

**INNOVATIVE EDUCATION:** Back-to-school special issue

**informs**

**ORMS** TODAY

August 2015  
Volume 42 • Number 4  
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# Great Expectations

The sky's the limit for quant grads,  
but will their education match their  
lofty goals?

- Analytics and the MBA curriculum
- Teaching professional practitioners
- Competitive simulations: game on
- Introducing analytics to adolescents
- Profiles of 2015 UPS Prize finalists

## Also Inside:

- O.R. takes on 'Grand Challenges'
- Roundtable profile:  
Analytics at IDA







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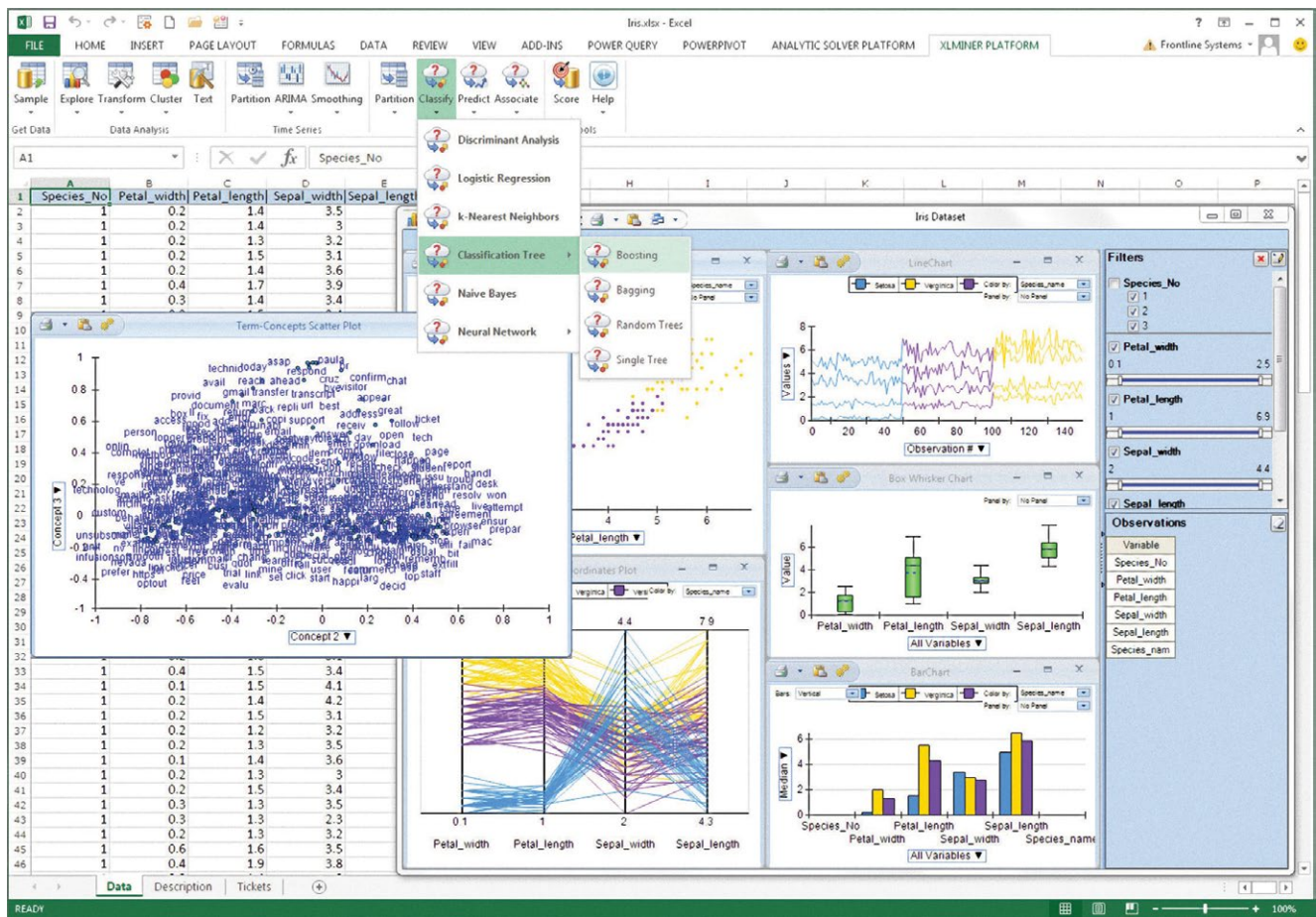




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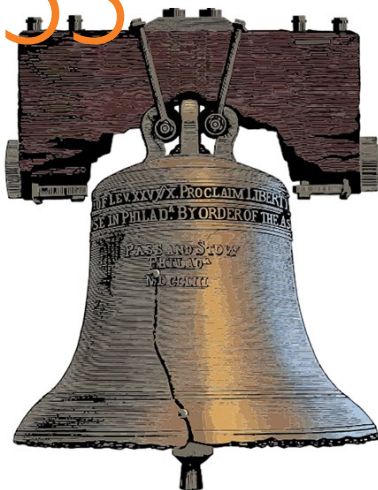
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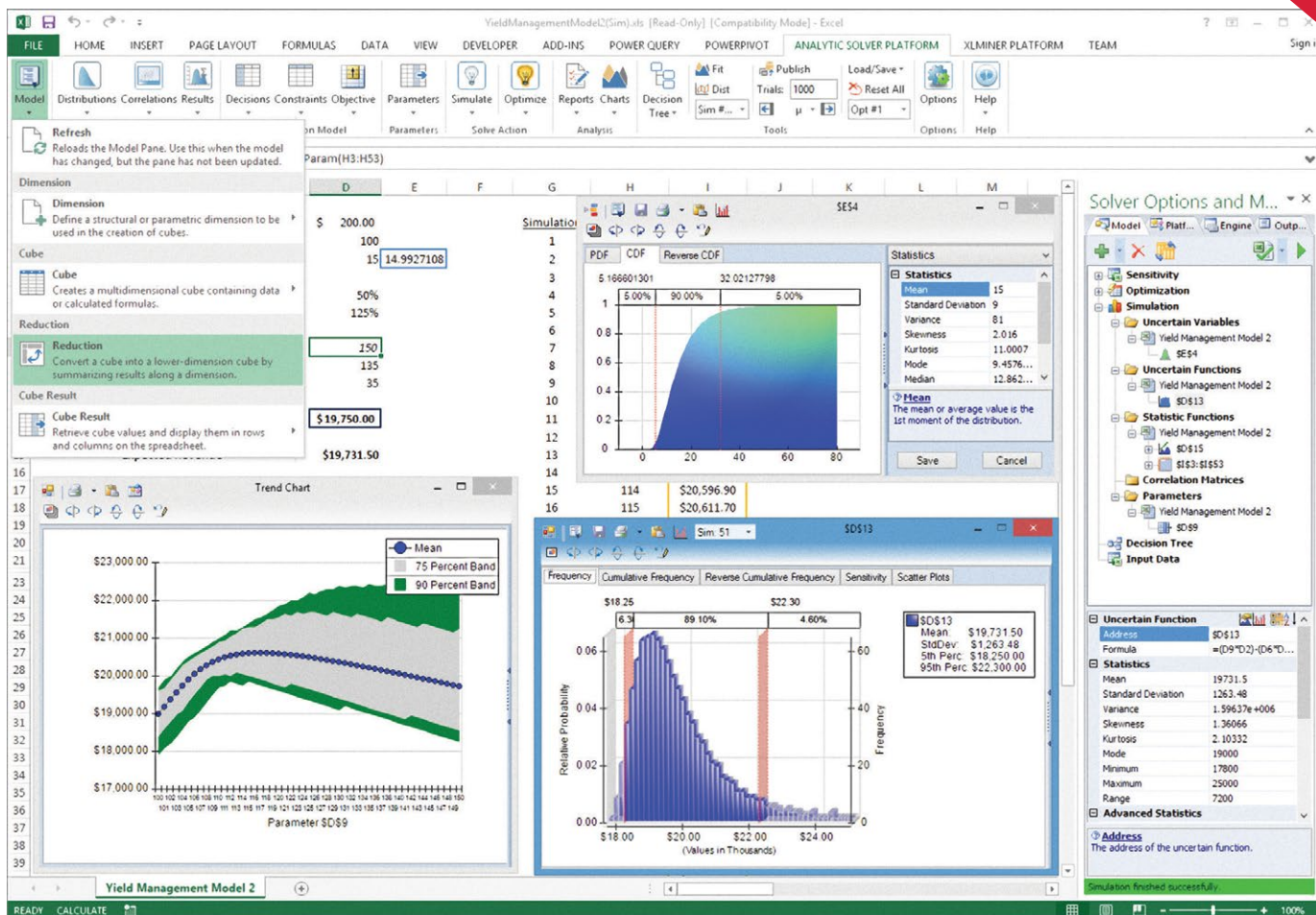
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# Those who *can*, teach

In an online exchange with Peter Bell regarding his invited article for this special “Innovative Education” issue of *OR/MS Today*, I posed the following question: During the last five or 10 years, at least 200 business schools have launched analytics programs to meet the obvious market demand. Yet, as Peter noted in his draft, other business schools have been dropping “analytics” (some form of operations research/management science/analytics) from their MBA core for decades, and the data shows that the trend is continuing. What is wrong with this picture?

“I have an answer,” Peter wrote back.

I always invite Peter to contribute to this special issue because, well, I have questions and Peter has answers – studied, clear answers – especially when the topic is the state of education in business schools. A professor of management science at the Ivey School of Business at Western University in Ontario, Canada, Peter is a past recipient of the INFORMS Prize for the Teaching of OR/MS Practice. He also served as chair of the INFORMS Franz Edelman Prize Competition (2013 and 2014). When Peter talks about the link between business school teaching and real-world practice, I listen.

So what was his answer to the “wrong picture” question? For that, you’ll have to read Peter’s provocative article in which he makes the case for why analytics belongs in the MBA core curriculum (page 22).

The first call I make after getting Peter Bell onboard for this special issue goes to the most recent recipient of the INFORMS Prize for the Teaching of OR/MS Practice. Who better to share some insight and advice on the art and science of teaching OR/MS practice than the person who just won an award for doing exactly that?

This year’s prize-winning professor, Jason Merrick of Virginia Commonwealth University, tells a personal and poignant story of how he found success by focusing on his learning rather than his teaching. Jason comes from a family full of schoolteachers, including his mother who imparted on her son a few simple principles of teaching, one of which prompted him to connect his research to the real world. For more on Jason’s journey, see page 26.

Next, Bernard Pagnoncelli of the School of Business at the Universidad Adolfo Ibañez (Chile) and Abraham Seidmann of the Simon Business School at the University of Rochester explain how they manage to reach and teach Millennials by “bridging the gap between a data-intensive and technological world and the classic professor-blackboard (or PowerPoint) paradigm.” Their secret weapon? Competitive simulation games. For more on the story, see page 30.

Are you smart enough to teach O.R. to a third-grader? That was the dilemma Ken Chelst, a professor at Wayne State University, faced this summer when asked to present a workshop for K-12 teachers in Minnesota. Chelst has a long history of developing introductory O.R. programs for high school students, but he drew the K-5 group of teachers for an afternoon session. Find out what happened on page 34.

Our “Innovative Education” coverage wraps up with profiles of the three finalists for this year’s UPS George D. Smith Prize for an “academic department or program for effective and innovative preparation of students intent on pursuing careers as practitioners of operations research.” Check out page 38 to see what they’re doing right. Learning is, after all, a lifelong endeavor. **ORMS**

— **Peter Horner, editor**  
peter.horner@mail.informs.org

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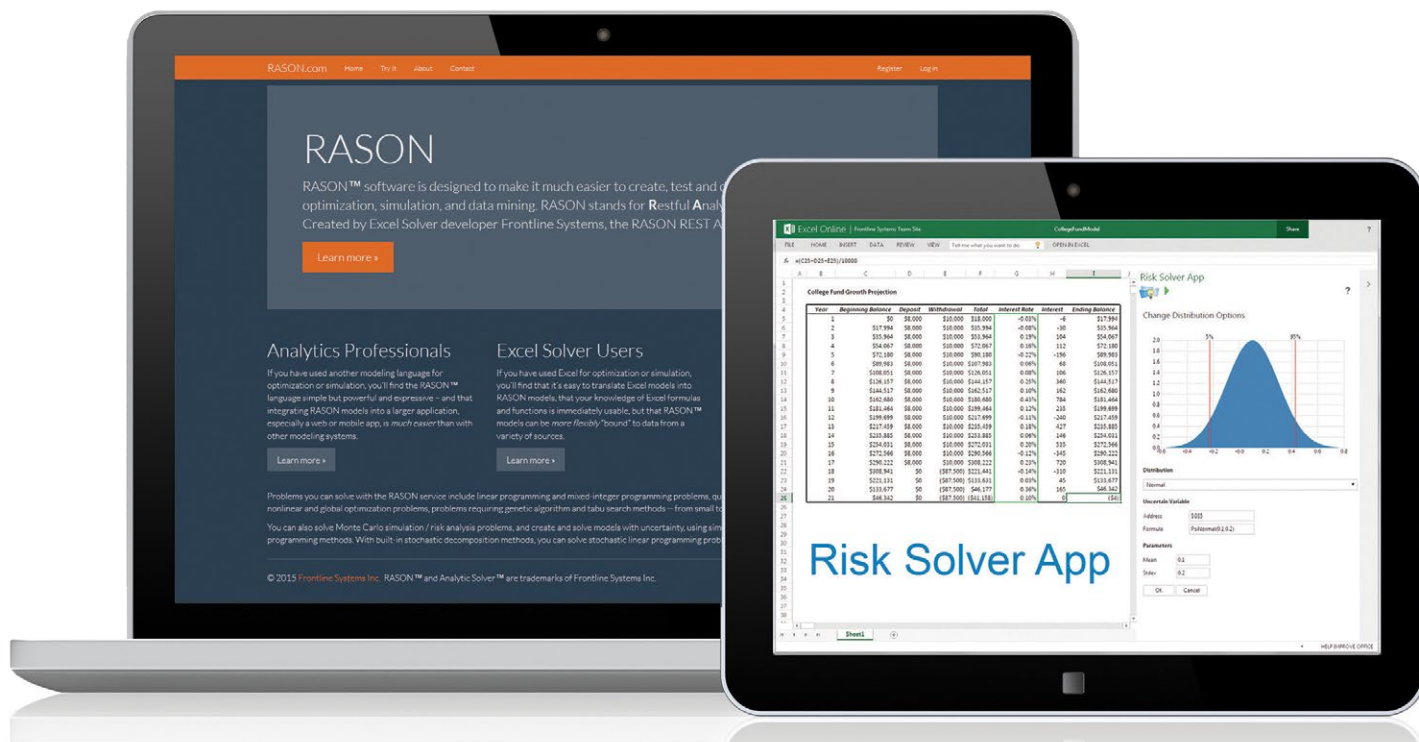
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# Focus on Careers

As the academic job market ramps up for the 2015 INFORMS Annual Meeting in Philadelphia on Nov. 1-4, I focus this article on careers and career enhancements. Nominations were due Aug. 8 for those wishing to attend the annual meeting's doctoral student colloquium, teaching effectiveness colloquium or new faculty colloquium [1].

Employers and job seekers should register with the INFORMS Career Center [2], which had 2,619 registered employer users and 5,211 registered job seeker users as of January 2015. Currently, we have well over a thousand live jobs and a thousand live resumes on the site. We reach out to potential employers and follow-up on leads on possible job postings for our Career Center from our community discussions on INFORMS Connect, such as the Job Board open community on INFORMS Connect [3].

INFORMS hosts two career fairs each year, on Sunday afternoons at the annual meeting in the fall (with 80-100 employers) and at the analytics conference in the spring (with 15-30 employers). Applicants can drop by employers' tables for information and confirm plans for (or in some cases, set up) personal interviews for later in the meeting.

Academic job seekers should be polishing their resumes, websites, teaching philosophies and research interests, arranging recommendation letters and practicing their "elevator speeches" (one minute on why their work is important/exciting) and "job talks" (the 60-90 minute colloquium talks they'd make at a school during a finalist interview). After applying, they'll receive some emailed invitations for short, 15- to 30-minute interviews at the annual meeting, with most personal interviews held Monday through Wednesday. Some schools will also talk with candidates in a drop-in format at the conference, especially during the job fair. Schools typically invite finalists

to second-stage interviews on campus or via remote phone interviews. Finalist interviews are typically held January through March for jobs beginning the following fall.

Those seeking non-academic jobs go through a similar application process, but the jobs usually start just a few weeks after the offer is accepted. In addition, a professional colloquium for practice-oriented graduate students and the Richard E. Rosenthal Early Career Connection networking events are held at the analytics conference in the spring. Applications for both events are due in early March [4].

Following are quotes from brief interview profiles (courtesy of the INFORMS Career Center) of established O.R./analytics professionals [5] to consider for new career directions and in building pride in our professional identities.

**Cynthia Barnhart**, chancellor, MIT: "To me, operations research is fun because it involves creativity – there isn't necessarily a single, cookie-cutter approach especially when trying to model large, complex systems like those in transportation."

**Deep Parekh**, manager, Consulting Services, Ernst & Young LLP: "The base of knowledge that you can gain via consulting is extremely wide and gives you the opportunity to go as deep as you want to go in any vertical."

**Brenda Dietrich**, IBM Fellow and vice president in the IBM Research Division: "Companies appreciate the business value of optimization and are investing in applications, and end users are becoming more computer literate and easier to satisfy."

**Leslie-Ann Asmus**, supply chain product manager, Chesapeake Supply Chain Division, Aspen Technology, Inc.: "My title of supply chain project manager translates to being involved in everything from pre-sales technical support to industry template development to project management and support."

For managing your ongoing career, in addition to conferences, publications, awards and volunteer opportunities, INFORMS has created the new Certified Analytics Professional (CAP®) certification and professional education courses [6]. For organizations, the Analytics Maturity Model [7] scorecard helps assess their internal analytics capabilities.

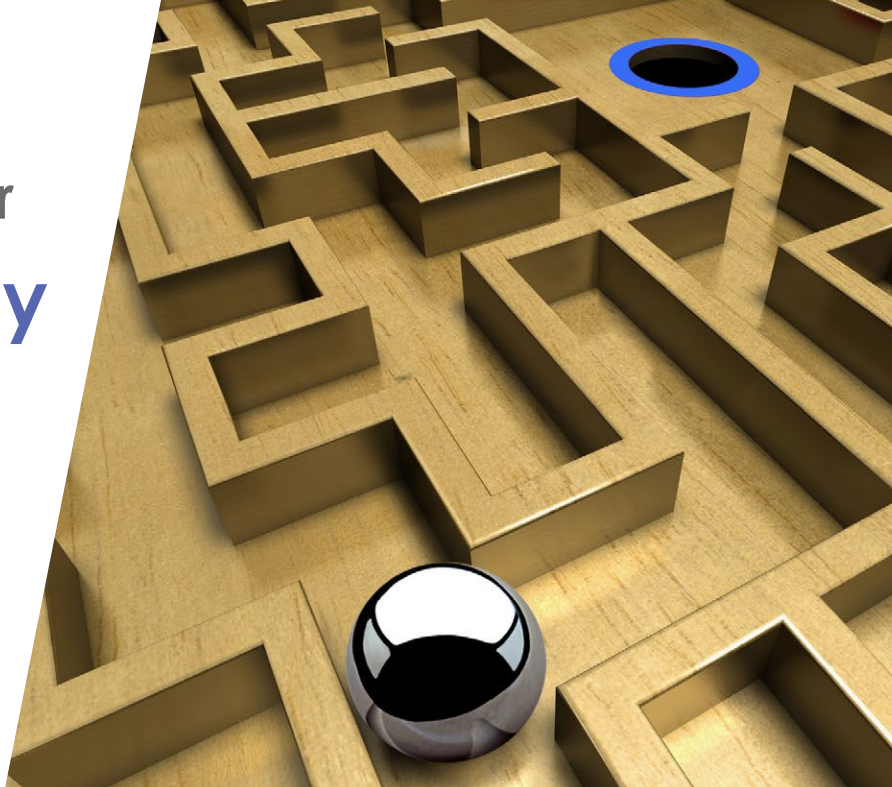
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# Teaching MBA students about big data

Since the INFORMS Big Data Conference in June 2014, I've had many conversations with instructors teaching OR/MS and analytics to MBA students. They've told me they don't really know much about big data, and are skeptical about whether there's anything new to teach. Few have taken steps to incorporate big data topics into their courses. With developments in big data accelerating, I've become concerned that instructors may miss something truly important. This article offers a brief "crash course" in big data, and argues that exposure to big data needs to be part of the MBA analytics curriculum.

## Big Data vs. 'Ordinary' Data

"Big data" deals with massive data sets, such as the terabyte of trade data generated by the New York Stock Exchange each day or the 1 million customer transactions handled by Walmart every hour. Big data architecture and technology is a response to physical limits of hard disks. Over the last 20 years, read speed has improved by about 23 times, but capacity has increased by more than 700 times [1], so the time taken to read the contents of a typical hard drive has increased from about 5 minutes to 2.5 hours.

What separates big data from "ordinary" data is that a large data set is spread across many computers and hard disks and processed in parallel – the only way to process this much data in reasonable time. But with hundreds to thousands of machines involved, some will inevitably fail. Hadoop and its distributed file system HDFS solves the

problem of scheduling work and recovering from failures across a cluster of computers and hard disks.

## Hadoop, Hive and Spark

In big data's early years (from Google's 2003 GFS paper [2] to about 2009), the focus was on basic data processing, using the disk-based MapReduce paradigm. Hadoop, developed and heavily used at Yahoo, became an Apache Foundation open-source project in 2008. But big data users soon moved beyond basic data processing. Hive, developed at Facebook [3], starting in 2009, and now as part of Hadoop, made it possible to treat a big data cluster like a data warehouse and query it using a variant of SQL called HQL.

In late 2013, Hadoop 2.0 made it easier to go beyond MapReduce on HDFS clusters, and utilize main memory as well as disk. This quickly led to distributed analytics algorithms, and the explosive growth of the Spark project [4], started at U.C. Berkeley's AMPLab, which became an Apache Foundation open-source project in early 2014. Spark now has more contributors than Hadoop itself, ranging from Yahoo, Netflix and Intel to Cloudera and HortonWorks.

## Large Companies Embracing Big Data

Introducing the 2014 New Advantage Partners Big Data Executive Survey [5] of 125 senior corporate executives representing 59 Fortune 1000 companies, Tom Davenport wrote that 82 percent of executives surveyed say that big data is "important or mission critical" to their

organizations. Two-thirds (67 percent) of executives reported big data initiatives running in production within the corporation. In June 2015, IBM announced [6] a major (\$300 million) commitment to Apache Spark, involving more than 3,500 IBM researchers and developers.

## Big Data Education at Scale

Perhaps more important, IBM said it would "educate more than 1 million

What separates big data from "ordinary" data is that a large data set is spread across many computers and hard disks and processed in parallel.

data scientists and data engineers on Spark through extensive partnerships with AMPLab, DataCamp, MetiStream, Galvanize and Big Data University MOOC." It appears that IBM, seeking to move quickly, is working with the new "ed tech" competitors rather than traditional university programs. I recently participated in a MOOC on Apache Spark [7] taught by U.C. Berkeley through edX – with more than 70,000 other students.

Compare these numbers with the oft-cited 2011 McKinsey study [8] predicting "a shortage of 140,000 to 190,000 people with deep analytical skills, as well as 1.5 million managers and analysts with the know-how to use the analysis of big data to make effective decisions." How long will the shortage last?

## How and What to Teach MBA Students?

Most data science or analytics courses offered by "ed tech" firms, and by university master's in analytics programs, emphasize programming in a language such as R, Python, Java or Scala. This could prove challenging for many business students without an engineering background.

Fortunately, big data tools have progressed far enough so this isn't



necessary. It's now possible to work with big data, using only SQL, Excel (with the latest version of Frontline's Solvers, supporting Apache Spark) and data visualization tools such as Tableau and Microsoft Power BI. With some imagination and determination, it's possible to give MBA students a "hands-on experience" working with big data, using these tools.

The main challenge for instructors lies in setting up a big data cluster of computers and hard disks, loaded with appropriate data sets. This sounds daunting, but the ability to run Hadoop and Apache Spark on a cluster of virtual machines on Amazon Web Services (AWS), Microsoft Azure and soon IBM's Bluemix makes it far more feasible. Frontline Systems is currently seeking a small number of instructors to share use of our Spark big data cluster on AWS, preloaded with our own test data sets, such as the ASA's airline data, New York City's

taxi cab trip and fare data, and the UCI Higgs Boson data set.

We want students to be able to ask and answer key business questions by exploring the data. For example, with 20 years of airline data [9] (29 airlines, 3,376 airports, 120 million records), we can study planned and actual flight departure and arrival times, seeking to predict delays. Doing this involves steps such as preprocessing, feature selection, adding weather information and using logistic regression to build a predictive model.

In the late 1990s, OR/MS courses in MBA programs experienced a "crisis of relevance." It was ultimately overcome by embracing new tools, updating the curriculum and improving teaching methods. I believe that big data presents a new challenge that, if not addressed quickly, could lead to another "crisis of relevance." Now is the time to dig in, embrace change and

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give MBA students the big data analytics experience they want and need for their future careers. **ORMS**

**Daniel Fylstra** ([daniel@solver.com](mailto:daniel@solver.com)) is the president of Frontline Systems, Inc.

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# Big data, blind spots, bias, brands and more

decision-making process, and implying that the values of the advice seeker is similar to the adviser.

“Asking for a recommendation can feel flattering to the other person,” says Lebel.

– *Fast Company*, June 26

## Your Guide to Analytics Patents

Analytics may be a young profession, but it is taking off, and its growth is evident in the rapid increase in analytics patents that have been granted by the U.S. Patent Office. As an analytics professional, you may find that patents play an important part in your life – the 40-plus patents that we co-invented at IBM were front and center for us.

Knowing the patenting process can be important for you and your company's success, protecting your most valuable work. And if you want to learn about advanced analytics, the patent literature is an important source of information.

In a study we wrote with Troy White of Clarkson University that has just been published in the INFORMS journal *Interfaces*, we examined keywords relevant to descriptive, predictive and prescriptive analytics found in U.S. patents that were issued between 2002 and 2013.

– *John Milne and Brian Denton in Allanalytics.com*, June 24

## Harnessing Big Data in Montreal

Imagine harnessing all the digital data out there – the zillions of Google searches and smart phone interactions – and then using the real-time information that has become so readily available to optimize services, solve problems and benefit society.

It wouldn't just be cool – it would be revolutionary.

Well, it's starting to happen, and a renowned data scientist who is coming to École Polytechnique de Montréal this fall is one of those spearheading the revolution.

[INFORMS member] Andrea Lodi, holder of the new Canada Excellence Research Chair (CERC) in data science for real-time decision-making, hopes to use the \$22 million he has been given to set up shop at Polytechnique to help make sense of the explosion of online data and convert it into knowledge that

INFORMS member Scott Nestler explains how the INFORMS Certified Analytics Professional (CAP®) ethics guidelines would have helped prevent a sports analytics scandal in the world of Major League Baseball and INFORMS Secretary Brian Denton, along with longtime volunteer John Milne, explain the finer points of patenting analytics in the most recent news stories about operations research and the allied field of business analytics.

Visit the INFORMS Newsroom at [www.informs.org](http://www.informs.org) for news about analytics and INFORMS press releases. Remember to share your news-making research with INFORMS Communications. Contact Barry List at [barry.list@informatics.org](mailto:barry.list@informatics.org) or 1-800-4INFORMS.

Meanwhile, here's excerpts from INFORMS in the news:

## Cardinals vs. Astros: An Analytics Morality Tale

As *Post-Dispatch* baseball writer Derrick Goold aptly reported in coverage of FBI allegations about the St. Louis Cardinals hacking scouting reports of the Houston Astros, this baseball drama contains a story about the increasingly competitive world of sports analytics. It is also a wake-up call for analytics professionals and other business leaders, not just in professional sports but across numerous industries, who have a vested interest in ensuring that this growing technical field adheres to stringent ethical guidelines and professional standards.

– *Scott Nestler in the St. Louis Post-Dispatch*, June 30

## How Much is Your Olympic Reputation Worth?

The ancient Roman philosopher Publius once opined, “A good reputation is more valuable than money.”

Well, new research appearing in this month's issue of *Management Science* suggests these words may be as true today as they were two thousand years ago.

Researchers David Waguespack and Robert Salomon examined whether “reputationally privileged” athletes (that is, athletes who had been successful in previous competitions, or those from countries with a track record of athletic excellence) were more likely to succeed at the Olympic Games than lesser-known athletes.

– *Psychology Today*, July 9

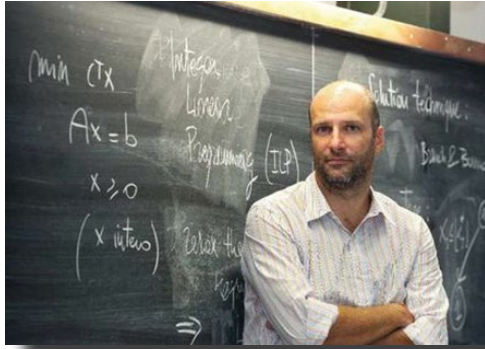
## It's OK for Male Execs to Ask Directions and Business Advice

[University of Pittsburgh Professor Dave] Lebel says research has found that it can be easier to ask for help when you turn it into advice seeking. In a study published in the June 2015 issue of *Management Science*, researchers from Harvard Business School and Wharton School at the University of Pennsylvania found that advice-seeking differs from other help-seeking behaviors because you're eliciting information for a course of action, retaining the



Were Cardinals hacking off the field as well as on?





**Andrea Lodi is holder of the new Canada Excellence Research Chair.**

will help organizations and governments make opportune decisions.

– *Montreal Gazette*, July 7

### Brands, Patents Protect Companies from Bankruptcy

If a firm faces troubled times during a stable market, strong advertising can carry it through. But when the market is turbulent, a firm's research and development is more likely to help save it from bankruptcy. A new study published in the Articles in Advance section of *Marketing Science*, a journal of the Institute for Operations Research and the Management Sciences (INFORMS), shows that "intangible assets" built with advertising (such as brands) and R&D (such as patents) can help protect firms from bankruptcy, but the effectiveness of each depends on the market climate.

The study, "The Impacts of Advertising Assets and R&D Assets on Reducing Bankruptcy Risk" by Niket Jindal of Indiana University's Kelley School of Business and Leigh McAlister of the University of Texas' McCombs School of Business, is based on data from more than 1,000 firms covering three decades.

– *Product Design & Development*, June 19

### How Job Stress Might be Killing You – and What You can do About It

Job stress is also tied to hypertension, obesity and even depression. Any one of these factors makes life more difficult and can even increase your risk of death. A study published in March in the journal *Management Science* looked at the effect of 10 sources of stress in the workplace and found that all of them contribute to increased healthcare spending among workers, and many to an increased risk of death. These

workplace stressors, which have been linked to cardiovascular disease and poor mental health, are responsible for more deaths annually than diabetes, Alzheimer's or the flu, according to the researchers.

– *US News*, June 15

### His Legacy: The Nash Equilibrium

In 2009, a global pandemic of H1N1 influenza, or swine flu, broke out. Vaccines were in short supply, raising concerns that governments of wealthier countries would buy up so much of the supply that poorer countries would be left without enough. Using the Nash equilibrium and related concepts in game theory, researchers determined that under some conditions it would actually be in the wealthier countries' best interest to give their vaccine supplies to countries that do not have enough. This can help prevent the spread of the epidemic, according to the paper published in *Operations Research* in 2009.

– *Tech Times*, May 27

### The Bias Blind Spot

It has been well established that people have a "bias blind spot," meaning that they are less likely to detect bias in themselves than others. However, how blind we are to our own actual degree of bias, and how many of us think we are less biased than others have been less clear.

Published in *Management Science*, researchers from Carnegie Mellon University, the City University London, Boston University and the University of Colorado, Boulder, have developed a tool to measure the bias blind spot, and revealed that believing you are less biased than your peers has detrimental consequences on judgments and behaviors, such as accurately judging whether advice is useful. **ORMS**

– *Carnegie Mellon University*, June 8

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# CAP update, Doing Good, Grand Challenges

## Update: Certified Analytics Professional program

Developing new test questions that keep the Certified Analytics Professional (CAP®) exam fresh is an important component of making certain CAP remains the premier global certification for analytics practitioners. The Analytics Certification Board and staff thank Innovative Decisions, Inc. (IDI) and especially Freeman Marvin, CAP, for recently hosting an item-writing workshop at their headquarters in Vienna, Va., as part of this ongoing effort.

If you are interested in sponsoring an item-writing workshop or submitting a test question, contact [info@certifiedanalytics.org](mailto:info@certifiedanalytics.org).

Although CAP is available through a computer-based testing format, INFORMS continues to host paper-and-pencil exams at selected sites, particularly at INFORMS conferences. To take advantage of these on-site exams, you must first apply and be approved for the CAP examination.

For ongoing computer-based examinations to test on your schedule, see [www.certifiedanalytics.org](http://www.certifiedanalytics.org).

## 'Doing Good' finalists tackle crime, medical challenges

The INFORMS Doing Good with Good O.R. Student Paper Competition is held each year to honor outstanding projects by students in operations research and the management sciences; projects that have a significant impact, particularly solutions aimed at important societal and humanitarian problems.

This year's winners will be announced at the 2015 INFORMS Annual Meeting, which will take place in Philadelphia Nov. 1-4.

The finalists' projects are:

- "Finding Patterns with a Rotten Core: Data Mining for Crime Series Detection," Tong Wang, MIT.

The contestant worked with the Cambridge, Mass., Police Department

to build a model that can automatically detect crime series, which analysts now spend hours a day doing manually. NYPD is currently working with the team's computer code, incorporating it into a custom software package for daily use.

- "Using Operations Research to Improve the Health of Patients with Type 2 Diabetes," Yuanhui Zhang, North Carolina State University

The contestant developed models to evaluate policy and examine clinical regimens involving glycemic control for patients with type 2 diabetes. The sophisticated math methods helped determine whether new medications are more effective than standard regimens.

- "The Optimal Policy Design to Motivate Blood Donation: Evidence from a Randomized Field Experiment and a Structural Model," Tianshu Sun, University of Maryland

Using a randomized field experiment involving 80,000 participants, the participant tested the effect of different policies in driving donations and found that blood banks can use rewards to motivate group formations that increase donations. Group rewards are four times more cost effective than individual rewards.

- "Improving Blood Collection Policies for Cryoprecipitate," Chenxi Zeng, Georgia Institute of Technology.

The blood product cryoprecipitate ("cryo") must satisfy an 8-hour collection-to-product completion constraint, which requires extra transport expense for the American Red Cross. The contestant reduced extra transport cost by 70 percent.

- "Ebola Treatment Facility Location Planning in Guinea (Analysis for the Centers for Disease Control and Prevention)," Kimberly Adelaar, Charmaine Chan, Matt Daniels, Javeria Javeria, Caleb Mbuvi, Chu Qian, Ivan Renaldi, Jonathan

Sutomo, Georgia Institute of Technology.

In the recent Ebola outbreak, treatment facilities were critical but beds were unavailable in some areas while unused in others. Results showed units set up quickly or in advance could have saved more than 2,000 lives.

- "Infusion Center Process Improvement and Patient Wait Time Reduction," Sung Keun Baek, Xiaoyang Li, Allen Liu, James Micali, Jisu Park, Mengnan Shen, Yunjie Sun, Emilie Wurmser, Georgia Institute of Technology.

The team combined patient interviews, math modeling and data analytics to reduce patient waits by 28 percent and improve patient satisfaction by 8.5 percent.

## INFORMS team addresses 'Grand Challenges'

A team chaired by Suvrajeet Sen of the University of Southern California that included many prominent members of INFORMS submitted a report to the National Science Foundation outlining how the operations research community could play the role of catalyst – utilizing its ideas and tools – and transcend disciplinary boundaries to help address many of the challenges.

The report suggested a two-pronged approach to speed up the research and exchange process: (1) An NSF announcement of "Grand Challenge Analytics" as one of its major Emerging Frontiers in Research and Innovation (EFRI) topics, and (2) an NSF-sponsored institute for "Multidisciplinary O.R. and Engineering," dedicated to coalescing a general-purpose theory, as well as building a community to support "Grand Challenge Analytics." **ORMS**

For more on the story, see page 44.

## CORRECTION: LP SURVEY

In the June 2015 issue, *ORMS Today* published its biennial survey of linear programming software based on the responses to an online questionnaire. Due to an error in the transfer of collected data, some responses were inadvertently listed in the wrong columns. The problem was quickly corrected on the online HTML (<http://www.orms-today.org/surveys/LP/LP-survey.html>) and digital (<http://viewer.zmags.com/publication/2e5dda2c/#/58>) versions of the magazine.





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# Not taught in school (but useful in the ‘real world’)

*All models are wrong, but some are useful.*

– George Box

(models) provide information that is *useful* for making decisions about what size bet to make, given the current state of the system. While many different card-counting systems have been developed, the most useful of these card counting systems are relatively simple because more complex card counting systems (which may be more accurate) are almost impossible to employ effectively for betting decisions in a chaotic casino environment. This is just one example of how, in the real world, there is often a trade-off

Someone recently commented (and asked), “It’s a great time to be a quant grad, but what didn’t they teach you in school that you really need to know?” The first three things that occurred to us are:

1. The need to fully embrace the second half of the famous quote from George Box [1].
2. How to communicate the results of your analysis to decision-makers.
3. The importance of creating a good visualization of your data/model (a subset of the previous task).

With regard to models, one of the most important keys “in the real world” is understanding the difference between a great-fitting model and a useful model and the need to structure your research and modeling toward improving the decision-maker’s ability to make decisions rather than simply getting a high  $R^2$  value. In academic environments, students are often introduced to a series of methods and then provided data sets with which to practice. The goal is almost always to develop the most accurate model possible from the available methods. In the real world, it is often more important to focus on developing models that are useful and then to improve the accuracy of the models over time under the constraint that their utility isn’t compromised. Examining the use of blackjack card-counting systems provides a good example of how model utility rather than performance is important in the real world.

## BlackJack Example

Blackjack counting systems are not very “accurate” in the sense that even when

the “deck is hot” (when the odds have swung in favor of the players vs. the dealer) there is still a very high probability that the dealer will win a given hand (and the bettor will lose their money to the house). These systems aren’t great predictors of the outcome of individual hands, as the model is often wrong. However, card counts are useful in that they can be employed in a systematic manner to win money, as documented in numerous recent popular books and movies. These counting systems

One of the most important keys “in the real world” is understanding the difference between a great-fitting model and a useful model.

space between model accuracy and model utility, with decision-making utility carrying more weight.

The point about communication skills was hammered home when the first author was teaching at the Naval

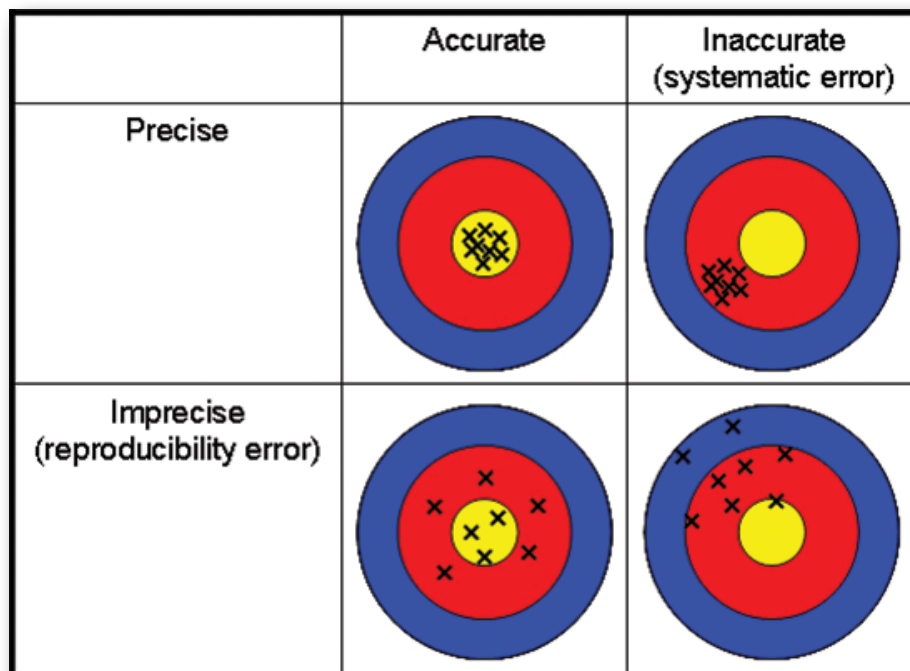


Figure 1: The authors recently saw an attempt to explain the terms precision and accuracy, and the difference between systematic and reproducibility errors. In lieu of three paragraphs of text, they suggest the graphic shown here.

Source: <http://www.sophia.org/tutorials/accuracy-and-precision--3>



Postgraduate School in Monterey, Calif. In the biennial (every two years) program review, the number one comment was that the graduates came with all of the technical skills that they needed, but their ability to communicate to senior leaders and decision-makers, whose time is limited and span of involvement is high, was lacking.

One common mistake made by many analysts is a failure to make a distinction between a technical report or presentation and an executive summary or decision brief. A technical report is a document written to record how an analysis was done (so that it can be replicated) and is designed to make a scientific and logical argument to support a set of conclusions. Therefore, a common outline for such a report might be: introduction, literature review, problem definition, methodology, results and conclusions. A presentation to a decision-maker using this format is likely to produce impatience and frustration – “Just get to the bottom line.”

## Executive Summary & Decision Brief

The structure of a good executive summary or decision brief relies on the logical argument of the technical report (and should only be written once this logic is firmly established) but *presents the logic in reverse order*. An executive summary should lead with a brief statement of purpose to orient the reader, and then summarize the conclusions and recommendations, i.e., the bottom line up front, the results of the analysis (preferably in an easy-to-read chart), and *briefly* highlight the methodology and data used. One way to highlight the distinction between the logic of a technical report and an executive summary is that the logic of a technical report can be summarized with a series of “Therefore . . .” statements, while the logic of an executive summary should rely on a series of “Because . . .” statements.

These ideas appeared in a blog post [2] by Polly Mitchell-Guthrie, chair of the INFORMS Analytics Certification Board (ACB), which oversees the Certified Analytics Professional (CAP®) program, in

2013. She writes, “Much as we lament the shortage of graduates from the STEM disciplines (science, technology, engineering and math), it is arguably more difficult to find within that pool graduates who also have the right ‘soft skills.’” Polly points out that “selling” – yourself and your skills as an analyst – to convince others that you can solve their problems and improve their decision-making is critical. She suggests Daniel Pink’s book, “To Sell Is Human: The Surprising Truth About Moving Others” [3]. While “hard math” is critical in many instances, convincing someone that you have the technical skills to solve their problem is often more difficult. This is further highlighted in the seven domains of the CAP Job Task Analysis [4]: business problem framing, analytics problem framing, data, methodology selection, model building, deployment and lifecycle management. Not surprisingly, many of the supporting 36 tasks and 16 knowledge statements involve communications skills.

These shortcomings among analysts are nothing new. In 2011, an *Analytics* magazine article [5] by Freeman Marvin, CAP, and Bill Klimack highlighted six “soft” skills every analyst needs to know: partnering with clients, working with teams, problem framing, interviewing experts, collecting data from groups and communicating results. Failure to effectively communicating results can lead to a project that is a technical success but has no impact. They propose that instead of dragging the decision-maker through the entire chronology of an analysis, tell a compelling story with a beginning, middle and end.

One of the best ways to tell a compelling story is to use pictures (or graphics) to communicate the results of an analysis. Unfortunately, methods and principles for visually communicating the results of an analysis are often not taught in technical programs even though, as Mike Driscoll asserts in a popular online presentation [6], the ability to “munge, model and visually communicate data” are “the three core skills of data geeks.” Reviewing the work of Edward Tufte [7] and William S. Cleve-

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land [8] provides an excellent foundation for visually communicating quantitative information. “Choosing a Good Chart” [9] by Abela is also useful, as it suggests an appropriate type of graphic for nearly any type of data and purpose.

## Summing Up

In summary, first focus on developing *useful* models. Second, when communicating with decision-makers, start by describing the utility of those models – how can they be used and what difference will it make. Only after communicating the practical effects of the employment of the model/analysis should you communicate how you arrived at your conclusions (follow the logic of the technical report backwards). Finally, the most compelling way to communicate these ideas is through the developing graphical products that clearly communicate the key results of your analysis. As they say, “A picture is worth a thousand words.” **ORMS**

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**Disclaimer:** The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Army, the Department of Defense or the U.S. government.

# Moon rover

A new moon on a nearby planet has recently been discovered, and a rover has been sent to the surface to explore. Many interesting features on the new moon have been identified, but the rover has a limited travel distance ability so not all sites can be visited.

In order to prioritize the scientific value of a site, “science points” have been assigned to each of the sites of interest (as indicated by the numbers inside the circles). The rover starts at location D6. Due to the battery limitations of the rover, it can only travel a maximum distance of 25 kilometers. Use a direct line between sites to calculate travel distance (for example, the

distance between G3 and H4 is 1.41km).

## Question:

What is the maximum number of “science points” you can achieve before the rover’s batteries run out?

Send your answer to [puzzlor@gmail.com](mailto:puzzlor@gmail.com) by Oct. 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](http://puzzlor.com). **ORMS**

**John Toczek** is the senior director of Decision Support and Analytics for Aramark Corporation

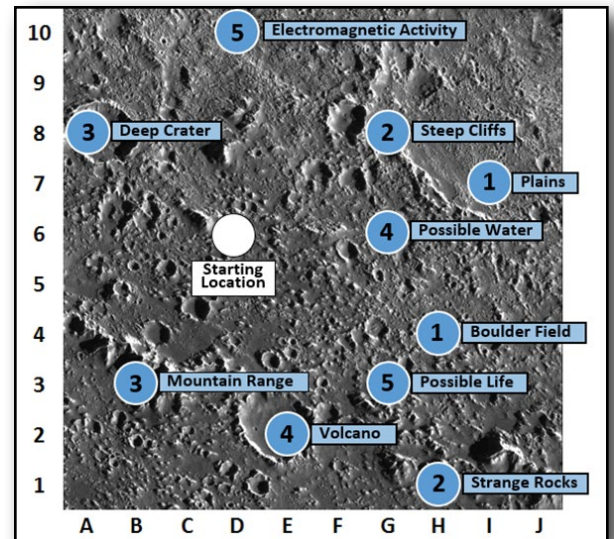


Figure 1: Searching for science points.

in the Global Operational Excellence group. He earned his BSc. in chemical engineering at Drexel University (1996) and his MSc. in operations research from Virginia Commonwealth University (2005).

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# What's Your StORy?

## Yi Liu



PhD Candidate at University of California, Berkeley  
Member of INFORMS since 2011. Chair of  
INFORMS Aviation Applications Section in 2013.



What interest do you have outside of work that might surprise us? This is probably not an interest but a skill: mental calculation. I started to practice abacus when I was in my second grade in primary school in China. After two years of training, I was able to do mental calculation. Even though I have not practiced after middle school, I could still multiple 4 digits by 4 digits. The side effect is that I am not very good at using a calculator.



If you could choose anyone, who would you pick as your mentor? Socrates. I resonate with Socrates that the best way for people to live is to focus on the pursuit of virtue rather than material wealth. He guarded his belief by accepting his death sentence and gave up the chance to run away. I admire him as a great and brave thinker.



What was your best INFORMS experience?  
It was 2013 INFORMS in Minneapolis. I received honorable mention in Best Student Presentation Competition from INFORMS Aviation Applications Section.



If you had to work on only one project for the next year, what would it be?  
I would like to analyze the difference in air traffic management (ATM) between the U.S. and China and identify ways to improve the ATM system in China.



What is the #1 most played song on your iPod?  
I don't have one.



When I graduate, my perfect job would be...  
The perfect job should let me do what I like, contribute the most, and make a difference. One good example is a faculty position. I enjoy identifying problems and exploring solutions through research. It is also awesome that you can keep pushing yourself beyond your limit in the process. As a professor, one may also cultivate more researchers and engineers through research supervision and classroom teaching.



More  
questions  
for Yi Liu?  
Ask her in the  
Open Forum  
on INFORMS Connect!

# Running an O.R./analytics group

## Survey of INFORMS Roundtable membership reveals keys to success, problems to overcome.

The INFORMS Roundtable, comprised of representatives from about 50 member companies, is organized to share best practices and recent developments in the practice of operations research, management science and analytics. The Roundtable meets formally at least three times a year. One such meeting focused on some of the key challenges facing analytic leaders in the practice community: organizing analytics teams; communicating value and realizing benefits; data, tools and working with IT/suppliers; and building cohesion and motivating and retaining analytics talent.

To understand the Roundtable's views and experience on these topics, the organizers conducted an unscientific survey of the membership using an online service prior to the meeting. Roughly 40 percent of the membership participated, representing manufacturing, oil & gas, consulting, transportation, healthcare, consumer goods and defense companies. Their responses and the subsequent dialog that they seeded form the basis of the perspectives presented here.

### Organizing Analytic Teams

In many organizations, there is no natural home for operations research and analytics activities and no standard way to organize and govern them. A variety of organizing structures are found in member companies: centralized, in which analytics activities are housed in a single business unit or organization; hybrid, in which multiple business units house analytics activities that are also coupled to a central organization; and decentralized, in which diverse business units house and direct their own analytics activities. Each of these approaches is represented in the Roundtable and can work

well depending on corporate objectives, needs and resources.

Regardless of the organizational structure, the need for high-level visibility, direction and sponsorship for analytic teams is clear. That analytics organizations have a leader "at the table" is important to their success; executive-level sponsorship is viewed as necessary to identify emerging analytics opportunities and to break through barriers in or between business units. This leadership tends to be at the managing director or partner level or higher.

### Communicating Value and Realizing Benefits

The variety of capabilities and tools delivered by member organizations is impressive: pricing/yield management, supply chain design, routing/scheduling, network/facility design, market analysis, fleet strategy, workforce design, portfolio optimization, call center/customer service, social media, claims analysis and forecasting. Most non-consulting organizations are set up as cost centers due to the nature of analytics work – long lead times, the unpredictability of the creative process, the challenge of quantifying value, etc. Even for established and well-known analytics and operations research groups, the challenge of demonstrating and quantifying the return on this investment is real and ongoing. Many groups report using a return on investment (ROI) approach coupled with a broader analysis including "soft" benefits such as corporate reputation, supplying talent to the parent company, etc. Even for successful organizations, it is often challenging to quantify analytics project benefits; for example, it

can be difficult to attribute benefits to analytics and operations research in isolation of the partner organizations that often are responsible for realizing the benefits of analytic solutions.

As indicated above, analytics organizations have created solutions for a wide variety of problems. However, these solutions may conflict with business experience or be difficult to implement due to legacy systems or entrenched processes. Best practices dictate that the business owner be engaged up front in defining the problem and its solution to help bridge this gap. Fostering strong and lasting ties between the analytics teams and their business partners is critical to implementing solutions that create business value. Communicating the solution and its benefits to business partners can also be challenging; visual analytics is viewed as a necessary tool to enhance this communication.

### Data, Tools and Working with IT/Suppliers

Roundtable member companies rely on a wide variety of analytical tools, with predictive analytics and optimization categories cited as most frequently used. Several members reported IT constraints – based on concerns such as indemnification and licensing – against using open source software, particularly in production applications, although some use it for prototyping. Traditional IT development processes and timelines can also be problematic for analytic teams due to the unpredictable creative process associated with many projects, which often requires iterative cycles of development and testing in collaboration with business partners. Member companies report that data access can be problematic for analytic groups housed outside of a firm's IT organization. Creating relationships with data providers will speed up the analytics process and enhance the overall effectiveness of the organization.

### Cohesion, Motivation, Retention

Internal and external conferences are regarded by member companies as a way to help motivate and retain talent. Internal analytics conferences and workshops, such

as those held by a large manufacturing company, are seen as a way for analytics professionals to connect with each other and share best practices, particularly when analysts are decentralized organizationally or geographically.

Most member companies have a career path for analytics professionals, but several report that it is limited in scope or opportunity compared to other paths, such as the more familiar management track or more widely populated general technical track. Member representatives touched on the need to provide growth opportunities and manage career expectations of younger analysts, who may be more interested in rapidly moving up the organization – or moving out, by changing companies – than in previous cohorts.

Analytics and operations research practitioners are in great demand, making recruiting and retaining talent a particular challenge. Due to resource constraints and the difficulty of recruiting new team

members, member companies will use third-party firms and “off-shoring” to augment the core analytics team. Advantages include greater flexibility and speed in ramping up and delivering high-priority projects, but disadvantages can include the failure to capture intellectual property generated in an outsourced project and the lost opportunity to build the internal organization’s skills. Most organizations will likely take a balanced approach using both internal and external talent.

### Summary

The INFORMS Roundtable comprises diverse organizations united by their desire to advance their technical capabilities, maximize the benefits of analytics and operations research, and improve opportunities for their analysts. Despite the differences in the role of analytics and how it is structured in these organizations, several common themes emerged as essential to developing a more

productive analytics organization: Executive sponsorship and leadership is key to success; measuring the impact of analytics is challenging but needed to help communicate value; business partners must be engaged up front in defining analytics problems and solutions; traditional IT processes can be problematic for analytics solution development and must be overcome; and managers must help provide growth opportunities since traditional analytics career paths may be limited. These findings represent opportunities for the betterment of the Roundtable member organizations and for INFORMS practitioners in general. **ORMS**

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# Analytics and the MBA program core

Why it is essential for every future manager to have an understanding of analytics and data.



By Peter C. Bell

*All photos courtesy of Ivey School of Business.*

recently attended the EURO conference in Glasgow, Scotland, and found the atmosphere to be very upbeat, reflecting my own perception of the current state of MS/OR/analytics (hereafter “analytics”). Researchers, practitioners and many academics believe that their work is being appreciated and that the future of analytics looks brighter than it has for many years. However, amongst this general sense of well-being, I heard that two major business schools have eliminated analytics from the core requirements for their MBA degree. One (Warwick) has switched analytics from required to elective in the full-time MBA program, while a second (Lausanne) has restructured their MBA core so that students can elect out of some former core courses, with the result that many elect out of analytics. Business schools have been dropping analytics from their MBA core for decades, and this data shows that despite the increasing buzz about analytics in the press and in business, this trend may be continuing.

At the same time we have seen an explosion in the appearance of master's degree programs in analytics (usually M.Sc. degrees), with many of the 200-plus new programs that have appeared in the last decade being offered through business schools. It appears that many business schools believe that analytics represents a growth opportunity but are unconvinced that analytics should be a required part of an MBA or business program. In my view, graduates of business programs are important to the future of analytics; those who understand the value of analytics and know enough analytics to spot opportunities where analytics can add value will either hire analytics professionals or outsource analytical work.

### Essential Skills

I, and many of my colleagues in analytics, strongly believe that it is essential for every future manager to have an understanding of analytics and data. Decision-makers will increasingly be exposed to recommendations and results derived from data and models, and they need to be able to assess the credibility of the assumptions and analysis as they decide what weight they will give to the analytics in their decision-making. However, while we in analytics think that the world has come to accept and value our skill set, many outside our field do not agree with us or are resisting this change. If we believe that every business student needs a basic understanding of analytics, how do we make this case to our academic colleagues?

Many business school faculty believe (and teach) that experience, intuition and leadership skills are the most important qualities for managers and may not attach great value to data and models as aids to business decision-making. These same colleagues may control program budgets and program design, and, if we are successful at teaching our students to be more analytical, these colleagues may have to change the way they deliver their own courses. For example, MBA students taking an operations management course following my analytics course complained that the instructor ignored an obvious opportunity to build an optimization model when discussing a case that required simultaneous decisions. In addition, a colleague teaching marketing happily told me that he refused to allow Excel models to be used in his classroom because when students had the model the decisions were obvious, and he could not have the kind of discussion he wanted. Given that increasing the analytical content of a business program is potentially disruptive for our colleagues and is likely to meet resistance, how can



Peter Bell is a recipient of the INFORMS Prize for the Teaching of OR/MS Practice.

we make the case that we belong as a required component of every business program?

Hard data to support the importance of analytics core courses in business programs is scarce. We can cite the frequent surveys that show large numbers of jobs open for analytics professionals although this plays directly into the hands of those planning or offering master's degrees in analytics where the objective is to train people to actually do advanced analytics. Perhaps more relevant data is the explosive growth in outsourcing and offshoring analytics (as illustrated by GENPACT, Mu Sigma, Cognizant, Dell Global Analytics and recently Walmart in India), suggesting that increasing numbers of businesses are buying analytics and facing the kinds of complex business decision issues surrounding outsourcing and offshoring analytics [1]. Finally, we can talk about analytical CEOs such as Jeff Bezos (Amazon) or analytical powerhouses (IBM, Walmart) where analytics is a major component of business strategy and has a direct impact on the ways these firms are managed. All this, however, is indirect evidence; ultimately we need to do a better job in marketing a basic understanding of analytics as an essential component of the future manager's skill set.

### CEO's Analytical Model of Life

"Teaching future managers about the importance of analytics" or "surviving as an MBA core course" are noble objectives, but these are tough to operationalize. A former student, who has been a very successful CEO at several companies, visited my class for a guest lecture. He was asked what is the first thing

While we  
**in analytics**  
think that the  
**world**  
has  
**come to**  
**accept**  
and value  
**our skill set,**  
many  
**outside**  
**our field**  
do not  
**agree**  
with us  
or are  
**resisting**  
**this**  
**change.**



## Analytics and the MBA CORE

**Three objectives** that seem to be **important** for most **business schools** are the **“rankings,” student satisfaction** and **opinions from recruiters** who hire your **students.**



he does when he becomes CEO of a new firm. His surprising (at least to the class!) reply was that he builds an Excel model of the firm and highlights the cells whose future values will determine his success or failure, then backtracks through the model to find those things that he can change that will positively affect the highlighted cells. With this understanding, he starts work. This “analytical” model of life as a CEO applies equally well to our teaching.

Business schools have many different market positions, and so there will be many different highlighted cells (“objectives”) across schools. A first step for all faculty is to understand your school’s positioning and to be sure that your activities support that position. Three objectives that seem to be important for most business schools are the “rankings,” student satisfaction (an important contributor to the rankings) and opinions from recruiters who hire your students. Analytics faculty who are looking to prosper in a business school may find it helpful to examine how their activities can be directed towards these objectives.

There are many business school rankings published annually, and the differences in the ranking of a school are often huge. For example, the Ivey Business School at Western University in Ontario, Canada, where I teach is a globally recognized general management school with a strong focus on leadership. The recent *Bloomberg Business Week* [2] rankings rated Ivey’s MBA at the top of 209 international MBA programs, while the 2015 *Financial Times* ranking has Ivey at number 97 [3]. How can the rankings be so different and how does this impact our objectives? First, not all schools contribute to all the rankings; it is just too much effort. Second, schools pay more attention to those rankings that support their market position. Again using the Ivey example, we do very well in rankings that emphasize student (or alumni) and recruiter opinions, job placement statistics and starting salaries.

Many would think that positioning as a general management/leadership school was incompatible with a strong presence for analytics, but “The Bloomberg Recruiter Report” [4], “based on a survey to 1,320 recruiters at more than 600 companies around the globe to discover the skills that are in high demand by employers and which business schools are best at teaching those skills,” suggests otherwise. According to the report, the recruiters ranked Ivey first among 122 global MBA schools for the teaching of leadership skills, strategic thinking, ability to work collaboratively and communication skills – all skills closely aligned with “general management” and “leadership.” Surpris-

ingly to many, Ivey was ranked second in teaching quantitative skills (first place went to the Tepper School at Carnegie-Mellon University) and in third place for teaching analytical thinking (after the Sloan School at MIT and Chicago-Booth.)

### School Ranking Lessons

Important lessons from these rankings are that Bloomberg sees quantitative skills and analytical thinking as “skills that are in high demand by employers” and uses recruiter opinions to assess these skills. This provides two very specific objectives for business school analytics faculty: first, to improve the quantitative and analytical skills of our students as seen by recruiters, and second, to focus attention on those skills in demand by the job market so that graduates meet or exceed recruiters’ expectations.

Comparing the Ivey MBA program curriculum with that of the No. 1 ranked Tepper School for quantitative content, it is immediately apparent that there are multiple ways to attack these objectives. Tepper’s approach to analytics is to market analytics as a major part of Tepper’s masthead: “Leadership + Analytics = A Powerful Career Advantage.” “We are one of the few MBA programs able to deliver a high level of preparation and training in both leadership and strategic analytics.” The Tepper MBA curriculum is very analytical and includes three required “quant” courses (“probability and statistics,” “optimization” and “statistical decision-making”) plus a required “managerial economics” course and two required “operations” courses.

In contrast, you won’t find much about “analytics” in the publicity materials for the Ivey MBA: “The Ivey MBA is a transformational experience for ambitious leaders who want to hone their skill set, develop their leadership abilities and accelerate their career success.” If you looked hard, you would find a single core course “decision-making with analytics” and an optional pre-program “quantitative analysis primer” for those who feel the need to get up to speed in Excel or basic statistics.

My limited research suggests that Tepper and Ivey may occupy the extreme ends of the spectrum from “analytics heavy” to “analytics light,” yet both are (according to Bloomberg) successful, suggesting that there is more than one way for business students to acquire quantitative skills. It is also likely that the success both schools have achieved with recruiters is no accident. Certainly the success that Ivey has had has been driven by a determination to offer great business courses that use analytics, and we measure our success very directly through feedback from students and recruiters.

Understanding student expectations and needs is the first step toward creating positive student feed-



back. Ivey students are interested in learning about business, so we believe that our courses should be about business first and analytics second. Our case teaching methodology supports this view; cases provide examples of real business problems and often include considerable details on real companies, industries and business people. A student-centric approach to delivering analytics requires balancing attention devoted to the business issue with the technical details of the analytics. Talking to colleagues teaching in programs where analytics is not flourishing leads me to believe that often the major reason for the lack of traction for analytics is a gap between the instructor's desire to deliver technical content and the students' desire to learn about business. Part of the issue appears to be that the supply chain for business school faculty does not include much exposure to business and management.

We have hired new analytics faculty almost every year for the last 10 or so years, and it can be a depressing process. We receive hundreds of applications from Ph.D.s in MS/OR/IE/analytics, and I first look for candidates with a degree in business or any evidence of any interest in business. This cut usually reduces the pile from hundreds to tens. I once suggested to a colleague that I thought that all faculty teaching business analytics should have an MBA and this was met with outrage. But you would not expect to be hired to teach university English without a degree in English or chemistry without a degree in chemistry. Why should business be any different? However, I can't remember the last time I saw a job application from a strong candidate with a Ph.D. in "analytics" and an MBA so the issue is moot.

### Fundamental Issue

The fundamental issue facing analytics instructors in business schools is that there are no "analytics" problems, but there are many marketing, finance, human resource, operations, etc. problems where analytics is really helpful in coming up with a solution. Teaching cases provides a convenient way to handle both business and analytical issues while encouraging student participation and interaction and developing other important skills such as communication and teamwork. While teaching cases requires a different mentality from lecturing and some cost in classroom setup and administrative overhead, a switch toward



*Bloomberg Business Week* rated Ivey's MBA at the top of international MBA programs.

this reality-based way of teaching analytics might be helpful if your core course is not attracting rave reviews from your students or recruiters.

Finally, as faculty we are accountable for the courses we deliver. While exclusion from the business school core can occur suddenly, prospering and growth is a much slower process. We prosper as a teaching area based on student and recruiter feedback. If we teach a great core course and market our electives well, we will have full electives and be invited to add more. Adding more electives enables the group to add more faculty, enabling it to add more electives and so on. Having key recruiters commenting positively on the "quantitative skills" of your students almost guarantees a place for analytics in the MBA program core. **ORMS**

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# Teaching the professional practitioner

VCU professor finds success by focusing on students' learning rather than his teaching.



By Jason R. W. Merrick

was honored to receive the 2014 INFORMS Prize for the Teaching of OR/MS Practice.

Looking at the list of names that have received the prize before me was humbling, including the first awardee, Ron Howard, one of the founders of my field of decision analysis. The prize is awarded to the teacher, but it is really based on the impact that your students have had practicing operations research and management science in their careers. I was very pleased to pick up the award on their behalf.

The idea of being recognized for teaching and practice would not have been obvious if one looked at my early education and research. I went to Reigate Grammar School in the United Kingdom and did "A" levels in math, advanced math, physics and chemistry. For my undergraduate, I went through a very theoretical program at Oxford University in math and computation (they didn't even call it computer science back then), followed by research in reliability theory and Bayesian statistics at George Washington University. My research used Bayesian semiparametric methods like mixtures of Dirichlet processes (and they are just as fun as they sound!).

## Hooked on Practice

However, in the third year of my Ph.D. studies I was involved in a study looking at oil spill risk in Prince William Sound in Alaska, the site of the Exxon Valdez disaster in 1989. We worked for a large stakeholder group including oil company executives and representatives from environmental groups and state and federal government. It was my first experience practicing decision and risk analysis.

The requirements on rigor were at the same level as my more theoretical research, programming a simulation of the study area and its vessel traffic and weather, and building risk models that combined data and expert judgment. But I also had to worry about the decision-makers, their understanding and their objectives, working to support their thought processes. They were making multi-million dollar decisions based on our analysis, but only because we followed the right approach to handling the stakeholder process as well as doing sound and careful analysis.

I was hooked. I went on to do additional oil spill risk studies in Washington state, as well as studies of passenger risk on ferries in San Francisco Bay and Washington state, and to create models used by the U.S. Coast Guard to make safety investment decisions around the country. I have also done projects with Capital One, Deloitte Consulting and most recently Procter and Gamble.

After the Prince William Sound study, I also started teaching at Virginia Commonwealth University. I must admit that I started my teaching career by copying my previous professors. I spent 30 hours a week preparing PowerPoint slides for lectures and thoroughly abusing animations and special effects. Despite the fact that students in the United States enjoy my English accent (or what's left of it), I found myself boring when I lectured, and my evaluations were not at the level I hoped in my first semester. So I started reading all the literature on teaching operations research.

At the time, there were numerous papers on active learning principles, setting up a business case and developing the techniques to solve the problem [1]. The case method is widely recognized as a breakthrough in teaching quantitative methodologies in business schools ([2], [3]). It provides relevance, the importance of which is well recognized among business school educators [4]. I devoured these papers and then decided it was time to talk to my mum; like everyone else in my family, she was a schoolteacher. My mum taught English and drama; my stepfather taught Latin and Greek; my sister taught law; and my stepsister still teaches in an elementary school. I came away from my conversations with my mother with a few simple principles:

1. Show your students that you care about them and their learning.



Jason Merrick (left) receives teaching award from INFORMS Past President Stephen Robinson (center) and committee chair Alexandra Newman (right).

2. Don't tell them everything you know; find out what they are struggling with and help them with that.
3. Tell them why they need to know about a given topic; get them interested.

This last principle led me to start talking about my work in the real world. Discussing important decisions allowed students to understand the relevance of the material we cover. I found the students more motivated and engaged, allowing me to focus on the first two principles.

## Cooperative Learning

I encourage (and often require) that students read the relevant material from the excellent textbooks now available in the field prior to class. This frees class time for active modeling and problem-solving with me acting as a facilitator after only a brief review. As cooperative learning has been shown to improve the understanding of concepts and interest in the material [5], students are encouraged to work in teams on the problems and cases addressed in class, drawing assistance from the faculty when necessary, but largely from each other. This is, for many, the most enjoyable part of the class and also the most effective in achieving our objective of knowing how and when to use the techniques correctly [6]. I suppose the buzzword is a flipped classroom, but I am pretty sure many instructors were using this approach long before it had a name.

It is also important to think about the type of course you want to teach. Stephen Powell [7] proposed teaching students to be active modelers, able to build "quick and dirty" models to solve common

As cooperative  
**learning**  
has been  
**shown to**  
**improve**  
the  
understanding of  
**concepts**  
**and interest**  
in the material,  
**students**  
are  
**encouraged**  
to work  
**in teams.**





## Teaching the PROFESSIONAL PRACTITIONER

While I  
**advocate**  
the role of  
**modeling**  
**in teaching**  
**students**  
how to  
**identify and**  
**implement**  
operations  
research  
**models**  
**in the**  
**workplace,**  
successful  
practice also  
**requires**  
that you  
**do it right.**

business problems. The results of this transition and the development of powerful, yet intuitive, spreadsheet-based software have had a significant impact on the breadth of implementation of OR/MS techniques. Wayne Winston [8] entreats the instructors of quantitative majors to teach algorithms and theory, asking who else will create the next generation of OR/MS algorithms and techniques. I do not see the choice as either teaching active modelers or algorithm developers, however. Frederic Murphy [9] identifies another important role on this continuum: that of the professional practitioner. He states that practice led to the founding of our field, and it is the practitioner that gives operations research meaning today.

### Making Effective O.R. Practitioners

What makes effective practitioners of operations research? First, they have to know the field of operations research. By this we do not mean that they should know all the latest theoretical developments in the research literature. Rather they should have a broad knowledge of the techniques in the field. They should know when these techniques can be applied to solve an organization's business problems, and they should know how to apply them by constructing appropriate models. In all likelihood, these requirements would be fairly widely accepted by most people in OR/MS. However, these requirements only ensure that the individual is an operations research practitioner, not necessarily an effective one.

While I advocate the role of modeling in teaching students how to identify and implement operations research models in the workplace, successful practice also requires that you do it right. It is my belief that to model correctly, there must be an understanding of the models and algorithms that are being applied. To use a common driving analogy, the everyday driver might be fine with just knowing how to drive a car, but the racecar driver knows what is happening under the hood.

I demand, however, that all theory must pass a litmus test. Why is this theory necessary to ensure the correct application of these techniques? For instance, an understanding of the feasible region of an optimization model can help in choosing an appropriate algorithm to solve it and thus determine what software should be used to implement it. To correctly use an appropriate multiple attribute value model, one must understand the concepts of mutual preferential independence and, if there is uncertainty, utility independence. Theory necessary for delving into the research literature may not be included until a doctoral level course. In this manner, I integrate

necessary methodology and algorithm development into the curriculum.

As recognized by Leon Lasdon and Judith Liebman [5], even this more theoretical material can be taught in an interesting and effective manner. Whether the first coverage of theory is by reading or lecture, a true understanding is only reached when the concepts are tested by problem-solving, and the problems are solved more effectively when done together. Thus, the principles of active and cooperative learning are applied as much to the theoretical coverage as to modeling. Moreover, as modeling and application are discussed first in my courses, it is natural for students to ask how the techniques work. If algorithms are approached by examining what may cause them to fail, then students become more interested in how and why they work. In this way, learning is improved.

### Project-based Classes

Most of my classes are project-based. While I do set a traditional take-home mid-term, the final assessment of performance in the class is an individual or group project. This allows me to coach students on how to implement the various techniques and methods and how to use operations research and decision analysis in their own careers. Allowing the students to choose their own topics forces them to make the material relevant to themselves and each other. As I teach decision analysis and simulation, this leads to some very interesting projects. I have had students doing work projects to:

- help a major bank implement new check scanning technology at the teller an average of nine months quicker than their competitors saving \$30 million;
- improve the process for removing counterfeit bank notes at the Federal Reserve;
- build a simulation of a payment-processing center and use the model to help reduce operational costs by \$5 million per year;
- develop new methods for designing radiation treatments for cancer patients that take the patient's preferences into account, not just the doctor's; and
- assess rehabilitation programs at a local jail to reduce the rate of recidivism.

Students have also done personal projects to:

- determine whether a spouse should return to work after having a baby;
- choose treatment and insurance options after learning they had a chronic and debilitating disorder;

## REFERENCES

- choose where to live and work after retirement from the military including the challenges of a blended family; and
- choose a house, apartment, job or car.

I have even used class projects to get the students help in designing a new Ph.D. program and re-design our master's program.

I did have one reservation in writing this article: I do not believe that an instructor should copy the teaching approach used by another successful teacher. They have a different personality, and they have a different community of students. They also have different experiences in their own practice of operations research. I believe that it is important to leverage your own personality and your own experience, and you should consider the student community at your institution.

I found that my teaching really improved when I relaxed and concentrated on the students learning, not my teaching. I personally get a lot of energy from seeing my students do thorough and careful analysis that helps them in their careers and personal lives. Operations research and decision analysis can have a tremendous impact

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in our lives, and I enjoy seeing this happen in my own work and in the work my students do. Getting a prize for doing what I enjoy was really just a bonus. **ORMS**

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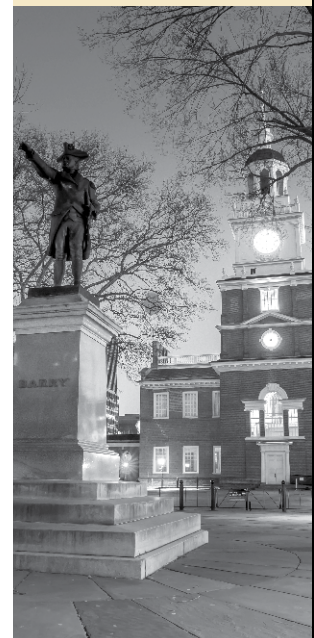
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# Competitive simulations: game on

Experiential learning offers students  
“bridge to reality” with goal  
to be the best manager among  
your peers.

By Bernardo Pagnoncelli and  
Abraham Seidmann

**D**espite the emergence of massive open online courses (MOOCs) and other digital alternatives, the penetration of advanced technologies into the actual content delivery in the classroom has been slow. A visitor from the 13th century would be astonished with technological advances in most areas of human knowledge, but the majority of university campuses around the world would hardly surprise such an unexpected guest. Society perceives the need for major changes in the way we teach the Millennials, bridging the gap between a data-intensive and technological world and the classic professor-blackboard (or PowerPoint) paradigm.



There is no unique answer to this problem. One alternative that is gaining popularity is the use of competitive web-based games, or simulations, as a complement to what the professor is teaching. Such simulations are not intended to replace the teaching faculty; rather they serve as a valuable tool for students who need to better appreciate the decision-making difficulties faced by managers operating in real life. These simulations are designed to add an important dimension of experiential learning and to act as a “bridge to reality.”

Through the games, students compete among themselves individually or in groups, and the goal is to be the best manager among your peers. The endogenous point of view is empowering and helps the faculty in building upon it later on. In his seminal work on “The Learn-By-Doing Approach to Life Skill Development” (2001), Keith Diem states that adults tend to recall 90 percent of what they see, hear, discuss and practice. This is in contrast with the common cognitive teaching process, whereby delivered instruction is memorized and later regurgitated for standardized testing purposes. The majority of information learned this way becomes meaningless and does not have a long-term retention prognosis for the learner.

The classic Beer Game, developed in the 1960s by Professor John D. Sterman at MIT, is still widely used by numerous universities around the world. In the game, students try to minimize the total inventory and backorder costs in the face of uncertain demand. Despite the simple structure of the game’s supply chain, the complex interactions of individual decisions tend to produce aggregate dynamics, which systematically diverge from the optimal supply-chain management policy.

This Beer Game has become the prototype example of a successful teaching tool to illustrate several behavioral biases affecting supply chain management, mainly the “anchoring and adjustment” heuristic for stock management that results in the bullwhip effect. Originally the game was designed to be played with boards and chips, but now there are several digital versions available on the Internet. Interestingly, despite the phenomenal educational value of this game, and the increasing pressures for improved teaching of quantitative methods, the



Screenshot from GameLab, an education-oriented simulation game.

“Beer Game” has remained for many years the only classroom game generally used in teaching operations management or management science.

### Natural Experimental Setting

Much as we use chemistry or biology labs, interactive simulations are a natural experimental setting to learn operations research and management science (OR/MS) principles, which can be too theoretical or detached from reality for most students if taught in the classical mathematical way. Few people would board an airplane whose pilot had only learned theoretical skills. Much like the hands-on flight hours needed to pilot an airplane, we believe engineers, managers and decision-makers in general must be exposed to simulations that mimic reality as a complement to the theoretical lessons. We propose to move a step further from participant-centered methodology, such as the case study method, and devote significant parts of OR/MS courses to experimental learning simulations. They are among the most powerful teaching and learning tools available. With experiential learning, the students are more engaged with their classroom and tend to better retain the material taught to them.

The dynamic aspect of OR/MS topics, such as supply chain management, makes them very hard to be taught using static elements on blackboard and slides. Equations, tables and charts are all stationary entities, and asking students to imagine a flow in a factory based on this type of information is quite a stretch. Dynamic classroom simulations offer a “microworld environment” in which students can make decisions as the system evolves, and they receive instant feedback on their actions. Most simulations allow the

Much as we  
use  
**chemistry  
or  
biology**  
labs,  
interactive  
**simulations**  
are a  
**natural  
experimental**  
setting  
**to learn**  
operations  
research and  
management  
science  
**principles.**



# Learning Via SIMULATION GAMES

## Learning by doing

The interactive classroom design:

- Students use laptops, WiFi and simulation game software (no download required)
- Teams of two or three students per laptop
- Typical setup: 20-minute introduction, 10-minute “signup,” 30-minute “competitive simulation,” 20-minute heated post-game discussion

Post-game briefing: 1. **experience** (action); 2. **share** (what actually happened during the game?); 3. **process** (what’s really important?); 4. **generalize** (so what?); 5. **apply** (What does it mean for managers? What’s the practical takeaway?)

professor to create scenarios with different degrees of difficulty, adjusting for the level of the audience (undergraduate, graduate, MBAs or executives).

Another fundamental element of OR/MS courses is the existence of uncertainty. Randomness is present in every part of almost all service organizations and supply chains. Managers need to learn how to deal with random arrivals of customers, or with uncertain clinical exam times, random failures in machines, unknown demand, etc. Most students have a hard time understanding why variability complicates matters in such systems, and the way we tame such randomness is not intuitive. The expected value kills uncertainty and delivers the solution with higher expected returns (the Newsvendor optimal order quantity is an example).

In a student’s mind, variability simply disappeared; as a simple example, most of our students expect that using the optimal order quantity at the Newsvendor Game will result in having the highest possible profit at each period. Digital simulations can easily represent a wide array of uncertain elements, and the decisions that are made are constantly evaluated subject to such variability. This feedback helps students adjust their decisions and learn through the process, suffering the consequences of poor decisions and moving to the bottom of the rankings in the in-class competition.

### Educational Simulations

Several simulations for educational purposes are available in the marketplace, and the main differences between them are with respect to complexity and quality of graphics. From our experience, short- to medium-length simulators (30 minutes to 2 hours) that encompass one or two key concepts are most effective. Simulations that last for weeks and sometimes months tend to mix too many concepts from operations, finance, economics, marketing, etc., and it is not clear what are the takeaways for the students after playing such games with so many moving parts.

The visual aspects of the game are also important to keep the student’s interest. While sim-

ulations do not need to be at the Playstation/Xbox level, students like clean interfaces with well-designed and realistic graphics. The vast majority of simulations available are made of static and outdated graphics, and in many cases the application will not run on the most recent versions of browsers or operating systems. In order to keep up with the fast pace of technological changes, simulation companies need to constantly update their software. This is the key to achieving widespread use of simulations in universities around the world.

With professors facing more pressure with teaching evaluations, we believe digital simulations are a powerful element to generate interest in the current generation of students. We developed our own web-based classroom simulation sets that were born out of the necessity to improve our teaching, to facilitate more interactive “learning by doing,” to make our topics more exciting and to spread those ideas to the OR/MS community.

In their comments after taking the course, students typically mention how motivated they were with the games, how much insight was gained while playing and how pleasant it was to learn through simulations. We also asked former students what they remembered from the course they took several years ago, and they invariably mentioned the simulations they played and the concepts they learned through their playing experience. It is time to approach teaching from the students’ perspective, and let them get their hands a little dirty while learning. **ORMS**

**Bernardo Pagnoncelli** ([bernardo.pagnoncelli@uai.cl](mailto:bernardo.pagnoncelli@uai.cl))

is an associate professor at the School of Business,

Universidad Adolfo Ibañez, in Santiago, Chile. **Abraham**

**Seidmann** is the Xerox Professor at the Simon Business School, University of Rochester, in Rochester, N.Y.

Pagnoncelli and Seidmann are developers of the web-based classroom simulation sets GameLab ([www.gamelab.cl](http://www.gamelab.cl)) and TradewindBusiness (<https://www.tradewindbusiness.com>), respectively.

Most  
students  
have a  
hard time  
understanding  
why  
variability  
complicates  
matters  
in such systems,  
and the way  
we tame  
such  
randomness  
is  
not  
intuitive.

# What's Your StORy?

## Alan Briggs, CAP



Project Manager & Data Scientist, Elder Research  
INFORMS member since 2011



Why did you become a CAP and how has it helped your career? The Certified Analytics Professional designation is something I'm really proud of. To be perfectly honest, I wanted to get it done early, fearing it would only get harder to attain as the program grew. Elder Research really delighted in my achievement and they've made a point to recognize me both internally and externally. Since completing the certification last year, I've been pleasantly surprised how much it's served as a conversation starter—people want to know what those initials are on my business card, and I'm eager to tell them.



What have you done to improve your data analytics knowledge in the past year? I'm fortunate that there is a thriving data community here in the DC Metro area. I really enjoy plugging in with other data scientists and analytics practitioners through Meetups and other informal events (there's plenty of OR folks there as well). More formally, I did part of a Coursera course, attended a variety of industry trainings, and did some independent study on a couple topics of interest. For me, the key to improving data analytics knowledge has been to keep an open ear for interesting applications and then mapping it back to a problem I'm familiar with.



What was your best INFORMS experience?

I'd have to say my best INFORMS experience was attending the INFORMS Professional Colloquium. It was the first INFORMS activity I participated in when I attended the 2011 Analytics Conference in Chicago. I've been privileged to participate in helping plan the event every year since, and have seen first-hand a number of careers transformed just as mine was. It's such a fantastic way to help students get involved with INFORMS and transition from academia into the practice of advanced analytics and OR.



What is your spirit animal? The moose, Alces alces, of course. In the early 90s I went on a canoe camping trip to Northern Minnesota with high hopes of seeing a real-life moose. Although I never saw one on that first trip, I returned years later for a summer job in college and finally got to see one.

More questions for Alan?  
Ask him in the Open Forum on INFORMS Connect!  
<http://connect.informs.org>







# Introducing analytics to adolescents

Are you smart enough to teach O.R. to a third-grader? How business analytics can reframe simple K-8 math problems.



By Kenneth Chelst

In my previous *OR/MS Today* article, I wrote that Common Core Standards in mathematics that are being adopted widely have critical elements that are fully aligned with the field of operations research [1]. The standards include two distinct elements. One relates to specific technical skills. The second element is called Standards for Mathematical Practice and would fit well in any operations research, management science or business analytics textbook. The standards require students to:

- make sense of problems and persevere in solving them,
- reason abstractly and quantitatively,
- construct viable arguments and critique the reasoning of others,
- model with mathematics,
- use appropriate tools strategically,
- attend to precision,
- look for and make use of structure, and
- look for and express regularity in repeated reasoning.

For the past decade, my team has worked on developing and disseminating a high school math curriculum entitled, “When will we ever use this?” (Volume I: Algebraic Modeling and Volume II: Probabilistic Decision Modeling). Originally funded by NSF under the title “Project MINDSET,” we have since completed the NSF project and broadened and rebranded it as “Applied Mathematics Practices for the 21st Century” (AMP21). This was done to more explicitly align with the above Common Core standards. Everything we have developed addresses most of these standards.

This summer we offered three-day workshops in the Los Angeles area hosted by the University of Southern California and in the Chicago area hosted by Northwestern University. More than 200 teachers applied to take the workshops. However, the programs were limited to 35 to 40 teachers each.

This high school effort was my passion; I had no grandiose dreams of moving beyond an elective mathematics course in operations research designed for juniors or seniors in high school. However, in order to ensure that aspiring athletes could take the course, one high school teacher went so far as to file paperwork and receive approval from the NCAA so that the course could count toward advanced mathematics.

### New Middle School Initiative

Three years ago, two of my colleagues in mathematics education at Wayne State were each on the cusp of obtaining substantial grants in different aspects of middle school mathematics teacher training. One, an NSF grant (Project MEDdeATe: Jennifer Lewis, PI), required a mathematician. I was asked to fill that role. The other, designed around engineering (Project ImPRINT – Improving Proportional Reasoning Instruction through eNginering Tasks: S. Asli Ozgun-Koca, PI), was natural for me to participate. Thus began my education in middle school mathematics.

One set of core middle school mathematics skills involves rates, ratios, percentages and proportionality. We began a series of weekly discussions only to find out that my math education colleagues and I did not necessarily use the terms the same way. In addition, it was not clear from textbooks which concept was most appropriate in different contexts. Textbook questions, asked students willy-nilly to calculate rates, percentages, ratios and proportions in diverse word problems. We eventually coalesced around a series of definitions with examples and published our first middle school math paper entitled, “Rethinking ratios, rates and percentages” [2]. This was followed by an applied example that was classroom tested: “Exercise Away the Big Mac: Ratios, Rates and Proportions in Context” [3].



Teaching K-5 teachers how to teach O.R. was a new experience for the author.

Image © Racorn | 123rf.com

From these experiences, I put on my business analytics cap and began to develop a simple series of questions to be asked about every word problem in their textbooks.

1. Why should anyone care about the problem context and the answer?
2. Is there a decision to be made?
3. Would simple counting answer the question?
4. Does the question only ask about what is? Are there opportunities to explore what can be or should be?
5. Can multiple similar examples be created that are different enough to maintain student interest?
6. Is there something to discuss in the problem context that goes beyond the basic mathematics?
7. Can students embed themselves in the problem context and produce different answers?

Brenda Dietrich, vice president in the IBM Research Divisions and a former president of INFORMS, highlighted the core problem: much of math education is descriptive mathematics. Students are asked to describe what is. One common example of a ratio word problem can illustrate this point.

*The ratio of boys to girls in the class is 3:2. There are 30 students in the class. How many boys are there? How many girls are there?*

As the problem is stated, it fails all of the above questions. The problem asks students to calculate what is and offers no reason to care about the finding. This problem fails one additional test: Did the person who created the problem have to know the answer in order to create the problem situation?

Brenda Dietrich,  
**vice president**  
in the  
**IBM Research Divisions**  
and a  
**former president**  
of INFORMS,  
**highlighted**  
the  
**core problem:**  
much of  
**math education**  
is descriptive  
mathematics.



## Introducing Analytics TO ADOLESCENTS

One indicator  
that a  
**math  
problem**  
is  
**relevant  
to students**  
is that  
**there is**  
something to  
**discuss  
beyond**  
the  
mathematical  
**calculations.**

Whoever asked the question had to know there were 18 boys and 12 girls in order to claim that the ratio is 3:2. The same would be true for an even dumber question found in textbooks. *There are 10 more boys than girls in the class of 30. Write a pair of equations to determine the number of boys and girls in the class.*

Whoever asked the question had to know there were 20 boys and 10 girls in order to claim that there were 10 more boys. Do we really want students to see simultaneous equations as an alternative to counting or partial memory loss?

### Relevant Context

In the world of business analytics there are limitless possibilities for using the knowledge of the ratio of boys to girls is 3:2. The ratio may have been determined by a survey in any number of contexts. The decisions could involve allocating shelf space in a store or allocating budgets to targeted marketing programs. We developed a relevant context around a school sports outing.

Sixty students are planning a sports outing. There are 40 boys and 20 girls in the group. They were considering three different sports activities for everyone. They wanted to keep the ratio of boys to girls the same on each team.

1. If they play full-court basketball, how many boys and girls should be on each team?
2. If they play volleyball with the standard six person teams, how many boys and girls should be on each team?
3. If they play softball, how many boys and girls should be on each team?

Question 1 is trivial, but Question 2 does not have an exact answer. It is not possible to keep the 3:2 ratio. This does not mean mathematics is useless because there is no exact answer, a radical idea in K-12 math education. Students would be encouraged to think about keeping each team's ratio close to 3:2 and

using other criterion to make the teams balanced. One bright child might suggest going with teams of five for volleyball instead of six. Question 3 poses two challenges. First, it is not possible to keep the exact ratio. Second, nine does not go evenly into 60. Again, the students could use math creatively to come up with suggestions for forming teams.

One indicator that a math problem is relevant to students is that there is something to discuss beyond the mathematical calculations. This team formation context offers the teacher an obvious opening for discussion. Is it important to keep the gender ratio constant when forming sports teams? What other criterion could be used? Would it vary by sport?

The "Exercise Away the Big Mac" example similarly addresses all of the above questions. Students use the Big Mac website to explore changes to the sandwich and determine whether or not the changes would enable the sandwich to meet specific nutritional guidelines that are expressed as percentages. They are then directed to a website that estimates the number of calories burned for different exercises. The goal is to burn off the Big Mac calories. Each student must input his or her own weight, as the calorie burn rate is dependent on this piece of information. Each student can select his or her own preferred exercise or activity.

As in the previous example, the contexts can lead to discussions about nutrition and exercise. In addition, teachers can create similar problems with other fast food websites that are very different, such as a series of questions around a Subway sandwich. Too often math texts have dozens of end-of-the-chapter problems that look all the same except for a word here or there and the specific numbers.

### Multiplication in Minnesota

Then I received a call from Susan Wygant, a mathematics specialist with the Minnesota Department of Education. She has been a supporter of our efforts ever since attending one of our one-day high school O.R. programs at the INFORMS Annual Meeting in Minneapolis in 2013. In 2014, she hosted our three-day workshop. This year she asked our team to create a one-day program for more than 60 specially motivated K-12 math teachers. Half of the program was for all attendees, and the other part of the day separated the teachers into three grade groups: K-5, 6-8 and 9-12. I drew the smallest straw and ended up with the K-5 group.

I went to the Engage NY math website [4] that has a complete mathematics curriculum along with large a set of problem contexts for each topic. I focused on third grade, looking for something I could turn around with analytics. Here is what I found and did.

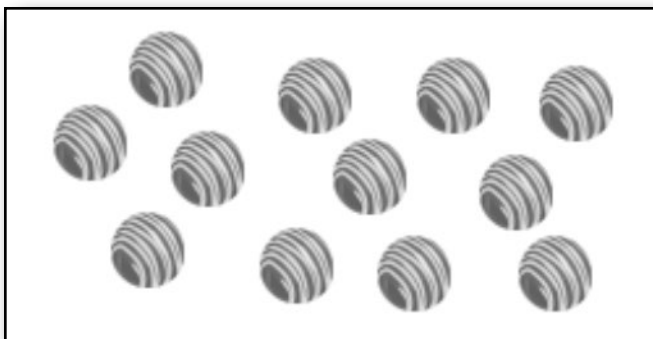


Figure 1: How to share a box of chocolates.



Caroline, Brian and Marta share a box of chocolates. They each get the same amount. Circle the chocolates in Figure 1 to show three groups of four chocolates. Then write a repeated addition and multiplication sentence to represent the picture.

In reframing this example, I wanted to inject analytics by:

1. making it a decision,
2. providing a motivation for using the picture,
3. creating an example in which the numbers do not work out perfectly, and
4. providing something to discuss.

Thus, the revised problem became:

1. Caroline, Brian and Marta want to share equally a box of 12 chocolates. How many should each one receive? Double check your answer. Circle a set of chocolates each child will receive.
2. Their friend Jamal came by. They decided to share the box with him as well. How many would each child now have? Color the pieces of candy that would be given to Jamal. How many chocolates will Caroline, Brian and Marta each give to Jamal?
3. Darlene came by and joined the group. They decided to share the box with her as well. What problem do they now have in dividing the chocolates equally? Why do they have a problem? What would you suggest they do? Explain your decision.

The teachers enjoyed the example because the first two questions would build the confidence of the students and teach different factors of 12. Question 3 teaches that 5 is not a factor of 12, but you still need to use math to divide up the chocolate. The students can also discuss what would be a “fair” division in the final case. The teachers were also encouraged to ask the following questions.

4. Why would you not use fractions to answer question 3?
5. What if the candy was in the form of 12 large Hershey candy bars? What could you do then?

### Challenge to Business Analytics Community

I am challenging any member of INFORMS who has a child, grandchild, niece, nephew, guardian, neighbor kid, etc. studying math in K-12. Get your hands on the child’s math textbook but commit no crimes in the process. Then pick up the same grade’s science textbook or history textbook or English literature book. Compare the level of sophisticated contexts in these diverse educational materials.

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4. <https://www.engageny.org>

It is embarrassing to see that the vast majority of mathematics problems would fit well in an early 20th century math textbook with minor modification to include travel time problems involving airplanes. Next, pick out a few of the word problems and apply the principles presented here to create a business analytics question. Send your concrete examples to me [kchelst@wayne.edu](mailto:kchelst@wayne.edu). I will be pleased to share your examples with math teachers by posting them on our AMP21 website. **ORMS**

**Kenneth Chelst** ([kchelst@wayne.edu](mailto:kchelst@wayne.edu)) is a professor of operations research in the Industrial and Systems Engineering Department at Wayne State University and co-founder of Applied Mathematics Practices for the 21st Century (<http://www.appliedmathpractices.com/>).



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# Profiles of UPS Prize finalists

**Trio of programs recognized for effective, innovative preparation of O.R. grad students aiming at practice sector.**

## Editor's note:

Each year, INFORMS awards the UPS George D. Smith Prize to an academic department or program for effective and innovative preparation of students intent on pursuing careers as practitioners of operations research. This year's UPS Prize went to the Centre for Operations Excellence at the University of British Columbia's Sauder School of Business. Lehigh University's Enterprise System Center and Department of Industrial and Systems Engineering and Carnegie Mellon University's H. John Heinz III College were finalists. We invited all three finalists to briefly describe their outstanding programs for this special "Innovative Education" issue of *OR/MS Today*.



The Sauder School of Business at the University of British Columbia won the 2015 UPS George D. Smith Prize.

#### UPS Prize Winner:

## Training O.R. students with impact: The Sauder School of Business story

By Harish Krishnan, Stuart Donald and  
Martin Puterman

**The Masters in Management in Operations Research (MMOR) program** at the Sauder School of Business at the University of British Columbia (UBC) provides rigorous and practical training in the quantitative analysis of business problems. Administered by the Centre for Operations Excellence (COE), the MMOR prepares students for rewarding careers as OR analysts and consultants. Since its establishment in 1998, the program has trained a generation of students for successful careers in both public and private sector organizations.

The COE program provides a unique bridge between academia and industry. MMOR students define, execute and communicate the results of annual projects carried out for industry partners. The students work in collaboration with a team of corporate sponsors, other students, staff and faculty advisors. They spend a portion of their time on site with frequent remote interaction with the corporate sponsor's team.

The main goal of this 16-month professional master's program is competency in O.R. practice. Accordingly, the program features a 4 1/2-month industry project as its centerpiece. After eight

months of coursework that provides students with a strong background in operations research and analytics, students are immersed in full-time work on their industry project.

In addition to a full complement of core O.R. and statistical courses, students take a consulting practices course which provides them with the communication and project management skills necessary to carry out a successful project and a best practices course, which explores a number of exemplary O.R. implementations drawn mostly from the Edelman Prize competition.

Students are paired and matched with a COE industry partner company to consult on a significant operational challenge faced by the company, one that they might otherwise approach a consulting firm to address. The students are supported by an extended team. One-on-one mentorship is provided by a COE staff project advisor, guidance is provided by a Sauder faculty advisor, technical support is available from a pool of summer students, and oversight is provided by the COE's directorship. The team as a whole puts in more than 2,300 work hours on each project.

At the start of the projects, students follow the lead of their project advisor. Over the course of the project as students develop their skills, they start taking a leadership role within the project team. Depending on their experience prior to the program and their inherent abilities, each student's trajectory to co-leadership is different. The project provides each student with an opportunity to build on strengths and overcome weaknesses, as well as to demonstrate their ability to creatively solve challenging and open-ended problems.

**Students**  
take a  
**consulting**  
**practices**  
course,  
**which**  
**provides**  
them with  
the  
**skills**  
**necessary**  
to  
**carry out**  
a  
**successful**  
**project.**





## UPS Prize FINALISTS PROFILES

Each project's trajectory is also different, depending on the nature of the problem at hand and the industry partner's needs. All projects involve a "discovery" phase, which includes gathering data and better defining the problem, a model-building and analysis phase and finally a "delivery" phase, where a tool or report is provided to the partner. The close working relationship with the partner is reinforced through multiple milestone meetings where students present their progress to the partner's senior management.

In the final semester, students complete their program with elective courses. They also present their project at the annual COE Roundtable, which showcases the students' work to representatives of the local business community. Students often receive employment offers prior to graduation from the industry partner that they worked with. Indeed, some of our long-term industry partners have employed several of our graduates and have established O.R. groups that are largely made up of MMOR graduates.

### Origins of MMOR

The program was founded in response to the needs of the local business community. In the 1970s, Vancouver had an active industrial O.R. community based primarily in the forest products industry. By the 1990s, however, the program had all but disappeared due to corporate restructuring and an economic downturn. With advances in desktop computing, local businesses were once again receptive to quantitative analyses and began contacting Sauder faculty for assistance with operations projects. In the absence of a formal structure to carry out projects, graduate students and professors were involved in projects on an ad hoc basis.

In 1995, Sauder Professor Martin L. Puterman with the support of Professor Derek Atkins, created the COE's predecessor, the Bureau for Research on the Application of Management Science and Statistics (BRAMSS). Similar academic-industry partnerships were developed at other universities, including MIT's Leader's for Manufacturing program and the University of Michigan's Tauber Institute.

However, unlike some of these programs that began with significant endowments, BRAMSS had no corporate champions willing to come to bat with large financial commitments. This required a made-in-British-Columbia solution. The Sauder program, which was renamed the Centre for Operations Excellence, had to be built from the bottom up. The challenge was to develop a program that delivered immediate benefits to corporate partners.

Project fees covered a portion of COE expenses, but the COE and its MMOR program would not exist today without the financial support of MITACS ([www.mitacs.ca](http://www.mitacs.ca)), a Canada-wide organization dedicated to supporting applied industrial applications of mathematics. MITACS provided a significant portion of the COE's initial operating funds and has continued to provide important funding up to the present.

The COE and its MMOR program can legitimately claim to have played a role in the resurgence of operations research in all facets of British Columbia industry. Graduates of the program have gone on to start their own companies, become industry leaders as well as professors at top universities.

Long-standing industry partners, including health authorities in British Columbia and private sector partners such as Boeing Canada, have sponsored projects over several years. Their interaction with the COE and MMOR program has also helped them develop their own operations research and analytics capabilities by building internal teams of analysts, many of them who are graduates of our program. COE projects have substantially influenced practice while also motivating innovative research and generating prize-winning cases.

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**Harish Krishnan** is an associate professor in the Operations and Logistics Division (OLD) and director of the Centre for Operations Excellence (COE) of the master's in management in operations research (MMOR) program at the Sauder School of Business at the University of British Columbia (UBC). **Stuart Donald** is managing director of the COE and lecturer in the OLD at UBC. **Martin Puterman** is professor emeritus and advisory board professor of operations of OLD at the UBC.

### UPS Prize Finalist:

## Carnegie Mellon's Heinz College emphasizes analytics for impact

By Ramayya Krishnan and  
Jon Nehlsen

**Stopping electronic intrusion** of the nation's most critical IT networks. De-incentivizing piracy of online music and movies. Influencing

teenagers not to make an emotional Facebook post that will follow them for the rest of their lives. These are some of the problems of our age. And these are the problems that students and faculty at CMU's Heinz College use analytics to study and solve.

Carnegie Mellon University's H. John Heinz III College approach to analytics education resides on the bedrock principle that analytic thinking and methods only matter if they can be used to solve real problems. The formula is simple:

### **Analytics + IT + Deployment = Real-World Impact**

Why is this approach important? It's important for three reasons. First, analytic thinking and decision-making require the ability to make sense of data in order to give structure to previously unstructured problems. Second, information technology training must be part of good analytics training because in the real world, data is often incomplete, resident in disparate systems and subject to poor input processes. Further, existing data often have to be supplemented with data from partners or the Internet. Technology training helps our graduates solve for these problems. Finally, organizations are subject to biases, politics and path dependencies which can make it difficult to digest new information or manage change. The emphasis on deployment skills helps graduates solve for these problems as well.

#### **Unique Structure**

The Heinz College is home to the graduate School of Information Systems and Management and graduate School of Public Policy and Management, a deliberate structure that exists only at Carnegie Mellon University (CMU). This gives the College great natural advantages in incorporating cutting-edge technologies and methods into curriculum that were, in many cases, invented or perfected at CMU. It also means that Heinz students naturally embrace large societal-scale problems and bring analytics to bear on problems of global importance.

Analytics is not a new idea at Heinz College. The College's roots date back to 1968, when William Cooper, a noted operations researcher, founded the School of Urban and Public Affairs with the mission to educate "men and women for intelligent action." Since its founding, more than 10,000 students have graduated from Heinz



**The Heinz College is home to the graduate School of Information Systems and Management and graduate School of Public Policy and Management.**

programs in Public Policy and Management and in Information Systems and Management and have pursued careers in all sectors of the global economy.

Each one of these graduates was steeped in a core curriculum that has always included management science, statistics, economics, data analytics and information technology coursework. Additionally these graduates have each learned leadership and deployment skills through mandatory training in professional speaking and writing, organizational behavior and meta-curricular leadership training activities with partners such as the Army War College. Experiential learning through required internships and semester-long capstone projects with startups, global firms and government agencies are a final important component of the Heinz College experience. These activities ensure that students spend substantial time deploying their skills in the real world before they even graduate. Says Professor Jon Caulkins of the Heinz College approach, "We put it together in a package that allows our students to take these tools and make the world a better place."

*Ramayya Krishnan is dean of the H. John Heinz III College and the W. W. Cooper and Ruth F. Cooper Professor of Management Science and Information Systems at Carnegie Mellon University. Jon Nehlsen is senior director of Institutional Relations at the H. John Heinz III College. He is an alumnus of the Heinz College and of the Wharton School.*

More than  
**10,000**  
**students**  
have  
**graduated**  
from  
**Heinz**  
**programs**  
and  
**pursued**  
**careers**  
in all  
**sectors**  
of the global  
**economy.**



## UPS Prize FINALISTS PROFILES

**UPS Prize Finalist:**

### Lehigh University's ESC and ISE Department offer vibrant educational ecosystem

By Ana-Iulia Alexandrescu, Tamás Terlaky, Emory Zimmers Jr. and Luis Zuluaga

**For the fourth year in a row**, the Enterprise Systems Center (ESC) and the Industrial and Systems Engineering (ISE) Department at Lehigh University in Bethlehem, Pa., have been honored as one of the top three finalists of the INFORMS UPS George D. Smith Prize. In close collaboration, the ESC and the ISE Department nurture a vibrant educational ecosystem to produce effective young practitioners of operations research (O.R.) and analytics. The main mission of Lehigh's ISE Department is to prepare undergraduate through Ph.D.-level students for successful careers as O.R. practitioners, equipped with skills to solve complex, real-life analytics problems. To successfully carry out this mission, the ISE Department offers many programs (two undergraduate, five master and one Ph.D.) through which students develop critical and analytical thinking, learn O.R./analytics skills and apply them in a real-world setting. The department

is quick to adapt to the rapidly changing industry landscape, as demonstrated through the development and success of innovative programs such as Analytical Finance and Healthcare Systems Engineering, both preparing successful practitioners that bring valuable insights to their fields.

Besides learning these techniques, ISE Department students are provided, through its ESC, with hands-on experience on applying this knowledge in collaborative projects with a large and distinguished pool of industrial partners. This is accomplished through long-term relationships with industry and government working to increase global competitiveness. The ESC also partners with the Industrial and Systems Engineering Department, centers, institutes and other departments within Lehigh and other universities to foster innovation and student learning. In particular, the ESC has completed more than a thousand research projects with 400 industry partners since it was established as a research center at the ISE Department, Lehigh University almost four decades ago.

The ESC developed the innovative layered mentoring model. More than 3,000 graduate and undergraduate students have participated in these projects, working in interdisciplinary teams with faculty and ESC mentors with substantive industry experience to help companies solve real-world operations problems. In turn, these projects have brought significant economic value for the ESC industry partners. These high-impact results ensure that the ESC will only continue to grow its footprint as a channel to deliver the latest developments in O.R./analytics from academia to the industry sector.

Thanks to the effective use of O.R./analytics quantitative skills and ESC's layered mentoring structure, Lehigh University graduates make substantial impact on the efficiency of partner companies. As a result, our graduates are highly sought-after by companies in all sectors. In particular, beyond engineering positions (about 35 percent), a large percentage of ISE graduates (about 35 percent) start at positions where these analytical tools are at the forefront (e.g., consultant, manager, analyst and Ph.D. positions). Moreover, over time, our graduates rise quickly through the managerial ranks. In fact, after 10 years of graduation, about 50 percent of our graduates position themselves at high-level positions in their respective companies (e.g., vice-president, president, chairman, CEO, manager, director, owner and partner). **ORMS**

*Within the Department of Industrial and Systems Engineering at Lehigh University, **Ana-Iulia Alexandrescu** is the director of HSE and a professor of practice, **Tamás Terlaky** is a professor and department chair, **Emory Zimmers Jr.** is a professor and **Luis Zuluaga** is an assistant professor.*



Lehigh's Enterprise Systems Center and ISE Department have been UPS Prize finalists three straight years.



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- 2015 UPS George D. Smith Prize: The Centre for Operations Excellence at the University of British Columbia, Sauder School of Business.



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# O.R. takes on 'Grand Challenges'

Report outlines operations  
research's potential role  
as catalyst for addressing  
engineering technological  
challenges.

By Suvrajeet Sen, et al.

## Contributors to the Report

"O.R. as a Catalyst for Engineering Grand Challenges," a report to the National Science Foundation, was compiled by a team of contributors led by Suvrajeet Sen of the University of Southern California. Other contributors, all of them prominent members of INFORMS and the worldwide O.R. community, included:

- Cynthia Barnhart, Massachusetts Institute of Technology
- John R. Birge, University of Chicago
- E. Andrew Boyd, PROS
- Michael C. Fu, University of Maryland
- Dorit S. Hochbaum, University of California, Berkeley
- David P. Morton, Northwestern University
- George L. Nemhauser, Georgia Institute of Technology
- Barry L. Nelson, Northwestern University
- Warren B. Powell, Princeton University
- Christine A. Shoemaker, Cornell University
- David D. Yao, Columbia University
- Stefanos A. Zenios, Stanford University

**The success of operations research (O.R.) has been built on the ability of the field** to transcend disciplinary boundaries in making fundamental research contributions using O.R. modeling approaches and methodologies. The Grand Challenges of the U.S. National Academy of Engineering (NAE) present an opportunity for the O.R. community to play the role of a catalyst, utilizing O.R. to facilitate some of the pressing technological challenges facing humanity today. This is the first of a series of articles that will explore potential avenues for future research in the key areas outlined in the NAE Grand Challenges. What follows is a condensed and edited version of the first portion of a report submitted to the National Science Foundation (NSF) in May 2014 (Sen, et al. 2014).

### Background

A panel of thought-leaders convened by the NAE (and facilitated by NSF) unveiled its vision of the Engineering Grand Challenges in 2008. Over the intervening years, this report has invited (and received) feedback from international leaders and professional organizations, including the Institute for Operations Research and the Management Sciences (INFORMS). As part of the INFORMS input, Barnhart et al. (2008) prepared a report on the role that the O.R. community was likely to play within the context of the challenges. An abbreviated version of that report appeared as the President's Desk column in *OR/MS Today* (April 2008).

As predicted, the O.R. community has been active in many of the thematic areas of the NAE Grand Challenges via publications on the highlighted research areas in our flagship journals, major conferences on topics at the intersection (e.g., the joint INFORMS-Medical Decision-Making Conference in Phoenix 2012) and several thematic conferences on the smart grid, homeland and cyber security, and others. Because O.R. brings together a combination of tools from computing, mathematics and economic sciences, such an effort is likely to unleash a vast array of new approaches onto the engineering grand challenges of today.

One of the distinctions between O.R. and other mathematical sciences is that many of our premier journals are not only devoted to novel O.R. methodology, but also to real-scale applications. This breadth prompted George Dantzig to label O.R. as a "can-do" discipline, which is the likely reason for major O.R. conferences that cut across both theory and applications, covering mathematical, algorithmic, organizational and practical implementations of O.R. This unique style of discovery may also be traced to the fact that, as a field, O.R. is applied daily to an amorphous body of applications covering a gamut of domains, including the Grand Challenges. For

these reasons, companies that are interested in research at the intersection of business analytics, computing and mathematical sciences routinely appoint doctorates from the field of O.R. to lead large research labs (e.g., IBM's T.J. Watson Research Center).

Major users of O.R., such as the Department of Defense, are clamoring for advanced O.R. tools for trade-off studies (Defense Science Board Report, 2011, especially Chapter 3). Other agencies have also found great value in O.R. tools, as exemplified in the following passage from the 2010 President's Council of Advisors on Science and Technology (PCAST) report (Holdren, et al., 2010, pp. 71):

### **"Progress in Algorithms Beats Moore's Law"**

*"Everyone knows Moore's Law – a prediction made in 1965 by Intel co-founder Gordon Moore that the density of transistors in integrated circuits would continue to double every 1 to 2 years.*

*Fewer people appreciate the extraordinary innovation that is needed to translate increased transistor density into improved system performance. This effort requires new approaches to integrated circuit design, and new supporting design tools, that allow the design of integrated circuits with hundreds of millions or even billions of transistors, compared to the tens of thousands that were the norm 30 years ago. It requires new processor architectures that take advantage of these transistors, and new system architectures that take advantage of these processors. It requires new approaches for the system software, programming languages, and applications that run on top of this hardware. All of this is the work of computer scientists and computer engineers.*

*Even more remarkable – and even less widely understood – is that in many areas, performance gains due to improvements in algorithms have vastly exceeded even the dramatic performance gains due to increased processor speed.*

*The algorithms that we use today for speech recognition, for natural language translation, for chess playing, for logistics planning, have evolved remarkably in the past decade. It's difficult to quantify the improvement, though, because it is as much in the realm of quality as of execution time.*

*In the field of numerical algorithms, however, the improvement can be quantified. Here is just one example, provided by Professor Martin Grötschel of Konrad-Zuse-Zentrum für Informationstechnik Berlin. Grötschel, an expert in optimization, observes that a benchmark production planning model solved*



**Making sustainability energy economical is a promising area for O.R. as a catalyst.**

Image © Rafomundo | 123rf.com

*using linear programming would have taken 82 years to solve in 1988, using the computers and the linear programming algorithms of the day. Fifteen years later – in 2003 – this same model could be solved in roughly 1 minute, an improvement by a factor of roughly 43 million. Of this, a factor of roughly 1,000 was due to increased processor speed, whereas a factor of roughly 43,000 was due to improvements in algorithms! Grötschel also cites an algorithmic improvement of roughly 30,000 for mixed integer programming between 1991 and 2008."*

The benchmark that Grötschel used was drawn from Bixby (2002), published in the INFORMS flagship journal *Operations Research*. These advances are more than just new computational benchmarks; they have enormous economic impact as well. For instance in the electrical power sector, O.R. models have transformed market operations with advanced software for scheduling, economic dispatch, power flow and many other functions. A recent Federal Energy Regulatory Commission (FERC) report (FERC 2011) attributes savings in the range of \$100 million annually for generator scheduling in just one of the markets (PJM, Pennsylvania, New Jersey, Maryland).

These vignettes suggest that we are witnessing a convergence of systems and computational thinking, which has made O.R. a central enabling technology for a variety of applications. Nevertheless, the level of penetration of O.R. in some important domains of science and engineering research has been somewhat limited. For far too long, researchers in science and engineering have failed to recognize the need for scalable models and algorithms. With the

**This effort**  
is likely to  
**unleash**  
a vast array  
of new  
**approaches**  
onto the  
**engineering**  
**grand**  
**challenges**  
of  
**today.**



Among the  
**advantages**  
that the  
**O.R.**  
**community**  
can bring are  
tools that  
**integrate**  
**data**  
and  
**decisions.**

increasing need for guided scientific exploration, O.R. approaches for scalable models and algorithms are becoming indispensable. Given the magnitude of problems like climate change, O.R. modeling should be playing a bigger role in understanding the impact of human choices on the future of the planet.

Among the advantages that the O.R. community can bring are tools that integrate data and decisions. This interplay is the key distinction between O.R. models and descriptive statistics. Moreover, the former also facilitates risk modeling in a resource-constrained setting. The time has come to engage both domain experts as well as O.R. experts, so that policies and decisions become an integral part of analysis, not an afterthought. Such collaboration has the potential to discover strategies to reverse the ominous climate-change trends that have been observed over the past two decades.

The NAE Grand Challenges were broadly classified into four categories: Sustainability, Security, Human Health and Joy of Living. The report by Sen, et al. (2014) described potential areas of intersection with and roles that O.R. can play in addressing the challenges in these domains. This article will summarize the four areas, and subsequent articles will address each in more detail. Please see the report for a fuller set of references, which have been abbreviated here.

## O.R. for Sustainability

Foremost among the challenges are those that must be met to ensure the future itself. The Earth is a planet of finite resources, and its growing population currently consumes them at a rate that cannot be sustained. Utilizing resources like fusion, wind and solar

power, preserving the integrity of our environment and providing access to potable water are the first few steps to securing an environmentally sound and energy-efficient future for all of mankind. Analyzing these challenges includes using data and models to choose among alternative strategic decisions, forecasting the effect of decisions on the future, and quantifying the uncertainty associated with this analysis.

While O.R. methods certainly support many individual features (e.g., nonlinear, dynamic, stochastic and discrete), combinations of these features are often necessary in many of the research questions that arise under the “Sustainability” banner. Combining these features will require significant extensions of the O.R. methodology available today. The following areas in sustainability were found to be particularly promising for O.R. as a catalyst:

- making solar energy economical,
- integrating storage with solar cells,
- providing energy from fusion,
- managing the power grid,
- geological carbon sequestration,
- managing water availability and quality, and
- other social sciences/economics considerations.

## O.R. for Security

The ongoing integration of the many infrastructure systems in the modern world – transportation, energy, water, communications, finance – has made these systems more vulnerable to both unintentional hazards and intentional threats. O.R. researchers and practitioners build operational models of such systems precisely because we know that the system’s performance can depend, often in surprising and subtle ways, on how various components and subsystems interact. As our interconnected systems grow in complexity, having a trusted operational model is even more essential for assessing system vulnerabilities and in turn addressing the challenge of how to secure that system.

O.R. is ideally positioned to address the following challenges: formulating operational models of appropriate fidelity; understanding vulnerabilities using models for chance hazards and malicious attacks; and allocating scarce resources to best secure systems. The following areas in security were found to be particularly promising for O.R. as a catalyst:

- restoring/modernizing critical urban infrastructure systems,
- preventing nuclear terrorist attacks,
- enabling/enhancing cybersecurity, and
- enhancing aviation safety, both on the ground and in the air.

## O.R. for Human Health

Healthcare expenditures continue to rise both in absolute terms and as a percentage of U.S. spending.

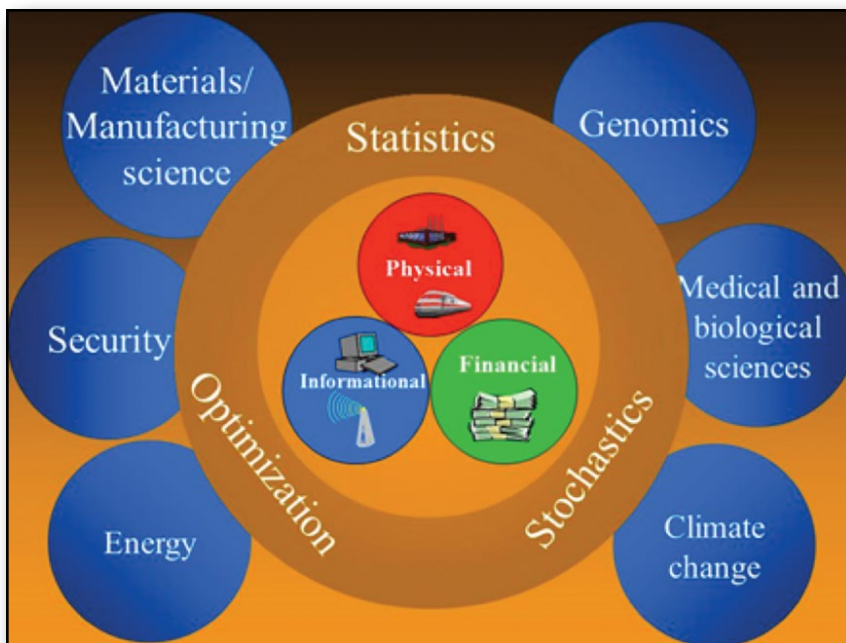


Figure 1: Visualizing the growth of operations research.

Both improved treatment and reduced expenditures are possible with proper analysis. In many cases, this requires studying the parts of the system as a whole. In other cases, individual procedures, treatments and medicines can be improved through analytical insights aided by data. In any case, the discipline of O.R. brings ideal tools to aid experts in traditional domains of the nation's healthcare system. The following areas were found to be particularly promising:

- advanced health informatics,
- engineering better medicines,
- reverse-engineering the brain, and
- improving quality while reducing costs.

### O.R. for Joy of Living

Of the four broad categories of NAE challenges, this area is the most nebulous for scientists and engineers, and in the report (Sen, et al., 2014), "Joy of Living" was interpreted as consisting of three core problem areas: 1) advanced personalized learning, 2) enhancing virtual reality, and 3) engineering the tools of scientific discovery. However, one recognizes that "Joy of Living" encompasses a much broader class of challenges dealing with improving the quality of life on a daily basis. For example, reducing traffic congestion in urban areas, improving response times of first-responders, designing smart, energy-efficient homes and others raise many interesting O.R. questions.

One such example is an application related to predicting movie recommendations associated with the so-called "Netflix Prize" problem. This problem is concerned with a matrix whose columns represent "user names," and the rows represent "movie names." The problem of predicting which movies should be recommended to a user can be formalized as a "matrix completion" problem of inferring some entries, based on partial data about movie likes/dislikes of some users. Among the more widely cited approaches to this problem is a method by Candes and Tao (2005) where the term "Dantzig-selector" was coined for a convex (linear) programming formulation of this problem.

Other machine learning approaches routinely draw upon optimization as a core technology for inference. Other "joys of life," such as sports, have also seen many applications of analytics; in addition to the well-publicized baseball movie "Moneyball," there is Major League Baseball scheduling, which is done routinely using O.R. models. In this sense, O.R. casts such a wide net in the "Joy of Living" area.

### Conclusions

O.R. has a long history of bringing analytics to real-world problems. The report by Sen, et al. (2014) is intended to accelerate collaboration between science/engineering on the one hand, and the computational, mathematical and economic sciences on the

other. Trial-and-error experimentation is giving way to greater focus on modeling, optimization and simulation as methodologies for seeking new discoveries in energy, materials, nano-technology, medicine and, of course, manufacturing systems and supply chains. In addition, the analytics boom propelled by O.R. is taking business enterprises to new levels of competitiveness. This combination of innovation and competitiveness bodes well for U.S. industry, and can only be sustained by greater cross-fertilization between O.R. and the more traditional areas of science and engineering.

The growth of O.R. may be visualized in the form of the graphic depicted in Figure 1. The innermost (light brown) circle holds the early disciplines that motivated O.R. These include computing/communications, finance, military, transportation and others. As a result of its support of these "traditional applications," the field of O.R. has created its own "ring" of concepts that integrate several fundamental pillars of O.R. knowledge. We expect that the next phase of O.R. growth will result from greater exchanges with domains associated with the Grand Challenges (which appear on the outer edges). Over time, these challenges will add new dimensions to O.R. that will then be represented by other new "rings" of O.R. concepts. This approach, which we refer to as multi-disciplinary operations research and engineering (MORE), will not only lead to new science and engineering knowledge, but to new transformative technologies and new O.R. as well. **ORMS**

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# Roundtable profile: Analytics at IDA

**An inside look at the  
Institute for Defense Analyses  
and why analytics has  
always played a vital role.**

**By David E. Hunter**

**Founded in 1956, the Institute for Defense Analyses (IDA)** is a not-for-profit corporation that currently operates three federally funded research and development centers (FFRDCs): the Systems and Analyses Center, the Science and Technology Policy Institute and the Center for Communications and Computing.

FFRDCs are unique, independent entities sponsored and funded by the U.S. government to meet long-term technical needs that cannot be met as effectively by existing governmental or contractor resources. These entities were initially established after World War II as the U.S. government and Department of Defense (DoD) tried to find a way to maintain continued access to the technical and scientific expertise that had proved so valuable during the war effort. IDA's sole business is operating its three FFRDCs.

Collocated with IDA headquarters in Alexandria, Va., IDA's Systems and Analyses Center assists the Office of the Secretary of Defense as well as other government agencies – such as the Department of Homeland Security, the Director of National Intelligence and the Department of Veterans Affairs – in addressing important national security issues, focusing particularly on those requiring scientific and technical expertise. IDA exists to promote national security, preserve the public welfare and advance scientific learning by analyzing, evaluating and reporting on matters of interest to the U.S. government. IDA's goal is to empower the best scientific and strategic minds to research and analyze the most important issues of national security.



# All About the Roundtable

To achieve this goal, IDA maintains a highly educated and diverse research staff. In fact, more than 90 percent of IDA's researchers have advanced degrees, with the majority having earned doctoral degrees in a technical field.

Each year, IDA researchers execute hundreds of projects for government sponsors. For each project, research teams comprising the precisely necessary scientific, technical and analytical skills – and with disparate life experiences and backgrounds – are assembled from across IDA's eight research divisions. IDA's flat organization and culture of internal collaboration allow researchers to easily and collegially interact with each other and the Institute's leaders.

Analytics has always played a vital role at IDA. IDA researchers do not use any one specific analytical technique or tool to solve all problems, but rather seek to employ the most appropriate techniques to address each individual research question. Following are some examples of analytical techniques used by IDA researchers to address specific research questions:

**IDA text analytics (ITA).** ITA is a customized software capability, built on proven open source components, for exploratory analysis of highly heterogeneous collections of documents (i.e., exploratory search). It is employed on a wide range of problems at IDA from cybersecurity applications to program evaluation. ITA uses a variety of different techniques based on machine learning and natural language processing to facilitate rapid insight discovery. It supports both search (e.g., looking for specific information) and discovery (e.g., interactive browsing to reveal information for which one may not have even known to look). ITA goes beyond simple keyword search tools through its implementation of analytics-powered facets (or filters), which allow an analyst to view a document set along different dimensions (or through various lenses). These facets, in addition to other visualizations and auto-generated reports, provide rich overviews of the entire information space and can help answer various researchable questions of interest.

ITA utilizes numerous techniques to implement such facets including: key phrase and concept discovery; topic clusters; supervised machine learning facets; customizable entity extractions; and file meta-data facets – location, time and format.

ITA is actively developed with new functionality made available regularly such as graph-based visualizations of text corpora, duplicate detection and various other reports to help answer researchable questions.

**Statistical analyses and data mining.** Statistical analyses and data mining are some of the more common analytical techniques employed by IDA researchers. These tools were particularly valuable a few years ago when the Department of Veterans Affairs (VA) asked IDA

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.

to investigate the causes of perceived inequities in the VA's disability compensation program. This multi-billion dollar program provides monthly payments to military veterans with injuries or disabilities incurred or aggravated during military service.

The IDA research team met with VA leadership, traveled across the country to interview hundreds of claims adjudicators, and – perhaps most importantly – collected and analyzed data on millions of disability compensation awards. During this project, IDA researchers formulated hypotheses based on their gained understanding of the VA adjudication process. Further, they employed advanced data mining and exploratory data analysis techniques to find additional factors and interactions implicit in the data.

From the hypotheses and data, IDA employed statistical analyses to test each hypothesis and to quantify the amount of the observed variations that is accounted for by each factor. The IDA analysis identified the main factors contributing to the observed variation, dispelled some common misperceptions, and made policy recommendations to further improve the equity and consistency of disability compensation awards.

**Econometrics and optimization.** Of the roughly \$500 billion dollar annual defense budget, about 20 percent is used for procurement – buying systems for our armed forces to use, as opposed to developing new systems or maintaining the systems we already have. What we buy ranges from bullets to ballistic missiles, half-ton trucks to M1 tanks, and inflatable rafts to aircraft carriers. About \$50 billion per year is spent on major defense acquisition programs (MDAPs), the most sophisticated and most expensive military systems. These are the nation's investment portfolio against future military operational needs. Understanding the cost, schedule and risks of any one major program is complicated. Understanding their interactions and behavior as a portfolio is even more daunting.

More than  
**90 percent**  
of IDA's  
**researchers**  
have  
**advanced degrees,**  
with the  
majority  
having earned  
**doctoral degrees**  
in a  
**technical**  
field.

## IDA modeled the cost and benefits of early warning and detection technologies employed to defeat biological weapons attacks on major U.S. cities.

IDA has been working with DoD to develop and improve a decision-support tool that models the cost and schedule of all MDAPs simultaneously. This tool, called “PortOpt,” allows DoD analysts to predict the likely cost and schedule impact of proposed procurement schedule changes, and to find practical schedules that minimize total procurement cost across all programs, given a fixed budget and fielding requirements. It also provides a means to estimate the overall cost and schedule impact on existing programs of adding a new program or cancelling a program. These capabilities have direct applications to affordability analysis, portfolio analysis, and reprogramming in response to unexpected budget reductions. PortOpt gives DoD the ability to identify – in days or weeks, rather than weeks or months – opportunities for savings, feasible responses to disruptions or impending budget crunches.

At the heart of PortOpt are two key analytical tools. The first is an econometric model of how future procurement costs for each program would vary as a function of production schedule. Because this is a causal model, sophisticated statistical techniques are required to distinguish the effect of schedule on cost from the equally common effect of cost on schedule, or the effect of technical challenges on both. The second key tool is a large mixed integer linear program (MILP) that approximately describes the problem of finding the minimum-cost set of simultaneous schedules subject to constraints on annual budget, latest permitted fielding dates, minimum and maximum production rates, plant capacity constraints and practical limits on which production schedules could be implemented in real life. The MILP uses piecewise-linear approximations to the econometric cost functions, resulting in a formulation with thousands of binary variables, tens of thousands of continuous variables, and tens of thousands of constraints.

**Discrete event simulation modeling.** IDA uses discrete event simulation modeling to assess defense weapon systems. A suite of similar models called IMEASURE, built with ExtendSim, examines various aircraft types; IDA has used these simulation models to examine fighters, helicopters, cargo aircraft and unmanned aerial systems.

Given a particular system’s reliability and maintainability (RAM) performance and a target operational capability metric, the model can be used to independently estimate maintenance manpower requirements by job specialty and/or appropriate spare stock levels. Alternatively, given a particular set of available

## FFRDCs: Unique capabilities

“FFRDCs were established to provide the Department of Defense with unique analytical, engineering and research capabilities in many areas where the government cannot attract and retain personnel in sufficient depth and numbers. They also operate in the public interest free from organizational conflicts of interest and can therefore assist us in ways that our industry contractors cannot.”

**Hon. Ashton B. Carter**  
Under Secretary of Defense  
Acquisition, Technology and Logistics

maintenance manpower and spares stock, the model can assess the system’s operational capability (mission capable rate, sortie generation rate, operational availability). We often use the model at IDA to make assessments and predictions of operational test performance or to estimate program unknowns (e.g., manning or sparing resource requirements) to support independent cost estimates. Aside from the RAM inputs, there are many additional data and modeling assumptions required to run the model (aircraft turn durations, abort rates, mission schedule, etc.), contributing to the intractability of solving such analytical problems without simulation.

**Cost/benefit analyses.** For the U.S. Department of Homeland Security, IDA modeled the cost and benefits of early warning and detection technologies employed to defeat biological weapons attacks on major U.S. cities. This work involved modeling the dispersion of aerosolized pathogens in various venues such as an outdoor park in Chicago, O’Hare Airport and Grand Central Terminal in New York City. The lifecycle costs and benefits (i.e., reduced mortality and morbidity) of these technologies were simulated over a range of pathogens, venues and operation cycles. The results suggest that net present value of all the technologies was positive.

### The Future

Over the past 60 years, IDA researchers have been asked to provide independent analytic assessments and analyses on a wide range of public policy questions. In fact, the variety of interesting work is one of the oft-mentioned reasons why so many talented people enjoy working at IDA. The future looks to be no different. While it is not possible to predict with certainty the specific research questions that IDA will be asked, they will most assuredly continue to involve some of the more critical aspects of national security. And IDA analysts and researchers will continue to leverage the latest analytic techniques to provide government decision-makers with high-quality independent assessments. **ORMS**

**David E. Hunter** ([dhunter@ida.org](mailto:dhunter@ida.org)) is an assistant director in the Cost Analysis and Research Division (CARD) at the Institute for Defense Analyses (IDA), as well as IDA’s representative to the INFORMS Roundtable.

# Join us this fall for PAW events focused on business, healthcare and government



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Sept. 27 - Oct. 1, 2015



**BOSTON**  
Sept. 27 - Oct. 1, 2015



**WASHINGTON DC**  
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Analytics is finding new applications in healthcare. While other sectors have already seen significant adoption of analytics, healthcare is catching up, and it's about time. For most healthcare delivery organizations, the focus on delivering the highest value has never been greater. The inaugural Editor's Cut volume "Healthcare in the Age of Analytics" examines the impact of analytics in all areas of healthcare from operations improvement to public policy guidance.

INFORMS Editor's Cut is a comprehensive online multimedia portal designed to enrich the knowledge base of those interested in analytics and operations research applied across a variety of topics. These unique collections, curated by recognized thought leaders, provide users with a simple and effective way to access the vast wealth of INFORMS content.



<http://pubsonline.informs.org/editorscut/healthcareanalytics>





## Join Us For Fascinating Plenaries and Keynotes Such As:

### PLENARIES

1. Margaret Brandeau (Omega Rho)
2. Michael Jordan (Berkeley): Big data, theory perspective
3. Bill Rouse (Stevens Institute of Technology): Health care
4. Alfred Spector (Google): Big data, practice perspective

### KEYNOTES

1. Mihai Anitescu (Argonne): Optimization, energy
2. Alper Atamturk (Berkeley): Discrete optimization
3. John Glaser (Siemens): Health care
4. Sanjay Mehrotra (Northwestern): Optimization, health care
5. Kavita Ramanan (Brown): Stochastic processes
6. Steve Wright (Wisconsin-Madison): Optimization, big data

Pennsylvania Convention Center & Marriott Philadelphia Downtown



November 1-4

## Registration is Now Open

## The President's Panel

Mark C. Reed, Ed.D., Saint Joseph's University

Ali A. Houshmand, Ph.D., Rowan University

Stephen K. Klasko, M.D., MBA, Thomas Jefferson University and Jefferson Health System

John D. Simon, Lehigh University

<http://informs2015.com>



# informs® news

## Inside News

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## Meeting in Philadelphia offers education, networking & history



**Independence Hall and many other historical landmarks await conference attendees in Philadelphia.**

Image © Wasin Pummarin | 123rf.com



The iconic Liberty Bell is a must-see for any visitor to Philadelphia.

Brown University and Steve Wright of the University of Wisconsin- Madison.

The city of Philadelphia is known for its arts, culture and history. It has more outdoor sculptures and murals than any other American city and is home to one of the largest art museums in the United States, the Philadelphia Museum of Art. The long flight of stairs to the main entrance of this building became famous because of the film *Rocky*. Philadelphia is also the home to 67 National Historic Landmarks, including Independence Hall and the Liberty Bell, which relate to the founding of the United States.

The Reading Terminal Market, a historic public market that offers everything from locally grown produce to table linens, occupies the ground floor of the center. There are a wide variety of restaurants in the area surrounding the Convention Center and conference hotels. A tour of Boathouse Sports will highlight the diversity, creativity and productivity that this leader in customer performance apparel is known for.

For more information regarding the 2015 INFORMS Annual Meeting, visit <http://meetings2.informs.org/philadelphia/>.

**ORMS**

The 2015 INFORMS Annual Meeting will be held Nov. 1-4 at the Pennsylvania Convention Center and Philadelphia Marriott Downtown hotel, which are located in the heart of Philadelphia. The convention center is connected to the Marriott via an enclosed skyway. The three other hotels that are offering an INFORMS group rate are located within a five-minute walk of the Convention Center and Marriott. The convention center and conference hotel are located just 10 miles from Philadelphia International Airport and easily accessible by the Southeastern Pennsylvania Transportation Authority, or SEPTA.

The meeting will offer not only educational opportunities but also several networking opportunities. The Welcome Reception will be held on Sunday evening (Nov. 1), subdivision meetings will be held predominantly on Monday eve-

ning (Nov. 2) and the General Reception will be held Tuesday evening (Nov. 3). The Career Fair will provide an opportunity to meet and collect resumes from many job seekers and the ability to set up private interviews.

An impressive list of plenary and keynote speakers will deliver talks from a wide variety of application areas, including data sciences, healthcare, energy, security, service systems, logistics, the environment and more. Margaret Brandeau of Stanford University, Michael Jordan of U.C. Berkeley, Bill Rouse of Stevens Institute of Technology and Alfred Spector of Google will deliver plenary presentations. Keynote speakers will include Mihai Anitesch of Argonne, Alper Atamturk of U.C. Berkeley, John Glaser of Siemens, Sanjay Mehrotra of Northwestern University, Kavita Ramanan of



## Position statement:

### Brian Denton



***"I have served as secretary of INFORMS for the past two terms, and I am optimistic about the future of INFORMS and the opportunity we have to increase its relevance to ourselves, as members, and to the public."***

What would your life be like without INFORMS? Answers to this question will vary a lot, depending on your particular background. From my perspective, it would leave a void in my professional career. I have been a member since I was a graduate student in the 1990s. When I started my career as a practitioner at IBM, INFORMS became my professional home, providing important opportunities to develop professional contacts and stay on top of cutting-edge research and practice.

During my career as a practitioner and a professor, the INFORMS Annual Meeting has been a regular event that I attend every fall, and I would certainly miss the opportunity to participate in this event and to catch up with my friends and collaborators. I would also miss our smaller and more intimate meetings such as MSOM, the Optimization and Computing Society meetings, the Healthcare meeting and others I have participated in over the years, often receiving valuable feedback on my research. I would miss our publications as a reader and as an author. Finally, I would not have had as many opportunities to develop my leadership skills through conference organizing, committee service, serving as a subdivision officer and most recently serving as a board member and executive officer of INFORMS.

The above question encourages reflection on what INFORMS does for you as a member. Another, perhaps equally important question, is what does INFORMS do for the public? The recent analytics movement has created many new opportunities to define, and in some cases expand, our role in society as management scientists, operations researchers, decision scientists and the many other names we call ourselves. We may lack the perfect definition of what analytics is, but there are many benefits that come with the increased exposure we are getting. At universities, this means new opportunities to increase student enrollment and hire new colleagues. In industry, this means a

heightened awareness of the critical role we can play in organizations. For consultants, this can mean more business opportunities and greater success at customer engagement.

Fortunately, INFORMS is in an excellent position to focus on the future. We set a new record for membership last year, and our funding reserve is at an all-time high. We have incredible staff members led by our Executive Director Melissa Moore. Many new endeavors are already underway including plans for new journals, new educational offerings, special topics conferences, analytics certification and others. If elected president, my first priority will be to focus on future strategic initiatives including the following:

1. To enhance the process by which members can propose new initiatives. Priority would go to proposals that cross disciplines and/or are likely to provide value to multiple subdivisions. This recognizes that sometimes a committed team of members and a small amount of funding is all that is needed to bring new ideas to light.

2. To create new member benefits that provide value through improvements to member services including online learning resources, a repository of teaching materials and an online platform for enabling sharing of datasets between practitioners and academics for research purposes.

3. To implement new processes for increasing the diversity of member engagement in volunteer activities with the goal of having INFORMS leaders, past and present, mentor junior members to build their leadership skills for the future.

I have served as secretary of INFORMS for two terms, and I am optimistic about the future of INFORMS and the opportunity we have to increase its relevance to ourselves, as members, and to the public. I am familiar with the INFORMS strategic planning process, staff functions, operations and all of the major Board activities. The core values I would bring to this position are: 1) the support of subdivisions as

a foundation of INFORMS and the home for many of our members; 2) the importance of fostering an environment where academics and practitioners can learn from each other; 3) strengthening support and bringing new ideas to our core functions, including our publications and meetings; and 4) building our reputation and our engagement with the public.

I am honored to be nominated for president of INFORMS. If elected I look forward to serving. **ORMS**

**Brian Denton** is an associate professor in the Department of Industrial and Operations Engineering at the University of Michigan in Ann Arbor, Mich. Previously he has been an associate professor in the Department of Industrial & Systems Engineering at North Carolina State University, a senior associate consultant at the Mayo Clinic and a senior engineer at IBM.

He has served INFORMS in many roles, including as past chair of the INFORMS Health Applications Section, program chair for the INFORMS Annual Meeting and chair of the Franz Edelman Award Committee. Since 2012 he has served as secretary on the INFORMS Board of Directors.

His research interests are in optimization under uncertainty with applications to healthcare delivery and medical decision-making.

He completed his Ph.D. in management science at McMaster University, his M.Sc. in physics at York University and his B.Sc. in chemistry and physics at McMaster University in Hamilton, Ontario, Canada.



## Position statement:

## Les Servi



***We must continue to respond to the game-changing analytics opportunities around us while tending to our precious world-class core which took us over 60 years to create.***

INFORMS is an energetic, adaptive, growing organization with international reach and a focus on increasingly central domains. The best of our members are giants on the world stage, and we have a pipeline of growing stars who will eventually join them. Our publications have exceptional impact and visibility. We regularly launch successful new publications, new subdivisions and new meetings in response to the changing world. Our volunteers are highly engaged guardians of our society's excellence. Our professional staff is simply extraordinary.

There is an opportunity to focus on larger issues since INFORMS' fundamentals are doing so well. If elected president of INFORMS I will use my experience and ties to many parts of INFORMS to strive to:

- **Maintain balance:** We must continue to respond to the game-changing analytics opportunities around us while tending to our precious world-class core which took us over 60 years to create. Doing so will be eased by the blurring boundaries caused by radical changes in computational power and data access but will also require thoughtful deliberations and a strong strategic will.
- **Promote excellence:** Our future excellence demands we make decisions that encourage the best of the next generation to choose to join us, help our new and seasoned members to thrive, and set the stage for our members to be invited to the table when important decisions are being examined. We need to promote the diversity of our membership, our leaders and our Fellows, because great organizations such as ours cannot afford any missed opportunities of talent and excellence.
- **Facilitate learning:** As our members' differing interests and needs evolve we must respond with targeted offerings. We must continually enhance learning for those cur-

rently in our field, those working toward or maintaining their CAP certification, those just joining us, and those wishing to alter the direction of their work. This entails generating new content, making our current content easier to access, and helping match our members with people, activities and organizations that can help them grow.

- **Engage organizations:** We must not only seek to benefit our members but we must also engage organizations. Their needs can drive opportunities by encouraging INFORMS membership and conference attendance, by reaching out to members who can help them, and by informing us of their most important technical challenges. Targeted engagement will be different for industry, academia and government organizations but each has great synergetic potential.

I have personally touched many diverse aspects of INFORMS: My first engagement with INFORMS was many years ago when I co-authored a talk as a student (and MITRE summer intern). Since then I gave countless talks, organized many invited sessions and clusters, led three subdivisions and one chapter, helped edit three journals, co-organized a regional meeting and was elected three times to serve on the INFORMS Board.

While on the Board I discussed and help voted in: (i) the initiation of the "Practice" INFORMS Spring meeting, (ii) a major INFORMS reorganization which made INFORMS more subdivision-centric, (iii) the institution of the Fellow Award, (iv) the Health Application Subdivision, and (v) the *Decision Analysis* journal. As treasurer, I helped stabilize INFORMS' finances and processes. Such diversity of experience will guide my effectiveness if elected president.

INFORMS is a complex organization. The operational business of INFORMS now has

many millions of dollars of income, expenses and endowment. Leading INFORMS is a solemn responsibility that I pledge to take seriously. I will do so by drawing on my experiences complemented by listening carefully to the INFORMS Board, staff and most importantly the members. My years working in both industry and non-profit organizations complemented by my sabbatical in two universities and my foray serving on a high-level government task force have helped prepare me to again serve INFORMS.

I feel honored to be nominated to run for INFORMS' presidency. I ask for your vote. **ORMS**

**Les Servi** currently leads the Decision Analytics Group at The MITRE Corporation. Previously, he served on a Defense Science Board task force, worked at MIT Lincoln Laboratory, Verizon Laboratories, Bell Laboratories and took a sabbatical at Harvard University and MIT. His corporate awards include one from Verizon's CEO and one from MITRE's president.

He is an INFORMS Fellow, helped start the Telecommunication Society, helped rejuvenate and currently leads the Boston Chapter, chaired the Applied Probability Society, started and currently leads the Social Media Analytics Section, currently serves as the chair of the Fellows Selection Committee, served on INFORMS editorial boards of Operations Research, Management Science and INFORMS Journal on Computing, elected to three Board terms including one as treasurer and chaired the Subdivision Council.

He received a Ph.D. in engineering from Harvard University. His papers and patents are in applied probability, telecommunications and social media analytics. Much of his work has both strong theory and practice components, which is where he believes the most interesting, valuable and satisfying work is to be found.

## In Memoriam

# John F. Nash Jr. (1928-2015)

"This man is a genius."

Professor Richard Duffin of the Carnegie Institute of Technology wrote a single sentence reference, recommending John Nash for the doctoral program in mathematics at Princeton in 1948. Nash graduated in 1950 and took a job in the mathematics department at MIT in 1951. From his thesis he published two papers: (1) "Equilibrium Points in n-Person Games" (1950), *Proceedings of the National Academy Sciences* (The total text in what turned out to be a Nobel Prize paper was 317 words); (2) "Non-Cooperative Games" (1951), *Annals of Mathematics*. The latter developed Nash's results further and contrasted them with Von Neumann and Morgenstern's famous book, "Theory of Games and Economic Behavior" (1944), which Nash described as about "cooperative games" and his own work about "non-cooperative games," noting that the former are zero-sum whereas the latter need not be.

Nash's initial paper proved that a finite non-cooperative game always has at least one equilibrium point, today called a "Nash equilibrium." This has the property that no player can obtain a better payoff by changing her/his strategy, if the other players do not change theirs.

The important new field of non-cooperative games was born. It is a better model of many real-world situations than a zero-sum assumption can produce. It is in common use today to analyze business, economic and political phenomena.

In 1978, INFORMS awarded the John von Neumann Theory Prize to John Nash and Carlton Lemke for their contribution to the theory of games. The theory of games was von Neumann's most distinctive contribution to the field of OR/MS. It seems fitting that the John von Neumann Prize should be shared by Nash and Lemke, who were major contributors to the theory of non-cooperative games, the principal extension of von Neumann's original idea. Furthermore, the prevailing trend among mathematicians has been to search for "elementary" (i.e., algebraic) proofs in new results. This tended to treat all game theory as a branch of the theory

of linear inequalities. Nash, however, had introduced a different approach with his idea of non-cooperative n-person games and his general existence theorem.

Nash's equilibrium proofs, however, were non-constructive, and for many years it seemed that the nonlinearity of the problem would prevent the actual numerical solution of any but the simplest non-cooperative games. The breakthrough came in 1964 with an ingenious method for solving finite, two-person games. Carlton Lemke and J. T. Howson devised it. It provided a path-following algorithm that was both a constructive existence proof and a practical means of calculation. Lemke took the lead in exploiting its many applications. The game theory aspect was strengthened because the path-following methodology is a way of finding and calculating Nash equilibria.

In 1994, the Nobel Prize in Economic Sciences was shared by John C. Harsanyi, John F. Nash Jr. and Reinhard Selten "for their pioneering analysis of equilibria in the theory of non-cooperative games." Nash's contributions were: "to introduce the distinction between cooperative games, in which binding agreements are not feasible and to develop an equilibrium concept for non-cooperative games that is now called Nash equilibrium." Harsanyi and Selten each founded new subfields with new literatures and applications, but they both trace their ancestry to Nash's first existence theorem.

Other important Nash research includes two path-breaking papers in 1954 and 1956. They prove that "every Riemannian manifold can be isometrically embedded into some Euclidean space." These provided the basis of much subsequent mathematics. Later, after bouts with mental illness from which he gradually recovered, Nash did important work in partial differential equations.

In 1957, Nash married an MIT physics student from El Salvador, Alicia Lopez-Harrison de Larde'. However, in 1959 he was stricken by mental illness, diagnosed as paranoid schizophrenia. Alicia had him admitted to McLean Hospital near Boston. He continued to have delusions that took him in and out of mental hospitals

near Princeton until 1970. He was largely supported mentally and financially by the mathematics community and by Alicia Nash through her professional income.

In 1998, Sylvia Nasar completed an extensive (461 pages) biography of Nash titled "A Beautiful Mind – The life of mathematical genius and Nobel Laureate John Nash." It was nominated for a Pulitzer Prize. Subsequently it was made into a movie, "A Beautiful Mind." The picture received four Academy Awards, including best picture.

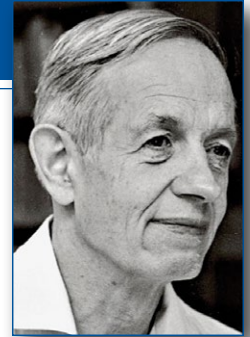
The director of the film, Ron Howard, said, "[The movie] captures the spirit of [Nash's] journey, and I think that it is authentic in what it conveys to a large extent. Certain aspects of it are dealt with symbolically. How do you understand what goes on inside a person's mind when under stress, when mentally ill, when operating at the highest levels of achievement. The script tries to offer insight, but it's impossible to be entirely accurate."

Of his portrayal by an actor in the film, Nash said: "It's not me, but Russell Crowe plays the part well."

John Forbes Nash, mathematician, was born June 13, 1928; he died May 23, 2015. **ORMS**

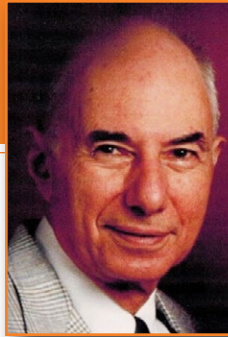
– John D. C. Little, MIT

**Author's note:** I was a doctoral student in physics at MIT from 1950 through 1954, overlapping Nash's first few years at MIT. In the late stages of my Ph.D. thesis, I informally audited a course in real analysis for a few weeks. It happened to be taught by Nash. People ask me what he was like. I found him to be competent but not especially inspiring. As I remember, he seemed somewhat abstracted, as if focused on something else. The only idiosyncrasy I recall is that, if Nash were near the window, he would occasionally absent-mindedly fiddle with the venetian blind cord, while he answered questions. Although I did not know it at the time, in this period, he was working on two brilliant papers that were published in 1954 and 1956.



## In Memoriam

# Matthew Rosenshine (1932-2015)



On June 11, 2015, we, INFORMS, and the OR/MS community lost a good friend and colleague, Dr. Matthew Rosenshine.

Matt was professor emeritus of Industrial Engineering at The Pennsylvania State University, specializing in operations research, queueing theory and stochastic processes. Prior to joining the Penn State faculty in 1968, he worked at the Cornell Aeronautical Laboratory in Buffalo, N.Y. Matt received his Ph.D. degree in operations research engineering from SUNY Buffalo in 1966, his M.S. in mathematics from the University of Illinois in 1956, his M.A. in mathematics education in 1953 and his A.B. in liberal arts (with a science emphasis) in 1952 from Columbia University.

Matt has numerous publications in the areas of air traffic systems modeling, control of queues and applications of stochastic processes to robotics. In addition to his many research accomplishments, he was a dedicated teacher. His honorary memberships include Sigma Xi, Phi Beta Kappa, Alpha Pi Mu, Omega Rho and Pi Mu Epsilon.

As many "senior" INFORMS folks will remember, Matt Rosenshine was a member of the INFORMS Public Awareness Committee (PAC), which devoted its efforts to operations research education of high school/community college math and science teachers. Those activities in-

cluded the development of modules dwelling on everyday applications of operations research, concentrating on linear programming, queueing theory, probability, statistics and simulation. Matt's contributions were instrumental in the success of these programs.

Also very important was his participation in the PAC's Teachers Workshops – a major all-day series of presentations – held during INFORMS Annual Meetings. Most noteworthy was the Seattle meeting, which drew 108 local school attendees. Matt's offerings in probability and statistics in that program were truly exceptional and helped to make it a memorable experience for the attendees.

Matt was personally involved in PAC's creation of a series of videos, most notably, "Operations Research + You = An Exciting Career." More than 2,000 copies were distributed nationwide, including to the entire Fairfax County (Virginia) Public School System, making it a huge educational community outreach endeavor.

We shall miss you, Matt, for your dedication to our profession, your always good humor and your deep, personal friendship. **ORMS**

– Frank Trippi and Don Gross

## People

Two University of Buffalo industrial engineering students – **Kyle Cunningham** and **Niraj Pandey** – developed an algorithm that comes close to matching, and in some cases improving, the schedule the National Football League produces each year. The algorithm minimizes a competitive imbalance by reducing the number of times teams play more-rested opponents coming off a bye week or Thursday night game.

**Murat Kurt**, assistant professor of industrial and systems engineering at UB, and

**Mark Karwan**, UB professor of operations research, oversaw the students' project.

The students' paper, "Alleviating Competitive Imbalances in NFL Schedules: An Integer-Programming Approach," was selected for presentation at the prestigious 2015 MIT Sloan Sports Analytics Conference Research Paper Competition. The project also received significant nationwide media attention, including the Associated Press, CBS Dallas-Fort Worth, KTVU-TV in San Francisco, ABC News and the *Fresno Bee*. **ORMS**

# Meetings

## INFORMS Annual & International Meetings

### 2015

**Nov. 1-4**

#### INFORMS Annual Meeting

Pennsylvania Convention Center & Marriott  
Philadelphia Downtown  
Philadelphia

Chair: Tamas Terlaky, Lehigh University  
<http://meetings2.informs.org/philadelphia/>

### 2016

**April 10-12**

#### INFORMS Conference on Business Analytics & Operations Research

Hyatt Regency Grand Cypress  
Orlando, Fla.

Chair: Elea McDonnell Feit, Drexel University

**June 12-15**

#### INFORMS International Conference

Hilton Waikoloa Village  
Waikoloa Village, Hawaii

Chair: Saif Benjaafar, Singapore Univ of Tech & Design

**Nov. 11-13**

#### INFORMS Annual Meeting

Music City Center & Omni Nashville  
Nashville, Tenn.

Chair: Chanaka Edirisinghe, Univ of Tennessee

## INFORMS Community Meetings

### 2015

**Dec. 6-9**

#### Winter Simulation Conference

Hyatt Regency Huntington Beach Resort & Spa  
Huntington Beach, Calif.

Chair: Charles M. Macal, Argonne National Laboratory  
<http://wintersim.org/2015/>

### 2016

**Feb. 4-7**

#### Organization Science Workshop

Canyon Resort  
Park City, Utah

Chair: Zur Shapira, New York University

**Go to [www.informs.org/Conf](http://www.informs.org/Conf)  
for a searchable INFORMS  
Conference Calendar.**



## WSC 2015: Social and Behavioral Simulation

By Charles M. Macal

The Winter Simulation Conference (WSC) has been the premier international forum for disseminating recent advances in the field of dynamic systems modeling and simulation for more than 40 years. In addition to a technical program of unsurpassed scope and quality, WSC is the central meeting place for simulation researchers, practitioners and vendors spanning all disciplines and working in industry, government, military, service and academic sectors. WSC 2015 will be held Dec. 6-9 in Huntington Beach, Calif., at the Hyatt Regency Huntington Beach Resort and Spa. The theme for WSC 2015 is "Social and Behavioral Simulation."

The appeal of simulation is its relevance to a diverse range of interests. WSC has always reflected this diversity, and WSC 2015 aligns with and expands upon this tradition. For those more inclined to the academic aspects of simulation, the conference offers tracks in modeling methodology, analysis methodology, simulation-based optimization, hybrid simulation and agent-based simulation. For those more inclined to the application of simulation, tracks include healthcare, manufacturing, logistics and supply chain management, military applications, business process modeling, project management and construction, homeland security

and emergency response, environmental and sustainability applications, and networks and communications.

The theme for WSC 2015, "Social and Behavioral Simulation," is timely and relevant. The explosion in the number of simulations that include descriptive models of behavioral and social decision-making is creating both opportunities and challenges to the business, operations and scientific communities. Presenters will discuss how simulation can help.

In addition to special tracks on social and behavioral simulation and agent-based simulation applications, conference keynote speaker Joshua Epstein, professor of Emergency Medicine and director, Center for Advanced Modeling in the Social, Behavioral and Health Sciences at Johns Hopkins University, will speak about the rise of artificial social simulation.

The military keynote speaker is Timothy H. Chung, deputy director of the Consortium for Robotics and Unmanned Systems Education and Research at the Naval Postgraduate School, who will speak about multi-agent coordination for information gathering applications.

A distinguished speaker lunchtime program features the "Titans of Simulation," Pierre L'Ecuyer and Averill M. Law.

The Modeling and Analysis of Semiconductor Manufacturing (MASM) is a conference-within-a-conference featuring a series of sessions focused on the semiconductor field. The Industrial Case Studies track affords industrial practitioners the opportunity to present their best practices to the simulation community. The Simulation Education track presents approaches to teaching simulation at education levels ranging from K-12 to graduate and professional workforce levels. Finally, WSC provides a comprehensive suite of introductory and advanced tutorials presented by prominent individuals in the field, along with a lively poster session, Ph.D. colloquium and a new attendee orientation.

The WSC is designed for professionals at all levels of experience across broad ranges of interest. The extensive cadre of exhibitors and vendor presentations, the meetings of various professional societies and user groups, along with the various social gatherings give all attendees the opportunity to become involved in the ever-expanding activities of the international simulation community. **ORMS**

**For more information,** visit <http://wintersim.org/2015/>.

**Charles M. Macal** is general chair of WSC 2015.

## Revenue Management and Pricing Award

The INFORMS Revenue Management and Pricing Section presented its 2015 Practice Award to a team representing Yihaodian, a Chinese online grocery business. The award recognizes the outstanding application of revenue management and pricing techniques. The winning entry was entitled, "Competition-Based Dynamic Pricing in Online Retailing."

The recipients included Yihaodian co-founder Gang Yu, along with Jun Li of the Ross School of Business at University of Michigan, Santiago Gallino of Tuck School of Business at Dartmouth College and Marshall Fisher of the Wharton School at the University of Pennsylvania. **ORMS**

**Pictured (l-r) are:**

Loren Williams (award committee), Jamison Graff (award committee), Santiago Gallino (award recipient), Jun Li (award recipient) and Ronald Menich (award committee chair).



## Frontline's V2015-R2 offers Excel users access to big data, advanced analytics and more

Frontline Systems is shipping a new product line release, Version 2015-R2 of its Solvers for Excel, including its flagship integrated product, Analytic Solver Platform, and its "professional entry-level" integrated product, Analytic Solver Pro.

The new release enables users, for the first time, to "pull" sampled and summarized data into Excel from compute clusters running Apache Spark, the open-source software widely embraced by big data vendors and users, and to "push" the results of analytic models into Power BI, Microsoft's new online tool for data visualization and reporting.

The release also includes new versions of XLMiner Platform, a tool for data mining and text mining in Excel; Risk Solver Platform, a tool for simulation/risk analysis, conventional and stochastic optimization in Excel; Premium Solver Platform, Frontline's best-selling tool for large-scale conventional optimization; and subset "professional entry-level" products Premium Solver Pro, Risk Solver Pro and XLMiner Pro.

"Our message was and is 'no-compromise analytics in Excel,'" says Daniel Fylstra, Frontline's president and CEO. "Now we're giving business analysts who aren't data science Ph.D.s easy access to big data, plus the tools to use that data in the most advanced analytic models."

Frontline's Solvers for Excel are upward compatible from the Solver included in Excel, which Frontline developed for Microsoft, and improved in 2010 and 2011. Users can solve problems hundreds to thousands of times larger than the basic Excel Solver, at speeds anywhere from several times to hundreds of times faster, and they can solve completely new types of problems. V2015-R2 works with Excel 2016 Preview edition, and it will be updated as needed for the final release version of Excel 2016.

With powerful "plug-in" large-scale Solver Engines, including the Gurobi Solver, XPress Solver and KNITRO Solver, users can solve linear mixed-integer problems with millions of decision variables, nonlinear problems with hundreds of thousands of decision variables, and many of the largest risk-based stochastic optimization problems that have ever been solved, on any platform.

The new release includes a built-in client that "talks to" a Frontline-supplied server program that runs within an Apache Spark cluster, communicating with the Spark master and worker nodes. Business analysts can access Spark data through a simple point-and-click user interface, with no programming expertise in Java/Scala, Python or R required.

By drawing a representative sample of big data from all the nodes in the cluster, Excel users can easily train data mining and text mining models directly on their desktops. By drawing summarized data such as sums, counts and averages of certain variables, grouped by other variables, Excel users can obtain just the data they need to drive simulation and optimization models.

The new release also includes a built-in client that "talks to" the new release of Microsoft Power BI – currently in public preview and preparing for general availability. With as little as one click, business analysts can "push" data such as final values of decision variables and constraints from an optimization model, or summary statistics, risk measures and percentiles from a simulation/risk analysis model, into their Power BI online accounts.

With a few more point-and-click steps in Power BI, users can obtain insightful visualizations that simplify communication of results with managers and stakeholders. And it's straightforward to ask questions, change assumptions, re-run the analytic models and update the Power BI visualizations.

In this release, Frontline has further upgraded users' ability to move from the desktop to the cloud. Since mid-2013, users of Excel Online in Office 365 have been able to use Frontline's Solver app, available free in the Office Store, to solve the same kinds of optimization models handled by the Solver in desktop Excel, that Frontline developed for Microsoft.

With V2015-R2, users can publish optimization and simulation models to Excel Online or Google Sheets, and solve them in the cloud with Frontline's Solver and Risk Solver apps/add-ons – up to the maximum size permitted by their desktop licenses. And they can store their models in Office 365 or SharePoint 2013, OneDrive or OneDrive for Business or Google Drive.

Users of existing Frontline Solver products can upgrade to V2015-R2 at

no cost with current annual support. Frontline is preparing a special program to enable faculty members to introduce their students to big data with realistic hands-on exercises, without requiring a big investment of money or time.

The Power BI client is included in each of Frontline's Pro and Platform products. The Apache Spark client is included in Frontline's four Platform products, with sampling functionality in XLMiner Platform.

**For more information,** visit [www.solver.com](http://www.solver.com).

## AIMMS featured in Gartner's 'Market Guide for Optimization Solutions'

AIMMS, an award-winning optimization platform, has been featured as one of seven major optimization software platforms in Gartner's new "Market Guide for Optimization Solutions." In the report Gartner states: "Optimization is a prescriptive analytics approach used to solve complex decision problems that involve conflicting objectives and constraints, making the best use of limited resources."

While awareness of this approach has traditionally been limited in corporate BI and analytics teams, increased awareness about the benefits of optimization is driving adoption. For instance, a related Gartner report, "Use Cases for an Enterprise Supply Chain Modeling Platform," highlights how companies are already using advanced analytics platforms to explore options and choose scenarios tailored to their strategy and business objectives. Interviews with AIMMS, as well as three AIMMS customers (BP, JBS and Papyrus), contributed to this report, which included benefits of using modeling platforms, lessons learned and recommendations.

According to Gartner, AIMMS' key differentiator is that "its platform is built to easily create and publish optimization applications. It offers a browser-based platform for instant publishing, deployment and collaboration on optimization-based and non-optimization-based applications and proofs of concept throughout the enterprise combined with development tools to create optimization solutions in line with the business problems." This provides users with a fully integrated model and application development environment, which includes

productivity tools, an open Web UI visualization standard and multiple solvers.

The flexible AIMMS platform can be used for network optimization, planning & scheduling, risk mitigation, cost to serve segmentation and much more. AIMMS clients such as Nike, Air Liquide and Shell have saved or avoided billions of dollars in costs and significantly reduced carbon emissions through the use of the company's optimization technology.

"We are thrilled to be recognized by Gartner as a key software provider," says AIMMS CEO Gijs Dullaert. "After being previously selected as a Cool Vendor in the space, we feel this is a noteworthy acknowledgment for us and the great accomplishments of our customers."

**For more information,** visit <http://www.aimms.com/>.

## Lindo's What'sBest! 13.0 includes wide range of enhancements

Release 13.0 of Lindo's What'sBest! software includes a wide range of performance enhancements and new features, including:

- Faster solutions on linear models with improved Simplex Solver: Simplex LP algorithm improvements boost speed and robustness. Primal Simplex Solver averages 90 percent faster and Dual Simplex Solver averages 45 percent faster.
- Better performance on integer models: Improved solution times across broad classes of IP models from enhancements due to improved knapsack related cuts, superior default node selection rules and branching variable selection rule options.
- Expanded capabilities of efficient solution of quadratic problems: If you work with covariance matrices, you'll appreciate the new Positive Definite (POSD) feature. If estimating a covariance matrix for a portfolio, a constraint may be added to force the matrix to be positive semi-definite (a property required of any covariance matrix). New reformulation capabilities give improved performance on quadratic portfolio

models with semi-continuous variables (e.g., min-buy quantities), and/or cardinality constraints limiting the number of assets in a portfolio.

- Smarter presolver: New preprocessing for linear programs significantly reduces coefficient density of certain dense matrices.
- Improved nonlinear solver: Upgraded default settings provide performance improvements overall on nonlinear models. Faster processing of long (1000's of terms) nonlinear expressions in nonlinear models.
- New functionalities: Support for additional math and probability functions, e.g., Erlang B and C formulae. Add a feature to generate a K-Best report when generating K best solutions.

What'sBest! is an add-in to Excel that allows users to build large-scale optimization models in a free form layout within a spreadsheet. **ORMS**

**More information,** visit <http://www.lindo.com/>.



THE FRANZ EDELMAN AWARD  
Achievement in Operations Research

## Call for Entries

A \$15,000 Competition with a \$10,000 First Prize  
Application Deadline: October 14, 2015

### Key Dates for the Competition

#### Wednesday, October 14, 2015

Deadline to provide a single pdf document containing a three page summary of your achievement, and a cover page with a 60-word abstract, and the name, address, phone number, and affiliation of each author.

#### Monday, December 14, 2015

Finalists will be selected based on the summaries and the INFORMS/CPMS verification process.

#### Friday, February 12, 2016

Deadline for finalists to provide a full written paper.

#### Monday, April 11, 2016

Each finalist group will give an oral presentation of their work in a special session at the INFORMS Conference on O.R. Practice in Orlando, Florida, April 10–12, 2016.



## About the Competition

The purpose of the competition is to bring forward, recognize, and reward outstanding examples of operations research and the management sciences in practice. The client organization that uses the winning work receives a prize citation; the authors of the winning work receive a cash award.

## Entry Requirements

Visit the website [www.informs.org/edelmanaward](http://www.informs.org/edelmanaward) for detailed information.

Entries should report on a completed practical application and must describe results that had a significant, verifiable, and preferably quantifiable impact on the performance of the client organization. Finalist work will be published in the January-February 2017 issue of *Interfaces*.

Any work you have done in recent years is eligible, unless it has previously been described by a Franz Edelman Award finalist. Previous publication of the work does not disqualify it. Anyone is eligible for the competition except a member of the judging panel.

## E-mail Submissions

Please e-mail your submission to:

[trick@cmu.edu](mailto:trick@cmu.edu)

Michael Trick

Chair, 2016 Edelman Award Competition Committee





**Air Force Institute of Technology  
Department of Operational Sciences  
Operations Research Faculty Position**

The Department of Operational Sciences at the Air Force Institute of Technology invites applications for a civilian tenure-track faculty position at the rank of Assistant, Associate, or Full Professor. Candidates should possess an earned doctorate degree in Operations Research, Industrial Engineering, Management Science, or a related field at the time of employment and experience appropriate for the position. The Department seeks applicants whose specialty and interests are in Deterministic Optimization but will consider qualified candidates with qualifications in Applied Statistics, Applied Probability, or Simulation. Rank and salary are commensurate with qualifications. This is a three-year, renewable, excepted service position. United States citizenship is required for the position.

The Department offers the M.S. and Ph.D. degrees in Operations Research. Successful applicants must have a strong commitment to teaching, research, publishing in high-quality journals, working within a research team, and a strong methodological foundation. Interdisciplinary research and multidisciplinary collaborations are encouraged.

To apply, submit a cover letter, resumé, statement of research interests, unofficial copies of academic transcripts and the names and addresses (including e-mail) of at least three references via email to:

Dr. Raymond R. Hill Jr., Search Committee Chair  
Department of Operational Sciences (AFIT/ENS)  
Air Force Institute of Technology  
2950 Hobson Way  
Wright-Patterson AFB, OH 45433-7765  
[Raymond.Hill.2@us.af.mil](mailto:Raymond.Hill.2@us.af.mil) and [Raymond.Hill.Jr@gmail.com](mailto:Raymond.Hill.Jr@gmail.com)  
<http://www.afit.edu/en/ens/>

Visit <https://www.usajobs.gov> to review the official announcement.

First consideration of applications is October 1, 2015. Applications will be accepted until the open position is filled. Expected start date is in Summer or Fall 2016.

The Air Force Institute of Technology is a Doctoral/Research university and is an equal opportunity/affirmative action employer. Women and minorities are strongly encouraged to apply.



TUCK  
AT DARTMOUTH

**Faculty Search  
Byrne Distinguished Professorship in  
Decision Science  
June, 2015**

The Tuck School of Business at Dartmouth seeks a full professor of operations research, management science, operations management, or a related field. This opening is for the Byrne Distinguished Professorship of Decision Science, one of only a handful of "Distinguished Professorships" on the Dartmouth campus.

We expect a successful applicant to be an acknowledged international leader in the decision sciences with an exemplary track record in creating methodological advances and their applications. Examples of research topics include, but are not limited to, risk analysis, stochastic processes, discrete optimization, game theory, statistical learning, and the mathematical analysis of economic and/or social networks. This position is one of a cluster of three appointments related to the decision sciences, with the other two in Dartmouth's Department of Mathematics. Therefore, there is the potential for cross-disciplinary work in applied mathematics with other departments across Dartmouth College. We seek a candidate who will produce research that has significant influence on the field and will teach at a level of quality consistent with Tuck's high standards.

Dartmouth College is an equal opportunity/affirmative action employer with a strong commitment to diversity. In that spirit, we are particularly interested in receiving applications from a broad spectrum of people, including veterans, women, persons of color, persons with disabilities, or any other legally protected group.

Applicants should submit a curriculum vitae, publications, and working papers by December 1, 2015. All materials should be submitted to, <http://apply.interfolio.com/30004>. Questions should be sent to the chair of the recruiting committee, [faculty.recruiting@tuck.dartmouth.edu](mailto:faculty.recruiting@tuck.dartmouth.edu).

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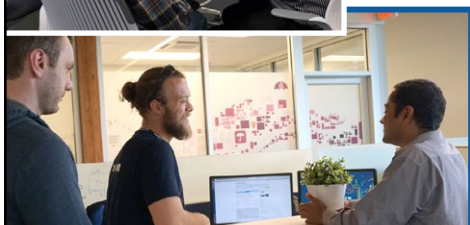
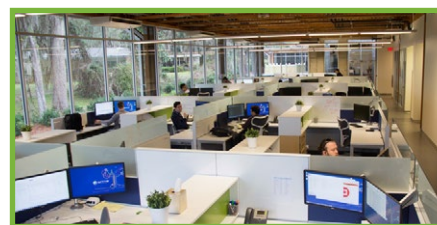
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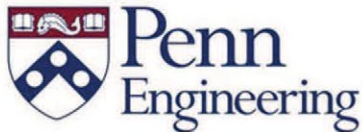
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## Faculty Director Search

### Jerome Fisher Program in Management & Technology

The School of Engineering and Applied Science (SEAS) and the Wharton School at the University of Pennsylvania have initiated a search for an outstanding scholar to serve as the Director of the prestigious Jerome Fisher Program in Management & Technology (M&T).

The M&T Program (<http://www.upenn.edu/fisher/>) combines academics from two phenomenal Penn assets, Penn Engineering and the Wharton School, into one unique educational experience. Founded in 1977, it has attracted some of the brightest undergraduates in the world. With over 1,900 alumni worldwide, graduates from the M&T Program are corporate leaders and innovators in a number of industries and fields, including investment banking, the technology sector, hedge funds and private equity, venture capital, aviation, medicine, biotechnology, consulting, law, and more. The M&T community in general is highly entrepreneurial, working on their own ventures or collaborating on start-up enterprises. With eight regional groups across the globe, M&T alumni love to stay connected, and frequently recruit fellow graduates and current students for internships and full-time positions.

The Director of the Jerome Fisher Program in Management & Technology should be an individual with an exceptional record of:

- A world-class scholar in a relevant area of engineering, management, innovation or related field with a broad understanding of issues across domains
- An international leader and educational innovator that has a vision for the future of the program in an era of growing innovation
- An institution builder that will work with faculty, students and leadership across SEAS and Wharton as well with an extremely deep alumni base in executing the vision.



Candidates must hold a Ph.D. in engineering, management, or related area. The academic appointment of the Director is expected to be at the level of tenured Full Professor holding the Jeffrey A. Keswin Professorship, and could be in any relevant department in SEAS, Wharton, or across schools, depending on the applicant. Diversity candidates are strongly encouraged to apply. Interested persons should submit their application here: <http://tinyurl.com/mandtsearch-upenn>. Questions regarding this unique opportunity should be directed to [mandtsearch@upenn.edu](mailto:mandtsearch@upenn.edu). Review of applications will begin August 1, 2015.

*The University of Pennsylvania is an affirmative action/equal opportunity employer. All qualified applicants will receive consideration for employment and will not be discriminated against on the basis of race, color, religion, sex, sexual orientation, gender identity, creed, national or ethnic origin, citizenship status, age, disability, veteran status, or any other characteristic protected by law.*



## NORTHWESTERN UNIVERSITY KELLOGG SCHOOL OF MANAGEMENT Evanston, Illinois FACULTY POSITIONS IN OPERATIONS MANAGEMENT

Applications are invited for faculty positions in Operations Management. The search is open to all ranks. A Ph.D. in Operations Management, Business, Engineering or related field must be in hand or expected by employment start date. Research potential, recommendations, and teaching capabilities will be the primary selection criteria. Candidates in all research areas of operations management will be considered, but they must have a thorough knowledge of operations management theory and practice. Successful applicants will be expected to do innovative research in operations management, participate in the school's Ph.D. program, and teach required and elective MBA courses.

Applications should be submitted at  
<https://www4.kellogg.northwestern.edu/recruiting/default.aspx?dept=OPRS>

For full consideration, please submit a curriculum vitae, three letters of reference, and copies of publications or work in progress no later than November 16, 2015. Department representatives will attend the INFORMS meeting in Philadelphia, PA, November 1 – 4, 2015. Candidates attending the conference are strongly encouraged to submit a curriculum vitae, a research abstract, and any supporting materials no later than October 21, 2015.

Applications will be accepted and considered until November 16, 2015.

*Northwestern University is an Equal Opportunity, Affirmative Action Employer of all protected classes including veterans and individuals with disabilities. Women and minority candidates are encouraged to apply. Hiring is contingent upon eligibility to work in the United States.*



NORTHWESTERN  
UNIVERSITY



QUEEN'S SCHOOL OF BUSINESS (Queen's University, Kingston, Ontario CANADA) invites applications for two tenure-stream positions in Management Science/ Operations Management. Candidates at all levels of experience will be considered. Entry-level candidates must have a PhD or be near completion. Applicants with research interests in all areas of operations management and management science will be welcomed, but we are particularly interested in at least one new faculty member with research interests in applications of online, real time, optimization and analytics. The successful candidate will exhibit potential for outstanding scholarly research and excellent teaching in support of the School's public and private programs and will be expected to make contributions in service to the School, to the University, or the broader community.

The MSOM group is a strong research group with particular expertise in revenue management and pricing, sustainability, energy markets, supply chain management and the interface of operations and marketing. For more information about our faculty see [http://business.queensu.ca/faculty\\_and\\_research/index.php](http://business.queensu.ca/faculty_and_research/index.php).

The University invites applications from all qualified individuals. Queen's is committed to employment equity and diversity in the workplace. All qualified candidates are encouraged to apply; however, in accordance with Canadian Immigration requirements, Canadian citizens and Permanent Residents of Canada will be given priority.

The University will provide support in its recruitment processes to applicants with disabilities, including accommodation that takes into account an applicant's accessibility needs - [klewis@business.queensu.ca](mailto:klewis@business.queensu.ca).

The effective date of the appointment will be July 1st, 2016, but is flexible.

## STANFORD BUSINESS

### STANFORD UNIVERSITY GRADUATE SCHOOL OF BUSINESS

#### Faculty Positions in Operations, Information and Technology

The Operations, Information and Technology (OIT) area at the Graduate School of Business, Stanford University, is seeking qualified applicants for full-time, tenure-track positions, starting September 1, 2016. All ranks and relevant disciplines will be considered. Applicants are considered in all areas of Operations, Information and Technology (OIT) that are broadly defined to include the analytical and empirical study of technological systems, in which technology, people, and markets interact. It thus includes operations, information systems/technology, and management of technology. Applicants are expected to have rigorous training in management science, engineering, computer science, economics, and/or statistical modeling methodologies. The appointed will be expected to do innovative research in the OIT field, to participate in the school's PhD program, and to teach both required and elective courses in the MBA program. Junior applicants should have or expect to complete a PhD by September 1, 2016.

Applicants should submit their applications electronically by visiting the web site <http://www.gsb.stanford.edu/recruiting> and uploading their curriculum vitae, research papers and publications, and teaching evaluations, if applicable, on that site. For an application to be considered complete, all applicants must have three letters of recommendation, CV and job market paper submitted by November 15, 2015. For questions regarding the application process, please send an email to [Faculty\\_Recruiter@gsb.stanford.edu](mailto:Faculty_Recruiter@gsb.stanford.edu).

*Stanford University is an equal opportunity employer and is committed to increasing the diversity of its faculty. It welcomes nominations of and applications from women, members of minority groups, protected veterans and individuals with disabilities, as well as from others who would bring additional dimensions to the university's research, teaching and clinical missions.*

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# The organ tuner's parable

"That should take care of this instrument for a while," the organ tuner smiled.

The OR/MS analyst, who also happened to be the chair of his synagogue's music committee, smiled back with approval. "I can hear the difference," he acknowledged. "I have to tell you, though, that I had a hard time getting the budget committee to approve this tuning, because we're in a bit of a financial crunch and several of them couldn't hear the difference."

"How did you get them to go along?" the tuner asked.

The analyst grinned. "I told them, look, this isn't just aesthetics, it's maintenance. You can pay for a \$300 tuning every year or you can start planning to replace a \$30,000 instrument in about 10 years. That woke them up."

"Nice job," the tuner laughed. "But I'm surprised that even that worked. As you can guess, I have a number of customers who have middle and upper management positions, and I've noticed a common complaint: When finances get tight, often the first items that get cut are maintenance and training. Another organ I've tuned several times is in a church that ended up having to replace the roof because they 'saved' a little money postponing repairs on some storm damage. You'd think more people would understand roofs than organs. But short-term costs seem to outweigh long-term benefits all too often."

"I've seen the training issue, too," the analyst said. "I don't know how many organizations I've worked with that paid big money for computer software packages but then didn't get their people trained in how to use the software. I've even seen a few instances where the training was free, sold as part of the software provider's package, but the buyer wouldn't even let

people have the time to take the training! You can guess what that approach did for productivity."

They shared another laugh.

"Sometimes the consequences go to more than money," the tuner added grimly. "You know about those three fatal crashes in the past few years on our public transit system, right? People tell me the problem was that the board of directors and the sponsoring governmental bodies kept cutting maintenance, especially after the recession clobbered their budgets, until pieces of track started failing. Then there was a big hue and cry, of course, investigations, searches for culprits – but not much change in maintenance funding after that initial burst of activity. I used to love this system, but now I'm nervous enough not to ride it much."

"Yeah, I ride it less too," the analyst concurred. "But another part of that was that they didn't have enough parking available at the big suburban stations. They relied on feeder bus service, but then – surprise, surprise! – they cut the bus service after the rail lines opened. So now they've been building parking garages, but that's another reason they were running short of money for maintenance."

"Penny wise, pound foolish, to quote an old English saying," the tuner commented. "And a lack of systems thinking, which is what you OR/MS people are supposed to be good at, right? Maybe they needed more of that. Or maybe they just needed more people like another guy I've met, the head of security for the system. He's a stereo buff. He was the one who figured out that their multi-million-dollar emergency response system was failing to communicate information and instructions to riders during crises because the announcements were going out through \$50 loudspeakers! He got

them to buy new, better speakers, so now you can often understand the announcements in the stations. Did you notice?"

"I did!" the analyst exclaimed. "I didn't know the story, but I did hear the difference. You've conversed with some interesting people!"

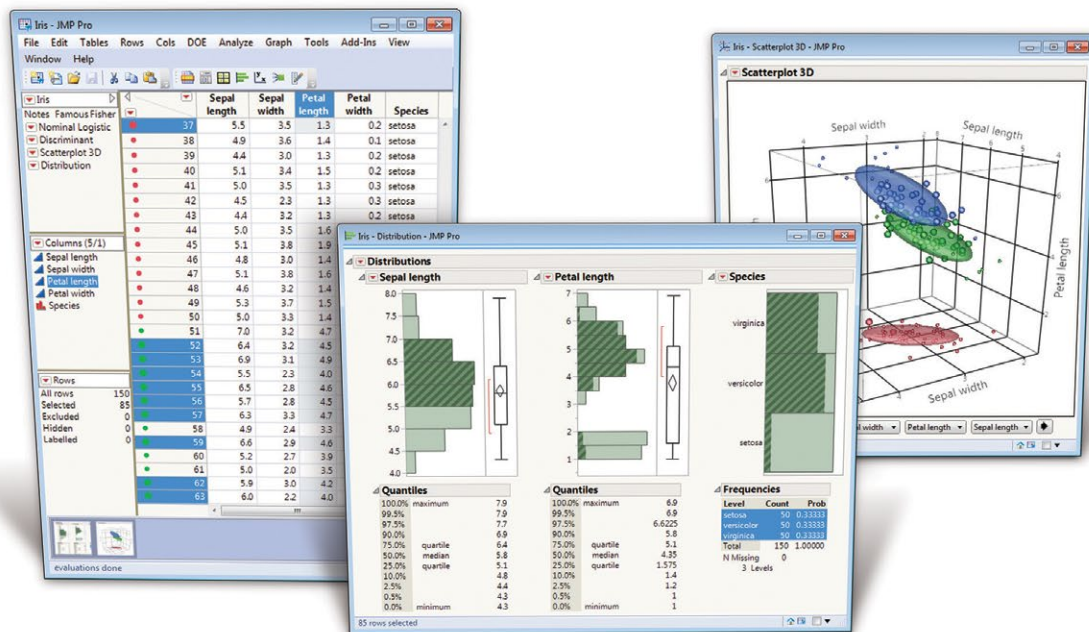
"Now that I'm thinking about it," the tuner said, "there's another story that fits the pattern. One of my customers is a military historian. He's read a lot about the Vietnam War, including Nguyen Cao Ky's book about why we lost. My customer told me that Ky was a conniving politician all the way, whose explanations were not necessarily to be trusted, but he was also a highly regarded fighter pilot and commander.

"And what Ky wrote," the tuner continued, "was that when he and other Vietnamese nationalists were fighting alongside the French against the Communist Viet Minh, they had a few dozen mechanics who could take a propeller fighter engine apart, pull out the spark plugs, file and re-gap them, and get another 50 to 100 flying hours out of that plane. Then the Americans came, with their F-111s, and the Vietnamese asked how to repair those engines. The Americans just laughed and explained: scrap the engine and install another one from the warehouse full of them at Cam Ranh Bay. So when the Americans left, and the steady supply of engines stopped coming in, there wasn't a mechanic in the Republic of Vietnam who could put a fighter back in the air when the engine failed – which F-111 engines did frequently, by the way, since reliability and ease of maintenance weren't major features of their design. How's that for a horror story?"

The analyst looked properly appalled. "That does explain a few things," he nodded. "But people take a long time to learn certain lessons, don't they?" **ORMS**

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**Doug Samuelson** ([samuelsondoug@yahoo.com](mailto:samuelsondoug@yahoo.com)) is president and chief scientist of InfoLogix, Inc., in Annandale, Va., and a senior operations research Analyst with Group W, Inc., in Merrifield and Triangle, Va., supporting the Marine Corps Combat Development Command (MCCDC) and, more recently, U.S. forces in Korea.



# EXPLORE

## Data analysis in flow

Introduced in 1989 with scientists and engineers in mind, JMP® software links powerful statistics to interactive graphics. It keeps data in flow, no matter whether it's small, tall or wide. Because there is a graph for every statistic, you can pursue your analysis without restraint. A sampling of its capabilities:

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- Nonlinear Modeling
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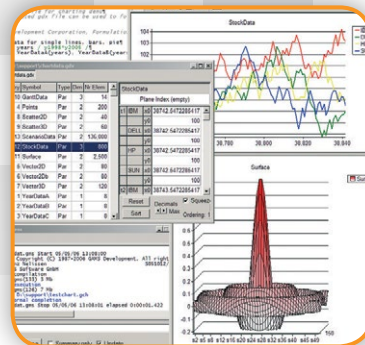
## GENERAL ALGEBRAIC MODELING SYSTEM

### High-Level Modeling

The General Algebraic Modeling System (GAMS) is a high-level modeling system for mathematical programming problems. GAMS is tailored for complex, large-scale modeling applications, and allows you to build large maintainable models that can be adapted quickly to new situations. Models are fully portable from one computer platform to another.

### State-of-the-Art Solvers

GAMS incorporates all major commercial and academic state-of-the-art solution technologies for a broad range of problem types.



GAMS Integrated Developer Environment for editing, debugging, solving models, and viewing data.



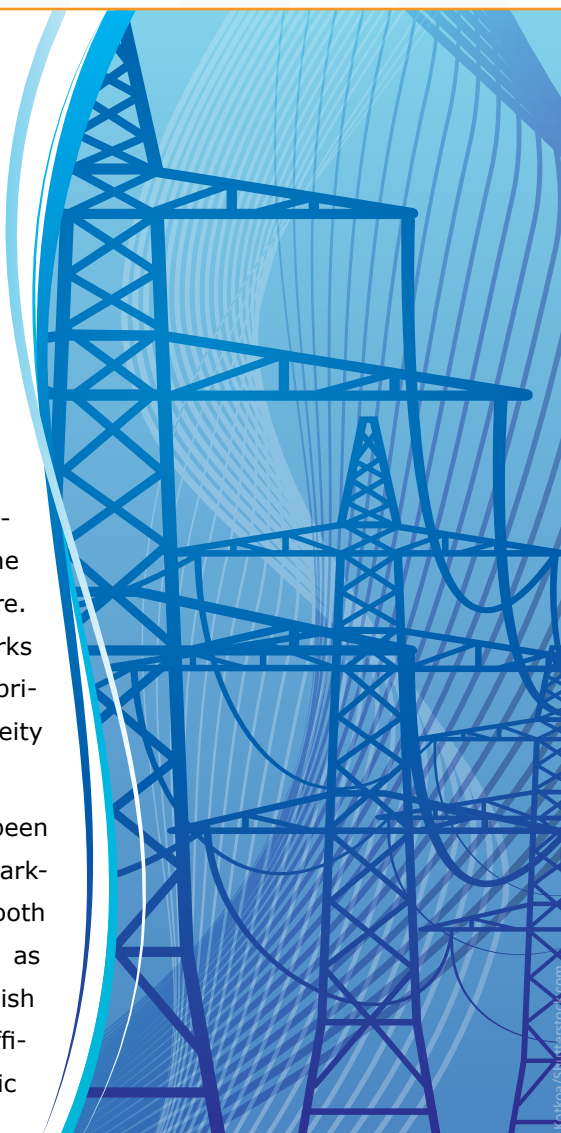
**energiavirasto**

### Efficiency Benchmarking for the Finnish Energy Authority

Companies operating electricity networks are typically situated in a local monopoly market. In order to encourage reasonable electricity prices for the end user, this industry is therefore state-regulated in many countries.

The Finnish Energy Authority (energiavirasto) provides incentives for companies to improve their efficiency while at the same time promoting investment in modern and reliable infrastructure. It establishes general efficiency targets and relies on benchmarks to adequately compare network operators' cost efficiency. A primary benchmarking challenge is to capture the vast heterogeneity of this sector.

For more than 15 years the Finnish Energy Authority has been concerned with developing and improving efficiency benchmarking. Since 2012 the StoNED method (Stochastic Nonsmooth Envelopment of Data) modeled with GAMS has been applied as a benchmarking tool with great success. In GAMS, the Finnish Energy Authority has found a precise, flexible and practical efficiency benchmarking tool that is capable of capturing the specific complexity of the sector.



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