# AC 2007-810: DEVELOPMENT OF AN ENGINEERING MASTERS DEGREE IN ENTERPRISE SYSTEMS INNOVATION & MANAGEMENT

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**Development of an Engineering Masters Degree in**
**"Enterprise Systems Innovation & Management"**

## Introduction

This short paper describes efforts within the Ira A. Fulton School of Engineering at Arizona State University to develop and deliver a trans-disciplinary engineering degree in Enterprise Systems Innovation & Management. The degree program was created as a result of repeated requests from a number of corporate partners and sponsors to deliver an *engineering* degree that enables diverse technically oriented middle management staff to advance in their abilities to lead and manage the enterprise.

Suggestions to provide such managers with standard master of business administration degrees were met with skepticism and doubt. Leaders of technology centric corporations were unconvinced that the standard MBA curriculum included the competencies they were seeking to develop. For example, one corporate partner mentioned that the MBA would not help the sales and marketing people better communicate with engineers and other technical staff. They wanted an engineering based degree that would provide engineers and non-engineers alike with a high level understanding of technology, enterprise systems, and the application of technical analytics to achieve high performance. Most importantly, they repeatedly stressed the need to provide degree participants with a thorough background in enterprise innovation. This is defined as a comprehensive view of the processes, tools, and disciplines essential to the creation of a thoroughgoing culture of innovation.

The problems with standard MBA curricula are legion and have been well documented in the scholarly literature.[1] In general, the standard MBA curriculum focuses on discrete business functional units, normally in isolation from the enterprise systems. Thus, students are sequentially taught finance, accounting, management, marketing, and so on. Little time is spent attempting to harmonize the theoretical language across the disciplines, and none is spent on understanding how these business functions inter-relate within the operating enterprise.

The degree that is being requested by corporate partners to the Fulton School professional development programs is one that would be appropriate to mid-tier managers and executives who have responsibility that requires inter-functional as well as intra-functional skills. Clients and partners alike were clear about the desired learning outcomes they were seeking. In particular, they told us that they wanted to achieve the following objectives within the enterprise:

- Effective cross-functional communication and team building
- Information systems that provide relevant decision and knowledge support
- Human resources systems that lead to high performance
- Financial and accounting systems that highlight cost and profit centers
- Strategy systems that enable firms to compete in an ever changing global economy
- New product development systems that enhance innovation
- Production and operation systems that manage costs without inhibiting innovation
- Supply chain and vendor management systems that balance insourcing with outsourcing

These are the unique challenges that can only be discovered by looking at the enterprise as a series of interconnected systems rather than discontinuous divisions or departments. The systems view of the enterprise is unique to engineering, yet it requires humility as the

engineering school is not equipped to deliver such a degree program on its own. Enterprise systems are comprised of individuals from a multiplicity of backgrounds and with a wide range of expertise. The ESIM curriculum must match this interdisciplinary nature by establishing a corresponding multi-disciplinary content base and faculty.

This paper will address the challenge of delivering a multi- and even trans-disciplinary curriculum based on the concept of the enterprise systems.

**The Systems View**

The systems framework for understanding the enterprise has been with us for more than half a century. The view originated out of the seminal work in general systems theory, which had its liveliest period of intellectual activity in the 1930s and 1940s.[2] The general systems framework was meant to provide a unifying understanding of the ever-expanding list of natural and social sciences, within the context of a naturalistic and evolutionary superstructure. General systems theorists were motivated to unite the social and natural sciences under this common theoretical superstructure, in the interest of healing the growing rifts between the various disciplines. [3]

Although the general systems movement ran out of steam before it captured a large following, it has been resurrected several times in the past few decades. Most notably, research at MIT under the scholarly eye of Jay Forrester resulted in the hugely popular and successful book authored by Peter Senge called "The Fifth Discipline".[4] Perhaps no other book based on general systems theory has been so widely read and its principles applied in organizations of all types.

The learning organization is based on five "disciplines":

- Systems thinking
- Shared vision
- Team learning
- Personal mastery
- Mental models

This framework of disciplines provides a substantial intellectual basis for curriculum development. Significantly, this perspective also resonates well with recent scholarly work that highlights the importance of "right brain" thinking to the competitive strategies of the modern enterprise. This point of view was developed by Daniel Pink in his recent book "A Whole New Mind".[5] Pink suggests that for most of the 20th Century the enterprise was dominated by left brain thinkers. This is embodied primarily in the reductionist and analytical perspectives that underlie the leading theoretical frameworks of the era. From scientific management to the conceptualization of the bureaucracy, each of these perspectives attempted to analyze the organization into its component parts, and then determine how best to re-combine them for maximum efficiency.

Today, organizational leaders are dealing with new competitive pressures that are not always reducible to simple atomistic elements. Global economic pressures, shifting capital market

interests, centers of offshore labor excellence, and rapidly emerging markets mandate new thinking and doing.

The systems perspective is not a panacea, but it is responsive to the demands of the modern age. Firms seeking only to compete in the new era are likely to be tomorrow's acquisition targets or worse, irrelevant former stars. The age of competition is passing into a new era. Imagine if IBM had chosen to compete in computer hardware rather than re-organize itself. Today, IBM is primarily a service company. It leveraged its huge asset base, customer lists, and human capital to continue to participate in the global economy in a new way. This major strategic change is part of the organic and adaptive principals that are being highlighted today as essential for long-term organizational growth and health.

The era of competition has passed to the era of "robust participation". Robust participation suggests that the modern enterprise is adaptive rather than reactive. Competition requires the enterprise to define its industry, understand its structure, and compete within the accepted norms of that industry. Robust participation includes the need to compete within the defined boundaries of a specific industry. It also includes the opportunity to seek new applications of the enterprise asset base. Organizations involved in robust participation recognize that there is no "end game" to the economic life of the planet and its people. The enterprise that seeks to base its activities on robust participation seeks to be a part of the global wealth generating systems. Robust participation does not preclude quarterly profit reports and dedication to the maximization of shareholder value. However, it does shift emphasis to the latter over the former. Companies that seek to specialize in robust participation as opposed merely to competing understand the long-term consequences and opportunities created by their decisions and actions.

**The ESIM Curriculum**

The ASU Fulton School of Engineering offers the ESIM concentration providing enterprise and technology managers a wide range of analytical and strategic methods in enterprise systems, innovation, and management. The following illustrates the core focus of the program:

- Enterprise product/service (offering) innovation
- Enterprise process innovation
- Enterprise strategy innovation
- Enterprise management innovation
- Enterprise asset innovation
- Enterprise design innovation
- Enterprise business model innovation

The Engineering Systems Innovation and Management program allows professionals the opportunity to enhance their leadership abilities, analytical thinking, and bring value to their organization and professional advancement. In today's global environment, business execution is becoming increasingly competitive. Managing resources, products, and customers across the globe magnifies the organizational challenges and requires more sophisticated systems, tactical thinking, and advanced methods of measuring, analyzing, and controlling performance.

Managers must understand the underlying issues across the enterprise to impact and create business value.

The Enterprise Systems Management curriculum is designed to provide participants with a systems view of the organization. As such, each class is trans-disciplinary and demands synthetic in addition to analytic competence from each student. The preliminary curriculum for this new master's degree program includes a six course core curriculum, in addition to several programmatic elective options.

The goal of this curriculum is to provide a wide range of enterprise managers and other professionals with the analytical and analogical tools of Enterprise Systems Management (ESIM). As it will be defined by this program, ESIM will cover a wide range of competencies pertinent to enterprise systems at all levels, including:

- Management and human resource systems
- Organizational design and structure
- Decision making and strategy setting
- New product/service development
- Project management
- Production and operations
- Information technologies and expert systems
- Financial and accounting systems

To accommodate this range of ESIM opportunities within the enterprise, the following core and elective curricula are proposed:

**Required Core:**
**FSE 598 Introduction to Strategic Enterprise Innovation**
*This course introduces students to the varieties of innovation that occur across the enterprise. Using a general systems perspective, the various innovation types are treated both independently and as an integrated whole. From product and process innovation, to management and strategy innovation, students will learn how these various forms of innovation add to enterprise value enhancement over time.*

**IEE 505 Enterprise Information Technology Systems**
*Students will learn enterprise information technology systems applications. Topics include information technology, data modeling, data organization, process mapping, application and database development, and user interface development.*

**IEE 532 Management of Technology**
*Students will learn how to design a technical strategy, technological forecasting, interfacing marketing engineering and manufacturing, designing and managing innovative systems, creativity, and application of basic management principles.*

**IEE 530 Enterprise Modeling**
*Enterprise Modeling, is a building block course that sets the stage for many Industrial Engineering and Systems Integration courses. The course is taught in four asynchronous modules using a "voice-over power point" format. In this way the student can access each of the modules at their leisure and listen to the instructor as if in the classroom. Deliverables will be scheduled during the class with no exams expected. During the summer this will be taught in a five week format, so each module will run roughly a week and the last week will be dedicated to creating the final management presentation. The course content pursues the following outline: a. The course begins by strategically positioning enterprise modeling as a business analysis and leaning tool. b. The course then introduces a series of modeling techniques that are used as the international standards for modeling. c. The course continues with the application of the modeling techniques to lean a process, create an integrated supply network, develop a knowledge management system, etc. d. The course ends with a capstone deliverable of a business management presentation by the student on how the enterprise modeling techniques can be positioned to effectively address a real business issue.*

**IEE 512 Financial Engineering (Finance and Accounting for Non-Financial Managers)**
*This introductory course for non-finance managers will focus on financial engineering covering traditional portfolio of theory, forwards, futures, financial stochastic models, option pricing, and risk management.*

**IEE 593 Capstone**

**Electives (Select 3 Courses)**

**IEE 552 Strategic Technological Planning**
*Studies concepts of strategy, strategy formulation process, and strategic planning methodologies with emphasis on engineering design, enterprise-wide systems, and manufacturing strategy complimented by case studies. Presents and uses an analytical executive planning decision support system throughout the course.*

**FSE 598 Collaborative Innovation Management and Value Creation (Duening)**
*This advanced course teaches students how to create an innovation culture throughout the enterprise. Best practice techniques from leading innovation enterprises around the world are studied and analyzed. Students learn to distinguish between the ingredients for innovation and the particular recipe of ingredients to be applied under varying enterprise environments. Students will also explore modern collaborative innovation techniques such as "open innovation", "peer production", "wikinomics", and others.*

**FSE 598 Contracts and Negotiation in the Extended Enterprise**
*Most business schools neglect to offer a full course in negotiating and managing contracts. The reason for this is that most business schools are oriented toward managing internal affairs, where contracts are not required. In today's extended enterprise, however, companies participate in complex business webs and networks of service providers. Contract initiation, negotiation, and service level agreement management and stewardship will be covered in this course.*

**FSE 598 Intellectual Property Management**
*Some regard intellectual property to be the number one asset for the modern enterprise. Global organizations face increasing pressure to develop and manage IP in new and more collaborative ways. This course covers the fundamentals of intellectual property development, including trade secrets, patents, and others. It goes further, however, in also discussing how the enterprise can leverage IP through licensing in, licensing out, spin-offs, spin-ins, and other ways of enhancing the top line through creative application of intellectual property.*

**FSE 598 Corporate Venturing**
*Corporate venturing was hot in the mid-1990's when firms in a wide range of industries attempted to use capital resources to invest in the dot-com bubble. However, when the bubble burst many firms quickly abandoned their corporate venturing units. Today, corporate venturing is enjoying a renaissance as firms seek to create value through innovation around the world and also seek to retain ownership in the value they are creating. This course will focus on the new form of corporate venturing, with an emphasis on strategic investing and partnership formation.*

**FSE 598 Engineering Entrepreneurship**
*Engineering entrepreneurship provides individuals throughout the enterprise with the knowledge and skills of opportunity recognition and advancement. The modern enterprise is characterized by global footprints, many of which are in emerging economies that present innumerable opportunities for scalable growth. Some firms have been setting a torrid pace to capture value incrementally in these emerging markets, potentially establishing market presence that will be increasingly difficult to upend. Firms today must cultivate entrepreneurship as part of their internal culture, breeding leaders who are able to identify, build a business case for, and take advantage of emerging opportunities.*

**IEE 534 Supply Chain Modeling and Analysis**
*The objective of the course is to expose students to the basic issues that need to be considered in designing and operating supply chains and a variety of modeling tools available for their analysis. Emphasis will be on application and development of mathematical modeling techniques for the analysis of strategic, tactical and operational supply chain problems including inventory management, transportation, distribution & facility location, supply contracts and coordination among supply chain partners. Other related topics to be covered include various critical concepts and strategies such as risk pooling, information sharing, and the role of information systems in supply chain management.*

**IEE 561 Production Systems (Factory Physics)**
*Understanding how factories operate, how performance is measured, and how operational changes impact performance metrics. Operational philosophies, increasing production efficiency through quantitative methods.*

**IEE 571 Quality Management**
*Total quality concepts, quality strategies, quality and competitive position, quality costs, vendor relations, the quality manual, and quality in the services.*

**IEE 572 Design of Engineering Experiments**

*This is a basic course in designing experiments and analyzing the resulting data. It is intended for engineers, physical/chemical scientists and scientists from other fields such as biotechnology and biology. The course deals with the types of experiments that are frequently conducted in industrial settings. The prerequisite background is a basic working knowledge of statistical methods. A formal course in engineering statistics at the level of ECE 380 is the official prerequisite, but this specific course isn't essential. You will need to know how to compute and interpret the sample mean and standard deviation, have previous exposure to the normal distribution, be familiar with the concepts of testing hypotheses (the t-test, for example), constructing and interpreting a confidence interval, and model-fitting using the method of least squares. Most of these ideas will be reviewed as they are needed. The course objective is to learn how to plan, design and conduct experiments efficiently and effectively, and analyze the resulting data to obtain objective conclusions. Both design and statistical analysis issues are discussed. Opportunities to use the principles taught in the course arise in all phases of engineering work, including new product design and development, process development, and manufacturing process improvement. Applications from various fields of engineering (including chemical, mechanical, electrical, materials science, industrial, etc.) will be illustrated throughout the course. Computer software packages (Design-Expert, Minitab) to implement the methods presented will be illustrated extensively, and you will have opportunities to use it for homework assignments and the term project.*

**IEE 598 Introduction to Systems Engineering**

This curriculum provides ESIM program participants with flexibility to choose a concentration in an area that suits their talents and career interests. Each concentration culminates in a capstone project that students complete based on the needs of their enterprise and their interests. Capstone projects will be pertinent to their specific concentration area, and are expected to draw upon the concept foundations of the core curriculum.

**Pedagogy**

There has been as much consideration of pedagogy as curriculum in the design of this program. It is anticipated that the program participants will consist primarily of practitioners who will have little patience for overly theoretical material that does not have readily apparent real-world application. The curriculum was designed to reflect that assumed bias and the teaching methods must follow suit.

As such the ESIM program will specialize in a pedagogy that combines lecture and concept transfer with case and use-case discussion and analysis. Concept transfer is considered to be an essential component of the system-theoretic curriculum. That is, learning to think in terms of enterprise systems has required the attending faculty to develop concepts and terms that are new to the holistic understanding of the enterprise. These concepts (vocabulary) comprise the paradigm shifting perspective of the general systems framework. Students must become familiar with the vocabulary of systems theory and of the concept of the "enterprise". These core

elements are used throughout the curriculum and leveraged to provide deep, trans-disciplinary, trans-functional understanding of the enterprise and its environment.

Case analysis is an important part of the pedagogy as well. The case method is widely practiced in leading business schools, but is unfamiliar to many in the engineering disciplines. Practical, rich, and relevant case material will enable students to apply their new found vocabulary in the relative safety of the classroom. Use-cases will be drawn from the actual workplace environments of the students. These will be drawn up by the students themselves based on guidelines provided by the ESIM program instructors.

Finally, each concentration area in the ESIM curriculum includes a capstone experience that students are required to complete. The capstone experience is designed by the student in consultation with an ESIM faculty member and a sponsor from their employing enterprise. Capstone experiences are designed to be similar in economic or performance impact to projects conducted by Six Sigma black belt holders. The latter are required to complete a project that has, at minimum, a $1 million impact on their employing enterprise.

The capstone projects for the ESIM concentrations will not have as stringent a requirement as a Six Sigma black belt, but it is intended to be practical, and comprehensive of the core and concentration curricula. Students will receive three credit hours for the practicum work.

**ESIM Distinction from MBA**

The ESIM program is being marketed to major corporations who have requested an alternative to the MBA. As such, the program is being pulled into the market on a just-in-time basis to select corporate clients. To date, the ESIM program has been presented to potential clients in a diversity of industries, including aerospace, defense, and retail. The response to the new curriculum and desired learning objectives has been overwhelmingly positive. The first cohort for the ESIM degree will enroll in Fall 2007.

The ESIM program is distinct from the standard master of business administration program, and this is one of its primary strengths. The higher education literature currently is filled with criticisms of the standard MBA curriculum offered at most business schools in the United States. This curriculum is centered on the corporation and its functions. While this is an appropriate orientation for companies and individuals with an enterprise focus, the MBA is no longer relevant to today's rapidly evolving enterprise and enterprise environment. Critiques of the MBA range from its focus on quantitative analysis over managerial and leadership skill building to its excessive focus on the discrete disciplines over a synthetic view of the enterprise as a whole.

The engineering school is far less mature in its dealings with the entire enterprise, and thus far more labile in its curricular and pedagogical orientation. Where the business school practices inter- and trans-disciplinary work only grudgingly, the engineering school with its focus on systems is *inherently* interdisciplinary in much of its research and teaching. Thus, the faculty in

engineering schools is more likely to be amenable to interdisciplinary programming than faculty in business schools, but no less committed to quality and academic rigor.

Another point of departure between the ESIM and the MBA is that the former is more closely aligned with actual practice in a wide range of industries. Faculty members in engineering are more likely to have hands-on industry-specific experience than faculty members in business schools. As such, the vocabulary and nomenclature that comprise the course are aligned with that being used in industry. Terms such as lean six sigma, quality function deployment, and house of quality are common throughout the curriculum.

**ESIM Home in the Engineering School**

At ASU the engineering school has devised a unique Master of Science in Engineering Science (MSES) degree program template that allows for the rapid development and approval of new degree programs. This unique model enables the school to respond on its own to market demands for programming, without needing approval from the board of regents. The template has been used for several unique masters programs, each of which has proven to be unique revenue generating programs for the school. The MSES template requires an existing department to sponsor the program, and it also requires approvals through the dean and university provost. Experience has shown, however, that departmental approval is normally not blocked by the dean or provost.

In addition to being offered primarily through the industrial engineering department, the program will be marketed and developed as a cross-over in-class/online degree program. Students will experience some of the course material in face to face classroom settings and some via the online format. This provides the potential for worldwide distribution of the program and makes it "friendlier" to individuals who are fully employed.

The ESIM at the initiating state university will find its home in the industrial engineering department. Experience shows that industrial engineering courses are closely aligned with the core curriculum in the ESIM program. At the large institution in which the new masters program has been initiated, many faculty members from industrial engineering have expressed a strong interest in participating. Some have offered insightful comments and critiques that have helped forge the core curriculum as well as the areas of concentration.

There are several admissions criteria to the ESIM that ensue from establishing its home in industrial engineering. For example, the department chairman has insisted that students enrolling in the program have a B.S. degree from an accredited university. This limits the program to students who have completed a technically-oriented undergraduate degree, but also opens it up to those who may not have completed an undergraduate degree in engineering. An additional requirement for admission to the ESIM program is demonstrated competency in college calculus. This can be demonstrated via undergraduate transcript or competency testing. Alternatively, the ESIM program will also offer a college level calculus course to students wanting to enroll but lacking this pre-requisite. The program will also offer a refresher course in college calculus and statistics for students who wish to enroll but who feel out of practice in these areas.

## References


[1] See for example Bennis W.G. and J. O'Toole, "How Business Schools Lost Their Way", *Harvard Business Review,* May 2005, p. 96-104.

[2] Von Bertalanffy, L., "The History and Status of General Systems Theory", *Academy of Management Journal,* December 1972, p. 407-426.

[3] In particular, the history of the "general systems theory" movement is embodied in the works of such thinkers as Ludwig von Bertalanffy, General Systems Theory: Foundations, Development, Applications (reprint, George Braziller, March 1976); Ervin Laszlo, The Systems View of the World: A Holistic Vision for Our Time (Revised 2nd edition, Hampton Press, June 1996); Stafford Beer, The Heart of Enterprise (New edition, New York: John Wiley & Sons, March 1995).

[4] Senge, P. The Fifth Discipline: The Art and Practice of the Learning Organization (New York, Currency Press, 1990).

[5] Pink, D. A Whole New Mind: Why Right Brainers will Rule the Future (Riverhead, March 2005).