Embracing the ENTERPRISE

BY WILLIAM B. ROUSE

Industrial and systems engineering must step up to the larger challenge

MUCH OF ENGINEERING is associated with design, development, and deployment of tangible artifacts such as airplanes, automobiles, bridges, buildings, chemical plants, computers, factories, networks, roads, ships, televisions, and trains. Some have argued that industrial and systems engineering (ISyE) suffers from the lack of a primary tangible artifact. This, they assert, makes it difficult to explain what we do, how we add value to the economy and society.

This lack is suggested as one of the reasons that college engineering freshmen do not choose ISyE as often as electrical or mechanical engineering. On the other hand, many graduating seniors are in an ISyE program. Many of Georgia Tech's 12,000 ISyE graduates — roughly 25 percent — have achieved top leadership positions in their organizations as CEOs, presidents, and the like. So the lack of a tangible artifact, if that is the case, does not seem to hinder people's careers.

How do these people achieve such notable success? After talking with many hundreds of successful ISyE graduates, it is clear what they do: They create and grow enterprises using the concepts, principles, models, methods, and tools they gained from their ISyE education. The whole enterprise is the purview of these engineers. Their artifact is the enterprise. Their focus is the breadth of things an enterprise does in pursuit of success, whether success is defined as corporate profits or delivery of public services. For this reason, ISyE graduates are, by far, the most diverse set of engineering graduates in terms of industries, positions, and career paths.

Evolution of ISyE

ISyE is the engineering discipline that deals with the whole enterprise from an engineering perspective with engineering methods and tools. Historically, our discipline focused on the shop floor with stopwatches, clipboards, and methods engineering. Our scope broadened to include manufacturing processes. ISyE methods and tools expanded to consider manufacturing systems in terms of elements of manufacturing processes and relationships among these elements.

More recently, our attention has broadened yet again to include logistics and supply chain management. This has led to focusing on processes both within and among production facilities, as well as upstream suppliers and downstream distributors. The optimization of supply chains to minimize costs and maximize profits has yielded very impressive results.

An even broader view is now emerging — the whole enterprise. Within a company, this often includes the end-to-end value stream from business capture to product development to manufacturing and assembly to product support to infrastructure (which includes finance, IT, and human resources). ISyE is now concerned with understanding how all of the elements of an enterprise play together as well as how this understanding can be used to maximize value.

However, even this broader view is too narrow. The combined forces of networking and globalization are making the boundaries of enterprises much less crisp. Telecommuting and outsourcing results in people often being in different times and places while also becoming partners rather than employees. Command and control management is fading because there are fewer situations in which this relationship makes sense.

The broader enterprise includes the company, its suppliers and distributors, customers, other stakeholders in the economic and social environment, and perhaps even competitors. Resources, incentives, and regulations become the fabric of business. The private and public sectors lose their crisp distinctions. Public policy influences important microeconomic decisions with significant macroeconomic consequences.

Enterprise systems

A major new initiative within ISyE is enterprise systems. This initiative is focused on both looking at the enterprise as an overall system and understanding the nature of systems that support enterprises. We need to address both strategic and operational issues. Examples of strategic issues of interest include modeling uncertainties and risks associated with major strategic investments and large-scale transformation of enterprise processes and cultures. Operational issues include, for example, supply chain characterization and optimization as well as revenue management in highly volatile markets.

ISyE approaches to such issues are empirically based while also being axiomatically oriented. Real-world data and case studies are central both as sources of insights and as means to evaluate ideas and results. The axiomatic orientation revolves around the ISyE concepts, principles, models, methods, and tools that have long been our profession's bread and butter and distinguish us from business schools.

A set of fundamental questions underlies these strategic and operational issues as well as our approaches to addressing them:

- **Complexity.** Systems with many elements, interconnections, attributes, and stakeholders are common domains of study and application for ISyE.

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WHO ARE THEY GOING TO CALL?

As chair of the School of Industrial and Systems Engineering at Georgia Tech, I meet many industrial engineers and am continually amazed at the range of their vocations and accomplishments. Most of them credit their IE education for enabling their achievements, but hardly any of them have (or ever had) the job title "industrial engineer."

There have been numerous suggestions in the profession that this is a problem: There are lots of IEs doing great things, but few people realize they are IEs.

Do we need to enhance the image of the profession so that the IE job title will be coveted? The image of IE is strongly related to what we do, not our job titles. Our image is related to what people perceive to be IE problems. When people have what they perceive to be an IE problem, they call an IE.

What are IE problems? This set of problems has evolved from the shop floor to manufacturing systems to logistics and supply chains. The next logical work arena, as I have advocated in this article, is the whole enterprise. IEs are the people to call when you have enterprise systems problems because industrial engineering is the engineering profession that understands how all the elements of an enterprise function together to create products, deliver services, and so on.

IE has long been the profession that has understood the human, financial, and technology factors that underlie enterprise success. However, we often have not taken our rightful place at the enterprise table.

Here's an example. The notion of enterprise architecture is receiving increased attention in large-scale, complex enterprises. In its simplest form, enterprise architecture includes three levels: operational, systems, and technical. The technical level is concerned with hardware, the systems level with software, and the operational level with work processes and tasks.

In my many consulting experiences where enterprise architecture was the topic at hand, the computing professionals, often with electrical engineering folks as well, have been responsible for all three levels. They least like dealing with the operational level because work processes and tasks are not their forte, so they get through it quickly. In effect, the IE level of the architecture is given short shrift because there are no IEs there to address it.

Why don't they just call an IE? The reason, I would argue, is because IEs have failed to claim a role in enterprise architecture pursuits. We simply don't see ourselves as players in this big game. Yet IE is the only engineering profession educated to address broad issues of how an enterprise functions, how its processes interplay, how work gets done, and how value is created. The other engineering professions, no matter how motivated and talented, are simply not prepared to address such issues.

Students need to be educated in how all the enterprise pieces fit together. They need to understand how best to address both strategic and operational enterprise issues. Practitioners need to earn and take their places at the enterprise table, addressing the issues where IEs are uniquely prepared to play key roles. As researchers, we should enable creation of the concepts, principles, methods, and tools needed by practitioners and impart the associated knowledge and skills to students.

The enterprise is ours. We need to embrace this perspective. Both IE and our many stakeholders will greatly benefit from the profession playing a major role addressing and resolving enterprise issues.

— *William B. Rouse*

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A typical goal is to understand and model enterprise systems with these characteristics.

- **Uncertainty.** The current and future states of enterprise systems are usually uncertain, especially far into the future. Uncertainties can surround the nature, magnitude, and timing of relationships and variables. Identification of relationships — for example, competitive positions — and estimation of variables — for example, market demands — are usually central concerns in enterprise systems endeavors.
- **Control.** In general, this concerns assuring that relationships and variables have desirable characteristics. More specifically, control includes allocation of resources and management of incentives and regulations. Optimization of control is sometimes possible. In many cases, control is limited to measurement and feedback as a basis for human monitoring and decision making.
- **Design.** In the context of enterprise systems, design is concerned with value streams and their relationships with market characteristics, product design, supply chains, manufacturing processes, and service delivery processes. This focus on value streams dictates an enterprisewide perspective. Narrower perspectives will inevitably result in suboptimization, whereby functions such as logistics or manufacturing may be optimized to the detriment of the broader enterprise.

Enterprise goals

Agility is a pervasive enterprise goal — the ability to respond flexibly to and take advantage of opportunities and challenges. Security is an increasingly common goal, especially in the past couple of years. A related goal is privacy, which may be challenged by security pursuits. Sustainability as a goal is concerned with minimizing consumption of nonrenewable resources and production of waste.

A central challenge for leaders is to design and manage agile, secure, and sustainable enterprises that create high value while not compromising privacy. To some extent, this challenge will be addressed by new technologies developed by myriad disciplines in science and engineering. However, the essence of this challenge is not technological.

Understanding the nature of organizations, how they can change, and how they are inclined to change are the keys to creating these types of enterprises. Much of the knowledge needed is coming from the behavioral and social sciences. From an engineering perspective, ISyE needs to create models, methods, and tools that can leverage the concepts and principles from these sciences. We need to translate basic knowledge into design practices.

We also need to infuse these design practices into engineering education. Topics that need to be integrated into the ISyE curriculum include:

- Modeling and design of enterprise value streams, including determination of how value flows can best be monetized.
- Rather than organizational structure, design of incentives, rewards, and regulations or policies are central.
- Information system design, including decision support, for all stakeholders in the enterprises.
- Financial modeling and optimization of portfolios of value options, including consideration of the "exercisability" of options.

There are, of course, many other similar topics. This list provides the flavor of the possible impact of enterprise thinking on ISyE education.

Research and education

An enterprise orientation has important implications for research and education in ISyE. This research focuses on the nature of enterprises as systems. Of particular interest is how enterprises can and should be transformed to leverage technology-based inventions — both products and processes — to create market innovations in the private and public sectors.

Understanding the nature of emerging enterprise technologies (such as collaborative tools and Web services) and assessing their implications for organizational practices and policies is imperative to such transformation. Short-circuiting the often very long adoption cycle for new technologies can provide strong competitive advantages. On the other hand, only a minority of technologies should be expedited into practice.

Research also must address the behavioral and social aspects of enterprise transformation.

Organizational change can be quite difficult, especially if management does not realize that it is an underlying issue. Research needs to focus on the nature of organizational culture and how cultural change can best be fostered. Obvious components of this include incentives, rewards, training, and education. Clarity of vision — and sustained leadership commitment to it — is, of course, an overarching success factor.

All of the above needs to be addressed with a portfolio of concepts, principles, methods, and tools of ISyE and a wide range of other disciplines. ISyE, with its systems orientation, is the natural integrator of these diverse perspectives. ISyE's methods and tools for formal modeling of systems are essential elements of in-depth understanding of enterprises in terms of such concepts as responsiveness,

stability, observation, and control.

Our great facility with modeling and simulation also plays a central role. The ability to simulate organizational changes prior to committing to them is highly desirable. And experiencing organizational changes via organizational simulation prior to proceeding with these changes is of great interest. Beyond modeling, this requires innovative approaches to visualization and interaction.

We also need to focus the physical, fiscal, and information security of enterprises. This involves understanding the nature of economic, social, political, and physical threats and the ways in which countermeasures interact with enterprise practices and processes. It also involves recognizing and developing best practices for managing security rather than assuming a solution can be installed.

This brief summary of selected research areas represents a rich set of potential doctoral dissertations as well as grist for numerous doctoral seminars. It is also easy to see a wealth of graduate-level projects or theses. The results of this breadth of research will, over time, become integrated in undergraduate education.

We also see numerous avenues for offerings in professional and executive education. We expect to experience a steady flow of staff members from our sponsors, including the private and public sectors, who will serve as visiting researchers and degree candidates in this overall endeavor.

Organizational implications

The breadth of this vision of enterprise systems is difficult to pursue within the confines of a single academic unit. Successful pursuit of this vision will require strong multidisciplinary collaboration across academic units in schools, colleges, and universities. Anyone who has been immersed in academia knows that such collaboration is not necessarily a natural act.

Success will require collaborators ranging from engineering and economics to architecture and art. Of course, not all initiatives require all disciplines. Nevertheless, when the full spectrum of enterprise-level issues is considered, the range of potential collaborators is quite large.

The question of how to organize such diverse collaborations has led me to talk with a variety of people who have undertaken similarly broad initiatives. One lesson learned is to avoid over-organizing. The consensus is to create flexible, initiative-driven teams, making maximal use of concepts for virtual organizations. The incentive and reward structures for these teams need to be crisply aligned with the visions for each initiative.

Interestingly, successful pursuit of this organizational model in an academic environment will, to a great extent, be a transformational initiative for the academic enterprise itself. Using desired enterprise impacts to drive initiatives and tailoring faculty incentives to these drivers will be novel in a university setting. If all goes well, it may be transformational indeed.

MORE ON THE ENTERPRISE

Hear more from Bill Rouse about enterprise engineering at the IIE Management Forum. The Forum takes place May 17 in conjunction with the IIE Annual Conference in Houston. Go to *www.iienet.org/annual/sems.htm* for information and to register.

Conclusions

The bottom line is simple to state but difficult to accomplish — and this in itself is an ideal challenge for ISyE.

Enterprise systems in ISyE are concerned with understanding and managing the complexities associated with large-scale private and public enterprises. This includes characterizing and estimating uncertainties and risks. It also includes optimization and control to allocate resources, monitor their deployment, and assess consequences.

Above all, enterprise systems involve seeing and addressing the system as a multidisciplinary whole.

There is no doubt that the benefits of this ISyE initiative will be broad and substantial. Stakeholders include a wide range of private and public enterprises as well as the economy and society more broadly.

The benefits these stakeholders seek include high-value impacts on quality of life, including economic, social, and physical security. Our profession has long focused on providing these benefits. Now we have the opportunity to deliver these tangible and substantial benefits to a wide range of constituencies.

William B. Rouse, Ph.D., is the H. Milton and Carolyn J. Stewart Chair of the School of Industrial and Systems Engineering at the Georgia Institute of Technology in Atlanta. He is responsible for leadership of the school, as well as development and management of the school's human and financial resources. Rouse has consulted with more than 100 enterprises and has more than 30 years of experience in individual and organizational decision making and problem solving, decision support systems, and information systems.