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sdmpulse

The newsletter of the Massachusetts Institute of Technology System Design & Management program

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Tech Trek Report

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Welcome

Thanks to several excellent articles by alumni of MIT System Design & Management (SDM), the 2016 spring edition of the SDM Pulse reflects the increasingly diverse applications of systems thinking to improve our lives. Among the highlights:

- an article on a systems approach to treating skin cancer;
- a report on improving operations in a free medical clinic;
- an examination of ways to use systems thinking to support and strengthen the science, technology, engineering, and math (STEM) pipeline.

In addition, SDM alumni and industry partners will be interested in the following, which underscore the many ways it’s possible to get involved with SDM:

- a fall 2015 tech trek report on how Amazon Robotics and Vecna Technologies are using systems thinking and robotics to provide better services;
- a sneak peak at the companies SDM students will visit on the spring 2016 tech trek to Silicon Valley—and information on how your company can get involved;
- news about SDM’s second annual Core Technology Showcase and Project Forum;
- information on upcoming SDM events such as the 2016 annual systems thinking conference and back-to-the-classroom sessions on September 27-28 at MIT; live and virtual information events for prospective applicants and companies interested in sponsoring students; upcoming webinars on applying systems thinking to various complex challenges; and more.

As always, we hope you enjoy this edition of the Pulse. We welcome your feedback and suggestions and look forward to seeing you at one or more upcoming SDM events!

Sincerely,

Joan S. Rubin
Industry Codirector
MIT System Design & Management
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Using the STAMP Safety Model to Better Treat Skin Cancer and Leverage New Technologies

The challenge: Skin cancer is the most common cancer worldwide. The most rapidly growing subtype of skin cancer is melanoma. Although the vast majority of melanomas occur on the skin’s surface and are visible to the naked eye, they cause the majority of deaths. In the United States alone, 13 percent of melanoma cases prove fatal. Patients and non-specialist physicians need better tools to identify and analyze skin cancer in the early stages to reduce the fatality rate for melanoma to under 1 percent.

The approach: Using the Systems-Theoretic Accident Model and Processes (STAMP) approach developed by MIT Professor Nancy Leveson to improve safety in the nuclear industry, a set of static and dynamic models were developed for:

- understanding current methods of identifying skin cancer; and
- identifying opportunities for technology to improve evaluation accuracy, physician workflow, and patient lesion tracking.

To build an understanding of the challenges involved in skin cancer evaluation, research and data gathering activities included:

- interviewing stakeholders who directly impact patient care and lesion diagnosis, including primary care physicians, dermatologists, and skin cancer patients;
- reviewing the literature on skin cancer as a disease and on technologies that can be used to assist in skin cancer identification; and
- conducting a total of 26 interviews with members of the three stakeholder groups.

The tools: Several systems-based approaches proved useful in identifying opportunities to improve delivery of skin cancer care. They were:

- System architecture stakeholder analysis. This tool helped us understand the role of each stakeholder in skin cancer care. The analysis revealed that patients, primary care physicians, and dermatologists all have different methods of assessing skin lesions—from patients assessing their own lesions to dermatologists selecting skin lesions for further microscopic analysis (see box on page 4). To begin the medical assessment process, a patient must first identify a medical concern and “enter” the healthcare delivery system.

- System dynamics stock and flow diagram. Building a process flow map (Figure 1, page 5) indicated the dynamic factors that impact skin cancer identification. Dynamic factors are important, as melanoma is a time-sensitive disease and can metastasize if not diagnosed early. This model illustrates how business pressures can limit the amount of time and information a physician takes into account when treating patients.
System Architecture Stakeholder Analysis: Personas and Needs

Dermatologists

- **Factors evaluated:** Dermatologists consider many factors when evaluating patients, including Fitzpatrick skin type, history of sun exposure, and skin lesion characteristics and comparison to other patient skin lesions. Dermatologists are likely to use a dermatoscope to magnify skin lesions and evaluate substructures.

- **Frequency with which they address skin cancer:** Dermatologists on average evaluate multiple skin cancers each month.

- **Skin cancer identification challenges:** Evaluating skin lesion growth rates can be difficult as this task depends on patient recall. Dermatologists also find evaluating non-pigmented melanomas and borderline early stage melanomas challenging, as these lesions present fewer symptoms compared to more developed skin cancers.

- **General challenges:** The high demand for dermatologists in the United States outweighs the supply. Additionally, these physicians are specialists who rely on other doctors to make the initial review of skin lesions.

Primary care physicians

- **Factors evaluated:** Primary care physicians take into account the visible properties of skin lesions and four to five other factors, including a patient’s recollection of the lesion changing and the patient’s personal and family history.

- **Frequency with which they address skin cancer:** On average, primary care physicians only evaluate one melanoma every few years; they typically see basal and squamous cell carcinomas multiple times annually.

- **Skin cancer identification challenges:** Primary care physicians have difficulty assessing borderline lesions with a few irregular characteristics and must evaluate many, many benign lesions each year.

- **General challenges:** Frequently patients have multiple health concerns they want their physician to address in a single, time-limited appointment. Primary care physicians must decide whether these health concerns can be managed at the primary care level or require a specialist.

Patients

- **Factors evaluated:** Patients assess changes to skin lesions that they can see easily. This most frequently includes noticing changes in lesion size and color, itchiness or ulceration, and prior family history.

- **Frequency with which they address skin cancer:** The vast majority of patients concerned about skin lesions do not have skin cancer.

- **Skin cancer identification challenges:** Patients concerned about skin lesions often determine whether or not to see a physician based on information they access online. Yet, about one-third of melanomas occur in hard-to-see areas. Additionally, most patients do not know how to evaluate lesions based on established criteria and do not monitor their skin regularly for changes.

- **General challenges:** Patients frequently manage multiple issues and/or pressing concerns in a physician’s office, including diseases with more obvious symptoms. This can take precedence over skin lesion concerns.
Figure 1. This stock-and-flow diagram illustrates the dynamic process flows within the skin cancer diagnostic system. Patients can access high-quality treatment only after they have been diagnosed with skin cancer. Prior to a skin cancer diagnosis, patients must evaluate their own lesions and be concerned enough to enter the healthcare system, leaving room for patients with skin cancer diagnoses at a young age or who have quickly growing lesions to have cancerous lesions medically evaluated at later stages in the cancer progression.

- Systems-Theoretic Accident Model and Processes (STAMP) control structure. The STAMP model enabled us to define and map the overall hierarchical structure and information flows of the skin cancer identification system. This model illustrates the importance of continuous feedback loops into and out of the healthcare system to maintain quality and safety in care delivery. (See Figure 2, page 6, and figure 3, page 7.)

The results: As a system, healthcare is delivered today in a “push” method, meaning action is taken once symptoms become obvious enough to the patient that he or she visits a physician. Primary responsibility for identifying lesions therefore lies with the patient and the patient’s social support network. Nevertheless, this research identified three key opportunities for system improvement.
1. Research has shown that primary care physicians are 52 percent to 72 percent effective at identifying melanomas as cancerous lesions.* Structural improvements are needed to improve how skin cancer care is delivered in the current healthcare system; lessons can be drawn from other major safety systems such as nuclear power plants.

2. More accurate and effective communication is needed at “joints” or interface points between stakeholders where information discrepancies often occur.

3. Cancer identification technologies, such as multispectral sensors, electrical sensors, and sensors of cancerous volatile organic compounds, need to be assessed to ensure they can be incorporated at different levels of patient care delivery to improve skin cancer evaluation accuracy and provide assurance to patients.

In addition, tools for continuous monitoring need to be developed for patients and non-dermatologist physicians. This will help ensure that patients recognize both visual warning signs and health factors that could influence their chances of developing skin cancer.

Conover will present more details on June 20 for the MIT SDM Systems Thinking Webinar Series. Registration will be available on June 6, 2016 at sdm.mit.edu.
System Redesign in Action at a Charity Hospital in Pakistan

The Indus Hospital project was initiated in 2007 by a group of medical doctors, entrepreneurs, and philanthropists in Karachi, Pakistan, with a mission to make a difference in the lives of disadvantaged communities. With its intended expansion to 1,500 beds in the next 10 years, it is likely going to be the largest comprehensive tertiary care hospital of its kind in the world, where all medical services, including high-end surgical procedures, are provided to anyone in need, absolutely free of charge and with dignity. To date, more than $50 million worth of services has been freely provided to the needy, and more than 2 million patients have been treated.

The challenge: Providing all services free of charge to all incoming patients in a poor metropolis with more than 20 million residents puts immense pressure on the hospital’s limited space and resources. Although a major hospital expansion is expected to be completed by 2024, the population served is also expected to expand by at least 20 percent a year. Meanwhile, the system is experiencing over 100 percent bed utilization in the in-patient wards, long pre-admission wait times, and long external wait times for patients to get initial consultations. Figure 1 (page 9) shows a typical timeline.

This situation puts extreme stress on resources, including consultants and staff, which threatens the “service with dignity” concept, thus damaging the hospital’s public image.

Approach and tools: Taking a systems view, the problem was modeled as a three-layered waiting system, representing the stages before consultation with a doctor, after consultation, and before admission to the hospital as shown in Figure 2 (page 9).

Since the post-consultation wait is not that stressful (due to the surety of an admission date and the satisfaction of having a diagnosis), the decision was made to focus just on the pre-consultation and the pre-admission wait times. Also, since $\lambda_2$ (the rate of patient arrivals at the post-consultation stage) is already very small, say five per day per consultant, the traffic intensity at that point is quite low and queue lengths are short.

The pre-consultation loop begins only after incoming patients have been seen at a “filter” clinic and it has been decided that they need some special treatment or diagnosis by a consultant physician; these patients are then booked for an appointment with a suitable consultant. There are 16 consultants on board, each having his/her own specialty, and each

...
available in the consultant clinic for four hours a day and spending an average of 15 minutes with each patient. The average rate of incoming requests for appointments is 35 a day for each consultant.

In the pre-admission loop, there are 105 beds available (41 in the male ward, 37 in the female ward, and 27 in the pediatric ward), and the total number of admissions per day averages 35. The average length of stay for admitted patients was 3.25 days.

\( \lambda_3 = 35 \text{/day} \) & \( 1/\mu_3 = 3.25 \text{ days} \) & \( s = 105 \)

Therefore resource utilization \( \rho = \frac{\lambda_3}{s\mu_3} = \frac{35.25}{105} = 1.08 > 1 \)

\( \Rightarrow \) bed utilization is above 100% & queue length ↑,
patient pre-admission wait times ↑.
Improving the situation:-
- decreasing \( \lambda_3 \) (not possible);
- decreasing \( 1/\mu_3 \) (possible);
- increasing \( s \) (not possible now).
To come up with recommendations for improving these processes, the following systems engineering tools were employed:

- queue modeling and the related concepts of resource utilization/traffic intensity;
- spring-mass-damper linear system modeling; and
- resource pooling.

The results: The analysis led to several system re-engineering recommendations, outlined below. Note that the first two results emerged from using queue modeling analysis to reduce traffic intensity.

1) The family medicine or “filter” clinic is presently manned by five to six junior medical officers, and these staff members are only able to handle patients with minor ailments. All other patients are referred to the hospital’s consultant clinics through appointments. This increases the load on the consultant clinics to such a degree that the average appointment wait time is three to four months. To counter this issue, it is recommended that an additional layer of medical residents be appointed to perform consultations at the filter clinic. Adding this layer of care would mean that only patients requiring an “expert” consultation would have to make an appointment for the consultant clinic. That would decrease the rate of patient arrivals at the pre-consultant stage, thus easing the pre-consultant situation.

2) Beds are so scarce in the in-patient pre-admission layer that several patients who arrive for admission have to be turned away and asked to check back the next day. The immediate strategy would therefore be to reduce the value of $\rho$ (traffic intensity) to less than one by reducing the average length of stay ($1/\mu$, or the end-to-end time taken to service a single patient in bed). This would be made possible by making the discharge process more “lean” and reducing the average length of stay to three days exactly through the following recommended measures:

- nursing staff and unit receptionists should get a heads-up system message on their computers when a patient is expected to be discharged;
- nursing staff members should initiate the patient discharge process as soon as they get an indication from the faculty, rather than waiting for faculty rounds to be completed;
- at least 12 hours before expected discharge, receptionists should ensure somebody is available to take the patient home;
- unit receptionists should maintain checklists to make sure none of the steps involved in the patient discharge process is missed, causing delays; and
- the hospital should offer to provide some of the post-surgery treatment to patients at their homes, thus reducing the length of stay.

3) Reducing the average length of stay would improve the bed availability in the wards. However, a more important strategy would be to synchronize the timing of new patient arrivals and in-patient discharges to reduce variability in the patient arrival and discharge processes. One strategy would be to make sure consultants make all patient discharge decisions by noon so that an across-the-board patient admission time of 1 p.m. could be fixed.

An even more useful tactic would be to address the variability in patient arrival times (for admission) and patient discharge times (from the beds) by introducing a “coordinator” who would essentially “dampen” all such variations, resulting in improved bed availability and reduced patient wait times. This would be achieved through making confirmation calls to patients scheduled to be admitted on a given day and periodically checking with the consultants
on the status of expected discharges. A similar “damper” is proposed to be introduced in the pre-consultation layer via a coordinator who would work to align patient appointments with consultants’ changing schedules. The two proposed “dampers” are indicated in small red arrows in Figure 2 (page 9).

Note that if we model the scenario as a spring-mass-damper linear system (see Figure 3, below), a concept borrowed from mechanical engineering, we could analyze the tradeoff between the cost of coordination and the benefits of improved capacity.

4) A deeper analysis revealed that the system of operations could also be improved by employing the systems engineering concept of resource pooling. This strategy would involve the following steps:

- combining the male, female, and pediatric wards into a single multi-purpose facility—(this is not currently possible due to cultural and other issues);
- removing the restrictions on bed utilization by specialty—(right now some of the 105 beds are reserved for orthopedic patients; this reduces the value of s and pushes ρ to a higher value.); and
- enabling the coordinator or “damper” for the pre-consultation layer to swap patients between consultants in the same specialty to further improve the situation.

**Next steps:** The chief operating officer of the hospital has assessed these recommendations, and several follow-up steps are being considered. For example, to address the backlog at the pre-consultation phase, the hospital is weighing the possibility of opening a resident clinic to take care of patients who are beyond the scope of care provided at the filter clinic but not in need of advanced, specialized care.

In addition, hospital management is trying to implement the recommendations for making the discharge process more lean, although this is challenging since these steps require staff to make behavioral changes. Policies and procedures for formulating highly empowered coordinating teams are now being discussed at a high level, and management believes implementing these dampers will significantly ease efforts to improve the discharge process. The resource pooling recommendations are likewise under consideration. Meanwhile, construction is under way on a new, bigger block of consulting clinics, which is due to be completed in June.

The author acknowledges SDM faculty member Dr. Deborah Nightingale and MIT Professor Andreas Shulz for providing inspiration. Thanks are also extended to Wasif Shahzad, MD, chief operating officer, Indus Hospital, for assistance in the completion of this project. Khusrow will speak about applying systems engineering to the services industry on June 6 for the MIT SDM Systems Thinking Webinar Series. Registration will be available on May 23, 2016 at sdm.mit.edu.
A Systems, Data, and Algorithmic Approach to Recruiting and Retaining Female STEM Mentors

The challenge: The number of girls entering the computing and high-tech professions is continually decreasing. Today women comprise only about 28 percent of the US technology workforce. Moreover, the number of girls dropping out of college-level science, technology, engineering, and mathematics (STEM) education is rising.

More Active Girls in Computing (MAGIC) aims to provide support through one-on-one, in-person, and remote mentoring that attracts middle and high school girls to STEM and enables them to navigate their educational and professional careers successfully. However, there is a dire need for female STEM mentors. MAGIC has seen record numbers of mentee applications each year, and finding motivated, energetic women with successful STEM careers whose backgrounds and skill sets match mentees’ interests and goals can be difficult.

The approach: We applied a data-based approach to gain insights into the strategies used and results produced within MAGIC’s mentor pipeline in an effort to find ways to improve this complex social system. Specifically, we used system and data analysis tools to:

- assess factors driving women in STEM to apply to be mentors;
- collect and analyze data from individual applicants about recruiting channels;
- collect and analyze data from entry and exit surveys conducted with MAGIC mentors;
- improve existing strategies for recruiting high-potential mentors; and
- recommend additional strategies MAGIC can use to expand the mentor pipeline.

The tools: We used system dynamics, data analysis, and a method known as the Hungarian algorithm to address different aspects of the challenge. Each is detailed below.

System dynamics: Developing a causal loop diagram (Figure 1, page 13) and a stock and flow diagram (Figure 2, page 14) helped us understand the feedback structure of MAGIC’s mentor recruitment and retention. This enabled us to identify the strategies working for and against our goals.

The causal loop diagram bears further examination as the two different kinds of loops represented—reinforcing loops (those with a positive effect) and balancing loops (those with a negative effect)—reveal areas where changes can affect the system as a whole. Detailed descriptions of each are below.

Reinforcing loops

- Word of mouth (R1): The success of mentor applicants produces an increase in favorable word of mouth, which increases awareness of the organization. That results in increased mentor signups.
• Feedback (R2): Mentors, board members, mentees, and mentees’ parents write positive reviews on an independent review site, producing an increased awareness of the program.

• Marketing (R3): Board members promote MAGIC through social media and networks, as well as via volunteer postings on websites. This results in increased awareness and mentor signups.

• Partnerships (R4): Academic and corporate partnerships developed by board members increase the number of mentor applications the organization receives.

• Market penetration (R5): Board members work on expanding the MAGIC program, which results in girls choosing MAGIC over other activities. As the program is offered to more girls, the organization gains a wider reputation, leading to more mentor signups.

• Mentees come full circle (R6): MAGIC mentees who choose STEM majors in college come back to the program as mentors.

Balancing loops

• Competition (B1): Potential mentors can choose to participate in competitors’ mentorship programs. Losing mentors to the competition decreases MAGIC’s appeal, resulting in fewer mentor signups.

• Dropout (B2): MAGIC mentors who drop out after mentoring for a year do not reapply, resulting in a decline in mentor applications.

• Attrition (B3): All MAGIC mentor applicants are required to go through background checks; some choose not to move forward because of this requirement.

• Mentor saturation (B4): As the number of mentor applications increases, fewer potential mentors remain in the finite pool of qualified women, leading to market saturation.
Data analysis: MAGIC continually collects and analyzes quantitative data about the channel(s) from which it receives mentor applications as well as from mentor entry and exit surveys. Qualitative information is collected as well. In regular monthly one-on-one meetings with MAGIC’s core team, all data is thoroughly analyzed.

Our data analysis showed that MAGIC gets the maximum number of mentors through the following three channels:

- Marketing;
- Word of mouth; and
- Personal contacts.

The Hungarian algorithm: Once mentors and mentees have been recruited, MAGIC’s overall success depends strongly on successful mentor-mentee matches. Inappropriate matches can lead to negative mentoring experiences for both parties, thereby making mentees less likely to complete their projects and mentors less likely to return to the program in subsequent years. Successful matches, in contrast, lead to positive feedback, both internally and externally, feeding the word-of-mouth reputation that

Figure 2: This stock and flow diagram reveals the effect of competition on mentees eventually filling the mentor pipeline.

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continued from page 13

**Number of Mentors**

<table>
<thead>
<tr>
<th>Source</th>
<th>Mentors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marketing</td>
<td>47</td>
</tr>
<tr>
<td>Word of Mouth</td>
<td>15</td>
</tr>
<tr>
<td>Personal</td>
<td>4</td>
</tr>
<tr>
<td>Mentees Full Circle</td>
<td>3</td>
</tr>
<tr>
<td>Partnerships</td>
<td>2</td>
</tr>
</tbody>
</table>
increases both mentor and mentee sign-up rates. To find the best matches, we employed a combinatorial optimization algorithm known as the Hungarian method.

We began by posing the mentor-mentee matching problem in the form of an assignment problem that frequently arises in resource or job allocation scenarios. The mismatch between mentors and mentees can be captured once you have a scoring function, so the assignment problem can be posed as a minimization of the sum of the mismatch scores. Note that the mismatch scores will depend on the skills of the mentors and the corresponding interest of the mentees, the personalities of the individuals to be matched, and their geographic locations (either local or remote).

For example, assigning three mentors to three mentees can result in mismatch scores (out of a maximum score of 100) shown in this table:

<table>
<thead>
<tr>
<th></th>
<th>Mentee 1</th>
<th>Mentee 2</th>
<th>Mentee 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mentor 1</td>
<td>20</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Mentor 2</td>
<td>30</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>Mentor 3</td>
<td>50</td>
<td>10</td>
<td>30</td>
</tr>
</tbody>
</table>

A score of 0 corresponds to a perfect match, while a score of 100 corresponds to an entirely undesirable match. Our goal is to minimize the overall assignment score. It is easy to see that the optimal assignment for the example above is to assign mentor 1 to mentee 1, mentor 2 to mentee 3, and mentor 3 to mentee 2. The overall mismatch score (or “cost”) of this assignment is 50 points. Any other assignment will lead to a less desirable score.

It is easy to solve the above example by inspection alone, since it is a small problem. However, for a large number of mentors and mentees, the overall assignment challenge becomes more difficult. Luckily, the Hungarian algorithm offers an efficient solution, enabling us to compute the assignment solution for large instances of the cost/score matrices. The Hungarian algorithm uses simple row operations to compute the assignment. In this way, one can use the assignment problem along with the corresponding algorithm to match mentees with mentors and ensure the success of the MAGIC program.

The results: MAGIC board members and the core team are now developing strategies that focus on bolstering the reinforcing loops that will lead to increased mentor signup. As a majority of mentors to date have been recruited through marketing, the organization also needs to develop new strategies to increase the pool of available mentors. The data collected from social media channels will enable MAGIC to develop digital marketing strategies.

In addition, MAGIC needs to build and retain relationships with all the mentees beyond completion of the program. This will ensure more mentees join the organization as mentors themselves.

The use of advanced algorithms for matching mentors with mentees will also ensure the success of the MAGIC program. Ideal matches should ultimately increase the number of mentees returning to the program as mentors.
Fall 2015 Tech Trek Report: Spotlight on Robotics

Editor’s note: Every year, SDM runs two tech treks—one in the Greater Boston area and one in California’s Silicon Valley—to offer SDM fellows opportunities to engage with, and learn from, executives at best-in-class companies. Designed to build upon students’ classwork at MIT, the treks enable fellows to tour a wide range of facilities, view product demonstrations, and engage in lively question-and-answer sessions with industry leaders. Students learn about companies’ strategic, operational, and tactical challenges as well as how these are being addressed from both technical and business perspectives.

Tech treks also establish and/or strengthen relationships between MIT SDM and companies’ senior leaders and recruitment professionals.

When: November 11, 2015

Where: Amazon Robotics (formerly Kiva Systems) in North Reading, MA, and Vecna Technologies in Cambridge, MA

Purpose:

- to give SDM students exposure to two robotics companies facing different growth trajectories in different domains;
- to understand the technical, managerial, and operational challenges of each and how they are being addressed; and
- to establish and build connections with best-in-class companies and develop long-term partnerships that can result in research, internships, and recruitment.

Attendees: 52 SDM students and three SDM staff members—Joan S. Rubin, industry codirector; Jonathan Pratt, director of recruitment and career development; and Naomi Gutierrez, career development and alumni associate.

Presenters from Amazon Robotics:

- Andrew Tinka, research scientist
- Brian Davis, director of manufacturing
- Brian Learned, senior production manager

Amazon Robotics overview: The company was founded by Mick Mountz, who previously served on the business process team for Webvan, an early entrant into the online grocery delivery service market. Webvan failed, in part due to an insufficient understanding of the business components of the effort, including...
materials handling and the high cost of order fulfillment. However, while running this service, Mountz learned an important lesson about the criticality of developing efficient methods for picking, packing, and shipping orders to ensure a system can successfully deliver goods.

Mountz, in partnership with robotics experts Peter Wurman and Raffaello D’Andrea, cofounded Kiva Systems to capitalize on the skills he had gained in this area. Kiva was anchored by cutting-edge robotics technology and optimization algorithms, resulting in robots that can navigate a warehouse and:

- locate where pallets are stored;
- determine which products go on which pallets;
- retrieve a specific pallet of goods; and
- deliver pallets to the employees who pack the orders.

In 2012, Amazon.com Inc. purchased Kiva Systems, enabling the company to bring production in house and decrease time to delivery.

**Highlights:** During their visit, SDM students

- visited the manufacturing floor and saw various stages of robot design and production;
- learned about several key challenges, including minimizing the time robots spend transporting goods;
- saw Kiva’s robots in action as they were put through their paces for the company’s comprehensive pre-delivery testing; and
- attended a networking lunch with senior company officials.

The Amazon visit was facilitated by Vikas Enti, SDM ’15, the company’s manager for data interaction and visualization engineering.

“Many high-level individuals joined us for lunch,” said Jonathan Pratt, SDM’s director of recruitment and career development. “I believe that this is a testament to the SDM program and to how well-suited these students are for their needs.”

**Presenters from Vecna Technologies:**

- Zachary T. Dydek, director of autonomous systems
- Daniel Grieneisen, technical product lead
- Fady Saad, SDM ’11, strategy, research, and business development director
- Diandra Drago Oliviera, director, talent acquisition

**Vecna Technologies overview:** Vecna Technologies is also in the robotics industry, but it is a young, developing company with a very different business model from that of Amazon Robotics. Vecna’s robots are designed to handle the distribution of prescriptions within hospitals.
a hospital by traveling autonomously between the pharmacy and various nursing stations. These robots are capable of mapping the hospital, learning routes, and navigating around people traveling through the hallways.

**Highlights:** During their visit, SDM students

- learned about Vecna’s expertise in autonomous delivery—for example, Vecna’s robots can navigate both buildings and elevators; and
- discussed opportunities for future growth with Vecna’s leaders—for example, the company is considering using robots for luggage delivery or meal service in hotels.

The Vecna visit was facilitated by SDM alumnus Fady Saad, Vecna’s strategy, research, and business development director.

SDM Industry Codirector Joan S. Rubin commented, “SDM’s tech treks give students exposure to the different challenges that various industries are facing. It also helps SDM build connections with companies for more long-term partnerships, which may involve research, internships, and recruitment.”

The fall tech trek was so popular that attendance had to be capped at 52 students, and Rubin said she expects the upcoming spring trek (see box) will also be at capacity. “This cohort of SDM students is incredibly enthusiastic about the opportunity to see companies managing technology challenges,” she said.

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### Spring 2016 SDM Tech Trek Preview

From March 21-25, 2016, SDM fellows will visit companies from multiple industries during the spring SDM Tech Trek to Silicon Valley. One highlight will be a trip to Amazon Robotics’ distribution center in Tracy, CA, which will enable students who attended SDM’s fall tech trek to see Amazon’s fulfillment robots at work (see article above). Other companies confirmed as of press time include Apple, Tesla, Intuitive Surgical, E&J Gallo Winery, Intel Corporation, Google, and Visa Inc.

The spring trek is being led by SDM ‘15s Vikas Enti and Kathryn Cantu, with organizational assistance from all participants.

*If your company would like to participate in future SDM Tech Treks, please contact Joan S. Rubin, SDM industry codirector, at jsrubin@mit.edu, 617.253.2081, or Jonathan Pratt, director of SDM recruitment and career development, at jonpratt@mit.edu, 617.327.7106.*
SDM Holds Core Technology Showcase and Project Forum

On January 11, 2016, Professor Olivier de Weck, faculty lead and coordinator of the SDM core teaching team, welcomed more than 120 MIT System Design & Management (SDM) master’s and certificate students, alumni, industry partners, staff, and invited guests to the MIT Media Lab for a daylong SDM Core Technology Showcase and Project Forum.

He then introduced members of the SDM core instructor team and their areas of focus:

- Bruce Cameron, PhD—system architecture;
- Bryan Moser, PhD—project management; and
- Pat Hale, SDM executive director—systems engineering.

As the day began, de Weck provided a brief overview of SDM and its overall learning objectives, including discussing the creation of the new SDM core course as it has evolved from three separate one-semester classes into an integrated, intensive, three-subject sequence that spans the fall, January Independent Activities Period (IAP), and spring terms while closely mimicking the systems thinking approach used in industry.

The rest of the morning was devoted to a technology showcase in which SDM students displayed posters detailing their research interests in avionics, electronics, energy, healthcare, information technology, materials, transportation, and other areas.

This was followed by an afternoon session in which industry partners and other invited guests described project opportunities in their domains that require the integration of the system architecture, systems engineering, and project management content from SDM’s core course. Students had an opportunity to indicate their interests in these areas and were then matched into teams to take on intensive, semester-long projects. These core course projects have proved to be significant integrative efforts for SDM cohorts. Indeed, graduates often cite this component of the program as an exceptionally effective method for learning how to apply systems thinking to real-world corporate challenges.

The showcase event concluded with a gala dinner featuring a keynote presentation by John Ochsendorf, a professor in MIT’s School of Architecture and Planning and a MacArthur Fellow, who spoke on the unique systems challenges faced in “MIT’s 100-Year Anniversary and Move to Cambridge.”

In addition to the technology showcase and project forum, the 2016 IAP offerings included a networks and graph theory workshop, a team-based design challenge, and lectures in system architecture and project management.
2015 SDM Conference Centers on Whole Systems Approach to Product Design, Development

A standing-room-only audience packed MIT’s Wong Auditorium on October 7, 2015, for the System Design & Management (SDM) program’s annual Conference on Systems Thinking for Contemporary Challenges. The overarching theme for this year’s event was a whole systems approach to product design and development.

Speakers comprised engineering, management, and design experts (many of whom are SDM alumni and faculty) from a wide range of sectors. Speakers and talk titles included:

- Neal Yanofsky, chairman, Cheddar’s Scratch Kitchen; board member and senior advisor, Snap Kitchen—Can Managers Contribute to Design that Creates Competitive Advantage (keynote)
- Todd P. Coleman, PhD, associate professor of bioengineering, University of California–San Diego—Why Digital Health Technologies and Analytics Are Not Enough: Building Community to Foster Healthier Lifestyles (keynote)
- Maria C. Yang, PhD, associate professor of mechanical engineering, MIT—Driving Early Stage Design Through Design Processes
- Matt Harper, cofounder and chief product officer, Avalon Battery; SDM alumnus—Conceptualizing and Executing Product Design in an Emerging Market
- Steven D. Eppinger, D.Sc., professor of management science and innovation, MIT; General Motors Leaders for Global Operations Professor of Management, MIT; codirector, SDM—Improving Decisions in Complex System Development Using Technology Readiness Levels
- Shaun Modi, cofounder, TM—How to Make (and Not Make) Something People Want

SDM also offered preconference back-to-the-classroom sessions on October 6, 2015, with two of SDM’s best and brightest faculty members:

- Concept Generation, presented by Pat Hale, executive director of SDM and senior lecturer, MIT; and
- Prototyping and Strategy, presented by Matthew S. Kressy, director of Integrated Design & Management, senior lecturer at MIT, and founder of Designturn.

Joan S. Rubin, SDM industry codirector and conference convener, said, “A whole systems approach to integrating design, engineering, and management can enable a critical competitive edge in quality, time-to-market, and overall success. Attendees learned how leading-edge businesses are achieving this and took practical ideas back to the office for implementing this approach.”
Rubin added that the 2015 conference was cosponsored by MIT as one of its official events for Boston’s inaugural HUBweek, a weeklong celebration of the innovation and energy that thrives in Boston. More than 40,000 people attended HUBweek events at MIT, Harvard, Massachusetts General Hospital, and other locations. “We’re pleased to note that the SDM conference will be featured again as an MIT-HUBweek event in 2016,” noted Rubin.

Save the Date!

2016 MIT SDM Conference on Systems Thinking for Contemporary Challenges

Please join us on September 27-28, 2016, for the annual MIT SDM Conference on Systems Thinking for Contemporary Challenges. This year’s event will focus on a systems-based approach to innovation.

**September 27:** Preconference back-to-the-classroom sessions (2-5 p.m., Wong Auditorium, MIT)

**September 28:** SDM Conference (8 a.m.-5 p.m., Wong Auditorium, MIT)

SDM Information Evening (6-9 p.m., Morss Hall, MIT)—Meet with SDM faculty, students, and alums to learn about the MIT master’s degree in engineering and management.

More about HUBweek

Come early or stay after the MIT SDM Systems Thinking Conference or stay afterward to participate in the second annual HUBweek, Boston’s weeklong celebration of innovation. Cosponsored by MIT, Harvard, Massachusetts General Hospital, and The Boston Globe, it will run from Saturday, September 24, to Saturday, September 30, 2016. The 2015 inaugural event drew more than 46,000 attendees, including 600 speakers and artists, industry professionals, students, and others who participated in 106 events. This year's HUBweek will offer even more!

Details: hubweek.org
Nissia Sabri Receives 2015 SDM Leadership Award

On October 6, 2015, the MIT System Design & Management (SDM) community honored SDM ’15 fellow Nissia Sabri with its annual MIT SDM Student Award for Leadership, Innovation, and Systems Thinking. Sabri received the award at SDM’s annual alumni-student mixer in Morss Hall on the MIT campus.

Created by the SDM staff in 2010, the award honors a first-year SDM student who demonstrates the highest level of:

- strategic, sustainable contributions to fellow SDM students and the broader SDM and MIT communities;
- superior skills in leadership, innovation, and systems thinking; and
- effective collaboration with SDM staff, fellow students, and alumni.

Sabri was acknowledged for numerous achievements. Among them:

- reaching semifinalist status for the MIT Clean Energy Prize and the Cleantech Open Northeast Accelerator;
- participating in a Greentown Labs accelerator and getting involved with a climate change hack-a-thon;
- developing a startup to notify residents of evacuation routes in times of flood;
- leading a startup lab workshop in Algeria, including developing two weeks of entrepreneurship classes;
- serving as a teaching assistant for SDM’s 2015-2016 integrated core class; and
- volunteering as a resource for her SDM cohort during a project focused on the nuclear disaster at Fukushima (she taught nuclear engineering fundamentals).

The award carries a monetary prize.

In addition to Sabri, this year’s nominees included Tochukwu (Tox) Akobi, Susan Conover, and Na Wei. Akobi was recognized specifically for his role as chair of the SDM Leadership Council; his many contributions in international activities involving Guatemala and Africa; and his work as a teaching assistant and research assistant in energy and cleantech. Conover was cited for her achievements as the SDM speaker series cochair; as remote representative for prospective SDM students; as research assistant for Associate Professor Maria C. Yang; and for her work as an SDM summer social chair and SDM tech trek company liaison. Wei’s contributions included serving as SDM team captain for the Sloan Olympics; working as a teaching assistant for SDM boot camp and 16.682; and interning at John Deere.

All nominees and the winner are selected by the SDM staff, with input from the first-year SDM community.
Naomi Gutierrez Named Career Development and Alumni Associate

MIT System Design & Management (SDM) has announced an expansion of Naomi Gutierrez’s role within the program. As career development and alumni associate, Gutierrez has assumed responsibility for all facets of SDM alumni relations in addition to her work in career development services for SDM students.

Gutierrez’s expanded role will include:

- conducting SDM alumni outreach;
- maintaining the expanded SDM job board;
- providing SDM grads with access to MIT Sloan’s alumni job listings; and
- arranging networking opportunities.

Prior to joining MIT, Gutierrez served as a program coordinator for the Psychology Department at Boston’s Suffolk University. She holds an MA in classics from Rutgers University.

“Our students and alums are SDM’s greatest assets,” said Gutierrez, who will be spearheading an alumni survey this spring to help SDM continue to improve its efforts to serve this constituency. “Before helping them advance toward their professional goals throughout their careers will continue to make the SDM community a place of fellowship, encouragement, and expanding opportunities for all.”

Naomi Gutierrez can be reached at ngg@mit.edu
SAVE THE DATE: Annual MIT SDM Conference on Systems Thinking for Contemporary Challenges and Related Events

**September 27-28, 2016**
For details, please see page 21.

**Grace Hopper Celebration of Women in Computing**
**October 19-21, 2016**
SDM will be exhibiting at this event in Houston, TX

**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 p.m. and are free and open to all.
Details/registration: sdm.mit.edu.

**March 21, 2016**
A Systems Approach to Cybersecurity
Charles Iheagwara, PhD, SDM alumnus

**April 4, 2016**
A Systems-Based Approach to Improving Customer Service
Richard C. Larson, PhD, Mitsui professor of engineering systems and director of the Center for Engineering Systems Fundamentals, MIT; aka “Dr. Queue”

**April 25, 2016**
Systems Thinking and Restorative Ranching
Burl Amsbury, Principal, Good-Again; SDM alumnus

**May 9, 2016**
Why Competing at Innovative Speed Is So Darn Hard
Steven J. Spear, DBA, senior lecturer, MIT Sloan School of Management and MIT School of Engineering

**May 23, 2016**
Can the Commissioned Sales Force Paradigm Succeed in the Semiconductor Industry?
Heath Marvin, field applications engineer, Microchip Technology; SDM alumnus

**June 6, 2016**
Applying Systems Engineering to the Services Industry
Uzair Khushrow, senior manager for planning and coordination, Colgate Palmolive; SDM alumnus

**June 20, 2016**
Systems Thinking Applied to Healthcare: A Case Study in Addressing Skin Cancer
Susan Conover, MS candidate, Singapore University of Technology and Design; SDM aluma


Event listings contain all details available at press time. Final information is available at sdm.mit.edu two weeks prior to each event.