

KEY ELEMENTS IN DEVELOPING AN ONLINE GRADUATE COURSE IN SYSTEMS ENGINEERING MANAGEMENT

P. B. Ravikumar

**Professor, Mechanical & Industrial Engineering Department
University of Wisconsin, Platteville, WI**

Abstract

The University of Wisconsin - Platteville offers a completely online Master of Engineering program. The curriculum consists of core courses, technical emphasis courses, and elective courses. The curriculum is enhanced consistently through improvements in existing courses and the introduction of new courses. A course on Systems Engineering Management is being developed by the author and will be offered online beginning in 2004. The Master of Science in Project Management program is also exploring the possibility of including the course in its curriculum. Key elements in the development of the Systems Engineering Management course are addressed. They include an overview of the Master of Engineering curriculum, background of Systems Engineering Management, the role of Systems Engineering Management in the curriculum, major topics planned for coverage in the course, strategy for teaching / learning, and addressing other factors relating to the online mode of offering the course.

Why Systems Engineering Management in the Program?

The American Society for Engineering Management (ASEM) defines Engineering Management as “the art and science of planning, organizing, allocating resources, and directing and controlling activities which have a technological component”¹. This definition is followed by the sentence: “Engineering Management is rapidly becoming recognized as a professional discipline.” Engineering managers are distinguished from other managers by the fact that they possess both an ability to apply engineering principles and a skill in organizing and directing technical projects and people in technical jobs”. The Systems Engineering Management course uses a systematic approach to both the system design / engineering and management aspects. In addition, the course offers the link between the system design and management functions. The focus on system level functions is consistent with the demands imposed by the design and development needs of new systems and/or the re-engineering of current systems. Current trends indicate that, in general, the complexity of systems is increasing, with constantly changing requirements and the introduction of new technologies on a continuing and evolutionary basis. It is now apparent that the new era of global transportation, global communication, global competition, and even global turmoil is not only different in type and direction, it is unique technologically and politically. It is a time of restructuring and invention, of architecting new products and processes, and of new ways of thinking about how systems are created and built.² It is now more important than ever to ensure that the principles and concepts of system engineering are properly implemented in both the design and development of new systems and/or the re-engineering of existing systems.³

Systems Engineering Management Background

Conventional education in engineering and management does not address *systems* concepts and as a result prospective project engineering management candidates from engineering and / or management are not well prepared to manage the system integration process. System level knowledge and thinking based on sound technical and scientific principles must support the decisions of project managers for successful systems engineering management. Such an approach is increasingly becoming necessary due to increased system complexity that has to be realized in less time to provide better performance, quality, and cost expectations demanded by the customer. Lack of a system level approach or a “top down” approach has been a major source of problems in achieving desired objectives. It is thus essential to learn the concepts of systems engineering and management so that it can be implemented in both the design and development of new systems and / or the re-engineering of current systems. The system must be viewed in terms of its components in an integrated manner through the entire life cycle beginning with preliminary design all the way to system retirement. The subject of Systems Engineering Management must include topics that support the technical as well as management functions to serve as the basis for successful systems engineering.³ Fig. 1 shows the application of principles of technology and management from a systems perspective to the system engineering process.



System Engineering (Organization and Management)

Concept ≡ Preliminary ≡ Detail Design ≡ Production ≡ System Operation ≡ Retirement
Design System Design and and / or and and
 Development Construction Support Phase Out



System Engineering (Technology)

Fig. 1 Management and Technology Applied to the System Engineering Process

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TABLE 1

<u>Core Courses</u>		
	<u>Mathematics</u> (Choice of 1 course)	
	MATH 5230	Linear Algebra
	MATH 6030	Statistical Methods with Applications
	<u>Computer Applications</u>	
	CEE 7830	Optimization with Engineering Applications
	<u>Technical Communications</u> (Choice of 1 course)	
	COMM 5010	Business Communications
	ENGL 5000	Technical Writing
	<u>Engineering Management</u> (Required)	
	PM 7010	Project Management Techniques I
<u>Technical Emphasis Courses (Total of 9 credits in a single emphasis area)</u>		
	<u>Engineering Design</u>	
	CEE 7830	Optimization with Engineering Applications
	MIE 6800	Finite Element Analysis
	MIE 7300	Experimental Design
	MIE 7550	Product Design and Development
	MOE 7980	Independent Study in Engineering (1 - 3 Cr)
	<u>Engineering Management</u>	
	MIE 6030	Production and Operations Analysis
	MIE 6830	Cost and Value Analysis
	PM 7020	Project Management Techniques II
	MOE 7980	Independent Study in Engineering (1 - 3 Cr)
<u>Elective Courses (9 credits from this area or from any of the above courses not taken)</u>		
BSAD 5620 Financial Management		BSAD 6110 Management Science
BSAD 7540 Advanced Quality Management		CEE 5810 Occupational Safety & Health for General Ind (2 Cr)
CEE 5820 Safety & Health for Construction Industry (2 Cr)		CEE 7160 Advanced Foundation Design
MIE 7330 Application of Control Theory in Dynamic Systems		MIE 7730 Design for Manufacturability
<i>MIE 7830 Systems Engineering Management</i>		

The On-line Master of Engineering Program

The Master of Engineering degree program offered at the University of Wisconsin - Platteville is 100 % online. The program requires 30 credits of advanced course work. The student must complete at least 15 credits at the 700 Level. The curriculum consists of Core Courses, Technical Emphasis Courses, and Elective Courses. Table 1 lists specific courses and requirements. The degree is tailored for those seeking a cross-disciplinary terminal degree. No campus visits are necessary. Students must maintain at least 3.00 GPA. At least 50 % of the credits must be earned from the University of Wisconsin - Platteville.

Role of Systems Engineering Management in the Curriculum

The list of courses and requirements outlined in Table 1 shows that the curriculum has been designed with the intent of addressing the needs of students who are mostly in the technical and management workplace seeking a terminal degree, often cross - disciplinary. Many of them might have gained experience in specific areas of their specialty and are preparing to move to higher responsibilities that are likely to involve system level engineering and management. As the curriculum shows, no one particular course addresses this system level integrated approach and hence the Systems Engineering Management course being developed fills this void.

Major Topics Planned for Coverage in the Course

A. Introduction to System Engineering:

It is important to provide a thorough introduction to system engineering given that *system* thinking is not all that prevalent. The current environment that calls for System Engineering and Management, and related terms and definitions are addressed.

B. The System Engineering Process:

Although considerable literature is available in the realm of conventional design processes and methods, it must be emphasized and learnt in the context of a systems approach through a system engineering process. This calls for the study of topics such as system feasibility analysis, system operational requirements, the maintenance and support concept, identification of technical performance measures, functional analysis, requirements allocation, system synthesis, analysis, and optimization, design integration, test and evaluation, production and/or construction, system operational use and sustaining support, system retirement and disposal.

C. System Design Requirements:

The development of specifications and design criteria will require a systems' perspective. It is helpful to present this section from different engineering discipline perspectives such as reliability engineering, human factors engineering, and quality engineering.

D. Engineering Design Methods and Tools:

Within the framework of a systems approach, it will be necessary to review or elaborate on engineering design methods such as the use of simulation in systems engineering, rapid prototyping, mockups, computer aided design, manufacturing, and logistics support.

- E. **Design Review and Evaluation:**
Design review and evaluation functions fit the systems approach naturally. Topics such as design review and evaluation requirements, informal and formal design review aspects, and design change as well as system modification process are covered in this section.
- F. **System Engineering Program Planning:**
The topics thus far focused on the system engineering process, the major steps in the process, and some of the technologies and tools available. It is now necessary to consider the *implementation*. As shown in Fig. 1, the appropriate combination of both *technology* and *management* is required to meet the objectives. The key to successful implementation is *planning*. Concepts such as Work Breakdown Structure (WBS) and System Engineering Management Plan (SEMP) have to be thoroughly gone through in this section, citing examples from large projects. Some of the projects undertaken by federal agencies can serve as excellent examples.
- G. **Organization for System Engineering:**
To implement plans such as SEMP requires an organizational structure. The organization structure must be such as to support the generation and implementation of the engineering requirements effectively. Topics such as consumer organizations and functions, producer organization and functions, and organizational structures such as functional, product-line/project, and matrix forms are to be addressed in this section.
- H. **System Engineering Program Evaluation:**
The topics thus far have addressed the planning, organization, and implementation of a systems engineering program. It is also essential to consider a formal evaluation, feedback, and control mechanism to measure, assess, and take corrective action as needed to successfully accomplish system design and implementation.

Factors to Consider in Offering the Course On-line

As the course is 100 % on line, factors unique to on-line course offerings must be considered during the course development and implementation. They include:

1. **Working with information technology and on-line course management personnel**
Teaching an on-line course requires a significantly greater amount of interaction with and support from information technology and on-line course management personnel. It is important for the faculty teaching the course to co-ordinate course requirements with such personnel in a timely manner to ensure that various resources and student activities are accomplished according to set plans. Examples include making on-line course content available as per study schedule and preparing exams /quiz in a timely manner to make them available on-line as per schedule.
2. **Getting trained in necessary online course offering and management software**
Although technical support personnel provide any necessary help, it is important for the

faculty teaching the course to get trained in the on-line course offering and management software that supports the course. This can significantly enhance the productivity and effectiveness of the course.

3. **Scheduling course revision / development so as to synchronize with the release of the latest edition of the textbook planned for the course**

If course revision / development is not synchronized with the release of the latest edition of the planned textbook for the course, the revision / development will have to be repeated when the new version is released. As much of the course information must be in tangible form for an on-line course, such an approach is very likely to result in duplicated waste of significant effort.

4. **Structuring the content to be user-friendly and modular for easier revisions / modifications**

Modular structure of on-line content

- * Provides user-friendly format for self-study by the students.
- * Helps make changes easily to portions of on-line content as needed.
- * Helps revise on-line content more easily for a new textbook or a new edition.
- * Provides flexibility to enhance content quality and/or quantity more easily.

5. **Adapting multi-media course content to the on-line environment**

Limitations of on-line course offering and management software to handle multi-media course content must be overcome (by alternative means if required) to ensure that such multi-media content is provided on-line just as it is done in regular classroom situations.

6. **Conforming with copyright issues**

It is of course necessary ethically and legally to comply with copyright and confidentiality protocols. This can be quite a challenge given that students are in various geographic locations with access to information from various sources not only in the public domain but also in the private domain such as their workplaces. It is important to make use of administrative support that is often available to address such issues.

7. **Offering useful on-line teaching/learning tools**

On-line group discussion forums, e-mail correspondence, on-line announcements, digital drop boxes for assignment and submission of tasks, and on-line quiz / exams are some of the on-line tools that must support the core on-line content which is the primary source of learning for the students besides the textbook. The on-line quiz/exams help assess student performance beyond projects and take-home exams. Consistent with the on-line mode of instruction, assessment of how well the course goals' were met can also be assessed on-line.

Conclusions

Key elements in the development of the Systems Engineering Management course were addressed. They include an overview of the Master of Engineering curriculum, background of Systems Engineering Management, the role of Systems Engineering Management in the curriculum, major topics planned for coverage in the course, strategy for teaching / learning, and factors relating to the online mode of offering the course. The course is being developed by the author as part of the curriculum leading to a Master of Engineering degree at the University of Wisconsin - Platteville and is set to be offered in the 2004 spring semester. The course fills the need for a course that addresses design and management functions from a systems perspective. In doing so, it also serves as a link between the design/engineering and management functions that are so essential to achieving successful systems engineering.

Bibliography

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Biography

Dr. P.B. Ravikumar is Professor of Mechanical and Industrial Engineering at the University of Wisconsin, Platteville. Besides on-line graduate courses in Systems Engineering Management and Design for Manufacturability, he teaches different undergraduate courses in design and manufacturing. He has over fifteen years of experience in engineering education and many years of direct and consulting experience in industry.