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Tech Trek Report
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The 2015 fall edition of the SDM Pulse highlights the application of systems thinking by alumni of MIT’s System Design & Management (SDM) program and by others in a wide range of domains. This issue also highlights the myriad opportunities available for you and your company to engage with SDM, as well as with SDM and Integrated Design & Management (IDM) fellows—among the best and brightest students at MIT!

Specifically, you will find:

- A report on how the US Army is using systems analysis to enhance the performance of tactical personnel;
- An article on measuring and improving business processes, applicable to any company;
- A look at how Chile’s Ministry of Energy is tackling sustainability in the energy-water nexus;
- Details on an advancement in human-computer communication that can help maximize sales;
- Reports on how companies are engaging with SDM, including a spotlight on the spring 2015 Tech Trek in the San Francisco Bay Area—and information on how your company can get involved;
- Snapshots of the newly matriculated cohorts for SDM and the inaugural class in its IDM track (the diversity of cultures, industries, and educational backgrounds represented is truly remarkable);
- News of a new book by SDM faculty members Ed Crawley and Bruce Cameron and the appointment of Andy MacInnis as IDM’s technical instructor; and
- Information on upcoming SDM events, such as this year’s annual systems thinking conference and back-to-the-classroom sessions, our alumni-student networking evening, live and virtual information events for prospective applicants and companies interested in sponsoring students, webinars on applying systems thinking to various complex challenges, and more.

We hope you enjoy this edition of the Pulse. As always, we welcome your feedback and suggestions.

Sincerely,

Joan S. Rubin
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A Systems Approach to Enhancing Intelligence and Improving Mission Performance in the US Army

The challenge: Modern Army analysts must generate and direct intelligence that supports the pace of tactical operations for a modular force with decentralized decision-making. Digital collection platforms, information systems, analytical software, and connectivity at the tactical level are useful, but insufficient. Analysts need training in data analysis fundamentals to understand the trajectory from raw data to decision-making.

The approach: Using a systems-based analysis to enhance intelligence can help Army units at the tactical level improve mission performance. This type of analysis uses systems design tools to:

- examine and model the design of military operations;
- define the analyst’s required capability in the context of tactical operations;
- explore, revise, and assess components of intelligence competency;
- assess the relative costs of competency gaps; and
- recommend improvements.

The tools: Five systems-based approaches were used to address this challenge. They were:

- system architecture
- system dynamics
- design structure matrix
- multi-domain mapping matrices
- system dynamics shortcut model

System architecture. The first step was to assess the architecture of the military’s intelligence system. This revealed that the decentralized decision-making that now characterizes the Army’s mission command requires precise tactical intelligence. Objectives for tactical operations are nested within those at the operational level, so the outcome of each mission affects the next one down the line. To propagate change in a desired direction, the unit must understand the current operational conditions and threat, which are characterized by a fair degree of uncertainty. Effective decision-making depends on the unit’s ability to reduce this uncertainty and move toward a desired end state.

System dynamics. The next step was to develop a model for mission performance based on the principles of system dynamics. This model stresses the significance of personnel considerations to the unit’s ability to successfully accomplish missions: operations in environments with greater uncertainty are more demanding of personnel resources.

continued on page 4
The model enables simulation of the system under a variety of scenarios and highlights the relative impacts of operational or intelligence capacity variables on mission performance. These outcomes include:

- Mission fails as a result of operational capacity exceeding the unit’s intelligence capacity; and
- Mission succeeds, but the unit must put in extra effort to compensate for limited intelligence.

Note that additional unit effort means additional exposure to risk for troops in the operational environment. This demonstrates that intelligence capacity is more than a force multiplier: It is a force preserver.
Design structure matrix (DSM). The formal mapping of a unit’s staff using the design structure matrix made it possible to see that some transfers of information occur as lateral exchanges while others occur hierarchically. Structural and organizational designs inherent to military culture and hierarchy, including potential disparities in rank and experience, can unfortunately create artificial barriers to communication.

For example, it is not atypical for an intelligence officer to rank one or two levels below an operations officer. This means the operations officer could have many more years of experience than the intelligence officer. To work well together, the intelligence officer must spend significant effort building knowledge of the unit’s operations, specific standards, and tactics just to be conversant with the person on whom all of his tasks depend. The communication barriers are significantly greater when an analyst perceptibly lacks competency in his field.
**Multi-domain mapping matrix (MDD).** Using a multi-domain mapping matrix to scrutinize the analyst’s role in unit operations reveals four major components of competency imperative to analysts’ abilities: intelligence methodology, integration with unit operations, communication, and information processing. The MDM illuminates the relationship of these components across 132 competency specifications. It also highlights the significance of each component and exposes design challenges.

Since the MDM contains DSMs that map components to specifications and vice versa, it also generates a DSM (Figure 3), which lends insight into the significance of each competency. Most notably, the new DSM reveals that competence in information processing is extremely important in the early phases of intelligence analysis and endures through decision-making. Thus, the capability of the analyst is the lynchpin for the unit’s intelligence capacity.

**System dynamics shortcut model.** The Army is still largely reactive when it comes to determining which human-to-digital interfaces maximize information transfer for combat operations. However, leaders are discovering that the tools are only as good

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**Update to Core Competencies**

**Enduring + Newly Identified Set = Enabled Intelligence Production**

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*This model, adapted from J.B. Morrison, reveals why well-intended shortcuts have detrimental effects on the analysts’ skill development and, consequently, the Army at large.*
as the analyst’s ability to apply them to the operations context. Blind application of tools essentially prejudices the organization against trusting its intelligence officers. Moreover, shortcuts reduce the number of tasks in the intel cycle, leading to a decrease in learning that affects the analyst’s qualification for intelligence positions of greater influence, propagating skill deterioration across the organization.

Without Change, Analyst’s Capability Erodes

Figure 4. The effect of decreased competency across the organization negatively affects the warfighter in two ways: increasingly higher levels of the organization lack the requisite capabilities to perform intelligence functions effectively, and resources are reallocated to intelligence and away the immediate mission, meaning fewer resources for preparing the warfighter for combat.

The results: As a team, the Army needs to revise training for tactical intelligence analysts to align their capabilities with the current and future needs of tactical operations. In order to deliver valuable intelligence insights to the unit, analysts must be competent in information processing and in communicating key intelligence insights to decision-makers.

There are currently myriad research efforts focused on how to extract value from large sources of data, leverage tools to optimize their utility, and identify and understand sources of uncertainty. As an intelligence community, we need to:

- unify these efforts and identify ways to enhance analyst training in both the near and long term;
- incorporate aspects of information processing, such as fundamentals of data analysis or statistical methods, into analysts’ initial entry and career development curricula;
- assess in depth the skills and teaching methods that provide the most value; and
- employ these findings to guide the development of a new curriculum and culture in military intelligence, providing the enduring foundation for intelligence capacity required for the modern operational environment.
Assessing Regulatory, Environmental, Economic, and Technical Components of Sustainable Energy and Water Use in Thermoelectric Facilities in Chile

Editor’s note: The following is a summary of a study performed for the Chilean Energy Ministry with the support of the Ministry of the Environment. The authors would like to thank the Chilean Energy Ministry and Ministry of the Environment for supporting this project.

The challenge: Water use at thermoelectric facilities presents a complex systems problem for several reasons:

- To operate safely and efficiently, the facilities need large amounts of water, yet water supplies are limited;
- The social and environmental impacts of water use are becoming increasingly significant worldwide; and
- A complex set of relationships exists among the overall environmental, economic, and social impacts of water use; how water is withdrawn from its source; how it is used at facilities; and how it is returned to the environment.

The most significant water use at a thermoelectric facility is associated with the cooling process, which in turn is tightly coupled to the overall performance and reliability of the plant. An adequate amount of water for the plant’s cooling system leads to a more energy-efficient thermoelectric facility—one that produces less atmospheric emissions per unit of electricity generated. This relationship creates an important tension in the design or upgrade of a plant’s cooling system between water use and performance.

Any cooling system design must consider a variety of factors, including:

- local environmental conditions and geography, including access to and availability of water;
- the ecosystems of the source body of water;
- local social context; and
- how specific system byproducts—such as water flow at the intake and the temperature of the water effluent—might stress the source body of water.

Inodú worked with the Chilean Energy Ministry and the Ministry of the Environment to identify and address some of the challenges posed by water use at thermoelectric facilities in Chile by conducting a preliminary assessment of the current regulatory, environmental, economic, and technical situation. This assessment helped address the following goals presented in the Chilean Energy Ministry’s Energy Agenda:

- supporting the sustainable development of thermoelectric generation projects;

About the Authors

Donny Holaschutz, SDM alumnus and cofounder of the energy and sustainability consultancy inodú, is a seasoned entrepreneur with experience in both for- and not-for-profit ventures related to energy and sustainability. He has consulted for startups, Fortune 500 companies, and government agencies in the United States and Latin America. He holds a master’s degree in engineering and management from MIT and bachelor’s and master’s degrees in aerospace engineering from the University of Texas at Austin.

Jorge Moreno, SDM alumnus and inodú cofounder, has extensive experience in the energy industry in the United States and Latin America. He holds a master’s degree in engineering and management from MIT and bachelor’s and master’s degrees in electrical engineering from the Pontificia Universidad Católica de Chile.
• making progress toward overall territorial regulations focused on efficiency and sustainability; and
• promoting energy efficiency as a state policy.

**The approach:** Inodú used an integrated set of methodologies grounded in systems thinking to elaborate its analysis.

First, we conducted an extensive literature review to gather facts and gain an understanding of the research, analysis, and regulation developed worldwide. Inodú found that in Chile most thermoelectric generation facilities are located by the coast, while in the United States, according to the Environmental Protection Agency, only 3 percent of power plants use ocean water. This indicated that solutions being developed for the United States might not necessarily apply to Chile.

Next, we engaged key Chilean stakeholders to gain a better understanding of how water is currently used and what solutions might be available. The stakeholders included:

• cooling system technology providers;
• thermoelectric facility technology providers;
• construction companies; and
• local generation companies.

Inodú also conducted a survey to calculate the potential for water withdrawal by the thermoelectric generation base. In Chile in 2013, the potential for water withdrawal from the Pacific Ocean was 530,400 cubic meters per hour (m³/hr) by thermoelectric facilities, the equivalent of withdrawing approximately 212 Olympic-size pools every hour* (see Figure 1). The potential for water withdrawal from water wells was 3,080 m³/hr.

* 2,500 m³ is a value commonly quoted for the volume of an Olympic-size pool.

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**Figure 1.** The water cycle is shown at left for Chile’s thermoelectric facilities, marked on the map at right.
Chile typically withdraws water from the Pacific using an overhead siphon, a method that differs from that used in many other countries. The potential for water withdrawal using an overhead siphon was 495,434 m³/hr in 2013 (see Figure 1). Mitigating the environmental impact created by withdrawing water with an overhead siphon requires a different approach than that used for some of the common intake structures found in the United States, such as the intake channel or submerged intake structure flush with shoreline. Engaging local construction companies allowed inodú to understand the unique Chilean coastal conditions that made the overhead siphon the preferred water intake system.

Several cooling system configurations unique to Chile have developed over time as shown in Figure 2. The withdrawal and return of water generates the following relevant environmental impacts:

- Impingement and entrainment of water organisms;
- Chemicals released into the water (chemicals are mostly used to keep cooling systems clean);
- Increases in water temperatures; and
- Water loss.

The environmental impacts caused by withdrawing and returning water can be affected by the selection of the cooling system and the use of proper safeguards applied to the water intake and discharge systems. The velocity at the intake, the water volume, the location of the intake and discharge systems and the types of safeguards used (screens, racks, biomass handling systems, etc.) also affect the overall environmental impact of the cooling system. Environmental safeguards installed in water intake systems in Chile are shown in Figure 3.

The environmental impact of water use can be greatly influenced by the type of cooling system selected. For example, once-through cooling systems use the most water but only consume small amounts of that water. Cooling towers and cooling ponds require less water, but they lose more water to evaporation. Finally, air-cooled condensers (dry-cooling) require no water, but they are significantly more energy inefficient than the other types of cooling systems. In addition, the topography of the coastline in Chile can play a significant role in the amount of energy needed to pump water from the coast to the location of the thermoelectric facility—a factor that affects the overall efficiency and environmental impact of the system.

We found that 95 percent of the water employed by thermoelectric facilities is used for cooling and that, in the whole water cycle, approximately 3 percent of the water is consumed. Most of the water is used by once-through cooling systems. Currently, the northern region of Chile demands more cooling water than the central region as shown in Figure 1. Both regions have significant inland water constraints, especially the far north, home to some of the country’s important mining operations as well as to the Atacama Desert, one of the driest deserts in the world.

Once we had an understanding of worldwide best practices, what was possible in Chile, and the current state of water use at thermoelectric facilities, we began exploring:

- What important tradeoffs would have to be considered to generate recommendations and future work; and
• the techno-economic performance of different types of cooling systems at the four locations where thermoelectric generation is currently centered in Chile (Mejillones, Quintero, Quillota, and Coronel).

To assess the techno-economic performance across locations, inodú developed cases for comparison. The effectiveness of cooling systems depends on local environmental conditions such as local air and water temperatures and humidity. The cases were developed by determining representative local environmental conditions at the four locations, then using the same thermoelectric facility for all cases as well as comparable design criteria.

In addition, to evaluate environmental and system performance, we explored:

• how changes in system configurations could reduce important environmental impacts associated with the withdrawal and return of water such as impingement and entrainment of water organisms, the use of chemicals in water, increases in water temperatures, and water consumption (loss); and

• how changes in system configurations could produce other environmental side effects such as changes in atmospheric emissions, noise, and plume.

The results: For a thermoelectric plant located by the coast, the analysis led to the conclusion that, in Chile, a once-through cooling system with the proper environmental safeguards tends to be the most adequate. In addition, cooling towers or other closed-loop cooling systems tend to be the most appropriate where the water intake elevation exceeds the elevation at which it is environmentally sustainable and economically efficient to pump the water volume required by a once-through cooling system. Dry-cooling systems should only be used when water usage concerns do not permit the use of a once-through cooling system or cooling towers. While dry-cooling systems decrease water use, they increase atmospheric emissions per unit of net-energy produced.

Ultimately, we found that clearer guidelines are needed to help stakeholders choose adequate cooling system configurations and safeguards that are socially, environmentally, and economically friendly. Inodú presented a set of next steps for creating such guidelines so that power plant developers and operators can reduce the environmental and social impacts of their power plants.
Understanding and Measuring the Impact of Enterprise Social Software on Business Practices

The challenge: Organizations are increasingly investing in enterprise social software, which provides networking and collaboration tools such as communities and people profiles, to support their business goals. However, many struggle to understand the practical impact of such technologies. The two major challenges are:

- insufficient user adoption, resulting in insufficient usage to demonstrate meaningful impact; and
- insufficient data for comparing performance with social technology to performance without.

To tackle these challenges, businesses must address the following questions:

- Has the technology investment been worthwhile?
- Which areas of my company have gained value from it? and
- Which areas of my company have seen no improvement?

The approach: For my SDM master’s thesis,* I developed research-based guidelines that can help companies understand and measure the impact of socially focused business processes—those that involve collaboration and coordination among people. These guidelines can help organizations to:

- understand the overarching challenges of user adoption;
- determine how to address adoption issues to improve impact; and
- identify business metrics they can use to compare performance before and after adopting social technology.

I developed these guidelines by examining five organizations that have adopted social technologies and measuring the impact on business processes. Each case study looked at:

- what was measured and when;
- the approaches used to foster adoption of social technologies; and
- the business impact.

The five companies were selected because all were utilizing social technology with their employees. In some cases, social technology was used with external contacts as well. All the companies were interested in understanding enterprise social software usage and impact.

Each identified a business process that the software was intended to improve. Three also

* The author wishes to thank her thesis advisor, Professor Wanda Orlikowski, for her support.
provided access to users and managers of the social technology for the purpose of assessing performance against a business objective before and after software implementation.

The tools: Interviews were performed to identify and understand practices that enable adoption of social technologies in the workplace. Interview data was analyzed for common themes, and case studies were created, then reviewed and approved by each participating company. Survey data was aggregated and summarized to highlight metrics in business performance before and after social software implementation.

The results: The research identified six key practices organizations can use to significantly improve the adoption of new social software and to maximize the benefits of the technology.

1. Describe existing business process(es) or initiative(s).

Before implementing or using social software, the organization should identify collaborative business processes or initiatives that require improvement with a goal of enhancing performance, then:

- interview the most important stakeholders to understand their needs;
- document the steps needed to complete each process, the key stakeholders involved in these various steps, and the relevant dependencies; and
- identify various aspects of the process, such as where time delays occur and why, to help clarify metrics that would be valuable in the next step of this framework. An example from the case studies is the requirement for stakeholder approval resulting in especially long delays. In addition, factors such as quality of output, access to people or information, and costs can provide information about the as-is process.

2. Before making any changes, measure performance of current business process(es) or initiative(s).

Identify work patterns, technology, or behaviors that describe how the process or initiative is performing in its current state. The analysis from the first step of this framework can aid in identifying the metrics for process improvement. This information can be collected through interviews, surveys, access to key performance metrics, and observational studies.

3. Remodel process(es) or initiative(s) with supporting technology.

Identify an expert process modeler to determine how the process can be remodeled to reduce or eliminate time delays, improve quality, or otherwise produce favorable outcomes. This knowledge can be acquired through training or partnering with a technology expert such as an assigned mentor or advocate.

4. Educate users and set expectations.

Organizations that integrate social technology to work within a process need to educate and inform all involved—both those who manage the process and those who implement it. Some organizations studied chose to focus on user education alone, while others also trained those responsible for oversight and execution. In some cases, management set expectations. In others, a team that had identified a better work process shared its knowledge with colleagues.

Regardless of who is spearheading the adoption of social technology, organizations need to clarify:

- the nature of each anticipated change;
- when changes will be implemented; and
- which tools will be used and which will be retired.

The above can avert the adoption issues that can arise when more than one tool or approach is in use at the same time.
5. Measure performance at regular intervals.

Once a new process has been instituted, the organization should revisit the metrics identified earlier to determine what effect, if any, the social technology has had. In some cases, such as customer support satisfaction, there may not be any noticeable change immediately. However, it is important to note any metrics that do show changes, such as length of time to complete the process or number of people involved, because they may provide insight over both the short and long term.

Figure 1 shows the effect of implementing social technology on the key metrics identified by the five organizations studied. Organizations should compare metrics such as these before and after social software is implemented to highlight areas where the process improved significantly and areas where more improvement might be achieved. Each organization studied had a different set of metrics, different goals, and used the revised process for a different length of time—yet in all cases comparing the company’s key metrics before and after social technology implementation was imperative to assessing the success of the process.

The goal of the organization’s process analysis should be to identify metrics that improved, those that remained unchanged, and those that performed poorly. For each category, the organization should identify contributing factors, such as stakeholders, process contributors, training, and technology, as discussed in Step 4.

<table>
<thead>
<tr>
<th>Metric Information</th>
<th>Before</th>
<th>After</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Case 1: Supporting Alternative Fuels Global Innovation Initiative</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent of alternative fuels used in production</td>
<td>5%-7%</td>
<td>25%-27%</td>
</tr>
<tr>
<td>Savings associated with the alternative fuels initiative</td>
<td>$0</td>
<td>$140M</td>
</tr>
<tr>
<td>Rank of alternative fuels adoption compared to competitors</td>
<td>Too low to rank</td>
<td>1*</td>
</tr>
<tr>
<td><strong>Case 2: Handling Customer Localization Requests</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of time to respond to customer request</td>
<td>4-8 weeks</td>
<td>6 days</td>
</tr>
<tr>
<td>Number of emails involved in process</td>
<td>61</td>
<td>0</td>
</tr>
<tr>
<td><strong>Case 3: Inspecting Packages for Customs</strong></td>
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<td></td>
</tr>
<tr>
<td>Number of inspections per day</td>
<td>8.62</td>
<td>9.09</td>
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<tr>
<td>Number of experts contacted per day</td>
<td>1.90</td>
<td>2.47</td>
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<tr>
<td>Number of packages inspected per day</td>
<td>13.54</td>
<td>14.66</td>
</tr>
<tr>
<td><strong>Case 4: Planning an International Conference</strong></td>
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<td>Length of time to plan the conference</td>
<td>6 months</td>
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<td>Number of emails to plan conference details</td>
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<tr>
<td>Number of planning meetings</td>
<td>23</td>
<td>13</td>
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<tr>
<td><strong>Case 5: Addressing Customer Complaints</strong></td>
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<tr>
<td>Hours spent resolving issues</td>
<td>29.86</td>
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<td>Number of emails sent and received regarding issues</td>
<td>27.86</td>
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<tr>
<td>Number of meetings required to resolve issues</td>
<td>5.71</td>
<td>3.00</td>
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</tbody>
</table>

* According to the Global CemFuels Award, 2014

Figure 1. Key metrics for five case studies are shown before and after process improvements.
6. Improve the process(es) or initiative(s) based on feedback and performance.

Step 5 will help organizations zero in on the metrics that are changing as a result of process modifications as well as the factors contributing to those changes. Understanding these developments can help organizations see where further improvements can be made to the process or to contributing factors. In some cases, additional feedback may be required, such as data on changing levels of customer satisfaction. Data not readily available can be collected through interviews, surveys, and a variety of other feedback collection techniques.

At this stage, the organization should make appropriate adjustments to the process. Organizations should return to Step 3 to remodel and describe the changes. The organizations should continue to Step 4 to re-educate users and participants and continue through the measurement and refinement of Steps 5 and 6.

The results: The research indicated that using the above guidelines made it possible to assess the impact of social enterprise software implementation on a company’s key metrics.

For example, in one case study, the analysis revealed that within six years, the company had significantly improved its rate of substituting fossil fuels with alternative fuels relative to its competitors. This substitution initiative generated about $140 million in savings per year and reduced the release of some 1.5 million tons of CO2 to the atmosphere annually.

In another case, instituting social technology significantly improved request coordination, boosting a number of key metrics measured by the company. Email, which had been the primary mechanism for information exchange, was removed from the process, and process time decreased from up to 40 days to six days. In addition, customer response time was reduced by weeks.

In a third case involving package inspections, participants reported:

- an increase in the number of inspections performed, packages inspected, and experts contacted;
- a reduction of approximately 15 minutes per day in the time spent on inspections; and
- an improvement in the quality of information available to inspectors, access to expertise, and mobile access.

These results show that following the framework described above can provide organizations with a clearer understanding of the impact of social software on their businesses. However, social software adoption is not an organizational state that can simply be achieved and then ignored. User needs are constantly changing, user-generated content begins aging the moment it is shared, and many facets of organizations—departments, processes, metrics, products, services, etc.—are as dynamic as the people within them. It is therefore important for companies to recognize that making the best use of social enterprise software requires ongoing evaluation and adaptation.
Advancing Human-Computer Communication to Maximize Sales

The challenge: In today’s fast-moving, dynamic business environment, it is tougher than ever for businesses to reach the right clients in a meaningful way and achieve results. Sales and marketing professionals need highly specialized and effective technology to source clients, engage them, and close deals.

This is especially true for top-of-funnel outreach. Even if a sales/marketing professional has carefully selected targets, “cold call” emails are almost always deleted immediately. How can prospective customers be incentivized to engage with the material for mutual benefit?

The approach: Nova Labs was formed to address this challenge using an integrative, systems-based approach—coupled with deep knowledge of typical top-of-funnel challenges—to develop hyper-personalized email outreach technology that surpasses what is currently available to sales and marketing professionals.

First we conducted a massive information-gathering mission by interviewing dozens of lead users in companies across the globe. The goal was to understand how potential users in the sales/marketing field spend each day on the job. Findings produced a clear view of common and best practices and typical products already in use.

Next, we researched the market landscape to gain insight into what gaps exist at the leading edge of sales automation technology.

Finally, we created a software-as-a-service, business-to-business product designed to meet the new-customer acquisition needs of medium and large companies. The goal of this initial product, Nova, is to optimize email outreach for clients. Nova’s underpinning is a scalable personalization technology that can be extended into other domains and ultimately become a platform for future products. This technology will enable our customers to personalize not just email, but ads, engagement/re-engagement communications, upsell opportunities, and more.

The tools: The systems thinking mindset, technology strategy, and user-centered design—as well as system architecture and dynamics methodologies—that form the foundation of MIT’s System Design & Management program have provided many of the fundamental concepts on which Nova Labs built its core technology.

The product design/synthesis/feedback process included:

- transforming all of our documented experiences plus the synthesized information collected from the sales/marketing professional interviews into baseline product requirements;
- choosing and configuring the technology stack to be used;
- determining initial/future sources of information from the public Internet with which to construct meta-profiles for each prospect;

About the Author

Bryan Pirtle, SDM ’13, is chief technology officer of Nova Labs, Inc. He employed techniques from MIT’s System Design & Management program to help shape the core of Nova Labs’ technology strategy and roadmap.
• creating a baseline scope for the personalization technology layer;
• designing the look and feel of user interfaces;
• designing the “glue layer” of how data flows to/from each interface, as well as usability/user experience;
• implementing all of the above in the chosen technology stack;
• sourcing beta clients and releasing the product to them; and
• feeding back client suggestions, concerns, and usability issues into the process to continue iterative
design.

After analyzing and discussing the results of our data collection efforts at length, we were able to characterize our target market as follows:

• The client: Sales development representatives, account executives, and personnel in inside sales roles.
• What the client does: Spends five or more hours each day researching individuals on prospect lists to determine the right personal touch to add to an initial message to engage each person.
• What the client currently uses: Static, template-based, single-email, and mail-merge (multiple-email, campaign-based) platforms that convert comma-separated values documents into bland, spammy-looking emails.
• What the client wants: Dynamic, data-driven technology that allows for utilization of publicly available data and performance analytics to construct appropriate targeting language automatically and insert it into emails to capture each recipient’s attention and/or establish a personal connection—at scale.

We thus determined that a technology that combines the successful elements of existing products on the market with an automated personalization text-generation layer would have the potential to revolutionize sales and marketing top-of-funnel and save hours per day per professional.

To deliver this product, we created a robust and sophisticated software stack capable of asynchronously compiling and delivering the data needed for the personalization process and desired user experience. Our current stack with high-level relationships between components is shown in Figure 1.
We decided to use contemporary open-source software built upon the Heroku platform as a service in order to achieve the following goals with our stack:

1. Stability, gained by using robust, mature frameworks and software platforms;
2. Flexibility, attained by picking and choosing the correct open-source tools and libraries for each product need; and
3. Focus on application design rather than infrastructure design.

We built the primary user interface as a Google Chrome extension application. This design choice was primarily made to make use of the Google Apps mail client that most lead users preferred. We chose AngularJS as the front-end Javascript framework and “glue layer” to provide a more robust and streamlined real-time “desktop experience” in the web environment. The asynchronous and real-time data needs of the application were also simplified by the use of AngularJS. Figure 2 shows the real-time analytics in action in a campaign.

Once a client uploads a list of target email addresses, the personalization engine is employed on the back end to search target sources on the Internet. The engine then constructs a meta-profile for each person using his/her email as the key. We chose several initial data sources, including social media data aggregator APIs as well as our own data scrapers and search technology. Proprietary algorithms are then used to construct the meta-profile and custom attributes—such as seniority, influence, playfulness, and international orientation—from the collected raw data.

Once the meta-profiles are constructed, the personalization engine uses natural language processing and machine learning as well as statistical analysis of past analytics data to determine the proper personalization snippets, including tone, to add to the email for each recipient. The user may also customize correspondence from all available personalization types and tones that the engine has previously created. The personalization engine learns from the choices users make to continually adapt to recipient preferences.

The results:

- Nova Labs has started beta testing with two dozen companies.
- The pipeline increases daily with more than 200 companies expressing interest in the product.
- More than 5,000 emails per week go through the Nova system.
- Nova-personalized emails perform more than 500 percent better on average than control (non-personalized) emails based on numerous experiments using real-world campaigns for both prospect engagement and response rates.

Nova Labs is continuing to meet its own internal milestones and is aggressively pursuing new client growth using its proprietary tools, product, and technology.
Spring 2015 SDM Tech Trek Report

A Systems-Focused Tour of Eight Top Companies in Just Four Days

By Joan S. Rubin, SDM Industry Codirector

High-flying startups grab attention for their innovative ways of conducting business, but the spring 2015 SDM Tech Trek demonstrated that successful companies—large and small, established and new, in a broad variety of industries—use systems thinking to achieve their strategic goals. Companies visited on the trek ranged from C3 Energy to SunEdison, Salesforce.com to AppDynamics, and from Intuitive Surgical to E&J Gallo Winery, SanDisk, and Yelp.

The spring SDM trek is one of two held annually—a daylong trip each fall to businesses in Greater Boston and a weeklong visit every March to companies in the San Francisco Bay/Silicon Valley area (see page 21). Over the years, fellows, faculty, and staff have visited many companies to learn firsthand about their strategic, operational, and tactical challenges, discuss the application and value derived from systems thinking, and examine how the use of systems thinking is increasing and evolving in industry.

Each trek is organized and led by SDM fellows, who target companies that will deepen their understanding of the diverse approaches available for applying systems thinking. This year’s San Francisco Bay Area/Silicon Valley trek was led by SDM ’15s Rany Polany and Deepa Fernades Prabhu. Organizational assistance was provided by all student participants as well as by SDM Industry Codirector Joan S. Rubin and SDM Director of Recruitment and Career Development Jonathan Pratt.

Tech Trek goals:

• Expand students’ knowledge of complex challenges across several industries.
• Strengthen relationships between the companies and SDM.

Companies visited:

- SunEdison
- Salesforce.com
- AppDynamics
- Yelp
- Intuitive Surgical
- E&J Gallo Winery
- SanDisk
- C3 Energy
- Yelp

Trip highlights:

• At SunEdison, Teresa Yang ’03, director of global design and engineering and Kevin Yates MBA ’13, manager of power origination, described the solar industry’s rapid evolution and discussed SunEdison’s vertical integration strategy for meeting the demands for clean, affordable energy. The visit concluded with a tour of the company’s control and logistics area, where students saw a demonstration of how uptime on the grid is planned and managed.

• Director of Academic Programs Lisa Tenorio welcomed the SDM group to Salesforce.com, and Vice President of Platform Development Marketing Adam Seligman provided a corporate overview. Senior Director Sarah Franklin then presented a live demonstration of the Salesforce platform. In addition, Reena Bhatia MBA ’09, strategic innovation executive, created an interactive design session to highlight the systems thinking challenges of operating in an environment that is sustaining 30 percent to 40

continued on page 20
percent annual growth rates. SDM fellows were divided into groups of four and given 30 minutes to come up with a solution to a design problem. Each team presented a unique solution to an audience of Salesforce.com executives.

- SDM fellows gained a multifaceted understanding of AppDynamics’ business thanks to presentations and interactions with several MIT alumni and company executives. Peter Kacandes LFM ’97 discussed the basic challenge the company is working to address—managing applications’ performance and availability across cloud computing environments as well as in its data center. Ariel Smoliar MBA ’13, principal product manager, talked about his journey to AppDynamics and the process of finding a career environment in which one can succeed. Students also had an opportunity to interact directly with staff and learn more about what it’s like to work at AppDynamics.

- Fellows toured Yelp headquarters, focusing on the sales, product, and engineering areas. They learned about Yelp’s internal hackathon events, in which engineers are encouraged to work on nontraditional, fun, and interesting projects, then saw some of the results. Vice President of Consumer and Mobile Products Eric Singley provided an overview of product management at Yelp, and then Product Manager Stephanie Teng discussed the challenges of building global software and how Yelp addresses them. A Q&A followed.

- Catherine Mohr ’90, SM ’92, an MD and vice president of clinical research at Intuitive Surgical, provided perspective on what is needed to build a successful technology. She noted that having a great idea is not enough and stressed the importance of understanding how a product can be used. She gave an overview of the company’s innovative robotic surgery technology, which SDMs had the opportunity to operate, then provided a tour of the company’s growing manufacturing operations. Mohr left the group with four key suggestions:
  - Keep focused on the big picture;
  - Dive in and do the hard work;
  - Be an opportunist; and
  - Reinvent yourself continually.

- The group visited E&J Gallo Winery’s production facilities, where a leadership team from the engineering and production groups discussed the unique challenges of managing highly variable inputs (the grapes) to make a consistent and recognizable end product. The students heard from senior executives in charge of winemaking, Six Sigma, production engineering, process technology, and applied technology. A group discussion and winery tour were followed by a networking dinner with the company’s management team.

- A team of SanDisk senior executives—including Stan Chapski, corporate engineering chief of staff; Shiva Estori Sathyanarayan, director of operations management; Nithya Ruff, director of marketing management; and Saclin Piplani, senior director of marketing management—participated in an interactive discussion with the SDM group. The SanDisk team described the need to innovate continually in a market whose capacity doubles every 12 months and emphasized the need for strong cross-functional teamwork. Lunch and small group discussions followed.
Each year, MIT SDM fellows, faculty, and staff visit leaders from best-in-class companies to learn about their global business challenges and how they are using systems thinking to address them.

In the upcoming academic year, SDM will hold two treks:

**Fall 2015**
*October:* During this one-day trek, SDM fellows will visit top technology-based companies in the Greater Boston area.

**Spring 2016**
*March 21-25:* This journey to companies in the San Francisco Bay/Silicon Valley area covers a wide variety of industries.

If your company would like to participate, 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.
Snapshot: SDM and IDM Cohorts Entering in Fall 2015

By Lois Slavin, SDM Communications Director

On August 24, 2015, MIT welcomed two new cohorts: 60 early to mid-career technical professionals who matriculated into System Design & Management (SDM) and 18 early career design, engineering, and management professionals who comprise the inaugural Integrated Design & Management (IDM) class. As in the past, fellows in the newest SDM cohort come from a wide range of industries, among them energy, healthcare, software, information technology, consulting, robotics, and the US military. Students in IDM’s inaugural class are equally diverse, hailing from the fields of high-tech, design, sustainability, engineering, and education.

MIT System Design & Management Class Entering in AY16

Demographics*
- 51 men / 9 women

Average age
- 33

Program
- 36 on campus / 17 commuter / 7 distance

Citizenship
- Argentina, Brazil, Chile, Colombia, Germany, India, Indonesia, Japan, Lebanon, Mexico, Morocco, Saudi Arabia, Singapore, South Korea, Turkey, United Kingdom, United States, Venezuela

Vikas Enti
Manager, Data Interaction and Visualization Engineering, Amazon Robotics

“SDM will enable me to solidify my systems engineering skills and develop deep business insights so that I can help create revolutionary products.”

Kate Cantu
Space Acquisition Program Manager, US Air Force

“I believe MIT’s reputation, and especially SDM’s, will give me an added level of credibility that can be difficult to earn as a female in a technical, leadership role.”

Chris Garcia, MD
Clinical/Research Fellow, Pathology Informatics, Massachusetts General Hospital

“SDM will provide me with a new perspective and skill set for redesigning clinical systems and processes to help transform and improve healthcare.”

Ashley Whitney
Senior Mechanical Engineer, Medical Technologies Division, Cambridge Consultants

“SDM will give me the tools and perspective to tailor systems engineering to projects at varying levels of complexity.”

Eugene Tham
Senior Lecturer, Republic Polytechnic, Singapore

“SDM will enable me to bring a management perspective to my job and will help evolve and broaden engineering education at Republic Polytechnic.”

*Admissions numbers accurate as of press time.
MIT Integrated Design & Management Inaugural Cohort

Demographics
- 9 men / 9 women

Average age
- 26

Program
- 18 two-year option

Citizenship
- Canada, China, Colombia, Costa Rica, India, Japan, Pakistan, Taiwan, United States

Kevin Yuen
Innovation and Strategy Consulting Associate, Innosight
“IDM will help to expand my skills beyond strategic planning to include prototyping, experimenting, and implementing initiatives.”

Sophia Yang
Experience Designer, DesignMap
“IDM’s emphasis on strategic and holistic thinking, interdisciplinary collaboration, and entrepreneurship can greatly benefit employers looking for hybrid professionals who can see the big picture as well as the concrete steps needed to achieve it.”

Ismail Degani
Cofounder, SnapJet
“IDM is the ultimate startup incubator. Its emphasis on great design and large-scale commercialization is perfectly aligned with my entrepreneurial goals.”

Jacqueline “Chacha” Durazo
Special Projects, Title IX Office, MIT
“I am going to change the world, and I believe IDM can help me prepare to do so.”

Huda Jaffer
Lead Designer, SELCO Foundation
“My IDM education will enable me to support the SELCO Foundation in designing an ecosystem for the world’s underserved populations that integrates sustainability at all levels: social, economic, and environmental.”
Jillian Wisniewski Named 2014 SDM Leadership Award Recipient

On June 7, 2015, the MIT System Design & Management (SDM) community honored SDM ’14 fellow Jillian Wisniewski with the annual MIT SDM Student Award for Leadership, Innovation, and Systems Thinking. Wisniewski was honored at SDM’s post-commencement celebration at the Liberty Hotel in Boston.

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.

Wisniewski, who received a monetary prize with the award, was acknowledged for numerous contributions to her cohort, the SDM program, and the MIT community at large. These include:

- serving as the SDM Leadership Committee’s curriculum chair;
- developing an optimization tool to assist fellows in SDM class scheduling;
- delivering a seminar at Lincoln Labs on her thesis research (for more on her research, see p. 3);
- serving as a teaching assistant in system dynamics courses and as a content advisor to an MFin student;
- being named a student fellow at Draper Laboratory;
- organizing and leading an SDM orientation for cadets at the US Military Academy, West Point; and
- coaching the SDM-Operations Research Center Frisbee team.

In addition to Wisniewski, this year’s nominees included James Barkley, SDM ’14, and Gaurav Khanna, SDM ’14. Barkley was recognized specifically for his roles as chair of the SDM Leadership Committee’s speaker series and social committee, as well as for broad and diverse outreach efforts within the SDM, MIT Sloan, and overall MIT communities. Khanna was cited for multiple contributions to the product management community within MIT and in the Greater Boston area.

All nominees and the winner were selected by the SDM staff, with input from the first-year SDM community.
Employment Report: 2014 SDM Graduating Class

MIT System Design & Management (SDM) educates future technical leaders in architecting, engineering, and designing complex products and systems, providing them with the leadership and management skills necessary to work successfully across organizations. Graduates leave prepared to manage effectively and creatively by using systems thinking to solve large-scale, complex challenges in product design, development, and innovation. Their unique and powerful combination of technical and managerial skills equips them to effectively lead in positions throughout a wide range of industries, across all levels and functions.

SDM annually surveys members of its most recent graduating class about their career paths. The resulting report provides an overview of the employment and compensation statistics gathered from self-sponsored students who graduated from the program in February, June, and September 2014. Information on the companies that hired them is also provided.

Highlights of this year’s report include the following facts:

- 97 percent of SDM graduates who responded to the 2014 survey are employed or pursuing further educational studies;
- Graduates reported an average base salary of $122,867—an increase of 52 percent over their base salaries as reported prior to entering SDM; and
- The top job functions being performed by the 2014 graduates were product development/management and engineering.


SDM Faculty Members Publish System Architecture Book

Bruce Cameron, faculty member in MIT’s System Design & Management (SDM) program and director of the System Architecture Lab, and Professor Ed Crawley, SDM cofounder and president of the Skoltech Institute of Science and Technology, have released a new book, System Architecture: Strategy and Product Development for Complex Systems. Co-authored with Cornell Professor Daniel Selva, the book builds on case studies from BMW, NASA, GE, and IBM to illuminate early decision-making in complex systems.

The product of 20 years of research and teaching in the System Architecture Lab and in SDM, the book includes a foreword by Norm Augustine, former CEO of Lockheed Martin, as well as contributions from a number of past SDM guest speakers.
Matt Kressy, director of Integrated Design & Management (IDM), has announced the appointment of Andrew MacInnis as IDM’s materials and methods instructor, effective July 1, 2015. In this role, MacInnis will teach design and prototyping to the inaugural IDM class as well as oversee operations in the new Integrated Design Lab, which is located in MIT’s International Design Center.

MacInnis comes to MIT with more than 20 years of iterative research and design expertise in the consumer, military, and sports industries. He also brings valuable hands-on experience gained from early career positions that evolved from shop hand to model maker, model shop manager, founder of Monster Prototype, and production manager/process developer. He holds a BFA in industrial design from the Rhode Island School of Design.

“Andy is one of the most accomplished creators I have ever met,” Kressy said. “We are thrilled to have him as part of our teaching team and look forward to watching our students marvel at what they are able to accomplish under his guidance.”

Most recently, MacInnis worked as product implementation manager at Revision Military, which designs and delivers protective equipment for soldiers worldwide. He was responsible for designing and establishing best practices in the composite and paint shops of the company’s composite center of excellence. He was a major contributor to the selection and refinement of materials and techniques for structural elements of a cutting-edge anti-ballistic helmet. He also wrote technical instructions and trained and managed staff.

“Our students are blessed to be coming of age in an era where options abound for the creation and development of their ideas. I am excited to guide each of them along their own paths to success,” MacInnis said.
SDM Conference Centers on Holistic Product Design and Development

The MIT System Design & Management (SDM) program’s annual Conference on Systems Thinking for Contemporary Challenges provides practical information for technical and business professionals on how to apply systems thinking to their most complex and pressing challenges. The theme for the October 7, 2015, conference is a whole systems approach to product design and development.

Speakers will include engineering, design, and management leaders (many of whom are SDM alumni and faculty) from a wide range of sectors. Topics will include:

- the increasing competitive imperative for products with greater consumer appeal;
- why the walls separating design, engineering, and management must be torn down—and how to accomplish this;
- how to build a systematic process for creating great products from great ideas; and
- tools and techniques that can be pulled out of the box to help organizations develop a systems-based approach to integrating design, engineering, and management.

“Systems thinking is increasingly essential to competing successfully, no matter what products or services you offer,” said Joan S. Rubin, SDM industry codirector and conference convener. “A whole systems approach to integrating design, engineering, and management can enable a critical competitive edge in quality, time-to-market, and overall success. At this conference, you will learn how leading-edge businesses are achieving this.”

Rubin added that this year’s conference has been designated one of MIT’s official “spoke events” for Boston’s inaugural HUBweek. Informally referred to as Greater Boston’s answer to SXSW, HUBweek is a weeklong celebration of the innovation and energy that thrives in Boston.

The SDM conference will include ample time for question-and-answer sessions at the end of each presentation as well as for networking with fellow attendees at a special reception that will take place immediately following the formal event. Attendees are also invited to the SDM Information Evening scheduled after the conference to learn more about SDM and its new Integrated Design & Management track. Details can be found at sdm.mit.edu.

Back-to-the-Classroom Sessions Featured

This year, SDM will offer preconference back-to-the-classroom sessions with two of SDM’s best and brightest faculty members. This event, slated for the afternoon of October 6, will include:

- “Transformation Through Constructive Change,” presented by Pat Hale, executive director of SDM and senior lecturer, MIT; and

For details, please visit sdm.mit.edu or contact Joan S. Rubin, SDM industry codirector, jsrubin@mit.edu.
Details for all events are at sdm.mit.edu.

Annual MIT SDM Conference on Systems Thinking for Contemporary Challenges and Related Events

All events will take place in Wong Auditorium at MIT

October 6, 2015
Preconference Back-to-the-Classroom Sessions
Annual Alumni-Student Networking Evening

October 7, 2015
A Whole Systems Approach to Product Design and Development

MIT SDM and IDM Information Sessions
Learn about the MIT master’s of science degree in engineering and management, the new Integrated Design & Management track, and the MIT-SUTD dual master’s degree program. Discuss career opportunities and network with SDM and IDM alumni, faculty, students, and staff.

October 7, 2015, and December 12, 2015
SDM Information Sessions (Recordings will be available on demand.)
Details/registration: sdm.mit.edu

November 5, 2015, and December 9, 2015
IDM Information Sessions (Recordings will be available on demand.)
Details/registration: idm.mit.edu

MIT SDM Systems Thinking Webinar Series
This series features research conducted by members of the SDM community.
Except where noted, all webinars are held on Mondays from noon to 1 p.m. and are free and open to all. Details/registration: sdm.mit.edu.

October 19, 2015
Using Systems Thinking to Design Healthcare Delivery for US Military Veterans
Andrea Ippolito, Presidential Innovation Fellow, White House; PhD student, MIT; SDM alumna

November 2, 2015
Understanding and Measuring the Impact of Enterprise Social Software on Business Practices
Suzanne Livingston, senior product manager, IBM Connections; SDM alumna

November 16, 2015
A Systems Analysis of Tactical Intelligence
Jillian Wisniewski, captain, US Army; system dynamics instructor, US Military Academy at West Point; SDM alumna

November 30, 2015
The Use of Hadoop-Based Analytics in the Healthcare Safety Net: Lessons Learned
David Hartzband, DSc, research affiliate, Sociotechnical Systems Research Center, MIT

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