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

sdmpulse

in this issue

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system design and management

Firetruck project proves hot task for systems team

By Jorge E. Amador, SDM '08

Editor's note: *The following article is based on a presentation created jointly by Ásbjörg Kristinsdóttir, Antonio Del Puerto, Charbel Rizk, and Jorge E. Amador.*

From left, Antonio Del Puerto, Charbel Rizk, Ásbjörg Kristinsdóttir, and Jorge E. Amador, outlined a better way to manage the manufacture of firetrucks for their class project in system project management.

Most of the core courses in MIT's System Design and Management (SDM) Program give students an opportunity to apply the concepts they've learned to real-world environments—but not everybody gets to work on firetrucks.

This past fall, four students in Professor Olivier de Weck's class in system project management had the opportunity to help E-ONE, a leading manufacturer, designer, and marketer of firefighting apparatus and equipment, to develop a set of best practices for product development for a class project.

Ásbjörg Kristinsdóttir (LFM '08 and current PhD student), Antonio Del Puerto (SDM '08), Charbel Rizk (SDM '08), and Jorge E. Amador (SDM '08) teamed up to help E-ONE analyze the development of a new entry-level pumper truck (code name TES).

In class, de Weck teaches a series of management principles and methodologies to plan and implement system and product development projects. The SDM team set out to use these tools to analyze and document the TES project and establish best practices for the company.

E-ONE typically produces fully customized trucks to order. The TES was a new approach for the company, offered with a complete set of pre-engineered options. This new program also had a compressed schedule—just six

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Welcome

Welcome to the spring edition of the *SDM Pulse*. In this edition we are providing readers with a bonus: more articles. We just can't resist sharing the many fascinating stories that have crossed our desks concerning SDM students and activities.

Let me highlight just a few. In the area of project management and product development we look at the issues raised in three different contexts. Jorge Amador, SDM '08, and his teammates share the project management challenges they faced helping a reorganized company to develop a new fire engine. Adrian Diaz, SDM '07, looks at global product development in an auto company that is under stress. And Josh Hanson, SDM '08, gives us a view into a product-enabled service in the health-care industry. In all of these cases you will see the applicability of SDM's systems thinking and methodologies.

Luke Cropsey continues discussing his work analyzing a complex system involving multiple stakeholders. In this follow-on to the article published in our last issue, he demonstrates the use of the enterprise purpose statement and the X matrix to ensure the alignment of stakeholder values.

Recognizing the importance of the human aspects of systems and management, David Kim, SDM '07, delves into the impact of generational differences in large, technically driven organizations. Some of David's findings may seem counter-intuitive, but they are supported by data.

In addition to illuminating several more facets of SDM activities in other articles, we also provide a glimpse of the 2009 SDM cohort and some of its activities during the January 2009 "boot camp." Articles on the SEAri summit and SDM's annual conference further provide a concise update on the latest systems thinking for companies. Overall, it is our hope that you can see a direct link between SDM classwork and research and the real-world, cutting-edge problems that you face in your company. We welcome your comments and questions.

Best regards,

John M. Grace

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Systems thinking applied to service-oriented Philips Lifeline

By Joshua A. Hanson, SDM '08

Joshua A. Hanson
SDM '08

Technology is just the beginning of the business at Philips Lifeline. Our product, the Personal Help Button, is inextricably linked to our service—a national call center that stands ready 24 hours a day to help more than 700,000 seniors maintain their independence.

Systems thinking is critical to this business model, best described as a product-enabled service (the equipment is leased and a monthly fee is charged for monitoring and support), because the product design and service design are truly interdependent.

As a product designer for Philips Lifeline, my role is as much about facilitating diverse groups of people (seniors, caregivers, call center staff, etc.) to create a network of personal safety as it is about designing a physical item. The goal is not to design products alone but to design meaningful service experiences. SDM's comprehensive set of tools—involving systems thinking, design optimization, and leadership—are helping me to take on the interconnected and multidisciplinary nature of product development in this company.

Philips Lifeline is focused on health care, which means that compassion is as important as engineering principles in my job. I have visited dozens of homes to expand my field of vision into the everyday lives of the senior population. In the environment of a client's home, I am able to witness the latent problems that focus groups are unable to uncover. Cognitive decline, macular degeneration, arthritis, and other issues can all affect how seniors interact with the devices that support their independence. I have found that such direct customer interactions are critical to understanding the linkages and dependencies that exist between our customers and the Lifeline product/service system.

Even something as trivial as how easy the packaging is to open ripples across different areas of the business, affecting cost (assembly time and shipping costs), customer satisfaction (arthritic hands hate scissors), and profit (monthly subscription fees don't start until the product is opened and installed).

Similar interdependencies emerge around more thorny issues, such as liability, regulatory compliance, privacy, usability, etc. In all these cases, small design decisions have big impacts on seemingly unrelated parts of the business. As our offerings grow from single products to an interconnected suite of products and services, it becomes more and more difficult to understand and build the complicated feedback loops that mediate these relationships.

So, is the antidote to systems of growing complexity to strive for simplicity, as Philips' corporate motto—"Sense and Simplicity"—suggests? That's not always possible. Fortunately, the SDM course in system architecture, a core requirement, has provided me with mental frameworks to both understand and manage the complexity of our home health-care systems. One straightforward example given in class is to imagine a paragraph of text without punctuation or spaces. It's simpler (fewer characters) than a well-punctuated paragraph, but it is far more difficult to read. The point is not to reduce complexity at all costs but instead to use system architecture principles to reduce "complicatedness" and present an image of the system that reduces ambiguity. As guest lecturer Victor Tang, ESD PhD '06, former vice president of IBM China, put it, "Complexity is like cholesterol; there is good cholesterol and there is bad cholesterol."

Innovation in a caring culture

In 2006, Lifeline Systems was acquired by Philips Electronics. This merger prompted a strategic shift in Philips' focus into the home health-care market and exploded Lifeline's innovation possibilities with the backing of the entire Philips research organization. Lifeline is now effectively positioned as the future hub of a complex network of interconnected products and services centered on helping seniors and their families to manage their own health and well-being from home.

For the first time, rapid product innovation is part of Lifeline's strategic mission to increase growth. And yet the old way—a rigid departmental structure, a fixation on incremental improvement, operational excellence, and caring—remains. Quality demands repetition, focus, and repeatable results. Innovation, on the other hand, encourages uncertainty, risk, and a suspension of disbelief. How can we foster innovation while maintaining the culture of caring and quality that our customers have come to trust their lives to?

Luckily, during this transition I was able to take SDM's class in organizing for innovation. The answer to this quality/innovation dilemma that emerged during the course lectures (and the last three years of successes and failures at Philips) is to move away from a rigid department structure and adapt a matrix organization reliant on project teams. Pulling people together from every department forces increased communication between isolated groups, fosters a shared sense of purpose and allows a well-coordinated plan of product/service development.

Ultimately, I have found that while simultaneously being an MIT student and a Philips employee has its stressful periods, the relationship between the two is very rewarding. The two create a mutually symbiotic relationship; Philips becomes stronger as a result of the broad cross section of SDM tools and approaches that students are exposed to, and the SDM program stays relevant to industry through the real-world problems brought into the program from Philips and other businesses.

Keeping up with SDM, family, and consulting job takes teamwork

By Paul Gomez, SDM '06

Paul Gomez
SDM '06

I'm sometimes asked how I got through the rigors of the System Design and Management (SDM) Program while simultaneously running an independent consulting business and raising a young family. I always say it helps if you thrive on stress and can function on five hours of sleep a night.

But in truth I had a lot of help. My wife, Diane, stayed home full-time with our children: Brian, who was 2 when I started in the program, and Juliana, who was born midway through SDM, in January 2007. I made sure that I was always home for dinner and took time to play with the kids, but from 7:30 am until dinner I was typically gone.

My colleagues at SDM also helped me keep up the juggling act, so I have a lot of teammates to thank for my success—people who were both really smart and really flexible. I found that when I was completely overloaded and couldn't finish my portion of a problem set, for example, they would pick up the slack. And I would do the same for them. It played really well into my chaos that I could rely on this team.

As for my business, the key to consulting is to have more than one client at a time and make them all feel as if they're the only ones. That was harder to do during SDM, so I scaled down my business a bit. But I also got lucky: my main client at the time was more concerned about results than availability, so I was able to catch up on work at night.

It helped that my business was well established when I started the program. I founded my small consulting firm, ThinkBox Solutions, doing custom software architecture and applications development, in 1996.

Interestingly, it was through my business that I first learned about SDM. While researching a server issue I stumbled upon the blog of Robbie Allen, SDM '05, who described how he had solved the same problem. Following a link to SDM, I read about all the classes and became intrigued. I like to take advantage of a lot of training—it makes you a better consultant—and at the time I felt like I wasn't doing enough. So I applied.

During SDM, I found the class in system architecture particularly useful because it defined the "ilities" that systems need—such as durability, maintainability, and flexibility—as well as their relationship to system complexity. Having formally recognized these qualities in class, I found I was better able to evaluate a proposed system design in my business, offer customers alternate designs and generally improve the way I architect complex software architectures.

Some of the topics related to the generation of new business from technology and dealing with patents also filled in gaps of things I didn't understand.

In addition, SDM's guest speakers were incredible. One was a civil engineering architect, Steve Imrich of Cambridge Seven Associates, who talked about form and function, which has so many parallels to my business. Ever since I heard him speak, I have worked to integrate into my designs what Imrich calls the "magic": some interesting and highly beneficial feature that the customer doesn't expect and hasn't thought about.

I have a lot of teammates to thank for my success—people who were both really smart and really flexible.

In addition to all I've learned through SDM, I've also made terrific contacts, both to my talented cohort as well as to MIT's faculty. So I have no regrets about working so hard to get through the program. I always wanted to go back to school, and I don't think I could have found a better fit. After all, MIT is the gold standard.

Ford takes holistic approach to global production

By Adrian Diaz, SDM '07

This is make or break time for the American auto industry—a fascinating and exciting time to be working for Ford Motor Co. Ford has introduced a new approach to its business called "One Ford," which is a holistic concept that takes advantage of the company's global reach to improve products and streamline production. This new approach is focused on developing one team, one plan, and one goal for all the company's products, a perfect setting for my SDM lessons to be put to good use.

Ford of Mexico colleagues Antonio Del Puerto, SDM '08, (left) and Adrian Diaz, SDM '07, pose in front of the new 2009 Ford Fusion Hybrid at the 2009 North American International Auto Show in Detroit.

In my job as a product development engineer at Ford of Mexico, I am working on a vehicle for the North American market that will capitalize on this new framework, using global platforms to develop customized vehicles for different markets. My experiences in SDM are helping me understand the fundamental underpinnings and assumptions of this concept from multiple perspectives, including those of systems engineering, product design and development, multidisciplinary system design optimization, as well as the human side of technology. Attending SDM while working has also made it possible for me to apply improvements to processes right away and capture them for my SDM thesis.

In my current project, for example, we are utilizing a global platform and substituting selected common systems to satisfy regional requirements. This may seem like a simple idea, but putting it into practice presents a number of interesting challenges. Some of these derive from the basic idea of developing a platform that can potentially satisfy all requirements for all regions whether any one feature is implemented in an area or not. This approach requires us to take into account all relevant requirements for various regions during the development of the initial vehicle concept design. This in turn means all relevant parties must be involved from the start.

Identifying requirements may sound easy, but this task gets tougher as systems requirements for different locations are added into the "One Ford" mix. Getting a clear snapshot of all requirements calls for experts from each market and from each discipline to collaborate on the initial phases of the design.With the systems mindset fostered in SDM through such courses as Multidisciplinary System Design Optimization, Systems Engineering, and System Architecture, I've learned the importance of methodically decomposing technical systems and identifying teams that have a stake in the product at the outset.

Unless we can successfully analyze each market's requirements early, downstream design changes will be needed, increasing costs. We know, for example, that differences in regulations in Europe and in North America mean that European vehicles may require different components than those typically found in North American vehicles.

For that reason, the company is developing new platforms that will make it possible to customize even the overall structure of the vehicle to meet different regulatory needs. Our goal is to move from the traditional approach, in which vehicles with major structural differences must be produced in different plants, to one in which the same assembly plant can produce vehicles with very different components. This flexible design will not only serve us well in competing in the global marketplace, but should make it easier to incorporate new requirements into future vehicles without retooling.

With so many people in so many countries involved in global product development, human interactions present huge challenges. One important lesson that SDM has drilled into my mind is that complex engineering systems have both technical and human elements. Courses such as Managing Innovation and Organizing for Innovative Product Development have helped me understand and deal with the human interactions that are key to a successful launch. This experience has sensitized me to the issues as well as provided me with tools to engage and contribute to the solution of real-time issues during product development.

At times this project feels like an uphill battle, but I believe that Ford and Ford of Mexico are headed in the right direction by taking this holistic, systems approach to vehicle design.

SDM tools serve US Air Force integration project

By Luke Cropsey, SDM '08

Luke Cropsey
SDM '08

Editor's note: *This is the second in a series of articles by SDM alumnus Luke Cropsey, who is integrating knowledge from various MIT resources and transferring it to his employer, the US Air Force. This article expands on the use of several tools introduced in Cropsey's first article, which appeared in the fall 2008 edition of the* SDM Pulse, *available online at sdm.mit.edu.*

Albert Einstein said, "The problems that exist in the world today cannot be solved by the level of thinking that created them"—and this is especially true in the design and implementation of complex socio-technical systems. The problems that emerge in bringing order out of complexity result from interactions that are already so entwined that simply understanding the problems' nature can be exceedingly difficult.

Addressing issues at a level deep enough to find solutions is even more challenging.

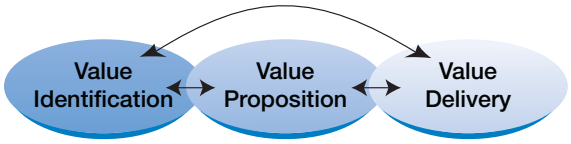

Figure 1. Value-creation framework.

Several tools taught in the SDM program have proved useful in controlling complexity and bringing analytical rigor to analyses, making it possible to work toward the solution of complex challenges with a high degree of confidence. In this article, I will examine two tools useful for aligning an enterprise to tackle complex problems: the enterprise purpose statement and the X matrix.

In Part 1 of this series, I explained that I am working on the integration of unmanned aircraft systems (UAS) into the National Airspace System. The overarching methodology I used to examine this problem was the value-creation framework developed by E. Murman et al. in *Lean Enterprise Value*, depicted in Figure 1. A key element in this approach is aligning value among enterprise stakeholders, which is especially challenging in situations where critical stakeholders appear to have value definitions that are at odds with each other.

In such situations, a structured approach to aligning value definitions is essential to creating lasting value. Figure 2 graphically illustrates that any solution must take into account both the stakeholders that are hierarchically above and below the activity under discussion (this is the vertical value alignment), as well as the needs of the multiple stakeholders that are involved across the scope of the enterprise (the horizontal value alignment).

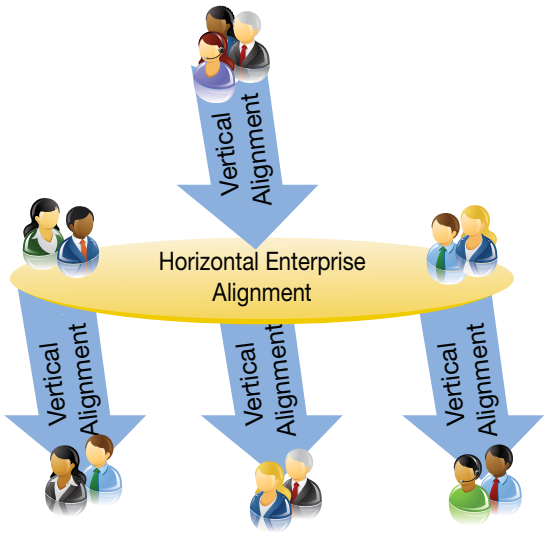

Figure 2. Vertical and horizontal value alignment.

Vertical alignment ensures that the project produces the required results, enabling those further down in the chain of command to work effectively and efficiently toward the organization's top objectives. Vertical value alignment is achieved using the enterprise context structure adapted from Professor Edward F. Crawley's system architecting playbook.

Horizontal value alignment keeps the project itself on track, integrating the needs of the numerous elements within the organization that have a stake in the project. The objective is to align the needs of all the stakeholders so that value flows through the entire extended enterprise.

Graphically depicting the UAS airspace integration effort as initially conceived (Figure 3), illustrates the problems of misalignment. First, the enterprise purpose (labeled "origin goal") does not fundamentally address the needs of the Federal Aviation Administration (FAA). (Note that "restore principle of maneuver,"[1] a higher level consideration in military doctrine, is outside the boundary of the enterprise because initially the UAS Airspace Integration Enterprise did not consider this to be part of their purpose.) Second, while training and operating UAS in the desired fashion certainly contributes to the broader upstream objective of "global strike," the overall intent is

[1] The "principle of maneuver" is a higher level objective of the military—one of nine "principles of war," outlined in U.S. military doctrine. The principle of manuever calls for placing the enemy in a position of disadvantage through the flexible application of combat power.

not adequately captured. “Training and operating” better describe the activities required for global strike capability. Significantly, what is missing is the fundamental capability that will fully satisfy both the FAA and the Department of Defense (DoD) value needs.

Creating a more useful enterprise purpose statement, by expanding the objective to “restore maneuver” as depicted in Figure 4, allows both the FAA (safety needs) and the DoD (war fighting capability needs) upstream values to be explicitly addressed and linked to a common purpose.

Figure 4 shows the same project with all the stakeholders’ objectives aligned. Expanding the enterprise objective beyond “train and operate” to “restore principle of maneuver” and moving that objective to the center of the enterprise meets both DoD and FAA upstream value needs, while providing clear connectivity to the downstream tasks that will further these goals. In addition, while “train and operate” weighted the enterprise toward DoD needs, moving to the higher-level goal of “restore principle of maneuver” adjusts the focus of the enterprise to balance the needs of both primary stakeholders.

The applicability of “restore principle of maneuver” is clear enough in the DoD context, but the value to the FAA may not be as readily apparent. Recall, the undergirding value basis for the FAA is that of flight safety. Creating an enterprise purpose focused on increasing the maneuverability of a UAS contributes directly to meeting the primary value of the FAA—safety. It is perhaps worthwhile to expand on the idea of maneuver in this context, because the concept goes beyond the simple ability to fly, turn, ascend, or descend more quickly, although this is a significant component. More fundamental to the idea of maneuver is the knowledge required to know where you need to be in relation to the things around you (and consequently, avoid flying into them). This relational aspect of maneuver holds the lion’s share of value for the FAA.

Fundamentally, the need to create simultaneous value for key stakeholders in the enterprise is what motivates changes to the enterprise purpose and/or scope. Often, significant analysis may be required to correctly identify enterprise purposes that do not provide a positive value exchange for each key stakeholder. Resolving this misalignment in the enterprise purpose to create the appropriate conditions for positive value delivery to each key stakeholder is the defining criteria for re-scoping the

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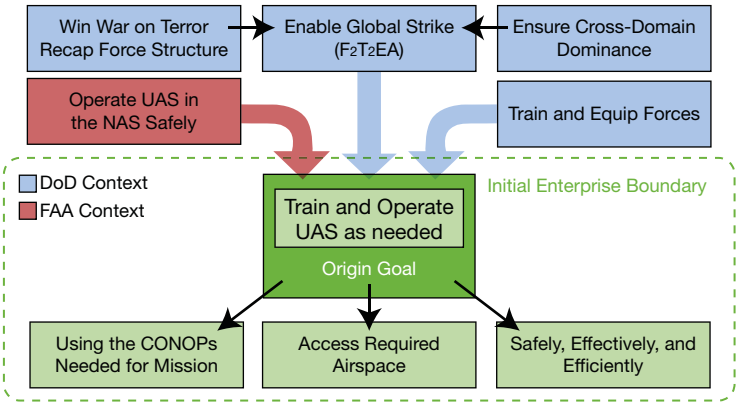

Figure 3. Enterprise context for UAS integration.

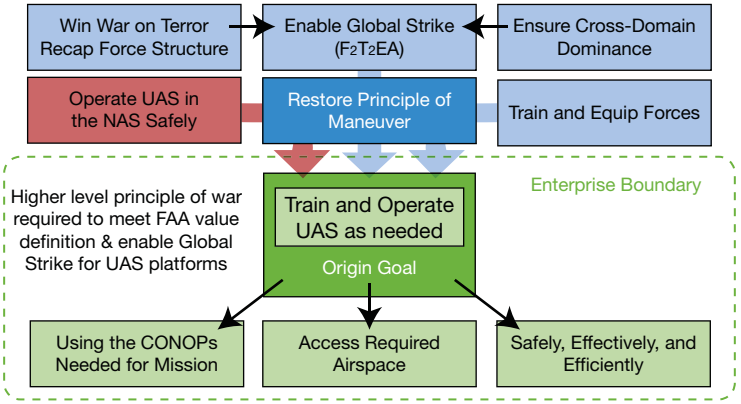

Figure 4. Expanded enterprise objective.

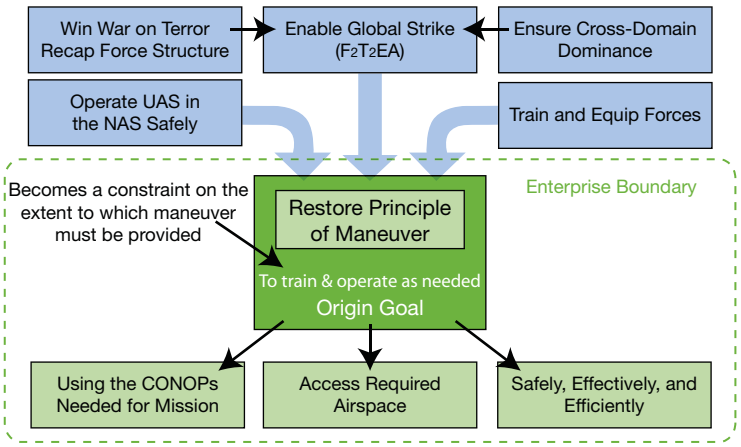

Figure 5. Final UAS airspace integration enterprise context.

SDM tools serve US Air Force project

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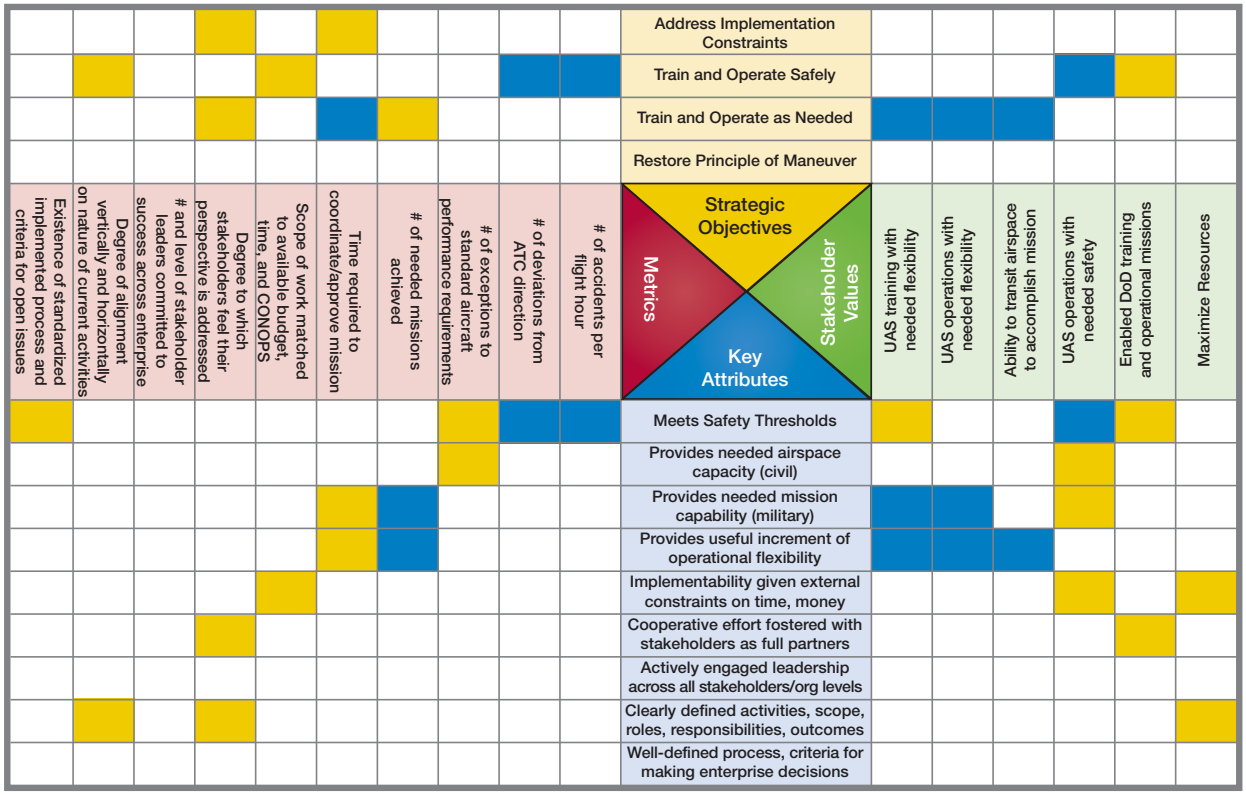


Figure 6."As-is" X matrix for the UAS airspace integration enterprise.

enterprise purpose and must be doggedly pursued until each key stakeholder is convinced their value proposition has been met. In the case of the UAS airspace integration enterprise, it took a change in purpose from "train and operate" to "restore principle of maneuver" before both the DoD and FAA value propositions could be satisfied. Arriving at an enterprise purpose readily identifiable by all stakeholders as providing intrinsic value to their organization is perhaps the most difficult creative aspect of the enterprise architect's tasks. It requires an in-depth understanding of the enterprise stakeholders and their needs as well as the ability to view the problem each of them desires to have "fixed" from a fundamentally different perspective. Scoping the activity so the objective is broad enough to address all needs of primary stakeholders while keeping the problem solvable at the enterprise level creates a tension that must be maintained using experience and insights gained during the data collection effort.

With the vertical alignment of the enterprise value structure resolved, the focus shifts to the horizontal alignment of activities within the enterprise to ensure effective and efficient execution of the enterprise purpose. The X matrix, developed by Deborah Nightingale and Alexis Stanke of MIT's Lean Advancement Initiative, provides a quick way to assess alignment of enterprise activities and metrics with enterprise purpose and value states.

Figure 6 depicts the "as-is" UAS airspace integration effort using an adaptation of the X matrix. There are four principal axes:

- *Strategic objectives*. Entries show the enterprise's overarching objectives and describe successful value delivery.
- *Stakeholder values*. Entries in the second axis, moving clockwise from the top, capture the primary value definitions across the enterprise's key stakeholders. The point of intersection between a "strategic objective" and a "stakeholder value" defines the degree of correlation between the two entries. Blue is used to denote a strong degree of correlation; yellow denotes a weak correlation; and a white box indicates no correlation. The colors make the degree of alignment easy to see.
- *Key attributes*. This axis captures what success looks like by describing how the stakeholder recognizes delivery of stakeholder values.
- *Metrics*. These provide a measure of progress

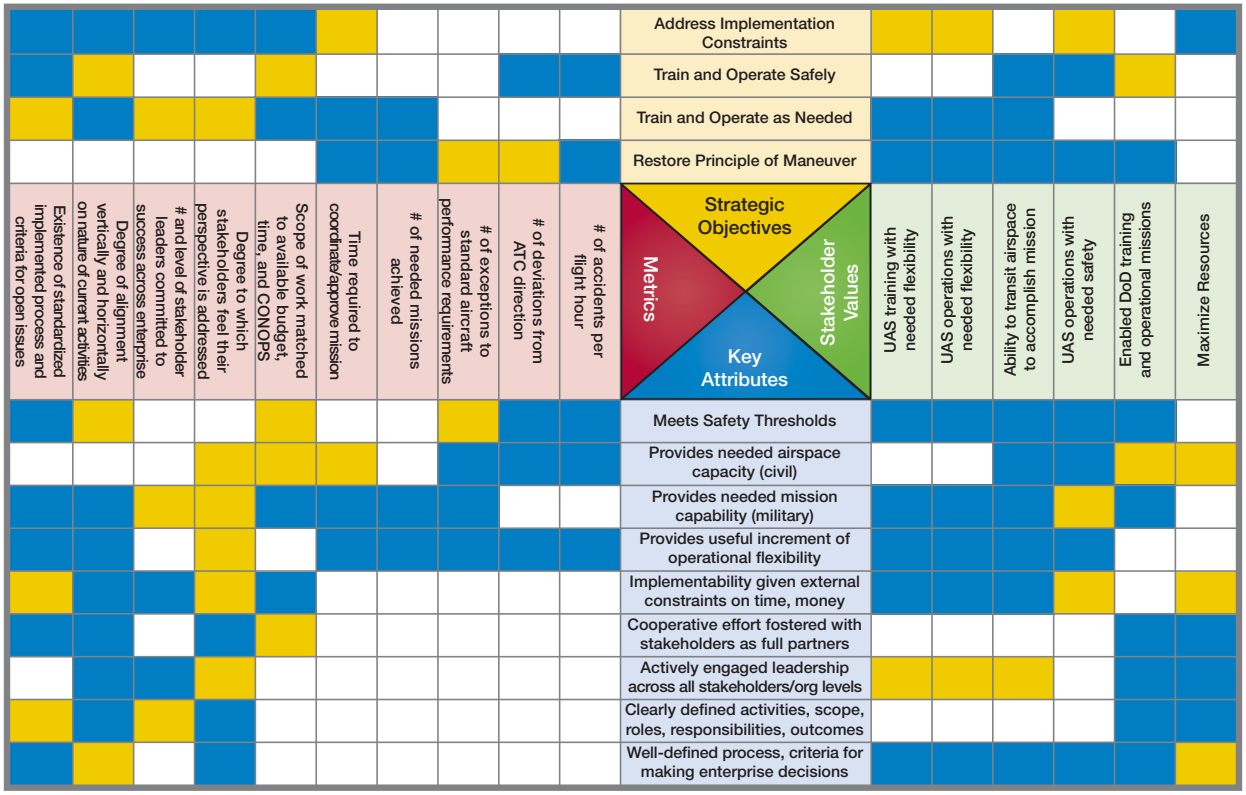


Figure 7."To-be" X matrix for the UAS airspace integration enterprise.

toward attaining the key attributes and, ultimately, the objectives.

The value of the X matrix lies in the process of laying out each of these four axes consistently and logically, then assessing the degree of correlation between each successive axis. Too often, an analysis of this type reveals significant shortfalls. As Figure 6 shows, the "as-is" state frequently lacks any significant degree of correlation moving clockwise around the X matrix. Here there is only one case where a strong degree of correlation is preserved across all four axes—in the "Train and Operate Safely" strategic objective, which is strongly linked to "UAS operations with needed safety," "Meets Safety Thresholds," and "# of Accidents per Flight Hour." Everywhere else, strong correlation across the enterprise is lacking.

Solid data collection and analysis is the key to constructing a useful X matrix. In Figure 7, the four axes are laid out according to what the data indicates the values should be for the UAS matrix. This "to be" X matrix represents the vision the architect has for the enterprise and the roadmap for the enterprise architecting activity that will follow. In contrast to the "as-is" matrix, every entry on each axis of the "to-be" matrix is strongly correlated to at least one or more entries on the adjacent axes. Even a cursory comparison between these two X matrices shows where improvements are needed.

A well-built X matrix provides the foundation for future value delivery. The structure of the X matrix forces a deliberate consideration of how the enterprise objectives and values are aligned with attributes and metrics. As obvious as this may seem, the number of organizations that actually employ a rigorous analysis of this type are few and far between. The method presents information in a simple enough format so that even complex enterprises can be taken in at glance. Armed with the insights provided by the X matrix analysis, the enterprise architect's task of synthesizing potential methods for delivering the desired results can be undertaken with a relatively high degree of confidence.

In my next article, I will discuss the use of Object Process Methodology (OPM) for architecting solutions using the information gleaned from the vertical and horizontal value alignment exercises just described.

SDM Best Thesis Prize awarded for generation gaps research

By David Kim, SDM '07

David Kim
SDM '07

Editor's note: *David Kim was awarded the SDM Best Thesis Prize in October 2008 for his paper, "Generation Gaps in Engineering?"*

The idea of a "generation gap" has profound implications for the business community—misunderstandings and conflict can damage work relationships, hurt productivity, and impede success. In addition, companies risk damage caused by "brain drain" unless knowledge can be successfully transferred from more experienced employees who are about to enter retirement to succeeding generations.

Nevertheless, I found that empirical research was lacking on generational differences and their effect on organizations. In my SDM master's thesis, I therefore investigated three questions within the context of an engineering organization: Do generational differences exist? How pronounced are they? And, if the differences do exist, what are the implications for the organization?

Through the literature, I found that the most widely accepted "generational" school of thought maintains that values are imprinted for life by defining historical events that occur as people mature into adulthood. This theory divides the current U.S. workforce into four distinct generations:

- *Traditionalists (born between 1900 and 1945)*. This generation numbers approximately 55 million as of 2005; those who remain in the workforce tend to be in management. Having lived through world wars and the Great Depression, Traditionalists value stability and respond best to command-and-control structures. Many still lack technological literacy—their understanding and proficiency in the use of computers, the Internet, and other tools of the Information Age are limited.
- *Baby Boomers (born between 1946 and 1964)*. At 80 million strong, Boomers dominate upper management today. Having lived through the booming postwar economy, they are marked by optimism and confidence. They are also very competitive. Baby Boomers, like Traditionalists, are still learning to use modern technology in everyday tasks.
- *Generation Xers (born between 1965 and 1980)*. This influential population of about 46 million is marked by skepticism. With shared experiences such as Watergate, the Challenger explosion, and the tripling of the U.S. divorce rate, they distrust relationships and put more faith in themselves. They respond to well-defined goals and leaders who give them autonomy. They are resourceful, independent, individualistic, and highly techno-literate.
- *Millennials (born between 1981 and 1999)*. Born into a world of advanced technology, the 75 million Millennials are bringing technical competence, high speed, and energy into the workplace. Born into affluence and relative peace, Millennials are confident and optimistic. They have high expectations of themselves and their employers. They favor an inclusive style of management.

It is easy to see the potential for problems between these groups, even though this list barely touches upon the many generational differences discussed in the literature. To help identify the "root" differences, I used a Mind Map, a powerful graphic tool for organizing the themes of a subject according to associations of greater and lesser importance. The Mind Map allowed me to organize and categorize the wealth of data and determine what I believed to be most important to an engineering organization's operation: differences in communication techniques, leadership preferences, learning styles, and work motivation.

Next I developed a survey to test whether these differences actually exist and can have an affect on a real organization. The key differences identified during literature research formed the basis of a questionnaire, constructed such that participants could not recognize its subject to be generational differences.

The 29-question online survey was distributed to an engineering team in a large defense company. The sample of 357 engineers—approximately 80 members from each generation—were randomly picked from locations on the east coast of the United States to minimize noise relating to potentially varying cultures across the country.

From the 177 responses received, the most significant finding was that generational differences were less pronounced than expected. Of primary significance was the fact that face-to-face communication was deemed critical and most effective by all generations, particularly for discussing technical questions. This finding confirms Professor Tom Allen's research, which found face-to-face communication vital to furthering technological innovation among engineers. The implication for organizations is that physically arranging office space so that many generations have the opportunity to come together face to face has immense potential to improve the flow of knowledge.

The data also indicated that, regardless of age, engineers are generally amenable to technology and computers. Foremost, almost everyone regarded computers as part of life; very few saw computers as annoying or complicated. And while much of literature indicated that older

generations struggle with newer forms of technology, the survey found older generations are using electronic communication without much difficulty. In fact, Baby Boomers were using e-mail more than any other generation.

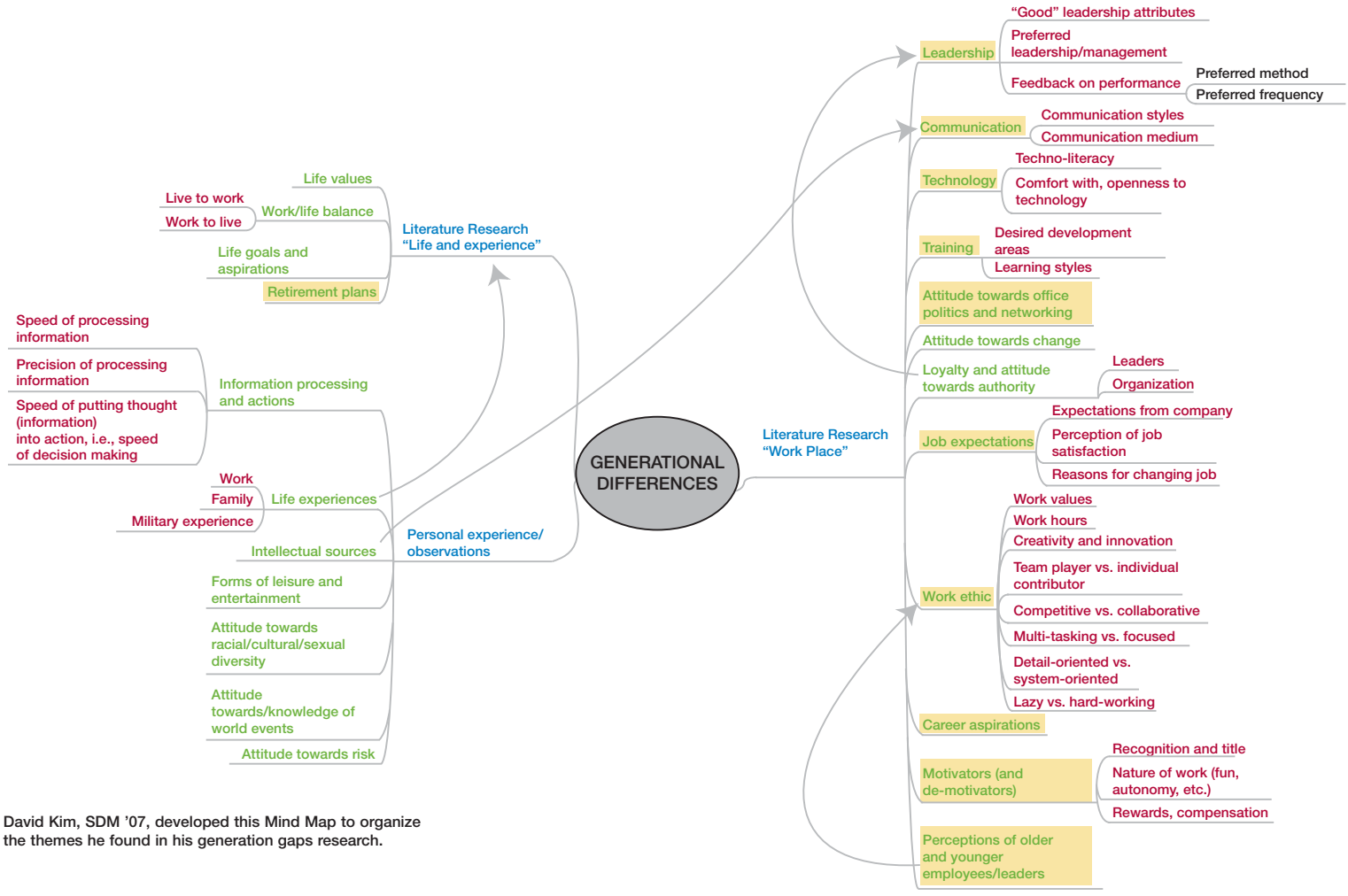
Since globalization has made it impossible for companies to rely entirely on face-to-face communication, this widespread comfort with newer technology suggests that engineering organizations can successfully employ innovative information technology (IT) approaches to communication when face-to-face interaction is not possible.

Another useful finding was that all generations value one-on-one training and mentorship. Since the survey also revealed that Traditionalists and Baby Boomers plan to work in some capacity after retirement, an organization might reasonably consider developing mentorship programs—pre- and post-retirement—to ensure the transfer of knowledge from one generation to another.

Other survey findings include:

- Attitudes toward both younger and older leaders were similar across the generations. This alleviates much of the concern expressed in the literature about younger leaders managing older employees.
- Engineers from all generations expressed the desire to further their education in their respective technical areas with younger generations also showing interest in leadership and management training.

Although I was only able to scratch the surface of the "generation gaps" issue in the SDM thesis, the discoveries were fascinating. I also realized that while categorizing can provide valuable insights, dividing people into groups can also lead to dangerous stereotyping. My hope is that, by presenting facts as objectively as possible, I was able to increase awareness of the complexity of the social issues that affect engineering organizations, as well as the importance of including these issues in any systems approach to managing such enterprises.



David Kim, SDM '07, developed this Mind Map to organize the themes he found in his generation gaps research.

Firetruck project proves hot task for systems team

> continued from page 1

months for product development—giving all stakeholders a sense of urgency.

Analysis

Goals for the class project were established through a series of discussions among the company, the team, the faculty mentor, SDM Industry Codirector John M. Grace, and the course teaching assistant, Athar Syed, SDM '07. The three main goals were to:

- Suggest a better sequence for the TES project tasks
- Suggest the application of new methodologies for project management that could be used for future projects
- Provide upper management with a clear view of all the tasks needed for product development

To meet these goals, the team decided to create a unique work breakdown structure (WBS) for the project and to analyze the task relationships using a design structure matrix (DSM). The SDM team took a three-phase approach:

Phase 1: Product familiarization. To learn more about firetrucks, their usage, and the perceived quality of E-ONE products, the team visited several fire stations in Boston. Members also researched the firefighting apparatus market and investigated competitive products.

Phase 2: Data gathering and company visit. Peter Guile, CEO of E-ONE, visited MIT early in the semester and provided the team with details about the company's business models and product plans. In addition, several conference calls were held with the TES engineering and project management team to define an initial WBS.

The SDM team then traveled to E-ONE's corporate offices in Ocala, Fla., and conducted two days of interviews with 16 engineers and managers. These interviews added to the team's understanding of the tasks and project details needed for the design of the TES.

Phase 3: Analysis and model development. The team developed the final WBS for the TES program and performed the task dependencies. A DSM was created to analyze these dependencies and to explore the possibility of improving the sequence of tasks for future projects.

The most onerous part of the project was coming up with a reliable WBS, understanding the company's needs and processes, and carefully mapping the dependencies. The interviews at the company revealed that each department (sales, product management, engineering, and manufacturing) had its own way of working, even using different task names to describe the same types of work. This legacy system of silos of expertise created significant issues in product development, manufacturing, and quality.

Although the company recently reorganized into value streams to "break down" these silos, there is still work to be done. In some cases, engineers seemed to think it was unnecessary to communicate engineering changes and improvements—an engineering area might release its parts to production without knowing how they would interact with the rest of the components. The SDM team's new work breakdown structure was designed to address this issue.

Next, the SDM team set up the DSM to perform the analysis. The final DSM was a matrix of 114 by 114 elements, and it was necessary to use a combination of PSM 32 software and some manual manipulation to perform the analysis.

Results

The design structure matrix was a very useful tool for observing and analyzing the relationship among the tasks needed to create the TES firetruck. Overall, six meta-tasks were identified, and 10 areas were found in which the project might hit a rework cycle due to the late discovery of various issues. The sequence of tasks created by the SDM team should make future projects more efficient.

The SDM team helped E-ONE create an integral product development process that will reduce time to market for new products. The DSM allowed the company to gain visibility of all tasks needed to launch a new product as well as the dependencies among tasks that are critical to establishing a useful schedule using the critical path method (CPM). Finally, the company will be able to use the results of the DSM analysis to better allocate resources.

Going forward, the team recommended that E-ONE continue to analyze the product development process, defining task durations more accurately in order to set up a CPM and identify critical tasks for better control. In addition, the company was advised to study the possibility of implementing the use of the DSM throughout the organization to highlight dependencies among different projects and teams.

SDM helps Wachovia tackle challenges in workload automation

By Jeffrey Norman, SDM '08 certificate program

Jeffrey Norman
SDM '08 certificate program

Editor's note: *Jeffrey Norman is enrolled in SDM's one-year certificate program, which provides companies with a quick infusion of systems thinking. In this article, he describes how he is putting his new skills to work at Wachovia, a Wells Fargo company and one of the largest banks in the United States.*

Each student in SDM's certificate program is required to complete a capstone project that addresses a real company problem using systems thinking. As a manager within Wachovia's information technology (IT) group, my area of focus is workload automation. At the time I joined SDM, the system we were using needed an overhaul. I therefore chose to tackle this problem for my capstone project.

Rolled out in the mid-1990s to provide event-driven automation for complex business processes, Wachovia's workload automation system was largely decentralized with little to no oversight. It had also grown in both size and complexity over the years, making the need for governance and architectural redesign evident.

I set out to re-engineer this system well aware of the challenges we would face. Not only did my team and I need to design, integrate, and implement a new system and a new process for using it, but we had to introduce and implement systems thinking across multiple user teams. Several processes spanned these teams, which meant that ownership and agreement would be an issue. We therefore needed to infuse a new way of thinking into the company—encouraging everyone to look at the entire system and the overall process holistically from a service/customer's perspective and not from that of an individual team.

We found that because existing processes were cumbersome, handoffs between teams were often poor and, in some cases, undocumented. The re-engineered process had to simplify the workflow and eliminate steps that failed to add value. This was the foundational premise. Simply speaking, without a usable and robust underlying process for the people using the system, the technology wouldn't work.

The new system would involve connecting several previously autonomous processes and subsystems into one holistic, all-encompassing system. A key challenge in the architectural design was to minimize complexity and avoid "overengineering" the system. Reusability was a vital consideration for the access control module that could be used across all subsystems. This would enable the system to adapt to new and changing needs.

Finally, concurrent with system design and architecture, a rollout plan for implementing the system with little to no impact on daily banking operations needed to be developed. This would be a tricky task for a system that supports more than 400 highly coupled applications.

Using the systems thinking methodology I learned in the SDM certificate program, I worked with my team to develop a plan to address these challenges. The components included:

1) Adopting systems thinking: Implementing a capability maturity model (CMM) for IT services would establish the framework for a holistic business model that addressed both process and technology and would provide the structure needed to manage a disciplined service. A tool used to measure the success of business processes, CMM would also serve as a feedback loop that systematically measured the service's maturity as incremental improvements were made over time.

2) Applying system design and architecture: Lean methodology was used to clean up existing processes and automate manual, error-prone steps. By mapping value back to the customer, processes were developed that were more intuitive and user-friendly. A blended design approach was applied. Although we frequently used a top-down approach (decomposition), we also employed a bottom-up approach (synthesis) to evaluate emergent properties and identify reusable elements. This was done iteratively at several layers in the architecture as the implications of our design became more apparent. Leveraging existing technologies, we designed an access control system to support our workload automation systems. What's exciting is that we feel it has the potential to be used across the entire IT infrastructure over time.

We faced several tough design issues, such as balancing the level of allowable access with tradeoffs between risk (strict process control) and faster cycle times (lower-level decisions). We also explored how the system could be designed with the flexibility needed to accommodate a maturing organization. We had to find fit, balance, and compromise on a number of key design decisions.

3) Implementation: While the plan was rolled out, we had one goal to keep in mind: zero production impact while minimizing operational risk. The high interdependency of applications using the system presented a unique challenge. We needed to somehow aggregate applications in groups so that highly interdependent applications were migrated together from the old system to the new system. We used Professor Steven Eppinger's design structure matrix (DSM) to identify and cluster interdependent applications, which helped us sequence the proposed implementation strategy.

With the recent Wells Fargo acquisition of Wachovia, our system will soon be put through its first test. We are hopeful that this scalable and extensible workload automation system will pass with flying colors!

International Symposium on Engineering Systems slated

This June, MIT will host the second International Symposium on Engineering Systems, a three-day event focused on the evolution of engineering systems approaches in research and education. Attendees will gain a broad perspective on the latest advances in research, as well as achievements in industry and future challenges in the field.

Keynote speakers will include Charles M. Vest, president of the National Academy of Engineering and former president of MIT, and Norman Augustine, retired chairman and CEO of Lockheed Martin Corporation. The symposium will take place June 15-17 in Wong Auditorium on the MIT campus.

The first two days of the symposium will include plenary sessions with senior representatives from academia, government, industry, and the National Academies. In a panel discussion on Monday, for example, John Reed, the retired chairman of Citigroup, will discuss the topic "critical issues and grand challenges" with Denis Cortese, the CEO of the Mayo Clinic, and Steven Koonin, chief scientist of BP.

In addition, top academics will discuss innovative new programs in engineering systems in a session on global university initiatives. Panelists will include Paulo Ferrao, director of the MIT Portugal Program; Dinesh Verma, dean of the School of Systems and Enterprises at the Stevens Institute of Technology; Martin Betts, executive dean of the School of Engineering Systems at Queensland University; and Yoshiaki Ohkami, a professor at the Graduate School of System Design and Management at Keio University.

The last of the plenary sessions will introduce key research areas in engineering systems, encompassing such topics as system architecture, enterprise perspectives, network analysis, computational social science, engineering systems design, sustainability, and critical infrastructure.

The third day will consist of concurrent breakout sessions on specific research areas. Emphasis will be on both engineering systems approaches/methodologies (e.g. complexity, flexibility, uncertainty, security, sustainability), and on applications or domains (e.g. transportation, energy, communications, aerospace, health care, manufacturing).

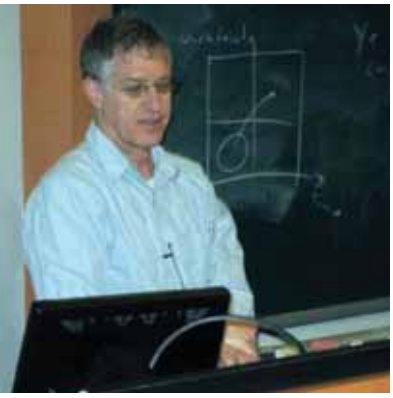
The Engineering Systems Symposium is sponsored by MIT's Engineering Systems Division and the Council of Engineering Systems Universities. Cosponsors include the International Council on Systems Engineering and the Institute of Industrial Engineers.

For more information and to register for the event, visit esd.mit.edu/symp09.

SDM offers new class in MBSE

By Lois Slavin, LFM-SDM communications director

Conceptual modeling is an essential element in systems architecting and engineering, providing a rigorous method for addressing the ever-increasing complexity of systems and products throughout the life cycle. This spring, MIT's System Design and Management Program is fortunate to have a leading expert in conceptual modeling, Professor Dov Dori, teaching Model-Based Systems Engineering (MBSE).



Professor Dov Dori teaches a new course at SDM, Model-Based Systems Engineering.

Dori, who developed and has been fine-tuning Object-Process Methodology (OPM) since 1992, is a visiting professor in MIT's Engineering Systems Division. He also serves on the faculty of Industrial Engineering and Management, Technion, Israel Institute of Technology.

Dori's MSBE class is a valuable one for SDM students. The course lays down formal foundations of MBSE with SysML—the new Systems Modeling Language from OMG—the Object Management Group—and OPM. By combining systems theory and practical, tool-supported conceptual modeling, the course integrates intuition and experience with a formal methodology while nurturing holistic systems thinking and developing modeling skills.

Topics include the creation of use cases, modeling structures with blocks, and modeling constraints with parametrics. OPM-specific topics include object-process language and diagrams; systems development and life-cycle support methodology; the generic ontology of objects, processes, and states; complexity management; metamodeling; and model-based simulation.

Required readings include *A Practical Guide to SysML: The Systems Modeling Language*, by S. Friedenthal, A. Moore, and R. Steiner, and *Object-Process Methodology: A Holistic Systems Paradigm*, by Dori. Students will also be given an academic version of OPCAT software, which is designed to support OPM.

Diverse group of professionals joins SDM as Class of 2009

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diversity, level, and type of expertise brought by each member of the class means that students learn not only from the faculty but also from each other."

Members of the faculty frequently learn from students as well, Hale said. "The professors say that having SDM students in their classes—especially those who are still working and taking the program part-time or at a distance—means that they have access to the most current challenges in the workplace."

The SDM 2009 cohort poses with Pat Hale, director of the SDM Fellows Program (back row left, waving his left hand).

This year, some of those challenges may involve BlackRock, an investment management firm. Tim Harsh, a director in the portfolio compliance group at BlackRock, is attending SDM part-time, primarily at a distance from Wilmington, Delaware.

"The SDM distance option was an attractive alternative to the traditional mode of graduate education because it offered minimal disruption to the work/life balance. Moreover, it's mutually beneficial to the firm and to the student. Here at BlackRock, it allows me to continue progressing in a successful career track and allows the firm to retain the experience base of a known and established performer," Harsh said.

"Even after just the initial January Session, I've already been able to bring back and apply some of the insights gathered," he continued. "Since I'm uniquely involved in our business operations, our technology and systems platform, as well as the management/leadership of our team, each of the constituents of the SDM program has applicability to my role." (See page 16 to read more about the January Session.)

Cynthia Hernandez, an MIT alumna enrolled in SDM's full-time on-campus option, provides another perspective.

"I am using SDM to change direction in my career," she said, noting that she voluntarily left her position as an advanced quality manager at a large automotive supplier in October. "SDM offers both the technical challenge I want and the business education I need to be more effective as a technical leader."

Hernandez said that although she has just started SDM, she can already see how it will help her serve her next employer. "SDM is giving me the ability to think about a large system and determine requirements for pieces of that system. This benefits not only companies with complex products, but companies with complex networks of suppliers, offices, and customers."

Anando Chowdhury certainly believes it will help his employer, pharmaceutical giant Merck & Co. "People claim that biopharma is radically different from any other domain. However, I am finding that the dynamics of systems, people, and technology that I'm learning about in SDM are truly universal."

"I sit on the leadership team of Merck Manufacturing Division's Global Science, Technology, and Commercialization group, where we integrate process technology and business needs to develop, launch, and supply medicines and vaccines," said Chowdhury. "Merck is transitioning from a traditional structure to a new operating model for end-to-end product development and deployment. We will need to learn all the lessons from SDM to bring this model to life. I see applications every day, in real time, and I have more solutions than I have time to deploy. It's a really good problem to have!"

SDM is able to serve such a diverse cohort because the program can be customized to serve individual educational and professional goals. Nevertheless, members of each year's cohort form strong bonds through shared experiences, in classes and through team projects. For the Class of 2009, that means they have just joined a network they're likely to rely on for years to come.

January Session gets '09 cohort up and running

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

The System Design and Management Program begins with an intense, monthlong session of classwork, team projects, and sleepless nights. Nicknamed "SDM boot camp," the January Session plunges midcareer professionals into the rigors of graduate-level coursework, bonding members of each year's cohort together through shared experience.

"If it were at all easy or less intense, you'd have the choice of being self-reliant," said Cameron Fisher, SDM '09, who went through the January Session this year. "This shows how teamwork can be a lifeline and a source of inspiration." Originally from Vancouver, Canada, Fisher is a management consultant in IT Strategy at IBM. He already has an MBA but joined the SDM program to enrich his technical and systems management skills.

"We all have been out of school for many years. This program immersed us in an educational environment and put us back in touch," said Leyla Abdimomunova, a senior banker from Kazakhstan. She also has an MBA but hopes to gain a deeper understanding of the technological challenges with which her clients are dealing.

In addition to Fisher and Abdimomunova, two other members of the diverse SDM '09 cohort took time from this year's January Session to talk to the *SDM Pulse* about their experiences: Sahar Hashmi, a physician and postdoctoral research fellow at Massachusetts General Hospital who is originally from Pakistan; and Cheri Burgess, a senior mechanical engineer at Lockheed Martin in California.

"It's fun to see so many diverse backgrounds and that we're all working well together," Burgess said.

The January Session introduces students to key elements of the SDM program—leadership, project management, system architecture—and immediately puts lessons to use in design challenges. For example, the session begins with team-building exercises that quickly pay off in a team robot-making project. This first-week project ends in an intense and entertaining robot competition that showcases the students' design and project management skills.

"I think it's very creative to have this challenge at the beginning," said Hashmi, who was operating on very little sleep the morning of the robot competition. "Everybody's stressed out but enjoying every moment of it."

Classes held in January include system architecture, probability and statistics, and the human side of technology. All four students said they enjoyed the courses they

Cameron Fisher, SDM '09, wears his team's logo for the robot competition that wrapped up the January Session's first design challenge. 'Teamwork can be a lifeline and a source of inspiration,' Fisher said.

Cheri Burgess, SDM '09, prepares to compete in the first design challenge, a robot competition held at the end of the first week of SDM's January Session.

took. “The human side of technology was excellent,” said Burgess. “Understanding the way people respond to change and how as leaders we can help people through those changes—this is a lot of what I do in my job, so it is directly applicable.”

Hashmi particularly enjoyed the product design course taught by Guillermo Aguirre, former Mexican undersecretary of technology, which culminated in a challenge to redesign an ordinary object, such as a sponge or chair. Hashmi said she plans to apply skills she learned to the management system of a trauma center, working to improve the processing of patients from arrival through intensive care to discharge.

Addressing real-world problems isn’t always easy. And so, as January wound down, a final challenge required students to apply systems thinking to complex world issues by holding formal debates on a range of topics: government-sponsored health care, the U.S. economic bailout, clinical trials in the developing world, ways to protect human rights, and global warming. Teams were paired to debate the affirmative and negative sides of each issue and didn’t learn which side they had to argue until the day of the debates.

The teams for this session worked together for three weeks, allowing members to bond and draw strength from their teammates—for classwork as well as challenge preparation. “It was an excellent team-building experience,” Hashmi said, noting that the long hours built camaraderie. “If one person was not prepared, we would sit down and help him.”

Abdimomunova said her teammates helped her understand some unfamiliar mechanical systems that were used as examples in system architecture. “If I were alone, I probably would have spent much more time on the same exercises,” she said.

Fisher, who managed to keep up with a multimillion-dollar proposal at work while attending “boot camp” (receiving formal recognition from IBM), agreed that support from the cohort was crucial for success. “The intensity of the workload calls for people to help each other because no one person can do everything,” he said.

In many ways, that is a key lesson of the January Session—an introduction to the complex human side of systems thinking. Pat Hale, director of the SDM Fellows Program, touched upon this lesson in addressing the cohort as the session came to a close. “What you’ve learned about each other will stick with you for the rest of the program,” he said.

Leyla Abdimomunova, SDM ’09, holds her team’s robot ready for action during the first design challenge of the January Session. The robot competition was one of three design challenges students faced—in addition to classwork—during January.

Sahar Hashmi, SDM ’09, takes time out from the January Session robot competition to talk about her SDM experiences. ‘I think it’s very creative to have this challenge at the beginning,’ she said.

SDM conference centers on sustainability

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

Sustainability—both in business and environmental terms—emerged as a central theme of SDM's Systems Thinking for Contemporary Challenges conference.

"The world is coming to an understanding of the need for systems thinking," MIT Sloan Dean David C. Schmittlein said in opening the fall event. "The problems that the world faces have smacked us upside the head. They have to be attacked as systems problems."

Thinking about whole systems can save companies money, create opportunities and improve the environment, said MIT Sloan Senior Lecturer Peter Senge, who linked climate change to a failure of systems thinking. "We're doing things all the time that have significant long-term consequences that we pretty much ignore," he said.

The work begins with a vision that encompasses the big picture, said Senge, citing the example of Nike, which set a goal of zero waste and tackled the problem as a design challenge. Today Nike rates all new products based on embedded water, energy, waste, and toxicity. "There's a fundamental shift that happens when you go from being less bad to being really good," he said.

"The whole concept that green costs more is an old paradigm. That's been shattered," said Paul Murray, director of environmental safety and sustainability at Herman Miller. By setting goals of zero waste, building green, and designing for disassembly, Herman Miller has saved millions through landfill avoidance, lower utility bills, and recycling.

Conference presenters also explored systems approaches to risk management.

"Everybody thinks safety costs—that accidents are just the cost of doing business. Absolutely untrue," said Nancy Leveson, an MIT professor of aeronautics and astronautics (aero/astro) and engineering systems. Designers need to take a systems approach to risk management by building in safety from the start—moving from preventing failure to enforcing safety constraints.

Systems also need to be designed to evolve and adapt to the risks of an uncertain future, said Olivier de Weck, associate director of ESD and MIT professor of aero/astro and engineering systems. Applying Darwinian principles to system design, de Weck pointed out that survivors both in nature and in business are those that are most adaptable to change.

This principle was reinforced by Lee Ng, a business director in the New Business Creation group at Agilent Technologies. "When you design a product, you need to be open because a buyer might want to use your product differently than you thought," said Ng, who is also a PhD graduate of MIT.

One example of evolvable design was explored by Annalisa L. Weigel, the Jerome C. Hunsacker assistant professor of aero/astro and engineering systems at MIT, who discussed flexible and sustainable space system architectures. Research has found modular designs could provide flexibility in a cost-effective manner, but the whole spacecraft production system would have to change, she said.

"Product design change alone won't solve big problems. Organizations, industry and market structures usually need to change as well," Weigel said.

And that goes to the core of SDM's systems approach. "Systems thinking is so prominent now because there are very few single theory problems to be solved versus complex systems like the economy and health care," said Pat Hale, director of SDM's Fellows Program. "We need to use all the disciplines at our disposal to deal with some of these problems."

Organized by SDM alumni and staff, SDM's Systems Thinking for Contemporary Challenges conference featured 13 presentations and drew more than 230 attendees to MIT on October 23–24, 2008. For more information, visit the news archive at sdm.mit.edu.

Save the date

By Lois Slavin, MIT SDM communications director

Every year alumni and staff from MIT's System Design and Management (SDM) Program organize SDM's two-day conference on systems thinking and its application to contemporary challenges. Together they work to identify experts from industrial, nonprofit, and governmental organizations who are successfully addressing complex challenges using a systems thinking approach. The agenda is carefully crafted to provide opportunities for systems thinkers to learn practical applications from some of the world's leading innovators from MIT and industry—as well as from each other.

Speakers are chosen not only for their expertise in addressing complex systems challenges but also for leading the implementation of the day-to-day tasks that sustain and strengthen this holistic approach. Topics can include best practices for applying systems thinking to areas such as sustainability and the environment, health care, product design, and the global economy.

This year, the event will be held October 22-23, 2009, on the MIT campus. Details will be published on sdm.mit.edu in mid-spring.

SEAri summit highlights systems research

Senior systems professionals and executives from industry and government—including representatives from several SDM partner organizations—gathered at the MIT Systems Engineering Advancement Research Initiative (SEAri) research summit, held at MIT on October 21, 2008.

Matthew Richards

Caroline Lamb

Tsoline Mikaelian

The annual summit offers researchers a chance to share their progress with the wider systems community. "The SEAri research group interacts with its sponsors on a regular basis as research projects progress, and the summit is a significant event for us to gain feedback," said SEAri Director Donna Rhodes.

This year, in addition to presentations by SEAri researchers, three advanced doctoral students discussed the progress of their research in detail, providing attendees with new insights and the students with valuable input. Twelve SEAri graduate students also discussed their work during a lively walk-around poster session.

SEAri doctoral research assistant Matthew Richards presented his work on architecting principles for survivable systems. According to Richards, "although survivability is an emergent system property that arises from interactions between systems and their environments, conventional approaches to survivability engineering are often reductionist in nature. As a result, current methods neither accommodate path dependencies nor facilitate stakeholder communication for trading among system life-cycle cost, performance, and survivability." Richards' research has yielded a preliminary set of metrics for the evaluation of survivability in tradespace studies during conceptual design. These metrics are based on a characterization of survivability as the ability of a system to meet required levels of value delivery during nominal and perturbed environmental conditions.

Another SEAri-affiliated student, Caroline Lamb (who is sponsored by the Lean Advancement Initiative at MIT), presented early results of her case studies on how collaborative systems thinking emerges in teams performing aerospace design. Lamb noted "collaborative systems thinking may offer an opportunity to leverage and develop a skill in short supply by concentrating on the team in addition to the individual." This research is designed to produce hard data that can be used to improve system design work by teams.

As it happens, one of the organizations attending the summit is performing studies similar to Lamb's. And, thanks to the event, a one-day follow-on research workshop was held at which MIT and the interested sponsor were able to share research approaches and interim outcomes. "This is an example of what our summit is all about—collaboration between our researchers and industry practitioners," said SEAri lead research scientist Adam Ross.

SEAri doctoral research assistant Tsoline Mikaelian also presented her interim research outcomes at the summit. Mikaelian is working on managing uncertainty in socio-technical enterprises using real options. Traditionally, real options analysis has been applied to the valuation of capital investments decisions, but recently this approach has been applied to the valuation of flexibility in system design decisions. The problem, Mikaelian says, is that different applications of real options are often considered in isolation. In her research, she is working to develop an integrated real options framework for holistic decision-making under uncertainty for enterprises.

Her work introduces a new characterization of a real option as a tuple consisting of a mechanism and type, which disambiguates among 1) patterns of mechanisms that enable flexibility and 2) the types of flexibility in an enterprise. A new classification of mechanisms and types of options based on "where" they are embedded within the enterprise architecture is then devised with the goal of enabling a more comprehensive consideration of real options opportunities.

Presentations from the summit are available on the SEAri website, seari.mit.edu.

Massachusetts Institute of Technology

SDM calendar spring–fall 2009

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.

June 15–17, 2009
Engineering Systems Symposium
The Emerging Field of Engineering Systems: Achievements and Challenges
Location: Wong Auditorium
Speakers Include: Charles M. Vest, president of the National Academy of Engineering and former president of MIT, and Norman Augustine, retired chairman and CEO of Lockheed Martin Corporation
Details: See page 14

July 20–23, 2009
MIT Engineering Systems Division and SDM at INCOSE 2009 Symposium
Location: Singapore

October 20, 2009
SEAri Research Summit
Location: MIT

October 21, 2009
Partners Meeting
SDM industry partners are invited to review curriculum activities, hear from MIT faculty on relevant cutting-edge research, review the year's best theses, and develop opportunities for internships and theses.
Location: MIT

October 22–23, 2009
SDM Conference
Location: MIT campus
Details: See page 18

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

Diverse group of professionals joins SDM as Class of 2009

By Lois Slavin, MIT SDM communications director

Each January brings a new cohort to MIT's System Design and Management (SDM) Program. Now in its 13th year, the career-compatible master's program—which can be completed on a full- or part-time basis, on the MIT campus or primarily at a distance—continues to attract the best and brightest midcareer technical managers from a wide range of industries around the world.

This year's class is no exception. Students hail from China, Chile, Mexico, Mongolia, Pakistan, Japan, and across the United States. Almost half the 60-person cohort holds at least one advanced degree, (including one MD), from institutions including MIT, Stanford, Rensselaer, Cornell, McGill, Keio University, and Bhopal University.

Members of SDM's class entering in 2009 have served in the Greek Navy, the Singapore Armed Forces, the Israeli Army, the U.S. Navy, the U.S. Army, and the U.S. Coast Guard. Moreover, they have worked in an almost entire alphabet of fields, including automotive, banking, consulting, defense, environmental engineering, foreign service, global positioning, hardware, insurance, logistics, networking, operations, pharmaceutical, quality control, risk mitigation, telecom, and voice recognition. Titles in the class range from engineer to entrepreneur to vice president.

Such diversity is typical of SDM. "SDM is largely about learning how to think differently, embrace different viewpoints, and ultimately create new, more holistic solutions to solving the complex problems facing our world," said Pat Hale, director of the SDM Fellows Program. "The

> continued on page 15