SPECIAL INTERNATIONAL ISSUE

ORMS TODAY

April 2016
Volume 43 • Number 2
ormstoday.informs.org

Chile: pork & profits

China: hydropower

Croatia: dairy farming

Hungary: transportation

Japan: Tokyo Gas

Norway: shipbuilding

Peru: mining conflicts

Sweden: airspace delays

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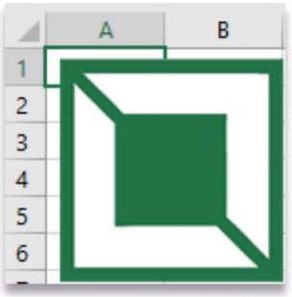

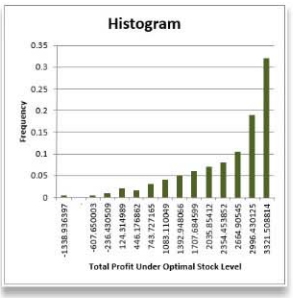

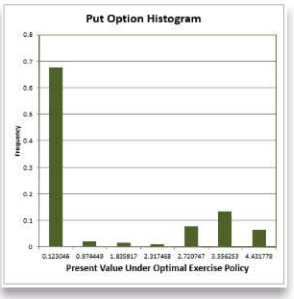

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On the Cover

Wide World of O.R.

So many diverse operations research problems, so many inspired solutions. Welcome to the annual special international issue of *OR/MS Today*, filled with intriguing stories from Sweden, Norway, Hungary, Croatia, Peru, Chile, Japan and China. Enjoy the worldwide O.R tour.

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Special issue:

International O.R.

departments

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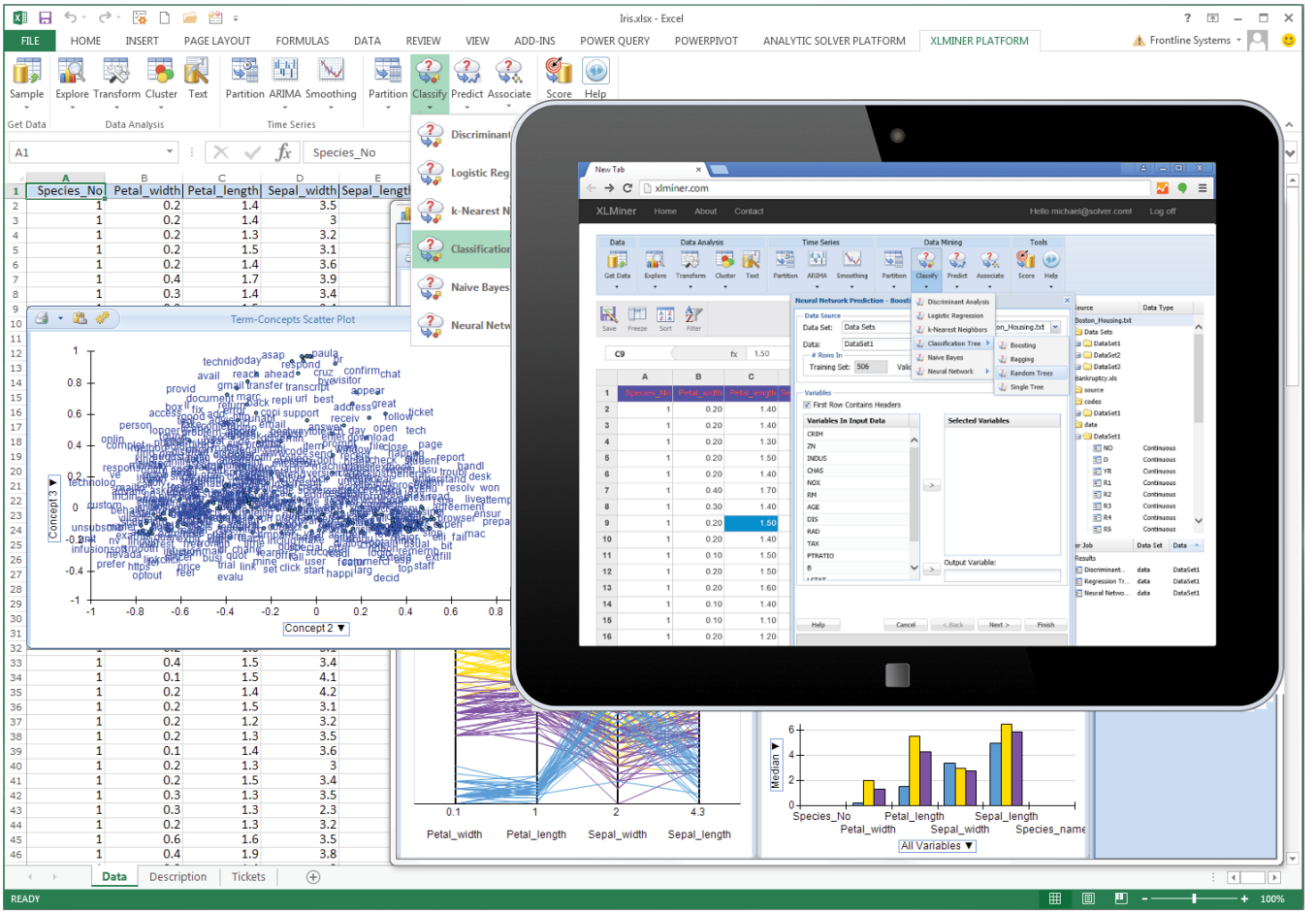

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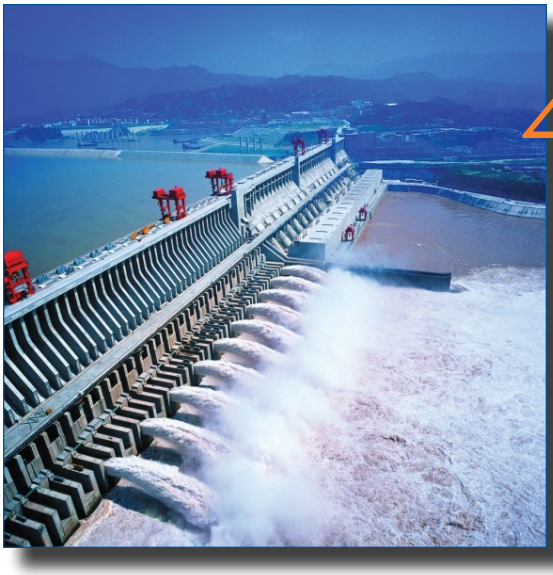

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Special issue:

International O.R.

informs news

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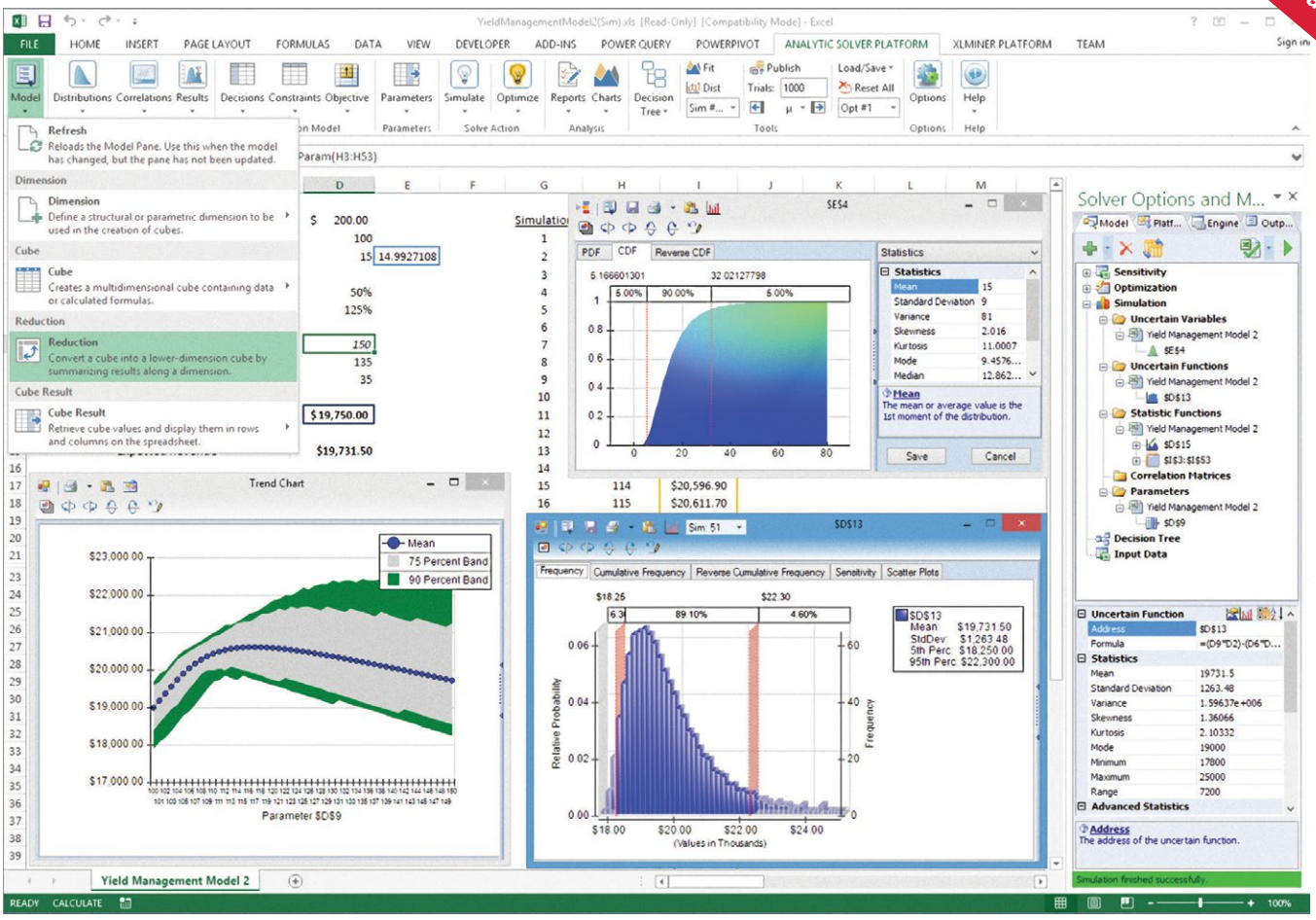

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ORMS TODAY

Wonderful, worldwide O.R.

For the 19th year, welcome to the annual special international issue of *OR/MS Today*. The highlighted projects change, but the goal of the special issue remains the same: to give readers a glimpse at how history, geography, natural resources and culture impact the way O.R. is preached and practiced around the world.

This year's worldwide tour begins in Scandinavia with contributor Valentin Polishchuk's article on "Optimal design of terminal airspace" (page 18). Citing a case study involving Sweden and Denmark, Polishchuk addresses air space congestion in the vicinity of airports, where most bottlenecks and delays occur, and how "optimizing the airspace over Stockholm will bring a number of benefits." In adjacent Norway, Hajnalka Vaagen offers another case study on the role of operations research and behavioral operations management in handling project complexity in specialized shipbuilding (page 22).

Traveling further south and east through Europe, our tour takes us to Hungary and Croatia. In Budapest, contributors Tibor Illés and Richárd Molnár-Szipai examine multimodal transportation with an eye on developing a decision support system to optimize travel throughout the bustling metropolitan area (page 26). In Croatia, a quartet of authors describe a collaborative effort among academics and the software firm Farmeron to apply O.R. to dairy cow farms. The goal: lower the cost of milk production (page 30).

Next, we fly to South America, where two more intriguing applications of O. R. await. For decades, mining has been the engine driving economic growth in Peru, making it one of the best performing economies in Latin America. Contributor Vincent Charles turns to "soft O.R." to balance the economic benefits of mining with environmental concerns and "wicked" social conflicts among local communities impacted by mining (page 34).

Pork is Chile's leading export meat; shipments reached $467 million last year. Contributor Marcela C. González-Araya describes her work with one of Chile's largest pork producers, work that focuses on a decision support system for production planning in a swine slaughterhouse (page 40).

The final two stops on the international tour take us to Asia. Kosuke Shaku and Toshinori Sasaya provide a behind-the-scenes look at the widespread use of operations research – from demand forecasting to emergency response – at Tokyo Gas, the largest city gas supplier in Japan (page 44). Our tour ends in China, where contributor Jiuping Xu tells a fascinating story linking hydropower engineering and water conservancy. Needless to say, effectively managing huge construction projects and efficiently harnessing vast water resources is critical as demand for energy increases along with environmental concerns (page 48).

This issue would not have been possible without the input of Jim Cochran, professor at the University of Alabama, chair of the *OR/MS Today* Committee and co-founder of Statistics Without Borders, who put me in touch with contributors through his global network of colleagues. And the concept of an annual special international issue of *OR/MS Today* would not even exist without Andres Weintraub, professor at the University of Chile and a former president of the International Federation of Operational Research Societies, whose suggestions and guidance helped launch the annual special issue and whose contributions and friendship have continued for more than 20 years.

As always, we hope you enjoy this worldwide, whirlwind tour of operations research at work, and we look forward to hearing your comments. ORMS

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OR/MS Today (ISSN 1085-1038) is published bimonthly by the Institute for Operations Research and the Management Sciences (INFORMS). Canada Post International Publications Mail (Canadian Distribution) Sales Agreement No. 1220047. Deadlines for contributions: Manuscripts and news items should arrive no later than six weeks prior to the first day of the month of publication. Address correspondence to: Editor, ***OR/MS Today,*** 506 Roswell Street, Suite 220, Marietta, GA 30060. The opinions expressed in ***OR/MS Today*** are those of the authors, and do not necessarily reflect the opinions of INFORMS, its officers, Lionheart Publishing Inc. or the editorial staff of ***OR/MS Today.*** Membership subscriptions for ***OR/MS Today*** are included in annual dues. INFORMS offers non-member subscriptions to institutions, the rate is $62 USA, $79 Canada & Mexico and $85 all other countries. Single copies can be purchased for $10.50 plus postage. Periodicals postage paid at Catonsville, MD, and additional mailing offices. Printed in the United States of America. POSTMASTER: Send address changes to OR/MS Today, INFORMS-Maryland Office, 5521 Research Park Dr., Suite 200, Catonsville, MD 21228. ***OR/MS Today*** copyright ©2016 by the Institute for Operations Research and the Management Sciences.

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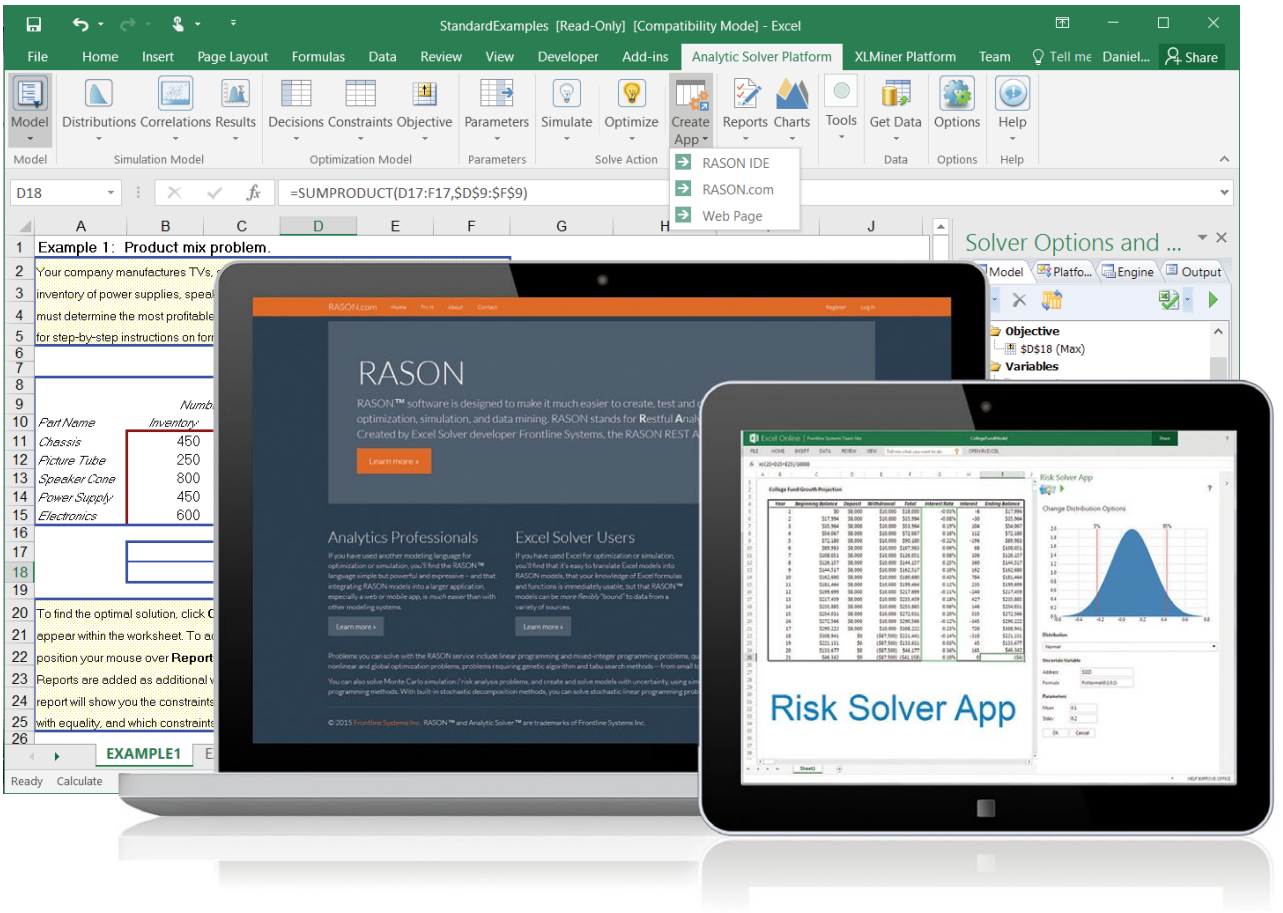

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~~President's Desk~~ | 'Member-in-Chief Memo'

Ed Kaplan
INFORMS President
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Make the world a better place

The tiny Central American nation of El Salvador has a population of about 6.5 million. Bordered by Honduras, Guatemala and the Pacific Ocean, the geography of this beautiful land ranges from mountain vistas to jungle and lush rainforests to picturesque coffee farms to spectacular beaches. Yet as reported repeatedly in the news, this small country also suffers from gang violence that is completely out of proportion to the size of the population. El Salvador has averaged 23 murders daily during the first part of this year, the majority due to gangs, and some parts of the country have effectively fallen out of government control. On top of this, El Salvador is in the midst of an outbreak of Zika virus.

Facing such problems, the government of El Salvador has ratcheted up both anti-gang and anti-Zika campaigns. However, there is another group that has come together to inspire education and research to address these and many other of El Salvador's societal problems. Under the leadership of Professor Oscar Picardo and with an assist from the Simon A. Levin Mathematical, Computational and Modeling Sciences Center at Arizona State University, San Salvador's Universidad Francisco Gavidia (UFG) just established the Centro de Modelaje Matemático "Carlos Castillo-Chávez." Named for Professor Castillo-Chávez of Arizona State, this is El Salvador's first-ever center for mathematical modeling.


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La Universidad Francisco Gavidia
por medio del Instituto de Ciencia, Tecnología e Innovación ICTI-UFG
y el Simon A. Levin Mathematical, Computational & Modeling
Sciences Center (SAL MCMSC) de Arizona State University

otorga el presente diploma de reconocimiento a:

Edward H. Kaplan

por su destacada participación como ponente en el:

Primer Congreso Internacional de Modelaje Matemático,
con Énfasis en Salud, Seguridad y Educación.

Dado en San Salvador, del 23 al 25 de febrero del año dos mil dieciséis

Dr. Óscar Ricardo Picardo
Director del ICTI-UFG

Carlos Castillo-Chávez
Director Ejecutivo del SAL MCMSC

So it was that in February, your member-in-chief (MiC) had the privilege of representing INFORMS at the Centro's inaugural conference. In the presence of the deputy minister of education and the UFG rector, professors and graduate students from El Salvador, South America and the United States presented talks applying models to gang violence, prison management, household control programs for *Rhodnius prolixus* (the main transmitters of Chagas disease), population mobility and the spread of Zika, HIV prevention and terrorism.

The opening of this center prompted quite a bit of Salvadoran media coverage, which caught the attention of the government. Professors Picardo, Castillo-Chavez and yours truly were invited to a hastily arranged meeting with the minister of National Security, the head of the National Police and the deputy head of the Prison Service to discuss what to do about the gangs of El Salvador, their internal organization and attendant violence. Without claiming expertise on the topic (though high-level expertise in this area does exist within INFORMS; Jonathan Caulkins's work comes to mind), there are really two basic ways to control the size of any population: increase the rate that people leave, and decrease the rate that people join. Applied to gangs, the police are responsible in the main for the first of these tasks, and the thousands of gang members arrested and in prison is testimony to this. Starving the gangs of new members requires much more than law enforcement. In those parts of the country with low school graduation rates and insufficient job opportunities, improving educational and job creation/training programs is imperative to provide alternatives to gang membership. Of course, this is easier said than done: As was pointed out at the meeting, most government buildings – whether post offices, schools, hospitals or police stations – are tattooed with gang graffiti, calling into question who the real authorities are. Nonetheless, diverting youth from joining gangs is crucial.

Establishing a mathematical modeling center will not make El Salvador's problems disappear, but there is no question that mathematical modelers, *and obviously that includes operations researchers,* can contribute. As noted in the February memo, the INFORMS Board unanimously adopted "making the world a better place" as an inspirational goal for our organization. Getting involved with centers such as El Salvador's is one way to do this, though there are many such opportunities around the world. As another example, your MiC will be accompanying INFORMS member Jim Cochran of Statistics Without Borders fame on a visit to Mongolia to explain basic operations research methods to statisticians (apparently there are few operations researchers in Mongolia, but there are statisticians).

Of course, making the world better does not require traveling to another country. Our own communities have plenty of problems that can benefit from the expertise INFORMS members have to offer. The INFORMS Pro Bono Analytics initiative (https://www.informs.org/Pro-Bono-Analytics) is a great way to connect with agencies or programs that could benefit from your efforts to help out.

Finally, as both inspiration and a ready source of public sector examples for your students or your own interest, check out the new Editor's Cut titled "Confronting Public Problems with Operations Research." Here you will find many published examples showing how operations research modeling has shed light on important societal issues. With both recent applications and classics from the archive, this volume highlights some of our members' best work. Remember – operations research is not a spectator sport, so let's keep doing stuff! **ORMS**

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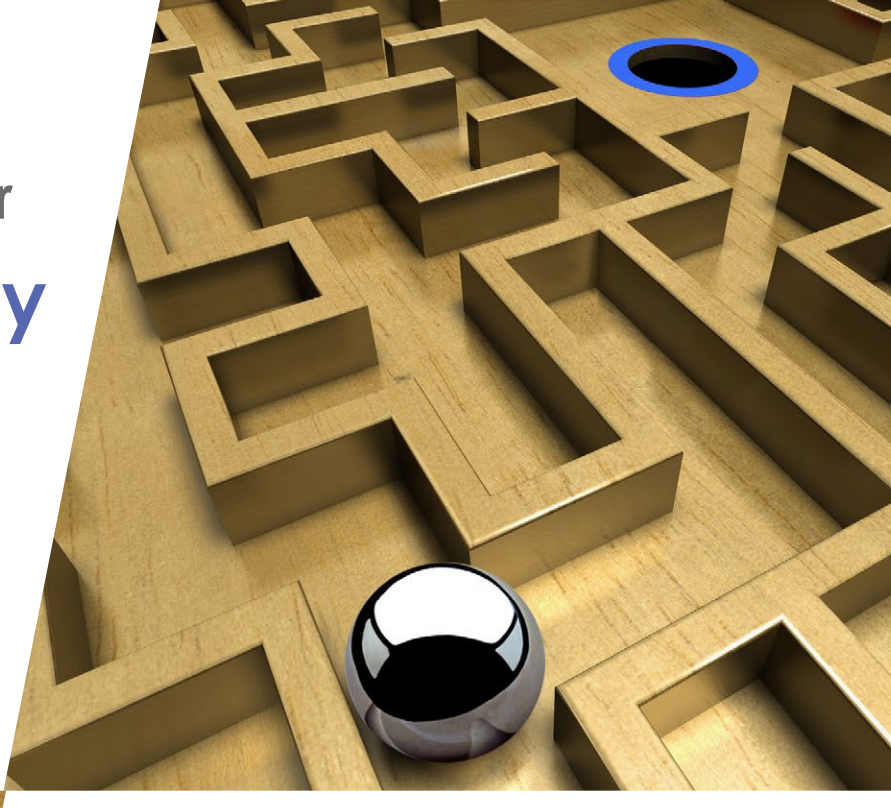

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CAP, rankings, jobs & mobile subway ads

In recent months, operations research, analytics and data science have been moving up in many key rankings. *U.S. News* moved up operations research in its list of best business jobs as well as its list of 100 best jobs. *Glassdoor* predicted that data science would be the hottest new job of 2016. INFORMS' CAP certification program has been catching the eyes of reporters at important tech publications such as CIO and *Infoworld*.

Visit the INFORMS Newsroom at www.informs.org for additional news about analytics and INFORMS press releases about intriguing scholarship appearing in INFORMS journals.

Following are excerpts of INFORMS in the news.

Career Boost: INFORMS CAP Certification

Certifications are a well-known option for career advancement in IT, and data science is no different.

"The certified analytics professional [CAP] credential tells employers that an individual has independently verified knowledge and experience in analytics," explains Polly Mitchell-Guthrie, senior manager at SAS and chair of the Analytics Certification Board at the Institute for Operations Research and the Management Sciences (INFORMS), the organization that runs the CAP program. Since the program launched in 2013, 300 professionals have earned the CAP certification.

- CIO, Feb. 25

O.R. Moves Up in 2016 *U.S. News* Rankings

The operations research profession is now No. 2 in business jobs, up from No. 4 in 2015. O.R. has also risen to 18 from 20 in the list of 100 best jobs.

- U.S. News, Jan. 27

Mobile Ads Move Passengers on Crowded Subway

What do irritable, squished riders on a crowded train do? According to a forthcoming study in the INFORMS journal *Marketing Science,* they often immerse themselves in their mobile phones to escape the crowd. And they shop and buy more in response to mobile ads in the crowded train.

- Media Street, Feb. 19

Riders on Crowded Trains Key on Mobile Ads: Marketing Science Study

A recent university study on the effect of hyper-contextual targeting and physical space found that passengers on crowded subway cars shop and buy more in response to mobile ads than those in less crowded cars.

A key takeaway is that riders in crowded subway trains are good targets for mobile advertising.

The study is published in the INFORMS journal *Marketing Science.*

- Mobile Marketer, Feb. 24

Break into Data Science with CAP Certification

Certifications are a well-known option for career advancement in IT, and data science is no different.

"The certified analytics professional [CAP] credential tells employers that an individual has independently verified knowledge and experience in analytics," explains Polly Mitchell-Guthrie, senior manager at SAP and chair of the Analytics Certification Board at the Institute for Operations Research and the Management Sciences (INFORMS), the organization that runs the CAP program. Since the program launched in 2013, 300 professionals have earned the CAP certification.

- Infoworld, Feb. 25

Data Scientist Hottest Job of 2016

Data scientist, named the best job in America for 2016 by job site *Glassdoor*, is the sexy mashup of traditional careers from data analysis, economics, statistics, computer science and others.

But it goes beyond collecting and analyzing data. It's a job for the curious, for the intuitive and for those who like to not just solve problems but figure out the problem. It's part science, part art.

The rise of data science is due to the explosive growth of data collection – or big data –and the need for companies to make sense of the mishmash of new types of data from smartphones, images, human behavior and even handwriting.

- Denver Post, Feb. 2

Imperative for Ethical Standards in Analytics: The CAP Model

An established code of ethical behavior for analytics professionals already exists.

That code is part and parcel of the Certified Analytics Professional Program (CAP) – a highly regarded professional certification for analytics practitioners managed by INFORMS – the largest international association of professionals in analytics and operations research.

Among other things, the code establishes certain standards for those who call themselves analytics professionals and guidelines for how they should behave and be judged by their peers and employers. ORMS

- Scott Nestler, Information Management, Jan. 25

What's Your StORy?

Tallys Hoover Yunes

Associate Professor of Management Science
School of Business Administration, University of Miami
INFORMS member since 1999

Which INFORMS event are you most looking forward to this year?
I wasn't able to attend the 2015 Annual Meeting because of the birth of my first daughter. I'm looking forward to the 2016 Annual Meeting. I miss seeing some of my favorite people.

Tell us something that not many people know about you.
I don't eat any kind of red or white meat for 360 days of the year. The other 5 days I allow myself to eat anything and typically go all out. To my wife's astonishment, my stomach still feels just fine after eating a ton of medium-rare *picanha* (a cut of meat) at a Brazilian *churrascaria* (an all-you-can-eat meat extravaganza).

What recent project have you been involved in that you are proud of?
Andre Cire, John Hooker, and I recently published a paper in the INFORMS *Journal on Computing* about using semantic descriptions of variables to improve optimization models. It was an idea that sounded crazy at first, but we persevered and obtained very interesting results. The feedback we received from several researchers has been great. I'm very proud of this project.

What is something you learned in the last month?
I recently led a group of graduate business students on an international immersion trip to Brazil. I learned that non-Brazilians are very fond of *caipirinhas* (Google it!) after they try one.

What is your least favorite mode of transportation? Can you apply a routing problem to make it better?
Airplanes. They don't need better routing to get better; they need to become more comfortable. I'd pay more for an economy ticket for an overall better experience.

What INFORMS journal do you read the most? Why?
Interfaces because it is a great source of real-life OR applications that I can use to motivate my students.

More questions for Tallys?
Ask him in the Open Forum on INFORMS Connect!
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Long path from writing textbooks to blogging

It's all the fault of David Anderson, Dennis Sweeney and Tom Williams. As an innocent Ph.D. student at the University of Cincinnati in the early 1970s, my three professors conveyed life lessons that have stayed with me for my 40 years as a professor. They taught me that writing textbooks (they are co-authors of a very successful series of management science and statistics books) is worthwhile, exciting and satisfying – but at the same time is extremely demanding, requiring tremendous discipline and sacrifice.

So in 1974, joining the University of New Orleans and meeting my new best friend – a freshly minted Ph.D. from the University of Oregon – Ralph Stair, I proposed we write a book together. Ralph, not under the Svengali influence of the fanatic workers I had observed for three years at U.C., was not so sure. (He owned a sailboat, and we all know how carefree sailors tend to be. Plus, life in New Orleans certainly had its cultural distractions!) But, in the end, Ralph and I drafted a proposal for a management science book and convinced Allyn & Bacon (now Pearson) to publish it, copyright 1976.

What a wonderful partnership – the first of several I developed over the years with co-authors. Our "Quantitative Analysis for Management" text is in its 13th edition (with the help now of Mike Hanna and Trevor Hale at the University of Houston). Ralph and I published five other texts over the next 15 years, including "Managerial Decision Modeling with Spreadsheets" (with Raju Balakrishnan, the dean at Michigan-Dearborn). Cengiz Haksever, at Rider University, became my co-author on "Service Management" (now in its 3rd edition). And in 1983, Jay Heizer and I teamed up to create "Operations Management" (now in 12th ed.) and "Principles of Operations Management" (in 10th ed.). The tally since 1976 is about 10 texts in roughly 56 editions. It starts to add up!

So I ask, why would any professor in his or her right mind forgo vacation after vacation to meet 56 publisher deadlines? How could anyone raise kids to sit on his lap while creating a new case study or homework problem? Why would anyone spend tens of thousands of hours proofing page after page and table after table? Did we not enter this profession for a lifestyle of freedom and flexibility?

Why would any professor in his or her right mind forgo vacation after vacation to meet 56 publisher deadlines?

The answer, in my case, is complex and has four parts. First, I think that growing up somewhat poor was a drawing factor in wanting to reach financial security. (I have to admit I was both impressed and influenced by my Cincinnati profs who showed the discipline to invest their royalties in apartment buildings).

Second, I know that writing has made me a better teacher. If I could explain a difficult concept in words in the book in a way that a 20-year-old could understand and appreciate it, I could convey it to my own students as well.

Third, I was obsessed with teaching from an error-free text. In our rigorous discipline, examples or problems with wrong answers, or test banks and PowerPoints that are unclear, drove me and my students crazy. It was tough, but I wanted my books to have, as quality control expert Phil Crosby would say, "zero defects."

And fourth, I discovered that I really, really enjoyed writing. For me, it is not a burden at all. It is a chance to stay current, to share knowledge and to help explain our field in a way that excites and motivates. I truly believe that operations management is the most critical and dynamic part of the worlds of business and government.

Because our texts are on three-year revision cycles, I found a way to keep our adopters/colleagues current every day. Four years ago, Jay Heizer and I started Jay and Barry's OM Blog (www.heizerrenderom.wordpress.com) for instructors teaching from our texts. I tend to create three to four new postings a week – 300-word summaries of exciting events in the news. (Why 300 words? Because our editors at Pearson posit that profs, like students, have short attention spans and lose interest after three short paragraphs). Now in "retirement," I read the *Wall Street Journal, New York Times* and *Financial Times* daily, and *Businessweek, Forbes, Fortune* and other magazines weekly/monthly.

Readership of our blog has grown and grown, with more than 400,000 visitors – plus about 500 daily subscribers – to date. The blog also has teaching tips, video tips, guest posts and sample syllabi from schools around the world.

Blogging is not for everyone. I have encouraged colleagues and other Pearson authors to use blogging as a way of communicating with students and adopters. But it requires time and effort to keep adding new content on a regular and timely basis. And most professors face more immediate deadlines in grading and research output.

For me, writing and blogging are fun, and I have never been happier. My advice: Whatever your path as an academic, I hope you also find your own personal joy. ORMS

Barry Render *is the Harwood Professor of Operations Management Emeritus at Rollins College in Orlando, Fla.*

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Cell towers

As the head of analytics for a cell phone company, you have been asked to optimize the location of cell towers in a new area where your company wants to provide service. The new area is made up of several neighborhoods. Each neighborhood is represented by a black house icon in the accompanying image (Figure 1).

A cell tower can be placed on any square (including squares with or without a neighborhood). Once placed, a cell tower provides service to nine squares (the eight adjacent squares surrounding it and the one it sits on). For example, if you placed a cell tower in B2, it would provide service to A1, B1, C1, A2, B2, C2, A3, B3 and C3.

The company recognizes that it may not be worthwhile to cover all neighborhoods, so it has instructed you that it needs to cover only 70 percent of the neighborhoods in the new area. Each cell tower is expensive to construct and maintain, so it is in your best interest to only use the minimum number of cell towers.

Question:

What is the minimum number of cell towers needed to provide service to at least 70 percent of the neighborhoods?

Send your answer to puzzlor@gmail.com by June 15. The winner, chosen randomly from correct answers, will receive a $25 Amazon Gift Card. Past questions and answers can be found at puzzlor.com. ORMS

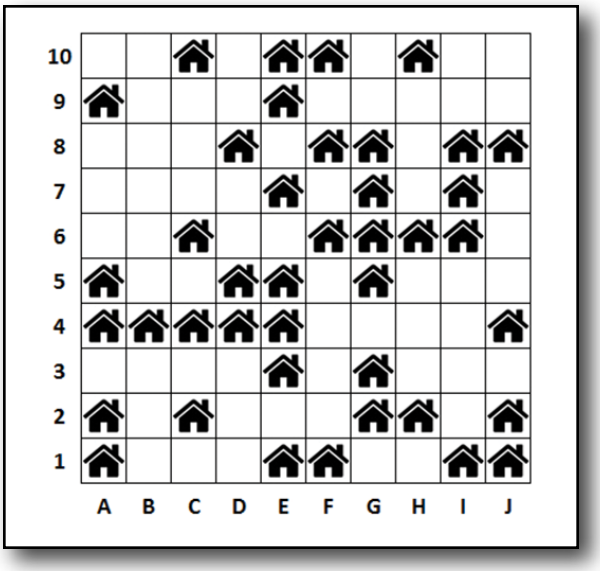

Figure 1: How many cell towers are needed?

John Toczek *is the assistant vice president of Predictive Modeling at Chubb in the Decision Analytics and Predictive Modeling department. He earned his BSc. in chemical engineering at Drexel University (1996) and his MSc. in operations research from Virginia Commonwealth University (2005).*

Steelcase WorkLife Centers around the world offer an array of applications and floor-plate designs (WorkLife Chicago).

Steelcase Inc.

Advanced Analytics team helps global company unlock human promise by creating great work experiences, wherever work happens.

By Tim Merkle

For more than 100 years, Steelcase Inc. has helped create great experiences for the world's leading organizations, across industries, through its family of brands including Steelcase, Coalesse, Designtex, PolyVision and Turnstone. Together, they offer a comprehensive portfolio of architecture, furniture and technology products and services designed to unlock human promise and support social, economic and environmental sustainability. Steelcase is globally accessible through a network of channels, including more than 800 dealer locations. Steelcase is a global, industry-leading and publicly traded company with fiscal 2015 revenue of $3.1 billion.

As the global leader in furnishing workplace environments, Steelcase has a unique ability to satisfy the needs of its customers anywhere in the world, wherever they work. The company's products and services are inspired by more than 100 years of insight gained from serving the world's leading organizations.

Headquartered in Grand Rapids, Mich., Steelcase's global reach provides a broad context for understanding emerging issues and what it means to be a responsible corporate citizen. In a fast-changing world that's more interdependent every day, Steelcase provides insights, products and services that help people do their best work. Unlocking human promise is the fundamental principle on which the company was founded in 1912, and it remains the focus today.

Steelcase began as The Metal Office Furniture Company in Grand Rapids and received its first patent in 1914 for a steel wastebasket – a major

All About the Roundtable

The Roundtable consists of the institutional members of INFORMS with member company representatives typically the overall leader of O.R. activity. The Roundtable is composed of about 50 organizations that have demonstrated leadership in the application of O.R. and advanced analytics. The Roundtable culture is peer-to-peer, encouraging networking and sharing lessons learned among members.

The Roundtable meets three times a year. Roundtable goals are to improve member organizations' OR/MS practice, help Roundtable representatives grow professionally and help the OR/MS profession to thrive. Further information is available at http://roundtable.informs.org.

The Roundtable also has an advisory responsibility to INFORMS. According to its bylaws, "The Roundtable shall regularly share with INFORMS leadership and advise the INFORMS Board on its views, its suggested initiatives and its implementation plans on the important problems and opportunities facing operations research and the management sciences as a profession and on the ways in which INFORMS can deal proactively with those problems and opportunities." The Roundtable meets with the INFORMS president-elect each spring to discuss practice-related topics of interest to him or her, and with the entire INFORMS Board each fall to discuss topics of mutual concern.

This series of articles aims to share with the INFORMS membership at large some information and insights into how O.R. is carried on in practice today.

innovation at a time when straw wastebaskets were a serious office fire hazard. That led to metal desks, and Steelcase has led the way with product and service innovations ever since. Across borders, time zones and languages, Steelcase's global network of capabilities – unmatched in its industry – gives the company roots and reach to provide products to its customers all over the world.

From environmental leadership to supporting diversity to strengthening communities, and spearheading efforts to improve urban schools, Steelcase invests in helping people realize possibilities. Through its own efforts and collaboration with others, Steelcase is recognized as a company that creates social, economic and environmentally sustainable value. As a global company, Steelcase is dedicated to creating relationships with diverse businesses to create a better, more sustainable world.

Award-winning Brody WorkLounge is designed for your body, brain and work.

Building an Advanced Analytics Team

In 2013, Steelcase formalized its commitment to become data-driven by establishing a new Advanced Analytics team. The team was organized not just to solve problems, but also to think through the solutions differently, specifically with data. As Steelcase enters its second century of operations, it strives to learn more from its data and leverage it to its fullest potential. To transform data to insights and drive action effectively, the Advanced Analytics team must approach data with greater care, and think past the initial transactional use of data and realize the greater value on "Day 2" and beyond. New people, processes and technology come together to bring a broad spectrum of methodologies to solve problems large and small. The Advanced Analytics team has partnered with the company's Business Intelligence Competency Center to provide end-to-end descriptive, predictive and prescriptive analytics to support the varying needs of the organization.

The Advanced Analytics team is comprised of analytics professionals with robust experience applying statistics, economics, computational science and operations research (O.R.). As a composite of four sub-groups (Statistical Learning, Computational Intelligence & Machine Learning, Operations Research and Architecture), the Advanced Analytics team is designed for agility; it handles a wide array of problems by varying the composition of the project teams. Early in the team's history, its executive sponsor drove engagements with key leaders throughout the business to assess initial analytics opportunities. This led to a large list of projects for the new team to undertake. The rapid influx of projects led to the growth of the Advanced Analytics team and a need for project governance. To that end, guidance committees representing every major business function were organized to develop, prioritize and support execution of projects within the Advanced Analytics portfolio.

Beyond Projects: Building Partnerships

Every project the Advanced Analytics team undertakes is an opportunity to increase revenues or deliver cost savings; moreover, it is an opportunity to deepen the trust and confidence in analytics. As an

With a **portfolio** spread across **major business** functions, the **Advanced Analytics** team **strives** to find **"one-to-many"** opportunities; that is, **solutions** where the methodology, **model or outputs** can be **utilized** by **multiple stakeholders.**

In a protected "incubator" environment, teams are free to test and develop fragile ideas, accelerating iteration and innovation (Innovation Center, Grand Rapids, Mich.).

internal consulting group, the team has become a hub of cross-functional information, plugged into the company's large global network at various levels. The team's portfolio is a diverse collection of projects from Marketing, Sales, Finance, Sustainability, Procurement, Manufacturing, Logistics, Quality and Information Technology. The team's analysts often find themselves working with multiple groups simultaneously on very different problems. In order to maneuver the complexity of Steelcase and meet customer expectations, the team relies heavily on its business partners and sponsoring organizations. Learning from the subject matter experts and studying the systems that create, modify and store their data is an important part of the team's process. The team does not operate unilaterally; rather, it exposes its business partners directly to the new analytical capabilities and methodologies employed by the team. This is critical to the customer experience, trust in solutions and growing a data-driven mindset.

Delivering Insight

With a portfolio spread across major business functions, the Advanced Analytics team strives to find "one-to-many" opportunities; that is, solutions where the methodology, model or outputs can be utilized by multiple stakeholders. We also want to help mentor and grow analytics capabilities throughout the global team. Certain areas of Steelcase were more prepared than others to leverage traditional analytics because their people, leaders and/or their data were more progressive and prepared. A few examples of early applications:

Optimizing networks: As Steelcase modernizes its industrial system, the team has found multiple opportunities to support network redesign. Efficient inbound and outbound transportation is critical to deliver product and ensure the customer experience is maximized. To this end, Advanced Analytics supported multiple efforts to study and optimize distribution networks. The most recent undertaken by the O.R. group was to rapidly formulate a capacitated optimization model to find optimal distribution center locations. A build-to-order business model resulted in some interesting constraints that not only challenged the team, but helped the team better understand operations in all three operating regions simultaneously. The resulting optimization model was designed to handle discrete inputs, but it could be modified for stochastic inputs in the future. We ran 300+ scenarios to identify the optimal locations for distribution centers in the current and proposed industrial system, thus providing a solid business case for implementation.

Right-sizing energy: As a passionate advocate and leading organization in environmental sustainability, Steelcase is very much interested in protecting the environment through reducing our carbon footprint and energy waste. The Advanced Analytics team partnered with the company's sustainability and procurement groups to study historical electricity consumption of the Grand Rapids facilities. The result yielded a new purchase strategy for electricity blocks. Leveraging optimization, the team not only right-sized purchased electricity blocks to handle Michigan seasonal weather and manufacturing swells, but through mapping the

problem we developed a vendor management strategy that yielded even more value. Through the use of data we challenged the vendor to provide us more flexibility shifting from annual block purchases to a more dynamic model.

Improved forecasting: Long histories and structured hierarchies were ripe for applying time-series forecasting to improve or provide forecasts to areas of the business previously without. Over the last 24 months, the Advanced Analytics team has kicked off multiple strategic projects to provide higher frequency, automated, hierarchical forecasts across Steelcase. The team has established a robust analytics ecosystem to provide tens of thousands of statistical forecasts to support various stakeholders. Additionally, we are currently piloting hybrid forecasts, leveraging system dynamic simulation and other non-traditional approaches for areas with less than desired histories. Clearer demand signals and the ability to navigate hierarchies are changing the way our business partners operate with data.

Near future: As our current partnerships shift into business implementation, we keep a weathered eye on the future. A few areas will get special focus from the O.R. group. We are actively developing projects that will apply stochastic processes, Markov chains, dynamic simulation, optimization, Industrial Internet of Things and game theory. Leveraging the depth and breadth of the entire Advanced Analytics team and strong business partners, the opportunities for complex ensemble solutions are abundant.

Continued Growth

Building on Steelcase's tradition and commitment to excellence, the Advanced Analytics team continues to drive math and science deeper into the core business processes throughout. The team is working closely with key executive sponsors to diversify its portfolio of solutions and grow descriptive, predictive and prescriptive analytics capabilities throughout an exceptionally talented global workforce. The strength of Steelcase's culture is the passion and resolve for solving wicked problems; the Advanced Analytics team is excited to offer its business partners new and expanding capabilities to translate data into actionable insight. ORMS

Tim Merkle *is the manager of Advanced Analytics at Steelcase, leading the analytics team and program to improve data-driven capabilities throughout the global enterprise. He is a former Marine Corps officer, combat veteran and current Steelcase representative to the INFORMS Roundtable.*

SAS jet takes off from Arlanda Airport in Stockholm, Sweden. The airspace around airports is where most congestion and delays occur.

Optimal design of terminal airspace

Scandinavian-based case study focuses on vicinity of airports where the most congestion happens, capacity has its bottleneck and delays occur.

By Valentin Polishchuk

Projected growth of air traffic industry is a sign of healthy economic and technological development, as well as an unprecedented challenge to mankind. Since a great deal of air traffic congestion happens during the initial and final phases of flights, super-dense operations (SDO) in terminal areas are a recurring topic in air traffic research. Case in point: Three out of four presentations in the Capacity and Airspace Design session at 2015 SESAR (Single European Sky ATM Research) Innovation Days (the main vehicle through which SESAR disseminates the results of its long-term and innovative research program and which has become a landmark event in the European research calendar) were about terminal maneuvering areas (TMAs).

Indeed, the complexity of traffic pattern near airports creates higher capacity needs, for the same number of aircraft in the air, than in an en route setting (e.g., according to the European ATM Master Plan, as few as 80 movements/hour already lead to high capacity needs in a TMA, while as many as 160 movements/hour create only medium capacity needs en route). In addition, separation standards to avoid wake vortex effects lead to increased sequencing intervals, potentially enforcing time-stretch maneuvers and holding to be executed inside or near the boundary of the TMA. (These issues are mitigated by recent efforts in re-categorization projects on both sides of the Atlantic that strive to define separation standards on per-aircraft-type basis, in contrast to the current system where each aircraft is classified into one of the few categories, and the separation is defined based on the categories of the leading and trailing aircraft.)

Terminal airspace design needs to take into account ground constraints, such as terrain profiles and noise-sensitive neighborhoods. Curved approaches and other techniques are developed in order to smooth air traffic flow in such scenarios. Last but not least, designing the airspace around airports must be done while making educated tradeoffs between cost efficiency and noise impact, traffic complexity and airspace capacity, landing rate restrictions and economic considerations, and many other conflicting objectives. Moreover, when a design has been made, the continuous developments and changes in these and other factors will eventually render the original construction inefficient, making it necessary to redesign the airspace.

Air transportation has a long history of fueling the operations research (O.R.) community with motivation to provide efficient solutions for large-scale optimization problems. A classical O.R. success story is its contribution to airline management, where fleet assignment, aircraft routing, crew rostering and other practical tasks are solved with methods developed by O.R. academics in response to the business demand. Our research looks at another vital ingredient of air transport: air traffic management (ATM).

The current ATM system consists of three major components: skyway design (laying out the "road network" in the sky), flow and capacity management (mapping the filed flight plans demand onto the available network resources) and air traffic control (monitoring the flights and leading them through the airspace sectors). Global growth of air travel, coupled with the ongoing and predicted boost of unmanned aerial vehicles and remotely piloted aircraft, puts an enormous strain on ATM, and both the SESAR and the NextGen (Next Generation Air Transportation Systems, the sister initiative in the United States) envision that the solution to the

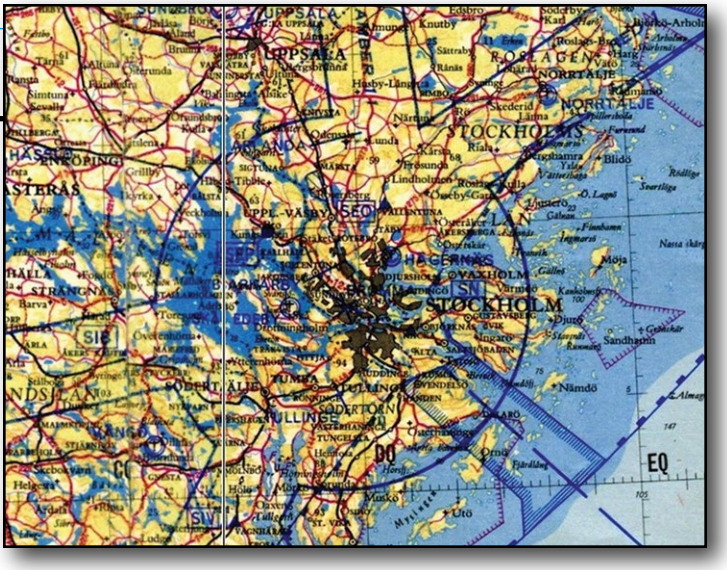

Figure 1: Stockholm TMA in the 1950s.

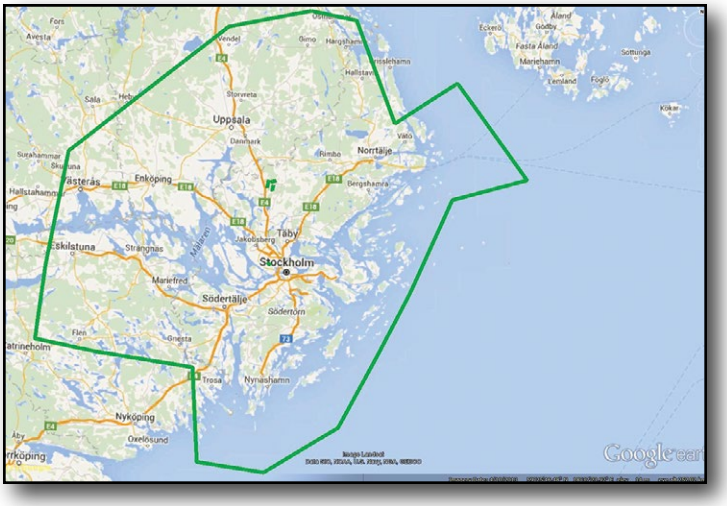

Figure 2: Stockholm TMA in 2016.

global challenge will come from the flexible use of airspace, which (in addition to more "political" steps, like sharing resources with the military) puts the flow and capacity management into the heart of the system, and treats both the flight paths and the control sectors as flexible entities rather than rigid structures changeable only on the strategic level ("providing structure where necessary and flexibility where possible").

In fact, flexible versions of parts of the ATM systems are already implemented and being deployed: Dynamic demand and capacity balancing (and dynamic airspace configuration, its U.S. counterpart) redistributes work among air traffic controllers (ATCOs) as the traffic complexity changes, while FreeFlight and Free Route Airspace (FRASE) allow the aircraft to fly directly from an entry to an exit point of the airspace. This is particularly true in the uncongested Danish-Swedish functional airspace block (FAB), where one can fly freely through the whole block, consisting of as many as three control centers in the two countries.

TMA design falls into the **broad class** of **typical O.R.** demand-to-resource **matching problems.**

FRASE essentially makes en route airways planners (those who decide the highways in the sky) lose their jobs (I once belonged to the cohort, doing my Ph.D. thesis on airways planning in the Department of Applied Math and Statistics at State University of New York at Stony Brook). Upon moving to Sweden, I realized that the focus of route planners should be on TMAs – the airspaces in the vicinity of airports (or air portals, several large airports in a small geographical area) where the most congestion happens, capacity has its bottleneck and delays occur. Even though the clear blue sky might look like it gives essentially infinite room for flying through it, in many places near the airports the ATM systems work at or close to the limit of their capacity. This became the focus of the ODESTA (Optimal Design of Terminal Airspace) project funded by Sweden's Innovation Agency VINNOVA and run by Linköping University (LiU) in partnership with Luftfartsverket (LFV), the Swedish Air Navigation service provider.

The core of the ODESTA research team consists of Christiane Schmidt, Tobias Andersson Granberg and myself (all affiliated with LiU), along with Billy Josefsson of LFV. Andersson, director of the flight transport and logistics program at LiU, is an expert in mathematical programming. Schmidt, a postdoc in ODESTA, comes from the field of computational geometry – airspace optimization has a solution of geometric tasks at its core. Yours truly, the principal investigator of the project, is an applied mathematician with concentration in operations research (O.R.). Finally, Josefsson is a former ATCO currently working as a manager in automation and human performance with the LFV.

Figure 3: SketchUp model of the 3-D structure of the current sectors over the TMA, made by ATCO students from the LFV's Entry Point North Air Traffic Services Academy.

The project also includes a group of industry and authority experts: Patrik Bergviken (Landvetter, LFV), Robert Graham (head of airport research at EUROCONTROL), Johan Holmer (Trafikverket, the Swedish Traffic Agency), Anders Ledin (Swedavia) and Anne-Marie Ragnarsson (Transportstyrelsen, the Swedish Transportation Authority). Their involvement helps to steer the project in the right direction when it comes to the real world, with all its operational constraints and political regulations, satisfying what actually presents a huge technological challenge.

The project reference group meets twice a year, and at the initial workshop, organized in May 2015, the group advised us to look not only at the grand challenge of optimally solving the airspace design problem in its full generality, but also to explore possibility of finding "quick-and-dirty" improvements that could be implemented without abolishing the current practices in the overall airspace management. The suggestion is very much inline with the general approach in attacking large-scale optimization tasks: Instead of trying to solve the big problem from scratch with some single-shot mega-potent solver, single out several smaller subtasks and optimize each of such components separately (keeping in mind further opportunities to optimize also interfaces between the components). One classical example of successful industry-wide use of this approach within aviation is splitting the fleet management problem (deciding which plane will fly each link on the schedule) into fleet assignment (deciding which aircraft type will fly each link) and aircraft routing (deciding rotations for each aircraft).

Indeed, from a top view, TMA design falls into the broad class of typical O.R. demand-to-resource matching problems. Specifically, the demand for TMA is formed by the flight plans of the aircraft that intend to land in or depart from the TMA. The resources are the runway(s) at the airport(s), the available fly zones, and the surveillance, navigation and control infrastructure, etc. While in principle it is possible to begin solving the airspace design problem from anywhere in the system, one natural approach is to start from a close look at the "outer" and the "inner" boundaries and gradually expand the optimization frontier, culminating in a "meet-in-the-middle" solution that has optimal designs on both sides.

In the TMA case the outer boundary (the "input," the demand) is defined by the flights through the airspace, and this has been the focus of the research so far. The results obtained by now [1, 2] give a baseline for TMA design assessment, delineate efficiency bottlenecks and determine room for potential improvement. Specifically, we quantified how many extra miles the aircraft have to fly in the

TMA due to the human factor – the fact that each flight must be monitored by ATCOs who have only a limited control capacity. Construction of (parts of) the solution by pushing off the "innermost" structures (the runways) and the design of the "middle-ware" (flight routes and control sectors within the TMA) are topics of forthcoming work in the project.

Effective transport is vital for a long and narrow country like Sweden, and the relatively low traffic demand gives an opportunity to actually optimize the use of transportation resources. In particular, VINNOVA regularly issues calls for research proposals in the area of transport and environment, and in 2014, LFV and LiU responded to the call by applying for funding for ODESTA. Joint research fits well into the LFV-LiU collaboration agreement signed in 2012 by LFV's director general and LiU's vice rector; in addition to research, the agreement covers a joint educational program in which ATCOs receive practical training from LFV along with a bachelor's degree from LiU. Securing common external research funding was a natural step in strengthening the cooperation. More generally, the teaming up of LFV and LiU was no coincidence but actually a consequence of Swedish government's (successful) effort to breathe (new) life into the (run down by the textile industry fall) city of Norrköping, to which several governmental establishments (including LFV, Swedish Maritime Administration, Swedish Migration Agency, et al.) were moved from the capital and where a campus of LiU was founded.

ODESTA started in the fall of 2015 and is funded for four years. Introduction of new technologies into ATM practice is a long multistep process that includes simulation and validation prior to deployment. Many follow-up activities are envisioned to continue past ODESTA's timeframe. The guinea pig for the developed algorithms will be the Stockholm TMA (S-TMA) where Sweden's largest and third largest airports (Arlanda and Bromma) are situated. A recent study by LFV confirmed the need for the airspace redesign, giving a green light to simulate and validate ODESTA outcomes in the S-TMA. Travelers to the Swedish capital shouldn't worry, though, that their flight paths will be produced by computer without human oversight. ATM remains a human-centered activity, and our implementations are seen merely as decision support tools aiding human experts in choosing the best out of the infinite number of options (the tools include test environments, graphical user interfaces, and much more).

Interestingly, each earlier effort in airspace design concentrated on only one of the two problems:

1. Given how the aircraft fly (based on the airways or on historical data), design the sectors around the flight paths that allow for the most effective control of the air traffic flow.
2. Given the control sectors, find the routes that best fit into the sectors (in particular, the flight paths should not cross between the sectors more often than necessary because every change of the sectors implies a communication overhead of coordinating the change with the ATCOs responsible for the sectors).

ODESTA's ambition is to surmount this delimitation and address the two problems within a single common optimization framework, providing an algorithmic solution for both problems simultaneously. That is, in its output, the project will provide both the sectors and the routes that together constitute optimal (or close to optimal) solution for the airspace design task. The most direct result of the research within ODESTA will be models and algorithms for an optimized airspace design. An obvious indirect result is, of course, the redesign of the Stockholm TMA, for which ODESTA will most certainly smoothen the way ahead. Much of the groundwork for an optimal redesign will be performed during the project, and relevant parties will have time and opportunity to discuss issues concerning the redesign at reference group meeting and at the workshops. It may even be the case that an actual redesign will have been made before the project ends, although we deem this as unlikely. If a redesign starts within the timeframe of ODESTA, the reference group and LFV will ensure that knowledge accumulated so far within ODESTA will be part of the process of redesign.

Optimizing the airspace over Stockholm will bring a number of benefits. In ODESTA, we will theoretically show how much the flight paths can be shortened and delays be reduced, thereby reducing noise and emissions, and how much predictability and capacity can be increased. We will also provide means to reach these benefits. We trust that the O.R. expertise developed within the project will also find use in other traffic-congested hotspots around the world, contributing to the mutually beneficial O.R.-industry collaboration. ORMS

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Effective transport is vital for a **long and narrow** country like **Sweden,** and the relatively **low traffic demand** gives an **opportunity** to actually **optimize** the use of transportation **resources.**

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Design uncertainty is the major driver of planning complexity in building specialized vessels used in offshore oil and gas exploration.

Design problems in specialized shipbuilding

Norwegian case study: The role of operations research and behavioral operations management in handling project complexity.

By Hajnalka Vaagen

"Built on trust" is the motto of the VARD Group AS, one of the most innovative global designers and builders of specialized vessels used in offshore oil and gas exploration. Despite being located in Norway – a high-cost country with suboptimal infrastructure and employment conditions – the company ranks among the best in terms of flexibility, delivery precision and short delivery times at competitive prices. In this environment, project work is the norm, and responsiveness to frequent technical changes is critical for performance.

"Trust" is undoubtedly an important competitive element of the Norwegian industrial culture. Given that, planning and scheduling large, complex projects normally requires advanced decision support tools, and operations research is expected to play a vital role in this task.

The peculiarities of shipbuilding for the oil and gas market segment, however, make planning very difficult, and the role of model-based decision aids is

limited when it comes to handling the true complexity. In this environment, vessels may change substantially from contracting to delivery due to frequent and unsystematic client input, as well as by frequent regulatory interventions, all while working on the edge of known technology [3]. Since short delivery times are critical, almost every ship is put into engineering and production before all the technical uncertainty is resolved.

The engineering of the vessel commonly starts when only the footprint of a strategic component is known, and large-scale strategic adaptations, far into the production process, may also occur. The planning complexity, therefore, arises from frequent design changes and advanced design and engineering taking place concurrently with production. Concurrency is challenging only if design is uncertain, which makes "design uncertainty" the major critical element of the planning problem; future decisions (on how to manage project task and resources) are conditioned on the future realization of the uncertain design. Despite this, design is often separated from project scheduling [3], mainly because ship design and engineering are still considered the domain of naval architects and engineers.

Before design and scheduling can be integrated, it's first necessary to know how to handle uncertainty and dynamics (that is, the steady arrival of new information) in pure project scheduling for a given design. Finding a way to formulate this stochastic dynamic scheduling problem is very difficult or even impossible for large projects [4], mainly because the order of decisions is not fixed but depends on previous decisions and the realization of random variables [6].

Recognizing the shortcomings of model-based decision aids to create flexibility in plans, these are in practice replaced by judgmental decision processes [1, 3]. Dealing with the described complexity judgmentally is, however, not less complex, even when the large number of behavioral issues that may negatively affect the outcomes (limitations in working memory, incentive misalignment, invisible and illusory correlations, just to name a few) are "ignored." In spite of this, the organization of shipbuilding projects at VARD demonstrates a high level of responsiveness and innovative solutions to quickly adapt technical changes throughout the construction processes.

Initial contextual studies point to "team abilities to share experience" and "tacit knowledge" as the drivers of responsiveness to changes. In social sciences, human relations and the value these relations have in sharing information, knowledge and resources define the social capital, which is quite often associated with enhanced innovation. Requesting and retrieving task related information and resources between project participants is considered a fundamental aspect of project execution [7].

Driven by the outlined challenges and industry practices, the design problem in planning complex projects was approached by connecting the classical O.R. elements of project scheduling with the social-behavioral aspects of handling technical uncertainty. In the case of VARD, this is being done through a long-term research engagement with SINTEF, the largest independent research organization in Scandinavia.

The multi-method approach extends the scope of research on classical O.R. approaches to project planning and scheduling in two distinct directions:

A. To connect the element of design to project scheduling, in one stochastic-dynamic program, to study the impact of design uncertainty on planning. Without this knowledge, it is difficult to achieve good solutions when advanced design is taking place concurrently with production.
B. To provide insight into how the behavioral characteristics of project participants in social networks – e.g., informal work connections, trust and risk behavior – affect responsiveness to unforeseen changes. This task connects social network perspectives to behavioral operations management.

The research steps with preliminary results and implementation are described below and outlined by Figure 3.

A. The O.R. approach – stochastic-dynamic programming

The planning complexity with stochastic changes in design specifications is approached by

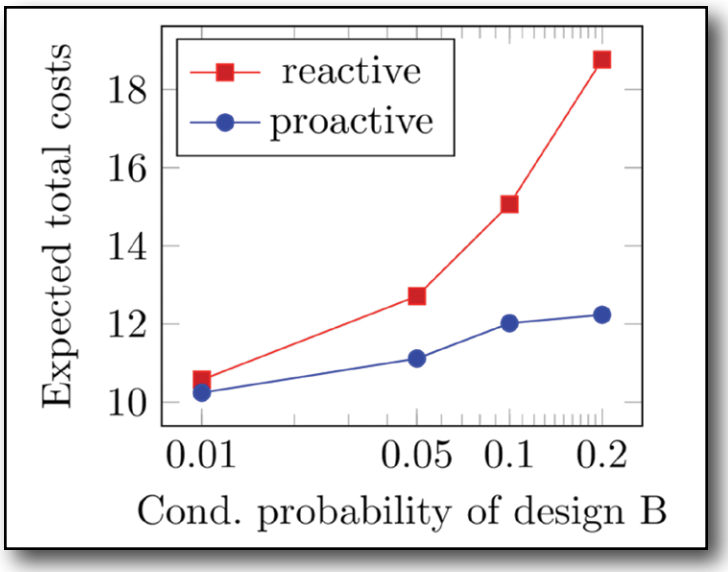

Figure 1: Comparison of the expected total costs of the reactive (deterministic) and proactive (stochastic) strategies.

The engineering **of the vessel** commonly starts **when only** the footprint of a **strategic component** is known, and **large-scale strategic adaptations,** far into the **production process,** may also **occur.**

The research demonstrates more than **35 percent cost reduction** when applying **proactive strategies** compared to **reactive strategies.**

small model instances, with the aim to learn what it is that makes solutions good. This enables finding good plans in the future without actually solving complex stochastic models. The model is described in [9]. The results indicate high value of flexible hedging strategies (proactive strategies) that capture the value of future design changes.

The research demonstrates more than 35 percent cost reduction when applying proactive strategies compared to reactive strategies, where static (deterministic) plans are updated in light of new (design) information. This is exemplified by Figure 1 for increasing probability of design alternative B (i.e., decreasing belief in the originally assumed design alternative A). These results have great managerial value, as they indicate the cost-saving potential of proactive approaches to design uncertainty in planning, and the properties of these strategies with guidelines on when and where to develop flexibility and buffers in plans. The insights and planning guidelines developed, listed in [9], are valuable to improve judgmental decision-making. Simulation-based planning approaches may also benefit from the knowledge on what solutions structures should be investigated; particularly, when a full scenario tree evaluation is not possible due to the size of the problem.

B. The social-behavioral approach – Behavioral mechanisms in the social network of project work

Without insight into the social mechanisms, the integration of human behavior into planning and decision-making would be limited to understanding the processes and heuristics involved in individual level decision-making, as described by e.g. [5], which may differ from those driven by social interactions. Social ties are particularly critical when tacit knowledge constitutes a large share of the available resources as it is in many organizations with long traditions. While the transfer of explicit resources may (but need not to) follow formal process charts, effective transfer of tacit knowledge requires regular personal interaction and trust.

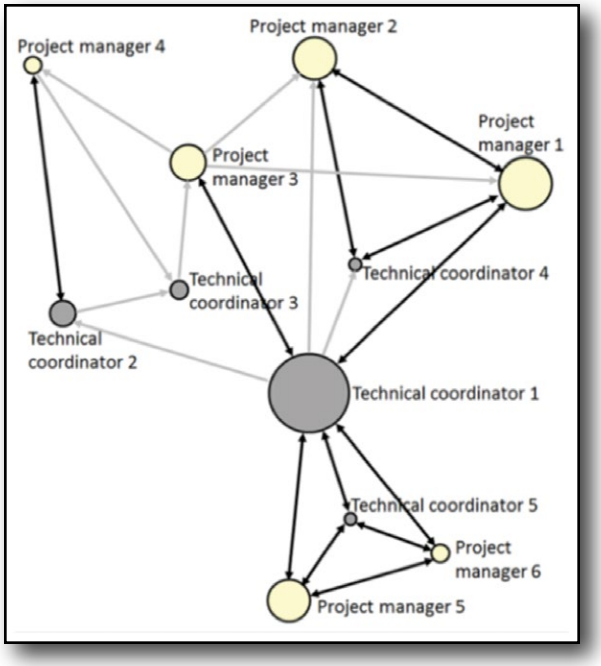

Figure 2: The "broker" role exemplified.

From a social network perspective, human interaction in a social environment can be expressed as a relation-based pattern, defined by symmetric or asymmetric (one-sided or two-sided) links between nodes (individuals) in the social environment. Such links or relations affect, for example, resource and information sharing, bargaining power and decision-making. Our social network analysis is, therefore, developed to provide insight into how the "informal" multiple relations (in daily work, technical uncertainty handling, friendship and true project network), trust and norms of behavior affect engineering responsiveness. The relational patterns are visualized, hypothesized and tested statistically [8].

The dynamic network visualization technique allowed quick identification of structural concerns in the engineering network; e.g., central and peripheral actors, strong triads that may facilitate or hinder the flow of information, gatekeepers and information brokers. These patterns exhibit different influences, behaviors and choices. For example, high centrality provides better access to critical information and theoretically is positively related to performance. Figure 2 exemplifies the "broker" role of one central actor in the technical uncertainty handling network. This actor connects the otherwise disconnected heterogeneous groups of project managers and technical coordinators (the two key functions in a project organization).

The social-behavioral approach uncovered high-performing groups and their ability to achieve synergies to handle technical changes in shipbuilding projects. These synergies are associated with the social capital of the group, mainly through cohesiveness of strongly interrelated actors, and through a positive and significant association between friendship and technical uncertainty handling networks. The solid base of interpersonal trust is translated into higher propensity for risk seeking [2]. These aspects, connected to extensive grade of tacit knowledge, in a flat organization that delegates decisions to lower levels, facilitates the development of high-performance teams, where people feel collaborative

(positive) pressure to find immediate solutions to unplanned changes.

Industrial Implementation

The uncovered social-behavioral characteristics confirm the strong handcraft traditions in the shipbuilding project work, but also highlight the improvement potential by industrialization through craftsmanship. Such an industrialization process is the scope of the current change program at VARD, with a focus on reorganizing the engineering department to better align with the existing social capital while creating lean processes. In this change program, both the O.R. and social network-related findings are applied. One concrete action relates to front-end loading (pre-project planning), connecting engineering activities and planning to design and procurement early in a project's lifecycle, at a time when the ability to influence is relatively high and the cost to make changes is relatively low. The aim is to early identify project uncertainty and activities with high impact on the schedule and performance, and develop proactive strategies to handle upcoming changes. The first ship with restructured engineering work is under construction, and great benefits are expected.

Conclusion

The NextShip project results are not a single tool or model, but rather a collection of (and cautious use of) various tools, approaches and insights, all focused on handling the design problem in planning to improve project flexibility and responsiveness.

The results trigger increased focus on the social interactions and behavioral reactions to handle technical uncertainty in typical engineering environments. These changes are difficult to quantify and therefore difficult to manage. The reaction pattern through team dynamics compensates (to some extent) for lack of flexibility in plans, as people feel collaborative (positive) pressure to find immediate solutions to unplanned changes by making use of their social capital.

The role of O.R. cannot be ignored, though, as without analytical guidelines, a new improvement idea might fail. O.R. has a lot to offer in the planning of complex engineering projects, but its value is not necessarily in solving the complexity for large real projects, as this may be very difficult or even impossible. Small model instances of the problem have proven useful in developing understanding on what makes solutions good and to enable developing good plans without actually solving complex models. This potentially improves the outcome of judgmental decision processes.

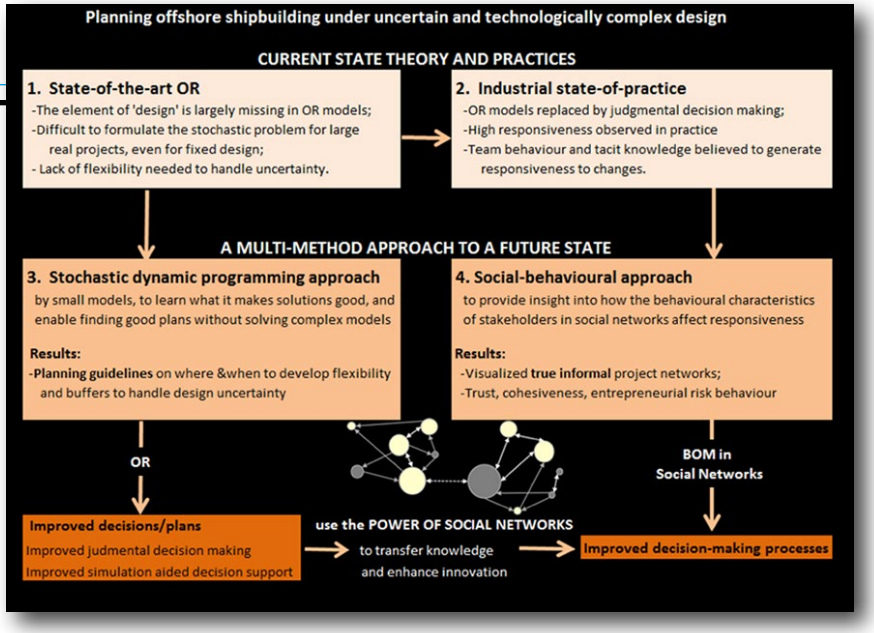

Figure 3: The multi-method approach to design uncertainty in shipbuilding planning.

However, because there is a "but" when uncertainty-handling is largely based on social interactions, it is not enough to know the right answer to what makes solutions good. It is also important to know how to utilize the power of social networks to transfer this knowledge.

The main message of this project is, therefore, on the high value of combining multiple research methodologies and disciplines to explore the real complexity of typical O.R. problems. ORMS

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ACKNOWLEDGMENT:

The research presented in this article is part of the NextShip project under Norwegian Research Council grant agreement 216418/O70. Special thanks to Arvid Sundli, senior vice president of operations, VARD Group AS, and Jan Emblemsvåg, senior vice president, Ship Design & Systems, Commercial Marine, for valuable input.

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The orange tram in Budapest is part of the BKK public transport system.

Multimodal transportation in Budapest

Case study from Hungary: Developing a decision support system to optimize travel throughout large metropolitan cities.

By Tibor Illés and Richárd Molnár-Szipai

Multimodal transportation involves using two or more modes of transportation in a trip. In an efficient public transportation network the passenger can combine a smaller number of fast, technologically advanced transportation systems (e.g. underground railway) with a larger number of slower modes of transportation that cover the area in a denser fashion (buses, walking). A major goal of modern multimodal passenger transportation (from an environmental aspect, but also to reduce traffic jams) is to incentivize using public transport as opposed to using automobiles.

Several online journey-planning tools are available to help travelers, most ubiquitous of which is Google Maps. Here the traveler selects his or her destination, with a few more optional details (time of departure, preferred modes of transportation), and the optimal routes are presented within a second.

The authors, faculty members of the Budapest University of Technology and Economics (BUTE), have been working with researchers from the Department of Networked Systems and Services to develop a similar service for the city of Budapest, Hungary, taking the unique characteristics of the area into consideration. Similar studies have already been carried out for Athens, Greece [1,2]; Toulouse, France [3]; and Genoa, Italy [4].

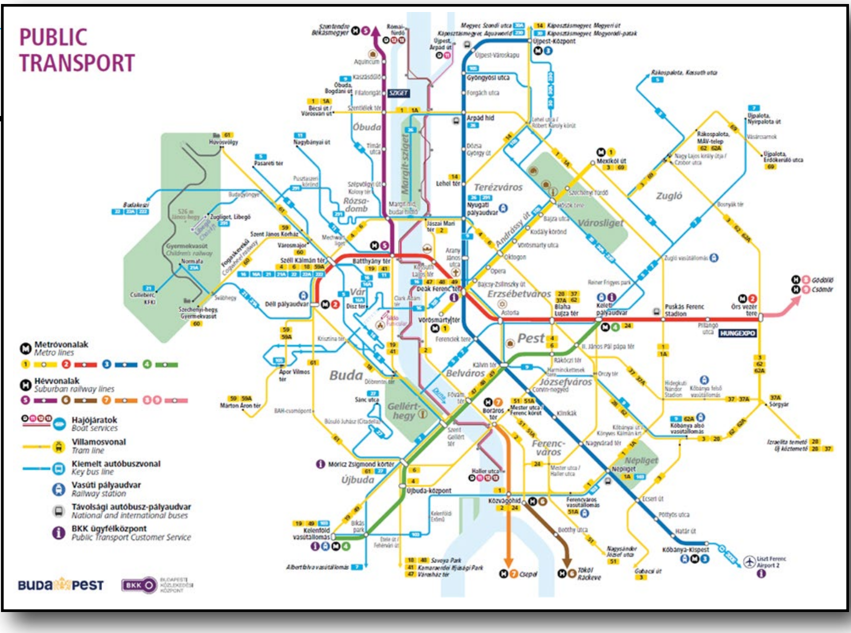

Figure 1: Main lines of Budapest's public transit.

Public Transportation in Budapest

Budapest is the capital and the largest city of Hungary. As of the 2011 census, it had 1.74 million inhabitants, which grows to 3.3 million people if we consider the Budapest Metropolitan Area. The Hungarian road and railway system is highly Budapest-centric, with most of the major highways and railways passing through or terminating within the city limits. The road system inside the city has several ring roads (the outermost one – ring road M0 – being a highway) and avenues radiating out from the city center.

The city's public transportation system is operated by BKK (Centre for Budapest Transport), and covers the city of Budapest and 80 surrounding suburbs. It consists of four metro lines, of which Line 1 is the second oldest metro line in the world. There are five suburban railway lines, 33 tram lines, 15 trolleybus lines and 264 bus lines, 40 of which also include night services. Moreover, the BKK also operates four city boat services and a fledgling bicycle sharing network.

The Project

Our research group was approached by a group from the Department of Networked Systems and Services to join them in developing a highly configurable decision support system for passengers who want to optimize their traveling plans. This endeavor was part of the INTCO project (Integration framework for the economical optimization of mobility and transportation) – a subproject of "AIMS Multimodal Mobility" – supported by the EIT ICT Labs (European Institute of Innovation & Technology, Information and Communications Technology Labs), of which BUTE is a partner university.

The challenges in the project were twofold: build a suitable model and develop the necessary algorithms.

The model needed to be sufficiently detailed yet manageable in size. It should combine the data available on the automobile network of the city with the public transportation network, using the data on parking lots, extended with the bicycle sharing points and the often overlooked pedestrian transport mode. Since the transportation system is constantly changing, the model needed to incorporate a stream of regularly updated data.

The algorithms had to accommodate the various needs of the passengers, such as: Does the traveler have a car available at a certain point? Is he or she willing to use the public transportation system or the bicycle sharing network? How many times is he or she willing to change modes of transportation? Some of the user preferences are hard to objectively describe, so the system needs to offer multiple travel plans. After all it is but a decision support system; the choice is up to the user.

Input Data

The basis of the models is the OpenStreetMap project [5], which is a free, editable map of the world built by volunteers in a manner similar to Wikipedia. At its core, OpenStreetMap is a collection of physical features (locations, road sections, buildings, etc.) with tags attached to them. The tags describe various attributes of the feature, starting from the basic type of the feature to such details as the speed limit on the road section or the ticket prices of the parking space. This data is represented in an xml-scheme, from which the relevant information can be obtained efficiently.

The data for the public transportation network comes straight from the Centre from Budapest Network in GTFS (General Transit Feed Specification, [6]) format. Developed by Google, the format is currently used in more than 18,000 cities worldwide.

The model needed to be **sufficiently detailed** yet manageable in size. **It should combine** the data **available** on the **automobile network** of the city with **the public** transportation **network.**

The model consists of several networks: **automobile, pedestrian, public transportation** and **bicycle networks.**

It contains the location data of individual stops, the routes built from these stops and the scheduling of these routes according to the day, precise to the minute (which, of course, is not necessarily realized every time).

The availability of OpenStreetMap and the General Transit Feed Specification for other cities makes the developed models and algorithms easily translatable to other locations.

Modeling

The model consists of several networks: automobile, pedestrian, public transportation and bicycle networks. These are reasonable transportation networks on their own, although only the pedestrian network can reach every possible destination point. The combined model can perhaps best be understood as having these four networks as layers on the same physical map. Between them, we make artificial connections that represent changing between modes of transport. The automobile network has connections to the pedestrian network at the parking spaces, representing leaving the car behind and continuing on foot. These connections are one-way only, as we can't expect a traveler to just go to an arbitrary parking space and take up a car (however, car rentals could be modeled in such a way). The public transportation network and the bicycle network also have clear connection points (vehicle stops and sharing points, respectively), which are usually bidirectional. The main difference between the two services is that public transportation works on a schedule, while bicycles are assumed to be available whenever necessary (see Figure 2).

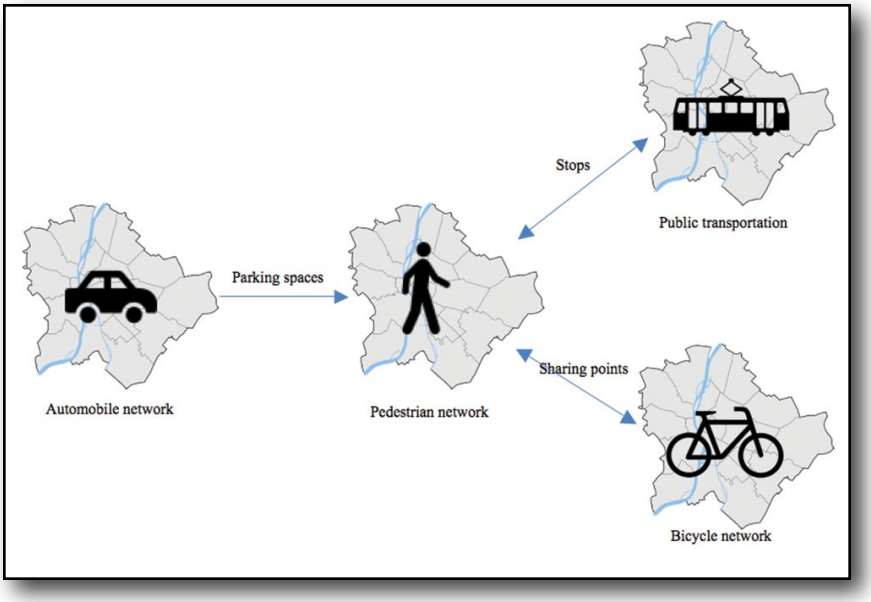

Figure 2: Network layers.

As a side note, due to the relatively low number of bicycle sharing points and the traveling time's insensitiveness to the time of the day, the optimal routes and traveling times between each pair of sharing points can be pre-computed, shortening the answer time to the user's query.

On the network, users select a departure location and time, along with an arrival location. Then they can configure preferences on which modes of transportation they wish to use. According to these options, we disable the connections to the undesired transportation modes in the user's session, while keeping the model intact, as rebuilding it before each query would take considerable time.

Finding Shortest Paths

The simplest task we can perform on the model is producing a travel plan from point A to point B, given the departure time and the allowed modes of transportation. This task in mathematical terms is equivalent to finding a shortest path in a weighted graph, which is a basic optimization problem. The slight modification, that public transportation works on a schedule, means we have to keep waiting times in mind and can easily be incorporated into the standard algorithm for this problem (the Dijkstra's algorithm).

It may be preferable to show alternative travel plans to users and let them decide based on their subjective preferences or based on some other information the model might not be aware of. Finding the first few shortest paths in a network is referred to as the Kth shortest path problem in optimization, and there are also efficient algorithms for it. We used the above-mentioned Dijkstra variant on subproblems generated from the optimal solution to the shortest path problem.

While the solutions gained are mathematically sound, they do not necessarily make sense in context. For example, if the optimal solution consists of walking, taking a bus and then walking to the destination, the second shortest path might be the same until getting off the bus, and then use a different, slightly longer walking path from the bus stop to the destination. One might say that these two paths are "not really different," but formalizing this subjective notion is not an obvious task.

One possible way to approach this task is pattern matching. In the previous example, the optimal solution might be described as "walking, bus line 7, walking." Continuing the search for the next shortest path we can discard each solution that fits this pattern. This method gives better quality recommendations, although some problems persist. One

such problem is that some bus lines might share a section of their routes, and thus "walking, bus line 173, walking" is not really different from the solution above. Another problem is that a lot of computational time is wasted on finding solutions that will be discarded.

Shortest Paths with the Smallest Number of Transfers

As described in the previous section, alternative solutions might be of interest, but it is a nontrivial task to find them. A special case that is of practical importance is minimizing both the time spent traveling, and the number of vehicles used.

In the mathematical literature, these problems are called multi-objective optimization problems. Usually, the objectives given contradict each other. The best solution regarding the number of transfers is to simply walk from the origin to the destination, even if it might take a lot of time. Conversely, the fastest solution might require multiple transfers. Comparing just these two solutions is not obvious, not to mention all the other solutions in between these extreme cases.

Some solutions can be compared objectively. Let's describe a solution's quality as a pair of numbers: time, transfers. If solution A is not worse in either indicator than solution B, and clearly better in at least one indicator, then we can objectively call it a better solution. In mathematical terms we say that solution A "dominates" solution B. Using this notion, the acceptable solutions are those that are not dominated by any other solution (Pareto-efficient solutions).

Finding all Pareto-efficient solutions of a problem is usually a hard problem. However, if – as in our case – there are objective functions with discrete values, it becomes easier. If the fastest travel plan has four transfers, then there will be no Pareto-efficient solutions with more than four transfers. Effectively, we have to solve five subproblems: What is the fastest plan from A to B with at most 0, 1, 2, 3 and 4 transfers? This problem can be solved with a further generalization of Dijkstra's algorithm.

Results

Our mathematical model was implemented using the C++ programming language. Running times of simple shortest path queries are a fraction of a second, and even queries asking for multiple paths with different number of transfers do not take more than two seconds.

One possible way of utilizing this model is the development of a mobile application for travelers. It could be enhanced by real-time data on traffic, parking availability, etc. An interesting research direction is the efficient control of a large number of people, where the individual objective is to reach the destination fast, but when the model has to account for the system's capacities as well (avoiding congestion, respecting maximum loads on public transportation).

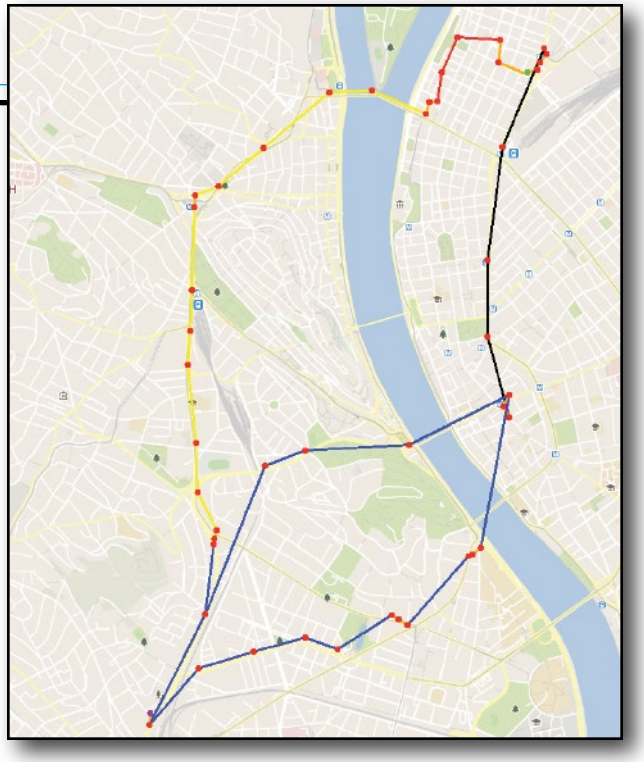

Figure 3: Alternate travel plans from Point A to Point B.

Another possibility is to use the model as a simulation tool. It could be used in the planning phase to answer questions on how introducing new public transport lines would change traffic behavior, as well as for predicting the effects of driveway maintenance of a frequented segment. ORMS

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Dairy farmers face a number of interesting questions, starting with: Could my cows produce more milk?

Markov chains and dairy farming in Croatia

Collaboration of Department of Mathematics University of Osijek and Farmeron produces promising results for production efficiency.

By Nenad Suvak, Zoran Tomljanovic, Kruno Strazanac and Marijana Zekic-Susac

Since its founding in 1992, the Croatian Operational Research Society (CRORS) has aimed to motivate its members and other researchers to develop new methods of operations research (O.R.), as well as to implement those methods in business practice. Many projects of applying O.R. methods in Croatian companies have been conducted in production, supply chain, sales, transport and other areas. Croatian researchers traditionally exchange their ideas and experience at the International Conference on Operational Research (KOI), organized by CRORS every other year. One example of successful implementation of O.R. methods is the collaboration of mathematicians from the Department of Mathematics, University of Osijek, with the software company Farmeron Ltd. Based in Osijek, Croatia, Farmeron develops information systems for dairy farms.

With the world's population expected to grow to more than 9 billion by 2050, all of us should be concerned about food sources and the way our food is produced. According to Farmeron, a cloud-based business IT solution provider for running agricultural enterprises, the next big revolution in agriculture won't come from new tractors or fertilizers. Rather, it will come from radical improvements in production efficiency – driven by data. The same goes for the world of dairy and cattle farming.

In this new environment, dairy and cattle farmers face a number of interesting questions: Could my cows produce more? Are we looking at the transformation of the dairy business model? How would increasing the cow conception rate affect my business? What if the price of corn goes up a dollar? How will my operation project out 18 months? Or three years? What if I get cows to eat another pound of dry matter? Is benchmarking against other farms valuable?

All of these questions – and many more – can be answered with the help of O.R. and analytical software tools that shift the focus from herd management to improving the odds of a dairy farm business succeeding in times of change.

Collaborations between academia and the business world often generate smart problem-solving solutions. Kruno Strazanac, head of technical support at Farmeron and a former graduate student in the Department of Mathematics at the University of Osijek, turned to the university's math department for help when presented with some practical, real-world problems. As a result of the discussions, the group came up with the idea of applying Markov chains in order to minimize the expected cost at dairy farms. That, in turn, led to collaboration on a scientific paper, "Markov decision processes in minimization of expected costs," co-authored by Strazanac, along with Marija Rukav, Nenad Suvak and Zoran Tomljanovic from the Department of Mathematics at the University of Osijek. The paper was first presented at the KOI 2014 conference, and an extended version of the paper was later published in the *Croatian Operational Research Review* journal (Vol. 5, No. 2).

The project deals with a specific problem that appears on dairy cow farms – the possibility of lowering the expected cost in milk production. The model the team developed provides a solid foundation that needs an upgrade with specific domain knowledge from a veterinarian and a nutritionist in order to be implemented as a decision tool in solving problems at farms. Farm activities such as animal feeding, medical treatment, breeding and milk production generate huge amount of data that make it possible to apply optimization and non-optimization models aimed at increasing farm efficiency.

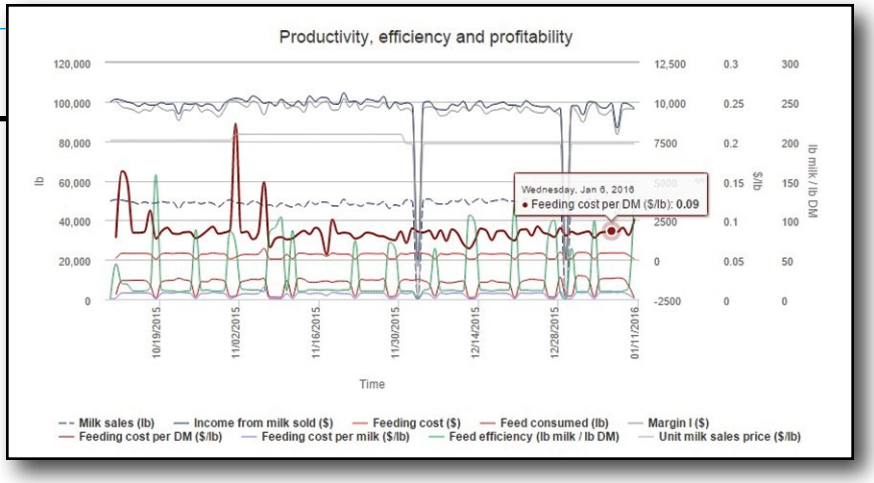

Figure 1: Productivity, efficiency and profitability chart analysis in Farmeron's software.

Looking forward, similar collaborations could be used to address such related topics as:

- optimization of livestock feeding;
- time series analysis of food prices and milk production;
- assessing the optimal time for removing an animal from a farm;
- analysis of influence of feed's nutritional value on the quantity, quality and income;
- analysis of influence of food optimization and food quality on the frequency of illness on the farms,
- analysis of statistically significant differences in productivity in case of different feeding procedures; and
- simulations of herd growth.

Together with other software companies in the Slavonia region that joined together in a non-profit association called "Osijek Software City," the employers of Farmeron contribute actively as guest lecturers on software programming at the University of Osijek. Given the impor-

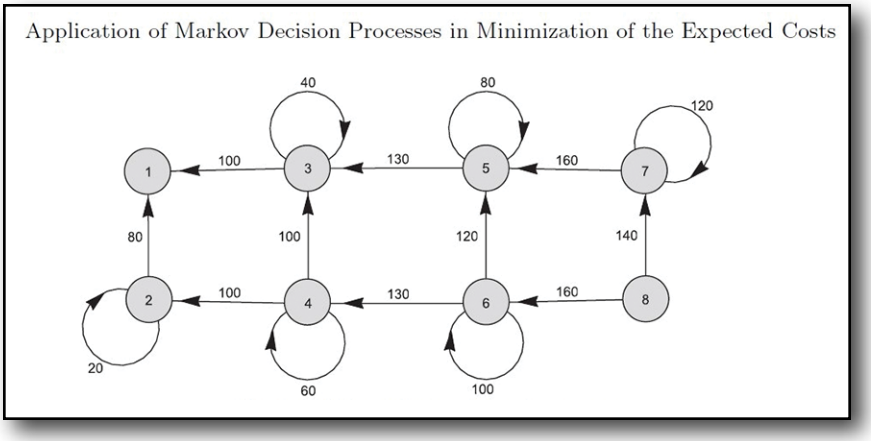

Figure 2: The scheme of decision costs.

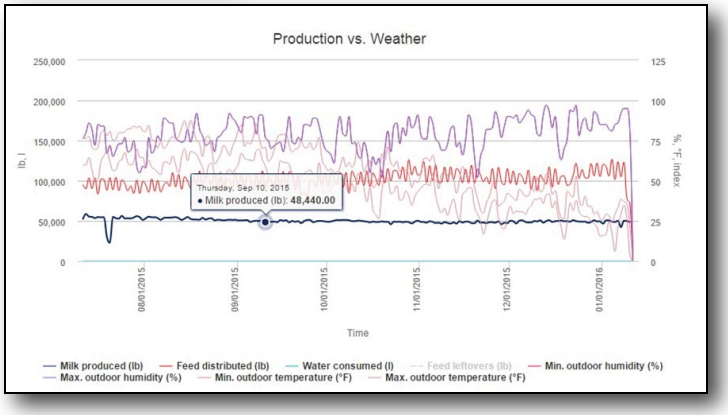

Figure 3: Analysis of production and weather conditions data in Farmeron's software.

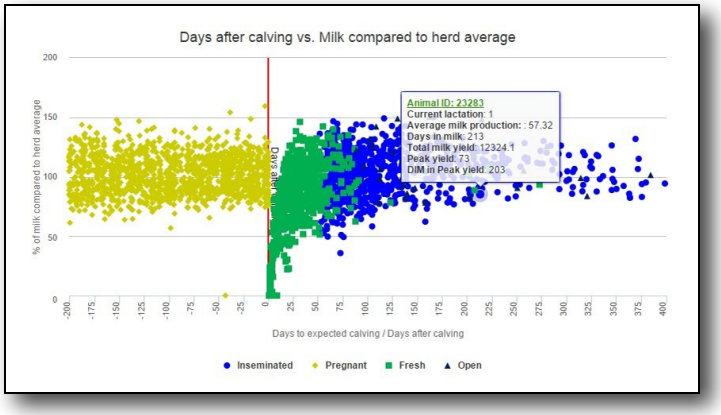

Figure 4: Days after calving vs. milk compared to herd average.

tance of scientific research for the growth of the economy, Farmeron continues its collaboration with scientific institutions throughout Croatia, as well as with the University of California–Davis and The Ohio State University in the United States. Besides investigating Markov chains, the company plans to test and implement more O.R. methods in its software to increase the efficiency of farm management and agricultural development in general. ORMS

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Kruno Strazanac *(kruno@farmeron.com) is head of technical support at Farmeron, where he coordinates data testing and analytics, account setups and overall back-office customer support activities.*

Marijana Zekic-Susac *(marijana@efos.hr) is a full professor, Faculty of Economics, University of Osijek, and president of the Croatian Operational Research Society.*

What's Your StORy?

Amanda Andrei

Senior artificial intelligence engineer,
MITRE Corporation
Member of INFORMS since fall 2015

What prompted you to enter this field? Why?
I became involved in the area of social media analysis when I was awarded an Early Career Research Project (ECRP) from MITRE. My topic was studying mixed-language social media in the Philippines. Around the time I started working on this project, Typhoon Haiyan/Yolanda hit the Philippines, and I focused on analyzing the Twitter communication emerging from the country. Since then I've applied social media analysis to various other topics, including healthcare and judiciary reform.

What is your favorite part about being involved in INFORMS sections and chapters, like the Social Media Analytics section?
I love working with highly intelligent and passionate people who want to apply their knowledge and skills to real-world problems. The Social Media Analytics section is interdisciplinary and diverse, which adds to the complexity and fun of working on a topic so new and rapidly changing.

If you had to work on only one project for the next year, what would it be?
I'd love to work on something interdisciplinary and collaborative at the intersection of science and art—like a theatrical performance that deals with artificial intelligence (I once saw a play where the Constitution was an automated text projected and interactively moving with the other characters—at the end of the show, we all applauded the software), or a computational problem like trying to get machines to recognize and analyze stories (right now at MITRE I'm on a project where one of our subjects is investigating narrative analysis from a machine-learning perspective – one of our main questions is, "How do you define a narrative?").

What is something you learned in the last week?
I finished the book *Why We Make Things and Why It Matters* by Peter Korn, a furniture maker. Part memoir, part philosophy, his writing made me think about different ways of thinking—for example, how carving a chair was a way to think without language and instead think with tools and wood.

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Peru is home to 200 operating mines and mining projects that could be worth as much as $59.5 billion.

Mining & mitigating social conflicts in Peru

Reflections from O.R. practice: How soft systems methodology can address "wicked" environmental and community issues to keep a key economic engine running.

By Vincent Charles

Peru is home to an estimated 200 operating mines and related mining projects that could be worth as much as $59.5 billion [1]. Two fundamental realities should be considered when it comes to the extractive industry in Peru: On the one hand, there is a great deal of pressure in and on the industry to get resources out of the ground. On the other hand, the industry is still facing many challenges. This article depicts the journey undergone in exploring one particular challenge that has been accompanying almost every new mining report: social conflicts.

Country Snapshot

Peru is located in South America, sharing northern borders with Ecuador and Colombia, an eastern border with Brazil, a southeastern border with Bolivia, and a southern border with Chile. In the west it is bordered by the Pacific Ocean. It is formed by 25 regions, which are located on the coast, the highlands and the jungle.

The Peruvian economy has grown at high rates in recent years, making it one of the best performing economies in Latin America during that time frame. Peru increased its per capita income by more than 50 percent over the past 10 years, and the projected rate of economic growth for 2015 was 2.9 percent. In a recent research study, Peru was classified as the country with the best "doing business" profile in Latin America [1].

The economic success has been to such extent that it made both academics and practitioners wonder whether it was indeed an economic miracle or just a mirage – this enquiry led to the creation of a Harvard Case Study [2], which anyone around the world can analyze and decide what the truth may be.

Peruvian Mining Industry and Social Conflicts

For the past three decades, Peru's model of economic growth has been fueled by the mining industry, and the expectation is that it continues to be the "engine of growth" of the country. Mining investment registers remarkable growth, with committed investments for 2011-2016 of approximately $42.5 billion. Peru holds an estimated 13 percent of the world's copper reserves, 4 percent of gold, 22 percent of silver, 7.6 percent of zinc, 9 percent of lead and 6 percent of tin. Peru is the third largest producer of copper, silver and zinc in the world and a major producer of gold.

The growth of the industry is dependent on the implementation of mining projects in the portfolio, which has shown significant signs of delay. According to a report issued by McKinsey & Company published in 2013, 40 percent of the projects in the portfolio have already been affected and/or delayed due to social issues and conflicts. These conflicts can and have resulted in the complete breakdown of the impacted companies' social license to operate. Statistics show that more than 40 percent of the conflicts involving local communities are about mining, having increased by 300 percent between 2008 and 2012, with an outcome of 2,312 civilians and police wounded and 195 killed between 2006 and 2011.

In the midst of this turmoil, local communities seem to have two major concerns: environmental degradation (water and land contamination) and lack of benefits to local communities affected by mining (the lack of improvement of daily life in the form of services, health, education or infrastructure, despite the enormous wealth generated by the mining industry).

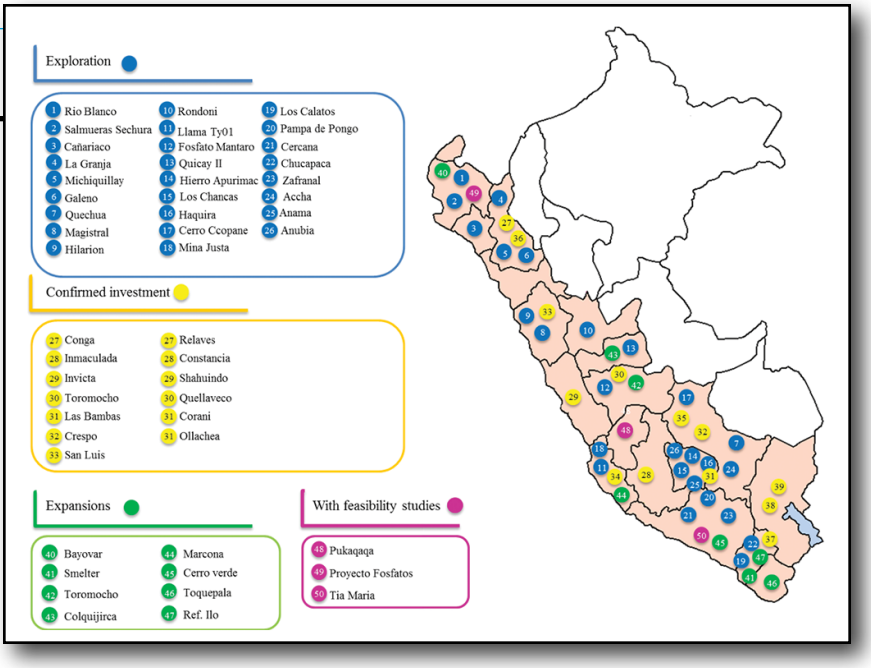

Figure 1: Considering the great number of mining projects being developed, social conflicts represent a real challenge to every stakeholder involved.

Source: EY Peru (2014) [1].

Taming the Wicked Social Conflicts

There is no doubt that the extractive industry can bring significant economic, social and environmental changes, having the potential to profoundly transform the Peruvian economy and communities. Throughout the years, many attempts have been made to resolve the conflicts, but these have generally been piecemeal short-term solutions. In 2012, for example, the government approved the Prior Consultation Law, which requires prior consultation with indigenous communities before any infrastructure or projects, especially mining and energy projects, are developed in their areas. However, it is this very last law that froze two multibillion-dollar mining projects: Conga (gold) in Cajamarca region and Tia Maria (copper) in Arequipa region, leading the president to call a state of emergency.

Some other examples that have made international news are the projects Cerro Quilish in Cajamarca, Tambogrande and Rio Blanco in Piura and Santa Ana in Puno. The situation of the mining conflicts is so complex that uncertainty and ambiguity prevail not only over the process, but over the relationships among the stakeholders, as well. All of the above factors contribute to the need for a better system for the extractive industry to support the Peruvian economy with greater concern toward social harmony.

The conflict involves myriad wicked problems – highly complex situations involving several interested parties with different perspectives over the problem situation in which there is no clear relationship between cause and effect, and which do not

Statistics show that more than **40 percent** of the conflicts involving **local communities** are about mining, having increased by **300 percent** between **2008 and 2012.**

Having no **well-defined objectives,** traditional mathematical **modeling tools of O.R.** become **ineffective.**

have a unique solution but only better or worse alternatives. Having no well-defined objectives, traditional mathematical modeling tools of O.R. become ineffective. However, they may be used at different stages as a means to pinpoint particular courses of actions to be further explored.

Different Roads to Problem Framing

What follows is a summary of the key features of both the hard and soft O.R. approaches adopted. The hard side of O.R. has been tackled through optimization and machine learning techniques, and it was mainly directed toward analyzing the already available data, before embarking on new avenues of enquiry. The soft side of O.R., as a means to deal further with the messy and unstructured problems, has been pursued through Soft Systems Methodology (SSM), complemented by Case-based Reasoning (CBR).

Developing a regional competitiveness index. The journey started in the late 2000s, at a time when we did not have access to any solid previous research study regarding the situation of the 25 regions of Peru. Ever since and almost every year, CENTRUM Católica Graduate Business School has been computing the competitiveness of the regions, based on five pillars (economy, firms, government, infrastructure, persons), factors and variables – in line with the approach of the International Institute for Management Development (IMD).

In 2013, we also devised an optimization-based method (Figure 2) to measure the regional competitiveness of Peru. This work received a "Most Innovative Study" award from Premio Poder to Peru's Think Tank of the Year. One of the remarkable insights was that the regions with the largest mining production in the country, mainly located in the highlands, do not necessarily rank high in competitiveness. This is known as the "resource curse," a paradox according to which regions with an abundance of natural resources, specifically minerals, tend to have less economic growth.

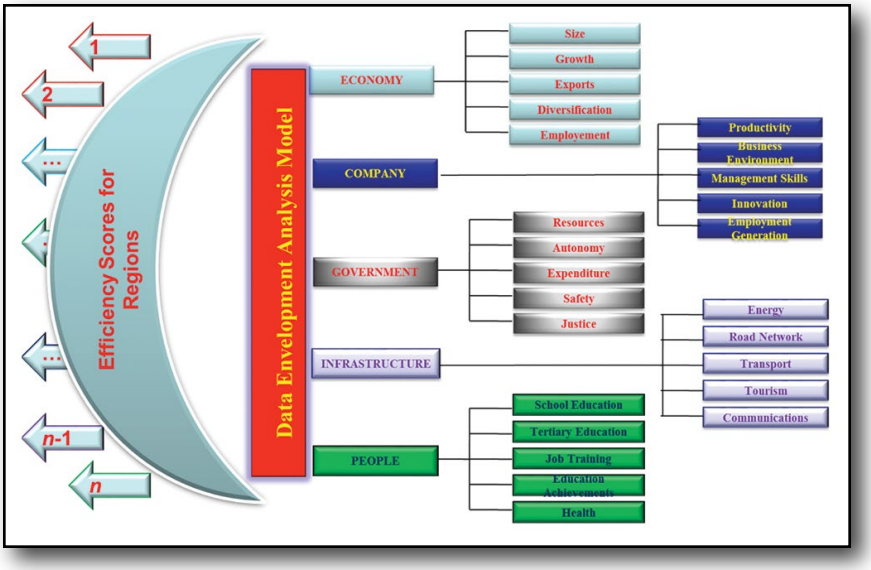

Figure 2: The structure of the regional competitiveness index.

Source: Charles & Zegarra (2014) [4].

Using machine-learning techniques to study the CSR practices of the mining firms. The general perception is that the more socially and environmentally responsible a company is perceived to be, the higher are the chances that the company will not be associated with or involved in social conflicts. The Corporate Social Responsibility (CSR) reports of the firms, although involving only documentary evidence, would be a good starting point to have an initial glimpse of such issues. But with voluminous CSR reports from multiple firms and spanning many years, analyzing them manually would become a "near-death experience." In 2013, and in collaboration with Cornell University, we proposed an automated way to extract important themes out of the CSR reports using machine-learning techniques – and we then used these themes to analyze the trends in various sustainability measures across firms and their alignment to global goals of sustainability.

The major themes of sustainability in the mining industry were formed based on themes previously identified by the Dow Jones Sustainability Index (DJSI) questionnaire (2009), the Mining and Metals Supplement of the Global Reporting Initiative (GRI) (2011), the study titled "Sustainability and Materiality in the Mining Sector" (2011) by Sustainalytics, the Principles of the International Council on Mining and Metals (ICMM) (2011), and the study "Sustainability in the Mining Sector" (2007) by FBDS. Preliminary results seem to indicate that firms lack coherence and discipline in their CSR strategies. We are currently working on intersecting the results with the knowledge of the experts in the field.

Using SSM to understand the socio-cultural aspects of the mining conflicts. SSM, the most well-known and widely used soft O.R. methodology, is comprised of several stages, not necessarily followed in a linear fashion. A rich picture (Figure 3) designed in Stage 1 is aimed at capturing the main actors and associated issues.

In Stage 2 we defined our root definitions using CATWOE, where:

- C (customers): Local communities, environmentalists
- A (actors): The state, mining companies, other companies
- T (transformation process): Unsatisfied local communities and environmentalists -> satisfied local communities and environmentalists

- W (worldview): The need for taking effective action to stop mining conflicts and prevent future conflicts
- O (owner): The state, mining companies
- E (environmental constraints): Environmental degradation, unruly behavior, unbalanced distribution of mining profits, lack of credibility of the public institutions, illegal mining

Based on the above CATWOE, various root definitions were generated, among which the following excerpt is chosen as an example: "The Peruvian mining industry is a system for ensuring that local communities feel they have their water and land cared for, are given opportunities for training and to learn new skills, have access to better services, health, education and infrastructure, having at the end of the day, a better life."

In Stage 3, a conceptual model (Figure 4) of the problem situation based on the above root definition was developed.

Stage 4 involved extensive work to compare the conceptual model advanced with what is perceived to exist in the real world. The realization was that not enough effort has been made in any area of concern of the local communities – with a fundamental issue residing in deficient communication and understanding. Furthermore, all the root definitions emphasized the strategic role played by all of the stakeholders in securing a better life for the local communities affected by mining, creating the context for social harmony.

But perhaps one of the greatest insights that we have obtained from the analysis performed in Stage 5 was regarding feasible and desirable changes to be made in the mining industry. One such insight pointed to the need to dedicate more resources to creating a platform that would allow the interaction between the various parties involved. The creation of a functional mining cluster as a possible change was laid on the table. Our next steps have been directed toward exploring this path.

Employing case-based reasoning to analyze the international experience. In line with the above insight regarding the development of a mining cluster in Peru, we have further directed our attention toward understanding the underpinnings of such an endeavor and alluded to the international experience. In this regard, we employed CBR, a process of solving new problems based on the solutions of similar past problems.

CBR involves four steps:

1. Retrieve the most similar cases.
2. Reuse the knowledge obtained from the cases identified to solve our problem.

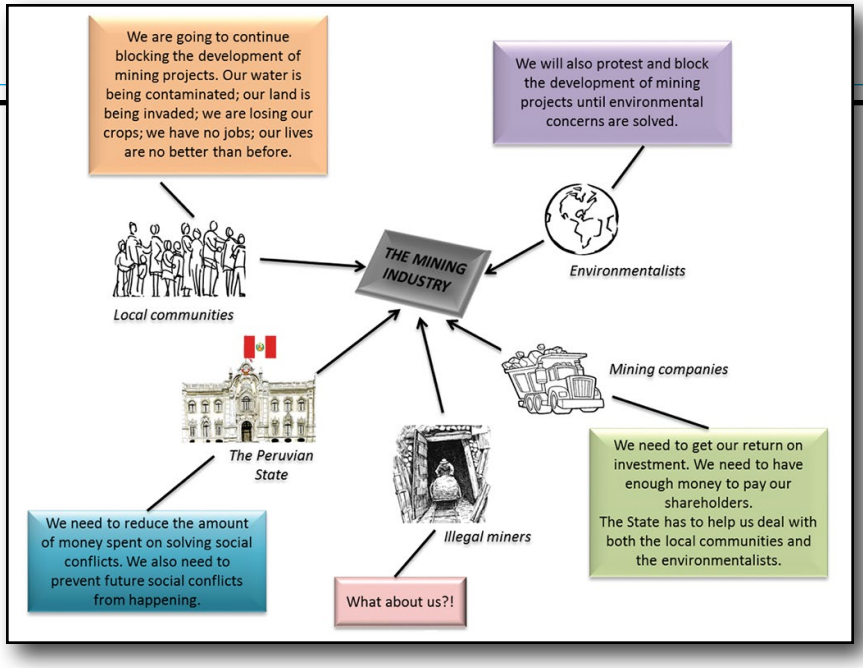

Figure 3: A simplified rich picture capturing the main actors and related concerns in the Peruvian mining industry.

3. Revise the proposed solution.
4. Retain the lessons learned and use this experience for future problem solving.

The last two steps of the CBR cycle are long-term approaches, and it is more in the hands of the concerned Peruvian authorities to find the means and to develop a strategy to implement our propositions.

Developing a mining cluster model for the Peruvian economy. Based on the CBR approach, we have retrieved both the most similar mining cases and the international stories of success from both Latin and non-Latin American countries. Hence, step 1 of the

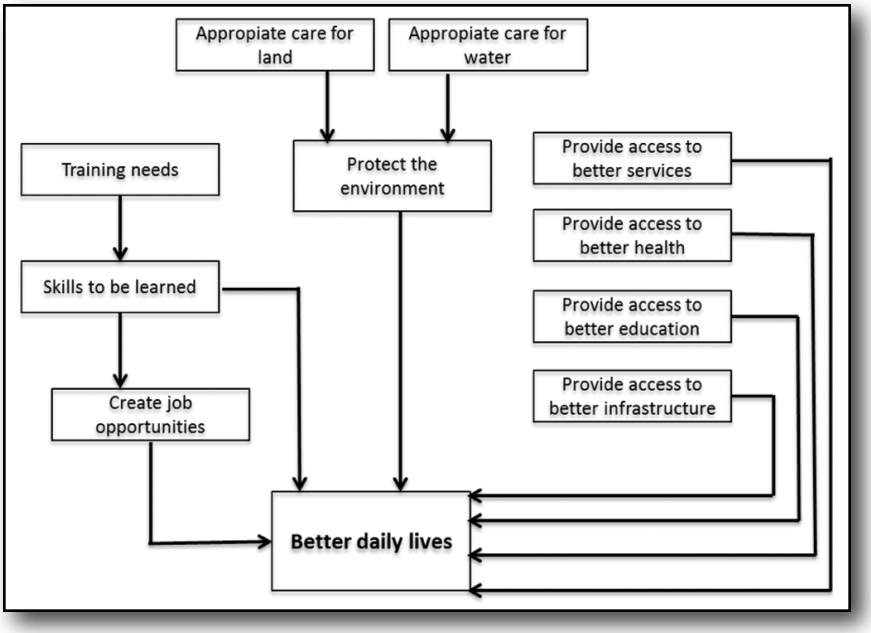

Figure 4: Excerpt from the proposed conceptual model (researchers' conceptualization).

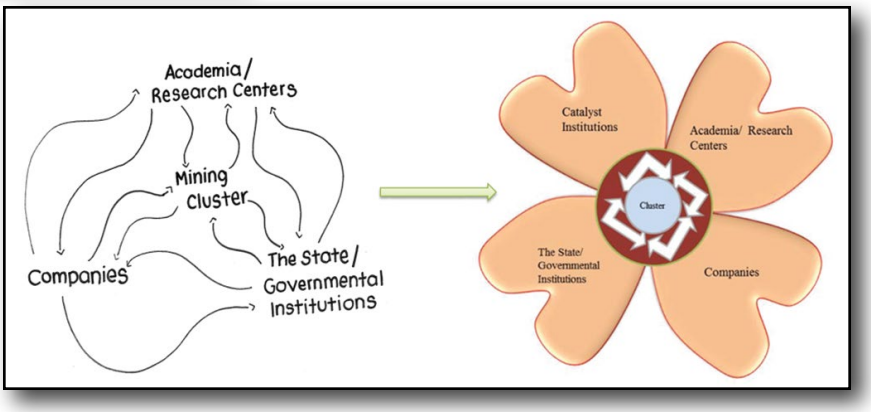

Figure 5: From the Triple Helix to the Four Clover Model for the Peruvian mining industry.
Source: Charles (2015) [6].

CBR process yielded a series of factors considered critical to the successful development of mining clusters: fiscal stability, adequate infrastructure, innovation and R&D capacity, skilled workforce and the presence of foreign investment. The analysis of all of these factors indicated the necessity of both the Peruvian State and businesses to interact and collaborate with the different academic and research institutes (the Triple Helix model).

Nevertheless, this result coupled with the insight obtained from Stage 5 of SSM led, in Step 2, to the need to adapt the Triple Helix and transform it into the Four Clover cluster model (Figure 5). In this model, a fourth partner, represented by the catalyst institutions (such as technology transfer, innovation centers and consultancy enterprises), is needed to promote dialogue and cooperation among the involved parties [5, 6]. This solution, although relatively simple, is quite uncommon in the Peruvian mining sector, as the process is primarily one of learning and negotiation rather than the technical solution of a problem. It requires extensive collaboration efforts, and it involves facilitated workshops of stakeholders that should be used to help them to think through the consequences of their beliefs, preferences and actions.

Lessons Learned and the Road Ahead

The Peruvian mining industry has the potential to generate significant investments toward economic development. However, these potentials are undeveloped as social conflicts militate against them. The research studies conducted so far enabled us to realize that we needed to intersect soft O.R.-based approaches with hard O.R. methods in order to obtain valid and practical insights.

In terms of practical implications, our analyses strongly suggest that attempts to understand the current situation must go as far as including analyses of social interactions on site. Soft O.R., complemented by behavioral O.R. as a means to capture human behaviors, can help in this regard. Concerned parties must understand that the complexity of social conflicts is determined not only by the variety of stakeholders and the economic-driven relationship existent among them, but also, to some extent, by socio-cultural aspects.

In many local Peruvian communities, the land is sacred and resettlement of their community for mining purposes is seen as both an invasion and a sacrilege. Unfortunately, concerned parties seem to miss its importance. In the messiness of social conflicts, there is some social order, which we may be able to discover only by personally and intimately immersing in it.

Another example is represented by the sensitive topic of illegal mining ("the hidden dinosaur"), which is present in 21 of the 25 regions of Peru and that also plays an important part in generating social conflicts. Besides the need to increase formalization in the sector, there is primarily a need for a more effective interaction, understanding and collaboration between the parties involved. Once more, this simply cannot be captured or modeled with mere numerics. Nevertheless, safety concerns in the Peruvian mining regions emerging from the above-proposed methodological approach are currently too big and too serious to be ignored.

The journey is long and wicked; nonetheless, progress has been made so far in structuring the problem and advancing conceptual models and possible solutions. It is our belief that the work advanced can form the basis for future real-world changes. And our journey continues. ORMS

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Pork is Chile's leading exported meat, accounting for $467 million in shipments last year.

Turning pork into profits in Chile

A decision support system for production planning in a Chilean swine slaughterhouse.

By Marcela C. González-Araya

According to the Chilean Office of Agricultural and Policies Studies (ODEPA), meat production in Chile is led by poultry, which is highly integrated and is concentrated in a small number of producers; poultry production totaled 669,054 tons in 2014. Ranking second, Chilean pork production has about 237,000 players who produce 550,000 tons or 38 percent of Chilean meat production. Beef production, with about 200,000 tons and 120,000 producers, ranks third.

Pork, however, is the main exported meat in Chile. According to the Chilean Association of Pork Producers (ASPROCER), in 2015 the value of pork meat shipments reached $467 million. This year, the pork sector constituted 60 percent of Chilean exported meat, and the trade balance was positive for the sector, exceeding $350 million. The leading destination of pork exports is South Korea with 30 percent, followed closely by the People's Republic of China.

Due to the growth of the Chilean pork industry in recent years, the sector has made an effort to maintain its international competitiveness and export to the most demanding markets in the world with high standards of quality and safety, such as Japan, South Korea and the European Union (EU) in order to compete with the world's largest exporters, led by the United States. This growth in exports has increased the complexity of the swine industry in Chile, forcing companies to become more specialized and dynamic in order to adapt to the changes and to maintain profitability over time. However, many Chilean companies are unable to react efficiently to these changes.

Because of this new situation, one Chilean pork company was interested in developing a decision support system (DSS) based on optimization models for planning production, inventory and storage operations in its slaughterhouse. In this way, the company wanted to improve its plant efficiency and control, and to reduce meat losses, as well as the length of the decision-making process.

The company, the fourth largest pork producer in Chile, devoted its efforts to the production, slaughter and export of pork. It is located in the south-central region of Chile and belongs to ASPROCER.

The company's slaughterhouse currently includes 350 direct employees and 150 indirect employees and processes about 300,000 pigs with a meat volume of 30,000,000 kilos a year. The plant has 10 chilling tunnels with a capacity of 200 tons, six chill rooms for carcasses and one cold storage with capacity of 1,200 tons.

For the development of the DSS, the slaughterhouse manager contacted the author from the Department of Industrial Engineering, Universidad de Talca, Chile, and her master's degree student in operations management, Rodrigo Sánchez-Ramírez, who was doing his thesis based on a slaughterhouse production planning problem of the company.

The DSS development was possible through a project for promoting productivity and competitiveness of the Chilean industry, where approximately 80 percent of the funds came from the state (Development Corporation of Production - CORFO), and the remaining amount came from the company. González-Araya was the director of this project and was in charge of its implementation, which lasted 30 months and was started in March 2012. Besides the director, the project team consisted of five engineers: two industrial engineers (Ariel Bustos-Véliz and Wladimir Soto-Silva), one computer engineer (Juan Monsalve-Martínez) and two engineers expert in swine processes (Rodrigo Sánchez-Ramírez and César Rodríguez-Muñoz).

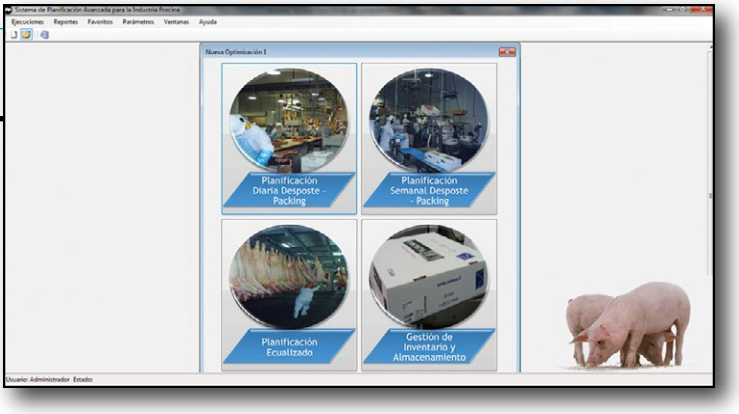

Figure 1: Screen of planning options for improving production processes.

The stages for the DSS development were: data collection and diagnosis of slaughterhouse production processes; models formulation, solution and validation; and design and implementation of DSS.

Production Planning in the Slaughterhouse

As evidenced in practice, Chilean swine companies have not invested in infrastructure to increase production capacity in proportion to the demand increase. Therefore, they had to focus on improving production practices, as is the case of the company where the DSS was developed.

In recent years, the company's exports have experienced sharp increases, as have the number of offered products. As an example, the variety of products increased from 50 in 2007 to 400 at present, thus increasing the complexity of coordination activities. Because of this, the slaughterhouse professionals stated that, despite having international markets required certifications, a computer system for process optimization was necessary in order to support decision-making production and logistics in the pork value chain. The lack of this tool meant that the time required for obtaining production planning estimates were high, involving breach of contracts by production delays and loss in product quality, among other issues. The complexity was compounded, because the product is highly perishable.

Before the DSS implementation, two engineers carried out the production planning. Once a week,

The company **wanted to improve** its plant **efficiency and control,** and to **reduce meat losses,** as well as **the length** of the **decision-making process.**

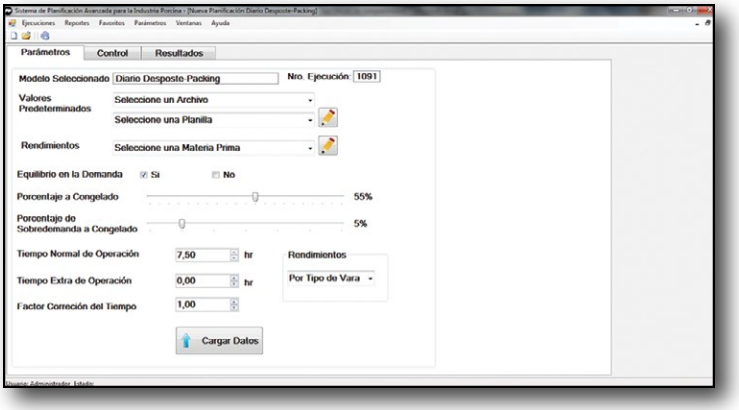

Figure 2: Data entry screen for daily planning model.

they took more than three hours to obtain a weekly schedule. This schedule considered one planning scenario. In addition, the company had a professional in charge of reviewing daily changes in the assumed data for planning. This way of planning did not allow the company to react quickly to reschedule production due to unforeseen circumstances, a common situation because of the variability of markets. Nor did it allow for sensitivity analysis of critical data used in planning. This situation is similar with other Chilean companies in the swine industry. Because of this, the client company decided to automate production planning, aiming to also reduce the time for doing weekly and daily scheduling.

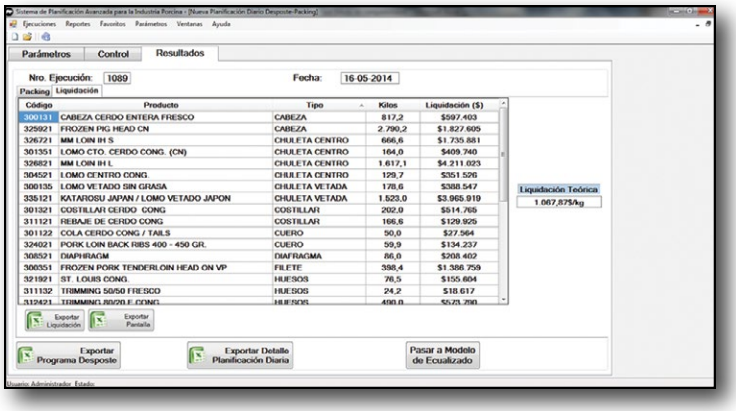

Figure 3: Products profit screen obtained by daily planning model.

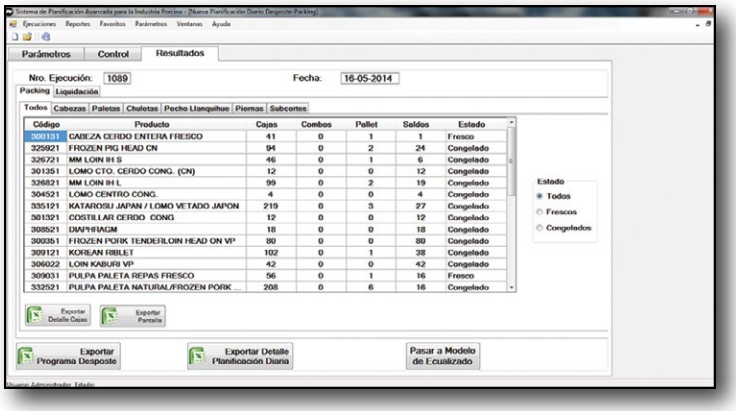

Figure 4: Products packing screen obtained by daily planning model.

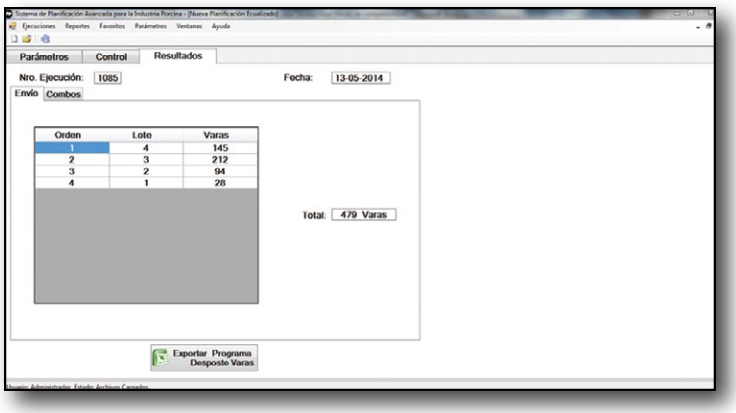

Figure 5: Batch sequence screen obtained by the model of chilling system management.

Additionally, like other industries, the swine industry is highly sensitive to the raw material productivity (final weight/live weight). Actual yields of productive tasks were unknown for the company, i.e., there were no estimates of yields according to different cuts (products and by-products) and pig varieties (kg/pig), so it was unknown if the pig allocation for obtaining the different cuts was efficient, hindering the reduction of raw material losses. For this reason, the DSS also incorporates records of production inputs and outputs (products and by-products), making it possible to obtain yields by pig breeds and kind of cut, as well as production analysis reports.

DSS for Advanced Planning Production

The DDS was designed to support operational decisions in a swine slaughterhouse, aiming to minimize costs of production, storage and meat losses. For this purpose, four optimization models were developed; each one was associated to a DSS module (see Figure 1). The optimization models are the following: daily planning model of cutting and packing; weekly planning model of cutting and packing; model of chilling system management; and model of storage management. As is seen in Figure 1, the user (slaughterhouse manager) can choose the planning option he/she requires to do.

The language used to program the DSS interfaces was Visual Studio 2010, and the optimization models were run in commercial software bought for this implementation.

For running the daily planning model of cutting and packing, it was necessary to do a data collection for estimating yields according to different cuts and pig varieties. Therefore, two interviewers were hired and a sampling design was performed in order to obtain robust yields estimations. This activity demanded more time and resources than other project activities. On the other hand, the required information for running the other models of DSS was available in the company's information system.

The daily planning model of cutting and packing allows the decision-maker to schedule the number of pork carcasses to use according to its weight and kind of cuts to produce, the kilograms of products and by-products obtained in normal time and extra time, the number of box and pallets to use, the unsatisfied demand kilograms of products and by-products and the products' profit. Previously, the decision-maker had to update data representing the

current state of the plant as demands, costs, operation times and chilling capacities. Figure 2 shows a data entry screen where the main of parameters are set by default. The user can change these parameters according to daily production requirements. Figure 3 presents the profit screen by product, and Figure 4 shows the number of box, pallets and remainder by product obtained with the daily planning model. All these results can be exported to an Excel file.

The weekly planning model of cutting and packing allows the user to estimate shipment date per customer, days late per customer, state of shipment per customer (ready or pending), number of carcasses to use by product in each shift, kilograms of products obtained per shift, kilograms of products shipped each day and kilograms of products in cold storage each day. The weekly and daily models are complementary since the weekly model allows an ideal production planning, and the daily model allows a reschedule based on changes that may occur during the week.

According to the results obtained from the daily planning model, the model of chilling system management seeks to schedule the entry of pig batches from the chill room to the slaughter room in order to improve efficiency of slaughter and packing processes and to reduce downtime. Hence, this model proposes, besides the pig batches entry sequence, the carcasses number to use per batch and by product, and the maximum number of products to yield per batch. Figure 5 shows the batch sequence and number of carcasses used in a day for achieving products demand.

Finally, the model of storage management organizes the products in the cold storages according to their class: ham family, loin, ribs and bellies, shoulder family and pork sheet. The model assigns the aisles to use by class, the name, code, class and position for each pallet, and the positions number to use per cold storage.

Conclusions

For developing the DSS, one of the main difficulties was to form the team, especially to find a computer engineer that understands optimization models and to hire industrial engineers able to program advanced routines. Therefore, for future projects, we recommend estimating the learning time of developers.

Besides the DSS implementation, an important contribution of this project was the yields estimations. These estimations also can be used in any Chilean company if it does not have the data, and the methodology for obtaining this data can be replicated. In addition, it is very common that companies do not register all necessary data for making decisions. On the other hand, companies usually collect data through information systems that are not used in any kind of analysis and do not carry out business intelligence.

ITEM	DESCRIPTION	VALUE (USD)
Fulfillment with foreign customers	4% of annual production	1,208,944.43
Increase of profit margin	USD 0.005 per live kilogram	2,266,770.08
Reduction of inventory stocks	0.10% of current production	10,804.94
	Total Annual Profit	3,486,519.45

Table 1. Estimated annual profit with DSS implementation

It is noteworthy that the formulated models can be adapted to other swine companies in a short time.

During this implementation, the company realized that some production processes could be improved and formalized, thus introducing changes in its practices. This kind of development makes it possible to identify inefficient tasks that can be corrected without investment in new technology.

Among the results for improving production planning, higher profit margins were obtained, reaching increases of half a cent (U.S.) per live kilogram, an important contribution in an industry of low profit margins.

Other indirect results perceived by the company with the DSS implementation are:

- Decrease of foreign customer loss for non-compliance. Each foreign customer loss generally amounts to USD 0.03 per meat kilogram, assuming it can be sold in the domestic market.
- Reduction of inventory stocks around 0.10 percent, due to the weekly schedule that allows a better control in the cold storages and optimizes how to complete the products shipments.
- All these improvements imply an annual increase of profits around $3.5 million as calculated in Table 1.

Future development of the DSS is to interact directly with the company's information system instead of reading entry data from Excel files. The use of Excel files was suggested by the company's managers because of some apprehensions about the information system manipulation. ORMS

Marcela C. González-Araya *(mgonzalez@utalca.cl) is an assistant professor in the Department of Industrial Engineering, Faculty of Engineering, Universidad de Talca in Curicó, Chile.*

One of the **main difficulties** was to **form the team,** especially to find a **computer engineer** who understands **optimization models.**

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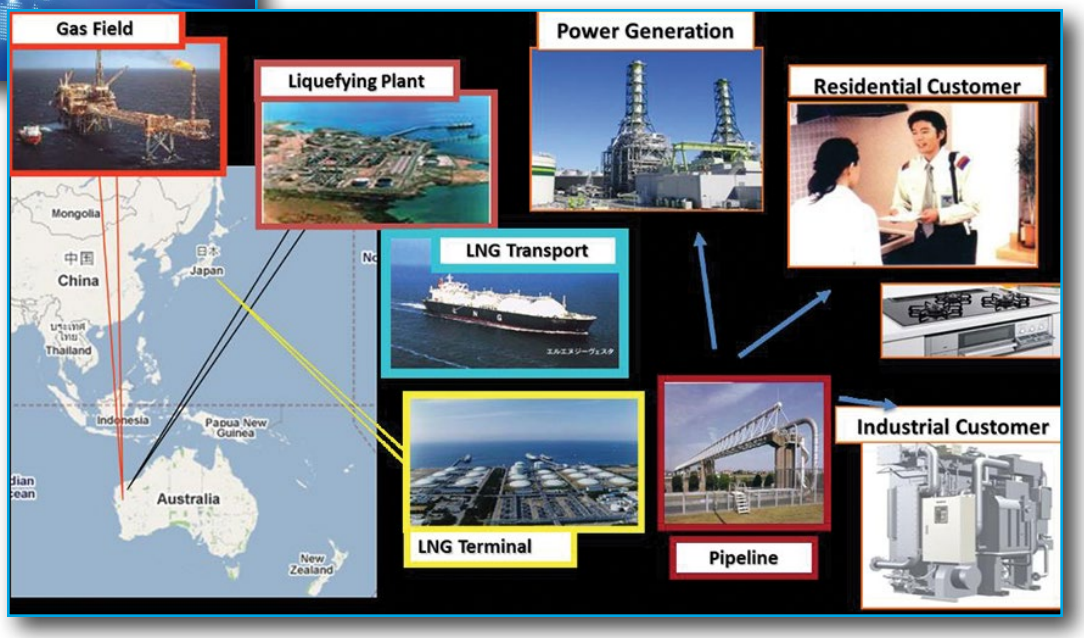

Figure 1: The business areas of Tokyo Gas.

Operations research at Tokyo Gas

From demand forecasting to emergency response, Japan's largest city gas supplier counts on O.R. to advise the company's decision-making process.

By Kosuke Shaku and Toshinori Sasaya

Tokyo Gas, which is Japan's largest city gas supplier catering to more than 11 million customers in the Tokyo Metropolitan area, has been conducting operations research (O.R.) for more than 40 years, mainly in the following areas:

- ***Marketing:*** How to increase the sales of gas, electricity and appliances (e.g., demand forecasting of gas appliances, gas/electricity pricing)
- ***Emergency response:*** How to respond swiftly to accidents (e.g., gas leaks) and emergencies (e.g., earthquakes), and optimizing the dispatch of employees
- ***Customer satisfaction:*** How to enhance customer service efficiency (e.g. human resource planning in call centers)
- ***Liquefied natural gas procurement planning:*** How to make decisions pertaining to the procurement of liquefied natural gas (LNG) (e.g., optimizing the balance between long-term LNG contracts and spot LNG contracts

This article introduces two typical instances that describe how O.R. is applied to our business.

Marketing:
Demand Forecasting of Gas Appliances

Tokyo Gas has more than 70 service shops that sell gas appliances (e.g., hot-water heaters), residential fuel cells (also known as ENEFARM) and floor heating systems, among others. In addition to increasing appliance sales, these shops help increase the volume of gas sales. Therefore, the sale of more gas-consuming appliances is promoted over that of less gas-consuming ones. For example, selling a residential fuel cell that generates both hot water and electricity is given higher priority than a conventional hot-water heater.

In order to devise a reasonable strategy to raise the sales of such gas-consuming appliances, we forecast the demand for such appliances by utilizing the customer relationship management (CRM) data from our CRM systems. These systems record the history of the company's relationship with every customer, such as the records of customers owning gas appliances. Related data from the system are pulled up in the following manner in order to estimate the replacement demand.

- Step 1: Count the number of stocked appliances.
- Step 2: Calculate the probability of replacement by conducting a survival analysis of the gas appliances.
- Step 3: Estimate the transition probability of the types of appliances that need to be replaced.

By multiplying these three elements, we are able to forecast the potential demand for each type of appliance.

The results of this analysis are utilized in the following manner:

Setting fair sales goals: As mentioned earlier, Tokyo Gas has more than 70 service shops. Given that these shops compete with one another with regard to the achievement rate of their sales goals, it is very important to set a fair sales goal that corresponds to the demand of each area to ensure proper sales management and efficient sales operations. However, determining "fair" sales goals is very difficult because the demand for gas appliances depends on the wealth or the condition of equipment in different areas. Therefore, we consider sales goals to be proportional to the scientifically estimated demand in areas consisting of individual service shops.

Reducing the cost of the wholesale purchase of gas appliances: To achieve incentives from bulk orders, Tokyo Gas purchases all the gas appliances that would be sold by all the 70 service shops instead of purchasing them individually. To reduce the purchase cost and avoid over-ordering, the precise forecasting of appliance demand is essential. Thus, we forecast the appliance demand for several upcoming years.

Area marketing (effective marketing that reflects area characteristics): The characteristics of each area served by our shops are distinctive. For instance, one service shop is located in an urban area with mostly apartment houses, whereas another is located in the suburbs with mostly stand-alone houses. As a result, the proportions of the types of gas appliances stocked for each area differ significantly. Thus, in order to implement effective sales promotion measures, we must

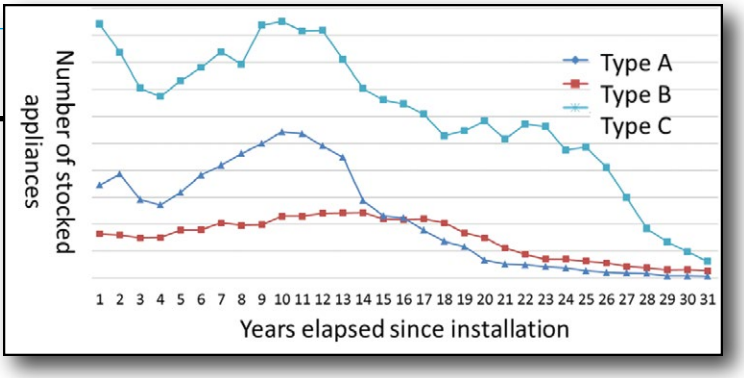

Figure 2: The number of stocked appliances (Step 1). Here, we aggregate the data on customer ownership of appliances based on the years elapsed and on the type of gas equipment (e.g., more gas-consuming water heater: Type A; less gas-consuming water heater: Type B).

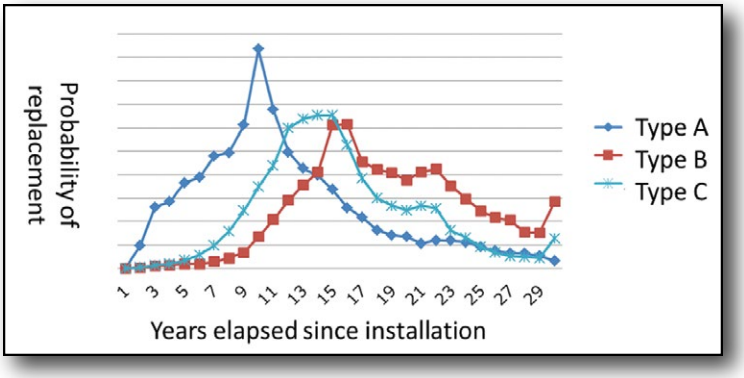

Figure 3: The probability of replacement (Step 2). We calculate the probability of replacement by using survival analysis by considering the so-called right censoring. Based on the years elapsed and the type of gas equipment, we aggregate the number of replacements as the numerator and the number of stocks as the denominator from the CRM system.

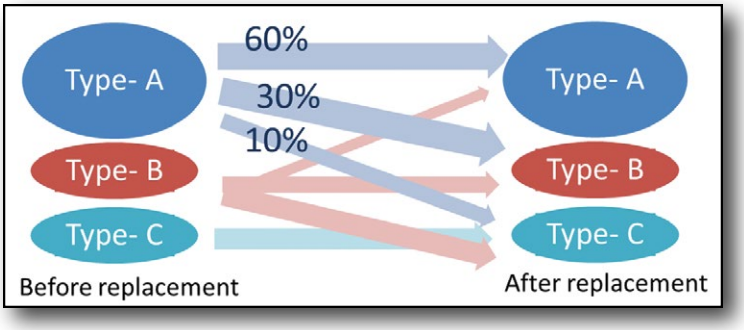

Figure 4: The transition probability of the types of appliances that need replacing (Step 3): the probability of change in the type of appliance from type-i to type-j.

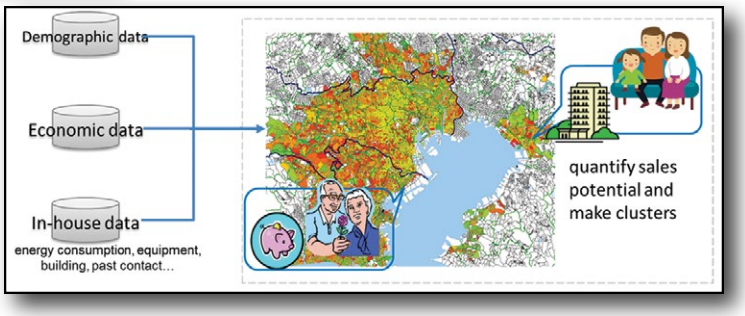

Figure 5: A conceptual image of area marketing.

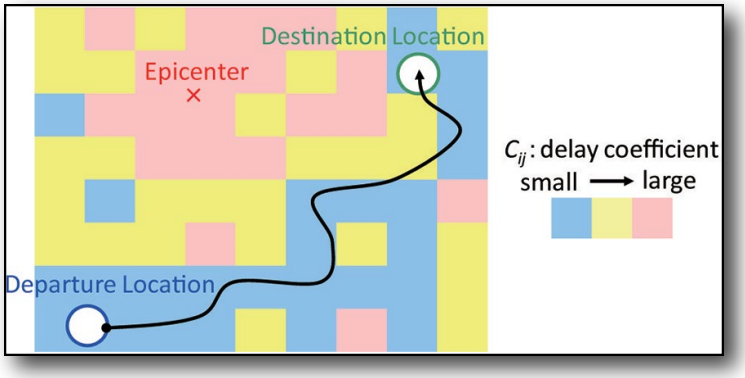

Figure 6: A conceptual simulated image of employee travel.

analyze the characteristics of and respective demand of each area. In fact, we are initializing a trial in which a service shop uses the estimated potential and cluster data on sales promotions. For example, we send direct messages to customers residing in an area with a high demand forecast in order to drive sales.

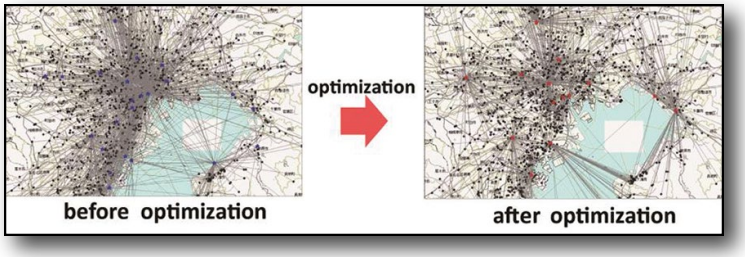

Figure 7: A conceptual image of dispatch optimization.

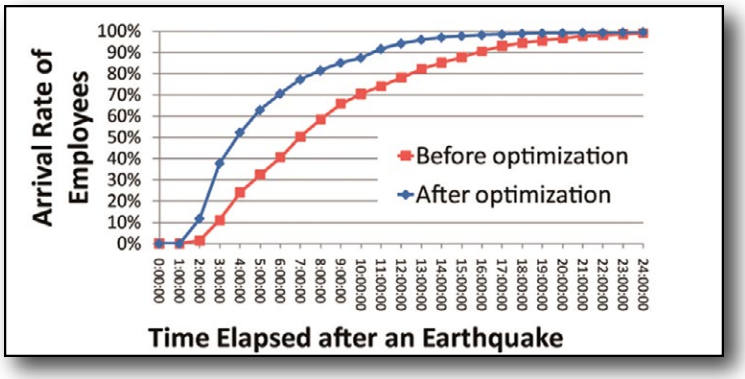

Figure 8: The effects of the optimization.

Emergency Response: Dispatching Employees in Case of an Earthquake

When large earthquakes occur, Tokyo Gas employees are dispatched to predesignated locations, even when they are off duty. Transportation systems often become non-functional, thereby forcing employees to walk long distances, consequently prolonging response times. In order to get employees together quickly, we optimize the assignment of each employees in the following manner.

Step 1. Simulation of employee travel: Search for the shortest path from the departure location to the predesignated destination by using Dijkstra's algorithm while considering road widths and the estimated delay coefficient.

Step 2. Dispatch optimization of employees: The average travel time required to reach each predesignated location is minimized under the constraint of staff requirements. We subsequently redesignate the target locations by optimizing employee dispatch to minimize travel time.

As a result, we allocated 1,300 employees to 13 offices. Our results showed that travel time can be significantly improved by this optimization; we thus changed the allocation rule successfully.

Future Work: Electricity and Gas Market to be Freed

In Japan, electricity and city gas sales have long been restricted to only one company in one district. However, the longstanding rules of electricity sales will be abandoned this April, and those of gas sales the following year.

In this scenario, Tokyo Gas is determined to begin the sales of low-voltage electricity and aims to become a "total energy company." We are currently conducting operations research in several relevant fields.

In order to win electricity accounts and defend gas accounts effectively, we are utilizing CRM data and other available data (e.g., national population census data) for segmentation, targeting and other marketing measures. In addition, we are optimizing our electricity/gas tariffs in order to realize strategic pricing.

To maximize profits in power procurement, we are optimizing the operations of our own power plants and amount of trading simultaneously (asset optimization and trading).

The fields in which operations research is essential for our business are increasingly expanding. ORMS

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The Three Gorges Dam, which spans the Yangtze River in Yichang, Hubei Province, China, is the world's largest power station in terms of installed capacity (22,500 MW).

China: Water conservancy & hydropower engineering

Effectively managing huge construction projects and efficiently harnessing vast water resources becomes more critical as demand for energy increases along with environmental concerns.

By Jiuping Xu

Civilization initially developed beside rivers and, as people's understanding of nature grew and societies matured, the resulting demands led to the development of water conservancy and hydropower engineering projects. The first embankment dam built in ancient Egypt around 2,900 B.C. was an example of early water conservancy engineering. The

legend of Great Yu, who controlled the waters in the Chinese heartland around 2,000 B.C., also reflected the wisdom of the ancestors. Around 1,754 B.C., the promulgation of the Code of Hammurabi started the civilization of the spirit of the water. The Law of the Twelve Tables, enacted around 450 B.C, gave rise to the water resources allocation equity principle and was the source of Ronald Harry Coase's thoughts on property rights theory. The Dujiangyan Irrigation system built in 256 B.C. was an engineering masterpiece in the history of hydraulic engineering project development. Over more than 5,000 years, water conservancy and hydropower engineering has been developed from the wisdom of many sages. In 1878, the first modern dam was built in France and four years later in 1882, the first hydropower station was built in Wisconsin in the United States, after which water conservancy and hydropower projects spread rapidly around the world. Today, large-scale water conservancy and hydropower engineering construction projects have become not only critical infrastructure for renewable energy development, but also strategic projects for the trade-off between economic development and ecological balance in river basins.

Large-scale **water conservancy** and **hydropower engineering construction** projects have become **not only critical** infrastructure for **renewable energy** development, but also **strategic projects** for the **trade-off** between **economic development** and **ecological balance** in **river basins.**

Scale and Distribution of Hydropower Resources in China

The world hydropower resources reserves are around 5.05 billion kilowatts (KW), of which China accounts for 694 million KW, ranking first in the world for both technical and economically available exploitation quantities. The installed capacity of economically available hydropower resources in China is about 541.6 million KW, and the annual generating capacity is about 2,474 billion KW, which is equivalent to an annual supply of 960 million tonnes of standard coal or 720 million tonnes of heavy oil. By 2015, China's hydropower installed capacity had reached around 325 million KW, with a revised future target set of 430 million KW (up from 380 million KW) by 2020. About 78 percent of the economically available hydropower resources in China are concentrated in the west, and are unevenly distributed in the middle and upper reaches of the Yangtze River, the middle and lower reaches of the Yarlung Zangbo River, the Yalong River, the Lancang River, the Dadu River and others in 11 administrative areas including provinces, autonomous regions and municipalities. With the above advantageous geographical conditions, the State Key Laboratory of Hydraulics and Mountain River Engineering at Sichuan University in southwest China has responsibility for the study and management of all relevant technical and environmental issues related to the water conservancy and hydropower engineering construction projects.

Necessity and Importance of Chinese Hydropower Resources Development

China became the second largest economy in the world behind the United States in 2015. This rapid economic growth has resulted in an increasing demand for energy, the exploitation of which has caused serious environmental issues, such as atmospheric haze, carbon emissions and water pollution. Coal remains the major source of China's total energy consumption, accounting for 64.5 percent in 2015. The second largest source, petroleum and other liquids, accounts for nearly 20 percent of China's total energy consumption.

In an effort to reduce the severe air pollution that has afflicted certain areas of the country in recent years, the Chinese government plans to diversify its energy consumption structure

The projects that are **planned** or **under construction** are increasingly **complex** in terms of **capacity** and **investment.**

by increasing renewable energy development. Hydropower is the most widely used form of renewable energy in China, and it has an extremely important position because China is ranked first in the world for available water resources, having around one-sixth of all water resources. However, compared with developed countries, hydropower resources development and utilization level in China is less than 40 percent of the economically available exploitation sources. Therefore, the potential for long-term hydropower resource development is significant.

Reason for Choosing Meta-synthesis Management

With the rapid developments in water conservancy and hydropower dam construction engineering technology, China has now entered an era of river basin cascade development, resulting in a significant increase in large-scale water conservancy and hydropower dam construction. The projects that are planned or under construction are increasingly complex in terms of capacity and investment, and contribute significantly to the promotion of economic development in the western areas of China. However, due to the massive construction size, complicated geographic situations, and difficult transportation and climatic conditions, large-scale water conservancy and hydropower dam construction management is facing unprecedented challenges. Construction plans formulated in advance are usually unable to adapt to the changes on the ground. These decision conflicts between the multiple construction sectors can lead to low resource allocation efficiency, construction delays, serious investment wastage and construction safety problems. Therefore, improving the efficiency, quality and safety of large-scale water conservancy and hydropower dam construction and realizing the optimal benefit of hydropower resources exploitation are critical current concerns.

Large-scale water conservancy and hydropower engineering construction projects are complex hierarchical and dynamic systems that can be divided into four stages: construction planning, materials purchasing and distribution, earthwork construction and concreting construction. The eight key problems encountered in these four stages include: 1) construction site layout, 2) materials purchasing and inventory, 3) hazmat transportation, 4) project scheduling, 5) earthwork allocation, 6) navigation scheduling, 7) equipment allocation, and 8) concrete pouring as shown in Figure 1. The inherent system complexities and interdependent characteristics of the construction system have motivated the development of a meta-synthesis management methodology to realize lean management for large-scale water conservancy and hydropower dam construction.

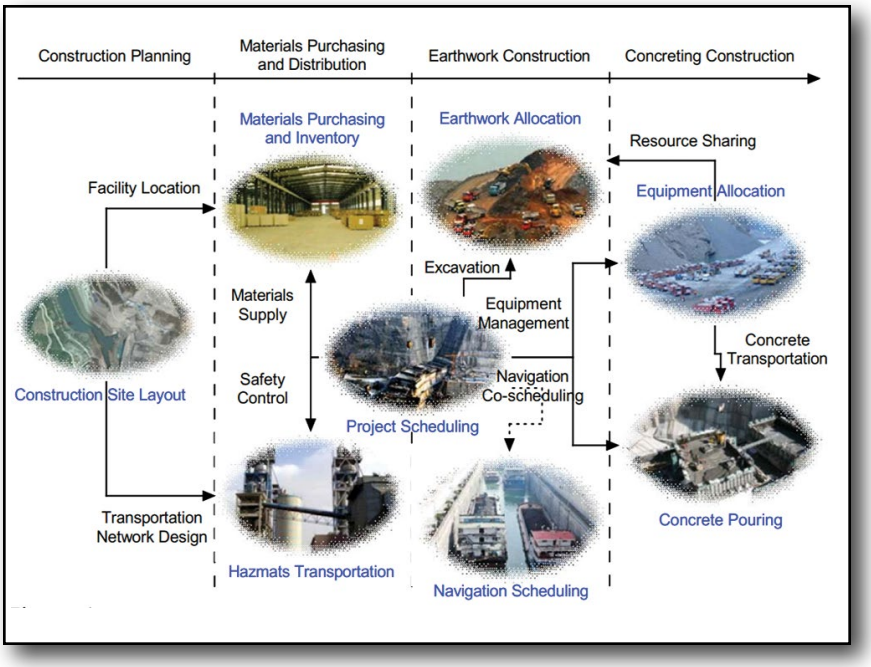

Figure 1: Problem map for the construction process of the main sections of large-scale water conservancy and hydropower engineering projects.

Eight Key Challenging Problems for Hydropower Dam Construction

In October 2007, a research team comprised of professors, engineers, postdoctoral fellows and Ph.D. candidates was established at the State Key Laboratory of Hydraulics and Mountain River Engineering with support from the China Three Gorges Corporation, the Yalong River Hydropower Development Company, Ltd., the Dadu River Hydropower Development Co., Ltd., the China Guodian Corporation and others. A research platform was consequently developed between the university research center and the hydropower development companies. Since then, the research team has focused on meta-synthesis management for large-scale water conservancy and hydropower engineering construction projects, and has participated in the construction of many of these projects.

The research team's studies have included developing multi-objective, multistage and multilevel model groups to solve complex problems

encountered in the construction process, such as transportation network optimization, vehicle routing selection, construction site layout and planning, project scheduling, construction materials inventory management, resource sharing-based equipment dynamic allocation with uncertainty, among others. To develop the theory and methodological system for the meta-synthesis management, investment management, project organization, construction planning, construction control, benefit evaluations and information integration have also been considered. The theoretical part of the team's research has been summarized in five books published by well-known publishers such as Springer and Taylor & Francis, and more than 60 academic papers have been published in peer-reviewed journals.

To promote sustainable hydropower dam construction under the meta-synthesis methodological framework, the team proposed the idea of ecological-based engineering management (Xu and Li 2012). Based on long-term research and practice, the team identified eight key challenging problems similar to those outlined above that were encountered in different, specific projects: 1) concrete transportation network optimization at the Jinping-I High Arch Dam Hydropower Project; 2) dynamic construction site layout and planning at the Longtan Hydropower Project; 3) project scheduling of large-scale deeply-buried tunnel group projects at the Jinping-II Hydropower Project; 4) multi-item dynamic purchasing and inventory control for construction materials at the Xiaolangdi Hydropower Project; 5) optimal control of resource sharing-based equipment and dynamic allocation with uncertainty at the Shuibuya Hydropower Project; 6) earth rock allocation and transportation under a multiple decision-maker environment at the Ertan Hydropower Project; 7) navigation coordinated scheduling for large-scale cascaded hydropower construction projects at the Three Gorges Dam Project; and 8) hazmat transportation network design with emergency response under uncertainty at the Pubugou Hydropower Project.

By combining system science and mathematical theories and methodologies, the team developed a decision and technological innovative paradigm called the "Theory Spectrum-Model Group-Algorithm Cluster" ("TS-MG-AC") paradigm, which has contributed to the study of the key problems using multivariant subjects, multi-level structures and multiple objectives to solve the eight key problems. These important modeling methods were summarized as classical methodologies for case studies in two books (Xu and Zeng 2014; Xu and Tao 2011).

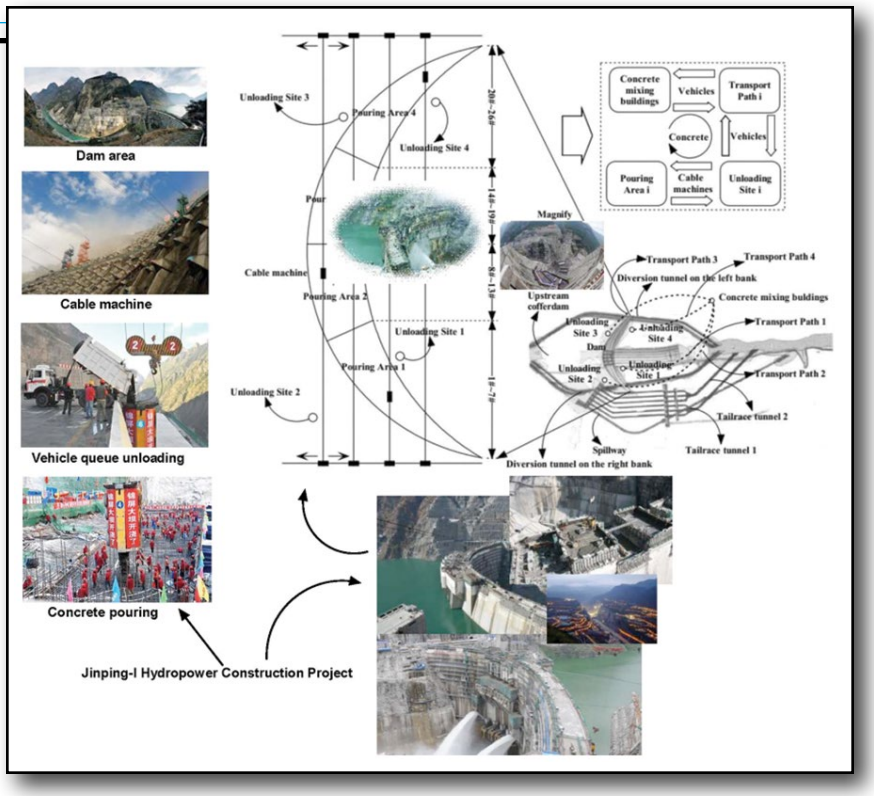

Figure 2: Meta-synthesis management applied to the multistage optimization of the concrete transportation system at the Jingping-I Hydropower Construction Project.

Applications to Chinese Hydropower Projects

The developed modeling approaches and algorithms have been applied to and implemented in several hydropower construction projects, including the Three Gorges Dam Project, the Jingping-I Hydropower Project, the Jingping-II Hydropower Project, the Longtan Hydropower Project and the Pubogou Hydropower Project. Taking the Jinping-I Hydropower Construction Project as an example (see Figure 2), the meta-synthesis management for the concrete transportation system significantly improved construction efficiency, with the net reduction in total operating costs for the concrete transportation system being about 4.17 million RMB (1 Chinese yuan = 0.1527 U.S. dollars) less than the planned budget, a reduction of about 7.33 percent. Further, the application of the meta-synthesis management also resulted in a net reduction in the total construction duration of about 3.97 months, a reduction of 6.91 percent. These construction efficiency improvements, therefore, brought considerable economic benefit to large-scale construction projects (Zeng et al. 2014).

The developed **modeling approaches** and **algorithms** have been **applied** to and **implemented** in several **hydropower construction** projects, including the **Three Gorges Dam Project.**

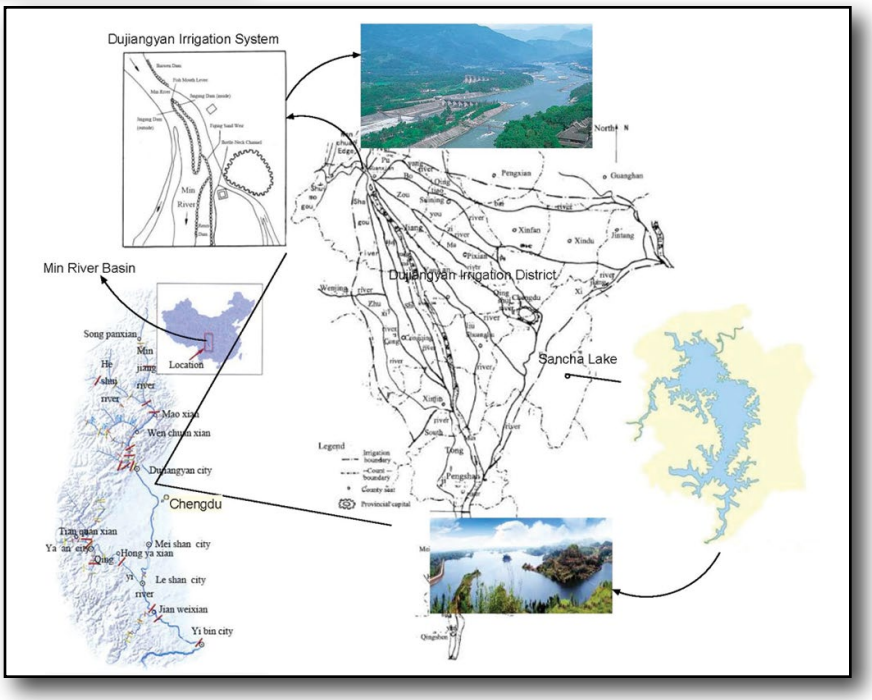

Figure 3: The Sancha Lake irrigation area in China.

Application to the Dujiangyan Longquanshan Irrigation System

For water conservancy management, the research team also developed the principle of multilevel water resource allocation optimization, especially for the bi-level optimization of regional water resource allocation and constructed wetland planning. Because of the new emerging problems arising out of the effects of climate change, we proposed and defined a leading-edge Stackelberg-Nash-Cournot dynamic equilibrium for multilevel water resource allocation. This work revealed the internal mechanism for the irregular distribution of water resources for climate change events, and explained the multilevel decision conflict structure in regional water resource allocation. This research work has assisted the Administration Bureau at the Dujiangyan Longquanshan Irrigation District in China in establishing a water supply management system for the Sancha Lake irrigation area (See Figure 3), within which a four-level early-warning mechanism for drought scenarios was successfully designed. "Equitable-effective-sustainable" macro-control policies and fundamental principles for the irrigation area were formulated, which has optimized water resource allocation for more than 1,500 hectares of farmland, 50 large-scale enterprises and 300,000 people, resulting in the sustainable utilization of the Sancha Lake irrigation area water resources and achieving significant social and economic benefits (Xu et al. 2013).

Future Research

To promote further improvements in water conservancy and hydropower construction engineering management, and especially to open the way for the development of integrated, systematized and sustainably-based modern engineering management, the team proposed four open engineering management (Jiuping Xu 2016) research foci for the future: 1) an effective integration management system for all large-scale hydropower construction projects; 2) isomorphism or homomorphism between the problem systems and the model systems of large-scale hydropower construction projects; 3) isomorphism or homomorphism between the model systems and the algorithmic systems for large-scale hydropower construction projects; and 4) the adjustability of major projects, such as considerations as to how large-scale hydropower projects may affect the ecological environment when the geological structure cannot be changed.

Today, integrated management has been recognized as a critical OR/MS methodology for the management of large-scale water conservancy and hydropower engineering construction projects not only in China, but all over the world. ORMS

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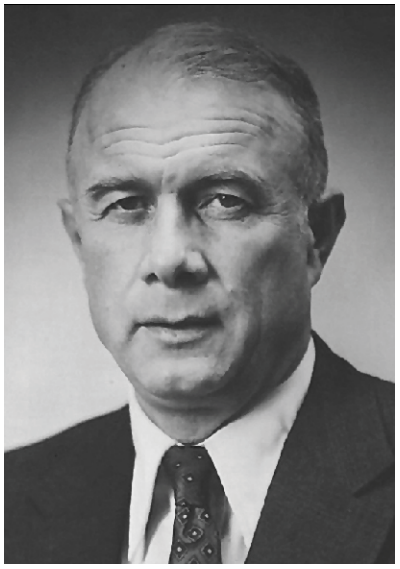

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Inside News

INFORMS International Conference set for Hawaii

Hilton Waikoloa Village Resort, site of the 2016 International Conference.

The 2016 INFORMS International Conference will take place on June 12-15 at the Hilton Waikoloa Village Resort on the Kohala Coast in Waikoloa, Hawaii.

The invited tracks will span the full range of emerging topics from global supply chains to social networks, and all aspects in between. This informative program is designed to educate attendees on current advances that are at the cutting edge of the field anywhere in the world. Through a series of diverse speakers, panels, tutorials and structured networking, this conference will offer attendees a forum for rich intellectual exchange on a broad range of OR/MS applications.

Gang Yu will deliver the plenary talk on Sunday, June 12. Yu is the co-founder and executive chairman of New Peak Group. Prior to founding New Peak Group, he was the co-founder and chairman of Yihaodian, a leading ecommerce company in China.

In addition to the technical tracks, the program also includes two receptions primarily focused on networking with colleagues and other international attendees.

Conference Chair Saif Benjaafar and the rest of the conference committee will host a welcome reception on Sunday evening. The Tuesday evening general reception will feature an authentic Hawaiian Luau that is sure to be a feast for all of your senses. Men and women in ornate costumes will perform a festival drum dance from the islands of Tahiti. A traditional Polynesian luau feast will be served as well. This event is included in the conference registration fee.

Registration fees for this event start at $630 for INFORMS members. Discounted student/retired rates are available. Early registration rates will expire on May 20.

For more information or to register, visit meetings.informs.org/2016international.

INFORMS nominations

The INFORMS Nominating Committee has provided the following slate of nominees for the elections to be held in summer 2016 (for offices beginning Jan. 1, 2017):

President-Elect
Nicholas Hall
Robin Lougee

Treasurer
Michael Fu
Dave Hunt

Vice President- Education
Jill Hardin Wilson (unopposed)

Vice President- Information Technology
Marco Lübbecke (unopposed)

Vice President- Meetings
Ron Askin (unopposed)

Vice President- Publications
Jonathan Bard (unopposed)

As provided in Bylaw 3, additional nominations by petition of at least 50 members for any of the open officer or vice president positions shall be accepted by the Secretary if received with all materials needed for ballot by May 31.

Call for nominations: INFORMS prizes & awards

John von Neumann Theory Prize

The John von Neumann Theory Prize is awarded annually to a scholar (or scholars in the case of joint work) who has made fundamental, sustained contributions to theory in operations research and the management sciences. The award is given each year at the INFORMS Annual Meeting if there is a suitable recipient. Although the Prize is normally given to a single individual, in the case of accumulated joint work, the recipients can be multiple individuals.

The Prize is awarded for a body of work, typically published over a period of several years. Although recent work should not be excluded, the Prize typically reflects contributions that have stood the test of time. The criteria for the Prize are broad and include significance, innovation, depth and scientific excellence.

The award is $5,000, a medallion and a citation.

The Prize Committee is currently seeking nominations, which should be in the form of a letter (preferably email) addressed to the prize committee chair (below), highlighting the nominee's accomplishments. Although the letter need not contain a detailed account of the nominee's research, it should document the overall nature of his or her contributions and their impact on the profession, with particular emphasis on the Prize's criteria. The nominee's curriculum vitae, while not mandatory, would be helpful. Please compress electronic files if 10 MB.

Nominations should be submitted to the committee chair (see below) as soon as possible, but no later than July 1.

See this page online for complete details:
http://www.informs.org/Recognize-Excellence/INFORMS-Prizes-Awards/John-von-Neumann-Theory-Prize/John-von-Neumann-Theory-Prize-Application-Process

2016 Committee Chair: David B. Shmoys, School of Operations Research and Information Engineering, 206 Rhodes Hall, 136 Hoy Road, Cornell University, Ithaca, NY 14853-3801; email: david.shmoys@cornell.edu

George B. Dantzig Dissertation Award

The George B. Dantzig Award is given for the best dissertation in any area of operations research and the management sciences that is innovative and relevant to practice. This award has been established to encourage academic research that combines theory and practice and stimulates greater interaction between doctoral students (and their advisors) and the world of practice. The award is given at the INFORMS Annual Meeting.

All certificates read as follows (1st & 2nd Prizes): for the best dissertation that is innovative and relevant to the practice of operations research and the management sciences.

The George B. Dantzig Dissertation Award Committee is now accepting entries for the 2016 award. The award for the best OR/MS dissertation serves to promote greater interaction between academia and industry by encouraging researchers to conduct innovative research that is relevant to practice in any area of operations research and management science. The first and second place winners will receive awards of $800 and $400, respectively. Additional finalists will receive honorable mentions with $100 awards. Prizes will be awarded at the 2016 INFORMS Annual Meeting.

Each entry must:

1. Consist of a doctoral dissertation written primarily by the entrant no more than 15 months prior to the submission deadline (completed between March 31, 2015, and June 30, 2016) and not previously submitted.
2. Present original ideas obtained predominantly by the entrant.
3. Clearly illustrate and demonstrate the relevance of the work in practice and the potential impact in industry.

Entrants should collect and submit the following items by June 30:

1. A letter of recommendation from the entrant's thesis advisor that describes the significance of the research and comments on the originality of the work.
2. A letter of recommendation from an industry associate that describes the relevance and the potential benefits of the research in their organization. This letter must be written by a manager familiar with the research who has served as an advisor to the research or as a coordinator to the on-site research project. The manager should be informed that they may be contacted by the committee members asking questions regarding the entrant's research.
3. A summary of the dissertation (less than five double-spaced pages) highlighting the significance of the problem, the novelty of the methodological approach, the contribution of the research to industry and the scope of the dissertation.
4. A self-contained paper (less than 25 double-spaced pages) based on the thesis so that the award committee can evaluate the contribution of the work.

Entrants should send the above items in an email (subject line beginning with "Dantzig" and items as separate PDF files) to the chair of the George B. Dantzig Dissertation Award.

See this page online for complete details:
http://www.informs.org/Recognize-Excellence/INFORMS-Prizes-Awards/George-B.-Dantzig-Dissertation-Award/George-B.-Dantzig-Dissertation-Award-Application-Process

2016 Committee Chair: Harry Groenevelt, associate professor, University of Rochester, Rochester, NY 14627; email: groenevelt@simon.rochester.edu

In addition, the signed originals of the letters of recommendation should be mailed, postmarked on or before June 30, to: INFORMS, Attention: INFORMS Awards, 5521 Research Park Drive, Suite 200, Catonsville, MD 21228; email: informs@informs.org

Lanchester Prize

Nominations are invited for the 2016 Lanchester Prize. This prize is awarded for the best contribution to operations research and the management sciences published in English in the past three years. The award will be given at the 2016 INFORMS Annual Meeting, if there is a suitable recipient.

To be eligible, a book, a paper or a group of books or papers must meet the following requirements:

- It must be on an operations research/management science subject.
- It must have been published in one of the preceding three years or, in the case of a group, at least one member of the group must have been published in one of those years.
- It must be written in the English language.
- It must have appeared in the open literature.

Books or papers may be case histories, reports of research representing new results, or primarily synthesis. For any nominated set (group of either articles or books) published over more than one year, it is expected that each element in the set is part of one continuous effort, such as a multi-year project or a continuously written, multi-volume book.

To be eligible for consideration, each book or paper must be nominated to the committee. Anyone may make nominations. The committee will use the following criteria in making judgments:

- the extent to which the contribution advances the state of the art of operations research and the management sciences;
- the originality of the ideas or methods;
- the new areas of application it opens up;
- the degree to which existing theory or method is unified or simplified;
- the clarity and excellence of the exposition; and
- the degree to which the contribution provides value for future applications or enables improved practice.

A nomination consists of:

- A nominating letter specifying the work being nominated and explaining why it is deserving of the Lanchester Prize. Nominating letters must include the titles of paper(s) or book(s), author(s), and the place and date of publication.
- Supporting letters, if desired. Supporting statements bearing on the worth of the publication in terms of the six criteria above will be very helpful, but are not required.
- Six copies of the work.

See this page online for complete details:
http://www.informs.org/Recognize-Excellence/INFORMS-Prizes-Awards/Frederick-W.-Lanchester-Prize/Frederick-W.-Lanchester-Prize-Application-Process

The prize is $5,000 and a commemorative medallion. If there are multiple winners, a medallion is struck for each and the monetary award is shared equally. Each author of an honorable mention receives a certificate, but no monetary award.

Nominations, by June 15, should be sent to: INFORMS, Attention: INFORMS Awards, 5521 Research Park Drive, Suite 200, Catonsville, MD 21228; email: informs@informs.org

2016 Committee Chair: Bert Zwart, Group Leader, Centrum Wiskunde & Informatica, Eindhoven, Netherlands, e-mail: Bert.Zwart@cwi.nl

George Nicholson Student Paper Competition

The George Nicholson Committee competition is held each year to identify and honor outstanding papers in the field of operations research and the management sciences written by a student.

The following conditions must be met for eligibility.

1. The entrant must have been a student on or after June 1 of the previous year under consideration;
2. The paper must present original research results (a summary of multiple papers is not eligible);
3. The research must have been conducted while the entrant was a student;
4. One or more advisors may appear as co-authors of a paper, but the student's contributions must make up the majority of the paper. The advisor (or nominator) must explicitly comment upon and specify in a letter the percentage of contribution of the student:
   a. in defining the problem and initiating the research that resulted in the paper;
   b. in conducting the research itself that resulted in the paper;
   c. in writing the paper.
5. An entrant can be a (co-)author in at most one paper submitted to the competition. More than one entrant per paper is allowed as long as they are eligible.
6. The paper must not have won a prize (1st or 2nd) in a previous Nicholson Competition.
7. Paper formatting requirements:
   a. The paper must use double spacing, 11-point (or larger) font, and 1-inch (or larger) margins (left, right, top and bottom).
   b. The paper must be of standard letter size (A4 will not be accepted).
   c. The entire paper (including title, abstract, authors names and affiliations, bibliography, appendices, figures, etc.) must not exceed 25 pages, and except for those containing references, each page should contain no more than 30 lines of text.

Prizes will be awarded and finalists will be invited to present their papers at the 2016 INFORMS Annual Meeting.

Submission procedure:

All student entrants must register for an EasyChair account through: https://www.easychair.org/account/signup.cgi?iid=37847

Once registered, entrants should use the submission page: https://www.easychair.org/conferences/?conf=nicholson2016

A complete entry consists of:

(1) an electronic pdf file of one self-contained paper in the specified format (papers not satisfying the format will not be accepted); and

(2) an electronic pdf file of a letter (the required attachment) signed by both a faculty advisor and the entrant attesting that the seven eligibility conditions have been satisfied by the entrant and the paper.

Note that the faculty advisor must explicitly comment upon and specify the percentage of contribution of the student in: (a) defining the problem and initiating the research that resulted in the paper; (b) in conducting the research itself that resulted in the paper; and (c) in writing the paper.

The student must also state whether or not this paper (or its lengthened/shortened form) has ever been submitted for publication, is currently under review or has been published. If so, the journal(s) and the outcome of the review or the current review stage(s) should be provided.

See this page online for complete details:

http://www.informs.org/Recognize-Excellence/INFORMS-Prizes-Awards/George-Nicholson-Student-Paper-Competition/George-Nicholson-Student-Paper-Competition-Application-Process

All entries must be submitted to EasyChair no later than June 5.

Applicants are strongly advised to check the INFORMS website for submission information.

2016 Committee co-chairs: Maria Mayorga, North Carolina State University, Raleigh, NC 27695; email: memayorg@ncsu.edu; and Peter Taylor, University of Melbourne, Melbourne, Australia; email: p.taylor@ms.unimelb.edu.au

Prize for the Teaching of OR/MS Practice

The Prize for the Teaching of OR/MS Practice will be given annually, if there is a suitable recipient, to a university or college teacher for excellence in teaching the practice of OR/MS. The purpose of this award is to recognize a teacher who has succeeded in helping his or her students to acquire the knowledge and skills necessary to be effective practitioners of operations research or the management sciences. An "effective practitioner" has respect for, understanding of, and the skills to surmount both the practical difficulties and the technical challenges of doing good OR/MS work.

The award will be presented at the 2016 INFORMS Annual Meeting. Nominations may be provided either by a nominator or the nominee. Nominations should include:

- nominee's name, affiliation, address, telephone, fax, email;
- a short (250-500 words) description, abstract or philosophical statement about the course or pedagogical approach;
- description(s) of specific projects, cases or scenarios used;
- statements of support from past students who are now in practice;
- statements of support from industrial sponsors and/or qualified observers and/or supervisors of students now in practice; and
- no longer than 20 pages in 12-point type.

See this page online for complete details:

https://www.informs.org/Recognize-Excellence/INFORMS-Prizes-Awards/Prize-for-the-Teaching-of-the-OR-MS-Practice

Nominators should alert the committee chair by email of forthcoming nominations at least one month before the submission deadline of June 30. Any questions should also be directed to the committee chair. The nomination should be submitted as a PDF file attachment to an email to the committee chair:

2016 Committee chair: Eli Olinick, associate professor, Southern Methodist University, Dallas, TX 75275-0123; email: olinick@lyle.smu.edu

In addition, one copy of the nomination should be sent to INFORMS, Attention: INFORMS Awards, 5521 Research Park Drive, Suite 200, Catonsville, MD 21228; email: informs@informs.org

Saul Gass Expository Writing Award

The Saul Gass Expository Writing Award honors an operations researcher/management scientist whose publications demonstrate a consistently high standard of expository writing.

This award recognizes an author whose publications in operations research and management science have set an exemplary standard of exposition. The awardee's written work, published over a period of at least 10 years, should indicate (in terms of breadth of readership) an influence and accessibility enhanced by expository excellence. Criteria include the lucidity, conciseness, logic and interest of the writing at all levels, from the general organization to the details. The author must have affected, through these publications, how something is done, studied, taught or thought about by some group within the OR/MS community.

The written work can contain any combination of practical, theoretical and pedagogical subject matter, and may be original, synthetic or historical. The corpus as a whole must be substantial in content, not necessarily prize-worthy in itself, but not trivial.

The publications in question can be books or papers in any combination, although enough of them must have been singly authored to demonstrate the awardee's expository skill. A team of authors writing together consistently over many years may also be considered for the award.

The winner will receive $2,000 and a framed certificate that includes a brief citation at the 2016 INFORMS Annual Meeting.

See this page online for complete details:

https://www.informs.org/Recognize-Excellence/INFORMS-Prizes-Awards/Saul-Gass-Expository-Writing-Award/Saul-Gass-Expository-Writing-Award-Application-Process

A nomination will consist of a written statement from a single individual of no more than 1,000 words. A nominator should consist of a single individual, who is a member of INFORMS, who has expertise in, or close to, the expertise of the nominee. Nominations should include references to examples of the nominee's expository writing, as well as evidence of the influence these works have had on the OR/MS profession. Nominations must be sent by July 1 to the 2016 Committee Chair:

Dr. Shane Henderson, professor, Cornell University, Ithaca, NY 14853; email: sgh9@cornell.edu

Doing Good with Good OR - Student Competition

INFORMS is again sponsoring a competition to encourage student research and practice that has societal impact. The "Doing Good with Good OR Student Competition" will feature the most exciting work performed by students in partnership with public and private organizations that yields tangible and beneficial outcomes for individuals, communities and organizations. Such work will be infused with OR/MS methods and could appeal to multiple disciplinary and application-area interests.

Submission process:

1. Nomination letter by the partner organization or a faculty member describing the societal impact of the work and the portion of the work (including the project duration) solely completed by the student entrant(s) during the time they were enrolled full time in a degree-granting program.
2. Two- or three-page summary document that describes what the entrants accomplished (focusing on the societal impact and the centrality of the operations research and management science tools used).
3. 60-word abstract of the achievement.
4. Submissions should be emailed to either of the Prize Competition co-chairs listed below.
5. Entrants will be expected to report on a project done in partnership with an organization that can certify that the results of the project have had, or are likely to have, a significant societal impact.
6. Any work with positive societal impact that has been completed within the last three years (class project, thesis research, independent study, internship, voluntary work) is eligible unless it has already received an INFORMS award.

See this page online for complete details:

http://www.informs.org/Recognize-Excellence/INFORMS-Prizes-Awards/Doing-Good-with-Good-OR/Doing-Good-with-Good-OR-Application-Process

INFORMS must receive completed submissions for this competition by May 16. The finalists will be announced by June 30 and must submit no later than Sept. 20 a full paper (maximum of 25 pages, double spaced, 12-point font) describing the project and its outcomes. The competition winner will be selected at the 2016 INFORMS Annual Meeting.

2016 Committee co-chairs: Chase Rainwater, University of Arkansas, Fayetteville, AR 72701; email: cer@uark.edu; and Karen Smilowitz, professor, Northwestern University, Evanston, IL 60208; email: ksmilowitz@northwestern.edu

Undergraduate Operations Research Prize

The Undergraduate Operations Research Prize Competition is held each year to honor a student or group of students who conducted a significant applied project in operations research or management science, and/or original and important theoretical or applied research in operations research or management science, while enrolled as an undergraduate student. The prize is given each year at the INFORMS Annual Meeting if there is a suitable recipient.

To enter, eligible participants should submit a paper to the Committee chair by July 1. Full eligibility and submission guidelines can be found below. The prize of $500 plus travel support to the INFORMS Annual Meeting will be announced at the Awards Ceremony of the Annual Meeting. All entrants satisfying the eligibility requirements will be invited to present their research at an Undergraduate Research Showcase session(s) at the Annual Meeting.

The following conditions must be met for eligibility.

1. Entrants must submit a paper (can be previously published or unpublished) presenting original research results.
2. The entrants are defined to be any co-authors on this paper who were enrolled as undergraduate students for at least one term within the 12 months prior to the award submission deadline in the year the paper is submitted for consideration, and who were undergraduate students at the time the project or research was conducted. The student(s) must have made a substantial contribution to the project and been the primary author(s) of the paper with only minor editorial assistance.
3. One or more faculty, graduate student or post-doctoral advisors may appear as co-authors of a paper, but at least one student entrant must be the first author.
4. A brief statement confirming the entrants' eligibility and detailing the entrants' contribution to the research should be submitted by the entrants' research advisor or another faculty member familiar with the entrants' work. To encourage cross-discipline submissions, the faculty advisor need not be an INFORMS member.
5. An entrant can be a (co-)author in at most one paper submitted to the competition.
6. The paper must not have won a prize in a previous year of this competition.

The paper must use double spacing, 11-point (or larger) font, and 1-inch (or larger) margins (left, right, top, and bottom). The entire paper (including bibliography, appendices, figures, etc.) must not exceed 25 pages and, except for those containing references, each page should contain no more than 35 lines of text. Attached to the paper should be an abstract of the work, not to exceed 100 words. This abstract will be used in the program for the Undergraduate Research Showcase session of the INFORMS Annual Meeting.

The criteria for review include:

1. For applied projects: Is the work significant? Did it require the clever use of O.R. methodology, and did it create substantial value for the project sponsor?
2. For research: Is the research novel? For example, does it address a new problem (theoretical or applied) of interest to the broader O.R. community, does it present a novel solution or modeling approach to an established problem, or does it provide new insight into an important problem?
3. Does the students' work demonstrate creativity and promise for future work in the field of operations research?
4. Writing quality: Is the writing coherent, fluid and adhering to a clear structure? Is the problem clearly explained and motivated? Is terminology clearly defined and notation consistent with accepted conventions?

Entries must be submitted by email to the Committee chair by July 1.

See this page online for complete details: https://www.informs.org/Recognize-Excellence/INFORMS-Prizes-Awards/Undergraduate-Operations-Research-Prize/Undergraduate-Operations-Research-Prize-Application-Process

2016 Committee Chair: Pavithra Harsha, IBM Research, Yorktown Heights, NY 10598; email: pharsha@us.ibm.com

Impact Prize

The Impact Prize, awarded once every two years, is intended to recognize contributions that have had a broad impact on the field. The contribution could be an idea or technique that is widely used, or it could be someone who played a major role in bringing significant methodology into widespread use (e.g. by playing a major role in the design of a software package that is now widely used, or through extensive writings and lectures aimed at practitioners). The award complements the Edelman Prize. Instead of focusing on a single large application with quantifiable impact, we are looking for ideas that are widely used. The award may go to some combination of the originator of the idea and/or the people or group who played a significant role in bringing the idea to a community who uses it.

Initial (brief) nominations are due by April 29. Complete nominations are due by July 1; e-mail applications are strongly encouraged.

For more information, visit: https://www.informs.org/Recognize-Excellence/INFORMS-Prizes-Awards/Impact-Prize/Impact-Prize-Application-Process

Committee Chair: Michael Fry, University of Cincinnati, Carl H. Lindner College of Business, Cincinnati, OH 45221-0130; email: mike.fry@uc.edu

Bonder Scholarships

The Military Applications Society (MAS) of INFORMS is seeking nominations for the 2016 Bonder Scholarship for Applied Operations Research in Military Applications. The purpose of this scholarship for applied O.R. in military applications is to promote the development and application of process modeling and operations research analysis to military issues. The scholarship provides funding to support the development of highly qualified individuals and promote the interchange of military O.R. research knowledge with INFORMS. The Bonder Scholarship consists of a grant of $4,000, plus award winner eligibility for up to $1,000 of travel funding. An additional $2,000 grant is provided and funded by the Seth Bonder Foundation.

For important details, visit the award web page: https://www.informs.org/Recognize-Excellence/Community-Prizes-and-Awards/Military-Applications-Society/Seth-Bonder-Scholarship-for-Applied-Operations-Research-in-Military-Applications/Bonder-Scholarship-Application-Process.

Submit applications and letters of support as pdfs by July 1 to Bill Fox, wpfox@nps.edu.

The Health Care Applications Society is seeking nominations for the 2016 Bonder Scholarship for Applied Operations Research in Health Services. Like the Bonder Scholarship in military applications, the scholarship is $4,000, and the opportunity to apply for an additional $1,000 travel grant. An additional $2,000 grant is provided and funded by the Seth Bonder Foundation.

U.S. and international students pursuing doctoral studies on issues in health care design, delivery or operations, particularly those with two to three years remaining in their programs, are encouraged to apply.

Candidates should submit the following materials:

- Detailed curriculum vitae, which must include a list all educational study after the level of a Bachelor's degree or equivalent (i.e., school, program, major, dates of attendance and graduation date if completed).
- Two letters of support. One letter should come from the student's primary academic advisor (usually the dissertation chair), and this letter should include a statement that the student has completed one academic year (at least eight months) but no more than three academic years (at most 36 months) in any doctoral program.
- Brief statement limited to one page describing why they are interested in applying operations research to healthcare issues.
- Three-page summary of their proposed program of research (including any graphics, but a bibliography is not counted in the three pages).

Selection criteria:

- The scholarship will be granted on the basis of excellence, innovation, preparation and probability of candidate's success.
- Candidates will be evaluated on the quality of their preparation to undertake a program of applied operations research in the field of health care.
- The proposed program of research will be judged according to its potential for making a significant contribution to the field of applied OR in health care systems, as well as the likelihood of successful completion.

Applications should be submitted by candidates, and letters of support separately by their authors, in portable document format (PDF) via email by June 1 to the committee chair.

For additional details, visit the award web page: https://www.informs.org/Recognize-Excellence/Community-Prizes-and-Awards/Health-Care-Applications-Society/Seth-Bonder-Scholarship-for-Applied-Operations-Research-in-Health-Services/Seth-Bonder-Scholarship-for-Applied-Operations-Research-in-Health-Services-Application-Process.

Send applications and additional required materials by June 1 to Mark Van Oyen at Bonder.VanOyen@gmail.com. All applicants will be notified by Aug. 19 of the competition results.

INFORMS Case Competition

INFORMS is pleased to announce its 16th Annual Peer-Reviewed Case Competition. This competition is jointly sponsored by the INFORMS Education Committee and INFORM-ED. It is designed to encourage the creation, dissemination and use of new, unpublished cases in operations research and the management sciences. All submissions and supporting documentation are due by Aug. 26. All cases will be reviewed in early September by a panel of judges familiar with the case method.

Up to four finalists will be selected and notified by the chair of the Case Competition by Sept. 15. Finalists will give 30-minute presentations of their entries at a special open session of the 2016 INFORMS Annual Meeting in Nashville. Tenn. The panel of judges will select the winning entry from these finalists based on these presentations. Finalists must present their cases at the fall 2016 INFORMS Meeting to be eligible to win.

Guidelines for submitted cases are:

1. No more than 10 pages (8.5" x 11.0") single-spaced (maximum of approx. 3,000 words); shorter cases are acceptable.
2. Exhibits are in addition to page limit.
3. Teaching notes of length as necessary to meet content expected.
4. A 12-point proportional font (such as Times New Roman) with 1-inch margins.
5. All submitted cases must be previously unpublished. Cases should be essentially new in their entirety. If the case contains material drafted originally by individuals or groups other than the author(s) submitting the case, then the intellectual history and ownership of these portions should be made absolutely clear. Contestants are responsible for assuring that this guideline is strictly met.

A complete submission package will consist of the following:

1. One electronic copy of a short (250-500 words) abstract, the case and teaching notes sent in a zipped file. The abstract should appear by itself on the second page and identify the industry, business issues, technical issues, pedagogical objectives and suggested uses of the case. The case, any exhibits and then the teaching notes should follow.
2. A completed Case Competition Submission Form.

Prizes include:

1. $500 and plaque to the best case
2. $100 and plaque for up to three runners-up

For more information, contact Palaniappa Krishnan, aka PK, at baba@udel.edu. ORMS

WSC 2016

The 2016 Winter Simulation Conference (WSC 2016) will be held Dec. 11-14 in Arlington, Va., at the Crystal Gateway Marriott. The hotel is located minutes from downtown Washington, D.C., and less than a mile from the Reagan National Airport. The METRO is connected to the hotel, which makes exploring the area's monuments, museums, shopping and restaurants very convenient.

WSC is the premier international forum for disseminating advances in the field of dynamic systems modeling and simulation. In addition to a technical program of unsurpassed scope and quality, WSC is the central meeting place for simulation practitioners, researchers and vendors. Research in modeling and simulation is driven by cross-fertilization between various disciplines. The theme for WSC 2016 is "Stimulating Complex Service Systems."

The call for papers is now open. Complete paper deadlines and requirements are available at www.wintersim.org. Todd Huschka is general chair and Stephen Chick is program chair of WSC 2016.

WSC 2016 is sponsored by ACM/SIGSIM. ASA, ASIM, IEEE/SMC, IIE, INFORMS-SIM and NIST are technical co-sponsors, along with SCS. ORMS

Call for nominations: *Interfaces* editor

The second term of Srinivas Bollapragada as editor-in-chief of *Interfaces* expires on Dec. 31. Based on recommendations from the INFORMS Publications Committee, the president of INFORMS appointed a committee to conduct a full search for a new editor-in-chief. The committee intends to propose a candidate for approval by INFORMS no later than June 1.

All members of INFORMS are invited to participate in this process. The committee seeks opinions and comments on: 1) the current state of *Interfaces;* 2) recommendations for change, if any; and 3) candidates for editor-in-chief.

Qualifications for the editor-in-chief of *Interfaces* will include: a demonstrated interest in a broad range of topics in the field; dedication and enthusiasm for *Interfaces* and applications of operations research, management science, and advanced business analytics; previous editorial experience; a vision of the role of scholarly publications in the electronic and open access age; the ability to effectively and efficiently manage the editorial process; a commitment to the workload involved with support from the candidate's employer; and membership in INFORMS or willingness to become a member upon being selected for the position.

Further information about *Interfaces* can be obtained at the journal's home page: http://interfaces.pubs.informs.org/.

Members of the search committee are Peter C. Bell (Ivey School of Business at Western University, chair), Robin Lougee (IBM), Doug Morrice (University of Texas), Ranga Nuggehalli (UPS), Larry Robinson (Cornell University) and committee liaison from the INFORMS Publications Committee.

Submit nominations/applications, including a resume and a brief statement of the candidate's vision and plans for the journal, by email to the committee chair by May 1: Professor Peter C. Bell, Ivey School of Business at Western University, London, Ontario N6G 0N1, Canada; phone: (519) 661-3288; email: pbell@ivey.ca ORMS

Meetings

Go to www.informs.org/Conf for a searchable INFORMS Conference Calendar.

INFORMS Annual & International Meetings

April 10-12, 2016
INFORMS Conference on Business Analytics & Operations Research
Hyatt Regency Grand Cypress
Orlando, Fla.
Chair: Elea McDonnell Feit, Drexel University
http://meetings.informs.org/analytics2016

June 12-15, 2016
2016 INFORMS International Meeting
Hilton Waikoloa Village
Waikoloa, Hawaii
Chair: Saif Benjaafar, University of Minnesota
http://meetings.informs.org/2016international

Nov. 13-16, 2016
INFORMS Annual Meeting
Music City Center & Omni Nashville
Nashville, Tenn.
Chair: Chanaka Edirisinghe, RPI
http://meetings.informs.org/nashville2016

April 2-4, 2017
INFORMS Conference on Business Analytics & Operations Research
Caesars Palace, Las Vegas
Las Vegas, Nevada

Oct. 22-25, 2017
INFORMS Annual Meeting
George R. Brown Convention Center & Hilton Americas
Houston, Texas
Chair: William Klimack, Chevron

INFORMS Community Meetings

June 16-18, 2016
2016 INFORMS Marketing Science Conference
Shanghai, China
Chair: Icey Han, Fudan University
http://www.fdsm.fudan.edu.cn/marketingscience2016/

June 30-July 1, 2016
MSOM Conference
University of Auckland Business School
Auckland, New Zealand
Co-chairs: Tava Olsen and David Robb, University of Auckland Business School
http://www.cscm.auckland.ac.nz/2016-msom-conference

Dec. 11-14, 2016
Winter Simulation Conference
Crystal Gateway Marriott
Arlington, Va.
Chair: Todd Huschka, Mayo Clinic

List retires from INFORMS

After 18 years of service to INFORMS, Barry List has retired. Throughout his career, List, who had served as director of communications, showed great dedication and commitment to INFORMS, its mission and, especially, its members.

His efforts were key to the development of the University Analytics Committee, the Public Affairs Committee, the Education Resources Library, the Analytics Maturity Model and a steady communications program, to name just a few.

When asked what was his most memorable work experience at INFORMS, List recalled interviewing Adm. (ret.) Michael Mullen, then Chairman of the Joint Chiefs of Staff, at the Pentagon. The interview focused on Adm. Mullen's education in operations research, how O.R. impacted his thinking on critical military matters and the current state of military O.R.

"I spent 18 wonderful years at INFORMS," List said. "There's a children's bedtime book that ends, 'You had a good day, it's time to say goodnight.' I wish my friends at INFORMS a figurative good night, and thanks for the years of support."

Barry List

INFORMS Executive Director M. Melissa Moore said, "Barry devoted his career at INFORMS working to publicize our members and promote their work and achievements. Barry cared about our members on a personal level, as well as their research. His deep interest in their work and success has made a lasting difference to them and INFORMS. All of us wish Barry well in his retirement. He's earned it!"

As for the future, List plans to explore "new adventures in PR and communications" and to "peck away" at a novel he's kept in a drawer for many years. ORMS

Frontline releases Solver SDK Platform V2016

Frontline Systems is shipping Solver SDK Platform V2016, a major new release of its popular analytics Software Development Kit, with new APIs and source code examples in R and Python – augmenting support for C++, C#, Java and other languages – plus a new embedded version of its RASON modeling language interpreter. Application developers can use these tools to extend any server-based, browser-based or mobile application to deliver analytic results, using the full range of optimization and simulation methods.

"With XLMiner SDK, our just-released toolkit for predictive analytics, we're now offering developers a powerful, comprehensive, yet easy to use tool set for the full range of advanced analytics - data mining, text mining, optimization and simulation," says Daniel Fylstra, Frontline's president.

Solver SDK makes it easy to create and deploy optimization and simulation models in three forms:

- Created in a programming language, such as C++, C#, Java, R or Python
- Created in Frontline's high-level RASON modeling language
- Created in Microsoft Excel, loaded into Solver SDK and run independently of Excel

It's easy to combine these approaches. For example, a C++ or Java-based server application can load an Excel workbook, update parameters in the model, and run an optimization or simulation. Or an R or Python application can treat a RASON model as JSON, modify and solve that model – locally or in the cloud using Frontline's RASON server and its REST API.

Solver SDK Platform features five bundled Solver engines, including a Simplex Solver, Barrier Solver, GRG Nonlinear Solver and Evolutionary Solver, plus a high-performance Monte Carlo simulation engine with multiple random number generators, sampling and correlation from 50 probability distributions, and a wide range of statistics for results. It can load and run eight different plug-in, large-scale Solver engines, such as the Gurobi, Xpress and KNITRO solvers. The SDK exploits multi-core processors in both simulation and optimization, without any programming effort by the user.

AIMMS featured in Gartner's 'Hype Cycle'

AIMMS, a leading business optimization software vendor, has been featured in Gartner's Hype Cycle for Supply Chain Planning. The company has been listed as one of the three sample vendors for prescriptive analytics.

Gartner defines prescriptive analytics as "a set of analytical capabilities that finds a course of action to meet a predefined objective, such as maximizing revenue or minimizing costs" – the output of which is a recommended action. As stated in Gartner's Hype Cycle, the use of prescriptive analytics can improve decision-making in several areas of the supply chain, including logistics, planning and manufacturing.

AIMMS clients such as Nike, Air Liquide, BP, JBS and Shell leverage prescriptive analytics to support fact-based, real-time decision-making in critical supply chain planning processes. The flexible AIMMS platform can be used for network and inventory optimization, planning & scheduling, cost to serve segmentation, boosting ERP agility and much more.

"As a company that has operated in the prescriptive analytics space for over 25 years, we are very pleased to be recognized as a key vendor by Gartner," says AIMMS CEO Gijs Dullaert. "Our clients have benefited from this technology for decades and we're thrilled to see that awareness about this exciting space is increasing in the industry."

Dirkse to lead GAMS' new management team

Alex Meeraus stepped down as president of GAMS Development Corp. in January to assume his new role as GAMS' senior adviser. He will also continue serving as a member of the Board. Meeraus' inspired leadership and guidance took GAMS from its founding in 1987 to the position it enjoys today.

Stepping into his new role as president of GAMS Development is Steve Dirkse, who will form a new management team with Michael Bussieck and Franz Nelissen. The management change coincides with a change in ownership at GAMS. Together Dirkse, Bussieck and Nelissen have more than 60 years of experience at GAMS in a wide variety of roles. They look forward to building on the foundation Meeraus established over the past three decades, and guiding GAMS' evolution to meet customers' future needs.

LA Kings, Galaxy score with fans using SAS analytics

The Los Angeles Kings and Los Angeles Galaxy certainly know about success on the ice and on the pitch. The two-time Stanley Cup winners and five-time MLS Cup Champions are now looking to software from analytics leader SAS to deliver a win in the stands or at home, giving each of their loyal fans more of what they want.

Championships are only part of what draws supporters to AEG Sports. The company also owns and operates premier stadiums and high-profile event venues all over the world. For example, the Staples Center in Los Angeles, home of the LA Kings, houses three additional professional teams and hosts world-class concerts and events. Powered by SAS, AEG Sports will build an analytics center of excellence (ACE) to dig through mountains of fan and operational data. They'll use it to predict the best promotion to extend to an LA Kings or LA Galaxy fan, or whom to alert about an upcoming event.

"With advanced analytics from SAS, we can mine the significant information we already have. Then we can visualize it to pinpoint how to elevate our service to our loyal sports fans," says Kelly Cheesman, chief operating officer of the LA Kings Hockey Club and AEG Sports.

SAS Visual Analytics and SAS Visual Statistics will also help AEG Sports forecast and report on team and facility performance. By examining sales and gate revenue for every event, management can update marketing and promotional plans on the spot. ORMS

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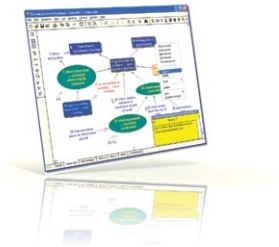

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DEA SolverPro

DEA SolverPro has been widely used all over the world. In response to numerous customer requests, we have released **Version 13** with "SBM Max."

On top of more than 186 models in 48 clusters, Version 13 added a new model, called **SBM Max**, replacing SBM Variations released earlier. The basic slacks-based measure models (SBM) usually report the worst efficiency scores for inefficient DMUs, i.e. the projected point is the farthest one on the associated efficient frontier. In contrast, SBM Max looks for the nearest point on the associated efficient frontier. Hence, the efficiency score is approximately maximized as contrasted to the ordinary SBM models. This KAIZEN model will open the door to the QC community.

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Postdoctoral research positions are available at HKUST, starting Spring 2016, in the laboratory of Professor Guillermo Gallego to study choice models, assortment optimization, dynamic pricing, and revenue management.

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Business Operations Associate (Job ID 9X7VGH) SB Group US has an opening for a Business Operations Associate in San Carlos, CA to execute business operations & strategy projects defined by SoftBank's management team. Duties include: Gather information and analyze current processes to develop solutions or alternative methods of proceeding to improve current practices, e.g. prepare recommendations to implement findings and best practices gathered globally. Confer with SoftBank's management team to ensure the successful development, implementation and scaling of new and improved processes and to ensure they align with SoftBank HQ's expectations and global practices; working at a cross-functional and global capacity. Support coordination between cross-functional teams across international entities, including setting & monitoring teams' priorities. Develop management communications materials for management team, as needed, supporting PR/IR, e.g. company town hall meeting, board meeting, shareholder meetings.

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To apply, mail your resume to: SB Group US, ATTN: M. Smith, 1 Circle Star Way, San Carlos, CA 94070, with reference to Job ID.

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Lecturer in Discipline Position in the Department of Industrial Engineering and Operations Research

The Department of Industrial Engineering and Operations Research at Columbia Engineering invites applications for a Lecturer in Discipline position starting in the 2016-17 academic year. Lecturers in Discipline are full-time non-tenuretrack faculty members who meet a need for instruction in specialized fields. The Industrial Engineering and Operations Research Department is committed to hiring outstanding teachers to support the growing needs of its exceptionally strong undergraduate and MS programs. The IEOR department promotes a culture of innovation and experimentation in teaching including blended and online learning environments.

We seek candidates with teaching interests at the intersection of Operations Research and Analytics, with an emphasis on business, healthcare, supply chain and / or transportation analytics. Candidates must hold a PhD or its professional equivalent in Operations Research or related fields. Since this is a teaching position, applicants must have excellent teaching credentials and communication skills. Experience with blended and online learning is a plus. The successful candidate should expect to teach advanced undergraduate and MS level courses including projects based courses that will require significant industry interaction. In this regard, a key role for the successful candidate would be to cultivate industry contacts.

Columbia fosters multidisciplinary research and encourages collaborations with academic departments and units across the university. The Department is especially interested in qualified candidates who can contribute, through their research, teaching, and/or service, to the diversity and excellence of the academic community.

For additional information and to apply, please see: http://engineering.columbia.edu/faculty-job- opportunities. Applications should be submitted electronically and include the following: curriculum-vitae including a statement of teaching interests and plans, and contact information for three experts who can provide letters of recommendation. At least two of the letters of recommendation must address teaching ability. All applications received by March 31, 2016 will receive full consideration. Candidates that are invited to interview will be required to give a 50-minute technical presentation.

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The Flintstones' parable

The group that had gathered to watch the Super Bowl moved on, as the game progressed, from their conversation about healthcare to the state of the OR/MS profession. Jim, who had talked about the threat of a flu outbreak at the Olympics in Rio, snorted scornfully at the fourth or fifth ad by a well-known company touting its new analytics software.

"Great-looking, entertaining ads," he said, "but there was something really odd about them – did you notice? They've been developing and promoting this product for about five years, but every ad was about what they claim it can do – not about anything it has done! It's the same thing the resume critique experts tell a lot of us about our resumes: Unless you're brand new, talk about accomplishments, not duties or capabilities, preferably with a client praising the achievement. I'd assume these folks know that, so what I take from these ads is that they haven't gotten it to do anything useful!"

"That might explain the big drop in their stock price over the last couple of years," Fred remarked dryly.

"But it's not just one company," Jim added quickly. "They're just one of the most prominent. It seems almost everyone's jumping on the bandwagon of 'analytics will save the world,' but try getting any agreement about what analytics is and how to get it to work for you. And a lot of these computer-based 'inference engines' we hear about turn out to require an awful lot of pre-processing and pre-structuring, usually not automated or anything close to it, before they can accomplish anything. Like many O.R. techniques, they're good for problems with set, well-defined categories and lots of good data, but not for the typical squishy, messy, ill-defined problems that decision-makers tend to care most about. I hope our profession, having jumped on that 'analytics' bandwagon too, doesn't end up being dismissed as irrelevant and unhelpful in a few years, when the promise isn't fulfilled."

"Don't we have some of those issues already?" Jane asked. "I know a lot of people, and academic departments for that matter, have wound up relabeling themselves as 'systems engineers' or 'decision scientists' or, now, 'analytics professionals,' because the name 'operations research' just didn't mean all that much to decision-makers."

"No kidding," Jim concurred grimly. "As you know, I'm pretty active in the profession, so I get into some interesting discussions about the future of the profession. I've been arguing for years that if we keep trying to define O.R. more and more precisely as a particular set of methods and tools, we'll end up, as Russ Ackoff predicted years ago, isolated in the basement, called in occasionally by the real decision analysts when they have a hard math problem to solve. But if what we offer is a uniquely productive way of looking at the world and solving problems that matter, then we have a great future. It's our choice.

"And a lot of these companies, and business schools for that matter, don't get it either," Jim went on. "More and more emphasis on a specific set of techniques and methods, less and less on solving unfamiliar problems, and then wondering why smaller, more agile competitors are eating their lunches. Thirty years ago, the book 'In Search of Excellence' convinced managers they didn't need quantitative support at all. Ten years ago, 'Competing on Analytics' convinced the next generation of high-level decision-makers that they did need quantitative methods, but didn't explain how to tell who was doing them right. So, either way, lots of organizations talk a great innovation game, often claiming they're analytics-based, but then keep on just doing what they've been doing."

"Ugh," Jane and Fred chorused. "Not encouraging."

"No, it isn't," Jim agreed, "but that isn't the worst of it. I've heard supposedly knowledgeable colleagues 'explain' the success of the big data and data science movements as, 'What's really going on there is that those people just don't know enough about analytical techniques to appreciate what we do.' Actually, I go to their meetings, and many of them have hard science doctorates and aren't shy about mathematical techniques at all. And actually, a lot of these big data and data science people do need us, because setting up data to support decision-making requires some structuring and association tracking that brute force data storage and retrieval, even massively parallel with huge computing resources, just can't do in any reasonable time. But, as with many other application areas, we won't be appreciated if we don't learn their language and explain things in their terms.

As with many other application areas, we won't be appreciated if we don't learn their language and explain things in their terms.

"So here we are in the modern version of The Flintstones," Jim concluded. "Too many organizations that used to be central to our profession are dinosaurs and don't even realize it. And you know the dinosaurs end up extinct."

"You do know that 'The Flintstones' was fiction, and dinosaurs never really coexisted with humans, don't you?" Jane inquired, laughing.

"Sure," Jim replied, "but here in real life we do have dinosaurs coexisting with their competitor species and having no idea of what's about to happen to them. By the way, you don't still own stock in any of these companies we were talking about, do you? Some have rebounded a bit lately, partly because of good ad campaigns and partly because of established reputations from past successes, and good marketers can always 'sell the sizzle, not the steak,' without providing a good piece of meat – for a while. But I'd bail out now, if I were you!" ORMS

Doug Samuelson *(samuelsondoug@yahoo.com) is president and chief scientist of InfoLogix, Inc., in Annandale, Va.*

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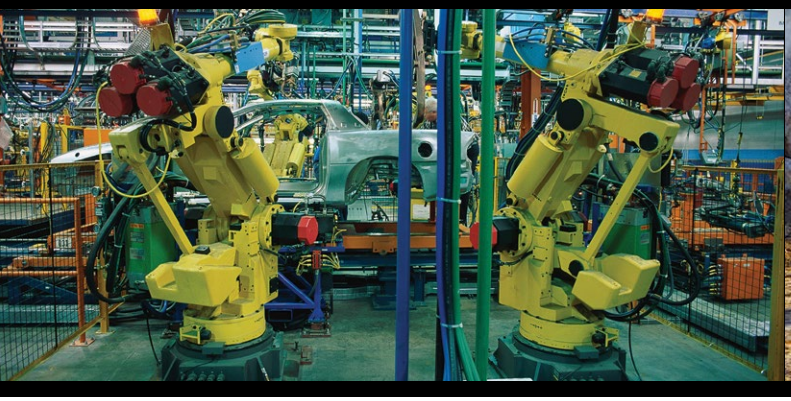

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August	Basic GAMS Modeling Advanced GAMS Modeling
September	Climate and Trade Policy Analysis with GAMS and MPSGE
November	Modeling and Optimization with GAMS (basic) Modeling and Optimization with GAMS (advanced)
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