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

vol. 6, no. 3 fall 2011

sdm pulse

MITsdm

in this issue

on the web

Addressing Blindness via Cell Phones

Problem statement: According to the World Health Organization, cataracts are the leading cause of blindness in mid- and low-income countries. India has the largest number of blind people globally—15 million—yet there is only one doctor for every 100,000 people, leaving the majority of cataract cases undetected.

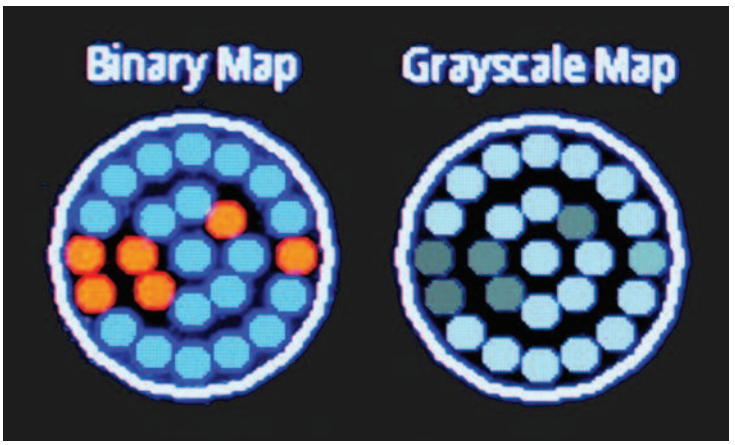
Goal: To improve early cataract detection and free up the limited number of ophthalmologists to concentrate on surgery.

Solution: *EyeCatra*, a portable self-evaluation eye diagnostic tool that attaches to a cell phone and uses a light-scattering technique to scan and map the eye for cataracts. It can be used in rural homes, schools, pharmacies, and health clinics.

SDM contribution: SDM '11 students Vivin Nath, Nirmalya Banerjee, and Rupreet Singh Soni are part of the EyeCatra team.

Learn more: Visit EyeCatra at web.media.mit.edu/~pamplona/CATRA/. Read about SDM students' contributions at globalchallenge.mit.edu/teams/view/200 and web.mit.edu/newsoffice/2011/netra-cataracts-app-0701.html.

Prototype phone with EyeCatra device attached and results shown on screen.



This cell phone display shows two maps of a patient's eye created by an EyeCatra scan. The first is an opacity map that shows binary information (does or does not have) regarding cataracts for each section of the lens. The second is an attenuation map created by measuring the brightness of two alternating paths of light through the lens.

> Watch for the red dot indicating expanded stories online

sdm.mit.edu

http://

Welcome

The staff of the System Design and Management (SDM) program, which marks its 15th anniversary this year, has had a busy summer—one focused on using systems thinking to evolve and improve the program. For example, after benchmarking best-in-class admissions, we have begun updating the process used to evaluate applicants. Consequently, we have implemented interviews for candidates seeking entry in 2012. We are confident that this will enable SDM to continue admitting not just the strongest cohort each year, but the most diverse as well.

In addition, I have spent the past several months talking with a range of industry folks about their expectations for SDM. One topic discussed was the *SDM Pulse* newsletter. I discovered that while readers value the subject matter, they are challenged to find the time to read long articles. Therefore, we are pleased to introduce a revamped format beginning with this issue. The new layout centers on easy-to-read abstracts and summaries, with links provided to in-depth articles and related information on SDM's website. Our hope is that the new *SDM Pulse* will give readers more accessible ways to explore and learn about SDM and systems thinking. I look forward to your comments and suggestions on this new approach.

As this issue goes to press, we are in the final stages of planning the annual MIT SDM Conference on Systems Thinking for Contemporary Challenges, which will take place on campus October 24–25, 2011. We look forward to welcoming back our alumni as well as our colleagues in industry and academia for what is always a content-rich, practice-oriented, and thought-provoking event. For those who can't join us in person, please note that conference content will be available on the SDM website shortly after the meeting's conclusion. We have an exciting lineup of speakers, so I encourage you to explore, learn, and enjoy.

Sincerely,

Joan S. Rubin
Industry Co-Director
MIT System Design and Management Program
jsrubin@mit.edu

TIMELINE

1996
The MIT System Design and Management (SDM) program is co-founded by Professor Thomas L. Magnanti of the MIT Sloan School of Management and Professor Edward F. Crawley of the MIT School of Engineering. The program is piloted with 11 students.

1997
SDM admits inaugural class of 35 students. It is MIT's first master's program with an option for distance learners, who are able to take MIT classes using videoconferencing, videotape, and web-assisted instruction.

Toyota begins sales of the Prius, the world's first mass-produced gasoline-electric hybrid car.

2000
This year was the deadline set by the Institute of Medicine for implementation of electronic medical health record keeping. While such records are now widespread, they are not yet universal.

2001
The first class enters the SDM Graduate Certificate in Systems and Product Development program. Initially a partnership between SDM and United Technologies Corporation, the certificate program has expanded over the years to serve students from other companies and interests.

Novartis receives FDA approval to market Gleevec, a targeted cancer therapy that becomes a blockbuster drug.

2002
SDM alumni hold their first conference, themed "Leadership in a Complex and Changing Business Environment."

Continued on page 3

Reflecting on **15** Years of System Design and Management

By Pat Hale, Director, SDM Fellows Program

Late in 1995, just after becoming Otis Elevator Company's first director of systems engineering, I was told that our parent company's corporate director of education wanted me to meet someone from the MIT Sloan School of Management to talk about educating product development engineers. That was the start of my personal journey with the System Design and Management (SDM) program.

Professor Thomas L. Magnanti explained that he and Professor Edward F. Crawley of the MIT School of Engineering were gathering stakeholder needs for a new career-compatible graduate program called "System Design and Management"—the first graduate-level, degree-granting program at MIT to include a distance education option. The program would partner with industry to educate future leaders in product development, with a curriculum that combined system-level engineering content with management courses adapted from the MIT Sloan MBA program.

As an MIT alumnus myself, I knew that an MIT graduate program would be a terrific option for my high-potential product development engineers at Otis, a division of United Technologies Corporation (UTC). I also had some thoughts about what the new degree should include. Magnanti and I spoke for about an hour, and I was soon able to confirm that Otis would send students to SDM's inaugural class.

Since that time, UTC has sent 45 students to the degree program and 164 students to the certificate program. Seventy-five percent of Otis's degree students and one of its certificate students rose to executive positions within a few years, as did many of the students from other UTC divisions.

After seven years at Otis, I left to start my own consultancy, and was hired through my company to run the SDM Graduate Certificate in Systems and Product Development program with Helen Trimble, who is now SDM's director of career development. In 2004, I joined MIT as the director of the master's degree program, and I have since discovered that I love teaching and mentoring the students and working with the staff.

It feels as if I am home now, after being associated with SDM since before the beginning.

Happy 15th birthday, SDM!

TIMELINE

Continued from page 2

2003
John Deere enters partnership with Home Depot to sell its signature green and yellow lawn tractors via a mass channel for the first time.

Apple launches iTunes, leading to the concept of integrated music delivery and use. This fundamentally changes the music business for both the industry and consumers.

2004
SDM begins providing career services to its self-funded students.

Pat Hale is appointed director of the SDM Fellows Program.

2006
SDM marks 10th year. Initially grounded in engineering, the program has expanded to include students from the financial, business, high-tech, and military sectors.

Nintendo unveils the Wii home video game console, making a distinct departure from previous video games by introducing a wireless controller along with games that get users up and moving.

2007
Apple releases the iPhone, essentially a pocket-sized computer with a revolutionary touch-screen interface.

2008
Pat Hale becomes president of the International Council on Systems Engineering.

Keio University in Japan launches its Graduate School of System Design and Management patterned on SDM.

SDM sponsors the MIT Conference on Systems Thinking for Contemporary Challenges, an outgrowth of the alumni-only conference now open to all.

2009
The Society of Women Engineers presents SDM with a certificate of appreciation.

2010
MIT SDM Systems Thinking Webinar Series launched.

2011
SDM joins the Master of Engineering Management Programs Consortium.

Developing Product Requirements Criteria at bioMérieux

For her capstone project in MIT's System Design and Management (SDM) program, Lisa Steinhoff, SDM Certificate '10, created a common product requirements document (PRD) and optimized systems engineering document templates. She also prepared a proposal for integrating these documents into the product development and design controls process at her company, bioMérieux. The purpose of the PRD was to provide a set of generic requirements that would remain consistent across all systems. The common PRD would allow the global company to improve its system development efforts, focus on what is specific to each new product, and transfer knowledge from site to site.

Most bioMérieux products consist of:

- a biologic disposable
- application PC software
- instrument hardware and firmware

These areas often are referred to as the subassemblies or components of the system. Defining what levels of documentation are required for each is helpful to project planning, verification and validation planning, and traceability. The documentation structure Steinhoff developed will be used across development sites to improve communication around planning, traceability, usability, and risk analysis.

Steinhoff credits SDM's class in system architecture with helping her to identify the need for a common PRD as well as the organization of documentation.

> To read Lisa Steinhoff's entire article describing her project, visit:
>
> sdm.mit.edu/news/steinhoff-biomerieux

http://

About bioMérieux

A world leader in the field of in vitro diagnostics, bioMérieux maintains a presence in more than 150 countries through its 39 subsidiaries and large network of distributors.

Criteria to Consider

The process Lisa Steinhoff used to develop generic requirements for bioMérieux products included evaluating each requirement against the following criteria:

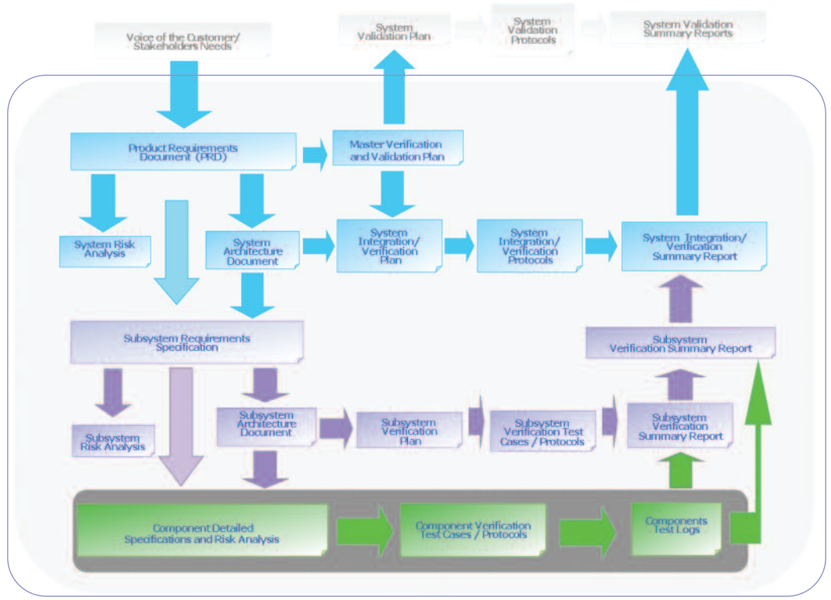
- Is the requirement at the ***system*** level?
- Is the requirement ***design independent***?
- Is the requirement ***generic***?
- Does the requirement relate to ***usability*** aspects of the system?
- Is the requirement ***SMACC****able*, that is:
  - **S**pecific: unambiguous and understandable, having only one interpretation or meaning
  - **M**easurable: defined in quantifiable terms that can be verified or validated by an objective method of analysis, inspection, or testing
  - **A**ttainable: achievable with existing technologies or demonstrated as feasible through research of new technologies
  - **C**onsistent: not in conflict with any other requirement
  - **C**omplete: all elements are identified, adequately defined, and can be approved for use in subsequent design activities

About the Author

Lisa Steinhoff has been an engineering manager in the Research & Development Engineering group at bioMérieux since 2001. She holds a BS in biomedical engineering and an MS in engineering management, and just completed SDM's one-year Graduate Certificate Program in Systems and Product Development.

Requirement	Project 1	Project 2	Project 3	Project 4
Cost Requirement	1	1	5	7
Dependability Requirement	2	4	0	6
Design & Manufacturing	5	0	0	5
Documentation Requirement	13	12	0	25
Functional Requirement	46	224	428	698
Functional/Performance Requirement	0	0	91	91
Human Factor	16	0	0	16
Interfaces	19	8	26	53
Maintenance Requirement	10	11	61	82
Manufacturing Requirement	0	13	31	44
Marketing	0	0	1	1
Performance Requirement	14	7	0	21
Physical Environment	1	3	6	10
Post-Market Surveillance	3	8	3	14
Regulatory Requirement	0	0	10	10
Safety Requirement	6	25	11	42
Transport Storage Requirement	8	1	0	9
Usability Requirement	10	4	17	31
Total	**154**	**353**	**690**	**1197**

The requirements count for each project examined illustrates the need for some commonality and more efficiency.



This chart shows what documents are required for each level of the system as well as which ones will serve as inputs to verification and validation testing. This documentation structure is designed to help development sites to speak the same language in terms of planning, traceability, usability, and risk analysis.

SDM Thesis Roundup

This sampling of SDM thesis research illustrates the range of systems questions that SDM students address. To read these theses in full, contact Joan S. Rubin, SDM industry co-director, jsrubin@mit.edu, 617.253.2081.

Application of System Safety Framework in the Hybrid Socio-Technical Environment of Eurasia

Author: Azamat Abdymomunov, SDM '10, founder of the Astana Innovation Center

Advisor: Nancy Leveson, PhD, professor of aeronautics and astronautics and engineering systems

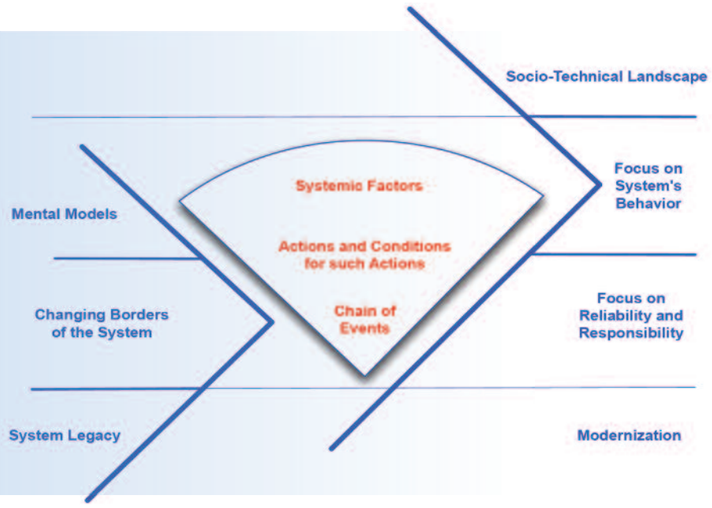
The Sayano-Shushenskaya Hydroelectric Power Station is Russia's single largest power facility and typically produces about 24.5 billion kilowatt-hours of electricity annually. A 2009 accident, caused by the failure of a turbine and the flooding that followed, killed 75 people and shut down the plant. This thesis examines the hybrid characteristics that emerged in the vital sector of the planned economy—the electricity sector—and how those characteristics contributed to the accident.

Abdymomunov, a former strategic advisor to the prime minister of the Republic of Kazakhstan, examines some of the root causes of the disaster. He notes that 20 years after splintering into 15 national entities, the Soviet region's political and social transformation has led to hybrid structures in political, economic, and technological domains. Different institutions and policies, state and private business entities, old and new technologies, and collectivist and individualist value systems coexist. The roles of government, state enterprise, private business, and civil society are not clearly defined.

He argues that the traditional approach to explaining the accident—characterized by a culture of blame, as well as a focus on reliability, responsibility, and modernization—fails to acknowledge systemic causes. The borders of systems change over time, evolving and adjusting to the external environment. In the case of the power station, the reform of Russia's electricity sector affected station safety and reliability.

Abdymomunov concludes that accidents are complex processes involving the entire socio-technical system. In the case of the Russian power plant, insufficient capital investment and backlog in maintenance shifts were key systemic factors that allowed organizational behavior to migrate from a safe to an unsafe state.

The system theory approach, illustrated at right, adds a number of elements to the analysis of accidents, including a look at the context or conditions at work when the accident happened and an examination of contributing systemic factors. The approach also incorporates broader systems and socio-technical concerns into planning to prevent a repeat of a disaster.



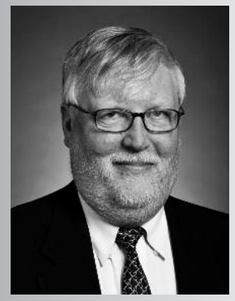
A Systems Approach to Food Accident Analysis

Author: John Helferich, SDM '10, adjunct professor at the College of Business Administration at Northeastern University and a Batten Fellow at the Darden School of the University of Virginia

Advisor: Nancy Leveson, PhD, professor of aeronautics and astronautics and engineering systems

Food-borne illnesses lead to 3,000 deaths per year in the United States. Some industries, such as aviation, have significantly increased safety through careful accident analyses and follow-up changes in industry practices. In the food industry, however, current methods of accident analysis remain grounded in regulations developed when the industry was far simpler than it is today.

Helferich, the former senior vice president of research and development at Mars Incorporated, explores whether the incidence of food-borne illness could be reduced by changing the method of accident analysis from the current approach to a system theoretic method. Currently, food accident analysis combines epidemiology—to identify and track illnesses to their origin—with a regulatory standards approach that is based on a linear model of accident causation.



Helferich asserts that causal analysis using system theoretic accident modeling processes (CAST) is a better method. CAST is designed to determine how and why accidents occurred by analyzing the control structure of the accident system.

To test whether CAST can provide more comprehensive insights into food system accident causation, Helferich analyzed a case study using both traditional and CAST approaches. The case study chosen is a 2008 outbreak of salmonella linked to the Peanut Corporation of America, which forced the company out of business and significantly drove down sales of peanut butter nationwide.

Helferich demonstrates that the application of a system theoretic accident analysis method such as CAST results in more learning than the current method of accident analysis. He concludes that the current food accident analysis system should be augmented with a systems-based approach to identify and control more extensive system hazards.

Platform Project Management: Optimizing Product Development by Actively Managing Commonality

Author: Raúl Pinillos Montaño, SDM '09, program management engineer at Ford Motor Company

Advisor: Olivier de Weck, PhD, associate professor of aeronautics and astronautics and engineering systems

Product developers continually strive to create better products faster and more cheaply. One way to do that has been to design common parts and create product families, which enables companies to increase profitability by sharing costs among different products. However, managing common designs in a product family is not a trivial task. Over time, product commonality typically decreases, a phenomenon called divergence.

Pinillos proposes a system dynamics methodology to explain the different impacts of divergence on the development projects within a product family. Using a model calibrated via a case study in the automotive industry, he simultaneously simulated lead and derivative projects based on product commonality.

Pinillos measured divergence rates and found they ranged from 0.4 percent to 1.2 percent loss of product commonality every month. Further, he found that this divergence caused significant damage to the product development projects—as high as a 22 percent schedule overrun or a 29 percent increase in personnel needed to achieve the planned project schedule. He reports that these effects grew proportionally to the divergence rate.

Pinillos concludes that actively managing product commonality can be an effective method to achieve a successful execution of the development projects when the product platform approach is utilized. Platform project management, he argues, can ensure that product commonality is achieved throughout the development process by balancing and trading off all the designs among the entire product family rather than by making decisions for each product in isolation.

fall 2011

sdmcalendar

sdmpulse

Vol. 6, No. 3
Fall 2011

Publisher: Joan S. Rubin, MIT SDM Industry Co-Director

Editor: Lois Slavin, MIT SDM Communications Director

Managing Editor: Kathryn O'Neill

Contributors: Pat Hale, Lisa Steinhoff

Proofreader: Linda Walsh

Design: Forsythe Design Inc.

Layout: Kathleen Forsythe

Printer: Arlington Lithograph

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

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

MIT SDM Systems Thinking Webinar Series

This series features research conducted by members of the SDM community.

All webinars are held on **Mondays**, from **noon to 1 pm,** and are free and open to all. Details/registration: sdm.mit.edu.

October 31

A Systems View of Enabling Enterprise Change

Mark Moran, John Deere, SDM '09

November 14

Power System Balancing with High Renewable Penetration: The Potential of Demand Response in Hawaii

Karl Critz, clean energy innovator and SDM student

November 28

How Systems Thinking Helps Entrepreneurial Ventures Start, Grow, and Mature

Sorin Grama, co-founder and CEO, Promethean Power Systems, SDM '06, and Sam White, co-founder and vice president for business development

December 12

Using Lean Thinking to Transform a Large Academic Medical Center

John E. Billi, MD, University of Michigan Medical School

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

AVAILABLE

on demand

Prerecorded **webinars** are available on demand at sdm.mit.edu/voices/webinars.html

Videos: 2011 MIT SDM Conference on Systems Thinking for Contemporary Challenges

Videos of presentations from the 2011 MIT SDM Conference on Systems Thinking for Contemporary Challenges will be available online beginning in late November. Topics include the impact of systems thinking on the future of engineering design, personalized medicine, product development, and education. Keynote speakers include SDM co-founders Professor Edward F. Crawley and Institute Professor Thomas L. Magnanti, as well as Julian M. Goldman, MD, medical director of bio-medical engineering for Partners HealthCare System.

sdm.mit.edu

Massachusetts Institute of Technology