetable, punctuality figures increased to new records, more passengers were transported and the profits of the company increased.

Unfortunately, during the last three winters NS faced many operational problems due to heavy snowfall. On such days, for example, switches do not work properly anymore, resulting in a disrupted traffic situation. That means the timetable is no longer feasible, and rolling stock and crew schedules need to be adjusted. Since this problem occurs in daily operation, fast decisions need to be made. Until now, this process has been done manually. In addition, a lot of communication is required resulting in slow decision making, and ultimately it can lead to an out-of-control situation in which no train traffic is possible at a major station.

This kind of situation can be avoided by using smart decision support systems containing OR methods that can quickly calculate good solutions. Two former winners of the RAS student paper award developed methods for fast re-scheduling of rolling stock and crew, respectively. Both methods were used in February 2012 to re-schedule the rolling stock and crew in the construction of an alternative timetable with reduced train traffic to prevent an out-of-control situation. With these methods, the total throughput time of constructing, communicating and implementing this new timetable was less than 16 hours.

In the future, we do not want to reduce the train traffic in advance on days with heavy snowfall but just react when disruptions occur. Therefore, NS invests in new real-time dispatching systems (for rolling stock and crew) that should feed the developed OR methods in real time with the right data such that they are able to calculate good solutions very fast. Furthermore, the solutions can be communicated quickly to the relevant parties within the company. In this way, OR can play an even more important role in the mobility of the Dutch people and eliminate much frustration on days with heavy winter conditions.

**RAILROAD FACTS**

- The Great Depression of the 1930s almost managed to completely destroy the U.S. railway industry.
- The largest modern manufacturers of trains are General Electric and EMD (Electro-Motive Diesel)
- The U.S. embraced four time zones only after trains enabled fast travel across the continent.
- The longest route for one train can be made between Moscow and Vladivostok on the Trans-Siberian Express railway line that is 9,297 kilometers long!
If you Google “Big Data” you will get a flood of information about it and definitely feel the craziness around it. The key word has been mentioned several times in our RAS newsletters, too. In this article, I would like to review a couple of aspects of Big Data and share some lessons learned, successful implementations and suggestions. This is also a follow up to our last year’s newsletter article “Data Mining at CSX.”

What is the Big Data all about?

I like Gartner’s 3Vs definition of Big Data: “Big data is high **Volume** (amount of data), high **Velocity** (speed of data in and out), and high **Variety** (range of data types and sources, such as unstructured data from social media) of information assets that require new forms of processing to enable enhanced decision making, insight discovery and process optimization.” To capitalize on the Big Data trend, a new breed of Big Data technologies such as Hadoop and others have emerged.

**A bit of knowledge well-used can give better results than the expensive Big Data platform.**

I have to admit that the Big Data challenges and opportunities are real. We should keep a close eye on the development of evolving technologies, and be prepared to jump in at the right moment. However, we do not have to wait for the new technology to be in place in our industry to start analytics on the railroad Big Data. As a practitioner in data analytics and having worked in other industries for years and now with the railroad for a reasonable length of time, my suggestion to my OR fellows here is to start “small” for the Big Data wave.

**Build an analytics ecosystem.** Add predictive analytics into your already existing descriptive analytics and prescriptive analytics capabilities. The diagram below is an illustrative interaction between these three capabilities. In the diagram, descriptive analytics relies on reporting, drill-down analysis, alerts and other business intelligence tools. Predictive analytics can utilize data mining techniques, and prescriptive analytics employs the often used OR techniques such as optimization and simulation. Together, these three can cover most of the analytical needs of any organization.

**The Ecosystem of Analytics**

- **Descriptive Analytics**
  - What happened?
- **Predictive Analytics**
  - What will happen?
- **Prescriptive Analytics**
  - What is the Best That Can Happen?

**Fully utilize the “classical” data mining techniques.** Our experience shows these techniques, either standalone or working together, are insightful enough to almost all data sets.

- **Clustering:** Segment objects according to their similarities. This can be the first step of data mining to allow other analysis to be conducted in the customized manner.
- **Correlation analysis:** Find relationships between measurements and their predictors to identify the driving factors. Methodologies include Regression, Decision Tree, Support Vector Machine, Bayesian Networks, Neural Networks and several other more advanced models.
- **Association analysis:** Find rules to identify items that often occur together.
- **Deviation analysis:** Localize the objects that are different from others.
- **Sequence/State transition analysis:** Identify the system’s evolution pattern over time.
Time series forecast: Predict the future by identifying trends, seasonality and cycles in the historical data, in some cases incorporating external explanation factors.

Adopt newer data mining techniques smartly to accommodate the variety of Big Data.

A very economical way is to transform unstructured data into structured data, or extract features from stream data to create structured data with much smaller size.

Text mining: Find intelligence from text. The text can be generated from social media messages, emails, notes and many other sources. The basic process is to first transform unstructured text data into a structured keyword matrix, and then apply some “classical” data mining techniques on the matrix.

Data stream mining: Extracting knowledge structures from continuous, rapid data records. A data stream is an ordered sequence of instances that in many applications can be read only once or a small number of times using limited computing and storage capabilities. Examples of data streams in railroads include locomotive GIS info, locomotive event recorder data or future PTC data. One question to ask before we utilize data stream mining is: Do we need real time analytics? In many cases, extracting features from the data stream first can help avoid the need for complicated modeling.

Social network mining: Defining relationships on social media to reveal evolving trends.

Consider providing insights for problems across all departments.

Some example applications are listed below. At CSX, we were able to successfully apply predictive analytics to the areas of safety, workforce management, car management, Maintenance of Way vehicle maintenance, terminal operations and many more. The initial data sets we have to deal with are big, but we found that they are perfectly manageable once we look into the details. In some cases the data sets even became too small!

Find leading factors for Train Accidents and Personal Injuries from combinations of employee behavior and environmental conditions by employee demographic groups.

Find indicators for employee engagement level.

Predict empty cars coming from interchange points.

Find items on cars and locomotives that are frequently repaired together to support predictive maintenance.

Find the life cycle of railroad assets.

Predict car/locomotive failures utilizing Joint Wayside Defect Detector data.

Identify faulty Wayside Defect Detectors.

Forecast crew starts to support short, mid and long term crew planning.

Analyze customer or employee sentiment through text analytics on emails, surveys and/or social media messages.

Pay attention to pitfalls.

**The data collection may miss some important records.** For example, we may have collected all instances of customer delivery failures and the associated factors, but ignored all instances of success. This creates difficulties for data mining algorithms to find root causes of failures.

**The meaning of the data may not be what you thought.**

**Your business partners may want to validate your model even if you use unsupervised learning methodology.** In the data mining paradigm, one can choose to use supervised learning or unsupervised learning, or even semi-supervised learning, depending on the data availability and the problem you are solving. Caution should be exercised if you have to choose unsupervised learning. At the beginning your business partners may agree that unsupervised learning is best or the only way you can conduct the analysis, but at the end they may still want to validate your model results in the way supervised learning works, which might not be achievable.
Think big on the Big Data analytics.

- **How do you partner with your IT department to build effective data marts out from data warehouses?** Data understanding and preparation process can take up to 90% of the efforts for predictive analytics projects. Processing data in a sustainable way may be a huge benefit for a variety of applications.

- **Make sure the new platform acquired, whatever it is, can plug in your existing analytics capability.** From working with some vendors, this might not be the case. For example, to plug SAS models into an IBM Big Data platform, the vendor might say something like “we can work on it to have that happen,” which means more work and a higher budget.

- **How do you build up an analytics capability across the organization?** Some organizational options are a centralized analytical team, analytical capability embedded in business sections while collaborating across business sections, or standalone capabilities in each business section.

- **Things to keep in mind for any project we would work on:** Problem selection, executive support, solution approach, user buy-in, working with university/vendor, etc.

---

**Rail Transportation Program at Michigan Technological University**

**Pasi Lautala, Director, Rail Transportation Program, Michigan Tech University; ptlautal@mtu.edu**

The Rail Transportation Program (RTP) at Michigan Technological University (Michigan Tech) has developed into one of the leading rail education and research programs in the United States. Established in 2007 within the Michigan Tech Transportation Institute (MTTI), the RTP provides the foundation for all rail-related activities in the field and has become a permanent part of university curriculum and research at Michigan Tech. The program has expanded from rail transportation and engineering-related education to conduct research on various rail transportation issues, including rural and multimodal freight rail transportation, human factors and rail safety, infrastructure evaluation and assessment and improved materials for rail industry. Recently, the research has expanded to include railway capacity aspects, especially simulation and modeling for shared rail corridors.

There is a growing interest in the U.S. to operate higher speed passenger rail services on shared-use corridors with freight rail services. Shared corridors tend to be challenging due to high heterogeneity, particularly in terms of available capacity. The projected growth in demand for rail transportation is likely to exacerbate the situation. Similar to the U.S., European passenger rail services are generally operated on shared-use corridors, but the infrastructure conditions and the operational priorities and patterns typically allow more reliable and higher speed passenger operations in comparison to U.S. trains.

There are two main approaches used to improve capacity levels: by applying new capital investment (upgrading infrastructure components), or by improving operational characteristics and parameters of the rail services (using modeling and optimization techniques). While the majority of past work in the U.S. has concentrated on the first approach, the second approach is a very common European practice, typically via rescheduling and timetable management modeling methods. Both continents use capacity and simulation software to analyze capacity allocations and operational limitations. However, the effects of software selection haven’t been investigated. This research uses U.S. and European simulation tools to examine different scenarios, and also includes a hybrid approach on a single case study (Figure 1), as well as applying a timetable compression technique (European approach) along a U.S. shared-use corridor (Figure 2).

---

**Figure 1** - Simulated train string-line schedule, applied in a common U.S. simulation package (top) and a European simulation package (bottom).
Recently, Dr. Kuilin Zhang joined our program under the university’s Strategic Faculty Hiring Initiatives in future transportation systems. He has developed a rail-based intermodal freight network simulator to model multimodal freight processes of containers, bulks, trucks, railcars, trains and ferries at a variety of terminals, such as intermodal transfer terminals, classification yards, sidings and ports. The simulator provides modeling to use in evaluating market potentials for international rail-based intermodal services in Europe. Figure 1 shows a bulk queueing model for the process at a classification yard. Jointly, we will develop courses on modeling and simulation for planning, operating and managing rail transportation systems.

**Process at a classification yard**

[Diagram showing various processes in a classification yard]

Figure 2 - Snapshot of a sample string-line developed in a European simulation package (left) with improved string-line (right) using compression tools of software.
Railroad, High Speed Rail, and Transit Initiative at University of Nevada, Las Vegas

Hualiang (Harry) Teng, University of Nevada, Las Vegas; hualiang.teng@univ.edu

Las Vegas was originally a railroad station between Salt Lake City and Los Angeles on the Union Pacific line, and nowadays it has become the center of entertainment in the world. Currently there are many railroad activities in planning in the Las Vegas area: high speed rail (XpressWest), traditional rail (X-Train), light rail and street cars. To be a global city, Las Vegas will be well connected locally and internationally by means of modern transportation systems including railroads. With this background, the University of Nevada, Las Vegas (UNLV) has established a Railroad, High Speed Rail and Transit Initiative in the College of Engineering. Under this Initiative, UNLV has formed one of the ten AREMA student chapters for which many seminars and field trips have been hosted and organized. International partnerships have been established that include undergraduate, graduate and scholar exchanges. A railroad certificate program has been established at UNLV which offer six courses in railroad: Introduction to Railway, Railroad Engineering, Railroad Operations, Public Transportation, Freight Transportation Systems, and High Speed Rail. Students who have taken four of these courses will be issued a certificate. Most of these courses have been taught at UNLV. As a matter of fact, in the Civil Engineering Department, there are at least three faculty members who have professional experience in railroads. In addition, UNLV has been a partnering university of the Mineta National Transit Research Consortium, under which research has been conducted on transit including rail. It is expected that our railroad program will be developed into an international center on railroad, high speed rail and transit in the future.

RAS Contest Funding Solicitation

Chair: Jagadish Jampani, CSX Transportation; Jagadish_Jampani@csx.com

RAS, a 15-year-old section, consists of over 130 members from around the world, including rail practitioners, academicians, students and consultants. Over the years RAS has provided an excellent platform in knowledge sharing among railroads and in increasing interest in rail industry to academicians and students. We believe RAS has had great success and is making a big contribution in rail analytics. Among various initiatives, RAS organizes the Student Paper Contest and the Problem Solving Competition every year. The Student Paper Contest has been continued for more than 10 years, whereas the Problem Solving Competition started in 2010. Both of these events have been very successful in raising great interest among academicians and students worldwide. RAS is a member-sponsored professional society that is heavily dependent on sponsors to continue successful initiatives such as the Problem Solving Competition and Student Paper Contest.

The Student Paper Contest is focused on rail applications to promote awareness of rail topics, encourage new rail research and develop a pool of intellectual talent interested in rail applications. In this contest, a contestant submits a paper of his or her previously chosen and independently generated research methodology. The outcome of the competition’s research can potentially be useful not only in developing real-world applications, but could also result in publications as book chapters and/or referred journals. All submissions are reviewed by a highly competent judging panel and winners get cash prizes and citations during the annual meeting.

The Problem Solving Competition was started to further promote awareness of interesting and intriguing rail problems. This initiative has been well received and has been very successful with representation from over a dozen countries. In this competition, the organizing committee (consisting of academicians and practitioners) provides an open research problem of high interest for the railroads and seeks submissions to perform research and submit reports with methodologies and results. Using a scientific methodology, the judging panel selects three finalists in addition to a few honorable mentions. More details about the competition, the submissions and winners are available on RAS website (http://www.informs.org/Community/RAS/Problem-SolvingCompetition).

“Sir, Sunday morning, although recurring at regular and well foreseen intervals, always seems to take this railway by surprise."
- William S. Gilbert
Incoming RAS Officers:

Krishna C Jha (Chair)
Innovative Scheduling
krishna.jha@InnovativeScheduling.com

Erick Wikum (Secretary)
TATA Consulting Services
eqha755@yahoo.com

Viraj Karnik (Treasurer)
NS Corporation
viraj.karnik@nscorp.com

Sandra D. Eksioglu (Vice-Chair)
Mississippi State University
sde47@ise.msstate.edu

Xuesong Zhou (PR Officer)
Arizona State University
xzhou74@asu.edu

Newsletter Staff:

Xuesong Zhou (Co-Editor)
Arizona State University

Jagadish Jampani (Co-Editor)
CSX Transportation

Saumya Ahuja (Designer)
Innovative Scheduling

RAS Dinner at INFORMS

This year we are hosting the RAS dinner together with the RAS Business Meeting. Hosting the dinner with the Business Meeting will save us walking time to the restaurant and also give us more time to socialize and enjoy good food with fewer time constraints. We would like to invite all RAS members for the dinner on Sunday (October 6) at the INFORMS Annual Meeting. The dinner is free for RAS members, and spouses are welcome too. The dinner will take place in room 211C at the convention center at 18:15 local time. We thank Innovative Scheduling and Oliver Wyman for sponsoring the dinner.

http://www.informs.org/Community/RAS/