Working as a senior project engineer in Ricardo Inc.’s Vehicle Engineering Group, I am constantly challenged. Ricardo is a premier provider of engineering services and strategic consulting to the world’s automotive, transport, and energy industries. A wide variety of companies come to us with tasks of all shapes and sizes. For that reason, Ricardo’s processes must be very flexible, and Ricardo engineers must be ready to tackle systems integration for almost any type of vehicle—from race cars, to HUMMERS, to armored vehicles. Ricardo has even applied expertise in engine and driveline development to developing technology for wind turbines.

Since systems design is what I do every day, I knew the SDM program would be right for me. In my time at Ricardo I have been able to develop a completely new architecture for a potential Humvee replacement, improve functionality and manufacturing of mine-resistant vehicles, and even develop systems engineering tools that aim to improve the government’s procurement process. I am now able to compare and contrast my experiences both with the course content at MIT and with the variety of accomplishments brought to the program by SDM students from many different fields and industries.

My role at Ricardo is a blend of engineering and management, so the Sloan portion of the program is just as important to me as the engineering component. Large projects require me to lead teams of engineers, analysts, and designers. Programs must be managed so that they are delivered on time and under budget, and engineering processes must be developed appropriately to the scale of each task. Project proposals need to be concise and well-written and must include accurate cost and resource predictions. Courses like The Human Side of Managing and Leading Technological Innovation have been particularly helpful, and I am looking forward to learning more in upcoming semesters.

One particularly interesting aspect of SDM has been the focus on innovation and technology strategy. Innovation is considered a core

SDM focus on innovation pays off for Ricardo engineer

By Paul Luskin, SDM ’08

Ricardo was selected as Navistar’s engineering partner for the Future Tactical Truck System, an opportunity to showcase advanced developing technology. Paul Luskin, SDM ’08, was lead engineer for chassis and powertrain.
Welcome

Welcome to the summer 2008 edition of the SDM Pulse newsletter. The articles presented in this issue should further your understanding of the breadth, depth, and scope of MIT’s System Design and Management Program.

Inside, SDM students, alumni, faculty members, and staff describe how SDM learnings can be applied in a wide variety of industries and functions.

Students Paul Luskin of Ricardo Engineering, Jose Antonio Almazan of Ford of Mexico, and Ragu Bharadwaj, a research scientist at a local biotech firm, share with us the ways in which they are applying SDM coursework to the work of improving their firms’ product development activities.

SDM alumni follow suit. Harris Lieber, a systems engineer at Bayer Healthcare, shares his experience applying systems engineering first in the automotive industry and more recently in the health-care industry. Sorin Grama continues his insider’s look at applying SDM lessons to the challenges facing an entrepreneur.

SDM faculty member Olivier de Weck discusses the background and research areas behind workshops on change management that he and his colleagues at the University of Cambridge have been developing. In the same article, you’ll learn about the thesis research of SDM alumna Monica Giffin, a systems engineer at Raytheon, who investigated the effects of engineering change on radar systems development.

Other articles offer a chance to learn about opportunities for industry to interact with SDM. Insights from the recent conference on strategies for balancing risk and opportunities in global product development, cosponsored by SDM and others, illuminate a problem area central to the SDM program from both an in-depth academic and a broad practical perspective. You can also read about student interactions with industry leaders, including former IBM Chairman Lou Gerstner and Andrew Grace, vice president of engineering design automation tools at the MathWorks. As part of the continuing effort to encourage dialogue among students, alumni, faculty members, and companies, we give you a preview of the SDM annual conference scheduled for October 2008—and we invite you to attend!

An introduction to SDM’s yearlong systems engineering certificate program is provided to show you additional options for developing systems thinking within your company. A update on MIT’s Systems Engineering Research Advancement Initiative continues our look at current research in systems engineering as a guide to the future.

We are introducing a new area highlighting books linked to SDM topics by giving you advance information on Professor Nancy Leveson’s forthcoming book on systems and safety.

Finally, a calendar showing SDM’s upcoming activities is provided.

As always, your comments and feedback are encouraged.

Best regards,

John M. Grace
Industry Codirector
MIT System Design and Management Program
jmgrace@mit.edu
MIT-University of Cambridge workshop to focus on engineering change

By Lois Slavin, MIT SDM communications director

When SDM ’06 alumna Monica Giffin examined radar systems development for her MIT thesis, she began with approximately 41,500 engineering changes requested over an eight-year period.

“The sheer volume of change requests is daunting (from the perspective of someone trying to understand them), and the relationships between the requests started out as complex and became more convoluted from there. By the time you hand a system over to the end users the complexity goes through the roof because as you develop, integrate, test, and field the system, every bug fix, every change, and every added bit of functionality has the potential to cascade into many additional and unforeseen accompanying changes,” said Giffin, a systems engineer at Raytheon. “We know it happens, we try to keep it from happening, but still we can’t prevent it.”

On October 30-31, 2008, a workshop titled “Engineering Change” will be held at MIT’s Endicott House for representatives from industry and academia to address the critical need for industry to deal more effectively with the impact of engineering changes on existing products and systems. During the two-day US workshop, attention will be focused on a systems approach that embraces the technical, managerial, and social components of engineering change. A major takeaway for MIT—in cooperation with University of Cambridge—is to develop the research agenda and theoretical foundations in the areas of design for changeability and engineering change management.

A UK workshop on this topic was conducted in April 2008 at Trinity Hall College, University of Cambridge. Both the UK and the US workshops were organized by Professors Olivier de Weck and Richard de Neufville at MIT’s Engineering Systems Division with Professor John Clarkson, Dr. Claudia Eckert and Dr. Rene Keller at the University of Cambridge. According to de Weck, working with Giffin on her thesis, “Change Propagation in Large Technical Systems,” was the inspiration for his involvement.

Understanding how to predict, engineer, and manage change is critical to competing successfully, whether in evolving existing products and platforms or developing new ones, according to de Weck, associate professor of aeronautics and astronautics and engineering systems. Change management will become increasingly important as the pace for customization in the global marketplace continues to accelerate.

Giffin says her research was intended to provide a better understanding of what actually transpires in industry. “The ‘holy grail’ of the research would result in creating tools or methodologies that help predict, or at least better manage, change propagation from the start,” she said. “That would save enormous amounts of time and money. The benefits can only increase as we conjure up ever larger and more intricate systems.”

Most complex products and systems are designed by modifying existing products and systems, de Weck explained, in order to limit the risk associated with product innovation and to reduce the complexity of the development process. Changes to existing products are also integral to the life cycle of all products—companies make changes to eradicate problems, make improvements, and to respond to evolving customer needs.

“In carrying out such changes companies are anxious to avoid unnecessary knock-on effects to other parts of the products, especially those where the design is already complete,” de Weck said.

When faced with the need to evolve existing offerings, product developers often approach the task in a linear way that can be problematic, de Weck said. In these instances, there is usually an opportunity to use a “clean sheet” approach similar to that used for a new product. “The reality is more complex,” he warned, “because the questions that need to be asked for next generation products are often different than those asked for the first generation.”

With a new product designers gather requirements, assess market needs, develop concepts, select one, evolve the prototype, test, then go to market. The reality for evolving existing products involves asking what to keep or change, such as requirements for meeting new emissions and crash standards or the preferences of new market segments.

Many companies, such as Xerox and Boeing, focus on how to integrate new technologies into an existing product to achieve a greater state of optimization and are actively engaged in planning for change and avoiding any unintended “knock-on” impacts.

Many decisions seem to be driven by organizational issues, not just technical and financial ones, de Weck says. “Perhaps surprisingly, while the challenges of engineering change have long been recognized as an issue by companies, academia has only realized its importance relatively recently and is still developing the research agenda and theoretical foundations in the areas of design
SDM grad applies systems lessons to manufacturing, health care

By Harris Lieber, SDM ’02

One of the most rewarding aspects of going through the MIT System Design and Management Program is the broad applicability of the lessons I learned. After many years at Ford Motor Company, in January 2007 I took a job as systems engineer at Bayer Healthcare Diabetes Care. I am happy to report that the skills I acquired at MIT are as applicable to health care as they were to the automotive industry.

When I arrived at MIT, I was already on the path toward a career in managing engineering tradeoffs between disciplines and taking a systems view of product development. I graduated in 1996 with a BA in engineering sciences and a bachelor of engineering, and then proceeded to get my master’s in engineering management in 1997, all from Dartmouth College.

My first job out of school was at Ford, and I was working on the electric powertrain of Ford’s hydrogen fuel cell vehicles when I joined the SDM program in 2002. After I graduated from MIT, I first officially held the title of systems engineer, working on a team developing an electric transaxle for a new generation of hybrid electric vehicles.

At Bayer, I am responsible for trading off interests of different functional groups, external partners, and suppliers, as well as making engineering tradeoffs. I evaluate the advantages of the lowest cost solution for a particular problem versus modular or platform architecture that can be flexible enough to optimize overall cost and development time for future expansion opportunities.

While Bayer may be most famous in this country for aspirin, it has a long history in the diabetes care business. Today, Bayer Healthcare Diabetes Care is one of the largest self-test diagnostic businesses in the world, with customers in 100 countries. Our products include two families of blood glucose meter systems and PC-based diabetes management software.

As small, portable consumer electronic devices become more ubiquitous, Bayer has become more focused on the design of our products and the overall user experience. Music players, PDAs, and cell phones concentrate on industrial design, touch and feel, and integration with their customers’ personal computers and other devices. We are taking our products in the same direction. The biggest challenge is that we cannot allow safety, accuracy, and ease of use to suffer as a result of improving these other attributes.

In my experience, the practice of systems engineering in the health-care field is similar in many ways to its practice in the automotive industry. The engineering practices of requirements management and risk management are used in both industries.

However, the influence of a systems engineer on the final product is, in my experience, very different. At Ford, two to six engineers were responsible for systems engineering on a very complicated subsystem of a vehicle. The subsystem sometimes fit into a platform that was already on the market and sometimes a totally new vehicle, but we always designed with very tight constraints. At Bayer, one systems engineer is responsible for two to six total product systems. The systems are far less complicated than a whole vehicle, but I deal with and understand the larger issues of product development and product marketing that were obscured by several layers of system design at Ford. I find that the systems engineer has far more influence over the final product at Bayer.

If there is one way in particular that my nine years at Ford prepared me for my career in the health-care industry, it is in the practice of failure modes and effects analysis (FMEA). This practice was an integral part of Ford’s system of robust product design, and it is also relied on heavily at Bayer.

The core courses of the SDM program definitely prepared me for life as a systems engineer. In particular, systems engineering and systems architecture are applicable every day. I even found myself illustrating an architecture problem with an object process model, which I’ll admit I didn’t expect while taking Professor Ed Crawley’s class in system architecture. In addition, three classes I would highly recommend for anyone who wants to go into systems engineering in a product development environment are product design and development, manufacturing processes and systems, and entrepreneurship lab.

Looking ahead, I think the SDM program could focus more on the regulatory impact on systems design. At Bayer, I have learned a great deal about how health-care products are regulated, and I have had to become very familiar with the applicable standards and directives. Identifying the applicable standards for a product and understanding the design impact of those standards is a large part of my responsibility; identifying the correct requirements to meet the standards and protect the end user’s safety without over-constraining a product design is a challenge for every project.

Another area of great concern in the health-care industry is product and system risk management. Two techniques we use extensively at Bayer are FMEA and top-down hazard analysis as detailed in ISO 14971 (an international standard). There is a lot of work going on at MIT on managing risk, as evidenced by a risk management conference at MIT which I attended in March (see story on page 6). The conference was cosponsored by the SDM program and several ESD faculty members gave fascinating presentations. I particularly appreciated the presentations by Professors Nancy Leveson and Olivier de Weck, which addressed new methods of more robustly quantifying and managing system risk. These professors’ work will make an excellent base for SDM theses in the health-care field.

Editor’s note: Read more about Professor Leveson’s work on Page 13.
Applying systems thinking and lean techniques to produce better drugs

By Ragu Bharadwaj, SDM ’07

Editor’s note: This is the third in a series of articles that follow Ragu Bharadwaj’s progress through the System Design and Management Program. Bharadwaj holds a PhD in biochemistry and is a research scientist at a local biotech firm.

In the first piece, Bharadwaj introduced the problems inherent to the drug development activities of today’s pharmaceutical industry and posited ways to improve these processes through the strategies and techniques taught in SDM. In the second, he discussed problems inherent in the drug development process. In this installment, he describes how systems thinking and lean techniques can improve the drug development process.

As I move well into my second year in the SDM program, I find that SDM courses are enlarging my thinking about how to address the vastly complex and enormously expensive problems of new drug discovery and development.

Today’s pharma industry is a classic systems problem waiting to be solved. The entire system from drug concept development through drug delivery and utilization is rife with problems, which has brought the industry to a crossroad.

Old patents are expiring, resulting in decreased revenue. The costly and decades-long process of developing a “blockbuster” product, gaining FDA approval, then marketing it, adds additional stressors in a market that is increasingly competitive. Given the departmental organization of pharmaceutical companies in general, functional silos and cultural norms need to be transformed within the industry, its outsourcers, and throughout the supply chain.

In senior lecturer J. Bradley Morrison’s system dynamics class, I learned how the tools of systems thinking can—and must—be applied to optimize processes during drug discovery in order to determine where to extract more value, and consequently save money and time.

Morrison’s class opened my eyes to the multidisciplinary nature of this incredibly complex challenge. One of the main reasons is cultural. The pharmaceutical sector is well over 100 years old and many of the legacy structures and norms no longer serve today’s high-speed, high-tech global environment.

Functional silos are a major culprit, as they were in another “old” industry—manufacturing. However, while manufacturing has evolved, pharma still has a way to go—scientists remain organized by departments, communicating more within these departments than with the outside. Over time, as the softer sciences and disciplines comprising pharma research have matured, attributes such as throughput lead time and cycle times in iterative functions in research have become more important. Unfortunately, the industry has remained unchanged, and functional silos persist in, for example, development. These must be integrated in order for scientists to share information and work together more efficiently. This problem extends beyond the company’s walls to include outsourcers and vendors as well.

In Morrison’s class we learned to apply systems thinking and lean techniques to help make these changes happen. For example, taking a systems view of the cycle time and documenting the steps in the drug discovery process can help provide quantitative data needed to build a case for optimizing systems. Systems thinking can unequivocally show where cycle times can be reduced across multiple functions.

The harder challenge will be getting scientists to want to change how they work. Most are used to focusing in on one research problem rather than thinking about the big picture. In addition, most come from established academic labs where they train not to work in teams as much as with unparalleled excellence on a single problem. Furthermore, most of them have jobs that incorporate research and production components. Changing the work culture of these scientists is necessarily harder than doing so for other fields, mainly because we are attempting to change some portions of a scientist’s job without affecting other portions.

SDM’s course in systems dynamics has helped me see that there are opportunities for pharma companies to find...
Experts share risk strategies

Systems-based, life-cycle approaches turn risks into opportunities

By Kathryn O’Neill, managing editor, SDM Pulse

In March, hundreds of senior executives converged for a 1½-day conference at MIT to learn how to apply a systems-based approach to risk and opportunity. MIT professors and industry experts offered strategies and tactics for managing risk throughout the product life cycle—from design to disposal.

How can companies design products with a view to the uncertain future? They need to foster innovation throughout their domain, said keynote speaker Nicholas M. Donofrio, executive vice president for innovation and technology at IBM Corporation. “Your ability to change successfully and deal with its problems, its risks, will ultimately determine your success,” he said. And adapting to change requires innovation.

“Innovation could be in the product, the process, even the management system,” said Donofrio, who emphasized that IBM takes a global approach to innovation—even confronting the effects of global environmental problems. “We’re doing a major study this year on water. We’re mapping the fresh water supply of the globe,” he said, looking at the full life cycle. “We have enough water but it’s not in the right place at the right time.”

Velcro USA Inc. president Joan B. Cullinane, who also keynoted, described her innovative efforts to structure an organization that takes a life-cycle approach to risk management. Cullinane, who is also vice president of Velcro Group Corporation, integrated Six Sigma into the business operations to minimize risk. She also clarified employee interconnectedness with a giant organization chart in order to ensure strategies were aligned throughout the company. As a result, Velcro is thriving—running 24 hours a day in New Hampshire and expanding its manufacturing capabilities.

Often, innovation comes in the form of new technologies that need to be infused into existing products—a process that comes with its own risks, said Olivier de Weck, MIT associate professor of aeronautics and astronautics and engineering systems. Corporations often struggle to evaluate all the factors involved, so de Weck has created a technology infusion model to help decision makers see the costs and benefits of potential product changes. “The question is, what is the value and what are the opportunities of new technologies? Technologies by themselves typically have no value—value only emerges once the technologies have been successfully integrated into a greater whole,” he said.

Stephen P. Hoover, vice president and center manager at the Xerox Research Center Webster, N.Y., suggested that innovation is partly about exploring potential risks at all stages of the life cycle—before you commit to a product. “Look at market, technology, and value chain,” he said. “If you do the work early and quickly, you can save a lot of money on bad ideas.”

MIT Professor David Simchi-Levi of civil and environmental engineering and engineering systems and director for the Forum for Supply Chain Innovation, explained the advantages of redundancy, network planning, and risk pooling. He also discussed the modeling of a relatively new consideration for planners—the increasing demands to reduce a company’s carbon footprint.

Several presenters described the modeling and analytics they use to assess risk and prepare for uncertainty. Bindiya Vakil, program manager at Cisco, described the risk engine her company uses: “It generates thousands of scenarios. It bombards the supply chain with disasters and shows where risk lies, how much revenue is exposed.”

Vakil’s fellow presenter, Cisco director of supply chain risk management John O’Connor said, “These analytics really give us a picture of where to focus our energies.”

Jeffrey Tew, technical fellow and group manager Manufacturing Strategy and Planning Group for the Manufacturing Systems Research Lab at General Motors Research and Development, described how GM handles supply chain disruption and brand protection. The two are highly interrelated, he said. “There are 40,000 small-scale automotive counterfeiters in China,” he said—posing a major risk to the GM brand. Tew described how GM uses RFID tagging, text mining in foreign languages, and temporal database management to combat the problem.

As University of Michigan Professor Wallace J. Hopp said in his talk, “Supply chain disruptions can do more than just cost you money. They can cost you position in the market.” He illustrated his points with relevant case studies.

Another prominent concern in global product delivery is safety—an issue that must be addressed with a systems-based, life-cycle approach, according to MIT Professor Nancy Levenson of aeronautics and astronautics and engineering systems. Most accidents are not random; they result from complex interactions among system components, including organizational culture. The only way to ensure safety, Levenson said, is to enforce safety constraints in design, manufacturing, and operations at every step along the way.

That’s what the US Navy submarine safety program, SUBSAFE, has been doing for more than 40 years,
On-campus sessions build SDM connections

Former IBM chairman Louis Gerstner shares views with students

MIT’s System Design and Management Program not only introduces students to the most current principles and methods in systems engineering—it connects talented students and their companies to each other, to MIT faculty members, and to leading experts in systems thinking from a variety of fields.

One way SDM builds these connections is by requiring all students to attend a once-a-semester weeklong period of on-campus activities.

SDM students who return to campus for these activities continue their coursework, communicate with friends, touch base with faculty, and enjoy a number of special events—including lectures and private sessions with systems leaders who come to MIT to share their experiences with, and to learn from, SDM fellows.

A highpoint of the March 2008 session was a private breakfast meeting of SDM fellows with Louis Gerstner, the former chairman and CEO of IBM and author of Who Says Elephants Can’t Dance, the story of IBM’s historic turnaround. Gerstner was introduced by MIT visiting professor Irving Wladawsky-Berger, who described the session in his blog.

Gerstner talked about the importance of company culture and ways to adapt culture to changing circumstances. To reform the culture at IBM, Gerstner had to retool compensation incentives to reflect overall company performance over individual unit performance. The change was difficult, but successful.

Gerstner also gave a public lecture at MIT to an overflow audience, focusing on the need for good leadership. According to Wladawsky-Berger, Gerstner emphasized the need for leaders to roll up their sleeves and work closely with the teams addressing complex problems. (Read Wladawsky-Berger’s blog at http://blog.irvingwb.com/blog/2008/03/lou-gerstner-at.html.)

Also during the March session, SDM students attended a luncheon presentation by Andrew Grace, vice president for engineering design automation tools at MathWorks, a major modeling and simulation software development firm.

Grace said that more and more companies—including Honeywell, BAE Systems, NASA, Rockwell Collins, and Lockheed Martin—are using model-based design for product development at various stages of the work flow, from research to product design, and from product implementation to product verification and validation. Grace demonstrated how modeling and simulation tools fit into the product development scheme at MathWorks and noted that model-based design is applicable in a range of firms from transportation to those involved with biological systems.

SDM cosponsored a major conference, Strategies for Balancing Risks and Opportunities in Global Product Delivery, during the week of the on-campus session (see article on page 6). The conference featured a poster session on SDM projects, and students who entered posters received free admission to all talks.

The March session also featured an open forum, called the Town Hall, at which SDM fellows were able to identify issues of concern, offer feedback, and share other information. And, as no SDM program would be complete without a party, the March session had its special party for all the students, their significant others and families at Summer Shack in Cambridge.
As a vehicle test and development engineer at Ford of Mexico, I’m aware that more than half the cost of developing a new car comes from prototyping, verifying, and validating vehicles. In many cases, physical prototypes are built and rebuilt, tested and retested in the lab and on public roads as the design develops. If the verification and validation process could be accomplished with fewer, more successful prototype vehicles—in combination with effective and efficient design verification plans—cars could be developed more quickly using far fewer resources.

Although Ford of Mexico doesn’t yet have major design responsibilities, I deal with these kinds of issues in my work because we often have to adapt designs from other Ford divisions to the needs of the local Mexican market. For example, subcompact low-cost cars designed with standard transmissions for Brazilian customers may need to be fitted with automatic transmissions and other commodities to satisfy Mexican market demands. Similarly, cars designed to meet US regulations such as emissions standards might need to be redesigned for Mexico to produce a less expensive vehicle that complies with Mexican regulations.

Unfortunately, adjusting even one part in the system can cause unseen interactions elsewhere. Prototyping and physically testing the redesigned vehicles is necessary to reveal problems—but the existing approach is inefficient.

At SDM, I am working to come up with a robust methodology for vehicle verification and validation—one that establishes a new requirement and specifications system for determining what is necessary to verify and validate, under the right conditions, and with the appropriate testing platform.

This approach will be grounded in extended systems engineering and system architecture principles to ensure an adequate representation of both system and environment in computational simulation tools. These computation simulation tools will provide a means for reducing development time, cost, and effort needed to conduct development and validation tests with confidence.

Testing within virtual platforms enables faster design iterations that can result in fewer but more representative prototypes. Some physical prototype testing will still be required since some tests, i.e. for vehicle durability, can’t readily be modeled. But efficiencies can also be found through careful project management. One method with great potential, discussed in our SDM class on system and project management, relates to the use of a design structure matrix. The matrix shows the systems and task dependencies and makes it easy to identify linkages between tasks and people to reduce iteration and communication times.

In addition to helping to pinpoint errors that affect the...
This image shows a computer-aided engineering analysis performed for the development of the automatic transmission version of a Brazilian vehicle called Fiesta—a very successful design project at Ford of Mexico.
Producing better medicines

additional revenue streams. For example, much of the
data that is gathered in clinical trials is not used for FDA
documentation submission. That data, however, still
resides in the company’s computers and can be sold.
Selling it would help reduce the cycle time in develop-
ment of other drugs, potentially benefiting the system as
a whole and ultimately, consumers and the health-care
system at large. Right now, the old model simply involves
selling the intellectual property in the form of patents, so
this is an area that could profitably be optimized. Perhaps
other assets of programs—such as aggregated structure-
activity data, information showstoppers in the projects,
could be examined for sale.

I plan to take Professor of the Practice Deborah
Nightingale’s class, Integrating the Lean Enterprise, to
learn tools and techniques to address the challenges of
changing the culture. Applying lean optimization in the
discovery process will help identify areas to increase
speed and reduce iterations. For instance, if there is a
two-to-four-week cycle time for a team of chemists to
test new variants of a molecule, lean principles can be
employed to determine the real time of the value-added
portion of the cycle—which might be just one to two
days for each week. Therefore if you double the number of
cycles in each time frame, you will be making fewer mol-
ecules and utilize a smaller amount of the overall cycle time
while producing richer information content (see diagram,
on page 5).

I believe that all of this can ultimately impact health-care
policy. At present Institute Professor Robert Langer at
Harvard-MIT Division of Health Sciences and Technology
(HST) is looking at renewable organs and tissues. This
raises huge social issues because as people begin to live
longer there will be a significant strain on resources.
There should be someone with a systems perspective
involving engineering, management, and social science at
a very high level looking at the potential problems.

I’m planning to take more classes at HST on the eco-
nomics of health-care industries, new disruptive technolo-
gies, and how to evaluate biotech companies from a
venture capital perspective. I also want to take a class at
Harvard School of Public Health, where they are using
systems thinking as the backdrop for looking at the cur-
cent problems in Medicare, Medicaid, long-term care,
health care, and insurance. (Publishers note: Cross-reg-
istration between MIT and Harvard at the graduate level
can enhance the overall SDM educational experience.)

I’m now looking at almost everything with a systems lens
and I believe I will apply my SDM learnings for years to
come.

MIT-University of Cambridge workshop

for changeability and engineering change management.”

Giffin noted that a major learning from her thesis is that
change propagation happens not just within a physically
or technically connected system, but within an organiza-
tion’s socio-political systems as well. “Seemingly minor
changes in the language used in the political arena to dis-
cuss a system can change the interpretation of opera-
tional policies, and eventually cascade all the way down
to hardware and software changes,” she said.

“Many decisions seem to be driven by organizational
issues, not just technical and financial ones,” de Weck
agreed. “The intersection of engineering, management,
and social science has not yet been fully addressed, so
an engineering systems approach is needed.”

Giffin, who will be attending the October “Engineering
Change” workshop, said she would like to work with
attendees to address an area not covered in her thesis—
the “people” network issue. “From my observations, the
tremendous impact that particular people who participate
in a given change have on the final outcome is often due
to their role in the social network, rather than their techni-
cal savvy,” she said. “There is a large amount of data
(that I gathered for my thesis but have yet to mine from
this particular perspective) from which I can hopefully
tease out some of those threads.”

The MIT-University of Cambridge workshop on engineer-
ing change is an invitation-only event. For information on
attending, please contact SDM Industry Codirector John
M. Grace, jmgrace@mit.edu, 617.253.2081.
Q. Tell us about the evolution of the product over the past year. What’s different now?

A. Much has changed in the last 12 months. Your readers may be scratching their heads trying to understand how our technology has evolved from a microgenerator made of car parts to a refrigeration system that requires no moving parts. Instead of using solar thermal concentrators to generate heat and then electricity we’re now using photovoltaic (PV) panels and thermoelectric modules to provide cooling only.

Several factors led to this decision. Last August we conducted a market study in India. We visited more than 40 different villages and talked to farmers, business owners, and village leaders. From this study we concluded that a cold-storage solution for fruits and vegetables is what’s most needed, so we’re now focusing only on providing a refrigeration solution.

The decision to drop the car parts idea was a little more difficult and convoluted. When we started this project we had a team of five and we incorporated as a nonprofit. After winning the MIT prize, two of us wanted to pursue a for-profit venture because we could get more funding and make a bigger impact, but the other three members wanted to keep it as a nonprofit while continuing their studies at MIT. Moreover, because they wanted to retain the technology licensing rights, we had to negotiate an agreement between the nonprofit and the for-profit entities. We couldn’t reach a simple agreement, so the team split up and we—myself and my current business partner—decided to pursue the for-profit opportunity with a different technology.

Q. What stage is the company in now? Prototype? Testing?

A. After the split, we took some time to reevaluate things. We were back to square one. We had a fabulous market opportunity, but no technology and no team to implement it. We were just two guys with an idea. Still, we didn’t want to give up on the idea, so we began to slowly build the business by looking at alternate technologies.

This is how we ended up with the PV panels and thermoelectric cooling solution. We received a small amount of funding from an angel investor and we’re now building a proof-of-concept prototype. We plan to test the unit this summer in Boston.

Q. What are the challenges?

A. Funding is always a challenge. It’s a catch-22: nobody will give you money unless you have a prototype, but you need the money to build the prototype (this is why, I think, so many startups come out of research labs or universities—because they’ve already built the prototype as part of someone’s research work).

Funding is always a challenge for us because we’re targeting developing world markets, which many investors perceive as both risky and unable to sustain a profitable business. Of course, we disagree. We just have to look for the right investors who understand this market.

Q. What surprises have you had and what lessons have you learned in the past 12 months?

A. Well, the team split was a bit of a surprise and a disappointment, but I understand why it happened. We’re moving on. The licensing issue was the last issue I thought would hold us back and, in the end, it was the single most important concern. I should have paid more attention to it early on.

A startup must constantly adjust to changing conditions. It must evolve, but not too quickly—otherwise it can lose focus and alienate people. I’ve heard that, at most, a startup has one or two opportunities to completely change its technology strategy. Anything more than that will make investors and employees nervous. Well, we took that opportunity and now I feel much better about our chances to succeed.

Throughout this roller-coaster ride, we’ve kept a laser focus on the customer, and we’re still very passionate about doing something for developing world markets. Our new technology strategy is just another form that fits the
SEArI enhances access to research

The MIT Systems Engineering Advancement Research Initiative (SEArI) seeks to advance the theories, methods, and effective practice of systems engineering applied to complex socio-technical systems through collaborative research. The group actively shares its research through engagement with sponsors and via events and publications for the wider systems engineering community. Recognizing that websites are proving to be another important mechanism for sharing knowledge, over the past year the research group has worked to enhance its website to provide timely access to its work.

Launched in the summer of 2007, the SEArI website provides public access to a large number of knowledge assets. Website visitors can find information about the research group and its program as well as gain access to four types of documents: presentations, publications, theses, and working papers. Where possible, all documents are available for download in the spirit of open information sharing. At present there are more than 100 conference, journal, and working papers online, covering many systems engineering research topics.

While the primary purpose of the site is to be a portal to research knowledge, SEArI is also using the website as a research tool. SEArI research scientist Adam Ross, architect of the website, describes its importance: “Our graduate student researchers can share information and documents, and they have a mechanism for research exchange via a wiki environment. Our hope is that use of the website will encourage higher levels of information exchange within the research team, as well as better preservation of research results for successive research projects.”

“Our overall strategy is to continue to increase the availability of research knowledge to the systems engineering community—in final form but also the interim results,” said SEArI Research Director Donna Rhodes. One mechanism to both accelerate the sharing of ideas and to help SEArI researchers gain valuable feedback to develop better research outcomes is the recent addition of working papers, which are available on the website before they have been formally published, Rhodes said.

Other information online includes SEArI research bulletins, notices of upcoming events, information on educational courses, and links to sponsors, partners, and other organizations in the systems community. In the future, SEArI intends to develop the website further as a mechanism for interactive collaboration between researchers and practitioners in the systems community.

Visit the SEArI website at seari.mit.edu or contact the leadership team at seari@mit.edu.

Hale named president of INCOSE

By Lois Slavin, MIT SDM communications director

Pat Hale, director of MIT’s System Design and Management Fellows Program, became president of the International Council on Systems Engineering (INCOSE) in January after serving for two years as president-elect. INCOSE is a not-for-profit membership organization founded to develop and disseminate the interdisciplinary principles and practices that enable the realization of successful systems.

A member for more than 14 years, Hale has served on INCOSE’s Board of Directors for eight years. He was president of the New England Chapter from 1994-1997, a member and later chairperson of the Communications Committee, and also served as treasurer.

Hale’s professional interests include application of systems engineering in commercial product development, complex naval system design, and engineering process frameworks and methods.

Prior to joining MIT, he completed a 22-year career in the US Navy, qualifying in both the Surface Warfare and Submarine (Engineering Duty) communities, and culminating in managing the design and construction of submarines in Groton, Conn. Following his Navy career, Hale held executive-level systems engineering positions in defense and commercial system and product development organizations, including serving as director of systems engineering at both Draper Laboratory and Otis Elevator Co., where he developed and implemented Otis’ first systems engineering process and organization.
SDM faculty member Nancy Leveson, professor of aeronautics and astronautics and engineering systems, has already revolutionized risk analysis for complex systems such as nuclear power plants and space shuttles. Now, she’s finishing up a book on her integrated approach that will be issued by MIT Press this fall.

“We used to build systems that were simple enough so that you could test everything, and test the interactions,” she says. “Now, we’re building systems so complex that we can’t understand all the possible interactions.” While traditional analysis assumes a linear, causal chain of events, accidents in complex systems often unfold in very nonlinear ways.

Leveson calls her new approach STAMP, for System-Theoretic Accident Model and Processes. She has set up a company to implement the system in analyzing a wide variety of systems in different fields, and chapters of her upcoming book are available on her website (sunnyday.mit.edu/book2.pdf).

Leveson says the turning point came in 2000, when she realized that after about 20 years, nobody was making any progress in figuring out how to manage the risks of complex systems, she says. "Usually, that’s means there’s something wrong with the underlying assumptions everybody is using."

She realized that the basic component-based approach to assessing risk was something that had prevailed at least since World War II, and it just didn’t apply to many of the highly computerized technological systems in operation today. "Accidents just occur differently. Risk has changed as the technology has changed." So she started developing her new approach, based on systems theory.

At first, she was afraid that nobody would take her radical new approach seriously. "I thought people would just think I was nuts," she says with a laugh. But when she started applying her new approach to specific cases, such as identifying the potential for inadvertent launch in the new missile defense system, it clearly worked: it identified significant hazardous scenarios that nobody had noticed otherwise.

"We tried it on extremely large, complex systems, and it worked much better than what people do now," she says. "I realized we could solve problems that weren’t solvable before."

The new approach to analysis led to a whole new way of dealing with the risk management of complex, socio-technical systems. Instead of looking at the individual components and trying to minimize the chances that each would fail, "what you really want is to enforce safety constraints" on the behavior of the entire system, Leveson says.

"Nancy Leveson has developed a control-based modeling approach to systems safety which can be applied to complex networks of hardware and humans," says MIT Professor of the Practice Jeffrey Hoffman, an aero-astro colleague. "Her work has elicited considerable interest inside NASA, where safety analysis has traditionally concentrated on the reliability of individual pieces of complex systems."

While NASA is using her new approach to analyze risks in the development of the Orion spacecraft that will replace the shuttle, and in developing a future robotic planetary probe, the Japanese space agency has gone even further: They sent two engineers to work in Leveson’s lab for a couple of years and observe how she does her analysis; they have been applying the lessons learned to their space systems while creating improved tools.

Though her work focuses on disasters, Leveson is upbeat about what she does. Using the old ways, she says, "it was discouraging to have something that only works in a small subset of cases." But with her new approach, she says, "it’s very exciting to have something that actually works, and to be able to apply this in the social and organizational realms."

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David Chandler, MIT News Office

SDM lessons help alum launch startup

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same function—something I learned from Professor Ed Crawley’s system architecture course.

Speaking of SDM classes, I’ve relied heavily on the lessons learned in our product design and development class, such as conducting customer interviews, ranking user needs, and generating target specs. All of these lessons came in very handy when we started designing a new solution for the market need.

Q. What’s next?

A. Pushing forward with our prototype, signing up new team members and strategic partners and, of course, looking for funding.

Q. How can Pulse readers learn more?

A. Our website (www.promethean-power.com) has minimal information right now, but we’re working on a new one, and we’ll have more updates in a couple of months. If anyone is interested in learning more about our work or even helping us change the rules of the game, contact me at sorin@sloan.mit.edu. Full details of the market analysis, business case, and economics of the system are available in Promethean’s business plan.
Flexible is a hallmark of MIT’s System Design and Management Program, which offers a suite of academic options to help companies implement systems thinking throughout their organizations. For companies that need a rapid infusion, SDM offers the career-compatible one-year graduate certificate program.

Companies that choose the certificate program often enroll several students at a time, all of whom continue to work. Typically, classes are attended at a distance, through videoconferencing. Certificate students take three SDM core courses, one each semester during the year. They spend two one-week sessions on campus and complete a capstone project.

Developed in 2002 to address the need to infuse systems thinking more quickly into some engineering organizations, the certificate program now also serves as a refresher course for senior engineers and as preparation for students who may enter the SDM program at a later date. Created at the request of United Technologies, the certificate program has grown significantly, drawing 35 students this year, more than three times as many as in that first year. In addition to the United Technologies companies (Pratt and Whitney, Hamilton Sundstrand, Otis, UTC Fire and Security, UTC Power, UTC Research Center, and Sikorsky), John Deere, Boeing, ArvinMeritor, the Instrumentation Laboratory, Wachovia Financial, Tata Interactive Systems and others have become involved in the program.

The classes required for the certificate program are the core courses taken by the SDM master’s students: system architecture, systems engineering, and product design and development (the core SDM courses are fully described in previous issues of the Pulse, available online at sdm.mit.edu/news_archive.html). SDM master’s and certificate students take these courses together.

The weeks spent on campus serve two purposes. The first is to bring certificate students together as a group for special lectures by MIT faculty that address system design and management issues and supplement the coursework. These sessions allow students to interact with one another and the faculty to develop a sense of the multidimensionality of systems thinking. In addition, representatives from sponsoring companies are encouraged to attend and become exposed to the material the students are learning in the program. This latter aspect has been shown to be of high value for putting systems thinking into action within the corporation.

The capstone project generally addresses a problem of interest to the sponsoring company. Ideally, a team of two or three students work together on the capstone, integrating and applying their SDM lessons for the benefit of the company.

The certificate program begins this year on July 10. For more information on the program, contact John Grace at jmgrace@mit.edu, David Erickson at dpe2@mit.edu, or Helen Trimble at htrimble@mit.edu.
Each year SDM alumni plan and host a two-day conference focused specifically on topics of leadership, innovation, and systems thinking. Held annually since 2001, the conference is open to all members of the SDM community, including partner companies, alumni, students, faculty, and staff.

The theme for the 2008 is “Systems Thinking for Contemporary Challenges.” Industry experts and MIT faculty will discuss best practices for applying systems thinking to areas that include sustainability and the environment, product design, technology strategy, entrepreneurship, and software.

For a list of confirmed speakers as of this writing, see Calendar on page 16. Additional speakers are being confirmed.

“The SDM conference is an opportunity for systems thinkers to learn practical applications from best-in-class academics and practitioners,” said conference chairperson Vineet Thuvara, SDM ’05, and senior manager for worldwide Windows server enterprise marketing at Microsoft Corporation. “Attendees will find ample opportunity to have their questions answered and to share their own experiences as well.”

We invite you to join us on October 23-24, 2008! For details and registration information, contact John M. Grace, SDM industry codirector, jmgrace@mit.edu, 617.253.2081.

SDM annual conference to explore best practices in systems thinking

By Lois Slavin, MIT SDM communications director

SDM focus on innovation pays off

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value at Ricardo, and in my first four months I have undertaken a deluge of coursework in this area, including User-Centered Innovation in the Internet Age. I am now trying to incorporate some of the processes and insights I have learned on innovation into my work, and I have begun presenting them to my colleagues. I have also been able to complete two class projects on alternative powertrain technologies, helping me put my Ricardo experience in hybrid-electric vehicles into the larger context of the marketplace and overall technological development, even as Ricardo opens a center for the development of battery systems for hybrid and electric vehicles.

While balancing the workload of an MIT student with a demanding full-time job is not easy, I believe that SDM was the right choice for me. The distance option was a great enabler as I was not comfortable with the opportunity cost of stepping away from my career at this point. There are some challenges, but I am confident that what I am learning will serve me well both in the months and years ahead.

Experts share risk strategies

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explained Alfred H. Ford Jr., deputy director of submarine safety and quality assurance for the Naval Sea Systems Command. Set up in 1963 in response to the loss of the USS Thresher with all 129 people aboard, SUBSAFE is an organizational system specifically designed to minimize risk. SUBSAFE incorporates critical self-evaluation, attention to detail, continuous training, and an unrelenting pressure to meet standards, Ford said.

The conference also included a poster session featuring thesis projects by LFM and SDM students. Cosponsors were SDM, MIT’s Leaders for Manufacturing Program, Industrial Liaison Program, and Forum for Supply Chain Innovation.
SDM calendar
summer–fall 2008

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.

August 19, 2008
SDM Information Evening
Location: MIT Faculty Club

September 16, 2008
SDM Information Evening
Location: Boston Marriott Burlington

September 25–26, 2008
MITRE – MIT Enterprise Modeling Exchange Conference
Location: MITRE Corporation, McLean, VA (video teleconference to MITRE Bedford)

October 20–24, 2008
SDM Business Trip
Location: MIT

October 21, 2008
SDM Information Evening
Location: MIT Faculty Club

October 21, 2008
SEAri Research Summit
Location: MIT

October 22, 2008
SDM Partners Meeting
Location: MIT

October 23–24, 2008
SDM Conference
Location: MIT
Theme: Systems Thinking for Contemporary Challenges
Speakers:
- Valerie Casey, global head for digital design, IDEO; founder of Designers Accord, a coalition of designers, educators, researchers, engineers, business consultants, and corporations who are working together to create positive environmental and social impact.
- Pat Hale, director, SDM Fellows Program, senior lecturer MIT Engineering Systems Division, president, International Council on Systems Engineering (INCOSE)
- Nancy Leveson, professor of aeronautics and astronautics and engineering systems
- Paul M. Murray, director of environmental safety and sustainability
- Ghirish Kumar Navani, cofounder, eClinical Works
- Lee Ng, director, new business creation, Agilent Technologies
- Dharmesh Shah, chief software architect and founder, HubSpot
- Yossi Sheffi, professor of engineering systems; professor of civil and environmental engineering; director, MIT Engineering Systems Division; director, MIT Center for Transportation & Logistics; director and founder, Master of Engineering in Logistics Program
- John deVadoss, senior director for technical strategy, Microsoft Corporation

October 30–31, 2008
CMI Cambridge-MIT Workshop on Engineering Change
Location: MIT Endicott House

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