CenterPoint

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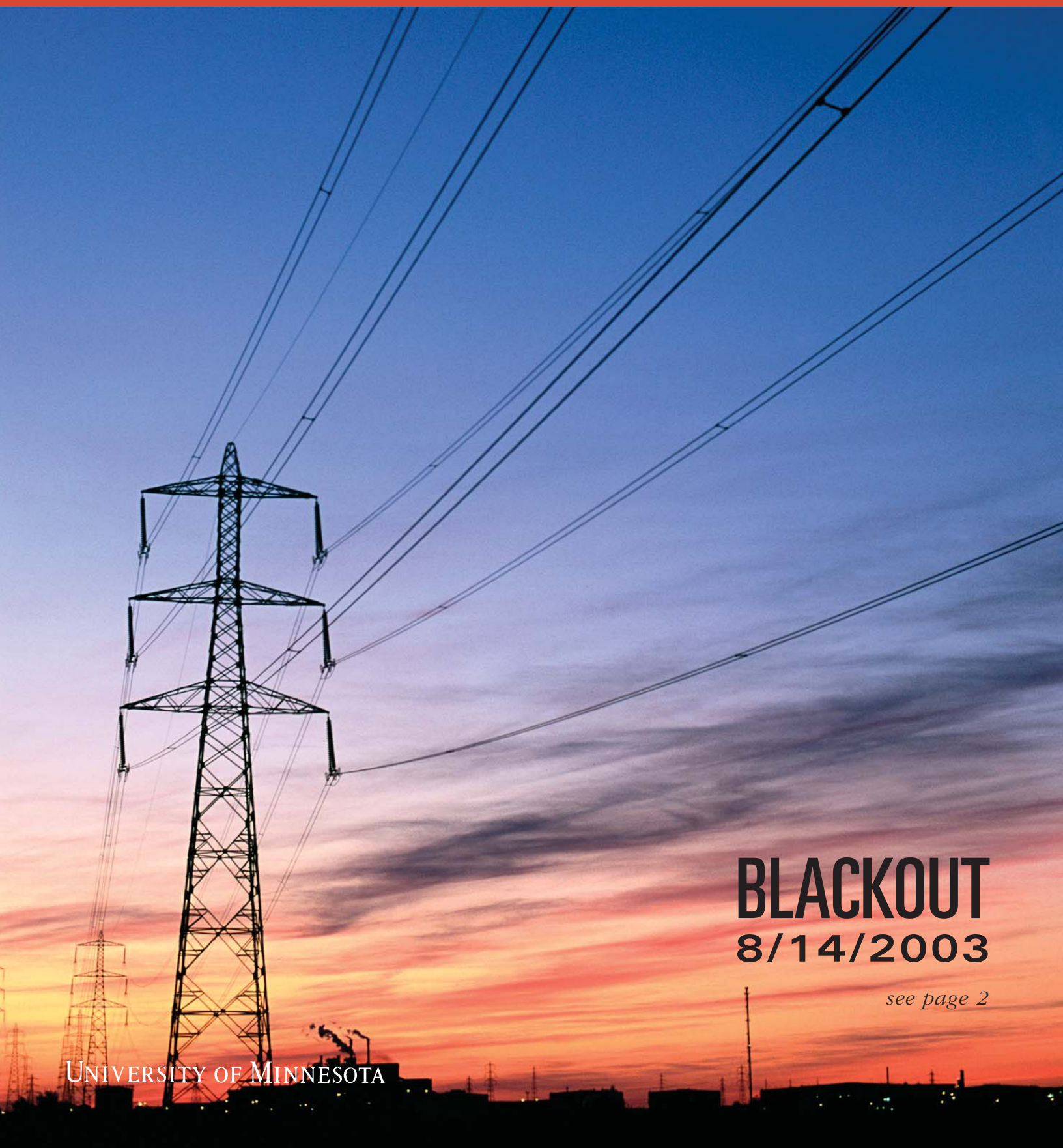

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UNIVERSITY OF MINNESOTA

BLACKOUT

8/14/2003

Could it happen here?

On Aug. 14, 2003, the worst blackout in the nation's history shut off the power and turned out the lights to an estimated 50 million people in several Midwestern and East Coast states, as well as southern Canada.

Thanks only to the quick thinking of grid operators did Minnesota escape the direct effects of the costly and disruptive blackout. Within a matter of minutes, they made decisions that most likely saved Minnesota and other states from the blackout.

But averting the August blackout does not mean Minnesota—its citizens and industries—should feel as though it will never happen here.

Repeat outages loom as a possibility for everyone, unless the nation starts to invest in new solutions, says Massoud Amin, director of the Center for the Development of Technological Leadership (CDTL), electrical and computer engineering professor, and one of the nation's leading experts on the country's electricity infrastructure.

Before joining CDTL, Amin spent five years at the Electric Power Research Institute (EPRI), a non-profit energy research consortium. In 1998, he launched and managed the Complex Interactive Networks/Systems Initiative (CIN/SI), a three-year, $24 million research and development program. CIN/SI created tools and techniques that support resilient, secure, and reliable operation of interdependent infrastructures by using distributed intelligence and self-healing technologies. In the aftermath of September 11th, he served as area manager of infrastructure security, grid operations/planning, energy markets, and risk/policy assessment. He investigated ways to strengthen the safety and security of the nation's energy networks.

Expertise in demand

Within minutes after the blackout hit, Amin's phone began to ring with calls from the media, from colleagues, and from government and industry officials.

Amin's comments on the blackout appeared in national publications, such as *The New York Times, The Chicago Tribune, The Times-Picayune,* and

Scientific American (see related story). He consulted with officials at EPRI and the United States Department of Energy, among others. In September, he gave a keynote address and a presentation about the blackout, as well as solutions, for legislative staff in Washington, D.C. He presented to industry representatives and professional organizations. The September/October issue of *IEEE Security & Privacy* featured an article by Amin that explores weaknesses in the nation's power grid and ways to strengthen the infrastructure.

Historical patterns

While the Aug. 14 blackout raised public awareness of the system's vulnerability, it did not surprise Amin. Although he could not have predicted the time or location, a history of the North American power grid reveals a pattern of blackouts over recent years. It was, Amin says, only a matter of time before a severe outage hit again.

Before the August incident, the last large losses of power affected the Western states in the summers of 1996 and 2001. According to an EPRI data analysis, statistics show the likelihood for more frequent blackouts with larger impact.

From 1991 to 1995, 66 outages of at least 100 megawatts occurred in the U.S.; from 1996 to 2000, such outages increased to 76. The average outage impacted 409,854 consumers in the later half of the decade, compared to 355,204 in the earlier part of the decade—a 15 percent increase in the number of people affected.

A massive and complex network

In many respects, the country's electrical grid is a wonder, says Amin. It topped the National Academy of Engineering list as the supreme engineering achievement of the 20th century, because of its intricate engineering, its importance to the development of other technologies, and its sheer impact on quality of life.

Yet, the pressure to deliver more and more energy within this complex environment is causing strains and increasing the system's vulnerability, says Amin. He points to a number of stresses on the system:

- Demand is outpacing investments to improve and maintain the current infrastructure.
- Deregulation creates new demands on an already limited grid capacity.
- The current power-delivery infrastructure cannot adequately handle the demands of high-end digital customers and the 21st century economy.
- The infrastructure has not kept pace with new technology. Few incentives exist for developing innovative technologies to provide more precise monitoring, controls, communication, and overall systems management and reconfigurability.
- The integration and reliability of other energy sources, such as micro turbines, fuel cells, and energy storage devices, with the current grid needs further exploration.
- Infrastructure improvements come with high price tags and risks that make such investments in upgrades less appealing to companies.
- The importance of keeping the nation's power supply secure also adds new pressures on the system.

System faults

The United States-Canada Joint Task Force on the Power Outage of Aug. 14 is investigating the blackout and its root causes. The cost also remains an unknown. Past blackouts have cost billions of dollars, crippling businesses, and, in some cases, contributing to deaths.

"Outages and power quality disturbances have a huge impact on our economy," Amin says. "Per year, the estimate is over $100 billion."

While Amin emphasizes that the blackout's root causes still remain unknown, he also stresses that the conditions under which the nation's power grid functions merit greater attention.

"We are operating the system very close to the edge," he says. "We are increasing the pressures on a system that is less and less able to absorb them. The nation's older and more capacity-constrained transmission lines are straining and sagging under the demand placed on them."

For example, the system's shock absorbers—its generation capacity margin to tap enough electricity during peak demand periods—has declined from about 25-30 percent in the early 1980s to about 10-15 percent, says Amin.

At the same time, the nation's transmission capacity resembles rush hour gridlock on a major freeway. From 1988 to 1998, demand for electricity grew by nearly 35 percent, while new transmission increased by merely 18 percent. From 1999 to 2009, analysts expect demand to grow by more than 20 percent, and planned transmission systems to grow by only 3.5 percent.

The personnel who regulate daily the intricate balance of power flowing from one part of the country to another also face increased pressures. They orchestrate the high-wire act that keeps electricity flowing, with tighter and tighter margins for error.

Toward a brighter future

The Aug. 14 blackout sets the stage for a very important discussion about the future evolution of the nation's power grid, says Amin.

"There is no silver bullet," he says, but there are promising avenues to explore. An investment in research and development offers the potential for positive changes.

Currently, the energy industry lags behind other industries in its investment in research and development. According to a 2003 National Science Foundation report, the computer and electronics industry spends about 10 percent of its net sales on research and development (R&D). The investment of electric utilities, though, amounts to less than 0.5 percent. The spending of R&D by the electric power industry is less than that of most other industries, often because the return on investment is not clear.

Technology offers a key to what Amin has coined as the "self-healing" grid, a more flexible network that can

make necessary adjustments while decreasing the risk of disruptions or significant outages.

One barrier to progress may be the nation's unwillingness to take long-term action based on the Aug. 14 and other blackouts.

"We have found responses to strengthen the system," says Amin. "The question is will the outcome of this power outage be forgotten until the next disruption or will it spur discussions that lead to new approaches?"

The necessary resources

Management of technology (MOT) can play an important role in supporting, developing, and implementing the technological solutions that reshape the current infrastructure into a more reliable and resilient power grid for the nation, says Amin.

"MOT involves applying a strategic perspective to technology development and effectively marshaling technical resources for innovations that meet strategic goals," he says. MOT takes into account the key pieces for change: technology policy, economic issues, identification and development of new technologies, and the process of successfully bringing those technologies to market.

Through its degree programs and connections to industry, CDTL can act as a resource in the search for technology solutions. "This is an area where I believe we can make an impact, where CDTL and the University of Minnesota community can leverage its expertise to improve the system. This is an opportunity for us to become involved and make a difference."

Amin already has incorporated this topic into the MOT policy class that he teaches. CDTL also will explore other ways to share knowledge about the issue.

Amin will continue his work on a national level, consulting and contributing to discussions. "These issues also require patient investments in education and R&D," he says. "We are talking about a system that touches everyone. I'm very optimistic that we will develop a more robust, secured, resilient system."

Contributions to our collective understanding

Since Aug. 14, media from throughout the country have turned to Massoud Amin, CDTL director and professor of electrical and computer engineering, for answers to their questions about the blackout and its implications for the future. Amin's media interviews included:

- *New York Times*
- *Chicago Tribune*
- *Congressional Quarterly*
- *The Times-Picayune*
- *Scientific American*
- *Healthcare Informatics*
- *Society of Industrial and Applied Mathematics (SIAM) News*
- *Oil Daily*
- *Natural Gas Week*
- *International Oil Daily*
- *World Gas Intelligence*
- *Energy Compass*

He also provided information regarding the outages and related infrastructure issues to a variety of organizations including:

- American Society of Mechanical Engineers (ASME)
- ASME Critical Asset Protection Initiative
- Institute of Electrical and Electronics Engineers (IEEE)
- IEEE Computer Society's *Security and Privacy Journal*
- U.S. Energy Association
- U.S. Congress
- Air Force Association, Minnesota Chapter
- Electric Power Research Institute
- National Science Foundation
- National Academy of Engineering
- Society of Industrial and Applied Mathematics (SIAM)

His keynote addresses included:

- U.S. Department of Energy (DOE) 2003 Conference
- 100th Fall Convention of the Rocky Mountain Electric League
- IEEE Twin Cities 2003 Awards Banquet
- Congressional Staff Briefing, "An Engineering Perspective on the Blackout of 2003," hosted by ASME, IEEE, and the U.S. Energy Association
- Congressional Briefing at the Inaugural Meeting of the House Research and Development Caucus
- EPRI Grid Reliability and Power Markets Council, Infrastructure Security, and Enterprise Information Security Meetings
- IEEE and International Council on Large Electric Systems Symposium
- 39th Annual Minnesota Power Systems Conference
- Santa Fe Institute
- Los Alamos National Laboratory

Here are some excerpts from media interviews:

• ***New York Times***, Sept. 2, 2003, "Experts Point to Strains on Grid's Specialists"

"The workers, called system operators, say they take pride in keeping the power flowing on an inadequate system. Their reflexes resemble those of 'a good combat pilot managing an aircraft that has been badly damaged,' said Dr. S. Massoud Amin, an electrical and computer engineer at the University of Minnesota.

Still, Dr. Amin and other experts say such skill is no longer enough to prevent further shutdowns. 'The trend we're observing,' he said, 'is toward increasing the stress and strain on the system, and on the human operators perhaps.' "

• ***The Times-Picayune***, Aug. 24, 2003, "Generating Debate"

"'Grid congestion and atypical power flows are increasing, while customer expectations of reliability are rising to meet the needs of a pervasively digital world,' Amin said.

Without well-planned investments in the near future, he warned, the nation's web of power wires could be 'left behind as an industrial relic of the 20th century.' "

• ***IEEE Security and Privacy***, September/October 2003, IEEE Computer Society

"Technology can make a vital contribution to security by enhancing power systems' inherent resilience and flexibility to withstand terrorist attacks and natural disasters. Creating a smart grid with self-healing capabilities is no longer a distant dream; we've made considerable progress."

How Are They Doing?

In 1997, the Center for the Development of Technological Leadership and the Department of Computer and Electrical Engineering collaborated to launch a new degree program—the master of science in software engineering (MSSE). Has the program made a difference for its early graduates? *CenterPoint* checks with several alumni who graduated in the program's first few years to learn more about the program's value to its students and their companies.

MILINDA RAMBEL STONE
PAGE TECHNOLOGIES

MEGAN GRAHAM
GUIDANT

LIANA KIFF
HONEYWELL

ARVIND GANESAN
UCLID SOFTWARE

LIANA KIFF

Immediate and long-term benefits

As a key member of a Honeywell software project team, Liana Kiff faced an important decision. The team was moving forward, but in a direction that Kiff thought might not result in a successful outcome. She faced a critical point: Should she abandon the project in its current form five months before the deadline or stay the course?

With the knowledge, skills, and confidence that Kiff gained through the software engineering program, she led the team down a different path. Within four months, the team developed and executed a new approach, and the project succeeded.

"I could make the decision because of the confidence that I gained from the program," says Kiff, senior research engineer at Honeywell "That success led to more recognition and respect."

In the last year, Kiff served as a principal investigator on a large, partly federally funded research initiative that uses technology to assist in elder care. What Kiff learned through the MSSE program helps her as she marshals the technical and human resources to work on projects for the company.

"Project management is really an art form in software engineering," she says. The program offered Kiff a solid foundation in that art, as well as access to the experiences of other professionals. The program's combination of theory with practical application is a powerful one, says Kiff.

"It made an immense and immediate difference to me," she says. "Almost every week there was something that I gained that I could apply immediately to what I was doing."

The program bolstered her management and technical skills. The degree has positively impacted her career, as she assumes greater responsibilities and moves forward in her career at Honeywell. "The degree is a key ingredient to success within the research organization, and that was immediately helpful in a direct way.

"It also makes me a more versatile employee and that is vital in an environment where flexibility is important. My career path is definitely more open as a result of the program."

MILINDA RAMBEL STONE

The power of practical knowledge

Like many software engineering professionals, Milinda Rambel Stone learned much of her knowledge on the job. She began her career as an analyst

LIANA KIFF
SENIOR RESEARCH ENGINEER
HONEYWELL

for a health care company, and by the time she came to the University of Minnesota Medical School in information technology, she wanted to supplement her experience.

When she heard about the new software engineering program, she was eager to apply. "I was in the technical field by default, and I wanted to have formal training in software engineering," she says.

The program broadened her depth and increased her credibility on the job. While in the program, she earned a promotion at the University. After completing her degree in 1999, she joined Page Technologies as a senior consultant. There she rose quickly to practice director and to her current position as vice president.

She credits the program with supplying practical knowledge that improved her project management skills and helped her on the job. "The students can take what they learn from that day's class and walk back into the office the next day and apply it. The benefits are immediately realized."

The program also provided her with a foundation that strengthens her ability to manage and lead, she says. "By my nature, I enjoy leading projects and teams. The program has helped me build my leadership skills, and that's what I love about it."

As a self-proclaimed software engineering process guru, Stone consistently follows the principles that the program reinforced. "I tell my clients that software is a tool to meet a business need, and the business need drives the software development."

Stone is such a believer in the program that she has recommended it to other professionals and also stays connected to it through the alumni network. When a position opens, she uses alumni contacts to search for candidates.

"I know the quality of people who come out of the program," she says. "I know that the program's graduates can make great contributions."

ARVIND GANESAN

Preparation for new possibilities

When Arvind Ganesan entered the software engineering program, he worked at Datacard as a software engineer. Within a year, Datacard promoted him to senior software engineer. After he earned his degree, he joined UCLID Software, LLC, as vice president of software development.

Ganesan has no doubt that the program contributed to his career advancement. "I felt more confident to take this kind of responsibility after I attended the program. I can tell that I have certainly used the project management skills and process knowledge gained from the program over and over again here at work."

His education came in handy for practical tasks during his transition from software developer to software architect and from project manager to vice president. It also played a role as he successfully established processes for UCLID, managed several offshore development programs, and guided staff.

Even more significantly, it transformed his perspective, preparing him for new possibilities.

"I can't see myself in any role other than technical manager and/or architect," he says. "After attending this program, I have ambitions of taking on larger and larger technical management responsibilities in bigger companies."

When Ganesan began the program, he wanted to learn software engineering best practices and software project management techniques. He gained a solid understanding of software development processes, software project management issues, and ways to solve these issues. His appreciation of the importance of software engineering processes and software quality assurance also grew.

Helping its students learn about key software engineering topics, the program also helps explain the effects and influences of software processes within companies and related management issues, he says. The knowledge allows students to make tremendous contributions to their organizations by reducing or by eliminating costly mistakes, boosting profits, and obtaining other tangible benefits for their companies.

"The program as a whole enables students to understand the 'big picture,' " he says. "This understanding of the overall picture helps a professional do a better job of catering to the needs of the customers, which is the ultimate motive."

MEGAN GRAHAM

Higher standards

In the medical device industry, new software development has resulted in new solutions for businesses seeking to improve patients' health. The pressure on such software to perform consistently is enormous and so is the pressure on the professionals who are responsible for software performance.

When Megan Graham joined the medical device manufacturer, Guidant, about five years ago, she came with an edge in the quest for software reliability and quality control. She already was a student in the software engineering program.

With a bachelor's degree in mathematics, Graham returned to college to enhance her on-the-job experience. "I was interested in the software area, but really didn't feel that I had enough formal education," she says. "If you really want to reach the next level, I believe that the software engineering program is the way to go."

Her courses gave her a definite advantage in her work. "It always seemed that no matter what we learned, there would be—some time, some place—an opportunity to use the information on the job."

MEGAN GRAHAM
PRINCIPAL SOFTWARE ENGINEER
GUIDANT

She still makes good use of her classroom experiences. She gained fundamental and pragmatic knowledge in her project management class that continues to serve her well as she provides leadership to projects and initiatives.

The program is challenging, but well worth the investment, says Graham. "I can't think of a course where I didn't learn a lot."

Her time in the program allowed her to make greater contributions to her work at Guidant, she says. In turn, Guidant recognized those contributions, increasing her responsibilities. Since leaving the program, Graham has received two promotions—one from software engineer to senior software engineer and, most recently, one from senior software engineer to principal software engineer.

In her current position, she focuses on software verification, using measurement to help drive improvements in processes. While the program helped her and other students, it also serves a larger purpose.

The program helps raise the bar for software engineering and development expectations, she says. "We rely on software in almost all business applications—it has tremendous impact," she says. "Ensuring the software reliability and quality is critical."

MILINDA RAMBEL STONE
VICE PRESIDENT
PAGE TECHNOLOGIES

Women in the Field

✶ Heidi Hamilton always enjoyed math and loved the outdoors. When she read about environmental engineering in a college brochure, she found her career path. ✶ Erin Schacht learned from her father, an engineer, about the possibilities of the profession. Math and science classes appealed to her also, so engineering seemed a good choice. ✶ Working part-time for the city of St. Paul Public Works Construction Department sealed the deal for Shawn O'Keefe. After the summer she spent in the field, she completed her degree in mathematics, changed directions, and earned another degree in civil engineering. ✶ When Petra DeWall was searching for a new career to make a new start, she wanted a stable profession, and engineering fit the bill. While in school, she began working for the Minnesota Department of Transportation, an opportunity that turned into full-time employment.

Shawn O'Keefe (left) *and Heidi Hamilton, engineers for the city of Minneapolis*

Hamilton, Schacht, O'Keefe, and DeWall all chose to enter the civil engineering field and love the work that they do. Because of their commitment, they also chose to pursue a master of science degree in infrastructure systems engineering (ISE). They remain minority members of a profession that has been traditionally dominated by men.

✶ The few and the devoted

In 1983, 5.8 percent of employed engineers were female, according to census data compiled by the Society of Women Engineers (SWE). That percentage reached a high of 11.1 percent in 1998 and declined slightly to 10.6 percent by 2000.

As a whole, the civil engineering field attracted fewer women than other engineering disciplines. In chemical and industrial engineering more than 16 percent of employed engineers were women. Only mechanical engineers—at 7.1 percent—had less female representation than civil engineers.

The local chapter of the SWE sponsors events to increase the awareness of teenage and younger girls about engineering as a career option and to encourage interest in science and math, says Julie Long, SWE president and engineer for the city of Bloomington.

"The greater the number of girls who pursue their interest in math and science, the greater the likelihood of increasing the number of women who enter engineering," she says.

✶ A mixed bag

Hamilton entered the University of Wisconsin at Madison and studied civil engineering. At the time, the United States Forest Service wanted to increase the number of women in its ranks and sponsored an internship program for college students. As a result of that program, Hamilton spent two summers and one fall semester working in Northeast Oregon.

Hamilton joined the work force as the first female engineer at Boswell Energy Center, a Minnesota Power generation facility in northern Minnesota. "I did notice that there was a

lot of support on one level, but on another level, some of my male colleagues weren't sure how to interact."

Eventually the awkwardness eased, and by the time Hamilton moved back to the Twin Cities and began work as an engineer for the city of Minneapolis, she no longer was the only female civil engineer. She hasn't experienced any significant issues as a result of her gender; in fact, she says, her gender opened career opportunities for her, such as her internship.

"Engineering can sometimes be intimidating when there are no other women in the field," says Schacht, engineer for the city of Maplewood. In reality, though, women can find other female colleagues. Her job puts Schacht in contact with female inspectors, interns, and administrators, she says.

"I do not feel that women face gender-specific challenges," says Schacht. "In my experience, the people I have worked with have treated me the same as they would have a male engineer."

O'Keefe also agrees. "Engineers face many challenges on a day-to-day basis, but if one does the job well and treats others fairly, most biases can be overcome."

DeWall says she has felt well-respected and supported at Mn/DOT. Currently assistant state aid bridge engineer, she has assumed positions of increasing responsibility. For DeWall, a greater challenge lies in juggling the demands of a hectic professional life and of a busy family life that includes raising a son. With a supportive husband and a knack for multitasking, DeWall keeps it all in balance.

The power of education

Hamilton, Schacht, O'Keefe, and DeWall all agree the ISE degree strengthens their abilities as engineers and opens new career options for them.

"The infrastructure systems engineering program was fantastic," says O'Keefe. "My degree enabled me to easily change career paths from being a utility engineer to a municipal engineer. An ISE degree demonstrates to engineers the importance of looking at every project from a system standpoint or the 'big picture' perspective."

With many engineers competing for the same job opportunities, the ISE degree gives its graduates a competitive edge, she says.

A firm believer in education, DeWall echoes O'Keefe's sentiments. Because she has spent her engineering career in the Mn/DOT bridge department, the program offered particularly valuable perspectives on other aspects of the infrastructure.

"Education is the key to anything," says DeWall. "The program gave me a grounding to go and build my career further."

Hamilton loved returning to school. "I liked the fact that I didn't have to quit work. I liked that there was an emphasis on practical application."

The complex nature of the infrastructure makes it even more important for civil engineers to pursue an advanced degree, Hamilton says. "What we learn allows us to make better decisions on the job."

Petra DeWall (left)*, Mn/DOT engineer, and Erin Schacht, engineer for the city of Maplewood*

A bright future

The four also agree that the future looks good for women in civil engineering. "There are numerous opportunities for male and female engineers within the field of civil engineering," says O'Keefe.

Women already in the field can help through their actions, she says. "I think the best way to get more women in engineering is to lead by example. As a whole, I think there exists a lack of knowledge in the general public as to what engineers do. We need to learn how to promote ourselves."

When she completes her program, Schacht plans to make good use of what she learns to handle more responsibilities at work. She looks forward to becoming a better engineer and advancing her career.

"I definitely feel that the future is open for female engineers," says Schacht. "I think that being female in this field can be more of an advantage rather than a disadvantage."

Karl Smith began his career at the University of Minnesota as a researcher. He felt at home in the laboratory and in the field, but the classroom was a different matter entirely.

Master Teacher

"I taught the only way I knew how, but it didn't work very well," says Smith. "It was frustrating. I thought there was a better way to do this."

Smith found a better way, earning his Ph.D in educational psychology and helping revolutionize his classes and the classes of numerous other faculty members throughout the University and the country.

Many students in the management of technology degree program (MOT) know firsthand the strengths of Smith's teaching philosophy and abilities. Smith has taught in the program almost every year since its inception in 1990. Currently, he leads the project and knowledge management course.

From the first class, MOT students find themselves active participants in their own learning journey. For example, students take part in a class exercise that condenses the project management process. They quickly learn what works and what doesn't work during the first session as each student team designs and builds

a tower of index cards in 20 minutes. After project completion, the teams assess their strengths and weaknesses. They also evaluate the decisions that either helped them succeed or contributed to their tower's downfall.

Smith champions the concepts of active learning, which encourage students to learn from their own experiences and the experiences of other students. In the active learning classroom, group experiences become a means for discovering new knowledge and ideas.

As one of the leading researchers on the role of collaboration and cooperation in learning and design, Smith is well-known for his work. He currently divides his time between the University and Michigan State University, where he shares his knowledge with faculty in the Lilly Teaching Fellows Program and other colleges. He participates in the National Science Foundation Center for the Advancement of Engineering Education and the Center for the Advancement of Scholarship on Engineering Education at the National Academy of Engineering.

At the University of Minnesota, Smith has served as co-coordinator for the Bush Faculty Development Program for Excellence and Diversity in Teaching. He has been recognized as a Morse-Alumni Distinguished Professor of Civil Engineering.

Faculty and students throughout the world use his books on cooperative learning. A fellow of the American Society for Engineering Education, he also has chaired the Educational Research and Methods Division of the American Society for Engineering Education.

With all his commitments, why does he continue to teach MOT students?

It's a simple answer: He enjoys it. The MOT students bring their own experiences to the classroom and share those experiences, which make the environment ripe for learning by all. In return, he sets the following objectives for students:

- To master concepts and principles for project and knowledge management and leadership
- To refine skills for formulating and solving project and knowledge management problems
- To improve proficiency using project and knowledge management software

To reach those ends, Smith involves the students in team projects, exercises, and simulations. He goes beyond encouraging students to look at concepts from different perspectives and asks them to take a stand as part of a structured controversy exercise.

After presenting definitions of knowledge management from well-established authors, Smith turns the floor over to the students, who debate the sufficiency of those definitions, pro and con. "The goal is to gain a new understanding of the issue that results from thinking about it in reverse."

"I like to think of MOT students as co-learners, and I treat them as colleagues. In each class, we all learn, and that is exciting."

— KARL SMITH

He also asks students to describe one of their most successful projects with the class. After listening to the stories, students develop a list of the common characteristics of those projects.

"You have to be able to understand the diverse perspectives that exist, and you ultimately have to make decisions," he says. Managers with the tools and expertise to marshal disputes into debates that result in new ideas will fare better.

Smith's course often emphasizes teamwork, which allows students to leverage their skills and experiences with other students. The course also addresses knowledge management and expert systems. Smith conducts workshops not only on active and cooperative learning, but also on problem formulation, modeling, and the building of small expert systems. Smith added this component to the course because managing knowledge leads to solutions and innovations.

"MOT graduates don't necessarily manage projects, but they manage knowledge and knowledge workers," says Smith. Understanding the power of knowledge management and methods only strengthens their ability to lead their companies.

The knowledge-management topic has captured the imagination of several students, who used ideas from the class to complete capstone projects that looked at related issues in their company. In the MOT program, students select a project that applies what they learned in the program to issues at work as part of a final capstone project. Because his class inspires students to pursue their interests, Smith often serves on capstone project committees for MOT students.

The learning that occurs in the classroom makes it fun and gratifying for both MOT students and Smith.

"MOT students bring their knowledge and experiences to the table," says Smith. "I like to think of them as co-learners, and I treat them as colleagues. In each class, we all learn, and that is exciting."

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Alternative format available upon request.

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