Newsjournal of the Society for Industrial and Applied Mathematics

siam news

Volume 48/ Number 3
April 2015

The Structure and Evolution of the Next-generation Electric Grid

By John Guckenheimer

The electric power grid is a quintessential complex system, one whose complexity continues to grow. This article briefly describes the structure and evolution of the grid, a few of the recent ongoing changes, and some of the problems described at a workshop sponsored by the National Academies Committee on Analytic Foundations of the Next Generation Electric Grid (see sidebar on page 8), in Irvine, California, February 11–13, 2015.*

■■■

The first electric power plant in the U.S. began operation in 1882. During the first half of the 20th century, the industry grew to serve the entire country and became a regulated monopoly. The grid emerged with the construction of transmission lines that could deliver power from one utility to others. Low-cost power from, for example, hydroelectric plants could be transmitted over long distances, and by connecting customers to multiple generators, the lines also provided greater reliability. During the 1950s and 60s, the amount of electricity produced and consumed in the U.S. increased by approximately 3% annually. That growth slowed during the energy crisis of the 1970s.

Until the 1990s, the industry was regulated on a state-by-state basis, with rates set to give utilities reasonable profits. To create greater flexibility through electricity markets and to stimulate technical innovation, which had stagnated, the industry was then restructured. In much of the country, entities called "regional transmission organizations" (RTOs) or "independent service operators" (ISOs) were created to establish wholesale markets and assume responsibility for the reliability of the grid. This brought a new level of complexity to the industry. Power shortages in California during the summer of 2000 led to extreme price fluctuations; the problems in California called attention to the need for careful regulation of the wholesale electric markets to protect the interests of consumers.

Electricity is an unusual commodity because it cannot be stored readily. Viewed as an enormous electric circuit, the grid obeys Kirchoff's laws for voltage and current in the system. It has been operated with

See **Electric Grid** *on page 8*

* https://vimeo.com/album/3275353

I. Edward Block, 1924–2015

Ed Block, who put his vision, talent, and drive to work for SIAM from the early 1950s through his retirement as managing director in 1994, died on February 18.

An obituary appears on pages 2 and 3.

Protecting an Ecosystem as Ocean Levels Rise: MPE in Action

By Hans Kaper

Our planet is being stressed. For some 150 years, we have run an uncontrolled experiment, assuming (wrongly) that our resources are infinite and that nature will adjust to our needs and desires. As a result, our climate is changing, ocean levels are rising, and the impact of natural disasters has been increasing. As mathematical and computational scientists, we should be concerned: We have a responsibility. The only tools available for studying future scenarios are mathematical models and computational experiments; large-scale controlled experiments are essentially impossible, and there is no planet B. The newly formed SIAM Activity Group on Mathematics of Planet Earth (see announcement on page 4) is SIAM's forum for discussions of mathematical and computational issues of climate, sustainability, ecology, socioeconomic systems, and the environment.[1]

In this article I give an example of MPE in action. The example comes from my native country, the Netherlands, and makes an excellent case for the importance of MPE. (I have not been involved in the research; the topic was suggested by an article in the June 2014 issue of the *Nieuw Archief voor Wiskunde*, published by the Netherlands Mathematical Society [1]. I thank the authors for permission to use their results.)

Flood Control in the Netherlands

Flood control is an important issue for the Netherlands—about two thirds of its area is vulnerable to flooding, and it is among the most densely populated countries in the world. Natural sand dunes and human-made dikes, dams, and floodgates provide defense against storm surges from the sea. River dikes prevent flooding from the major Rhine and Meuse Rivers, while a complicated system of drainage ditches, canals, and pumping stations (historically, windmills) keep the low-lying parts dry for habitation and agriculture.[2]

The current sea defenses are stronger than ever, but in 2008 a government committee reported that an expected sea level rise of 65 to 130 cm by the year 2100 might make further upgrades to the flood control and water management infrastructure necessary.

The first of the committee's 12 recommendations[3] was that the present flood-protection levels of all diked areas be improved by a factor of 10. The national government requested a cost–benefits analysis, which would find an optimal balance between investment costs and the benefits of reduced flood damages. The researchers who took on the task developed an optimization model, generalizing a model produced in the 1950s by Van Dantzig after a catastrophic flood in 1953 [3].

The project, which is estimated to yield savings of €7.8 billion, received the prestigious international Franz Edelman Award[4] in 2013. What follows is a brief overview of the research; details can be found in technical papers by project participants [2, 4].

Model Formulation

Flood-protection levels have been defined for each of 95 flood-prone areas in the Netherlands. These areas, which are referred to as "dike-ring areas," are protected from flooding by a ring of contiguous segments. A ring can have up to ten segments, which can be a mix of dunes, dikes, and human-made structures; each segment has different characteristics with respect to investment costs, flood probabilities, water level rise, etc. Figure 1 shows some of the main dike-ring areas with their flood-protection standards. Not all segments need

See **Flood Protection** *on page 4*

Figure 1. *Dike-ring areas in the Netherlands, color-coded according to flood protection standards. From Klijn, van Buuren, and van Rooij (2004) / Rijkswaterstaat [7].*

Nonprofit Org
U.S. Postage
PAID
Permit No 360
Bellmawr, NJ

SOCIETY for INDUSTRIAL and APPLIED MATHEMATICS
3600 Market Street, 6th Floor
Philadelphia, PA 19104-2688 USA

siam news
Volume 48/ Number 3/ April 2015

Obituaries

I. Edward Block, a founder and long-time managing director of SIAM, died on February 18 at the age of 90. From 1952, when SIAM was officially incorporated, through 1976, the beginning of his full-time employment at SIAM, until his retirement in the fall of 1994, Ed had a hand in every aspect of every step of SIAM's development and growing presence in the international mathematical sciences community. It was no accident that he chose the title "managing director."

Ed graduated from Haverford College in 1944 with a bachelor's degree in physics. He was then inducted into the Navy and immediately assigned to the Naval Research Lab, where he spent just slightly more than a year (1944–45) as part of the mathematics group, "building and testing electronic circuits for radar anti-jam."* In 1946 he entered Harvard as a PhD student, still in physics. He continued to be drawn to mathematics, however, under the influence of several people at Harvard, including Garrett Birkhoff (who would become SIAM president in 1967–68). Looking back, Ed explained, "The use of mathematics in solving real-world problems . . . and I might add computers to that when they became useful in solving real-world problems, is really the theme of an awful lot of what I did."

In a sense, SIAM emerged from a mistake—in a lemma in Ed's original, almost complete Harvard dissertation. Deeming the problem unfixable, he abandoned the topic and began a completely different dissertation, this time in singular integrals, under the supervision of Joseph Walsh. Having accepted an instructorship at the University of Michigan contingent on completion of his PhD, Ed was reluctant to take up the post before the (second) dissertation was absolutely complete. (This part of the story will surprise no one who knew him.) By 1952, when he received the degree, thoughts of an academic career had dissipated and Ed embarked on a series of jobs in industry, always in the Philadelphia area.

As a mathematical analyst (1951–54) at Philco Corporation, a radio and television company, Ed missed the congenial ambiance of graduate school, in particular the Thursday afternoon colloquium. It wasn't long before—in Atlantic City, at a meeting of the American Institute of Electrical Engineers on servo mechanisms—he had the idea that Philadelphia needed an industrial mathematics society. Realization of the idea took the form of a series of evening lectures, held in the Picture Gallery of nearby Drexel Institute of Technology. The first speaker, in March 1952, was W.F.G. Swann, a physicist from the University of Pennsylvania ("Mathematics, the Backbone of Science"); he was followed in April by Mina Rees of the Office of Naval Research ("The Role of Mathematics in Government Research") and, in May, William E. Bradley, Jr., co-director of research at Philco ("Is it Mathematics?").

Lt. I. Edward Block, U.S. Navy.

Philco and Drexel were among the early supporters of the activities of Ed and his colleagues—Drexel with meeting and, later, office space, Philco with funding as well as some of its energetic employee's time. Bradley, the first president of SIAM (1952), resigned (to Ed in an often recounted story, in a parking lot), after a very short time in office; Philco had drawn the line, requiring that Bradley spend more time on company business. Ed's parents, too, were early supporters, recruited to help stuff envelopes.

Ed moved on to Burroughs (1954–59), where he ran the Computer Center, and, in 1959, to Univac, where he eventually became manager of the Applied Math group before leaving in 1964. His work at Burroughs called on his technical skills, as well as on his growing "other side"—management and the selling of jobs to customers. "The challenging part about it was delivering what I promised," he said of the latter. "The kick that I got out of all of this was that I was doing something for an engineer, and I got a special delight out of seeing the reaction of the engineer when he saw how he could use the mathematics and the computer to solve a problem." He added (on a note that will not be necessary for many readers), "That's consistent with SIAM, by the way."

As a member of the SIAM Council, Harold Kuhn (who would become SIAM president in 1954–55) urged Ed and his colleagues to think nationally. Ed credited Kuhn not only for arranging SIAM's participation in the 1954 joint AMS–MAA meeting, held in Pittsburgh, but also for having SIAM mentioned in a local newspaper—Kuhn had spoken to reporters on the importance of mathematics in solving industrial problems, and on the role of SIAM in promoting the mathematical methods.

Providing a backdrop for many of these early activities was the ENIAC, completed at the University of Pennsylvania's Moore School of Electrical Engineering in 1946, too late for use in World War II, but a source of fascination for many in the area, including Ed. J. Presper Eckert and John Mauchly, the main designers of the ENIAC, formed

See **Ed Block** *on page 3*

*Quotes in this piece are from the unedited transcript of an interview of I. Edward Block conducted by Thomas Haigh in Laverock, Pennsylvania, July 26 and 27, 2005. SIAM will post an edited version of the transcript when it becomes available.

A SIAM President Remembers I.E. Block

As the host society for ICIAM 1991, held in Washington, DC, SIAM faced countless organizational challenges. Ed Block and Bob O'Malley made headway on some of them during a working session at the 1990 SIAM Annual Meeting.

I was very involved with SIAM, and its meetings, publications, and promotion of applied mathematics, from my earliest postdoctoral appointment in 1966 through serving as president in 1990–91. SIAM had great leaders, including presidents Dick DiPrima (1979–80), Hirsh Cohen (1983–84), Ivar Stakgold (1989–90), and Avner Friedman (1993–94), among many others, before and since. But it was Ed Block who year after year worked harder than anyone else developing an unending sequence of journals, meetings, book series, activity groups, and international collaborations.

Ed had a Harvard PhD, experience with early computer manufacturers, and the drive to do everything well. He served as SIAM's managing director, unofficially and officially, for forty years. One consequence is that our applied math society remains based in Philadelphia. The organization grew and prospered, along with applied mathematics in universities and industry. Ed developed a large dedicated staff, drew lots of talented members to the Council and Board, and drove increasing interactions with Washington and other professional societies in the math sciences and beyond.

My most intense joint effort with Ed concerned the second ICIAM meeting, held in Washington, DC, in 1991. As the program chair, I made many trips to Philadelphia to do detailed planning. I often stayed at Ed's home, and we would use Entertainment coupons to cut meal costs in half. The meeting was a big success scientifically, twice the size of any SIAM annual meeting. As usual, Ed took the pictures, scheduled meetings with all those who could provide input regarding his latest ideas for projects, and knew who hadn't paid the registration fee. By this time, he could no longer proofread all the individual journal articles, but he still got involved in planning and writing for the next issue of *SIAM News*.

Ed's family has suggested that memorial contributions be made to SIAM to endow the I.E. Block Community Lecture. They knew how much this would mean to him.—*Robert E. O'Malley, Jr., Professor Emeritus, Department of Applied Mathematics, University of Washington.*

siam news

ISSN 1557–9573.

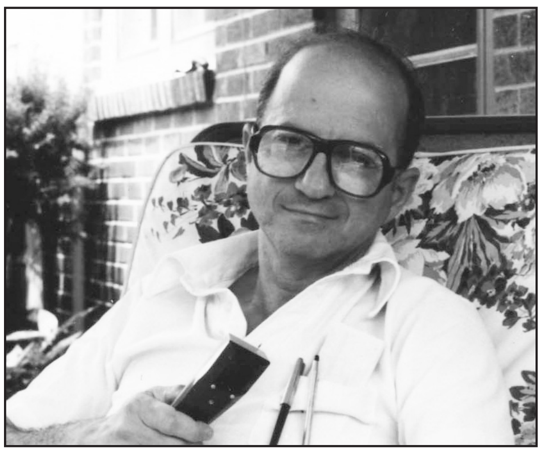
Ed Block

continued from page 2

the Eckert–Mauchly Corporation in 1946. Ed often reminisced about the writing of the SIAM bylaws at the Eckert–Mauchly division of Remington Rand Univac; those familiar with the early history of SIAM will know that Mauchly was the fourth SIAM president (1955–56).

Even in those very early days, Ed was convinced of the need for a journal and a newsletter: "I felt that it was important to have something in print that would reflect the society that we were talking about . . . just to give this thing presence. . . . If you have some hard copy and it's publicly available, . . . then it makes the thing stick. . . . I might add that that whole idea prevailed through all of my years at SIAM."

Ed had, and vigorously put forward, ideas about the proper subject matter for SIAM.



Ed relaxing on the back porch. Photo courtesy of the Block family.

Following the early lectures, the group ventured into computing issues, with "a smattering of operations research, a smattering of stuff in electrical engineering, a little physics here and there." Had it continued along those lines, he believed, the society would not have survived: The focus needed to be shifted to mathematics, without bringing it under the umbrella of the American Mathematical Society, which he characterized as being about "pure mathematics and very academic."

The first issue of the *Journal of the Society for Industrial and Applied Mathematics* was published in September 1953, with four papers, including "Automatic Digital Computers in Industrial Research," the first in a series. As acting managing editor of the journal—which for nine years was SIAM's only journal—Ed solicited papers, chased down authors who were slow to fulfill their promises, and on at least one occasion transcribed an author's spoken word to print; he also found a printer, whose activities he oversaw, along with publicity and distribution. All the while, he had his eye on the big picture, and as he recounted in the oral history interview, the process of spinning off more specialized journals (beginning with *Series A: Control* in 1962 and *Series B: Numerical Analysis* in 1964) was not completely smooth.

A 1957 conference on matrix computation, held at Wayne State University, marked a turning point for the SIAM journal, Ed said. As agreed beforehand, Don Thomsen (SIAM president, 1958–59) made an announcement inviting speakers to submit their papers to the journal. The stream of submissions that ensued, Ed recalled, turned "a catch-as-catch-can journal for papers that we could scrounge from people" into an established journal. "And it turned the SIAM journal's orientation toward numerical computation and numerical analysis."

The impact of that solicitation was felt for several years. Meanwhile, Alston Householder (SIAM president, 1963–64) approached Ed for help with the administration of the second Gatlinburg Symposium. Householder and the other organizers of the invitation-only symposia on numerical linear algebra would review and arrange for refereeing of the papers, which would get SIAM's new numerical analysis journal off to a good start. (After Gatlinburg IV, the symposium moved to other locations and was held every three years; SIAM continued to provide administrative support. After Gatlinburg X, the series was renamed the Householder Symposia on Numerical Linear Algebra.)

It may be that every publisher has stories of gems that got away. For Ed, a prime example was *Mathematical Tables and Aids to Computation*, "a relatively practical numerical analysis journal" supported by the Navy, which was looking to turn it over to another organization. Phil Davis, a friend of Ed's from graduate school, then at the National Bureau of Standards, introduced him to the editor of the journal, and Ed was enthusiastic about the offer to make it a SIAM publication. But SIAM by that time had a Board of Trustees and Council, and a role for computing in an applied mathematics society wasn't seen by all as a natural fit. In the end, the Council voted it down; today, known as *Mathematics of Computation* (MOC), the journal is published by the AMS.

In a related story with a happier theme, Phil Davis had gotten a paper by Milton Abramowitz and Irene Stegun, "Pitfalls in Computation," for the December 1956 issue of the SIAM journal. Ed, who as always handled practical details, phoned Abramowitz (he and Stegun were both at NBS) to find out how many reprints they would like. Taken aback by Abramowitz's request for 1000, Ed was even more surprised to receive a request for another 1000 a month later, and yet another 1000 some months later. "If you know the math community," Ed commented, "some authors get two or three requests for a reprint. . . . And remember, this was numerical analysis," and the SIAM Council had said no to the computation journal.

SIAM published the first issue of *SIAM Review* in 1959. Other new journals appeared at irregular intervals during Ed's tenure, including the *SIAM Journals on Applied Mathematics* (1966), *Mathematical Analysis* (1970), *Computing* (1972), and *Scientific and Statistical Computing* (1980). *SIAM Journal on Algebraic and Discrete Methods*, which also appeared in 1980, would be divided into *Matrix Analysis and Applications* and *Discrete Mathematics* in 1988. *SIAM Journal on Optimization* was introduced in 1991. The SISSC and SIMAX startups featured frequent interactions with Gene Golub, the founding editor of both (and SIAM president in 1985–86).

An earlier (mid-50s) journal project initiated by Ed and Brockway McMillan (SIAM president, 1959–60) was an English translation of the Russian probability journal *Teoriya Veroyatnostei i ee Primeneniya*. "It was a way of doing something in probability and statistics," Ed said. "But it was highly theoretical . . . and maybe that's why we had problems trying to make something more happen."

The development of Ed's publishing skills and instincts can be traced to his years in the computer industry in Philadelphia; he honed those skills during the 12 years he spent at the Auerbach Corporation, a technical publishing company in the Philadelphia area. Ed was drawn to the company's loose-leaf reports, and he defined several additional products that the company could publish—in data communications, software, hardware, and office equipment. He took to Auerbach his experience in getting the SIAM journals to the point that they ran smoothly, each with enough appropriate submissions to keep it from the edge of extinction. What he learned at Auerbach, in turn, fed back into SIAM's publication programs. Auerbach was Ed's last "day job"—when he left, in 1976, it was to accept the full-time, paid position of managing director of SIAM.

As for everything SIAM undertook, Ed had strong opinions about a book program for SIAM. Books would give members another outlet for publishing their work, but Ed also believed that publishing and advertising books "would spread SIAM around the world, and for me that was a very important thing to do."

Ed Block and SIAM director of finance Bob Bellace, who had been colleagues at Auerbach, listened to a talk at the SIAM 50th Anniversary and 2002 Annual Meeting in Philadelphia. Photo by Lois Sellers.

Ed relished telling the story of the acquisition of the *LINPACK Users' Guide*, by Jack Dongarra, J.R. Bunch, Cleve Moler, and G.W. Stewart, first published in 1979. It was Cleve Moler (a member of the SINUM editorial board and, in 2007–08, SIAM president) who sold Ed on the idea during a SIAM meeting in Madison, Wisconsin. "We walked out to the shore of the lake that borders the meeting hall," Ed recalled, "and sat on a stone wall with our feet dangling over the edge of the water for a very pleasant hour or so chat about these ideas." The book would be a manual of matrix algebra of all kinds, and with the *SIAM Journals on Numerical Analysis* and on *Computing*, Ed reasoned, SIAM had a framework for selling a book on the topic. "We sold something like 9,000 or 10,000 copies in the first year," Ed said, estimating that sales reached 15,000 before a second edition was published. "So that really established SIAM as the society for mathematics and computing."

Everything SIAM did came in for lengthy discussions, thorough planning and prediction of the outcomes. This applied to sections and chapters of SIAM, to SIAM Activity Groups (the earliest, the SIAM Activity Group on Linear Algebra, was established in 1982), to the Visiting Lecturer Program, and to the SIAM prizes.

For Ed the launching of a prize was about as difficult as the launching of a new journal. The John von Neumann Lecture, which Ed remembered as conceived in 1959 in the lobby of the New Yorker Hotel, was SIAM's first prize and is considered the most prestigious SIAM prize today. Present with Ed at its creation were four SIAM presidents: Donald Thomsen, Brockway McMillan, F.J. Weyl (1960–61), and Alston Householder. Discussion and definition of the lecture and the attached honorarium happened rapidly, and Lars Ahlfors, one of Ed's professors at Harvard, gave the first John von Neumann Lecture in 1960.

Over the years, SIAM became a visible presence internationally. Cooperation with societies in other countries led to highly active participation in ICIAM 1987, in Paris, and especially in ICIAM 91, in Washington, DC, as recalled by Bob O'Malley in the accompanying piece.

Asked at the end of the oral history interview about the contribution of which he was most proud, Ed was at his most concise: "SIAM," he said. "That's all I can point to. It's as simple as that."

Not quite: For 25 years, Ed held a series of jobs and, in parallel, spent vast amounts of time as a SIAM volunteer, followed by 18 years as a SIAM employee. Through those years, he was a proud and devoted husband, father, and grandfather. His wife, Marline, died in 2013; Ed is survived by their children, Nancy, Kathie, and Steve, and eight grandchildren.—*GRC*

Kelvin's Circulation Theorem and an Isoperimetric Inequality

MATHEMATICAL CURIOSITIES
By Mark Levi

Kelvin's theorem in two dimensions states that the vorticity (the curl of the velocity field) in an inviscid incompressible fluid is transported by the fluid—that is, it remains constant along the trajectories of the fluid particles. The following intuitive explanation, I think, shows what's really going on.

We begin by dyeing a small circular disk of fluid at $t = 0$, as shown in Figure 1. The surrounding fluid applies torque $\tau = 0$ to our disk (relative to the disk's center); this is so because the tangential component of the force on the boundary is zero for the inviscid fluid, by the definition of viscosity. For the angular momentum L of the blob (computed relative to the blob's center), we have:

$$dL/dt = \tau = 0 \text{ at } t = 0. \qquad (1)$$

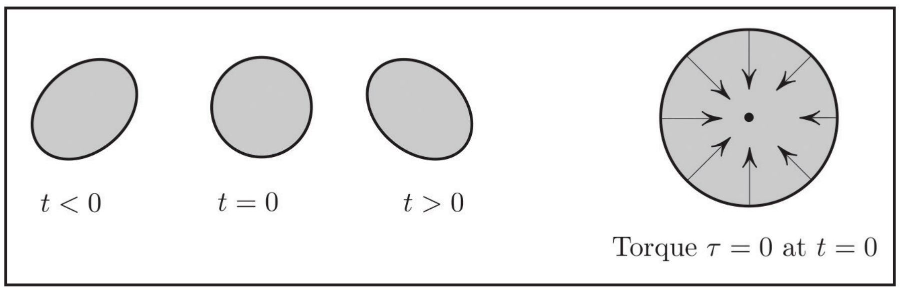


Figure 1. *Kelvin's theorem by (instantaneous) conservation of angular momentum.*

The vorticity $\omega = 2\Omega$ is twice the average angular velocity Ω of the radii of the disk; (1) thus becomes

$$d/dt(I\Omega) = \dot{I}\,\Omega + I\,\dot{\Omega} = 0 \text{ for } t = 0,$$

where I is the moment of inertia of the blob. But $\dot{I}(0) = 0$, as the circular disk minimizes the moment of inertia among all other shapes of the same area (here we use the incompressibility). We conclude that $\dot{\Omega} = 0$ and thus $\dot{\omega} = 0$.

In summary, Kelvin's 2D theorem boils down to two facts:

- zero torque from the surrounding fluid on a round disk, and
- the isoperimetric inequality:

$$\int_{x^2+y^2\le r^2} (x^2+y^2)\,dxdy \le \int_D (x^2+y^2)\,dxdy$$

valid for all domains D of area πr^2. Standard analytical proofs rely on vector identities and tend to obscure this intuition.

An interesting and non-trivial exercise is to extend this approach to the proof of the 3D version of Kelvin's theorem (according to which vorticity stretches with the fluid, i.e., satisfies the linearized equation).

Mark Levi (levi@math.psu.edu) is a professor of mathematics at the Pennsylvania State University. *The work from which these columns are drawn is funded by NSF grant DMS-1412542.*

Flood Protection

continued from page 1

to be raised by the same amount, or at the same time; the decision problem concerns the question of when and how much to invest in each individual segment. The objective is to find an investment plan that minimizes the total expected costs for a given finite planning horizon $[0, T)$.

The number of segments in a ring is denoted by L. The height of a segment can be changed only at discrete times t_k and must remain unchanged during the subinterval $(t_k, t_k + 1)$, where $0 = t_0 < t_1 < \cdots < t_K < T$; it also does not change beyond the planning horizon. An investment plan is an ordered pair $(\mathbf{U}, \mathbf{t})$, where $\mathbf{U}$ is a matrix whose (positive) entries u_{lk} correspond to the increase in height of segment l at time t_k, and $\mathbf{t}$ is a vector $(t_0, \ldots\ t_K)^T$. The objective is to find an investment plan that minimizes the sum of the investment costs and the expected damage costs,

$$\text{minimize } \mathcal{I}(\mathbf{U}, \mathbf{t}) + \mathcal{E}(\mathbf{U}, \mathbf{t}) + \mathcal{R}(\mathbf{U}, \mathbf{t}). \quad (1)$$

Here, $\mathcal{I}$ represents the total discounted investment cost within the planning horizon $[0, T)$; $\mathcal{E}$, the total expected damage in the same planning horizon; and $\mathcal{R}$, the total damage after the planning horizon.

Numerical Results

The solutions of the nonlinear optimization problem (1) can be found numerically (after some approximations) for dike rings with modest numbers of segments. Figure 2 shows the cumulative height increases for a six-segment ring during a 300-year planning horizon; Figure 3 shows the resulting segment flood probabilities. These numerical results were obtained with realistic parameter values from Deltares,[5] an independent institute in the Netherlands for applied research on water, subsurface, and infrastructure. Notice that at $t = 20$ the height of segments 2, 3, 4, and 6 is increased, while segments 1 and 5 remain unchanged. Figure 3 shows why it is not necessary to increase the height of these two segments: Their flood probabilities are still very low compared to the other segments. Figure 3 also shows that simultaneously increasing the height of all segments is not necessary but generally leads to good or even optimal results.

Practical Impact

The solution to the optimization problem (1) has been used to construct flood-protection standards [5, 6]. Increasing the legal protection standards of all dike-ring areas tenfold, as recommended in 2008, was found to be unnecessary. The current protection standards are (more than) adequate, except for three specific regions that the optimizers identified. For these three regions, new standards have been developed and endorsed by parliament.[6]

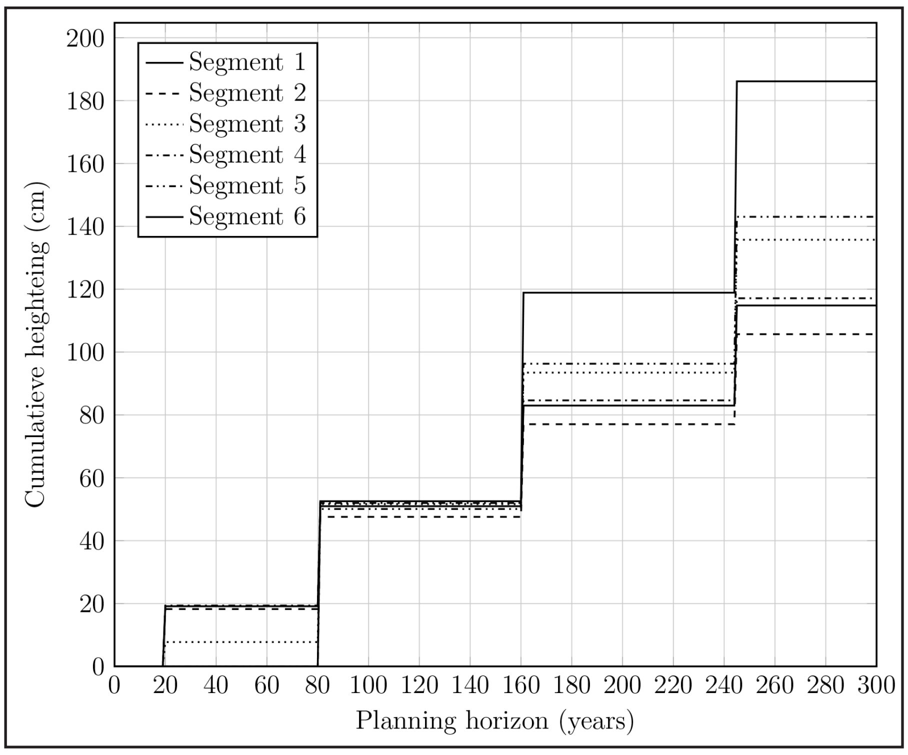


Figure 2. *Cumulative height increases of dike segments in a six-segment ring. From Figure 1 in [1].*

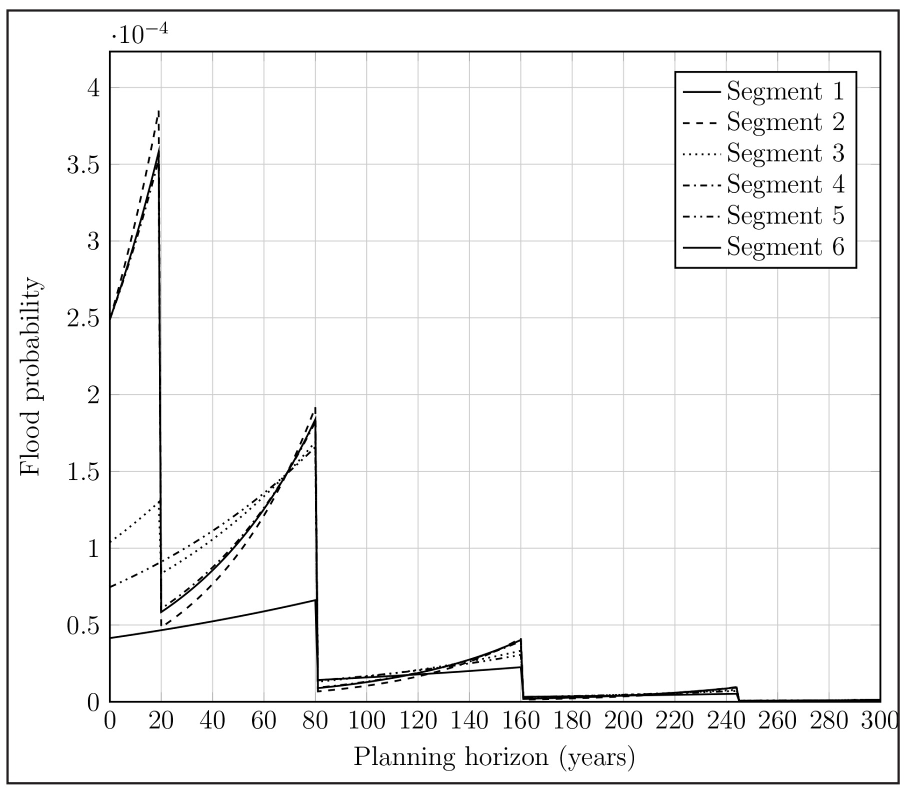


Figure 3. *Flood probabilities for the six segments of the ring from Figure 2. From Figure 2 in [1].*

References

[1] R.C.M. Brekelmans, C.J.J. Eijgenraam, D. den Hertog, and C. Roos, *A mixed integer non-linear optimization approach to optimize dike heights in the Netherlands*, Nieuw Archief voor Wiskunde, Series V, 15 (2014), 113–118.

[2] R.C.M. Brekelmans, D. den Hertog, C. Roos, and C.J.J. Eijgenraam, *Safe dike heights at minimal costs: The non-homogeneous case*, Oper. Res., 60 (2012), 1342–1355.

[3] D. van Dantzig, *Economic decision problems for flood prevention*, Econometrica, 24 (1956), 276–287.

[4] C.J.J. Eijgenraam, R.C.M. Brekelmans, D. den Hertog, and C. Roos, *Flood prevention by optimal dike heightening*, submitted for publication, 2014.

[5] C.J.J. Eijgenraam, J. Kind, C. Bak, R.C.M. Brekelmans, D. den Hertog, M. Duits, C. Roos, P.J. Vermeer, and W. Kuijken, *Economically efficient standards to protect the Netherlands against flooding*, Interfaces, 44 (2014), 7–21; http://pubsonline.informs.org/doi/abs/10.1287/inte.2013.0721.

[6] J.M. Kind, *Economically efficient flood protection standards for the Netherlands*, J. Flood Risk Management, 7 (2014), 103–117; doi:10.1111/jfr3.12026.

[7] F. Klijn, M. van Buuren, and S.A.M. van Rooij, *Flood-risk management strategies for an uncertain future: Living with Rhine River floods in The Netherlands?* AMBIO, 33:3 (2004), 141–147.

Notes

[1] SIAM Activity Group on Mathematics of Planet Earth (SIAG/MPE); http://www.siam.org/activity/mpe/.

[2] Wikipedia, *Flood control in the Netherlands*; http://en.wikipedia.org/wiki/Flood_control_in_the_Netherlands.

[3] Deltacommissie, (2008); http://www.deltacommissie.com/en/advies.

[4] Franz Edelman Award for Achievement in Operations Research and the Management Sciences; https://www.informs.org/Recognize-Excellence/Franz-Edelman-Award.

[5] Deltares; http://www.deltares.nl/en.

[6] Delta Commissioner, Delta Programma 2015—Werk aan de delta (in Dutch, 2014); http://www.deltacommissaris.nl/deltaprogramma/publicaties/.

Hans Kaper, founding chair of SIAG/MPE and editor-in-chief of SIAM News, *is an adjunct professor of mathematics at Georgetown University.*

SIAG/MPE Now Accepting Members

The SIAM Council and Board of Trustees have approved the SIAM Activity Group on Mathematics of Planet Earth. SIAG/MPE (http://www.siam.org/activity/mpe/) will focus on planet Earth, its life-supporting capacity, and the impact of human activities on it. It will provide a forum for discussions of mathematical and computational issues of climate, sustainability, ecology, socio-economic systems, and the environment. Activities will include a biennial SIAM Conference on Mathematics of Planet Earth (with the first to take place in the fall of 2016), and minisymposia at SIAM Annual Meetings and other conferences.

SIAM members can join online (https://my-helper.siam.org/forms/join_siag.htm) or by phone (+1-215-382-9800). Members who are renewing for 2015 can join the SIAG when they renew online. Reminder: Up to two activity groups are free for student members, and the cost of each additional SIAG membership is $10.

NSF's Big Data Initiative: Opportunities for Applied and Computational Mathematics

By Michael Vogelius, Xiaoming Huo, and Nandini Kannan

The Big Data paradigm has emerged as a result of the vast amounts of data that are becoming available across science, business, and government. Realizing the potential of big data will require fundamentally new techniques and technologies to handle the complexity, size, and rate of generation of these data. Principled, innovative approaches are needed to address the challenges associated with the management, modeling, and analysis of such unprecedented amounts of data, including automation of aspects of the data-enabled discovery processes, development of new computational, mathematical, and statistical methods for data analysis, and creation of novel visualization techniques for drawing insights from data.

The National Science Foundation has released a revised version of the solicitation "Critical Techniques and Technologies for Advancing Foundations and Applications of Big Data Science & Engineering (BIGDATA)." All the NSF Directorates, including the Directorate of Mathematical and Physical Sciences (MPS), are participating in this crosscutting initiative. Xiaoming Huo and Nandini Kannan from the Division of Mathematical Sciences are among the cognizant program officers.

This solicitation should be of particular interest to the applied and computational mathematics communities, with its emphasis on both fundamental theoretical and methodological issues related to big data, as well as the development of algorithms, tools, and techniques for the analysis of big data from different application domains.

The BIGDATA program invites proposals in two categories:

> "*Foundations* (F): those that focus on the development of novel techniques, or novel theoretical analysis (including statistics and probability) or experimental evaluation of techniques, that are broadly applicable; and
>
> *Innovative Applications* (IA): those that focus on the development of innovative techniques, methodologies, and technologies for specific application areas or innovative adaptations of existing techniques, methodologies and technologies to new application areas."

Potential research areas and challenges in big data include:

- Reproducibility, replicability, and uncertainty quantification
- Data confidentiality, privacy, and security issues as they relate to big data
- Generating hypotheses, explanations, and models from data
- Prioritizing, testing, scoring, and validating hypotheses
- Interactive data visualization techniques
- Scalable machine learning, statistical inference, and data mining
- Eliciting causal relations from observations and experiments
- Addressing foundational mathematical and statistical principles at the core of the new BIGDATA technologies

The applied and computational mathematics communities have played a major role in this area, and we hope that researchers from the community will take advantage of this new opportunity. The program page http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504767 provides a link to the solicitation, the list of program officers representing the different directorates, and a link to recent awards made through this program. The solicitation provides information on proposal preparation and submission, review criteria, and required supplementary documentation. The deadline for submission of BIGDATA proposals is May 20, 2015.

Readers who are interested in serving as reviewers for proposals or who would like additional information are encouraged to contact Xiaoming Huo (xhuo@nsf.gov) or Nandini Kannan (nakannan@nsf.gov).

Michael Vogelius is director of National Science Foundation's Division of Mathematical Sciences; Xiaoming Huo and Nandini Kannan are program directors in DMS.

Maria Klawe's Mighty Blow for Women

By Paul Davis

Few technological types missed the story of long-time SIAM member Maria Klawe's pushback while interviewing Microsoft CEO Satya Nadella last October at the Grace Hopper Celebration of Women in Computing. In response to Klawe's query about women seeking raises, he replied, "It's not really about asking for the raise, but knowing and having faith that the system will actually give you the right raises as you go along. . . . That, I think, might be one of the additional superpowers that, quite frankly, women who don't ask for a raise have. Because that's good karma." To applause from the audience, Klawe parried, "This is one of the very few things I disagree with you on."[1]

Satya Nadella and Maria Klawe at the Grace Hopper Celebration of Women in Computing. Photo courtesy of the Anita Borg Institute.

This confrontation didn't seem to be a case of Davida besting Goliath or of telling truth to power. Although Harvey Mudd College, of which Klawe is president, and Microsoft Corporation are obviously quite different, Klawe and Nadella are both very, very good at what they do, are well respected among their peers, and evidently think well of one another (Klawe, for example, is a member of Microsoft's board of directors).

Peers like these two could speak frankly and publicly to one another, especially in a setting like the Hopper conference. Nonetheless, most of the cheers from the sidelines after the encounter seemed to be for Klawe, despite Nadella's speedy, public backpedalling from his karma comment before the day had ended.

Had Klawe struck a mighty blow for women? She has written of her own failure to ask for a higher salary when negotiating to become dean of engineering at Princeton. Presumably taking a different tack, another female scientist, Rensselaer president Shirley Jackson, is reported to be the highest paid American university president by a wide margin. One suspects that her status was hardly a consequence of karma alone, even at its most forceful.

In a news interview following the Hopper conference, Klawe offered her own sympathetic interpretation of Nadella's comments. After observing that they had been nearing the end of the 50-minute interview, she said, "He is such an amazing leader. He is very passionate about supporting women in tech careers. He had answered every other question and gotten applause and cheers from the audience. . . . Then I asked him that question and he gave that answer . . . I wanted to politely disagree because I . . . know it's very important for leaders to expose their own failings—and I have lots of them!" She went on to recount her failed salary negotiations at Princeton.[2] Was she pulling her own punches?

No. In fact, the boxing metaphor fails because the main event is not this notorious encounter. It is her entire career of encouraging women to enter and succeed in STEM fields, efforts that are mirrored in the work of other distinguished members of the SIAM community—for example, Richard Tapia—with other underrepresented groups.

Why is such encouragement needed? For us data-driven types in STEM fields—and even for those working in less obviously quantitative fields, such as classics and philosophy—the connections between expectations in our disciplines and underrepresentation were explored in a recent paper in *Science* (S.-J. Leslie, A. Cimpian, M. Meyer, and E. Freeland, "Expectations of brilliance underlie gender distributions across academic disciplines," January 16, 2015, 347 (6219), 262–265).[3] The authors' bottom line is that belief in field-specific innate ability ("expectations of brilliance" in the paper's title) among those who control the gates of graduate study and employment, as well as among those who seek entrance, is closely correlated with participation rates by gender and race. Men are well represented in fields in which innate ability is deemed important (e.g., mathematics and related fields), women in those in which effort is highly valued.

In an editorial accompanying that article, Andrew Penner suggested, "Given how vital people think mathematical ability is for success in STEM fields, it will also be important to examine whether mathematical ability is viewed in particularly innate terms. If so, then we might expect fields in which mathematics is viewed as more central to have particularly low participation of women."[4] Could mathematicians' feelings about the importance of innate ability affect more than just mathematics?

Instead of her personal feelings about "field-specific innate inability," Klawe has written and spoken more colloquially of her feelings of being an impostor—"the frequent feeling of not deserving one's success, and of being a failure despite a sustained record of achievements." She had her first impostor's experience as a grad student in the mid-70s when she attended a conference on the geometry of Banach spaces: "I was convinced everyone could tell I didn't belong." The latest was barely a year ago, when she placed 17th on *Fortune's* list of the "World's Greatest Leaders" in recognition of Harvey Mudd's success in having women constitute 40% of its computer science majors.[5]

So maybe matters of gender and racial balance in our own profession of mathematics—no matter how broadly defined, it is still the gateway to much of science, technology, and engineering—are less about mighty blows than thoughtful self-examination of our own attitudes, followed by appropriate action. That seems to have been Nadella's response to Klawe's simple "I disagree."

He retreated from what he called his "completely wrong" answer in a posting that evening on Microsoft's News Center: "Without a doubt I wholeheartedly support programs at Microsoft and in the industry that bring more women into technology and close the pay gap. I believe men and women should get equal pay for equal work. And when it comes to career advice on getting a raise when you think it's deserved, Maria's advice was the right advice. If you think you deserve a raise, you should just ask."

Of course, it's not for nothing that women lag behind men in both pay and numbers in many places within reach of SIAM, from Silicon Valley to the ivory tower. Are we mathematicians, regardless of stripe, allowing a myth of innate ability to bar capable, hard-working women from our profession? Is the same happening with other minorities?

How many smart people do you remember from grad school who never quite

See **Maria Klawe** *on page 8*

How Can the SIAM Community Help Embed Math Modeling in K–16 Curricula?

By Rachel Levy, Kara Maki, and Kathleen Fowler

SIAM has a vital role to play in supporting the integration of mathematical modeling into K–16 education. Current efforts led by SIAM members demonstrate that students can experience mathematical modeling and industrial mathematics in many contexts: school coursework and projects; summer, weekend, and after-school camps; and, at the undergraduate level, internships and capstone experiences. The SIAM Committee on Education, which plans to pilot new ideas in coordination with the new SIAM Activity Group on Applied Mathematics Education, would like to hear from readers about related efforts.

One important way in which applied mathematicians can help is to support teachers as they implement the Common Core State Standards for Mathematics (CCSSM) practice called "model with mathematics." To begin, we can help teachers understand what mathematicians mean by the word "model," which teachers use in many ways. Teachers refer to both demonstrating a mathematical technique and using manipulatives to illustrate mathematical ideas as "modeling the mathematics." And teachers may think of traditional story problems as mathematical modeling, when they represent only a small element of what we might do as mathematical modelers.

Mathematical modeling and industrial mathematics can be a natural way to introduce more open-ended and realistic problems to school curricula. As applied and industrial mathematicians know, modeling inspires/requires creativity, teamwork, communication, and perseverance through iteration, as well as testing and evaluation of results. Students trained in these metacognitive skills will be able to master information and solve problems more easily.

The CCSSM raise the question of how mathematical modeling can be introduced as early as elementary school. A three-year NSF-funded project, IMMERSION (Integrating Mathematical Modeling, Experiential Learning and Research through a Sustainable Infrastructure and an Online Network), was initiated in an NSF–SIAM–ASA Modeling Across the Curriculum workshop. This program will be implemented at three institutions (George Mason University, Montana State University, and Harvey Mudd College), in collaboration with three school districts (Fairfax, Virginia; Bozeman, Montana; and Pomona, California); it will provide professional development in mathematical modeling for in-service elementary school teachers, follow-up lesson study in which teachers observe each other implementing lessons, and regional conferences. Outcomes of the project will include freely available online mathematical modeling resources disseminated via a new SIAM-sponsored repository of curricular resources for mathematical modeling.

Exposing students to mathematical modeling may be especially valuable in developing a diverse STEM-workforce pipeline, but we need to do more longitudinal work in this regard [1]. Many researchers are looking into the influence of informal science experiences on students' study and career choices. With the issue of gender imbalance, for example, mathematical ability has been shown to be a key barrier to girls' pursuit of STEM degrees, and strongly dictates the male–female difference in choice of scientific versus non-scientific majors [2]. The mathematics barrier persists even among female students who have had informal STEM experiences [4]. McCreedy and co-workers found that young women participants in any of six different informal STEM programs still perceived math as a barrier to science participation. Their recommendation to informal STEM educators is to integrate math more strategically into STEM programs: "There is an opportunity for informal STEM programs to make math more engaging and meaningful by embedding it into the rich authentic activities that are so common in such programs."

Mathematical modeling naturally embeds mathematics into studies of the world around us, including culturally and geographically relevant problems [3]. An example of one such effort is the FOCUS program (Females of Color Underrepresented in STEM) at George Mason University, run through the STEM Accelerator program (which recently won the "2015 Program that Works" in the state of Virginia).[1] The initially small four-day FOCUS camp has received an award from the Northern Virginia's Business Women's Giving Circle to expand and include 100 girls. Each day focuses on a different letter from STEM through mathematical modeling activities.

Teachers will need support as they begin to implement mathematical modeling tasks in the classroom. A great resource for communicating the many elements of the iterative modeling process has been developed in conjunction with the Moody's Mega Math Challenge, a modeling competition for high school students; having gradually expanded since its introduction in 2006, the competition will soon become nationwide and then international. The materials, freely available online,[2] include a handbook, reference cards, and a mapping between modeling practices and the CCSSM. The site also shows problems and solutions from previous years, which provide a great view of the multiple ways in which students have approached the problems. Another set of resources and problems can be found at the Hi-MCM[3] and MCM/ICM[4] sites, and at COMAP's Modeling Forum.[5] These COMAP programs attract teams at high school and undergraduate levels internationally to modeling competitions each year.

Two summer experiences provide examples of ways to draw young people into mathematical modeling. The SMASH Experience for Girls, held at Rochester Institute of Technology, was developed to explore how mathematical modeling can be used to help break mathematics barriers that may keep girls from entering STEM fields.[6] This week-long experience is aimed at girls entering 8th grade. Underlying SMASH is the hypothesis that informal math and science learning experiences, guided by the principles of mathematical modeling and coupled with self-affirmation activities, will increase participants' intrinsic motivation for learning mathematics as well as their confidence in their ability to do mathematics. The week's curriculum, after introducing participants to the steps involved in constructing mathematical models,

See **Education** *on page 7*

Education

continued from page 6

positions them to pose their own questions about the world and to begin thinking about how they could use mathematics to answer those questions.

Eighth-grade girls participated in Rochester Institute of Technology's SMASH program, gaining first-hand lab experience. After reviewing a lesson on ratios, the students created serial dilutions for an enzyme-linked immunosorbent assay. The next step was fitting the ELISA data to a line to help with a crime scene investigation. Photo courtesy of SMASH.

A summer rollercoaster camp at Clarkson University is part of the university's state-funded Science and Technology Entry Program, IMPETUS (Integrated Mathematics and Physics for Entry To Undergraduate STEM) for Career Success.[7] The camp, now in its ninth year, gives students programming and modeling experience that they can use to design their own virtual roller coasters. The students test their projects and ride their roller coasters on a Max Flight VR2002 Virtual Reality Programmable Roller Coaster.

A resource for readers interested in incorporating mathematical modeling into their undergraduate curricula is PIC Math (Preparation for Industrial Careers in Mathematical Sciences).[8] SIAM is a sponsor of the program, which provides training for faculty through a summer course, content for a semester-long, credit-bearing course focused on industrial problems, and a contest for students. The course could be used as a senior capstone, major requirement, or an elective.

To communicate many of these ideas about mathematical modeling to a wide audience, SIAM and COMAP are organizing an international writing collaboration to create a report titled *Guidelines for Assessment and Instruction in Math Modeling Education* (GAIMME). This report is modeled on the very successful GAISE reports,[9] which helped bring more statistics into the K–16 curriculum. SIAM also participates in outreach to the public about applied and industrial mathematics through two national events: the USA Science and Engineering Festival and the new Math Midway, created by the Museum of Mathematics (MoMath)[10] in New York. Many parents who attend these events have questions about careers in mathematics and about mathematics enrichment programs. The events have been a great way for SIAM student chapters to participate in outreach.

"It is exciting to see so many really great initiatives under way," says Peter Turner, chair of the new SIAG on Applied Mathematics Education. "Some of these had their seeds in, or reflect collaborations that started at, the two SIAM–NSF Modeling across the Curriculum workshops. The future for both the SIAG and the SIAM Committee on Education is bright and includes ever closer ties with sister professional organizations, notably the ASA, MAA and NCTM."

The SIAM community has many opportunities to inspire the next generation of problem solvers and leaders. We encourage interested readers to join the SIAG on Applied Mathematics Education[11] and volunteer for projects organized by the SIAM Committee on Education. "The SIAM education committee is very excited to form new links between academia and industry and involve SIAM members in education initiatives," says SIAM VP for education Rachel Levy. "We hope many members will join the new SIAG/ED and participate in the first SIAG/ED conference, which is coming soon."

An instructor at Clarkson University's summer roller coaster camp prepared two participants to test their design on the Max Flight VR2002 Virtual Reality Programmable Roller Coaster. Photo courtesy of Christopher Lenney, © Clarkson University.

References

[1] The Cognition & Technology Group at Vanderbilt, *The Jasper Project: Lessons in Curriculum, Instruction, Assessment, and Professional Development*, Routledge, New York, 1997.

[2] R.D. Goldman and B.N. Hewitt, *The Scholastic Aptitude Test explains why college men major in science more often than college women*, J. Counseling Psych., 23:1 (1976), 50.

[3] D. McCreedy and L.D. Dierking, *Cascading influences: Long-term impacts of informal STEM experiences for girls*, Tech. Rep., (2013).

[4] B. Greer, L. Verschaffel, and S. Mukhopadhyay, *Modelling for life: Mathematics and children's experience*, in Modelling and Applications in Mathematics Education, P.L. Galbraith, H.-W. Henn, and M. Niss, eds., Springer, New York, 2007, 89–98.

Notes

[1] http://stem.cos.gmu.edu/2014/03/04/focus-females-of-color-underrepresented-in-stem/
[2] http://m3challenge.siam.org/resources/modeling-handbook
[3] http://www.comap.com/highschool/contests/himcm/
[4] http://www.comap.com/undergraduate/contests/mcm/
[5] http://www.mathmodels.org
[6] http://www.rit.edu/cos/smash
[7] http://web2.clarkson.edu/projects/impetus/summerprogram.php
[8] http://www.maa.org/programs/students/undergraduate-research/pic-math-preparation-for-industrial-careers-in-mathematical-sciences
[9] http://www.amstat.org/education/gaise/
[10] http://momath.org
[11] http://www.siam.org/activity/ed/

Rachel Levy, an associate professor of mathematics at Harvey Mudd College, is SIAM's vice president for education. Kara Maki is an assistant professor in the School of Mathematical Sciences at Rochester Institute of Technology. Kathleen Fowler is an associate professor of mathematics at Clarkson University.

Professional Opportunities

Send copy for classified advertisements to: Advertising Coordinator, SIAM News, *3600 Market Street, 6th Floor, Philadelphia, PA 19104–2688; (215) 382–9800; fax: (215) 386–7999; marketing@siam.org. The rate is $3.00 per word (minimum $375.00). Display advertising rates are available at www.siam.org/advertising.*

Advertising copy must be received at least four weeks before publication (e.g., the deadline for the June 2015 issue is April 30, 2015).

Advertisements with application deadlines falling within the month of publication will not be accepted (e.g., an advertisement published in the June issue must show an application deadline of July 1 or later).

Students (and others) in search of information about careers in the mathematical sciences can click on "Careers and Jobs" at the SIAM website (www.siam.org) or proceed directly to

www.siam.org/careers

Electric Grid

continued from page 1

few constraints on loads: Customers have been free at all times to use as much or as little electricity as they desire. In this mode of operation, the production of electricity must be varied in real time to match the loads. An excess of producers must be available at almost all times to cope with emergencies or extreme loads—during a summer heat wave, for example.

The RTOs and ISOs conduct daily auctions to select the producers that will be used, with the final unit commitment adjusted in hourly and five-minute increments. These decisions are based on the solution of large mixed-integer optimization problems that take into account constraints, most notably transmission line capacities. State-of-the-art optimization algorithms have become an important tool for system operators, and it is highly likely that further algorithmic advances will translate into further dollars saved. Currently, the unit commitment decisions are based on linearized, static approximations of the grid and do not reflect transient dynamics or alternating voltage and current properties of the power flows.

Electric power generation today is dominated by large power plants, most of which are slow to start or stop. Under these conditions, how is the grid to respond instantaneously to fluctuations in demand or to events like lightning strikes and equipment failures? The answer is embedded in the physics of alternating current: Frequency changes and phase relations between voltages and currents affect the amounts of power delivered. The speed of large spinning dynamos and "reactive power" of three-phase AC circuits adapt to the changing loads. The system must operate with reserve capacity sufficient to prevent unforeseen events from destabilizing the system. When destabilization does occur, protective devices, such as circuit breakers and relays, shed loads or reconfigure the topology of the network to prevent blackouts and/or equipment failures.

New technologies are having an impact on this control environment. Among the major changes are the following:

(1) The amount of energy that can be obtained from renewable sources (mainly photovoltaic panels and wind turbines) is increasing rapidly. These resources provide intermittent power in both predictable (day/night) and unpredictable (cloud cover) ways, and they lack the inertia of large generators. Both of these characteristics make the scheduling and unit commitment problems for the system operators much more challenging. Rooftop solar panels, moreover, are installed with the capacity to reverse power flows in the distribution system and feed energy back from customers to the grid.

(2) "Smart grids" refer to technologies that provide feedback from end users to the systems controlling the grid. One way to control loads is to have devices turned off automatically at times of high demand. Water heaters, refrigerators, air conditioners, and washing machines all consume large amounts of power but need not run continuously. Even more power is required to charge electric vehicles, but their batteries have the potential to store substantial amounts of energy, which could be fed back into the grid. Clearly, the bidirectional energy flows of smart grids make the control problems for the grid much more complicated. In the current environment, there is an interface between high-voltage transmission and local, lower-voltage distribution systems. Smart grids and smaller, highly distributed generation resources blur this separation.

(3) Devices that monitor and measure the state of the grid have improved enormously. Several years ago, under the American Recovery and Reinvestment Act, a synchrophasor initiative funded the development of phasor measurement units (PMUs), which provide time-stamped information about voltages, currents, phase angles at 30 Hz, and other quantities at 30 Hz and higher. More than a thousand of these devices have been installed nationwide, giving qualitatively improved measurements of grid dynamics. We are only beginning to formulate ways in which this information can be used to improve grid performance. For security reasons, the PMU data will not become public, but mathematicians can certainly help with the creation of algorithms for analyzing or using the data.

■ ■ ■

The electric grid is an indispensable part of the national infrastructure on which we rely every day. There is a great deal of uncertainty about how the grid will evolve. Change in generation fuels is occurring faster than anticipated just a few years ago, with the conversion of coal plants to natural gas and the growth of renewable sources. Regulation at state and national levels plays an enormous role in the construction of new resources, such as transmission lines, and in the operation of electricity markets.

Low-cost, efficient storage devices could greatly simplify the reliability problems of the grid and/or enable the proliferation of decentralized microgrids. In a contrasting scenario, smart grids in which demand response enables operators to control end-user devices would smooth demand peaks and adapt to intermittent generation of power. Greatly improved real-time monitoring of the network could help in the detection and prevention of impending equipment failures and unstable power flows.

Satellite image of North America at night. Image courtesy of NASA.

Building on the success of optimization algorithms in the operation of wholesale electricity markets, we need to create interdisciplinary research communities that can facilitate the use of mathematics in creating the enabling technologies for the next-generation electric grid.

Readers may be interested in two earlier reports, which can be accessed at http://www.siam.org/about/nsf.php, http://mitei.mit.edu/publications/reports-studies/future-electric-grid.

John Guckenheimer is the Abram R. Bullis Professor in Mathematics at Cornell University.

Building a Multidisciplinary Community

The ad hoc National Academies Committee on Analytic Foundations of the Next Generation Electric Grid, with 15 members drawn from mathematics and engineering, is co-chaired by John Guckenheimer (Cornell) and Tom Overbye (UIUC). The committee's charge is to produce a report that addresses the questions:

(1) What are the critical areas of mathematical and computational research that must be addressed for the next-generation electric transmission and distribution (power grid) system? Do current research efforts in these areas (including non-U.S. efforts) need to be adjusted or augmented?

(2) How can the U.S. Department of Energy help build the multidisciplinary community—including cutting-edge knowledge of mathematics, statistics, and computation, along with a deep understanding of the emerging electric grid and of the questions that need to be answered if its potential is to be realized—needed to address this research frontier? What mix of backgrounds is needed, and how can the community be developed? How can DOE extend its reach beyond its existing ties?

Maria Klawe

continued from page 5

clicked mathematically over the long term? How many in our profession have made valuable contributions even though they weren't too high on anyone's league table of innate ability? Who helped you and why, even if you are an impostor (secretly, of course), certain that you lack innate ability? Whom have you encouraged lately—and why?

And if you are still sure that brilliance alone defines professional mathematicians, consider the question Penner poses at the close of his *Science* editorial,[4] "Perhaps it is time to ask a new question about gender representation in STEM: Would society be better off if men were more like women?"

Notes

[1]N. Wingfield, *Microsoft Chief Sets Off a Furor on Women's Pay*, The New York Times, October 9, 2014.

[2]*Maria Klawe: "Surprised" by Microsoft CEO's comments about women's raises*, video of interview by Bloomberg WEST; http://www.telegraph.co.uk/technology/microsoft/11158247/Maria-Klawe-surprised-by-Microsoft-CEOs-comments-about-womens-raises.html.

[3]Summarized in *The Economist*, January 17–23, 2015, 74–75; http://www.economist.com/news/science-and-technology/21639439-women-are-scarce-some-not-all-academic-disciplines-new-work-suggests. Some online comments from women readers of *The Economist* summary offer anecdotal reinforcement of the findings of Leslie et al. A number of the comments (presumably from men) are genuinely disturbing.

[4]A.M. Penner, *Gender inequality in science*, Science, January 16, 2015, 347 (6219), 234–235.

[5]M. Klawe, *Impostoritis: A lifelong, but treatable, condition*, Slate, March 24, 2014; http://www.slate.com/articles/technology/future_tense/2014/03/imposter_syndrome_how_the_president_of_harvey_mudd_college_copes.htm.

Paul Davis is Professor Emeritus of Mathematical Sciences at Worcester Polytechnic Institute.