

SECOND INTERNATIONAL ENGINEERING SYSTEMS SYMPOSIUM

Brief Report and Outcomes

1. Introduction and Background

The [Second International Engineering Systems Symposium](#), “Engineering Systems: Achievements and Challenges,” took place June 15-17, 2009, at the Massachusetts Institute of Technology. Co-sponsored by [MIT Engineering Systems Division \(ESD\)](#) and the [Council of Engineering Systems Universities \(CESUN\)](#), the symposium drew participants from around the world. Presenters and audience members came from academia, industry, and government. Total attendance was nearly 300 people, about half of whom came from outside of the MIT community.

Several general themes and conclusions emerged from this highly successful event. One concerns the increasing importance of engineering systems as a field, evidenced by the fact that it is being adopted by more and more institutions of higher education around the world. In this context, there is a stronger recognition of the critical role of the social sciences within the field than ever before. It became clear that there are principles of engineering systems, as well as common methodological frameworks, that cut across all the various systems the field addresses.

Participants responded positively to the notion, suggested by a number of speakers, that engineering systems represents 21st century systems solutions to problems that in many cases grow out of the advances of 20th century engineering. These problems are becoming easier to recognize, but taking steps to address them is more difficult because they are so very complex. The challenges to implementation of solutions today typically involve political hurdles, such as those that are so apparent in addressing the healthcare or financial systems.

The symposium comprised two full days of plenary sessions, a poster session at the conclusion of the second afternoon, and a third day of research sessions in three concurrent tracks. More than two dozen invited speakers participated in the plenary sessions, along with eight moderators. The research sessions on Day 3 involved nearly fifty presenters and twelve moderators. (To view all presentation slides, visit the [agenda page](#) of the symposium website.) Welcoming remarks were offered by MIT President Susan Hockfield, and several keynote addresses were given over the three-day event, including by Charles M. Vest, President of the National Academy of Engineering and President Emeritus of MIT; Thomas Peterson, the new Assistant Director of the National Science Foundation’s Directorate for Engineering; and Norman Augustine, retired Chairman and CEO of Lockheed Martin Corporation.

A half day was devoted to invited talks on “Methodologies and Large-scale System Applications,” in which faculty from a variety of institutions discussed system architecture, system design, social networks, the enterprise perspective, and sustainability and infrastructure. The final day comprised additional panel discussions, a poster session, and some 50 accepted papers presented in 12 concurrent sessions covering topics such as energy policy, flexibility, design, and risk analysis.

This was the second such symposium; the first was held at MIT in March 2004. With overwhelming support from participants of the need for engineering systems, Professor Thomas J. Allen (MIT) described that first gathering as a “call to arms.” One industry senior executive in attendance described development of the field as an “international priority” for the engineering profession. The 2009 symposium had different objectives. It was an occasion to assess the accomplishments since that first meeting, both intellectually and with regard to new engineering systems programs around the world. It also provided a forum to examine, from an engineering systems perspective, current and future challenges and opportunities in critical large-scale systems such as financial services, healthcare, and energy, and to look to the future of engineering systems a decade hence.

Daniel Roos, the Japan Steel Industry Professor of Engineering Systems and Civil and Environmental Engineering and director of the MIT Portugal Program, opened the first plenary session with a personal observation that helped put the critical need for engineering systems in context. “The scale, scope, and complexity of critical large-scale societal systems are increasing, as is the rate of change. Consider the automobile system that essentially has not changed in 100 years, comprising four wheels, a cabin, and an internal combustion engine. Designing that automobile system has always been a complex process in which one must balance consumer demand with societal concerns about energy, the environment, safety, and recycling.” Now it is evolving to an automotive network system of systems “in which one must be concerned with the interaction of infrastructure, energy, and information. ... This is just one example to make the point that what is discussed at the Engineering Systems Symposium are critical issues that have an impact not only on the future of the engineering profession, engineering education, and practice, but also have a significant societal impact.”

3. Why Engineering Systems Matters

In her opening remarks, MIT President Susan Hockfield noted that the symposium attendance “underscores the interest in engineering systems” and made particular mention of the presence of “so many university representatives.” Engineering systems, explained Hockfield, is “an emerging field and, in order to develop and grow, will require a unified and unifying effort by the academic community to reach its full potential.” She then went on to put MIT’s Engineering System Division and engineering systems in general into a broader context.

“The importance and relevance of ESD has only grown since its launch,” she said. “ESD researchers study the kind of large, complex, socio-technical systems questions that increasingly define our era, and that I believe will increasingly determine our shared future. To tackle these problems, ESD is radically cross-disciplinary. This is a signature of this era’s most exciting fields. By bringing together faculty from engineering, management, and the social sciences, ESD generates enormous creative energy, and it is also helping us to generate this kind of integrative thinking among our students, so that they will become the kind of engineering leaders and systems thinkers who will take on the great human challenges of today’s and tomorrow’s world.”

Charles Vest gave the first keynote address of the Symposium, titled [“Grand Challenges and Engineering Systems; Inspiring and Educating the Next Generation.”](#) His address set the tone for the entire discussion of why engineering systems is so important a discipline.

Vest bemoaned the low number of engineering majors among U.S. undergraduate students, especially as compared to students in Europe and Asia. “Why aren’t more kids inspired to study engineering?” he asked. His answer involved how the word “engineering” has come to be used, how jobs in the field have changed, and—in particular—*perceptions*. “Engineering is not perceived as a field in which you can make people’s lives better as an engineer,” Vest noted. “We need to make engineering education an exciting, creative, adventurous, rigorous, demanding, empowering environment. This is more important than specifying curricular details.”

He also referenced an article in the June 4, 2009, issue of *Forbes* magazine that named “engineer” as the “hardest job to fill in America.” Employers, the article points out, would rather hire one engineer trained in several areas than two or three engineers with a variety of specialties. Further, the Obama administration’s pledge to rebuild America’s infrastructure is driving an increasing need for engineers. “It seems to me,” declared Vest, “that these two things are beginning to get at the heart of this topic of engineering systems.”

Noting that there are two “major frontiers” in engineering, Vest spoke of the “tiny systems—the bio, info, nano space that is filled with things that are getting ever smaller, faster, and more complex.” This, he said, “is where a lot of the action is, it’s obviously very attractive to young people, and a lot of our best cutting-edge work is going on there.” But, he insisted, “we’ve got to worry more about the big, macroscopic systems: energy, environment, health care, manufacturing, communications, logistics, and so forth. These things are where the rubber really meets the road between engineering and society.”

Vest explained that “science and engineering have, for practical purposes, merged” in the tiny systems domain. “In a similar way,” for the engineering systems domain, “we have to engage, integrate, and merge with the social sciences writ large. We also need management, the arts, the humanities, and communication. If these things are going to become real, if they are to be politically achievable, achievable by business, and sellable to the general public, we need to work together at the same level of integration that engineering and the natural sciences do on the small side.”

The NAE, for its part, has established fourteen “Grand Challenges for Engineering” for the 21st century, aimed at “stirring the souls” and inspiring work at the frontiers of technology, both “tiny systems” and “macro systems.” Like Vest’s remarks on education, the Grand Challenges were at the center of nearly every discussion going forward in the Symposium.

Vest's notion of large-scale thinking was echoed by Yoshiaki Ohkami, Professor and Dean of Keio University's Graduate School of System Design and Management in Tokyo, Japan, in a later plenary session. He explained that his school's focus on engineering systems represents a shift in perspective: while Japan is often known for its success in developing very small, highly advanced technical devices, engineering systems research looks at key large-scale, complex systems. Likewise, many of the academic programs discussed at the symposium emphasize a holistic approach to engineering, set in the broadest of contexts. Programs encompass complex systems and systems of systems—recognizing that you cannot separate a discussion of a complex system from a discussion of the enterprise that creates and manages it.

After Vest spoke, the next session looked at a set of [“Critical Issues and Grand Challenges”](#) in particular industries. Moderated by James Champy, Chairman of Consulting, Perot Systems, the session featured presentations and discussion about four key systems, how the engineering systems discipline relates to them, and what challenges are faced in each.

John Reed, retired Chairman of Citigroup, Inc., addressed financial service systems, and outlined the major challenge of rebuilding and reconfiguring the global industry. Reed painted a picture of the system as one with interfaces across the global economy. It serves as the transmission mechanism for monetary policy and has substantial intra-industry flows that create systemic risk. While governed generally by economic rules, it is a system that also exhibits non-economic behavioral characteristics. Tracing the history of how the financial system found its way into the current global economic crisis, Reed prescribed that the industry must be “rethought and rebuilt” in way that won't destroy the real economy, and that a “systems view—including behavioral considerations—is essential” to meeting the challenge.

Denis Cortese, CEO of the Mayo Clinic, discussed healthcare as a system and described some of the steps being taken at the Mayo Clinic to meet current challenges. Cortese's presentation posed several questions aimed at demonstrating that the debate over healthcare reform, from his perspective, is looking in the wrong direction. Seeking a “vision for healthcare” that he says is lacking, he asked: Who would like to be sick tomorrow and be admitted to the best hospital? Who wants to be sick tomorrow? Who wants to be a patient tomorrow? Cortese contended that the fact that no one answers “yes” to these questions establishes the vision, which includes integrating and coordinating care so that we keep people from getting sick, we create ways to improve the health of the population, and we use individual medicine focused on the patient—all focused on *value*, not on cost. He also pointed to some structural faults in the healthcare system, noted the lack of a coherent architecture for the system, and spoke to the need to integrate various elements that are not well integrated today, particularly payment mechanisms.

Steven Koonin, Undersecretary for Science, U.S. Department of Energy, discussed energy and the environment from a systems perspective, “focusing on the challenges and not the solutions.” Koonin identified three main global energy challenges: “energy poverty of about 2 billion people who need fuel for cooking and heating and electricity for lighting and communications”; security of supply; and greenhouse gas emissions. Putting this in a systems context, he said that “we must identify, develop, and implement the most cost-effective and material solutions, and use the levers that we have, which are technology, economics, and policy.” Expanding on the systems context, he described each as “systems issues”: the climate system, the inertia of energy systems,

the optimal use of diverse energy sources, instrumentation/control/optimization of the grid, sustainable agronomy for biofuels, and optimization of buildings and cities.

The final speaker in this session was Irving Wladawsky-Berger, Chairman Emeritus of the IBM Academy of Technology and a visiting lecturer at the MIT Sloan School of Management and Engineering Systems Division. He spoke about complex organizational systems. “We need to look at the world as a system of global systems,” said Wladawsky-Berger, “and we need to optimize those systems around customer-centric values.” He pointed to the “big role” services play in these systems, and the “big role of information-based intelligence to be able to manage these very complex systems.” According to Wladawsky-Berger, “The key challenge for the knowledge age is to leverage technology, science, and innovation to make major improvements in the productivity and quality of complex organizations and the very way in which the world works.” The emerging tools to help include the emerging cloud computing model and the capabilities in real-time information analysis—which are allowing for a convergence of the world’s physical and digital infrastructures.

Speaker after speaker posited that meeting the challenges being discussed, both the Grand Challenges of the NAE and the industry-specific ones brought up in the plenary sessions, required systems thinking. Yossi Sheffi, in a session titled “MIT Perspective on Engineering Systems,” helped move the discussion of the challenges to a broader, conceptual, and theoretical level. Sheffi is Director of MIT Engineering Systems Division, as well as Professor of Engineering Systems and Professor of Civil and Environmental Engineering.

Sheffi described ESD’s view of engineering systems as comprising both a class of systems and an emerging field of scholarship that balances both quantitative and qualitative arguments, which “is what creates the most angst among some other engineering faculty.” Networks, and in fact “layers of networks,” Sheffi said, “are at the heart of most engineering systems; think of a social network overlaid on a transportation network.”

The ESD lenses through which engineering systems are viewed include: the interface of humans and technology; uncertainty and dynamics; design and implementation; networks and flows; and policy and standards. Through these lenses, ESD confronts issues and employs methods that go well beyond traditional engineering; as but one of many examples, real options, from the finance discipline, are used in applying the integrated screening model to oil and gas development.

“We internalize many of the constraints in our analysis,” Sheffi explained, “which means expanding the system. Take, for example, optimizing pilot assignments for airlines; when you try to write the optimization equation, you typically would take the labor contract as given. But adding a labor lawyer to a committee to look at how to optimize the system, *including* changing the labor law, that is where engineering systems parts company with traditional engineering. We try to look at the big picture.”

Subra Suresh, Dean of the MIT School of Engineering and Ford Professor of Engineering, echoed some of Vest’s earlier presentation. Speaking of the “engineer as problem solver,” he noted that the great accomplishments of the 18th through early 20th centuries nevertheless “created their own set of shortfalls or negative impacts on society.” The accomplishments of the

20th century “brought social and technical changes on a broad scale—but engineering did not generally include social sciences and long-term societal impact.”

Suresh expressed the view that “most of the Grand Challenges for the 21st century are to fix the successes of the greatest achievements of the 20th century.” Enter engineering systems. Suresh said, “Engineering today is an intellectual discipline critical to the creation of the next wave of fundamental scientific discoveries and critical to the translation of fundamental science to complex products, processes, and tools that benefit society and that account for long-term societal consequences of engineering.”

3. The Current State of Engineering Systems

Central to the discussion in many of the plenary sessions was the issue of how engineers are being trained to meet the challenges they will face as they leave their academic institutions and enter the workforce. Representatives from a variety of academic programs in engineering systems from around the world discussed their programs, offering specific details and highlighting general approaches and challenges. Two plenary sessions were devoted to these issues: a “[CESUN Directors Roundtable](#)” included presentations and discussions on the issues faced by academic programs in engineering systems and how the programs might continue to evolve and grow in the future; a session titled “New Global University Initiatives in Engineering Systems” featured presentations from representatives of institutions on three continents.

Although academic programs vary greatly in terms of names of degrees, course requirements, size, and structure (as discussed below), they share some common, often-overlapping attributes that also serve to define the field of engineering systems more specifically. These attributes include: a focus on real-world challenges, integration with social sciences, and large-scale thinking. Dinesh Verma, Dean of the School of Systems and Enterprises at Stevens Institute of Technology, described engineering systems as “a practice-oriented discipline rather than a theoretical discipline.” Along this line of thinking, several presenters described their programs as being “more problem-focused than methods-focused,” with an emphasis on the application of methods in the real world. The types of problems programs tackle often stretch and challenge traditional methods and tools. Notable in the case of Stevens is that it began as a department but became an entire school, reflecting the broader outline of engineering systems as a field.

The academic programs focus on applications of engineering systems methods to a wide spectrum of real and relevant challenges, such as management of the Internet, analysis of healthcare delivery policies, national security issues, sustainable energy solutions, space systems design, and logistics and supply chain analysis. The real-world nature of the research has led many of the programs to develop valuable partnerships with industry and government. The strong connections to industry, manifested in research opportunities and projects involving real-time problem solving for both faculty and students, is a common characteristic of engineering systems programs.

The specific research topics of the different programs are shaped both by global relevance and local demands and realities. For example, the Queensland University of Technology School of Engineering Systems in Brisbane, Australia, has established smart transport, aviation/airports,

energy, a Complex Urban Systems Project (CUSP), and orthopedics as its five areas of research focus. These were explained by Duncan A. Campbell, Associate Professor in Engineering Education. MIT Portugal Program's academic programs, presented by Paulo Ferrão, Director of the program in Portugal, focus on the areas of bioengineering, sustainable energy, engineering design and advanced manufacturing, and transportation. Several of the programs noted the increasing popularity of research in the field of energy.

Helping set the stage for the Symposium were the reported results from a survey CESUN conducted about a year ago to gain some insight into how its university members are addressing the issue of engineering systems. The questionnaire revealed that the number of academic units devoted to engineering systems is growing, and most units are relatively new. As of last year, 7 percent of respondents had formed academic units in the previous year; 35 percent were less than five years old; and 78 percent were less than 10 years old. In contrast, traditional engineering departments have existed for decades. Because these new units tend to be interdisciplinary, their institutional structure varies widely. Roughly 20 percent each are separate schools within their larger universities, departments within engineering schools, divisions within which faculty have dual or joint appointments, or programs, with a variety of other units comprising the remainder. One of the important defining characteristics of these units is that they have faculty from management and the social sciences, and in particular there is a significant increase in the importance of the social sciences.

Elisabeth Paté-Cornell, chair of the Department of Management Science and Engineering at Stanford University, spoke to this latter point in one of the plenary sessions. She described her department's forte as the integration of engineering and social sciences, recognizing that people are intrinsically involved in many important systems. Paul Fischbeck, Professor of Engineering and Public Policy (EPP) at Carnegie Mellon University, explained that EPP has been integrated with social sciences since the beginning of its 33-year history. Deep integration and interaction with social sciences are essential to its four major research areas: energy and environment, risk analysis and communication, information and communication technology policy, and management of technical innovation and R&D policy.

The academic programs often address challenges with multiple stakeholders, using approaches from behavioral economics and social psychology to analyze problems. The focus goes beyond solving an engineering problem to transforming policy so that the solution is sustainable.

While most units address similar areas of study, they have a range of names. The survey encompassed 27 universities and revealed 20 different unit names; one name was used three times, four names were used two times, and all other names were found only once. Examples of these names include: Systems and Industrial Engineering; Management Science and Engineering; Decision Science and Engineering Systems; Engineering and Public Policy; Systems and Enterprises; and, of course, Engineering Systems. This translates into a lack of a common identity, or what a marketing firm might describe as a "branding problem." It is worth mentioning because there is an emerging consensus that a more common identity is necessary to achieve some of the things to which CESUN aspires.

Given an objective of achieving a more common identity, a question arises regarding the substantive similarity of the academic units surveyed, irrespective of their different names. The survey found that engineering systems units tend to focus on four clusters. The first is industrial engineering, operations research, and systems analysis. The second cluster is systems engineering. In the third—socio-technical systems, technology, and policy—institutional issues are as important or more important than the technical issues, and qualitative analysis, not only quantitative analysis, plays a significant role in the solution of problems. The fourth cluster is engineering management, concentrating on entrepreneurship and innovation. Most of the units surveyed cover at least two of the four cluster areas; the MIT Engineering Systems Division, for example, covers all four.

Engineering systems academic units are broadening into new areas. The survey provided a long list; the main areas are healthcare, energy and environment, and transportation and infrastructure. Unit names, especially those of the older, more established units, often do not reflect current activities. It is not uncommon to find a unit with the name Industrial Engineering, established many years ago to study Taylorism, that now focuses on healthcare and energy from an enterprise perspective.

Despite these gains, the survey found that industry continues to lead academia in recognizing the importance of engineering systems. Respondents felt that there is often resistance or outright opposition to engineering systems programs from traditional engineering departments within their universities. Only 17 percent rated the acceptance of engineering systems by other academic units as “good” or “very good”; in contrast, the level of acceptance of engineering systems by senior university administrators is rated as good or very good by more than 61 percent of the respondents. The resistance from engineering departments in academia comes from two main sources. One has to do with fixed amounts of available resources: as new units are added to the university, there are often fewer resources to go around. More troublesome, though, is that among the heads of some engineering science departments, there are serious concerns about the legitimacy and importance of engineering systems as a new field of study. The turnover among department heads can sometimes fuel this problem; a supportive leader may be replaced by one who is much less supportive.

Speakers in plenary sessions specific to academic programs discussed a number of issues that will be critical to the continued development and success of the various programs, including

- the challenge of hiring the right faculty members who possess deep expertise in their domains; many programs currently have several “professors of the practice” who fulfill this role;
- the need for students who can approach problems holistically, yet who also have strong technical backgrounds and are firmly rooted in engineering;
- the challenge of finding funding and space for graduate students; also, for programs encompassing undergraduate and graduate students and multiple disciplines, there is the challenge of establishing a central location; and

- the scarcity of genuinely “engineering systems” journals in which to publish, and the impact this has on tenure-tracking and program-ranking.

Despite these challenges, the expansion of engineering systems in academic institutions is a positive sign for the future, as the complexity of systems and systems of systems grows and there is a growing recognition that holistic solutions—the purview of engineering systems—must be found.

4. How Engineering Systems is Being Advanced

In his keynote address titled [“The Mysterious Field of Engineering Systems.”](#) Norman Augustine touched on the question of how to define “engineering systems” and set the stage for many of the later discussions. “The average person doesn’t care how you define a system, so long as it does what they want it to do,” he remarked. The key, he explained, is to look at the right things at the right time. “Not very many people would have listed Mrs. O’Leary’s cow as an important part of the system *Chicago* before the great fire.” He went on to discuss a “dirty dozen” traps of systems engineering, and within his examples touched on many of the industries and specific problems addressed by speakers in subsequent sessions. The dozen are: the overlooked element, the sacrosanct requirement, the ubiquitous interface, the single-point failure mode, the non-redundant redundancy, sneaky circuits, non-linearities, propagating changes, engineering’s answer to the poison pill, the missing linkage, failing without grace, and the great bugaboo: humans.

The afternoon of the Symposium’s second day was devoted to invited talks that touched on a wide variety of engineering systems methods and fundamentals. First up was a session in which Olivier de Weck provided an overview of methodologies. He is Associate Professor of Engineering Systems and Aeronautics and Astronautics at MIT, and Associate Director of MIT Engineering Systems Division. He addressed the intertwined complexity of technical and social systems and how neither can be solved in isolation. He then provided an overview of both empirical and theoretical research methods, positioning them as inductive or deductive; highlighted some of the progress over the last ten years in terms of emerging principles and methods for engineering systems analysis, design, and management; and showed some examples of the impact on the real world. He closed with some suggestions for future engineering systems research.

John Doyle next discussed system architecture. Doyle, the John G. Braun Professor of Control & Dynamical Systems, Electrical Engineering, and BioEngineering at the California Institute of Technology, began with the theoretical foundations of robust system architectures, and presented some successful architectures of the simplest scale. His focus was on the sustainability of systems architectures, with examples of the “robust yet fragile” and the concept of “constraints that deconstrain.”

John Clarkson’s topic was system design. He is Professor of Engineering Design & Director, Cambridge Engineering Design Centre, Cambridge University (England). Clarkson focused on the absence of communication between the engineering design and systems engineering communities, the imperative to understand how design processes work, and the need to rethink

how students are taught about design. He called for finding not only new layers of design, but achieving the ability to translate between them. Models, said Clarkson, are essential, but provide only a limited view; model-building is a valuable process, but it is much more challenging to actually use what you have built.

The second group of “Invited Talks on Methodologies & Large-scale System Applications” began with Luis Amaral, Associate Professor of Chemical and Biological Engineering and Northwestern University (Illinois), who opened his remarks by noting, “The motivation for engineering systems work is knowing what is going to happen and when.” He also discussed the importance of determining the ways in which systems that we build integrate with other systems, and he distinguished between “complicated” and “complex.” His talk stressed the importance of network information, the kinds of insights provided by network measures, how insight guides detailed modeling, and the idea that insight may even replace detailed modeling.

Francisco Veloso, Associate Professor of Engineering and Public Policy at Carnegie Mellon University, began with some research on quality management system standards (ISO 9000), and then focused on a case study of the Silicon Valley semiconductor industry. He attributed superior performance there to high levels of labor mobility, as well as spinoffs, and showed how one firm’s people can be a regional engine of growth.

The last of the second day’s “invited talks” was on sustainability and infrastructure. Paulien Herder, Executive Director of the Next Generation Infrastructures Programme at TU Delft (Netherlands), explored infrastructure complexity and how physical networks of various kinds can lead to emergent behavior. She distinguished between physical and social networks and the different emergent behaviors that result from them. The essence of her talk was that there are various approaches and results for designing complex, sustainable infrastructures under uncertainty.

Day Three was devoted to twelve panels on various specific research topics, held concurrently in clusters of three. A broad range of industries and challenges were addressed in each. To view the presentations and accompanying papers, please go to the [Symposium website](#).

5. Looking Ahead

Many speakers at the Symposium spoke prospectively about the future of engineering systems. Rich discussions about the future took place in plenary sessions both by panelists and questioners, as well as in the lobby and at meals. One particular plenary session, Looking Ahead to 2020, addressed the future directly. Speakers included David H. Lehman, Senior Vice President and General Manager of The MITRE Corporation’s Command and Control Center; Robert E. Skinner, Jr., Executive Director of the Transportation Research Board; Heinz Stoewer, Distinguished Visiting Scientist at the Jet Propulsion Lab and Chair Emeritus at TU Delft; and Joel Moses, MIT Institute Professor. Their discussion touched on the question of taking engineering systems to the “next level”: following the trail blazed by engineering systems that has led to common approaches and understanding, but that still required finding a way to transmit complex engineering systems concepts to policymakers.

Joel Moses, looking ahead to 2020, posed five particular challenges. By that time, he would like to see

- a greater understanding of the fundamentals of engineering systems, identified as complexity, the “-ilities,” and network science.
- an examination of the fundamental assumptions of each engineering field.
- learn from each other as much as possible, as well as from management and the social sciences.
- more attention to the ability of individuals to think broadly and holistically about things, and to see the whole picture.
- a clearer distinction between systems thinking and holistic thinking.

As one participant put it, the Symposium discussion posed three key issues. One relates to how we improve existing systems. We know a lot about what can be done, but we can get even better. The second is that we are only scratching the surface with respect to methods and tools. And the third is that we are entering into a totally different, social network environment—with, as Irving Wladawsky Berger described, billions of mobile devices, trillions of sensors, and so on—that will likely change completely the way we think about designing systems. Are these three different paths? Can they come together? What may happen in terms of each?

Some at the Symposium expressed a desire to see more research to help clarify and codify what engineering systems is all about. Others believe it is more important to take on challenges than come up with the unifying principles. Nevertheless, one thing is certain: the rich discussion will continue. At a recent meeting, the board of directors of CESUN decided to make the International Engineering Systems Symposium a permanent event, to be held every three years. The next Symposium, then, will take place in 2012, with the location yet to be determined. Stay tuned.