The Newsletter of the
RAILWAY APPLICATIONS SECTION

From the Editors' Desk:

FALL 2012

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In the past months, we interviewed the heads of Operations Research (OR) departments at the four US Class I railroads: Pooja Dewan (BNSF Railway), David Ramcharan (Union Pacific), Dharma Acharya (CSX Transportation), and Clark Cheng (Norfolk Southern). We sought their opinions on what does it takes to build successful Operations Research based analytical applications for railroads? While each railroad had their own flavor, we found surprising similarities in their answers. We summarize these answers below and hope that you will find them just as insightful as we did.

Role of OR Departments: OR departments at railroads are regarded as the advanced analytics departments or R&D units within the organizations. They work closely with the business units to understand the problems faced by them, build pilots internally or with vendors, license off-the-shelf software products, and facilitate their deployments within the company. At times, they use university alliances to develop algorithms for solving complex decision problems or perform proof-of-concept studies. Algorithms developed are then productized and supported by the internal IT teams. Thus, their main function is to leverage technology to make a difference and create value for their organizations.

Problem Selection: Problem selection is very important. Earlier, business owners proposed decision problems. We used to assist them in solving these problems using appropriate methodologies. But lately, there has been a change in our approach. We do not work on any and every problem that is brought to our notice by business units. We are more selective about what problems to study. We create a list of projects that come from different sources – both internal and external. We assess the impact factor of each, determine which are more aligned with company's short term and long term objectives, prioritize them, look at the resources available, and then decide the projects to pursue in a specific year.

Focus on ROI: Railroads have technology councils and advisors that perform a deep review of projects requested by different business units. They analyze each project from the potential benefits creation point of view. They use ROI (Return on Investment) calculations to decide what projects to fund and what not to. They often go back to past projects and assess whether the project yielded its promised ROI or not. Thus, it is very important that ROI is the primary driver in our problem selection. When selecting a project and assigning resources to the project, we should assess how much will it cost, how long will it take, how much value is expected to be created, what are the chances of success, how difficult is the change management process, will there be resistance to change from users, and what is the expected ROI. We must focus on projects with high ROI. Create success stories as successful projects will generate respect for OR within the company, and facilitate future funding for OR based projects.

Executive Support: We need championship from senior executives for making advanced analytics solutions work at railroads. Working on flagship projects will give OR more visibility within the organization. We need to find out what is on the top of the priority list of our executives? What interests them? What is their risk taking level? We need to focus on tools that our executives want. We need their support to secure resources and their push to operational persons to use our systems. There is always a resistance to change; thus, it is important that OR departments are connected with high level executives so that, if required, executives can facilitate the change management process.

Solution Approach: We need to work closely with the concerned business unit to understand decision problems faced by them and determine the appropriate solution approach. Optimization is not always the right solution. Often, some visualization or reporting is what they are looking for. Sometimes, data analytics or data mining or statistical analysis will give them all the help they need. Sometimes, they want only the decision support – a calculator that will evaluate their decisions. Occasionally, simulation will do the trick. These are all different tools in our toolbox and we should be flexible to use the right tool for the given problem. And, do not try to fit the square peg in the round hole.

Inside

User Buy-in: Users are resistant to change if they are not engaged during the development process. Ensure that we have buy-in and acceptance of the ultimate user of the system. OR team should work closely with the business to understand their needs and the methodologies used to meet their needs. If their inputs and feedback are taken throughout the design and development process and proper training is given to them, they are more likely to use analytical solutions. Thus, we need to work at both levels; at business user level by winning their support, training, technology transfer, and at higher executive level for funding and to put pressure on people to use them.

Future of Models at Railroads: Through experience, we have realized that it is not easy for model-generated solutions to outperform efficient and seasoned planners. But every planner is not a good planner and models can definitely help most planners. Further, as experienced planners are retiring and are being replaced by inexperienced and more computer savvy personnel, the use of analytical applications will continue to grow in railroads.

Team Quality: Team quality plays a very important role in project success. It is not about the quantity, it is all about the quality. We should create good teams comprising of smart, motivated, and innovative individuals. Railroads problems are very complex and there is resistance to change old habits that have lasted for decades. Thus, there will be challenges. Teams should be resilient enough to stand up and fight the challenges that come in creating these changes. When faced with challenges and difficulties, they need the ability to face them and come up with bigger and better ideas.

Buy vs. Build: When it comes to building decision support systems, we are constantly faced by decisions whether we should buy it or build it ourselves. Should we build it with internal resources or do it with a vendor? These decisions depend upon how soon we need the application, and whether we have the skill set required to do that project in-house. Developing large systems often takes more resources than we have available and we take help from external vendors to develop them. We consider these decisions on a case by case basis, and consider cost and time of development. We look at several factors: how mature is vendor's product, whether it can be customized to meet our needs, how much it is going to cost, and what will be its maintainability? If we do it ourselves, then what the cost will be and how long it will take, and do we have the resources to build it? Based on these factors, we tend to make decisions in the best interest of our respective organizations.

Working with Universities: Most railroads work with universities. Railroad's funding facilitates research of professors and students, and prepares students for employment in the railroad industry. Universities provide fertile grounds for germination of new and innovative ideas. When working with universities, we should try to balance between academic and industry objectives. Students' objective in these projects is to gain industry experience, write papers, and graduate. Our objective is to create something useful for our company. It is possible to balance these objectives if we monitor these projects carefully. Also, we should not expect universities to produce commercial quality software products. We should expect some good ideas that we should be able to perfect and productionize using our internal resources.

Challenges Faced by OR Departments:

- Sometimes, it is difficult to prove the value of our services to business partners. It is hard for them to visualize the ROI of our work. However, gradually advanced analytics is getting more and more recognition among railroads.
- It is important to have right partnership with business problem owners. This requires fair amount of marketing of value of OR to them.
- Data quality is among our biggest challenges. Data is very important for any kind of modeling and our data quality is not good. We have holes in the data. Our data warehouses do not have good quality data. Real-time availability of the data is another issue. In many cases, model results could not be implemented as the input to the model was not right. Railroads need to invest more in making good quality data available for analytical solutions. ■

Annual Report by RAS Officers

Chair: Homarjun Agrahari, FEDEX; hagrahari@fedex.com

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

Secretary: Shrikant Jarugumilli, BNSF Railway; Shrikant.Jarugumilli@bnsf.com

Treasurer: Yudi Pranoto, Norfolk Southern; Yudi.Pranoto@nscorp.com

Wow, it is a year already!! It feels like we just met in Charlotte. Time flies! We are fortunate to have a year packed with activities. We are especially thankful to volunteers who have been leading and serving on various committees. In this article, we give you a summary of our activities; some of the activities may have an article in this newsletter. Before we list these activities; however, we would like to express our gratitude to our sponsors. RAS is proud of serving the members via activities that help advance the application of Operations Research to railroad problems. These activities involve significant amount of money in the form of prize 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 from our sponsors: BNSF Railway Company, CSX Transportation, and Union Pacific Railroad.

As in past years, we will be hosting the RAS dinner on Sunday. The dinner is sponsored in part by Innovative Scheduling and Oliver Wyman. Innovative Scheduling is also sponsoring this newsletter. We thank them for continued support, generosity, and hope to continue this relationship in the future.

New Public Relations Officer Position

Around the middle of the year, we reported to you that we submitted the amended RAS constitution to INFORMS board for approval. After one round of revision, the INFORMS board approved the new Public Relations Officer position. The modified constitution has been updated on RAS website. The Public Relations officer will be responsible for:

- Executing new additions to RAS website
- Managing RAS distribution list
- Ensuring RAS newsletter has quality content and is published and distributed in a timely fashion
- Identifying content, frequency, and methods of communicating with the membership
- Identifying and executing strategies to retain current members and recruit new members
- Periodically (at least once a year) soliciting feedback on member satisfaction

As in the case of RAS Secretary and Treasurer, the public relations officer will be elected for one year.

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 far reaching impact. Their contributions have given RAS a new direction and continues to inspire others to follow their footsteps. The RAS Distinguished Member Award is given to recognize such individuals. This award was established in the RAS business meeting in Charlotte last year. The award committee comprises of the current officers, past award winners, and past RAS presidents. Five past RAS chairs - Ajith Wijeratne, Michael Gorman, Carl Van Dyke, Ravindra Ahuja, and Pooja Dewan were nominated for the award. After one month of deliberations, the committee selected our founding chair Ajith Wijeratne as the inaugural award winner.

We congratulate Ajith for this award.

2013 Problem Solving Competition

You spoke, we listened! Many of the participants gave us feedback at 2011 Business Meeting as well as over our LinkedIn discussions board that it will help to have more time to solve the problem. We understand that announcing the problem in April only gives participants about six months to solve the problem, and more time could result in increased participation and may raise the bar. The 2013 Problem committee was set up earlier this year and its members are: Burak Eksioglu, Sandra Eksioglu (chair), Jagadish Jampani, Shrikant Jarugumilli, Yudi Pranodo, Guvenc Shahin, Kamalesh Somani, Alper Uygur, Carl Van Dyke, and Xuesong Zhou. The committee has already started planning for the 2013 RAS Problem Solving Competition. The goal is to announce the problem statement to INFORMS community during the Annual Meeting in Phoenix. The full package including the problem description and database samples will be completed by mid-November. We hope that the earlier announcement will give participants more time to work on solving the problem. It will also allow some faculty members to consider this problem when preparing case studies or semester-long projects in OR related classes they teach.

RAS Sessions in Upcoming INFORMS Annual Meeting

Each year, RAS organizes a cluster filled with interesting topics presented by experts in the areas of railway/operations research and analytics from around the globe. Thanks to all session chairs' hard work, this year we have eleven sessions lined up in addition to the traditional sessions of Student Rail Research Competition and Problem Solving Competition sessions. Below are these sessions:

1. Roundtable - Analytics for Intermodal (two sessions)
2. RAS Student Paper Award
3. RAS Problem Solving Competition
4. Impact of Positive Train Control on Railways
5. GIS-based Analytical Tools in Railroad
6. Railway Capacity Analysis
7. Shared Corridors and Joint Facilities
8. Unit Train Scheduling
9. Use Business Analytics to Improve RR Operations
10. Recent Advances in Yard and Shop Optimization and Analytics
11. State-of-the-art Implementation of OR Applications
12. Railway Optimization Models

In total, we will have over 40 presentations in the coming INFORMS National Annual Meeting.

RAS and Networks

Thanks to efforts of Juan Morales (BNSF) and Prof. Ravindra Ahuja (Innovative Scheduling) and kind consideration of editor-in-chief of ***Networks***, winning entries of RAS paper award and RAS problem competition will be considered for publication in ***Networks***. We believe this will have a positive impact on RAS activities and will benefit its members.

RAS Resources – Problems Repository

As you may recall, we introduced the RAS problem repository at our business meeting in INFORMS Annual Meeting last year. The objective of this problem repository is to facilitate a platform where:

1. Real-life railroad application problems are presented along with dataset(s) and solutions publicly available for anyone to research, develop and test solution approaches.
2. Researchers may showcase their results, engage in questions, answers and discussions and measure the performance of different solution approaches.

You can find the problem description and data files on our website: http://informs.org/Community/RAS/Problem-Repository. We encourage researchers to utilize LinkedIn for discussing the problems. If you are interested in adding a problem to RAS Problem Repository – please contact RAS officers (http://informs.org/Community/RAS/Officers).

Treasurer

Our treasurer Shantanu Chakraborty resigned around July this year following which RAS Board (which includes Past President and current officers) suggested appointing Yudi Pranoto (Norfolk Southern) to serve as the Treasurer to which Yudi agreed. We are thankful to Shantanu for his services and to Yudi for stepping up.

Quick Quote

A helping word to one in trouble is often like a switch on a **railroad** track... an inch between wreck and smooth, rolling prosperity.

- Henry Ward Beecher

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

- Mark Twain

Got News to Share?

Published a paper? Published a book? You are hiring full time or intern? If you have news that you would like to share with RAS members, please let us know. We can help spread the word.

Look forward to seeing you in Phoenix!

Visit RAS on the Web!

- Get details about upcoming meetings
- See our Problems Repository
- Learn more about our Problem Solving Competition
- Contact the Officers

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

RAS Problem Solving Competition 2012 Results

Kamalesh Somani, CSX Transportation, Kamalesh_Somani@csx.com

This is the third year for the RAS Problem Competition. Railroad operations are inherently complex, large scale, and the source of many challenging OR problems. This competition is designed to introduce participants to exciting and challenging analytical applications in railroads.

Thanks to generous support from our sponsors (BNSF Railway, CSX Transportation, Innovative Scheduling, Oliver Wyman, and Union Pacific), we are able to offer a total prize money of $3,750 (first prize: $2,000, second prize: $1,000, and third prize: $750) to Problem Solving Competition winners. In addition to these cash prizes, the first prize winner's contribution is also 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 process.

The 2012 Competition Problem

This year the participants were asked to solve the Movement Planning Problem for Dispatching on Multi-Track Territories. The Movement Planner Problem can be described as follows: Given a dispatching territory, a dispatcher's task is to give track authorities to trains to maximize the overall system efficiency of the trains while abiding by a number of business rules. This is done by deciding which trains takes the siding when two trains traveling in opposite directions meet each other, or when a faster train overtakes the leading slower train. The dispatcher must also decide on the departure and hold times at the terminals where trains originate, terminate, or stop for work events (picking up cars, setting out cars, inspection, fueling, changing crews, etc.). A full description of the competition problem is available at RAS website: http://www.informs.org/Community/RAS/.

Finalists

We had 50 registrations from teams around the world. Finally, 9 teams submitted their solutions and reports. The problem owner Alper Uygur was assisted by Xuesong Zhou throughout the competition timeframe, and they spent tremendous amount of time preparing the problem statement, data files, and toy examples with the help of the 2012 RAS Problem Competition Committee. Alper provided answers for FAQ from the registered teams. Xuesong created a graphical user interface to display solutions and check for some basic violations. Alper also wrote a script to calculate the objective function value from the proposed train movements in the output reports and the script was also used for checking the solutions' overall feasibility. The judging panel went through a rigorous process to objectively rank, and selected the following three teams as finalists, listed in the alphabetical order of the title:

1. **Mixed-integer Programming Based Approaches for the Movement Planner Problem: Model, Heuristics and Decomposition.**

   Team: **Chiwei Yan**, Department of Industrial Engineering, Tsinghua University, Beijing, China; and **Luyi Yang**, Department of Industrial Engineering, Tsinghua University, Beijing, China.

2. **Movement Planner Algorithm Design for Dispatching On Multi-Track Territories.**

   Team: **Frank Fischer**, Chemnitz University of Technology, Department of Mathematics, Chemnitz; **Boris Grimm**, Zuse Institute Berlin, Berlin, Germany; and **Torsten Klug**, Zuse Institute Berlin, Berlin, Germany.

3. **Solving the Dispatching Problem on Multi-track Territories by Mixed Integer Linear Programming.**

   Team: **Maurizio Boccia**, Università del Sannio, Italy; **Carlo Mannino**, SINTEF ICT, Norway; and **Igor Vasiliev**, Institute for System Dynamics and Control Theory of Siberian Branch of Russian Academy of Sciences, Irkutsk, Russia.

These three finalists will compete at the RAS session on Sunday (October 14) at 11:00 - 12:30. The winners will be announced the same evening at the RAS Business Meeting. The three finalist team reports will be made available on our website (www.informs.org/Community/RAS/) soon after the announcement. We invite you to come and support these bright minds.

Recognition

I would like to thank problem owners (Alper Uygur and Xuesong Zhou) and the other committee members (Bruno W. Repetto, Carl Van Dyke, Erick Wikum, Homarjun Agrahari, Jagadish Jampani, Krishna Jha, and Yudi Pranoto). They have offered their help in all possible ways as a volunteer outside their day-to-day work duties to make this competition a success.

If you have suggestions to improve the RAS Competition, please send them to Kamalesh_Somani@csx.com, or the 2013 RAS Problem Solving Competition Chair, Sandra D. Eksioglu at sde47@ise.msstate.edu. See you soon in Phoenix! ■

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 2011-2012 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.

Ten 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 Phoenix, AZ. 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 in the RAS website.

> **Quick Quote**
>
> Sir, Sunday morning, alt-hough recurring at regular and well foreseen intervals, always seems to take this railway by surprise.
>
> **- William S. Gilbert**

I had the honor of leading an elite paper Reviewing Committee made up of ten members from different academic and industry backgrounds. The Committee was appointed before any paper was registered for the competition. 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

1ST

Real-time Crew Assignment in Double-ended Districts with Primary-Secondary Queues

by Xiaoyan Si, University of Texas at Austin.

Coauthors: Anantaram Balakrishnan,and April Kuo.

Abstract: In the face of high crew costs, railway companies need effective crew deployment and utilization in order to reduce expenses and increase their profitability. This paper develops an optimization model and several effective methodologies and techniques to assist short-term crew assignment for double-ended districts of U.S. freight railways. The model was validated on 140 real-life problem instances provided by BNSF Railway. Most of these instances were solved to optimality within one minute.

2ND

A Recoverable Robust Solution Approach for Real-time Railway Crew Rescheduling

by Lucas P. Veelenturf, Erasmus University, Rotterdam.

Coauthors: Daniel Potthoff, Dennis Huisman, Leo G. Kroon, Gabor Maroti, and Albert P.M. Wagelmans.

Abstract: We present a novel approach for railway crew rescheduling when a disruption occurs. In this approach, we take into account the uncertain duration of a disruption. Most duties are rescheduled such that, if another scenario that the expected takes place, they can be easily recovered. This requires less rescheduling if new information becomes available, and thereby leads to less uncovered tasks. We test our approach on a number of instances of Netherlands Railways (NS).

3RD

Optimization-based Decision Support System for Train Dispatching

by Sifeng Lin, University Texas at Austin.

Coauthors: Anantaram Balakrishnan and Alper Uygur.

Abstract: Effectively dispatching trains on each territory to reduce waiting time and increase velocity is an important tactic to improve the utilization of expensive and scare rail transport resources. Using a discrete time representation, we propose a novel integer programming model for the train dispatching problem, and explore strategies to solve the real-world problem instances to optimality. Our techniques to refine the partition of track sections, together with three sets of valid inequalities to ensure unidirectional movements strengthen the model in the literature, and improve the computational performance considerably. We also propose a sequential routing heuristic to generate a good initial feasible solution obtained by the integer programming solver. ■

Renew your RAS Membership

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

Homarjun Agrahari, FedEx Corporation, hagrahari@fedex.com.

See the graph on the left? Almost 65% percent drop in student membership from 2011 to 2012! Yes, we were surprised too.

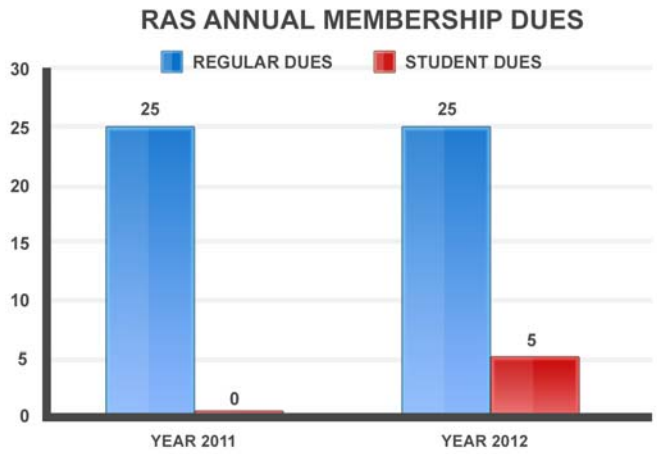
We wondered why this huge drop in student membership? Well, we tried to look for answers and being OR practitioners, we applied analytics to figure out the reason – but that did not help. Then, we looked for other factors – for example, Membership Dues, and we found a very strong correlation between membership and membership dues – and it seems our student members are very price sensitive.

INFORMS made a policy change in 2011 and discouraged all sections from giving free memberships. So, RAS student membership dues were increased from $0 per year for years before 2011 to $5 per year in 2012, and that explains the drop! Let us try convincing you that nothing provides more value, dollar for dollar, than RAS student membership!

Student Membership Benefits:

$5 per year gets you the following:

- RAS Dinner Reception ($50 Value).
- Railroads offer an abundant new areas for OR applications. Priceless!
- Win first prize in RAS Problem Solving Competition, a return on investment (ROI) of 400.
- Win first prize in Student Paper Contest – an ROI of 200.
- Job notifications.
- News from one of the most growing industry.
- Network with professionals in the rail area around the globe.



If you traded one drink or beer and got yourself a RAS membership – we promise you will get much more in return. If you attend the RAS Reception – you may get the drink back anyway! Join RAS. See you in Phoenix! ■

RAILROAD FACTS

- US railroads established the original four time zones.
- An empty car will stop in 1/3 of the distance of a loaded car.
- The longest railroad bridge in the world is the Danyang–Kunshan Grand Bridge in China measuring 102 miles.
- Believe it or not, putting salt on a railroad track in Alabama was once punishable by death.
- China's new electric bullet train has a top speed of 311 mph (fastest in the world).

INFORMS 2012 Annual National Meeting Sessions

Chair: Aihong Wen, CSX Transportation, Aihong_Wen@csx.com

This year we have 13 sessions lined up with diverse topics such as PTC, Capacity, Unit Train Scheduling, GIS-based Analytical Tools, Analytics for Yard and Shop, Railway Models under Uncertainties, Shared Corridors, and more. Our round table will focus on Analytics for Intermodal. A panel of experts from both industry and OR community will share their thoughts about current and potential applications of analytics in the railroad industry. Some of the sessions are listed as joint sessions with CPMS and TSL, which will help RAS to attract different audiences. And as always, we are excited to see presentations from the winners of the Student Paper Award and finalists of the Problem Solving Competition! **All sessions are scheduled in Room North 228A in the Convention Center.**

Sunday Oct 14, Room North 228A (Convention Center)

8:00 – 9:30

SA43: RAS Student Paper Research Contest

Chair: Juan Morales, BNSF Railway

1. Real-time Crew Assignment in Double-ended Districts with Primary-Secondary Queues (Xiaoyan Si)
2. A Recoverable Robust Solution Approach for Real-time Railway Crew Rescheduling (Lucas P. Veelenturf)
3. Optimization-based Decision Support System for Train Dispatching (Sifeng Lin)

11:00 – 12:30

SB43: RAS Problem Solving Competition

Chair: Kamalesh Somani, CSX Transportation

1. **Mixed-integer Programming Based Approaches for the Movement Planner Problem: Model, Heuristics and Decomposition**

   Team: Chiwei Yan, Department of Industrial Engineering, Tsinghua University, Beijing, China

   Luyi Yang, Department of Industrial Engineering, Tsinghua University, Beijing, China

2. **Movement Planner Algorithm Design For Dispatching On Multi-Track Territories**

   Team: Frank Fischer, Chemnitz University of Technology, Department of Mathematics, Chemnitz

   Boris Grimm, Zuse Institute Berlin, Berlin

   Torsten Klug, Zuse Institute Berlin, Berlin

3. **Solving the Dispatching Problem on Multi-track Territories by Mixed Integer Linear Programming**

   Team: Maurizio Boccia, Università del Sannio, Italy

   Carlo Mannino, SINTEF ICT, Norway

   Igor Vasiliev, Russian Academy of Sciences

13:30 – 15:00

SC43: Joint Session RAS/CPMS - Panel Discussion I: Analytics and Intermodal

Chair: Bruce Patty, Veritec Solutions
Panelists: Gino Phillips, APL; **Craig Littzen,** Swift; **Vernon Prevatt**, CSX

This roundtable will take place in two sessions. During the first session, the panelists from the intermodal industry will share their thoughts about current and potential applications of analytics to this industry. After their opening presentations, there will be an opportunity for the audience to ask questions and participate in an open discussion.

16:30 – 18:00	**SC43: Joint Session RAS/CPMS - Panel Discussion II: Analytics and Intermodal** **Chair: Bruce Patty**, Veritec Solutions **Panelists: Mike Gorman**, University of Dayton; **Steve Sashihara**, Princeton Consultants; **Dharma Acharya**, CSX Transportation
18:00 – 19:15	**RAS Business Meeting (Room North 228A in Convention Center)**
19:30 – 22:00	**RAS Dinner: Alice Cooperstown** located at 101 E. Jackson Street, Phoenix. AZ 85004. Sponsored by **Innovative Scheduling** and **Oliver Wyman**.

Monday Oct. 15, Room North 228A (Convention Center)

8:00 – 9:30	**MA43: Impact of Positive Train Control on Railways** **Chair: Car Van Dyke,** Oliver Wyman 1. PTC Overview, Risk Factors, and Research Needs (Carl Van Dyke) 2. Capacity Implications of PTC Now and in the Future (David Thurston) 3. Development of Positive Train Control at CSX Transportation (Suneil Kuthiala) 4. Potential Synergies from Positive Train Control (Bruce Patty)
11:00— 12:30	**MB43: Railway Models under Uncertainties** **Chair: Rapik Saat**, University of Illinois at Urbana-Champaign 1. Railroad Hazardous Materials Transportation Risk Analysis under Uncertainty (Xiang Liu) 2. Terminal Health and Solution Path (Brian Blevins) 3. A Framework for Track Geometry Defect Risk Prediction and Maintenance Schedule Optimization (Qing He) 4. Train Dispatching Model with Stochastic Capacity Breakdowns on an N-tracked Rail Network (Lingyun Meng)
13:30— 15:00	**MC43: Recent Advances in Yard and Shop Optimization and Analytics** **Chair: Krishna Jha**, Innovative Scheduling 1. Applying AnyLogic Simulation Software to Flat Yard Analysis (Roger Baugher) 2. Delivering Value from Hump Yard Simulation Models (Jeremiah Dirnberger) 3. Optimal Locomotive Shop Location and Capacity Planning (Kamalesh Somani) 4. Analysis of Railroad Terminal Operational Decision Making (Edward Lin)
16:30— 18:00	**MD43: GIS-based Analytical Tools in Railroad** **Chair: Clark Cheng**, Norfolk Southern Corporation 1. Map-Based Data Visualization and Business Intelligence Solutions for Transportation (Ravindra Ahuja) 2. An Open-architecture GIS Component for Creating Multiband Traffic Density Maps (David Hunt) 3. Network Planning Workbench, An Analytical Tool for Monitoring and Improving Operating Performance (Viraj Karnik) 4. Estimating Customer Service Times using GIS Information (Shantih Spanton)

Tuesday Oct. 16, Room North 228A (Convention Center)

8:00 – 9:30

TA43: Joint Session RAS/TSL - Railroad Optimization Models
Chair: Aihong Wen, CSX Transportation

1. Overview of Decision Support Systems for Intermodal Operations (Yudi Pranoto)
2. Movement Planner (Srinivas Bollapragada)
3. Improve Operations by Drayage Optimization (Xiaoqing Peter Sun)
4. Train Design Optimization in a Congested Railroad Network (Abdullah Al Khaled)

11:00 – 12:30

TB43: Railway Capacity Analysis
Chair: Matthew Petering, University of Wisconsin--Milwaukee

1. Incremental Capacity Expansion – Heavier Loads, Faster Empties and Quicker Meets (Hans Boysen)
2. Analyzing the Progression from Single to Double Track Using Simulation Techniques (Samuel L. Sogin)
3. Mixed Integer Programming for Capacity Analysis of a Single Track Railway Part I: Two Train Types (Matthew Petering)
4. Mixed Integer Programming for Capacity Analysis of a Single Track Railway Part II: Generalized Model (Mojtaba Heydar)

13:30 – 15:00

TC43: Unit Train Planning and Scheduling
Chair: Erdem Eskigun, CSX Transportation

1. Coal Monthly Reservations Planning (Ece Icyuz)
2. Unit Train Generator (UTG) – A Statistical Approach to Forecast Unit Trains (Viraj Karnik)
3. Freight Railway Operator Timetabling and Engine Routing (Lukas Bach)
4. Unit Train ETA Forecasting (Erdem Eskigun)

13:30 – 15:00

TD43: State-of-the-Art Implementation of OR Applications
Chair: Marc Meketon, Olivery Wyman

1. Implement OR Model-driven Information Systems at Norfolk Southern (Clark Cheng)
2. Unsung Heroes for MultiRail Development (Marc Meketon)
3. Interactive Decision Support Systems for Better Railroad Planning (Ravindra Ahuja)
4. BNSF Visualization Studio (Rachel Salvagio)

Wednesday Oct. 17, North Room 228A (Convention Center)

8:00 – 9:30

WA43: Studies on Shared Corridors
Chair: Xuesong Zhou, University of Utah

1. Use of Socio-Technical Roadmapping in Transportation Infrastructure Planning (Scott Grasman)
2. Identifying and Prioritizing Shared Rail Corridor Technical Challenges (Rapik Saat)
3. Auction Pricing of Network Access for North American Railways (Steven Harrod)
4. Maintenance Scheduling for Shared Freight and Passenger Rail Corridors (Brennan Caughron)

PLASMA – Approximate Dynamic Programming Finally Cracks the Locomotive Optimization Problem

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For decades, freight railroads in US have tried to use the power of mathematical programming to optimize the flows of locomotives over their networks. The problem was always that classical mathematical programming formulations could not handle the complex operational details that characterize freight railroads in US and Canada. Consist formation, foreign power, communications equipment, flush toilets, and shop routing are just some of the critical details that need to be handled if a model is going to accurately capture locomotive productivity.

In addition, there is the problem of uncertainty in transit times, yard delays, equipment failures, train schedules and tonnages. Given both the complexity and uncertainty, some have turned to rule-based simulation models, creating open debates within at least one railroad between whether optimization or simulation is the best approach. Approximate Dynamic Programming (ADP) can be viewed as an "optimizing simulator." It combines the intelligence of optimization with the flexibility of simulation. ADP solves sequences of small optimization problems, while still stepping through time just as a simulation model would. However, ADP requires that we run the simulation repeatedly, and uses the principle of feedback learning to learn the value of locomotives in the future. The result is an intelligent simulator that can respond in a realistic way to changes in fleet size, new train schedules, and new operating policies. PLASMA is currently running at Norfolk Southern for strategic planning (such as fleet size and mix), or for short-term operational forecasting (say a week into the future). It can also be adapted to be used for real-time locomotive assignments, but this version has not been implemented.

Features:

It is useful to start by highlighting some of the features of PLASMA:

- Each locomotive is modeled individually, making it possible to capture both horsepower and tractive effort, ownership, special equipment, shop status, and consist breakup costs.
- Arrivals and departures of trains and locomotives are modeled down to the minute.
- PLASMA will delay trains as necessary, prioritizing trains by importance.
- PLASMA can add locomotives to a train to reposition the power, or it can schedule light engine moves (moving locomotives without a train).
- PLASMA will optimize consists while working to get locomotives to their shop appointments on time. PLASMA will simultaneously balance the demands on each shop to minimize shop congestion.
- Foreign power is routed toward interchange points, although PLASMA can decide to hold on to foreign power if needed.
- When used as a strategic planning system, PLASMA is used to decide the fleet size and mix for a planned schedule.

PLASMA can be run in the deterministic mode (which is how Norfolk Southern uses the system at the moment), or stochastic mode, where it explicitly models uncertainty in transit times and yard delays. It can also capture uncertainty in train schedules and tonnages. When uncertainty is introduced, PLASMA adopts a more conservative style, holding onto power to be prepared for contingencies. For more on PLASMA, see http://www.castlelab.princeton.edu/plasma.html.

How it works

ADP breaks the problem of optimizing locomotives over time into a series of assignments of locomotives to a single train at a time. A single subproblem is depicted in Figure 1, where we show the assignment of individual locomotives to trains.

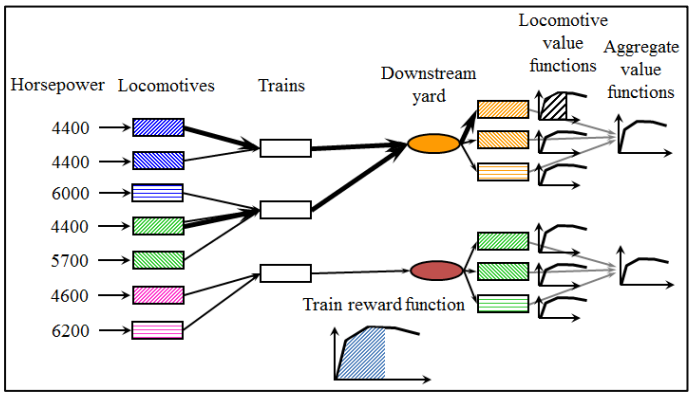

Figure 1. The locomotive assignment sub problem, with value function approximations to capture the value of locomotives in the future.

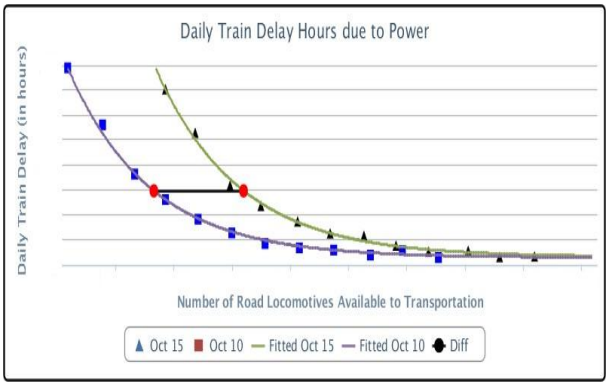

Figure 2. Delay versus fleet size curves for 2010 and projected 2015 train schedules.

The value of locomotives in the future is captured by a nonlinear *value function approximations* (VFAs) which capture the value of different types of locomotives in the future. VFAs are estimated internally within the model through repeated simulations. The VFAs represent the magic of approximate dynamic programming, and this is how a single large problem is broken into a series of smaller problems. The value functions are learned by simulating our way through time, solving one assignment problem at a time.

Usage at Norfolk Southern

PLASMA is the model within a larger locomotive planning system called LARS, developed by Norfolk Southern. The LARS Fleet Size model has proven to be a valuable tool to Norfolk Southern's fleet management process since 2008. With new locomotive order-to-delivery cycles generally totaling a year or more, determining accurate future locomotive fleet requirements is critical. To accomplish this, a marketing forecast (carloads on a lane basis) for a future period (typically one to five years out) is converted into a train plan with the assistance of train and block models. Separately, a known historical period is used as a basis for comparison. After varying the fleet-sizes on the input and estimating train delay for each run, a comparison plot can be made to determine differentials at any specified service level.

A sample of this comparison is shown in Figure 2 where October 2015 is the forecasted period using October 2010 as the base. The red circles represent the historical service level for 2010 in terms of delay due to the lack of available locomotive power. The ability of the model to replicate historical performance metrics was an important plateau that gave management the confidence to use the system for projecting future locomotive requirements. The difference, represented by the horizontal bar, is the change in units required in 2015 to retain 2010 service levels. In addition to providing these point estimates of locomotive demand, the LARS fleet size model has been applied to develop statistically-based ranges of future locomotive requirements based upon forecasted operating plans and observed variations in other operational parameters (e.g., train speed and crew start).

For the past four years, LARS' fleet-size estimates have been a critical decision driver for NS's annual locomotive purchases which totaled 172 units from 2008 to 2011. ■

Data Mining at CSX

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Did you follow the discussions around the story of Target using data mining to identify pregnant women and sending special promotions? Have you been watching the television series "***Person of Interest***"? In this show, a computer genius gathers big data from multiple sources of traffic cameras, crime reports, facial recognition, customs, and so on to determine who is about to commit a crime. In your daily life, you may not notice but data mining is certainly doing some calculations on you: Your phone will ring if you use your credit card to pump gas on your vacation trip; you get a rate for car insurance that was tailored to your attributes like how far do you drive, how many children do you have, and others you may not think of; not to mention seeing "*Customers who bought this item are also interested in these items" when you shop online*." Clearly, other industries are using data mining to drive values to their businesses. At CSX, we believe that it is time for railroads to utilize the power of data mining and build the ground for predictive analytics now, but we do not have to use it in the same way that Target does it.

Data mining is a technique that discovers or extracts non-trivial, implicit, previously unknown and potentially useful patterns or knowledge from huge amounts of data that is usually high dimensional (related to the popular buzzword "Big Data"). The name is often used interchangeably with Predictive Analytics, Machine Learning, Knowledge Discovery, Artificial Intelligence, and many others. Although overlapping with traditional statistical data analysis in several ways, the central components of data mining are computational efficiency, automatic data processing, dynamic and interactive data visualization techniques, and algorithm development. Based on the nature of the business problems to solve, data mining algorithms can be grouped to tasks of classification, clustering, association, regression, time series forecasting, deviation analysis, sequence analysis, and text analytics. While "Big Data" is making big news every day, CSX has acquired predictive analytics tools and started to build pilot projects in order to realize its potential benefits.

One of the initiatives is using data mining to identify bad rollers (railcars that fail to reach clearance points or fail to couple) in hump yard by attributes of car, track, and weather. Our business partners have been very supportive of this initiative, due to the fact that bad rollers in classification yards create productivity issues, and poor rolling behavior may be early indicators of car defects.

Mechanical and Engineering areas is definitely a big playground for data mining. Wayside defect detector data, track inspection data, maintenance history, and similar data resources are obvious areas that data mining techniques can consume. Some of the example questions to answer include: How to predict car failures? How to predict track failures? Which car/loco/component defects are more likely to happen together? What are the most likely next defects given the current defect? How long can we expect the car/loco/component to function well after a specific repair/maintenance? It also does not hurt to ask questions like: Is there any abnormal fuel consumption at certain locations? Are there any abnormal billings from car shops?

For an intermodal project, we are using time series forecast techniques to predict trailer and container volumes in terminals by OD pair, unit type and day. The statistical forecast is expected to provide terminal managers insights of trends, cycles and seasonality in their volume, and also a "seed forecast" that they can override. The forecast will be used as an input to our optimization model that routes the flat cars over the network efficiently. Used wisely, time series forecast can be instrumental in yard and line of road strategic planning as well as dynamic planning by providing volume prediction at desired levels.

In the Human Resources area, data mining is finding its potential applications in strategic workforce planning, crew management, and addressing employee engagement issues proactively. We see various data mining algorithms can be applied in this area; however, the biggest impact may be triggering us to integrate multiple data points, and viewing the manpower issues quantitatively and proactively.

Along these same lines, it may not be practical to say data mining can work on every aspect of railroad business, but it can certainly be applied to several aspects of the business. Either used

alone or combined with other analytical tools such as optimization, data mining could add invaluable insights to decision making processes across the organization. An anonymous person once made the statement "*We are drowning in data, but starving for knowledge,*" which is why data mining becomes all the more important. ■

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Operations Research Projects at Norfolk Southern

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Norfolk Southern Operations Research (NS OR) has been actively working on two fronts simultaneously: planning tools/decision support systems, and real-time operational systems. On one hand, NS OR continues developing and enhancing its planning tool suite and decision support systems for network planning, blocking and classification, train scheduling, locomotive fleet sizing, railcar fleet sizing , traffic demand forecasting, train crew planning, line-of-road capacity planning, and rail yard capacity planning. On the other hand, NS OR has been involved in the development of a number of critical operational systems such as real-time locomotive assignment, hump yard management, next-generation car scheduling, local service planner, empty equipment distribution, business intelligence (BI), and analytics and data visualization. This article gives an overview of the OR applications in both planning arena and operational environment at Norfolk Southern.

> **Quick Quote**
>
> "Rail travel at high speeds is not possible because passengers, unable to breathe, would die of asphyxia."
>
> **Dionysius Lardner**
>
> **(19th century)**

On the planning side, NS OR's integrated planning tool suite has played and continues to play an important role in improving Norfolk Southern's operating efficiency and reducing operating cost. Starting with traffic demand forecast, the tool suite assists Transportation with developing new and future train plans to meet the traffic demands and customer service commitments. Once a train plan is finalized, it triggers the down-stream asset planning processes for locomotive requirement, train crews, terminals, line capacity, and track infrastructure. For example, over the last four years, the locomotive fleet sizing model, jointly developed with Dr. Warren Powell of Princeton University, has been used by the management to determine locomotive storage during economic downturns and make acquisition decisions when the business comes back. All the planning tools mentioned above have already been in production. However, based on the feedback and new requirements from the business partners and end users, those tools have been under constant improvement and enhancement.

On the operational side, NS OR, along with other departments within NS, has been actively involved in developing real-time operational systems. The locomotive routing and assignment system (LARS) recommends shop routing for the locomotives that are due for scheduled maintenance. Furthermore, based on the optimization model, LARS assigns locomotives to outbound trains at each terminal. The yard planner is a hump yard management system which assists yardmasters and trainmasters with managing a hump yard by optimizing work orders for humping, classification and building outbound trains. The next generation car scheduling system overcomes the limitations with the existing blocking and classification system and identifies the optimal routes based on not only distance but also transit time and train capacity constraints. The local service planner consolidates and balances local train schedules and determines the optimal routes and sequences for local deliveries. The intermodal empty equipment distribution system optimizes the disposition of empty intermodal flatcars, either double-stack or conventional. NS is also in the process of revamping its empty equipment distribution system for general merchandise. NS OR has also been developing analytics and data visualization systems using business intelligence (BI). One example is the OR Map Dash Board which displays all the active trains system-wide with their current location and status on an interactive GIS map. Another example is the Network Planning Workbench (NPW). NPW contains the train performance analysis which allows operating departments to review historical and current train performance and research root causes for delays and service issues. NPW also has the built-in what-if capability for real-time terminal bypass planning. Except the OR Map Dash Board and NPW, all the operational systems mentioned above are under development. The OR Map Dash Board and NPW have already been in production. ■

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RAS Dinner at INFORMS

We would like to invite all RAS members for a dinner on Sunday (October 14th) at the INFORMS Annual Meeting. Please show your commitment to RAS by joining us at the dinner. The dinner is free for RAS members, and spouses are welcome too. The dinner will take place at 7:30 PM at **Alice Cooperstown located at 101 E. Jackson Street, Phoenix. AZ 85004**. The restaurant is three blocks away from the convention center and conference hotels. The dinner is sponsored by Innovative Scheduling and Oliver Wyman. Due to limitation on the number of seats, please RSVP to Jagadish_Jampani@csx.com and only the first 70 RSVP's will be accepted.

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