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The newsletter of the Massachusetts Institute of Technology
System Design and Management Program

sdmpulse

in this issue

MITsdm system design and management

New SLaM Lab helps SDM put systems thinking into action

By Michael Davies and Dan Sturtevant, SDM '07

Editor's note: *This is the first of a series of articles about the new Systems, Leadership, and Management Lab. Michael Davies, a senior lecturer in MIT's Engineering Systems Division (ESD), and Dan Sturtevant, an SDM alumnus and ESD PhD student, are the instructors for the course.*

Michael Davies
Senior Lecturer, SDM

Dan Sturtevant
SDM '07

In fall 2009, the SDM program launched a new course: the Systems, Leadership, and Management Lab (SLaM Lab). As the name suggests, the course objective is to enable participants to integrate "hard" systems and engineering skills with "soft" management and leadership skills through a lab program, working on real-world problems.

Participants in MIT's System Design and Management Program (SDM) come from a variety of engineering backgrounds and are a rarity among postgraduates in the sense that they bring a maturity to the classroom that can only come from real experience in the field. These professionals, averaging 7-10 years of experience, return to education in pursuit of the additional tools they believe they need to become leaders in technical organizations.

As a result, SDM's curriculum encompasses both "hard" technical disciplines and "soft" management skills. Some courses aim to enhance students' ability to conceive of, and design, complex systems. These courses include product design and development, systems engineering, and system architecture. A second set of courses provides skills and theory about the human side of technology. Classes cover marketing, innovation, and strategy. A motivating concept behind SDM is the idea that the individual who possesses strengths in both areas, and who can integrate them, will have the ability to lead the technical enterprise much more effectively than someone with management or engineering skills alone.

In 2008, SDM students and faculty discussed concerns that the curriculum was not integrating these two threads as effectively as possible. In particular, although many students brought with them the practical engineering experience that provided a strong context in which topics such as system architecture could be grounded, fewer had practical experience in management and strategy. In addition, although the program addressed leadership topics in many

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Vol. 5 No. 1 | spring 2010

Publisher: John M. Grace, MIT SDM Industry Codirector

Editor: Lois Slavin, MIT SDM Communications Director

Managing Editor: Kathryn O'Neill

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Design: Stoltze Design Inc.

Layout: Janice Hall, TTF Design

Printer: Arlington Lithograph

MIT's SDM program is cosponsored by MIT Sloan School of Management and MIT's School of Engineering. SDM resides within the MIT Engineering Systems Division.

For further information on MIT's System Design and Management Program, visit sdm.mit.edu.

MITsdm system design and management

Welcome

We begin this edition with an absolutely fascinating description of a practical new leadership course, the Systems, Leadership, and Management Lab (SLaM Lab). This evolving course combines leadership development with hands-on analysis, giving students an opportunity to work on an existing and relevant strategic technology and leadership problem for a participating company.

Next we introduce a new feature, providing insight from one of the companies most involved in SDM, in this case John Deere. The article outlines John Deere's rationale for getting involved in the SDM program, its approach to candidate selection, and an introduction to three of the 40 students the company has sent through SDM's certificate program in systems and product development.

Of course, students are the heart of the program, so we also include several articles highlighting their work. John Kluza, winner of the 2009 SDM Best Thesis Prize, gives us a glimpse into the intricacies of energy storage technologies for the electrical grid. Kluza's work provides a wonderful illustration of how energy storage needs must be addressed in a system context to obtain meaningful solutions.

Also reporting on thesis work, Alex Krikos provides a striking view of cloud computing as a disruptive technology. In his article, he lays out the possible implications of this technology for significant business opportunities and challenges in the future.

SDM student Anando Chowdhury explores the major considerations involved in merging two very large pharmaceutical firms, Merck and Schering-Plough. Chowdhury, who is very involved in the merger, gives us a view of how the tools and methods taught in SDM can be used to aid various aspects of the merger.

Providing a little more insight into SDM, George Apostolakis, President Obama's nominee for commissioner of the Nuclear Regulatory Commission, discusses the challenging Engineering Risk Benefit Analysis (ERBA) course that he has taught for many years in the SDM program.

Matthew Thompson, the chairman of the SDM student-run Industrial Relations Committee (IRC) also provides us with an insider's view of the significant impact that the IRC can have on SDM's relations with firms.

The perennially challenging January Session has kept its reputation intact, and the *Pulse's* own managing editor, Kathryn O'Neill, reports on the design challenges presented this year. In addition, *Pulse* Editor Lois Slavin introduces us to the diversity of the 2010 SDM cohort.

We begin following SDM alumnus Ken Huang's entrepreneurial efforts as he applies his experience as well as SDM tools and methods to building a service business. We will continue to follow Huang's progress in future editions of the *Pulse*. We also get a view of building a leadership style from alumnus Oz Rahman.

Two more thought-provoking articles round out this edition. One is a wonderful exposition by alumnus Geoff Langos of a flaw in the application of Hobson's choice to engineering and management. And the second deals with the time-varying nature of system design through the introduction of the concept of epochs in a system's lifespan.

Here's hoping you find this issue inspiring. As always, we welcome your feedback.

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Sending employees to SDM program pays off for John Deere

***Editor's note:** Niels Dybro compiled this report from a number of sources at John Deere. Dybro is a staff engineer at John Deere's Moline Technology Innovation Center. The one-year SDM program discussed below, which leads to the Graduate Certificate in Systems and Product Development, features three courses from the SDM curriculum—system architecture, systems engineering, and product design and development—as well as a capstone project.*

John Deere is the world's leading provider of equipment for agriculture and forestry and a major provider for construction, lawn and turf care, landscaping, and irrigation. John Deere also provides financial services worldwide and manufactures and markets engines used in heavy equipment. Since it was founded in 1837, the company has extended its heritage of integrity, quality, commitment, and innovation around the globe.

John Deere has been involved with the MIT System Design and Management Program (SDM) for over four years. John Deere recognizes that systems engineering is a critical competency for managing the complexity of current and future products and services. Its goal is to move from a component-centric organization to a systems-centric organization, one that seamlessly integrates mechanical, electronic, hydraulic, power, information, and communications technologies.

To find SDM certificate program candidates in our diverse, decentralized company, we have organized a Nominating Team consisting of engineering managers and senior engineers who advocate the systems engineer approach. The Nominating Team members span each business unit and most of the design engineering centers in John Deere. Each team member identifies potential SDM certificate candidates in their business unit, often working within the business unit's human resources process. Then the team member works with the individual's supervisor to ensure the candidate's qualifications using a matrix, similar to a trade-study, with must-have "needs" and scored "wants" criteria. These include a range of qualities, from basic engineering skills to leadership and systems thinking abilities.

Finally, the team meets to review all candidates and their evaluations to make sure each is qualified, and we can reach consensus on the pool of candidates as a whole. At that point, we inform the candidates so they can decide whether they have the interest and can make the commitment to the program.

Over the four years John Deere has sponsored students for the SDM program, 40 engineers from around the enterprise have participated in the certificate program, and four are currently pursuing master's degrees.

Here are three examples of what certificate candidates do at John Deere and what they have learned from the program:

Genevieve Flanagan is the test laboratory automation lead for the John Deere Power Systems' Engine Engineering Test facility located in Waterloo, IA. In this role, she is responsible for developing and coordinating all of the software, databases, and applications in the automated engine test cell system.

Flanagan completed the SDM certificate program in 2009, and is now a member of the 2010 SDM master's program. She has a bachelor's degree and a master's degree in mechanical engineering.

During the certificate program, Flanagan's cross-unit team developed an architecture for a sensor network optimized for the worksites that John Deere serves. Creating a network that provides a means for worksite data to be collected is a critical enabler for an integrated decision support system for customers.

Robert Haun is a senior engineer in Advanced Research and Development. He has been with John Deere for 12 years and has a bachelor's degree and a master's degree in mechanical engineering. He is currently working on a robotic military vehicle program in the roles of lead systems engineer and lead mechanical engineer. He is involved in the development and integration of drive-by-wire solutions onto base production utility vehicles and the integration of high-level robotics technologies. He interfaces with technology partners to incorporate customer-specific payloads and with military customers for requirements-gathering, demonstrations, training, and deliveries.

Haun was in the first SDM certificate program group to be sponsored by John Deere. His team's capstone project utilized tools from the program to select EPA Tier Four engine emissions solutions for the 25 to 40 Hp tractors. Through Pugh concept selection, they found that they needed to change their focus from assigning values to criteria as in a typical decision analysis to developing new concepts.

Tyler Schleicher is senior systems engineer in JD Intelligent Vehicle Systems. He has been with John Deere

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SDM Best Thesis Prize awarded for grid-scale energy storage research

By John Kluza, SDM ’08

John Kluza
SDM ’08

***Editor’s note:** John Kluza was awarded the SDM Best Thesis Prize in October 2009 for his thesis, “Status of Grid-Scale Energy Storage and Strategies for Accelerating Cost-Effective Deployment.”*

The electric grid is so ubiquitous in the modern world that its presence and functionality are taken for granted. However, there are increasing challenges to the continued success of the electric power system, including the growing need for dependable electricity, the desire for improved system efficiency, the influx of intermittent renewable generation, and the limitations of aging, expensive grid infrastructure.

As a student in MIT’s System Design and Management Program, I became keenly aware of these issues during my summer 2008 internship at A123 Systems, a lithium ion battery manufacturing startup that was founded on MIT technology. While there I learned that work was under way to build and pilot grid-scale energy storage systems using A123’s batteries. Large-scale energy storage promises to solve many of the grid’s current problems, so this project—based on one of a variety of emerging storage technologies—fascinated me and got me curious about how such systems might be deployed cost-effectively.

This started me down the path of my thesis topic. First, I identified all the unique benefits that could be produced by grid storage, based on a variety of secondary sources and discussions with forward-thinking utility representatives. I also gathered information on what financial benefits could be produced. These benefits could be found throughout the electric grid value chain—from generation to transmission and distribution (T&D) to customer loads (see Figure 1).

Most of the energy storage applications fell into two categories: 1) “energy-oriented” applications that could be accomplished using long-discharge batteries (for example, storing low-cost energy produced off-peak and delivering it back to the grid during peak periods) or 2) “power-oriented” applications that require fast-responding, brief-discharge batteries (for example, frequency regulation, which resolves momentary imbalances between electric generation and load).

Each of these categories has its own system requirements, and each individual application also has further unique requirements of the grid storage hardware. Through my secondary research, I developed a list of 14 energy-storage applications with estimated financial benefits ranging from $72/kW installed over 10 years to $1,649/kW installed over 10 years.

I then identified which types of energy storage technology could be used for these applications and, for the purposes of my thesis, constrained my work to distributed systems with more than five minutes of discharge time (denoted by the red circle in Figure 2). The major types of technologies investigated were sodium-sulfur batteries, flow batteries of the zinc-bromine and vanadium redox type, lithium ion batteries, advanced lead acid batteries, and high-speed flywheels.

Through discussions with storage manufacturers as well as secondary research, I identified the unique advantages and estimated cost of each technology. The capital costs for these systems varied widely, from $370/kW to $4,000/kW measured by power, or from $347/kWh to $8,000/kWh measured by energy. Systems were generally more appropriate either for power or energy applications as reflected by the capital expenditure (capex) per unit of energy stored or power capacity. Systems were also evaluated using another metric that is more meaningful for comparing energy applications to natural gas peaker plants and

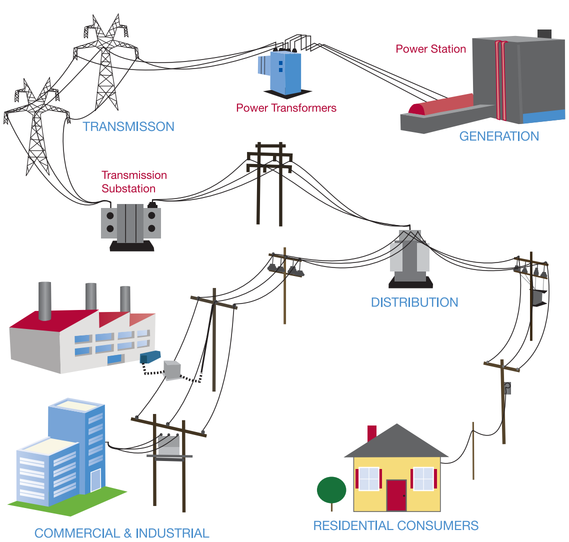

Figure 1: Electric grid value chain

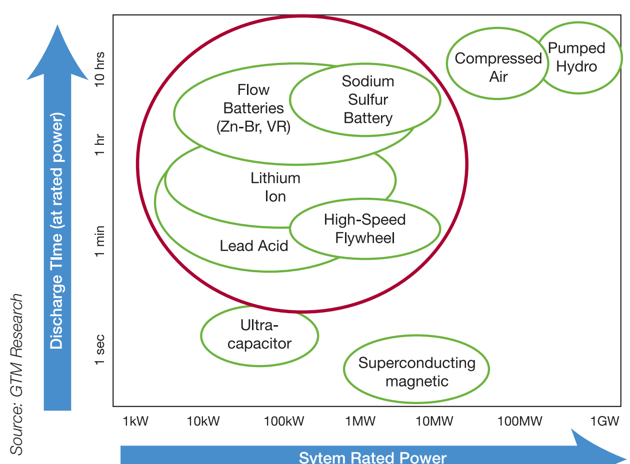

Figure 2: Comparing power and energy ability of energy storage options

natural gas combined cycle gas turbine (CCGT) plants. It is called cost per kWh cycled, and it measures both efficiency and cycle life as well as capex per unit of energy stored (Figure 3).

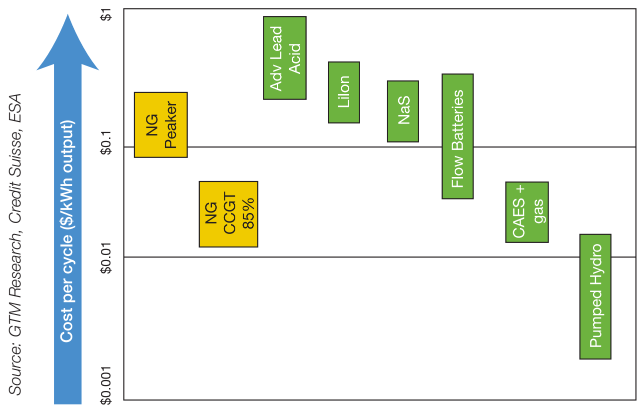

Figure 3: Capital expense per kWh cycled

		Zn-Brflow Battery	VRB Flow Battery	NaS Battery	Lithium Ion Battery	High-Speed Flywheel
1	Wholesale Load Shifting	-	-	-	-	-
2	Renewable Power Management	0	-	-	-	-
3	T&D Capacity Deferral Focused	+	-	-	-	-
4	Ancillary Services Focused	-	-	-	+	+
5	Community Support	-	-	-	+	-
6	Industrial Energy Management	+	-	0/+	-	-

Figure 4: Profitability expectations

Finally, I distilled the majority of actual or proposed distributed grid-scale energy storage options into six classes, estimating the maximum benefit produced for each based on the combination of applications that could be supplied simultaneously. I then reviewed each class from a technical feasibility and regulatory perspective and estimated the cost of a grid storage system based on each type of technology. The expected maximum benefit was compared to the expected cost to identify which combinations of applications and technologies could potentially produce a cost-effective installation. Due to the approximate nature of the available data points, the estimation was restricted to: likely to lose money (-), likely to roughly break even (0), or likely to offer a positive net present value (+), as shown in Figure 4 for the installation classes and technologies investigated.

This research led me to draw a number of useful conclusions, including identifying many markets for grid storage of varying maturity, size, and value. Frequently the best approach to deploying a cost-effective installation in these markets will include combining applications that have easy-to-accrue benefits. Additionally, while not necessarily grid scale, displacing oil- or diesel-fired generation is often cost-effective and can be an entry point for suppliers.

More specifically, I found that there are classes of installations that may make economic sense given the proper conditions. For example, the power-oriented market is attractive now with existing technology. The most accessible application in this market is ancillary services, such as frequency regulation, because energy storage is exceptionally well suited to provide it and there is an open, cash market for these services in some regions of the United States. Lithium ion systems can currently be used cost-effectively for ancillary services and in the future can potentially provide community energy storage. High-speed flywheels are expected to become attractive for ancillary services in a few years. (See Figure 4.)

I found that the energy-oriented market opportunity is currently limited both for cost and regulatory reasons. Distributed energy storage systems still need to reduce their cost per kWh cycled to be competitive. Also, for many applications there is no clear mechanism for paying the owner of the grid storage system.

Nevertheless, sodium-sulfur batteries, currently the most common technology, are attractive in the near term for industrial energy management in many regions, including the United States. Other applications are also attractive in foreign countries, such as Japan, that have different electric system constraints and regulations, including renewable power management, wholesale load shifting and T&D capacity deferral. Additionally, zinc-bromine flow batteries are expected to be attractive in the near- to mid-term for T&D capacity deferral, industrial energy management, and renewables management.

Across the board, it is complicated for the owner, such as a utility, to accrue all the financial benefits generated by the grid storage system due to the interdependent nature of the electric grid. Some benefits are produced as avoided costs instead of cash, and the regulations governing the electric grid are not always conducive to creating and collecting the benefits. The importance of regulation and government policy in making these systems economical cannot be overstated.

Though there are many challenges for storage on the grid, I am optimistic that energy storage will ultimately strengthen the grid and enable cleaner, less expensive electricity. I hope that this research will help to clarify the topic for readers so that more work can be done on the topic, accelerating the deployment of grid-scale energy storage.

SDM thesis explores disruptive technology in cloud computing

By Alex Krikos, SDM '09

Alex Krikos
SDM '09

***Editor's note:** In this article, Alex Krikos summarizes the research he conducted for his SDM master's thesis, "Disruptive Technology Business Models in Cloud Computing"*

The term "cloud computing" is just now gaining traction in the marketplace, but the idea of creating a scalable and flexible shared computing solution via the Internet has been around for more than a decade. Today, cloud computing is steadily replacing more rigid software and services licensing models, thanks both to an improvement in technological capabilities and to changes in marketplace demands.

As I contemplated investigating cloud computing as a research topic for MIT's System Design and Management Program, I considered how on-demand and utility-based computing resources have been used in the past. Over 10 years ago, Hewlett-Packard used its expertise in workstations and servers to host applications in a network-based and time-shared environment. What was lacking was a sophisticated, three-tiered framework of building blocks to manage data centers, develop applications and platforms, and deploy applications and services. These building blocks have become the foundation of cloud computing.

Today, cloud computing has all the markings of a disruptive technology—those that change the game as it's currently played both by traditional software licensing businesses as well as by private, on-premises data centers. Cloud computing offers greater scalability, utility-based pricing, and ubiquity among applications, consumers, and potentially among cloud computing vendors. The drawbacks in the so-called *public cloud* include security, compliance, and enterprise information technology (IT) control.

To analyze whether cloud computing could be considered a disruptive technology, I tested three criteria as developed by Harvard Business School Professor Clayton Christensen in "*The Rules of Innovation*." The first two focus on the markets that cloud computing impacts, and the third centers on the ecosystems that support its success.

1. Cloud computing as an innovation must enable less-skilled and/or less-wealthy individuals to receive the same utility as was previously available only to more-skilled and/or more-wealthy customers.
2. Cloud computing must target customers at the low end of a market with modest demands on performance. However, it must do this with a performance trajectory capable of exceeding those demands and thus take over markets tier by tier. As a corollary to this second criterion, the cloud computing business model needs to allow the disruptive innovator to achieve attractive returns at prices that are unattractive to the incumbents.
3. Cloud computing must be supported by an ecosystem structured as either a fully integrated single entity or a set of modular, niche entities.

As shown in Figure 1, cloud computing emerges as a disruptive technology when the evolution in traditional software licensing and premises-based technologies outstrips the market's ability to absorb it. While there is no single, composite performance metric for the software and services domain, the constituent elements include security, cost, application management, ease-of-use, scalability, and enterprise IT control. Figure 1 diagrams the strengths, weaknesses, opportunities, and threats (SWOT) that define the incumbent software licensing and premises-based data center landscape along with disruptive cloud-based solutions.

Based on my research and my 20 years of experience in the computer industry, I placed the competitive landscape and SWOT for the incumbent license/premises-based data center at the high end of customer demands where performance is sufficiently high to outstrip market demand. This is where the incumbent technologies are most vulnerable to disruptive technologies.

The incumbents' strengths include high levels of security, compliance, and enterprise control. However, the traditional license/premises-based data center is vulnerable to highly scalable, low-cost cloud computing providers. The emergent cloud computing disruptive technology has strengths in scalability, virtualization, and low-cost, utility pricing. While it has drawbacks in the realms of security, enterprise control, and open standards, cloud computing is a disruptive technology because it not only offers low-cost solutions at lower initial performance levels, but also has a performance trajectory capable of meeting and exceeding market demands over time. Analysts including Forrester and Frost & Sullivan assert that end-to-end cloud computing providers such as Amazon, IBM, HP, and Savvis are committed to continuous performance improvement.

In the future, cloud computing is likely to make significant gains in security and compliance-rich applications, which are essential requirements of an enterprise-grade cloud.

However, enterprise control will likely remain a significant weakness as the cloud engenders third-party control. Analysts suggest that progress in open standards and private/public hybrid clouds may take as many as five years to gain traction. It is also likely that the cloud computing landscape will be fraught with competition between single end-to-end solution providers and the individual modular firms that make up its ecosystem.

The performance trajectories of cloud computing and the market's ability to absorb them, while notional, are expected to increase over time as modular firms such as 3Tera and Citrix push the performance envelope for open standards and virtualization. However, even as cloud computing takes hold as the dominant computing paradigm, it can be expected that this technology will once again outstrip the market's capability to absorb it—leading to new disruptive technologies. For example, as applications in the public cloud come under increasing scrutiny in the security and compliance arenas, hybrid clouds will likely emerge as a new disruptive technology.

Cloud computing satisfies the three market and ecosystem criteria outlined above for disruptive technologies. First, the inception of the public cloud and its next-generation advances in hybrid cloud technologies allow those with modest means to secure the same computing services that only those with greater means could formerly obtain. Second, the public cloud and its evolutionary improvements target the low end of the market, at an initial reduction in performance, but with a performance trajectory capable of meeting and exceeding market demands.

In addition, the emergent disruptive technology firms in cloud computing are able to make attractive returns, at prices unattractive to incumbents, as a consequence of the cloud's value proposition of shared environments, which defray costs among a large subscriber base. Third, cloud computing has an ecosystem emblematic of a true disruptive technology. Leaders in cloud computing have been represented by fully integrated, end-to-end solution providers and by collections of niche, modular firms.

In conclusion, the future of cloud computing is moving toward more ubiquity, as greater demands from customers and greater capabilities from providers unfold. There are a number of market drivers that are orthogonal to the more well-known advantages of cloud computing. Most of these market drivers focus on the increasing presence of entrepreneurship. In the next decade, the number of baby boomers will vastly increase where entrepreneurial opportunities are more feasible than corporate ones. In addition, the immigrant workforce will play a vital role in the adoption of cloud computing. My research indicates that first-generation immigrant Americans are 70 percent more likely to choose entrepreneurial professions than are native-born Americans. Cloud computing will be a catalyst to entrepreneurship—lowering prohibitive cost and time barriers to entering a host of businesses ranging from financial services to health care.

However, cloud computing providers shouldn't rest on their laurels of scalable, virtualized, and utility-based solutions. It would behoove the astute cloud computing provider to incubate separate business units that address disruptive technologies in the areas of security, compliance, enterprise IT control, and open standards, which had formerly excluded low-end markets.

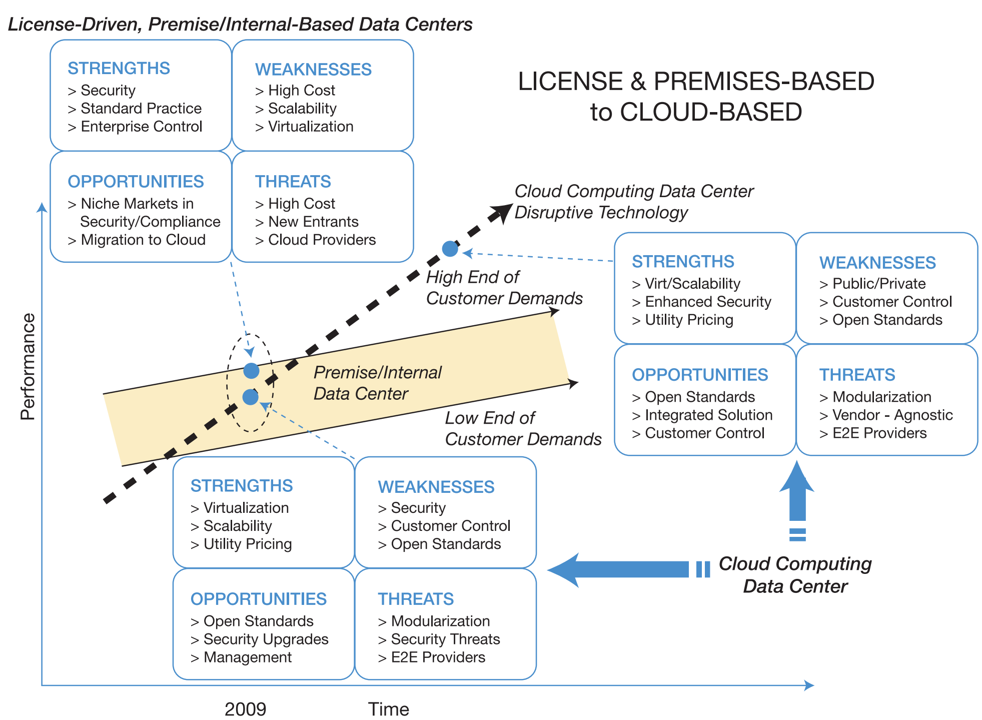

Figure 1. In this graph, the yellow band represents the range of customer demands, which rises over time. The current state of technology, represented by a dot, is at the high end now—but does not hold the promise of cloud computing. Indicated by the dotted line, cloud computing is shown as likely to exceed rising customer demands over time—making it a disruptive technology. The strengths, weaknesses, opportunities, and threats of the different scenarios are also labeled.

Bridging the gap: A look at the Industrial Relations Committee

By Matthew Thompson, SDM '09

Matthew Thompson
SDM '09

As an engineer with nine years of experience in the medical device, defense, and space industries, I've had the opportunity to work on exciting products with great potential, only to see some fail due to a poorly informed decision or a misguided understanding of a customer or stakeholder. The frustration of seeing hard work destroyed on a whim drove me to seek change. I decided to pursue graduate education through MIT's System Design and Management Program (SDM) to answer the question: How can I help individuals and organizations make better decisions?

Now a year later, after many late nights and countless group meetings spent with exceptional colleagues from varied personal and professional backgrounds, SDM has led me to an answer. I have developed a solid base of knowledge and tools that allows me to understand, analyze, evaluate, and communicate solutions to those who need them. As daunting as the challenges of the business world are, I have the confidence to tackle them and lead the design and management of complex systems.

The Industrial Relations Committee's December 9, 2009, meeting was attended by, clockwise from bottom right, James Peruvankal '10, SDM Industry Codirector John M. Grace, Jui Lim '09, Amith Pervaje '09, Operations and Partner Integration Director Jon Griffith, Leyla Abdimomunova '09, Cyndi Hernandez '09, Charles Atencio '09, Juan Spiniak '09, and Arjun Shrinath '10.

With my original question answered, I began to ponder a new one: How do we educate the business world about the value of SDM fellows? An MBA or master's in engineering is common and easy to understand, but an MS in engineering and management is rare and little known. Fortunately, the SDM program helped me again. After stepping into the role of chair of the SDM Industrial Relations Committee (IRC) in February 2009, I gained an understanding of this question and am now in a very good position to help answer it.

The IRC is a team rich with diverse industry experiences that is working to communicate the value of SDM graduates to the business world. The student-run committees, including the IRC, are designed to promote the continuous improvement of the SDM program. The IRC is tasked with improving the program's relationship with industry, making it a bridge between SDM fellows and the business world. Over the last year, committee members have worked hard to promote SDM, both internally and externally. Though our efforts have been sincere, we know we can do more.

In 2010, we hope to build on the work of this past year's committee and improve partner companies' access to the knowledge and skills of our diverse student body by identifying opportunities for more participation. From student projects in product design and development to assessing strategies for new, high-technology product lines, we can share the value of the SDM experience with companies and help them improve the bottom line. Through the hard work of SDM Industry Codirector John M. Grace, we are reaching out to partners to identify better avenues of collaboration. Aligning the academic interests of students with the real-world needs of partner companies can generate fresh ideas and new ways of thinking within organizations: systems thinking.

The potential doesn't end with classroom projects. Companies also have the opportunity to connect with talented students and MIT faculty by seeding the topics of academic work—particularly through the SDM master's thesis, which brings students, faculty, and industry together to create new knowledge and products guided by the company's needs. Students want to work on problems that are relevant to the real world, and companies need new ideas to tackle the problems of an increasingly complex business environment. We plan to work more with Grace to facilitate the sponsorship process for interested companies and establish connections to students.

Like the other SDM student committees, the Industrial Relations Committee is a work in progress. With a blank slate before us at the start of the year, the members of the IRC seized the opportunity to pursue the growth and improvement of our program. In the face of the frustrating hiring conditions of a weak economy, we've taken up the role of raising the visibility of the program. A recent initiative to evolve the content and design of our website is in progress with changes taking place soon. We have also collaborated with our dedicated career development director, Helen Trimble, who has worked to increase the program's visibility in career fairs and directly with potential hiring companies. Trimble has campaigned to promote the value, experience, and special skills SDM students bring to employers.

Another effort the committee has taken up this year is the development of a speaker series. Invited guests from

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SDM students puts lessons to work in wake of Merck merger

By Anando Chowdhury, SDM '09

Anando Chowdhury
SDM '09

Editor's note: *Anando Chowdhury is director of Organizational Strategy, Management, and Operations for the Global Science, Technology & Commercialization organization at Merck/MSD, which sponsors his enrollment in MIT's System Design and Management Program (SDM). In this article, Chowdhury discusses how the lessons he's learned at SDM are benefiting his company.*

The merger of Merck and Schering-Plough last year brought together two major science-based health-care companies. The new Merck/MSD offers a more diverse pipeline of products, consisting of drugs, vaccines, and biologics, and promises to become a more far-reaching global entity—helping millions of people with innovative health-care products.

In the days and months that followed the approval of the merger, I got the opportunity to help the new company begin some of the most challenging and exciting work of the whole process—operational integration.

I have the distinct privilege of working on the leadership team of a technical organization called Global Science, Technology & Commercialization (GSTC) in Merck's Manufacturing Division. GSTC is accountable for the stewardship of manufacturing technologies within Merck as well as the product and process development, commercialization, launch, and support of Merck drugs, vaccines, and biologics. To fulfill the promise of a new kind of health-care company, it is at this functional level that the real merger must happen, and I've found the work to be both complex and rewarding.

Mergers of this magnitude don't happen that often, and when they do, the stakes are extremely high. Doing the right things at the right time and in the right way is crucial. This is where MIT's System Design and Management Program (SDM) was able to make a strong contribution.

I have found SDM's mindset, methodologies, and tools applicable to many of the challenges I have faced during this integration process. During the early days of the new company, I was exposed to the system project management work of Olivier de Weck and James Lyneis, as well as the lean enterprise work of Deborah Nightingale—all three MIT faculty members. These frameworks have been influential in helping me to shape Merck's new organizational structure. Here are some examples:

System models serve as tools for conceptualizing what to expect during the merger

When two large and successful companies such as these come together, the integration work flows in two directions. Initially, decisions are made at the company level. This involves tasks from the pre-deal business case development all the way to the execution of successful integration plans. These are strategic decisions that have implications for every division in the company.

At the divisional level, decisions focus on the tasks required to manage a major operating area of the joined company—e.g. manufacturing or research and development. Those decisions then need to be translated down to the the functional level of my organization, GSTC. We are looking at the tasks required to integrate the two companies at the lowest level, including work practices migration, organizational designs, and most importantly, the implementation of hybrid solutions and best practices from both companies until we become a new, more powerful whole.

To understand this dynamic, I utilized a very simple system dynamics model (shown in

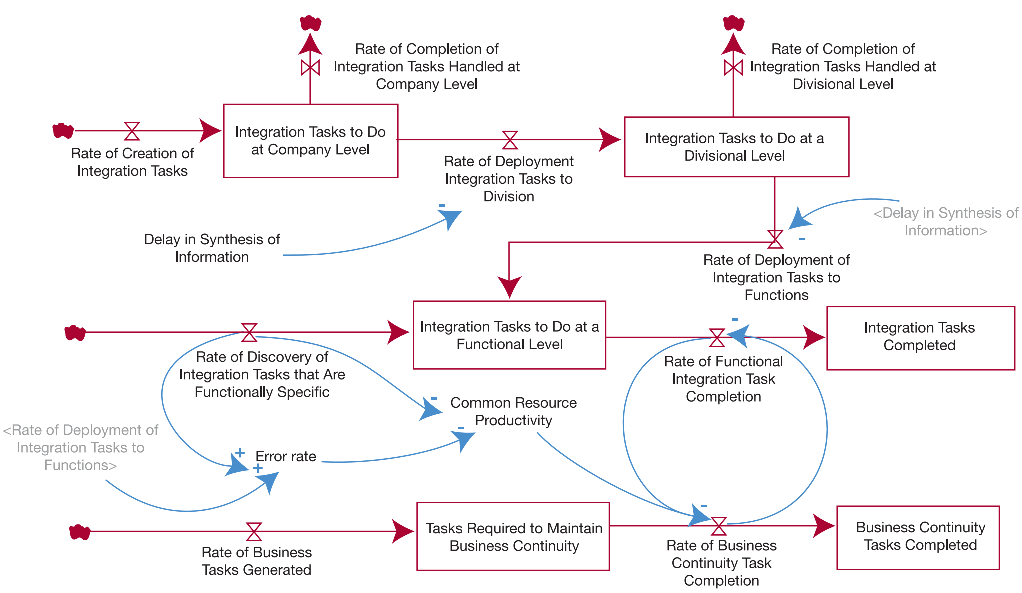

Figure 1. This systems dynamics model was developed to help visualize what to expect at various levels of the merger.

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SDM students puts lessons to work in wake of Merck merger

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Figure 1), which I developed with Taroon Aggarwal, SDM '09. Even beyond any numerical quantification, the visualization has been incredibly helpful to understand what to expect and plan for as decisions make their way up and down the various levels during the merger. As de Weck and Lyneis's work has shown, understanding the dynamics of delays and flows of information is critical. It is with this understanding that one is able to make rational choices and plans during integration.

Design structure matrices help company to align strategies and initiatives

Each of the two powerful companies had several strategic initiatives under way at the time of the merger. While integrating at a functional level, it is important to create new ways to manage the initiatives from both organizations more effectively and ensure that overlaps are synergistic and not at cross-purposes. In trying to map these areas of synergy and staging, we are experimenting with using the design structure matrix (DSM), a useful tool for organizing tasks. This tool is incredibly intuitive, and the various groups (often spanning hundreds of project leaders and team members) have been able to map the critical organizational initiatives to a DSM.

Initially, we just mapped and brainstormed the interactions between various initiatives (see Figure 2). But then, we partitioned the DSM and two natural meta-portfolios arose (see Figure 3). Uncovering this underlying structure allows information to be governed, managed, and structured much more effectively. This increases the confidence that we can work toward a system where the whole is truly greater than the sum of the parts.

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Figure 2. Two design structure matrices were created to help map critical organizational initiatives for the Merck merger. This initial diagram shows a simple brainstorming of interactions.

Fostering a lean enterprise mindset helps improve products and processes

As the new organization is being established, we have created a subfunction called organizational strategy, management, and operations (OSMO) that I have the honor of leading. Moving ahead, the installation of a lean operating model will be critical. It is not only critical for ingraining lean and systems thinking into the products we support in manufacturing, but also to the products and processes we design and develop.

We have been incredibly successful in ingraining and utilizing a design-for-robustness mentality in our product development efforts. The frameworks Nightingale presents in her work show clearly how these methods can only succeed if the organizational operations are tied closely to the process results we wish to achieve.

Thus the enterprise itself must be assessed, designed, and perfected. In the coming months, building this system and culture will be critical to achieving the promise of the new company—and it will be a major focus for me and my team. The lean enterprise toolkit provides a roadmap to get there that we will be leveraging heavily.

These are just a few examples of how a system design and management approach can help in the high-stakes environment of a mega-merger. "Given the increasing complexity of our business, it is no longer possible to make strategic advances by focusing on single elements. Using a systems approach, like the frameworks offered up at MIT, will be critical for formulating successful future business strategies," says Senior Vice President Michael P. Thien, who leads the GSTC organization.

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37 - Strategy Management Operations Unit	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		■

Figure 3. This second design structure matrice shows the result of partitioning the DSM, which revealed two natural meta-porfolios.

SDM puts new cohort straight to work on real-world projects

By Kathryn O'Neill, managing editor, *SDM Pulse*

Practice, practice, practice.

That could be the motto of MIT's System Design and Management Program (SDM), because in many ways what sets the program apart from MBAs and other more typical forms of graduate education is its emphasis on learning by doing—*mens et manus*, mind and hand.

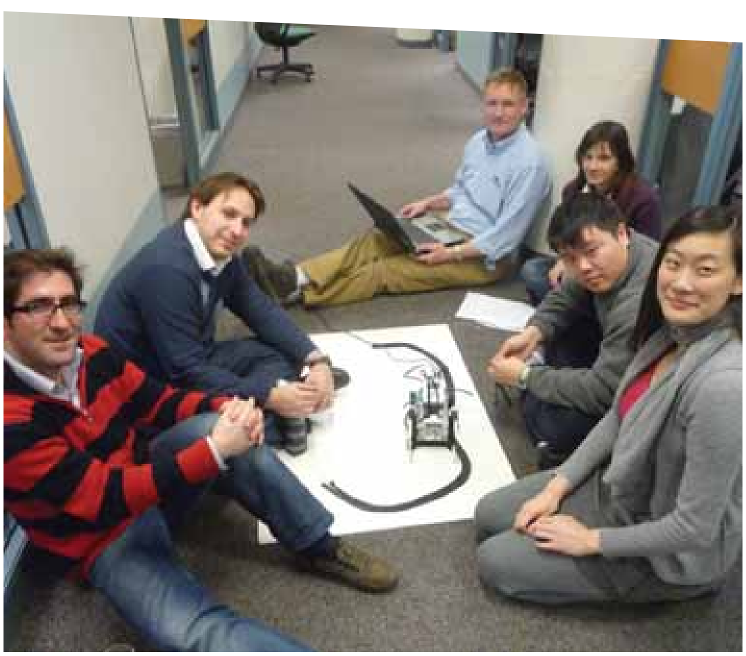
This philosophy is immediately evident during the grueling monthlong January Session (often called "SDM boot camp") that begins the program. Students pack in several hours of classwork each day—taking courses in leadership, probability and statistics, system architecture, and the human side of technology. Plus, they put what they've learned into immediate action in a series of three tough design challenges.

Just one week into the program, SDM students start working on projects for actual business clients. "They get real hands-on experience in as real a situation as possible," said Dr. Guillermo Aguirre, the instructor for this challenge (the second and longest of the three) and the former technology director for Mexico's National Council for Science and Technology.

"Here there's a real market. Someone wants this," said Vijan Bhaumik, SDM '09, one of a group of 14 experienced SDM students who helped run the January Session.

As part of the strategy for the SDM boot camp outlined by SDM Fellows Program Director Pat Hale and SDM Industry Codirector John M. Grace, Aguirre brought in eight companies with a variety of systems problems for the students to tackle. Projects ranged from developing a marketing plan for a new medical monitoring device to creating both a new line of products and a new business strategy for a furniture manufacturer. Each company made contacts available to answer student questions about business needs.

"It's very intensive. Every day for two weeks we spent a couple hours on this," said Jaime Garza Ramirez, SDM '10, a supply chain consultant for Suntec who worked on the office furniture challenge. "We analyzed the product's structure, its form and shape, and then [Aguirre's] consultants helped us build a prototype." Garza Ramirez's team ultimately produced a new cubicle design that provides more usable space by abandoning the traditional rectangular shape for hexagons.



SDM colleagues work on the first design challenge of the January Session—programming a robot with Mindstorm. They are, from left, Rafael Marañón Abreu, Jaime Garza Ramirez, Doug Schofield, Amparo Cañaveras, Billy Hou, and Jennifer Wang.

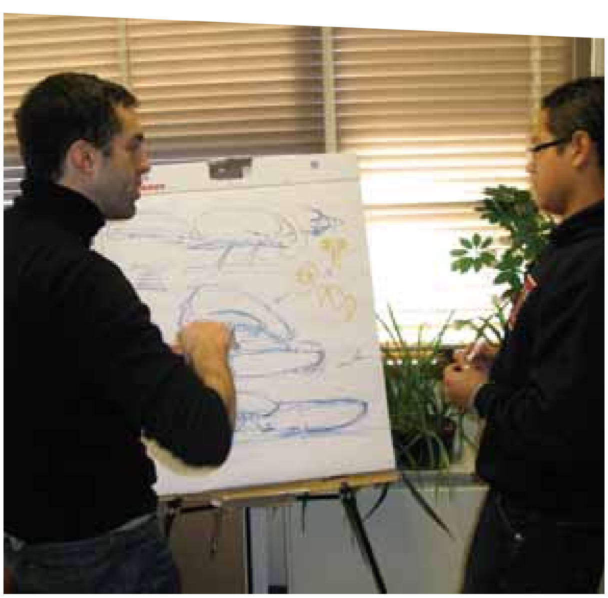
During the second design challenge of the January program, Jen Wang, SDM '10, works on a Halloween mask design prototype for REV, a latex figure and accessories company based in Cuernavaca, Mexico.

At the end of the challenge, teams presented the results of their work to the entire cohort: a new method for killing botulism in food packets; a modernized Halloween mask; a marketing plan for a kitchen scrubber; and more.

"It's the first time I've worked outside of software," said Rutu Manchiganti, SDM '10, whose team worked on a new design for a high-end obstetrics table. "You quickly find what you do well and what you don't. And for what you don't, you learn to find a teammate who can help."

Learning to work well in teams is one of the fundamental lessons of the January Session, which is why the first design challenge focuses primarily on building the team skills students will need throughout the SDM program. For this challenge, students were split into teams and given five days to assign tasks, form strategies, build, program, prototype, and test their designs for a robot competition.

Of course, programming Mindstorm robots is easier than solving major systems problems for a company, so Aguirre provided some assistance for the second challenge. He worked with the companies to properly frame the problems in advance. And, since the students only had two weeks for this challenge, Aguirre brought in a team of industrial designers to help build working prototypes.



Blade Kotelly, SDM '10, works with industrial designer Alberto Soto, right, to conceptualize a new product for Mexican sponge manufacturer Somaki.

"The students had to test their designs," Aguirre said, noting that the students who worked on furniture, for example, were able to actually sit at a prototype desk and see for themselves how well it functioned. "That is experience. You cannot simulate that," he said. "Amazingly, a lot of products that go wrong, go wrong because the designers never got their hands on the actual product."

"I think—I hope—that we have actually delivered some value to this company," said Jess Posey, SDM '10, whose team explored ways to commercialize intellectual property for a Mexican research and development institute.

Aguirre definitely saw value in the team's results. "In some cases I couldn't see any way of getting a better result for the company. They just did a superb job," he said.

One company representative who was able to attend the final presentations agreed, remarking that her organization definitely planned to put the students' ideas to the test.

The January Session ended with a third challenge, in which students were asked to research one of three major systems issues: improving large-scale disaster recovery (e.g. earthquake, tsunami, hurricane); enabling economic development with minimal carbon impact; or promoting the study of science, technology, engineering, and mathematics (STEM).

Each team had to decompose and/or define the problem and make a connection to a local nonprofit working to address that problem. In their final presentations, teams explained why SDM should support the organization of their choice. Winning organizations—the Tzu Chi Foundation (disaster recovery); the Appropriate Infrastructure Development group (carbon impact); and the Museum of Science Engineering Is Elemental program (STEM)—each received $500 from SDM.

Posey remarked that although his first weeks at SDM were definitely like "drinking from a fire hose," he is already seeing the value of the program. "What I like about this is there's some realization that engineering and technical functions can't exist all by themselves," he said, comparing SDM to the program he attended to get his MBA. "At the end of the day, cool as it is, the question is: Will the customer buy it?"

NRC nominee who teaches SDM students praises program

By Kathryn ONeill, Managing Editor, *SDM Pulse*

Professor George Apostolakis

As President Obama's choice to become a member of the US Nuclear Regulatory Commission (NRC), MIT Professor George Apostolakis is no stranger to systems challenges.

At the NRC, "90 percent of problems are systems problems," Apostolakis said. The work is multidisciplinary, involving not only "hard" disciplines such as nuclear reactor physics and materials science, but also the inevitable challenges of managing people and preventing human error.

Nevertheless, Apostolakis said he's found traditional engineers find it very difficult to accept that human issues are so important. "They consider it 'soft,'" he said.

> **'You can't be the leader of a company and be an equation kind of guy. You need a broader view.'**
>
> Professor George Apostolakis

MIT's System Design and Management Program (SDM) is valuable precisely because it zeroes in on these kinds of problems, said Apostolakis, who has taught SDM students since the program's inception. "You can't be the leader of a company and be an equation kind of guy. You need a broader view," he said.

"Not to diminish detailed engineering work, but this by itself is not enough," he said. "A lot of difficult and interesting problems that have a societal element to them are really systems problems."

The KEPCO professor of nuclear science and engineering as well as a professor of engineering systems, Apostolakis teaches a course in engineering risk benefit analysis (sometimes referred to as ERBA). The class introduces SDM students to risk assessment, decision analysis, and cost-benefit analysis—three major approaches to solving problems through the use of probability theory. The goal is to expose students to real-life problems that are systems-based and to give them tools with which to address them.

In every module, Apostolakis invites guest speakers to provide students with examples from their experience. He's had representatives from NASA explain how they assess risk before a space launch, for example, and how they conduct tradeoff studies to explore the value of alternative designs.

Members of MIT's Department of Facilities have also come to class to explain how they prioritize the infrastructure renewal process on campus by applying decision analysis, a methodology that helps managers to analyze and compare choices.

Facilities might consider whether delaying a project will pose any hazard to humans, how much it will cost, how much disruption the work with cause, and how long it will take. Once various factors have been weighed and the methodology applied, the result is a clear and logical ranking of options, Apostolakis said.

"It's a very practical application," said Apostolakis, noting that the decision analysis module is universally popular with students.

In addition to teaching ERBA, Apostolakis has also served as thesis advisor to a number of SDM students over the years. In particular, he remembers one who evaluated the water supply of a city to determine its vulnerability to terrorist attack. The city found the material useful in its decision-making, he said, which is not always the case with academic work.

Another SDM student considered what NASA could learn from its experience with past technologies to estimate the reliability of new systems (the so-called "heritage problem"). "I was very pleased" with that project, Apostolakis said.

"SDM students are usually more mature (than other ERBA students) and more willing to deal with systems issues," Apostolakis said. "A program like SDM—it's a great thing."

SDM grad reaps benefits from program's leadership training

By Oz Rahman, SDM '09

Oz Rahman
SDM '09

When I joined MIT's System Design and Management Program (SDM) in January 2009, I knew that the program had recently revised its curriculum to place an increased emphasis on "leadership." But I'll confess I didn't really know what that meant. How do you teach leadership?

What I've discovered is that SDM does not depend solely on theory, but emphasizes practical leadership skills through case studies, role playing, guest lectures, world-class professional coaching, and a variety of self-assessment tools combined with guided self-reflection. Unlike the conventional MBA program I completed previously, SDM's practical focus on leadership can make an immediate impact on students' academic, personal, and professional lives.

During my time in the program, I particularly benefited from a tool known as a 360-degree feedback assessment. This provides feedback on an individual's performance from information gathered from a representative sampling of managers, peers, and direct reports at his or her workplace—using web-enabled surveys. Confiden-tiality is maintained throughout the process, as feedback is elicited by an MIT-sponsored assessment provider and responses are combined into feedback categories for each student.

At SDM, a professional coach reviews the assessor feedback and then shares this feedback with the student in a private coaching session. The coach helps the student to interpret the feedback and determine a development plan that will enhance the student's professional performance. This process is completed during SDM's intensive, month-long SDM boot camp in January—the starting point for each SDM cohort. Therefore, it helps to establish an important baseline for student performance. It is also a good example of the way in which leadership activities are firmly embedded within the context of SDM's principal objectives—a unique aspect of the program.

For me, the 360-degree assessment was an awakening. I arrived at MIT after two and a half years at Harley-Davidson where I had been promoted twice and reached the position of Master Black Belt for the company's Six Sigma program. I felt like I was on top of the world.

What I learned in the 360-degree assessment is that my personal feeling was apparent to everyone in the workplace. Consequently, I rated poorly in my ability to work with and influence others. While I had thought I was very influential (I always got my way, didn't I?), I learned that I was really a bully. I was pushing my initiatives and ideas with little regard for the thoughts and concerns of others, while fueling resentment among my team members.

Because I had always thought of myself as personable and well-liked, this feedback was extremely valuable in helping me see how those I worked with perceived me. I understood that though our team was achieving results in the short term, if my teammates did not truly buy in to what we were doing, these results would not be sustainable.

I was able to apply my learnings on the job immediately because at the time that I joined SDM, I was also starting a new career. I was working as a senior manager of quality assurance at Boston-Power, a lithium ion battery producer, and viewed my new position as an opportunity to improve my collaborative skills and become a true leader. I began constantly seeking input from others, brokering agreements between multiple stakeholders, and proposing mutually beneficial solutions rather than pushing through my own agenda or ignoring opposing viewpoints. (The criticality of stakeholder alignment is a principle that occurs repeatedly in the SDM program and one that is intimately linked to the effectiveness of SDM's leadership development activities.)

The change has been reflected in the next 360-degree assessment I took as part of SDM's course, Leadership: The Missing Link, taught this past fall. I was able to compare and contrast the feedback and measure my growth. Not only did feedback from the second assessment indicate a more collaborative working style, it also showed clearly that one of my skills that Boston-Power values most is collaboration.

Because our business is global, I am constantly balancing the needs of diverse stakeholder groups in the quality services that my team provides. The second 360-degree assessment highlighted my ability to align stakeholders and subsequently develop systems that met all stakeholder needs. This behavior would not have been part of my working style had I not received the feedback from my original 360-degree assessment nearly a year earlier and the support given to me by the coach, the SDM faculty, and my fellow students.

Of course, the 360-degree assessment is just one of the

> continued on page 22

Entrepreneur employs SDM lessons in business launch

By Ken Huang, SDM '05

Ken Huang
SDM '05

I have always wanted to become a successful entrepreneur, and with the help of MIT's System Design and Management Program (SDM), I am now well on my way. I founded Sayagle Inc. in January 2009 to meet the need I saw for an online social marketplace —a one-stop site that combines the best elements of such websites as Facebook and Amazon.com, but with new features that are uniquely our own.

Our mission at Sayagle is "to provide a location-based virtual marketplace that empowers friends, family, and merchants to enhance life beyond the screen." What that means is that rather than go to Facebook for social networking, Go Daddy for e-commerce hosting, and Google Latitude for online and mobile advertising, for example—you can do it all at Sayagle. And, the information we give users is relevant to where they are—so they don't go looking for Korean restaurants in Boston and find ones in Chicago.

Already the company has a staff of 34 and about 30 paying business customers. (One of our first clients, nexiwave, is a professional conference call services company founded by SDM alums.)

How did I get here?

Like virtually all SDM students, I arrived at MIT with several years of business experience already in hand. A software engineer by training, I had worked at Lucent Technologies and Nortel Networks, and had risen to the position of assistant vice president for technology at JP Morgan Chase.

But the skills I learned at SDM—and the people I met there—have helped me to take my career to another level. For example, the class in system architecture helped me to identify object protocol model (OPM) attributes and define value. At Sayagle, we are creating value-added services for consumers and merchants simultaneously—users can purchase items or services at the best prices, and merchants can reach their target audience quickly and with significant sales volume.

We're doing this by creating a symbiotic relationship between merchants and consumers.

Sayagle merchants provide the content and conditions of their deals to Sayagle, which in turn promotes the deals to users. Sayagle's proprietary recommendation engine passively observes and adapts to the social networking behaviors of both user and merchant and then matches consumers with the best deals and merchants with the best customers.

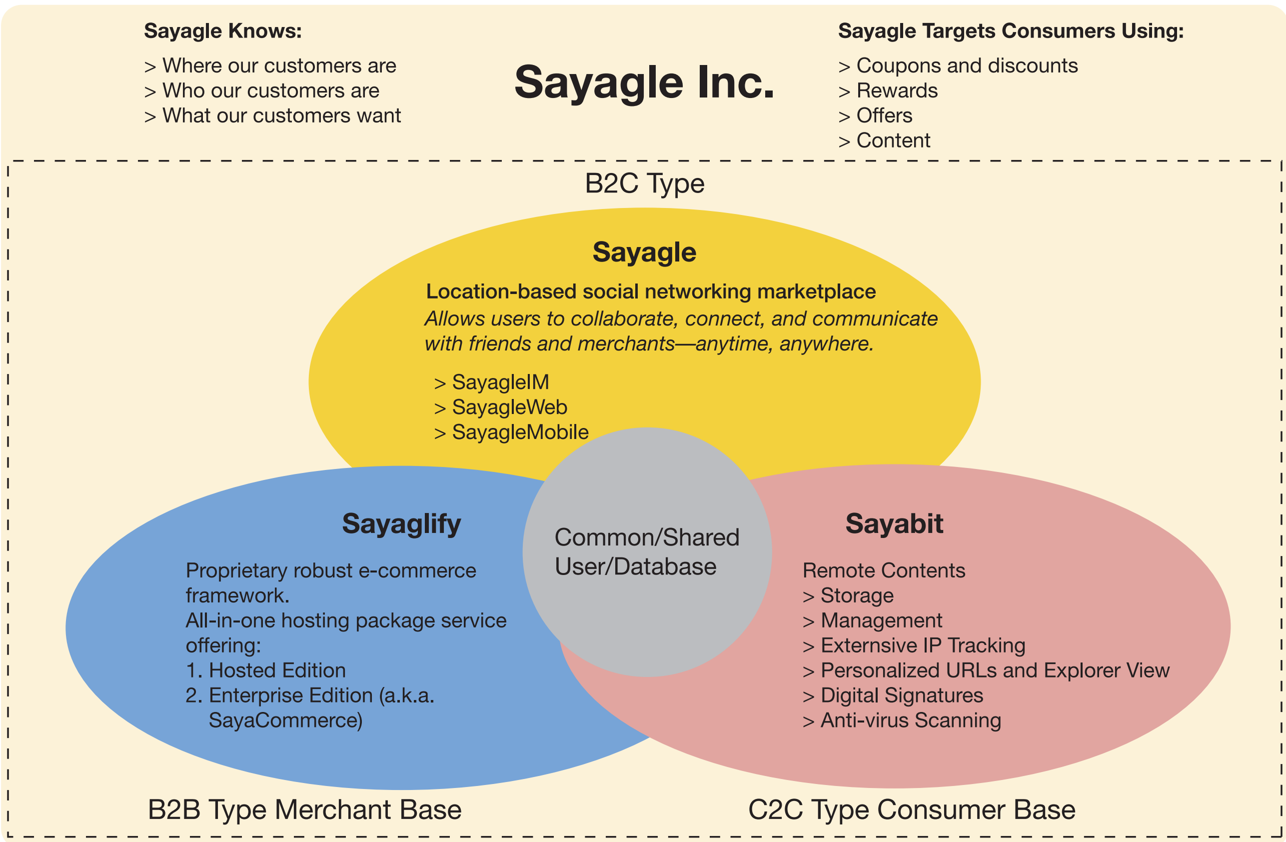
This recommendation engine is a key Sayagle difference, and I was able to create it thanks in part to the statistical models introduced in Engineering Risk Benefit Analysis, an SDM class taught by Professor George Apostolakis (see article, page 14). Sayagle maps the selections that a user has made in the past and uses a proprietary algorithm to identify the degree to which he would like a certain item that he has not seen yet.

The engine intelligently matches the items that have the highest probability score for user purchases, providing the merchants with the most relevant cities with the highest density of a target audience for its product offerings. Simply, it matches the users and merchants with the highest success rate for reaching a business transaction at any given time.

Once I had developed my business model, I evaluated the competitive landscape using tools taught in SDM's class in product design and development. Understanding all the critical path variables in my system and staying attuned to all of my competitors will help me to keep Sayagle on course at all times.

I have also used systems dynamics and system architecture principles in building the company itself. I took a holistic view of workflow and filled in-house jobs as necessary—beginning with developers, who needed to be employees because we're still in a stealth mode—and was able to get the technical team up in four months.

In launching Sayagle (which is largely self-funded), our goal is to provide a paradigm shift from traditional broadcast-based advertising to social-based and proximity-based advertising. I believe e-commerce is the future for all business, and having a web presence is essential. So, in order to grow our customer base, we are providing free web hosting services to many users to bring them on board. Currently, we are focusing our attention on small and medium-sized businesses, which understand the importance of having a web presence



and are seeking affordable payment plans.

This initial application, which we call Sayaglify, not only provides funding for the company, it forms the beginning of the merchant community that we need in order to provide interactive communication between consumers and merchants. This site is already up and running.

The next application, launched in February and called Sayabit, provides consumers with remote content storage (e.g. for photos). To seed this group and build our base of consumers, we are currently offering free hosting to student groups.

Sayagle itself will connect these two groups, providing instant messaging, web, and mobile access to all the site's features. Data portability will be a key feature within the Sayagle domain, with users able to access or share personal data and provide location-based contextual information via mobile devices.

It is, I hope, a systems solution to the expanding problem people face of having too much electronic clutter in their lives.

Much work remains to be done, but I am confident that with SDM's toolkit, I have put Sayagle on the path to success.

Editor's note: *The* SDM Pulse *will monitor Sayagle's progress and provide readers with updates on the business in future issues.*

SDM alumnus applies interdisciplinary skills at Vonage

By Geoff Langos, SDM ’02

Geoff Langos
SDM ’02

Editor’s note: *An alumnus of the System Design and Management Program, Geoff Langos is currently vice president of information technology at Vonage.*

In 2001 I was working for a large telecommunications company. Starting with a mere handful of engineers, I built a team that had grown to 60, was supporting thousands of end-users, and was integral to launching a new business line. The company’s management, impressed by the team’s performance, came to me and asked if I wanted to stay close to the technology or to manage people.

My answer was “yes to both.”

I was being given the classic Hobson’s choice offered to many engineers who enjoy both building things that work and managing the people who do the work: Stay in technology or hop aboard the management train and leave the bench (and their fellow engineers) behind.

Photo: Randy Wishman

Geoff Langos, standing, looks at a simulation of a new mobile product in the test lab with Vonage employees Mahima Ramesh and Christopher Capasso.

I didn’t believe the choice should have to be binary, but when I looked at classic MBA programs to develop management skills I found that although some had courses on engineering management (but didn’t focus on it), most were trying to attract engineers who needed to retool and leave engineering—which I most definitely did not want to do.

For me, the answer was the System Design and Management Program (SDM) at MIT, which I completed in 2004. SDM’s goal is to train engineers to lead, not leave engineering.

I believe that the stereotype of the stubborn engineer who cares only about the problem he or she is trying to solve at any given moment may be exaggerated, but is nonetheless grounded in a reality that people who propose to manage them must learn to address. At SDM, the cases studied are about facing the challenge of both the technical problem and the business problem. In other words, SDM, as opposed to the traditional MBA program, focuses on those unique problems that engineers will have to address while at the same time broadening their perspective to include such business elements as marketing, sales, and finance.

For example, one case I studied concerned a company that made pads designed to go in between machines that drove concrete pylons into the ground. The pad was designed to save wear on the machines and drive the pylons faster. The business problem was how to price and market the pad.

The average or naïve engineer might say, “Who cares? The pad works.” But in business, as in life, there isn’t just one answer. (In fact, the pad didn’t improve performance well enough to justify a price that would ensure profitability.) You have to learn how management is going to think and how engineers are going to think.

At Vonage, one of the IT systems failed recently and I struggled to explain that it really wasn’t a technical failure as much a process and prioritization problem in getting the system upgraded to a new one. Then I remembered SDM’s accident sequence diagram, used in the systems engineering course, and returned to management able to illustrate what had happened organizationally and technically, demonstrating that the failure was not simply an IT problem. If you can’t do that, you lose credibility with the business.

Today, with my business credibility intact, I’m able to stay close to the technology and lead engineers, proving that, thanks to SDM, the Hobson’s choice presented to engineers—technology or people—is fallacious.

New SDM cohort reflects diversity needed for complex challenges

By Lois Slavin, SDM Communications Director

Sir Tim Berners Lee, inventor of the World Wide Web, once said "We need diversity of thought to face new challenges." MIT's System Design and Management Program (SDM), addresses this philosophy by weaving diversity of thought throughout the program—in its systems-based approach to leadership and addressing complex, interdisciplinary challenges, in its team-oriented, project-based engineering and management curriculum, and most importantly, in the composition of its student cohort.

The SDM 2010 cohort poses with SDM Industry Codirector John M. Grace, back row left, and SDM Fellows Program Director Pat Hale, back row right.

Each year, SDM deliberately selects a cohort whose members reflect the diversity of thought necessary to address the world's most pressing challenges. In addition to meeting the Institute's highest standards of admissions and academic excellence, every SDM class brings a wide range of experience and expertise to MIT.

The cohort that entered in January 2010 is no exception. Students range from an advisor to the prime minister of Kazakhstan to a former senior VP at Mars, Inc. They hail from a wide array of industries, including aerospace, high-tech, consulting, finance, defense, the military, oil, film, state government and more. They come from countries around the world, among them Canada, China, India, Israel, Spain, and the United States.

"Because SDM is about complex technical, managerial and social challenges, diversity is critical to teaching our students how to be inclusive in the midst of uncertainty and how to lead and engage others in innovation, teamwork, and systems thinking," said John M. Grace, SDM's industry codirector.

Among the 50 students comprising the new class, almost 30 have already earned a master's degree and several hold two or more. Four hold MBAs; two hold doctorates; and a third is working towards an interdisciplinary PhD at MIT in parallel with his SDM studies. Three students who recently earned SDM's graduate certificate in systems and product development are now pursuing the SDM master's.

The diversity of the cohort goes beyond academic and professional backgrounds, extending into students' outside interests too. They include a Formula 1 race car driver, a bagpiper, an "artistic roller skater," a cellist who once played with Yo Yo Ma, and a member of an a capella singing group called Tonehenge.

Like the 14 SDM cohorts that preceded them since the program's inception in 1996, the 2010 cohort is made up of experienced professionals ranging in age from their early 30s to mid 50s. Like their predecessors, they intend to enhance and strengthen their technical expertise and acquire the management skills that will enable them to provide value to their workplaces that goes beyond a traditional master's degree in engineering or an MBA.

"The SDM master's is not an MBA" said Pat Hale,

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SEAri addresses challenge of 'epochs' within system's lifespan

Systems Engineering Advancement Research Initiative

The process of designing complex systems to meet specific stakeholder needs is a challenge in itself, but the real world ups the ante even further because it is constantly changing.

Although traditional systems engineering approaches often assume one fixed context, a real system is likely to encounter multiple contexts throughout its lifespan. At the MIT Systems Engineering Advancement Research Initiative (SEAri), researchers have observed that systems are fielded in a period of time—or "epoch"—in which a system's needs and context are relatively fixed. But then a change in political, economic, resource, or market factors—or even a security threat—triggers a new epoch.

This view of systems reflects the uncertain and dynamic world in which we live. While many traditionally designed systems may perform well initially, they can prove ill-equipped to adapt to new stakeholder needs or to seize opportunities as the world changes around them. They may also develop unexpected vulnerabilities.

For example, military systems designed for air-based conflicts may become useless when the conflict moves to a ground-based environment. A well-designed construction vehicle may prove unaffordable when more stringent emissions standards make upgrades necessary. The world is filled with such examples, and while not all systems can be made valuable for all circumstances, there are design strategies that can make some systems more changeable or versatile. The key to better designs for dynamic relevance, according to SEAri researchers, is *epoch-based thinking*.

At SEAri's annual research summit, held in October 2009, SEAri researchers and invited attendees discussed the critical need for addressing epoch shifts that disrupt system value delivery. In addition, research staff and graduate students shared progress on new methods to respond to this challenge.

SEAri research scientist Adam Ross describes epoch-based thinking as "a tool to support systems leaders in anticipating and assessing impacts of possible future shifts in policy, resources, technologies, leadership, markets, and stakeholder needs." According to Ross, "we have been making significant progress in developing advanced methods to permit more effective evaluation of system performance across such shifts in contexts and needs, leading to formulation of strategies for designing and evolving complex systems that are appropriately resilient and/or changeable." The approach has its origins in his prior doctoral research conducted in MIT's Engineering Systems Division and has been evolved over several years and follow-on theses.

"Epoch-based thinking has become critically important for the engineering of complex systems and also for architecting enterprises that are capable of thriving in a dynamic world," said SEAri director and research scientist Donna Rhodes. "While we cannot predict the future, we can make better decisions about complex systems and enterprises through formal approaches in order to anticipate possible futures and responsive strategies."

The SEAri group is currently working on parametric model-based approaches as well as "back-of-the-envelope" (or concept-level) approaches for epoch-based analysis. A number of recent master's and doctoral theses have also furthered the epoch-based methods using computational approaches. And, SDM student Kevin Koo has recently been working with SEAri to research the application of epoch-based thinking to a defense system-of-systems application. Koo is one of five SDM students SEAri researchers are presently supervising on thesis research that will impact systems practice in industry and government.

To foster epoch-based thinking, in July 2010, SEAri will offer a two-day short course—Epoch-Based Thinking: Designing Complex Systems for an Uncertain World—which is open to interested professionals through the MIT Professional Education Programs. The course will engage participants in examining the challenges and motivations faced by systems leaders and will teach how these new methods can be applied to designing and evolving complex systems and enterprises.

More information on SEAri and its research is available at seari.mit.edu.

New SLaM Lab helps SDM put systems thinking into action

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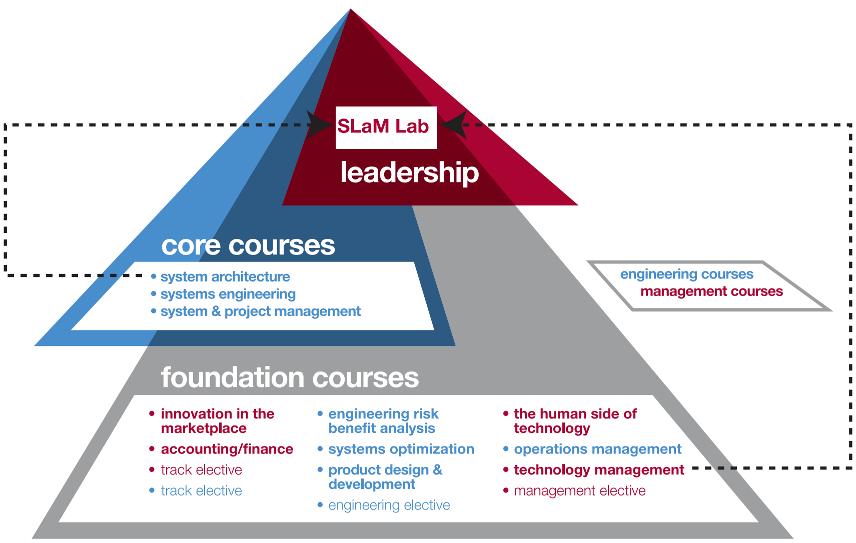
of its offerings, leadership skills were not taught explicitly. As a result, some SDM fellows chose to pursue other lab classes at MIT. In sum, there was growing impetus for a leadership course focused specifically on the needs of SDM fellows.



SLaM Lab was envisioned as an experiential course that would tie together the lessons of system architecture and technology strategy while giving students practical experience working with real clients on problems of significant strategic importance. The format was adapted from other excellent MIT lab courses, such as E-Lab (which focuses on entrepreneurship), G-Lab (global and emerging markets), iTeams (technology commercialization), and S-Lab (sustainability).

Students would work together in small teams for outside companies on projects that involved real-world ambiguity and noise and that required them to discriminate between the problems as presented and underlying reality, rather than on neatly packaged problem sets or case studies. Perhaps most importantly, projects would be selected based on their potential to make a real impact for the client organization.

As strong believers in a collaborative and participative approach, we approached this fall's first class with respect for the diverse experience and perspective of the SDM fellows. The 12 students who chose to be in the first class knew that their role was not only to work on the projects, but also to actively act as sophisticated lead users helping to shape content and providing direction and feedback on this prototype program. Because this was a new course, and the first of its kind within the SDM curriculum, the participants' input and impact resulted in major changes to the syllabus between September and December. We iteratively decided what the class focus should be based on personal knowledge gaps and the evolving needs of the clients we were working with through the fall.

Course learnings focused on the practical means for applying knowledge gained in SDM to the real-world issues presented by current (and future) projects. At the outset, the class focused on issues of leadership and teamwork. In the first week, students completed a Belbin Team Role assessment to learn about the different styles each naturally brought to projects. Students learned about the theory behind these psychological tests and discussed how results could be used to guide team formation and productive interaction. Some reading and discussion focused on leadership within different contexts. Of special interest were topics related to leading teams composed of creative knowledge workers. Over the course of the semester, each student formulated and refined his or her personal philosophy of leadership.

As the course evolved, the development of some key practical skills gained prominence. The first included techniques used by strategy consulting firms to organize and reason logically about ambiguous information. For example, we used Barbara Minto's "Pyramid Principle," a process for creating clear documents.

The second major area included the art and science of presenting graphical information clearly. In November, the class chose to attend a day-long seminar offered by Edward Tufte, an expert on the subject. The knowledge students chose to pursue had a significant influence on both the content of the final recommendations that they offered, and the form or structure of their final client presentations. All of them eschewed conventional slide presentations for more sophisticated representations, such as large-scale one-page displays or interactive presentations. In every case this had a major positive impact on the companies that we were working with, and

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New SLaM Lab helps SDM put systems thinking into action

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some of the key graphics have been very widely circulated.

There were four key criteria for the projects that formed the core of the course: there should be a systems challenge; there should be a related leadership or management challenge; the project should have real-world impact, working on issues that mattered to the host companies; and the projects should have meaning for the participants, be something that they were enthusiastic about it because they could make a difference.

Seven candidate projects were proposed by students, faculty, or third parties; three were chosen for engagement. One team worked with leading global cell phone manufacturer Nokia to devise a strategy to increase software developer "mindshare" within the United States. A second team worked with local wireless power company Witricity, an MIT spinoff, to devise a standardization and intellectual property strategy. A third team worked with founders of the Venture Café (a venue for entrepreneurs to meet in Kendall Square) to explore how to make their proposed social hub sustainable.

In the next issue of the *Pulse*, we will expand on each of these real-world projects, and explore the impact of the lab's work on the organizations.

Bridging the gap: A look at the Industrial Relations Committee

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industry come to the MIT campus to share their career experience, leadership challenges, and the pressing problems faced by their organizations. The committee has brought in speakers from Microsoft, Lockheed Martin, and the US Coast Guard with more to follow in the year ahead. It is the vision of the committee to involve interested industry partners to interact with students directly and share the systems challenges of their businesses, including both technical and managerial issues. We hope to develop a continuous flow of new speakers, constantly reinvigorating the thought among the students as to why this program is so important and useful to the world.

The IRC looks forward to engaging the SDM fellows of the 2010 cohort and incorporating their ideas and energy into this dynamic development process. The hard work of the 2009 IRC should give us the momentum to take leaps forward in improving our relations with industry and integrating them more successfully into the program, thus improving the value of a SDM fellow in the eyes of the business world.

SDM grad reaps benefits from program's leadership training

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tools SDM uses to build better leaders. In addition, SDM provides multiple opportunities to exercise the leadership skills that we are learning through the team projects that are assigned throughout the program. After many of these activities, we receive confidential feedback from our team members about our performance. This helps us to understand what role we played in the group and to make changes, if necessary, before taking on the next group activity.

SDM students also have the opportunity to take a leadership role in the program itself, through committees that range in scope from organizing social activities to facilitating better relations with the program's industry partners. We even have intramural sports teams, giving us a chance to exercise our leadership skills in a completely different environment.

It appears that, when linked to concrete efforts to deal with real business problems, leadership skills can be developed in an academic environment. While the teaching of leadership skills is certainly a major value-added component of the SDM program, I think the wealth of opportunities for practical application of these skills is what truly sets SDM apart.

Sending employees to SDM program pays off for John Deere

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for nine years and has a bachelor's and master's degree in agricultural engineering. He received his SDM certificate in September 2008.

The coursework was a great supplement to what he does in his day-to-day work, which involves ensuring the precision farming products that John Deere develops will meet customer's needs and expectations in the field. To do that, he is responsible for identifying the stakeholders and documenting their needs along with how they expect their products to meet those needs.

Schleicher also leads or participates in concept selection, product architecture, make/buy and re-use decisions. His three-member capstone team's project was a cross-divisional effort to merge GreenStar precision control with a Compact Utility Tractor, thereby providing customers with hands-free final grading capability. The resulting prototype was called GradeStar, which utilized many of the SDM tools in a real-world application.

We anticipate that by sending people through the SDM program we will create future engineering leaders for the company. We also believe we now are near critical mass for making a lasting impact on John Deere's business through deployment of common vocabulary, common tools and methods, and people who can spread this knowledge among the workforce for even greater benefits.

New SDM cohort reflects diversity needed for complex engineering, management challenges

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director of the SDM Fellows Program and senior lecturer in engineering systems. "For technical professionals it goes well beyond a traditional MBA because it enables students to cultivate the best skills in both management and engineering.

Albert Po Chia Chen, a product support manager at Entegris in Taiwan prior to joining SDM, is a case in point. "After the financial tsunami, more and more people are questioning the traditional MBA," he said. "I believe that SDM can equip me with enhanced technical skills, in addition to those in business, that I can apply in different arenas."

For Rutu Manchiganti, a former senior staff systems engineer at Motorola whose hobby is artistic roller skating, SDM offers the best of both worlds. "I want to get a management education without losing the engineer in me," she said.

Matt Harper, a product manager at Prudent Energy International who plays bagpipes in his spare time, said he applied to SDM because he wanted a formal business education "without having to learn to think like a finance guy."

The senior member of the cohort is John Helferich, a retired senior vice president at Mars, Inc. who oversaw R&D for pet care, candy, and rice products. "I want to learn to lead change through societal means," he said. While at SDM, he plans to focus on food safety and sustainability and continue to teach as an adjunct faculty member at Northeastern University.

For most members of SDM's new cohort, the program offers new ways of thinking, engineering, and managing that will help the address the world's new challenges. "SDM's emphasis on systems will give me a broad technical skill set that I can use beyond just semiconductors," said Swope Fleming, who aims to branch out from that field into clean energy. "SDM will help me bridge the gap between my engineering background and the business world."

Massachusetts Institute of Technology

SDM calendar spring–fall 2010

If you or your colleagues are interested in attending any of the events listed, please contact SDM Industry Codirector John M. Grace at jmgrace@mit.edu or 617.253.2081.

March 9, 2010
SDM Information Evening
Location: MIT Faculty Club

Time: 6–9 pm

May 7, 2010
Final Presentations from ESD.40 Product Design and Development
Time: 5–10 pm

Note: By invitation only. For more information, contact Qi D. Van Eikema Hommes at qhommes@mit.edu or 617.253.8973 or SDM Fellows Director Pat Hale at pat_hale@mit.edu or 617.253.9668.

May 23– 26, 2010
The Fifth Conference of Learning International Networks Consortium (LINC)
University Leadership: Bringing Technology-Enabled Education to Learners of All Ages

Location: MIT

Details: linc.mit.edu/linc2010/

June 29, 2010
SDM Information Evening
Location: South Shore–TBA

Time: 6–9 pm

September 14, 2010
SDM Information Evening
Location: Burlington, MA—TBA

Time: 6–9 pm

October 19, 2010
SEAri Research Summit 2010
Location: MIT Media Lab (Building E14)

Time: 8 am–5 pm

October 19, 2010
SDM Information Evening
Location: MIT Faculty Club

Time: 6–9 pm

October 20, 2010
SDM Partners Meeting
SDM industry partners are invited to review curriculum activities, hear from MIT faculty on relevant cutting-edge research, and develop opportunities for internships and theses.

Location: MIT Media Lab (Building E14)

Time: 8:30 am–5 pm

October 20, 2010
SDM Alumni and Student Mixer
Location: MIT

Time: 6–9 pm

October 21, 2010
2010 MIT Conference on Systems Thinking for Contemporary Challenges (Day 1)
Focus on service systems, health care, design, and sustainability

Location: MIT Media Lab (Building E14)

Time: 8:30 am–5 pm

October 21, 2010
SDM Conference Reception and SDM Best Thesis Award Presentation
Location: MIT Media Lab (Building E14)

Time: 6:30–9:30 pm

October 22, 2010
2010 MIT Conference on Systems Thinking for Contemporary Challenges (Day 2)
Focus on service systems, health care, design, and sustainability

Location: MIT Media Lab (Building E14)

Time: 8:30 am–3:30 pm

Event information includes all details available at press time. For more current event information, go to sdm.mit.edu and esd.mit.edu.